IDENTIFYING SOCIOECONOMIC CONSTRAINTS TO AND INCENTIVES FOR FASTER TECHNOLOGY ADOPTION: PATHWAYS TO SUSTAINABLE INTENSIFICATION IN EASTERN AND SOUTHERN AFRICA (*ADOPTION PATHWAYS*)

KENYA ADOPTION PATHWAYS 2013 SURVEY REPORT

Obare, G[1].; Muricho, G[2]., Kassie, M[2]. and Kariuki, I[1].

[1]Egerton University, Nakuru, Kenya

[2]International Maize and Wheat Improvement Center, Nairobi, Kenya

The Adoption Pathways project is supported by the Australian International Food Security Research Centre (AIFSRC) and managed by the Australian Center for International Agricultural Research (ACIAR). The project implemented and led by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with the five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) Universities and Research institutes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The Adoption Pathways project seeks to understand the constraints to and incentives for faster adoption of sustainable agricultural intensification (SAI) practices in Eastern and Southern Africa. SAI practices include use of improved seeds, fertilizer, herbicide, pesticide use, manure application, soil and water conservation and minimum/zero tillage s. The project further seek to better understand the role of gender in the process of taking up SAI practices in the face of climate variability and changing policy environment and how these impact on production risks that farmers face, among others.

The study findings in this report show that agriculture is the main source of livelihoods for farmers and that the majority of decision makers on general agricultural production activities are males. However, majority of those who report agriculture as the main primary occupation are females. Beside, majority of those who make plot level agricultural production decisions are females (38%) followed by joint decision making (35%) and then males (27%).

Bungoma and Meru counties the most educated household heads. Furthermore, education level of the household head was positively and significantly associated with higher adoption levels of SAI practices particularly fertilizer, pesticide and manure use. On the other hand, it was negatively and significantly associated with herbicide use, minimum tillage, soil and water conservation, and maize-legume crop rotation. The household size in absolute numbers and adult-equivalents are higher in the western compared to the eastern region counties. Nevertheless, the distribution of household size by gender shows that females are more compared to males, and this applies across the study counties. Household farm sizes are higher in Bungoma and Siaya Counties, while the smallest sizes are reported in Meru County.

The most widely owned household assets among the surveyed households were mobile phones (80-90%), radio (85%) and bicycles (about 55%). Donkey/ox-carts, pushcarts, tractors, ox-ploughs and water pumps are some of the other assets that were owned by a small number of households. The difference on the decision on assert use and disposal was not significant across gender, other than on the decision to give an asset away (made by female) and to keep in case of divorce, which was entirely male-dominated. With respect to livestock, mortgaging or selling, hiring out, keeping in case of divorce, and on new purchased males dominated females, while females dominated males on the decision to give away. Poultry was, nevertheless, the dominant livestock asset across the counties.

Social capital development was limited. This was according to the number of family members who belong to a group. Majority of households were members of merry-go-rounds and increasingly in crop marketing groups. Females reported significantly a bigger number of people that they can rely on, in case of a problem, in the village including traders. However, males have significantly more friends or relatives in leadership positions, in addition to reporting that they can rely on government support in cases of emergencies or shocks.

The perception on soil fertility indicators and characteristics vary according to gender. Furthermore, males use relatively more improved maize seed varieties than females. Improved OPVs are seldom adopted across counties. More critically though, is the finding that higher maize land productivity is reported on those plots that are managed by men.

Maize-legume intercrop, the use of improved maize variety and inorganic fertilizer is practiced by the majority of farmers. Minimum tillage is practiced by about 7% of the respondents, while 8% practice maize-legume rotation. Farmers in the western region appear to use relatively more of the available SAI practices than those in the eastern region. It is also apparent that more females practices maize-legume inter-crop than males. On average, the majority of households are reported to have adopted about four SAI practices per plot. Imenti South leads in the adoption of an average of three practices while Siaya reports about two.

The SAI practice combination and its impact on income and labor use was determined by among others farm inputs, access to information and access and availability of credit. Farmers that are in organized groups tend to adopt more of improved seed variety and fertilizer, while the elderly used more fertilizer and manure packages. Likewise the soil fertility level influenced the adoption of fertilizer and pesticide packages. Farmers with small land sizes use more than two SAI practices on their sub plots. Farmers' income influences uptake of more SAI practices more so those that use fertilizer. Packages containing fertilizer, manure and pesticide report more labor-use intensity, with women providing the bulk of the labour. In general the highest returns from farming are achieved when SAI practices are adopted in combination rather than in isolation.

A strong and robust relationship between labor required and the number of SAI practices used, as well as the primary occupation of the smallholder farmers, was evident. The size of land that farmers own and their education level are critical in determining the number of SAI practices used. Likewise famers' income was also key in determining the number of

technology they would use on their plots. Moreover, the frequency of contact between extension officers and farmers that positively affects the number of SAI technologies used. Crop rotation was found to increase yield under all the three cropping systems considered. Improved seed also increases yield when used on maize bean intercrop and pure maize stand systems, and that bean pure stand yield increases are reported under use minimum tillage and soil and water conservation.

The relationship between cropping systems and SAI practices uptake show that herbicide use drastically reduces farmers’ income on intercrop and pure maize stand plots. Social capital is positively associated enhanced uptake and that the choice of a cropping system is not gender neutral.

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During the field survey that was conducted during September/October 2013, a lot of farmers in the SIMLSESA study sites in Kenya, from Bungoma, Embu, Meru, Siaya and Tharaka Nithi counties were involved. They put up with long hours of interviews. This time would have been into alternative use. Without their patience and willingness to provide the desired information and data, the survey would have been unsuccessful and subsequently this report would not have been produced. We greatly acknowledge the time that they set aside to make the exercise a success.

The research assistants who were instrumental in the collection of field survey are greatly acknowledged. Furthermore, the project benefited from the tireless efforts of John Mburu, Wilckyster Nyarindo and Jonah Kiprop who assisted in the data cleaning and management.

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We are responsible for errors of omission and commission.

CHAPTER ONE: INTRODUCTION

1.1 Project background

Development opportunities and intensification pathways for African farmers are increasingly conditioned by complex interactions between socioeconomic factors and heterogeneity in production environment. Most previous technology adoption and impact studies in Africa have used cross-sectional survey data which cannot address many important research and policy questions and fail to capture the dynamics of technology adoption decisions in response to changes in the economic, socio-cultural and agro-climatic conditions. Moreover, studies that assess the direct and indirect livelihood impacts of technology adoption are limited in the context of Africa. Without an in-depth understanding of the economics of farming decisions under uncertainty, technology scaling out interventions and policy decisions will be made based on incomplete information.

To address this knowledge gap, this project aims to draw on and expand existing datasets assembled through sustainable intensification of maize and legumes in eastern and southern Africa (SIMLESA) project to initiate panel datasets in sentinel villages. These sentinel sites represent maize-based farming systems in five African countries (Ethiopia, Kenya, Tanzania, Malawi and Mozambique) for monitoring development changes.

The overall objective of the project is to improve our understanding of how socioeconomic factors (including gender) and changes in farming systems, as well as external factors like climate variability and policies, shape adoption processes and production risks faced by smallholder farmers in Africa. It will also strengthen local capacity for applied policy-oriented research on technology adoption and impacts. In brief, the four specific objectives are to: 1) Enhance the technology adoption process by generating knowledge and panel data on how markets, assets, institutions, gender relations, farmer's risk and time preferences and technology policies constrain or facilitate adoption; 2) Advance the understanding of how farmers' livelihood strategies and SAI investments interact and influence vulnerability and farm household adaptation to climate variability and change; 3) Generate evidence on the socioeconomic impacts of adoption of multiple and complementary SAI technologies; and 4) Enhance the capacity for gender-sensitive agricultural technology policy research and communication of policy recommendations.

These objectives will be achieved through the analysis of existing household level datasets to produce results that inform technology targeting and adoption in SIMLESA project sites and by establishing and analyzing panel datasets in sentinel villages across five countries. The analyses will contribute to better understand household decisions on technology adoption and resource use, which in turn will help design policy options to reduce risk and vulnerability, increase farm productivity and food security, and enhance development pathways for smallholder producers in the region.

The project will produce immediate outputs by synthesizing information from analysis of existing data and literature to accelerate technology adoption in SIMLESA areas and assist broader gender-inclusive technology targeting across countries. Over the medium to long-term, benefits include developing knowledge and understanding of the underlying forces of adoption; identification of drivers (both accelerators and impediments) of change; tools and methods for analyzing impact of new technologies; and practical and actionable policy recommendations for improving the adoption of new technologies. It is estimated that over the 10 years, more than 71,000 farmers in SIMLESA target areas will directly benefit from faster adoption of technologies, and another 60,000 farmers in non-SIMLESA areas will benefit through technology spillover. The outputs and results of this project will immediately benefit SIMLESA and other ongoing and future ACIAR and AIFSC supported projects in terms of understanding and identifying opportunities that work best. The results will be shared with key stakeholders through local partners, policy workshops and other dissemination approaches.

Partners directly involved in this project include CIMMYT, IFPRI, University of Queensland (Australia), University of Life Sciences (Norway), Ethiopia Institute of Agricultural Research, Egerton University (Kenya), Sokoine University of Agriculture (Tanzania), University of Malawi, and Eduardo Mondlane University (Mozambique). The contents in this report are a result of data analyses from the Kenyan research sites.

1.2 Survey sampling and data collection

1.2.1. Study sites

This study was conducted in Embu, Meru and Tharaka-Nithi Counties in the Eastern Region formerly known as Eastern Province and in Bungoma and Siaya Counties in Western Region formerly known as Western Province. The map of the study area is shown in Figure 1.1
Embu County borders Tharaka Nithi to the north and covers an area of 2,818 per square km. Embu County borders Tharaka Nithi to the north, Kitui to the east, Machakos to the south, Muranga to the south west, Kirinyaga to the west and Meru to the North West. The County covers an area of 2,818 per square km with a population density is 183 people per square km. In addition the county receives a bimodal rain pattern, with the peak rainfall with the peak rainfall generally occurring between March and June. Meru County has a total population of 1,356,301; 320,616 households and covers an area of 6,936.9 per square km, with a population density of 195.5 per square km. Temperatures range from a minimum of 16°C to a maximum of 23°C. The rainfall ranges between 500mm and 2600mm per annum. With the main agricultural activity including, dairying, French beans, yam, cassava, pumpkin, millet and sorghum, the poverty level still remains at: 41% (Meru Central) and 47.3% (Meru North).

Siaya County has a total population of 842,304; with 199,034 households and covers an area of 2,530.5 per square km. The Population density is 332 per square km and 57.9% of the population live below the poverty line. The area receives an annual rainfall of between 1,170 mm and 1,450 mm with a mean annual temperature of 21.75^{o}c and a range of 15^{o}c and 30^{o}c. The poverty level is high ranging from 57.9% (rural) and 37.9% (urban) .Other than agricultural land, the area has vital resources such as fisheries, indigenous forests, rivers and timber with main economic activities including subsistence farming, livestock keeping, fishing, rice farming and small scale trading.

Bungoma County is in the western region of Kenya. It has a population of 1,375,063 and an area of 3,032.2 Km ^{2} with a population density: 453.5 people per Km^2.The economy of the county is mainly agricultural, centering on the sugarcane and maize industries. The area experiences high rainfall throughout the year, and is home to several large rivers, which are used for small-scale irrigation. The temperatures range from minimum of between 15 - 20

°C. With the agricultural production of Sugar, Coffee, Maize, milk, Tobacco, Bananas, Sweet Potatoes, poverty level still remain at 53 % of population living below poverty line.

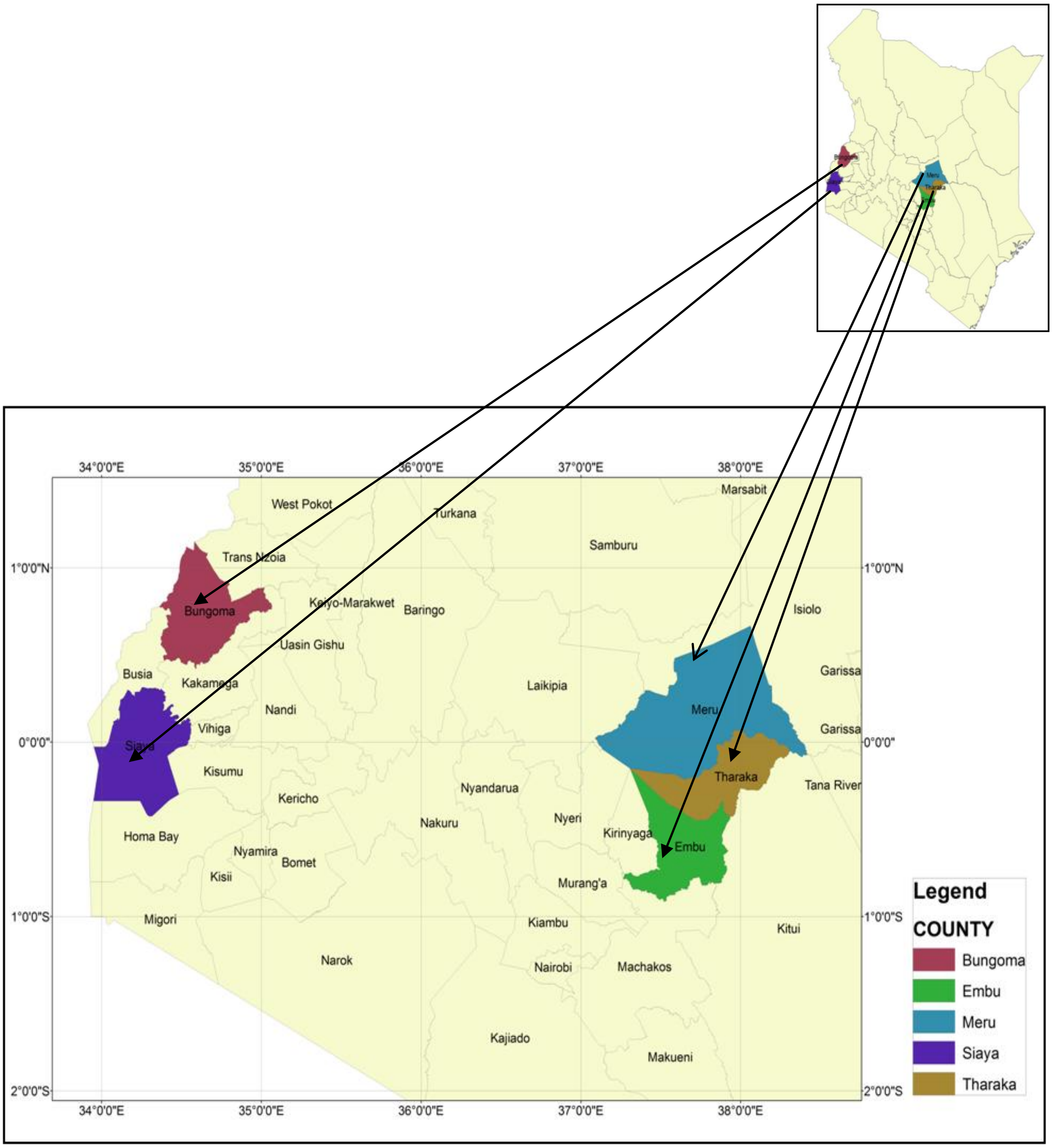

Figure 1.1: Map of study area

Source: Virtual Kenya and Google Earth Pro. 2014.

Tharaka Nithi County is a county in eastern region. It has a Total Population of 356,330; 88,803 Households and covers an area of 2,638.8 SQ. KM with temperatures ranging between

11°C and 25.9°C, while rainfall ranges between 200mm and 800mm per annum. The Population density is 138 people PER SQ. KM and 65% of the population lives below the poverty line. Some Strengths of Tharaka Nithi County include; natural resources as Arable land, Sand Quarries, Forests, Wildlife and Tourist Attractions. The main economic activities in the county include Farming, Pastoralism, Gemstones, Sand, Stone quarry. The conditions in these five counties therefore provide a climate that is suitable for the establishment and growth of maize and legumes with potential for poverty reduction in a county characterized by high poverty levels with low income levels of less than 1 USD per day (GoK, 2005).

1.2.2 Sampling procedure

In Kenya, the project is carried out in five counties from western and eastern regions namely: Siaya and Bungoma counties in western region and Embu, Tharaka Nithi and Meru counties in eastern region. These counties were purposively selected based on agro ecological zones (high altitude-eastern and lower altitude-western) and their maize-legume production potential. A multi stage sampling was employed to select lower levels sampling clusters i.e. divisions, locations, sub-locations and villages during the baseline survey of the predecessor project, SIMLESA.

1.2.3 Data collection and analysis

Primary data was collected from about 535 smallholder farmers out of the 613 that were surveyed during the SIMLESA baseline survey in the year 2011. This represented an overall attrition rate of about 13%. A higher attrition rate was in eastern Kenya counties of Meru, Tharaka and Embu compared to western Kenya counties (Table 1.1). Various reasons were attributed to this attrition ranging from households having moved to other far distant villages to others that had dissolved.

Table 1.1 Sample size

County	SIMLESA baseline (2011)	AP survey (2013)	Attrition rate (%)
Bungoma	150	137	9
Embu	111	93	16
Tharaka	101	81	20
Meru	102	81	21
Siaya	149	143	4
Total	613	535	13

Like in the baseline survey, data was collected through semi-structured questionnaires administered to sampled households by trained enumerators. Before the actual survey, the questionnaire was pretested in non-sampled villages. This questionnaire pretesting was not only used to gauge the suitability of the tool in collecting the required data but also to evaluate the trained enumerators on the capability of administering the questionnaire.

During the SIMLESA baseline survey, one standardized questionnaire was administered to each of the 613 farming households that were sampled. However, since APW aimed at collecting more gender disaggregated data, two sets of questionnaires were developed to achieve this goal. The first questionnaire was at household level and it was administered to the household head or his/her spouse whenever the head was not available. This questionnaire sought to collect basic household characteristic data such as household composition, housing conditions, crop production activities at plot level, utilization of harvested crops, access to extension and other services, maize and legume variety knowledge, climate change experiences and household annual cash expenditure on food and non-food items. The second questionnaire was at individual level and it was administered to both the main respondent of the household questionnaire and his/her spouse separately but at ago to avoid data contamination. The data collected using individual questionnaire included membership to farmer group and other social networks, household livestock and non-livestock asset ownership and control, saving and credit access, access to extension services and other information, income activities, maize and legume variety knowledge, climate change perceptions, household food security and decision making on key aspects of household livelihoods. Observation method was also used in capturing the natural physical features of the study area such as the state of infrastructure and approximation of the distances. Data were cleaned, organized and analyzed using SPSS and STATA softwares.

Both descriptive and econometric analyses were conducted. Descriptive analyses summarize the variables of interest mainly at three levels i.e. at national level, county level and at the level of the gender of the household head. Econometric analyses sought to evaluate the causal interdependence between adoptions of SAI technologies and determine the impact of farmers' choice of combination of SAI practices on maize-legume income and labor, using Multinomial Endogenous Switching Regression Model. Factors that determine the use of one or more practices were also analyzed using ordered probit model. Finally, the relationship between cropping choices and technology uptake were analyzed using stochastic production function.

1.3 Purpose of the report

The purpose of this report is four-fold; firstly and more generally, the report is aimed at presenting survey results from the AP project to the end-users, which are then supposed to be used as inputs for further research, as well as implement recommendations that seem more promising in generating most benefits to the intended farmers. For the developers of the SAI, packages the report presents results that are likely to identify priority areas in the development of SAI packages.

Secondly, the report is also aimed at policy makers for the purpose of informing the policy making process in so far as requisite SAI practices for sustainable agriculture is concerned. In this way the results in this report can be used in identifying priority policy areas for immediate intervention and the policy variables that are likely to best enhance SAI uptake.

Thirdly, the extension service providers would be able to use the information in this report to better and effectively extension support services for enhanced SAI packages uptake. This information will be empirically backed and the aim is essentially to support agricultural packages that are more effective in sustainable agriculture conditional on trade-offs imposed by household settings, vulnerabilities due to shocks and risks, productivity and gendered SAI packages uptake preferences.

Finally, the report is also aimed at farmers who are the primary users of the SAI practices. The cumulative efforts by the extension service providers, policy makers, researchers are likely to benefit the farmers when the SAIs is judiciously used. The end results would be increased uptake SAI practices and the mitigation of effects brought about by climate change effects and other related shocks.

CHAPTER TWO: SOCIOECONOMIC CHARACTERISITICS

2.1 Demographic characteristics

About 19% of the surveyed households were female headed. Siaya County had the highest proportion of female headed households (32%), followed by Tharaka County (20%) and then Bungoma County (14%). Majority of these household heads reported farming as their main occupation (72%) followed by salaried employment. Embu County had the highest proportion of household heads that had farming as their main occupation while Bungoma district had the lowest (Table 2.1a). These results clearly indicate that farming is main economic activity among the sampled households. Most of these household heads were married and living with their spouse (73%) while almost 16% were widowed. However, Siaya County had a remarkably lower proportion of household heads that were married and living with their spouses (59%) while at the same time this county had the highest proportion of household heads who were female headed and widowed (Table 2.1a). This later results could imply that there are higher levels of de jure female headed households in Siaya County than any other.

Table 2.1a Socioeconomic characteristics by county

Characteristic	Bungoma (N=137)	Tharaka (N=81)	Embu (N=93)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Female headed households (% households)	13.9	20.4	11.1	8.6	31.7	18.5
Main occupation of household head (% hhlds):						
Farming	64.2	69.6	81.5	67.9	76.9	71.7
Salaried employment	19.0	9.8	7.4	9.9	6.8	10.9
Self employed off-farm	6.6	7.6	3.7	8.6	7.0	6.7
Casual labourer off-farm	2.2	5.4	3.7	3.7	1.4	3.0
Others	8.0	7.6	3.7	9.9	7.9	7.7
Marital status of household head: (% hhlds):						
Married living with spouse	73.0	73.9	85.2	86.4	59.4	73.4
Married but spouse away	11.7	6.5	4.9	3.7	11.9	8.6
Divorsed/seperated	0.0	0.0	0.0	3.7	1.4	0.9
Widow/widower	14.6	14.1	9.9	4.9	27.3	15.7
Never married	0.7	5.4	0.0	1.2	0.0	1.3
Other demographic characteristics:						
Eduaction of household head (years)	9.4	8.4	7.1	8.1	7.1	8.0
Age of the household head (years)	50.7	54.0	48.1	53.4	56.0	52.7
Household size (absolute numbers)	7.1	4.4	5.2	4.8	6.5	5.8
Household size (adult equivalent)	5.9	3.8	4.5	4.2	5.3	4.9
Dependence ratio						

Further descriptive analysis showed that the average age of the household heads among the surveyed farmers was about 53 years. Embu County had on average the youngest household heads (48 years) while Siaya County had the oldest (56 years). On the other hand, the average number of years of formal education was about 8 years among the sampled households with Bungoma County having household heads with the highest level of education at about 9 years while Embu and Siaya County had the lowest average education level for the household heads at about 7 years each (Table 2.1a). However, western Kenya Counties of Bungoma and Siaya had the biggest household sizes compared to eastern Kenya Counties of Embu, Meri and Tharaka. While the average household size among the surveyed households was about 6 and 5 in term of absolute numbers and adult equivalent, respectively, Bungoma County and Siaya County had about 7 and over 5 absolute numbers of the members of the household and adult equivalent, respectively compared to just about 5 and about 4 for their eastern Kenya counterparts (Table 2.1a).

From a gender perspective, female headed households had significantly older household heads than male headed households. The average age of household heads among the female headed households was about 58 years compared to 51 years among the male headed households (Table 2.1b). Also, household heads of female headed households had significantly lower levels of education (about 7 years) compared to those heading male headed households (about 8 years). However, female headed households had a significantly smaller household size in terms of adult equivalent than their male headed households. Though female headed households had also a smaller household size in absolute terms than male headed households, the difference was not statistically significant (Table 2.1b).

Table 2.1b Socioeconomic characteristics by gender of the household head

Characteristic	Male (N=447)	Female (N=88)	Total (N=535)	t-value	p-value
Eduaction of household head (years)	8.3	6.8	8.1	-2.04	0.041
Age of the household head (years)	51.4	58.3	52.6	4.42	0.000
Household size (absolute numbers)	5.9	5.5	5.9	-1.29	0.197
Household size (adult equivalent)	5.1	4.4	4.9	-2.61	0.009
Dependence ratio					

2.2 Asset ownership and holding

The most common types of assets of rural farming households are land, livestock and non-livestock assets. Land is the basic production asset for the rural farming households while non-livestock assets consists of mainly agricultural production assets like ox-ploughs, knapsack sprayers and even transport and communication equipment like bicycles, wheelbarrows, carts, mobile phones and radios among many more others. On the other hand, livestock assets include large ruminants like cows, oxen etc. and small ruminants like sheep and goats among many others too. These assets are very important to rural farming communities because a part from facilitating them to accomplish their farm activities like ploughing and on-farm transportation, they also act as a store of wealth especially livestock. Therefore, their ownership is very critical not only as a means to accomplish farm activities but also as a wealth indicator.

2.2.1 Land ownership

The descriptive statistics showed that the average owned farm size among the surveyed households was about 1.03 ha (Figure 2.1). However, the distribution of farm size across the quartiles is much skewed. While the lowest quartile have an average farm size that is half the second quartile and the second quartile has similarly about half of the farm size owned by the third quartile, the third quartile has an average farm size that is almost a third of the fourth (highest) quartile. This skewedness in land distribution could have an implication on agricultural productivity and intensification.

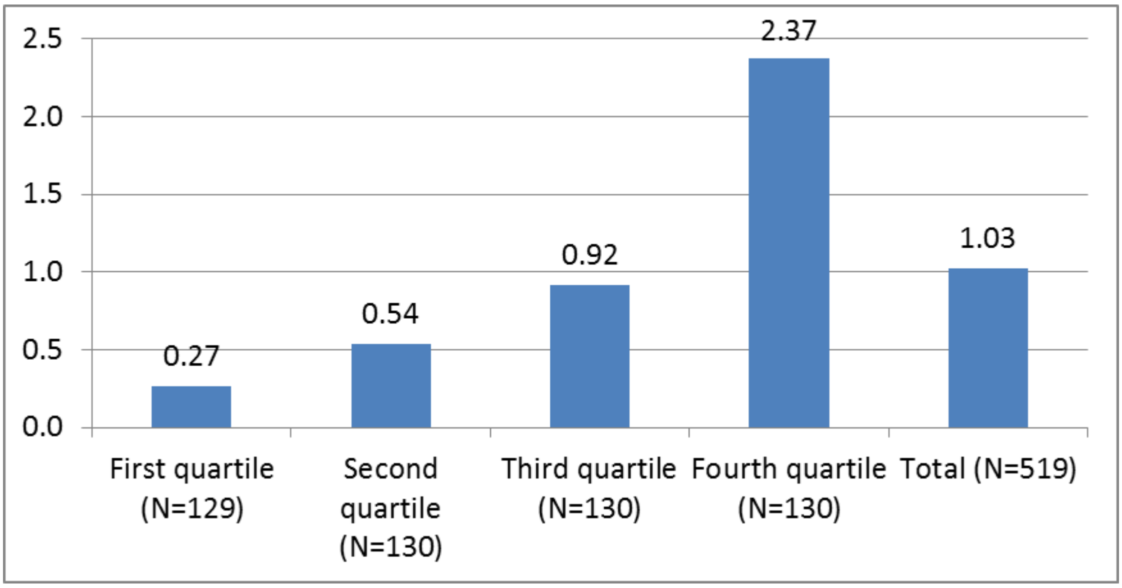

Figure 2.1 Own farm ownership by quartiles (ha)

The districution of own land ownership by quartiles in each of the surveyed counties was as shown in Table 2.2a. the sreuslts showed that Siaya County had the highest average own farm size (1.2 ha) while Embu County had the smallest (0.7 ha). Bungoma County had the highest skeweness oof land ownership with the the first quartile owning just about 8% of what the fourth quartile own. On the other hand, Meru County had the lowest land ownershipo skewedness with the first quartile owning about 22% of what the fourth quartile own. Generally, laqnd ownership skewedness was relatively higher in western Kenya Counties (Bungoma and Siaya) compatred to eatern Kenya Counties (Embu, Tharaka and Meru).

Table 2.2a Own farm size distribution by county (ha)

Quartile	Bungoma	Embu	Tharaka	Meru	Siaya
First quartile	0.21	0.20	0.27	0.44	0.30
Second quartile	0.49	0.38	0.63	0.74	0.61
Third quartile	0.78	0.71	1.06	1.01	0.97
Fourth quartile	2.48	1.43	2.65	1.98	2.86
Total	0.99	0.68	1.15	1.05	1.20

Further analysis of land ownership by gender showed no significant differenmce between male headed households and fenmale headed households (Table 2.2b). this means that female headed households had same access to own farm size like male headed households thau equal opportunity on this asset. However, there wasa higher disparity between the land poor among female headed households than among the male headed households. The first quartile of female headed households owned on average about 9% of of the average farm of the fourth quartile while the first quartikle of male headed households owned about 12% of what was owned by the fourth quartile (Table 2.2b).

Table 2.2b. Own farm size by gender of the household head (ha)

	Male	Female
First quartile	0.27	0.24
Second quartile	0.57	0.47
Third quartile	0.94	0.77
Fourth quartile	2.30	2.61
Total	1.02	1.04

2.2.2 Non-livestock assets ownership

Descriptive statistics of ownership of different assets by the surveyed households were as presented in Table 2.3a and Table 2.3b at county level and by gender of the household head, respectively. The most widely owned transport asset was the bicycle (55%) followed by wheelbarrow (39%). There was a significant association in between household ownership of bicycle and the county where that household was from. Siaya County had the highest proportion of the household that owned bicycles (69%) while Embu County had the least (39%). These differences in ownership of bicycle could imply that this equipment/asset is an important means of transport in Siaya than any other surveyed county due to the fact that

Siaya County terrain is relatively flat but also the road network in Siaya County is relatively poor compared to the other four counties.

Table 2.3a Ownership of non-livestock assets by county (% households)

Variable	Bungoma (N=137)	Embu (N=93)	Tharaka (N=81)	Meru (N=81)	Siaya (N=143)	Total (N=535)	X^2-value	p-value
Transport assets								
Bicycle	51.8	38.7	56.8	50.6	69.2	54.8	22.93	0.000
Motor bike	10.2	10.8	16	7.4	11.2	11	3.27	0.514
Donkey/ox cart	3.6	4.3	2.5	3.7	0.7	2.8	3.72	0.445
Wheel-barrow	24.1	48.4	27.2	49.4	46.9	38.7	28.46	0.000
Information assets:								
Mobile phone	83.2	83.9	88.9	92.6	92.3	88	8.69	0.069
Radio/cassette	81.8	88.2	88.9	86.4	86.7	86	3.05	0.550
TV	20.4	32.3	23.5	38.3	21	25.8	12.64	0.013
Other assets:								
Ox-plough	15.3	3.2	6.2	0	12.6	8.8	21.98	0.000
Water pump	2.2	4.3	6.2	3.7	2.1	3.4	3.53	0.473
Knapsack sprayer	30.7	46.2	63	48.1	17.5	37.4	56.61	0.000

On the other hand, in terms of information and communication equipment, the most widely owned asset was mobile phone which was closely followed by radio ownership. About 88% of the surveyed households owned mobile phone while 86% owned radio (Table 2.3a). this mobile phone ownership indicates a very high mobile telephony penetration compared to other countries in the region. This high mobile telephony penetration in Kenya could be linked to other services that famers receive over the mobile telephony application platforms like *m-pesa*, *m-sokoni* and many more others. Similarly, with over 80% radio ownership, mobile telephone and radio plus TV that is owned by about one quarter of the surveyed households, provide a good platform to disseminate extension and other agricultural market information to rural farming households. The later platform (TV) has been widely used to disseminate wide ranging agricultural extension information through the popular *shamba shape-up* programme of Citizen TV which broadcasts nationally.

Analysis of ownership of other farm implements indicated that about 9% of the surveyed households owned ox-plough, which is an important implement for plough especially in western Kenya counties where these ploughs are drawn by trained oxen and thus the name ox-plough. Even from the results shown in Table 2.3a, it is clear that ox-plough ownership is more popular in western Kenya Counties of Bungoma and Siaya compared to the other three eastern Kenya Counties of Embu, Tharaka and Meru. On the other hand, knapsack sprayer ownership among the surveyed households was about 37%. A higher proportion of households from eastern Kenya Counties owned knapsack sprayers that are usually associated with intensive farming activities like horticulture where the knapsack sprayers are used for spraying the crops or even in minimum/zero tillage where this equipment is used to apply herbicides. Also, in intensive livestock keeping like zero grazing, knapsacks are used to apply acaricides to livestock in order to control pests (e.g. ticks). This intensive farming activities feature more in eastern Kenya counties compared to western Kenya Counties and therefore this could be the reason for significant association in owning this equipment and the survey county.

From a gender perspective, ownership of bicycles, wheelbarrows, radios, TVs and knapsack sprayers were significantly associated with the gender of the household head (Table 2.3b). A higher proportion of male headed households owned these assets than the proportion in female headed households. With 59% of male headed households owning bicycles while only 36% of female headed households owned this important local farm transportation equipment, this implies that female headed households could be highly constrained in procuring bulky farm inputs like fertilizer and seed. Female headed households could also be facing acute problems of transporting their farm produce to markets compared to their male counterparts. The same inference could be drawn on wheelbarrow ownership where almost 41% of the male headed households owned wheel barrow while just about 30% of the female headed households owned this equally important on-farm transportation equipment. Similarly, with a higher proportion of male headed households owning radio and TV than female headed households (Table 2.3b), this could be a clear indication that extension and marketing information channeled through these two channels is likely to disadvantage female headed households. It therefore means such extension and market information could reach more households without gender discrimination if they were channels through mobile phone application platforms like *soko-hewani* sponsored by the Kenya Agricultural Commodity Exchange (KACE).

Table 2.3b Ownership of non-livestock assets by gender of the household head (% households)

Variable	Male (N=435)	Female (N=99)	Total (N=534)	X^2- value	p-value
Transport assets					
Bicycle	58.9	36.4	54.7	16.456	0
Motor bike	11.7	8.1	11	1.09	0.297
Donkey/ox cart	3.2	1	2.8	1.44	0.230

Wheel-barrow	40.7	30.3	38.8	3.67	0.056
Information assets:					
Mobile phone	89	83.8	88	2.01	0.156
Radio/cassette	89.2	72.7	86.1	18.32	0.000
TV	29.4	10.1	25.8	15.71	0.000
Other assets:					
Ox-plough	9.2	7.1	8.8	0.45	0.501
Water pump	3.9	1	3.4	2.08	0.149
Knapsack sprayer	41.1	21.2	37.5	13.68	0.000

2.2.3 Livestock ownership

Livestock is very important assets among rural farming communities. It is used as a store of wealth, provide traction power, improve soil fertility through it manure and even in come and food security when sold and or eaten on the farm. Figure 2.2 shows the average total livestock owned by the surveyed households in the five counties in term of l=tropical livestock units. The average TLU cross the five counties was about 1.6 with Siaya district having the highest TLU at about 2.3 while Tharaka County had the least TLU of about 0.9 (Figure 2.2). Generally, the western Kenya Counties (Bungoma and Siaya) have a higher TLU compared to the other three eastern Kenya Counties. Like already mentioned, this could be associated with the fact that eastern Kenya Counties practice more intensive livestock keeping like zero grazing compared to western Kenya. That could have been the reason why ownership of assets associated with intensive farming like knapsack sprayers was higher in eastern Kenya than western Kenya. Similarly, higher TLU in Siaya County could be associated with larger farm sizes in this county than the other four counties as shown in Table 2.2a.

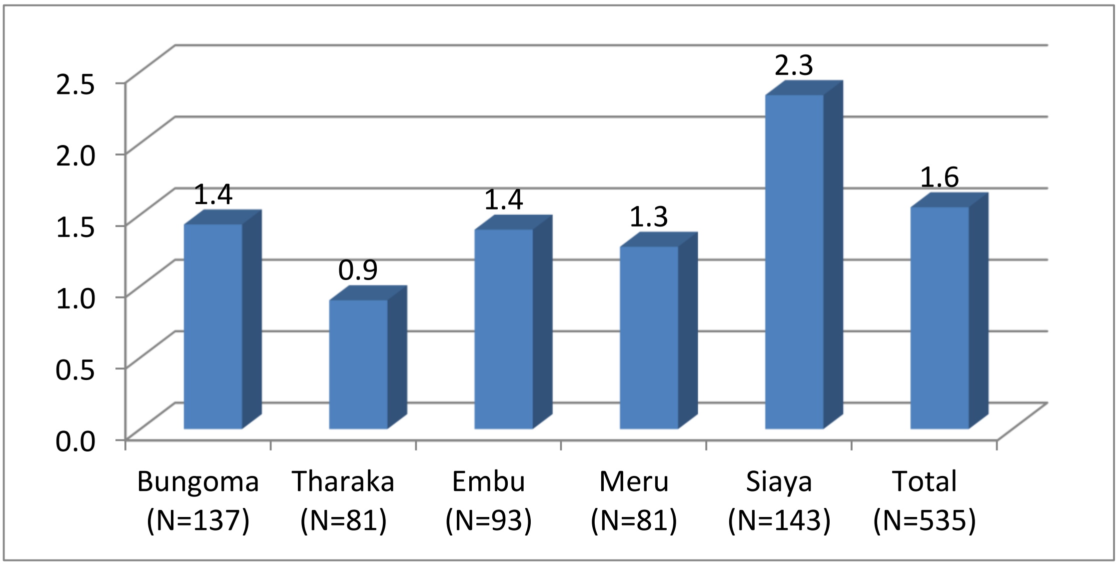

Figure 2.2 Livestock ownership by County (TLU)

From a gender perspective, the descriptive statistics showed that male headed households had a significantly higher TLU than female headed households. While male headed households owned on average TLU of about 1.6, female headed households owned TLU of about 1.2 (Figure 2.3).

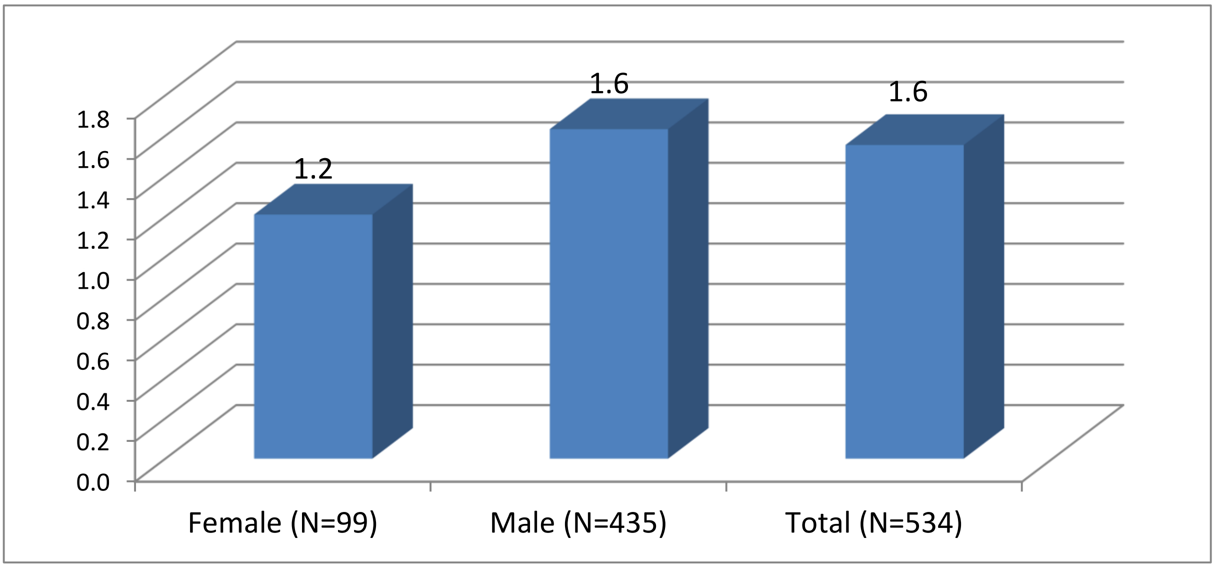

Figure 2.3 Livestock ownership by gender of the household head (TLU)

Results from further analysis on household ownership of selected specific livestock types were as presented in Table 2.4a and Table 2.4b. About 7% of the surveyed households owned oxen. However, oxen ownership was more popular in western Kenya Counties (Bungoma and Siaya) compared to eastern Kenya counties (Embu, Meru and Tharaka). This oxen ownership shows a consistent trend with ownership of ox-plough as presented in Table 2.3a where again the latter asset was more popular in western Kenya than eastern Kenya. The rationale for this result is that ploughing among smallholder farmers in western Kenya is mainly by use of oxen drawn ploughs while is eastern Kenya it is mainly by use of hand hoes probably due to relatively smaller farm sizes in eastern Kenya compared to western Kenya. On the other hand, about 39% of the surveyed households were found owning small ruminants. This ownership of small ruminants was more popular in eastern Kenya Counties of Embu, Meru and Tharaka compared to western Kenya counties (Table 2.4a). These differences in ownership of small ruminants could be associated with small farm sizes found in eastern Kenya compared to western Kenya counties.

Undoubtedly, almost 80% of the surveyed households were found owning poultry with western Kenya Counties having the highest proportion of households owning this livestock type than their eastern Kenya counterparts (Table 2.4a). Poultry, especially chickens are highly valued in the culture of communities found in western Kenya compared to eastern Kenya – more so among the Luhya community found in Bungoma County.

Table 2.4a Ownership of livestock by county (% household)

Livestock type	Bungoma (N=137)	Tharaka (N=81)	Embu (N=93)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Oxen	13.1	2.2	4.4	1.2	7.7	7.1
Small ruminants (goats/sheep)	19.0	44.1	56.8	69.1	38.5	41.9
Poultry	83.9	67.7	67.9	70.4	79.7	75.5
Pigs	3.6	3.2	3.7	12.3	5.6	5.4

At the gender level, a higher proportion of male headed households were found owning virtually all livestock types compared to the proportion of female headed households (Table 2.4b). The proportion of male headed households that owned oxen was almost double that of female headed households. For western Kenya, this means that female headed households are constrained in terms of ploughing their farms since oxen provide main traction power for farm ploughing.

Table 2.4b Ownership of livestock by gender of the household head (% household)

Livestock type	Female (N=99)	Male (N=435)	Total (N=534)
Oxen	4.0	7.8	7.1
Small ruminants (goats and sheep)	40.4	42.3	41.9
Poultry	66.7	77.7	75.7
Pigs	4.0	5.7	5.4

2.2.3 Social capital and other rural networks

With rampant market failures in most developing countries including Kenya, market transactions are mediated through informal institutions where trust based on social capital is critical. As such, there are various forms of social capital and rural networks among smallholder rural farming households to mitigate market failures. The descriptive analysis of these social networks and networks among the surveyed households was carried out and the results were as presented in Table 2.5 and Table 2.6.

About 92% of the surveyed households belonged to at least one group. There was a significant association between household group membership and the county that that household came from. Generally, group membership was more popular in western Kenya

Counties compared to the eastern Kenya counties. Siaya County had the highest proportion of households that belonged to at least one group (95%) followed by Bungoma County (94%). Embu County had the lowest proportion of households that belonged to at least one group i.e. at 83% (Table 25a). The most popular group among the sampled households was church/mosque. Almost three quarters of the surveyed households belonged to church/mosque group. Church/mosque groups were particularly more popular in western Kenya counties of Bungoma and Siaya compared to the three eastern Kenya Counties. In fact, the results showed that over 80% of the surveyed households belonged to church/mosque groups while those in eastern Kenya were less than 80% (Table 2.5a). Another common group among the surveyed households was merry-go-round groups. About 45% of the surveyed households belonged to merry-go-round groups with Embu County having the highest proportion of farmers belonging to this group (50%) while Tharaka County had the lowest proportion (32%). The third most popular group among the sampled households was savings and credit groups with about 24% of the surveyed household belong to these groups (Table 2.5a).

Table 2.5a Social capital and other rural networks by county (% households)

Group membership	Bungoma (N=137)	Embu (N=93)	Tharaka (N=81)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Savings and credit	18.2	38.7	29.6	18.5	20.3	24.1
Merry go round	47.4	49.5	32.1	46.9	47.6	45.4
Farm input supply	5.1	2.2	4.9	3.7	5.6	4.5
Crop/seed production	3.6	8.6	8.6	4.9	6.3	6.2
Water users association	2.9	11.8	24.7	23.5	3.5	11
Farm crop marketing	0.7	7.5	17.3	6.2	2.8	5.8
Women association	13.1	7.5	12.3	12.3	20.3	13.8
Youth group	8	2.2	0	6.2	2.1	3.9
Church/mosque group	81	53.8	65.4	75.3	82.5	73.5
Any group	94.2	82.8	92.6	90.1	95.1	91.6

Further analysis of social capital at the gender level showed that a slightly higher proportion of male headed households belonged to at least one group compared to female headed households (2.5b). About 91% of the male headed households belonged to at least one group compared to about 91% among the female headed households. On the other hand, a slightly higher proportion of female headed households belonged to church/mosque groups (74%) compared to male headed households (73%). Similarly as expected, a higher proportion of female headed households belonged to merry-go-rounds (48%) compared to male headed households (45%). However, in terms of membership to savings and credit groups, a higher proportion of male headed households belonged to these latter groups (25%) compared to female headed households (18%). This latter finding implies that female headed households are more credit constrained compared to male headed households. Generally, the most popular groups among female headed households were church/mosque groups, merry-go-round and women association while the most popular groups among the male headed households were church/mosque, savings and credit and merry-go-round (Table 2.5b).

Table 2.5b Social capital by gender of the household head (% households)

Variable	Female (N=99)	Male (N=435)	Total (N=534)
Savings and credit	18.2	25.5	24.2
Merry go round	47.5	44.8	45.3
Farm input supply	6.1	4.1	4.5
Crop/seed production	5.1	6.4	6.2
Water users association	5.1	12.4	11
Farm crop marketing	2	6.7	5.8
Women association	22.2	12	13.9
Youth group	2	4.4	3.9
Church/mosque group	73.7	73.3	73.4
Any group	90.9	91.7	91.6

Rural networks were also analyzed and results presented in Table 26a and Table 26b. From Table 26a, the results showed that most of the respondents in the survey had stayed in the village of interview for about 32 years on average. Embu County had the respondents who had stayed in the village of interview for the longest time (34 years) while Bungoma County had the shortest (29 years). Striking results were on the issue of number of dependable relatives and non-relatives staying in the same village like the sampled household. Un-expectedly, the average number of dependable relatives living in the same village (7) was lower than the number of dependable non-relatives living in the same village (10). Western Kenya Counties had the lowest number of dependable relatives and non-relatives living in the same village compared to eastern Kenya (Table 2.6a). Similar trends were observed for number of relatives and non-relatives that were living in the same village with the respondent and those living outside the respondents' village (Table 26a). Also, the surveyed households knew more grain traders that lived outside the same village like themselves compared to those living in the same village. The average number of traders staying in the same villages like the respondents was about 4 while those staying in different villages were about 5 (Table 2.6a).

There was also an assessment of other social networks including having relatives/friends in leadership positions, trust of grain traders, reliability of government support and confidence in the skills of government extension officers. The results showed that about 45% of the sampled households had relatives in leadership positions. There was a significant relationship between having relatives/friends in leadership positions and the county where the household came from. A higher proportion of households from western Kenya Counties of Bungoma and Siaya had relatives/friends in leadership positions compared to those in the three eastern Kenya counties (Table 2.6). Bungoma district had the highest proportion of households who had relatives/friends in leadership positions (55%) Embu district had the least (35%). Similarly, western Kenya Counties (Bungoma and Siaya) had the highest proportion of households that trusted grain traders and could rely on government support in times of need compared to the other three eastern Kenya Counties (Table 26a). On average, about 66% and 46% of the surveyed households trusted grain traders and could rely on govern support in times of need, respectively. Western Kenya Counties reported over 70% and 50% households that had trust in grain traders and could rely on government for support in times of need, respectively. This is compared to less than 70% and less than 50% who trusted traders and could rely in government support in time of need, respectively, in eastern Kenya Counties (Table 2.5a). Lastly about 78% of the sampled households in the five counties had confident in the skills of government extension officials. There was a significant association between the County and the confidence of the households in government extension officials. Meru County had the highest proportion of the households that had confidence in government extension officials (83%) while Embu County had the least (54%). There was a

Table 2.6a Rural networks by county

Other social network	Bungoma (N=137)	Embu (N=93)	Tharaka (N=81)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Years respondent living in village	29.1	33.7	33.2	32.0	32.4	31.8
Number of dependable relatives in the village	5.6	10.2	9.6	7.5	4.2	6.9
Number of dependable non-relatives in the village	6.6	12.1	14.2	13.4	8.8	10.3
Number of dependable relatives outside the village	7.9	9.8	8.1	9.0	6.2	7.9
Number of dependable non-relatives outside the village	7.6	10.6	9.1	14.7	10.3	10.2
Number of grain traders known in the village	3.8	3.6	3.6	5.2	3.1	3.8
Number of grain traders known outside the village	4.7	3.3	4.9	6.7	3.5	4.5

Friends or relatives in leadership positions	54.7	34.8	37	45.7	46.2	44.9
Grain traders trustworthy	74.5	50	54.3	67.9	72	65.5
Can rely on government support	51.1	35.9	37	46.9	53.1	46.3
Confident of the skills of government officials	71.5	54.3	69.1	82.7	78.3	71.7

From the gender perspective, respondents in female headed households had stayed in the survey village for a longer period on average (34 years) than respondents in male headed households (31 years). Similarly, a higher proportion of female headed households had confidence in government extension officials compared to the proportion in male headed households (Table 26b). Otherwise on the other network variables under review, male headed households had higher numbers or higher proportions than female headed households (Table 2.6b).

Table 2.6a Rural networks by gender of the household head

Rural networks	Female (N=99)	Male (N=435)	Total (N=534)
Years respondent living in village	33.7	31.3	31.8
Number of dependable relatives in the village	4.4	7.5	6.9
Number of dependable non-relatives in the village	7.0	11.1	10.3
Number of dependable relatives outside the village	6.2	8.3	7.9
Number of dependable non-relatives outside the village	6.6	11.0	10.2
Number of grain traders known in the village	3.4	3.8	3.8
Number of grain traders known outside the village	3.3	4.7	4.5
Friends or relatives in leadership positions	37.8	46.7	45
Grain traders trustworthy	64.3	65.7	65.5
Can rely on government support	43.9	46.7	46.2
Confident of the skills of government officials	74.5	71.3	71.9

CHAPTER THREE: ADOPTION OF SUSTAINABLE AGRICULTURAL INTENSIFICATION PRACTICES (SAIPS)

3.1 Overview of SAIPs

Population growth in developing countries like Kenya is at all-time high and agricultural resources are under pressure not only to provide food for the additional mouths but also to provide livelihood for the majority of these populations that reside in rural areas with agriculture as their main source of livelihood. In a country like Kenya where only a third of its land mass is considered arable, this pressure to produce food and earn livelihoods will likely push agriculture into fragile ecosystems of the country. The environmental repercussions of extending agricultural activities in these fragile ecosystems are dire. The alternative to circumventing this eminent problem is intensification of farming activities in the high potential areas. There are a number of well researched and approved agricultural intensification practices including but not limited to improved high yielding crop varieties and animal breeds, approved agronomic practices including fertilizer, cereal/legume intercropping, soil and water management practices, minimum/zero tillage and conservation agriculture among many more practices. In this report we address the adoption of these SAIPs though adoption of improved animal breeds is beyond the scope of this report.

3.2 Adoption spread of SAIPs

The results from descriptive analysis of adoption levels of SAIPs were as presented in Table 3.1a and Table 3.1b. The most widely adopted SAIPs across the five surveyed counties were improved maize varieties, maize/legume intercropping, inorganic fertilizer and crop residue retention on the farms (Table 3.1a). About 76% of the sampled households in the five counties had adopted improved maize varieties. Eastern Kenya counties of Embu, Meru and Tharaka had the highest adoption levels of improved maize varieties (88%, 91% and 92%, respectively) while Siaya County in western Kenya had remarkably very low adoption rate (39%). On the other hand, about 72% of the surveyed households had adopted maize/legume intercropping technology. Contrary to the trends observed in adoption of improved maize varieties, eastern Kenya Counties had the lowest adoption of maize/legume intercropping technology compared to western Kenya counties. While the highest adoption of maize/legume intercropping technology in eastern Kenya was 73% in Embu County, Bungoma County in western Kenya had an adoption rate of 80% while Siaya County also in western Kenya had an adoption rate of about 89% (Table 3.1a).

However, fertilizer adoption trends across the five sampled Counties was similar to adoption trends of improved maize varieties i.e. eastern Kenya counties had higher proportions of households that had adopted fertilizer compared to their western Kenya counterparts. The overall adoption spread of fertilizer among the surveyed households was about 69% (Table 3.1a). Embu County had the highest proportion of households that had adopted fertilizer (94%) while Siaya County again had the lowest proportion of households that had adopted fertilizer (42%). On the other hand, crop residue retention adoption rate across the surveyed counties was about 48%. Like maize/legume intercropping technology adoption rates, western Kenya counties had the highest rates of crop residue retention on the farm compared to their eastern Kenya counterparts. Siaya County had the highest proportion of households that retained their crop residues on the farm (60%) while Tharaka County had the lowest (39%).

Table 3.1a Adoption of SAIPs by county (% households)

SAIP	Bungoma (N=137)	Tharaka (N=81)	Embu (N=93)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Improved maize variety	88	92	88	91	39	76
Maize legume intercropping	80	47	73	54	89	72
Inorganic fertilizer	61	85	94	86	42	69
Crop residue on the farm	49	39	42	41	60	48
Terraces	28	63	54	59	30	43
Grass strips	47	60	55	45	18	42
Maize legume rotation	19	57	28	34	8	26
Trees on boundaries	26	20	22	15	32	24
Minimum tillage	12	37	19	48	11	22
Conservation agriculture	2	8	2	3	4	4
Mechanized	25	3	7	28	8	14
Mulching	15	1	7	8	8	9
Soil bunds	1	3	4	10	2	3

The results of adoption of the most widely adopted SAIPs bring out several insights on the farming systems across the two regions of eastern and western Kenya. First, it seems like adoption of improved maize varieties go hand-in-hand with adoption of fertilizer. These two intensification technologies were both more popular in eastern Kenya than western Kenya. It is important to note that the two SAIPs are more capital intensive and need better market access compared to the other two (maize/legume intercropping and crop residue retention) that were more widely adopted in western Kenya than eastern Kenya. Therefore, eastern Kenya farmers are generally better off in terms of poverty indicators compared to western Kenya as demonstrated in national welfare monitoring surveys by the Kenya National Bureau of Statistics. Equally important is the fact outlined in section 2 above that eastern Kenya farmers practice more intensive agriculture compared to western Kenya farmers. For example, the low levels of crop residue retention on the farms in eastern Kenya could be associated with the fact that farmers in eastern Kenya are practicing intensive livestock keeping practices like zero grazing and thus feed the crop residue to their livestock rather than leaving it in the fields. These eastern Kenya farmers compensate crop residue retention on the fields by applying fertilizer.

Further analysis was conducted to evaluate the adoption spread of SAIPs across households headed by male and females. Again, considering the four widely adopted SAIPs in the five surveyed counties, the results showed that a higher proportion of male headed households had adopted improved maize varieties and fertilizer than those in the female headed households. About 79% and 71% of male headed households had adopted improved maize varieties and fertilizer, respectively, compared to 59% each among the female headed households (Table 3.1b). On the other hand, a higher proportion of female headed households had adopted maize/legume intercropping and crop residue retention on the farms than those in male headed households. About 82% and 53% of female headed households had adopted maize/legume intercropping and crop residue retention, respectively, compared to 71% and 47% among the male headed households (Table 3.1b).

This gender analysis of adoption spread points out that more female headed households adopted SAIPs that are less capital intensive while the converse was true for male headed households. Therefore, the implication of these findings is that there is need to make female headed households access capital that is needed for them to invest in improved seeds and fertilizer. In the absence of capital, more intensive but less capital intensive technologies need to be developed and availed to female headed households in order to improve their productivity and welfare in general.

Table 3.1b Adoption of SAIPs by gender of the household head (% households)

SAIP	Male (N=447)	Female (N=88)	Total (N=535)
Improved maize variety	79	59	76
Maize legume intercropping	71	82	72
Inorganic fertilizer	71	59	69
Crop residue on the farm	47	53	48
Terraces	44	39	43
Grass strips	44	32	42
Maize legume rotation	26	22	26

Trees on boundaries	24	24	24
Minimum tillage	22	19	22
Mechanized	15	10	14
Mulching	9	5	9
Conservation agriculture	3	5	4
Soil bunds	4	2	3

3.3 Adoption intensity of SAIPs

In order to mitigate against several crop production risks, farm households that adopt SAIPs sometimes adopt them in combinations and not singularly. Descriptive analysis was carried out to find out the number of SAIPs that households adopted and the results were as presented in Figure 3.1, Table 3.2a and Table 3.2b. The SAIPs considered in this analysis were improved maize varieties, fertilizer, maize legume intercropping, maize legume rotation and minimum/zero tillage practices. From Figure 3.1, it is evident that the average number of SAIPs adopted among the surveyed households across the five counties was about 3. Eastern Kenya counties of Embu, Tharaka and Meru had higher adoption intensities compared to their western Kenya counterparts. Tharaka and Meru Counties had the highest number of SAIPs adopted per household i.e. about 3.2 each while Siaya county in western Kenya had the lowest adoption intensity of about 2.3 (Figure 3.1).

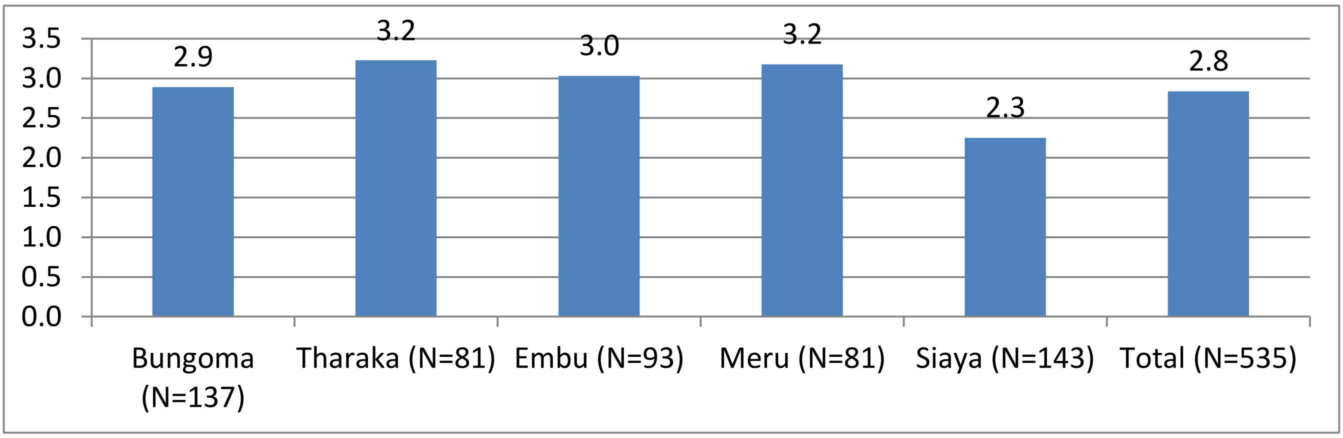

Figure 3.1 Number of SAIPs adopted by County

The results from gender analysis of SAIPs adoption intensity were as presented in Figure 3.2. Female headed households adopted less SAIPs (2.6) compared to male headed households (2.9). Reasons for female headed households adopting less SAIPs are not clear but they could be associated with female headed household having less capital, especially for the capital intensive SAIPs like improved seed and fertilizer outlined in the preceding subsection 2.2.

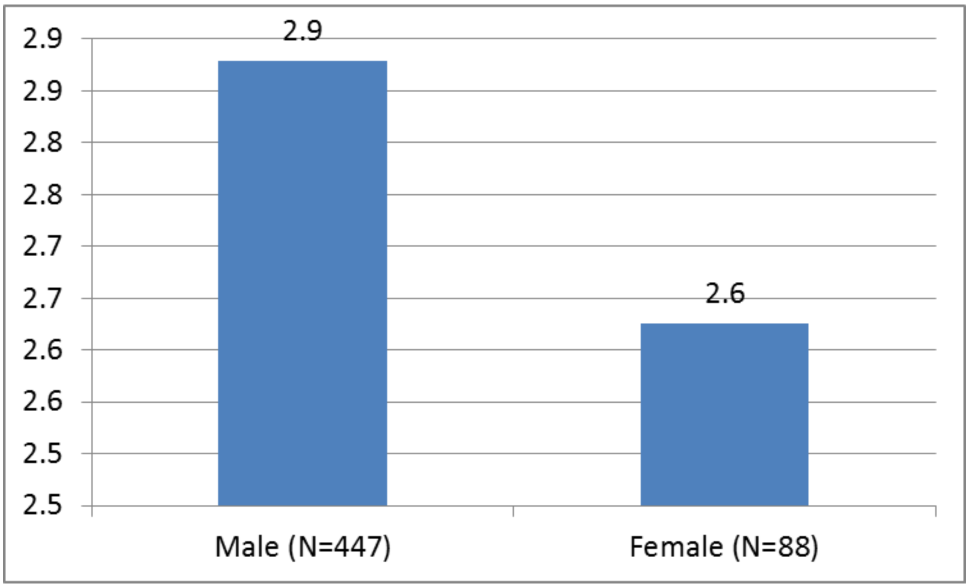

Figure 3.2 Number of SAIPs adopted by gender of the household head

3.4 Impact of household resources on adoption intensity of SAIPs

Though there exists a wealthy empirical literature showing that SAIPs are very important in increasing household agricultural productivity and thus income (Teklwold et al., 2014), the adoption of these important technologies in developing countries like Kenya remains low. It is therefore important to investigate the factors that condition household decision to adopt SAIPs. In this report, kernel density graphs were used to shade light on how some selected variables influenced household adoption decisions. Some of these variables included labour availability and market access.

From Figure 3.2, it is evident that household with more labour, measured in terms of man equivalent, were unlikely to adopt many SAIPs. The implication of this finding could be that some of these SAIPs are labour reducing in terms of labour needed for some farm activities like ploughing and weeding. For example a household that practices minimum till or mulching is likely to spend less time on ploughing and weeding thereby saving on labour. Therefore, households that are labour constrained are likely to adopt more SAIPs compared to otherwise as shown in Figure 3.2.

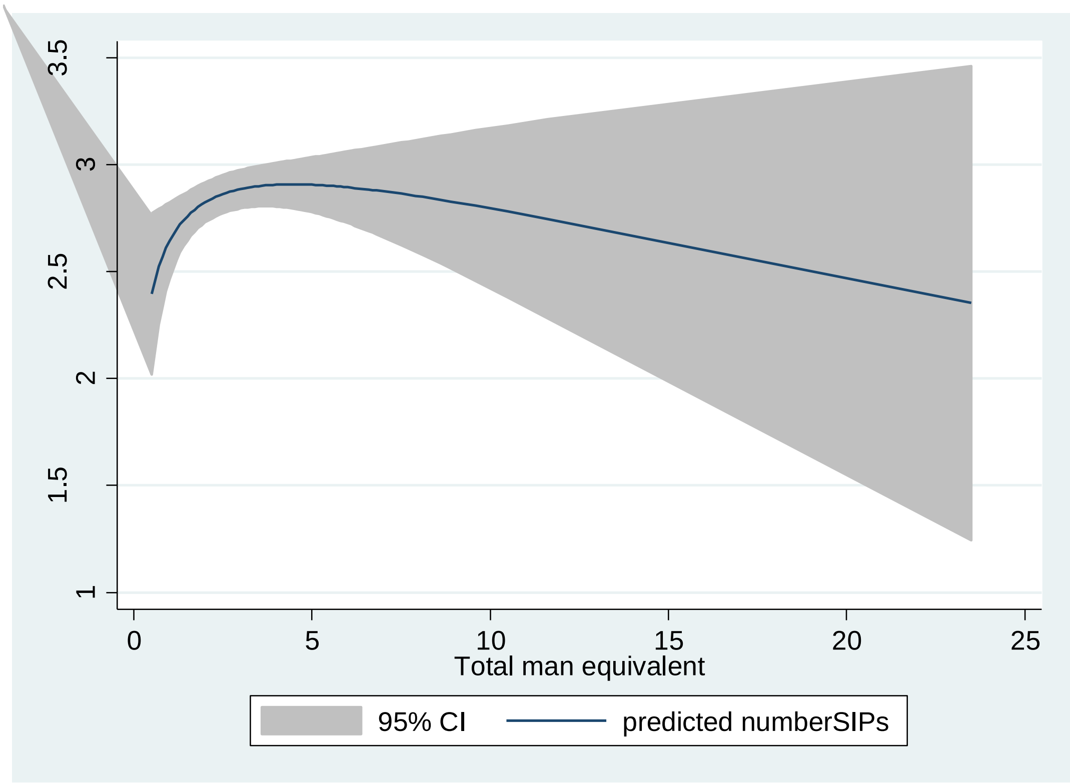

Figure 3.2 Relationship between number of SAIPs and household labour

Similarly, further analysis showed a generally negative relationship between distance to the main market and SAIPs adoption intensity (Figure 3.3). This is particularly critical when it comes to market sourced intensification technologies like improved seed and fertilizer. Given the fact that there is empirical evidence to show that SAIPs can improve household welfare significantly, there is need to shorten the distances between main markets and the households. This distance shortening could be done in several ways including improving the transport and communication infrastructure and or give traders who deal in these technologies incentives to set up their distributional outlets in remote areas where these farmers are found. The incentives could come in terms of tax exemptions or tax holidays for example.

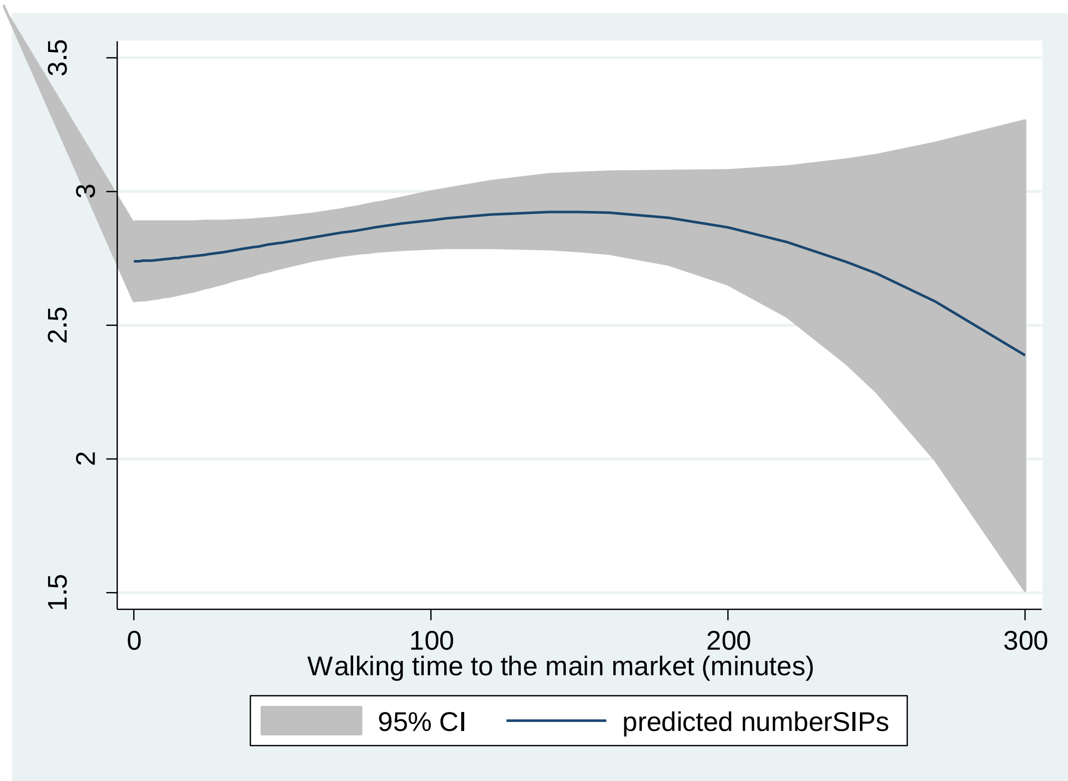

Figure 3.3 Relationship between number of SAIPs adopted and distance to the main market

3.5 Conservation agriculture (CA)

Conservation agriculture was broadly defined to include three parameters i.e. minimum/zero tillage, crop residue retention and maize legume intercropping. A household was considered to have adopted conservations agriculture if he/she was found at least practicing the four technologies at ago in at least one of his/her plots. About 4% of the surveyed households were found to have practiced CA at least in one of their plots (Figure 3.4). Tharaka County had the highest CA adoption rate of about 8% while Embu County had the lowest adoption rate of about 2%. However, from a gender perspective, a higher proportion of female headed households (5%) were found to have adopted CA compared the proportion among male headed households (3%).

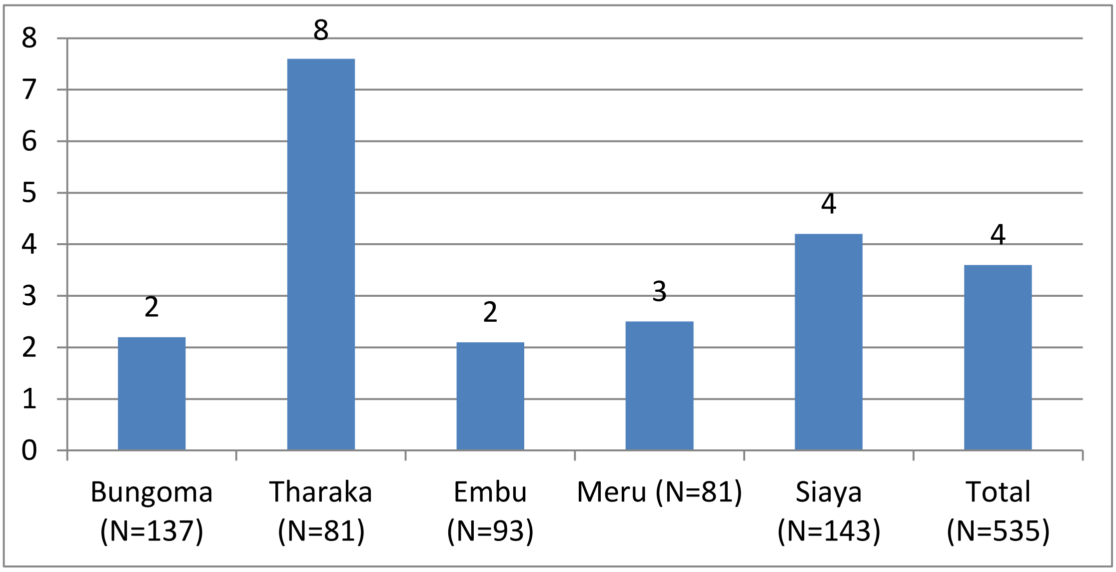

Figure 3.4 Adoption of CA by County (% households)

3.5 Adoption of improved maize varieties

Maize is the main staple grain in Kenya and in fact, food security in the country is synonymous with availability of maize. However, productivity of this main staple has not kept pace with demand that is mainly driven by rapid increase in the population. Several approaches have been proposed on how to increase maize productivity in the country. Top on the proposal of increasing maize productivity has been wide dissemination and adoption of improved maize varieties among smallholder farmers who constitute the largest proportion of producers (about 75% of the maize produced in the country). Due to its importance in the diets of almost all rural households in the country, and especially among the sampled counties, almost all the surveyed households were found growing the crop (Figure 3.5).

In this section, results of descriptive statistics of maize adoption – both spread and intensity are presented and discussed. Broad categories of improved maize varieties are considered i.e. hybrid varieties, open pollinated varieties (OPVs) and combined hybrids and OPVs under the category of improved maize varieties. Further descriptive analysis was also conducted to assess the adoption of the four most widely adopted specific maize varieties among the sampled households. These descriptive statistics are presented at the national level (full sample), at the county level and at the gender of the household level in order to see the variation across these major groupings.

3.5.1 Adoption spread of improved maize varieties

Adoption spread as adopted herein refers to the proportion of the surveyed households that were found growing improved maize varieties. From the sampled households, about 97% of these households had grown maize. This shows how important the crop is among the cropping systems of the households in the sampled counties. On the other hand, about 75% and 2% of the sampled households had adopted improved hybrid maize varieties and improved OPV maize varieties, respectively (Figure 3.5). Overall the adoption spread of improved maize varieties among the surveyed households was about 76%. Clearly, these statistics show that hybrid maize varieties are more popular than OPVs among the sampled households. Reasons for preference of hybrids over OPVs are not clear though they could be related to productivity as it will be seen later in the successive parts of this section.

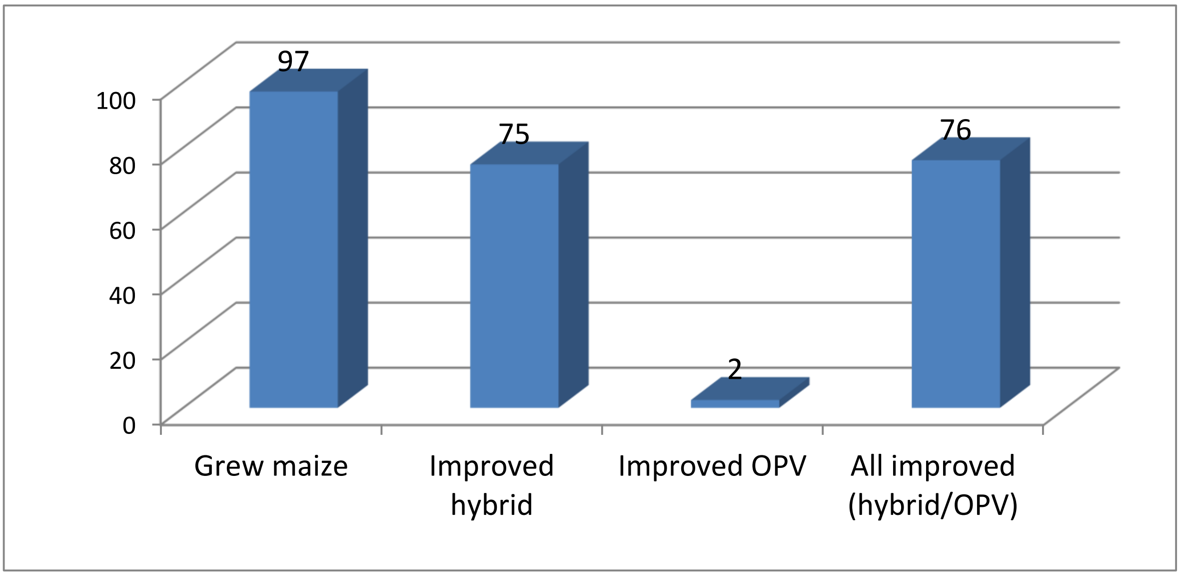

Figure 3.5 Adoption spread of improved maize varieties (% households) – N=535

Further descriptive analysis was carried out to assess the spread of different maize varieties across the five sampled counties. The results showed that all sampled households in Bungoma County and Embu County grew maize while Siaya County had the least proportion of households that grew maize among the sampled counties (Table 3.2a). In terms of improved maize varieties, the descriptive statistics results showed that Siaya County had exceptionally the lowest proportion of households that grew improved hybrid maize varieties i.e. while Siaya County had only 39% of the households growing hybrid maize varieties, Tharaka County had 92%, Meru County had almost 89%, Bungoma County had 88% and Embu County had 82% (Table 3.2a). Improved OPVs were only grown in Embu (10%) and Meru Counties (4%). However, overall, the results showed higher proportion of sampled farmers in eastern Kenya counties adopting improved maize varieties compared to western Kenya. Tharaka County had the highest proportion of households that had adopted improved maize varieties (92%), followed by Meru County (89%), Bungoma County (88%), Embu

County (87%) and then lastly Siaya County (39%). It is very apparent from these results that concerted efforts need to be put in place to increase adoption of improved maize varieties in Siaya district which lacks behind at less than 50% among the five sampled districts. Reasons behind the extremely low levels of adoption of improved maize varieties in Siaya County compared to the other sampled counties need to be investigated further and appropriate measures taken to address this big technology adoption gap.

Table 3.2a Adoption spread of maize varieties by county (% households)

Maize variety	Bungoma (N=137)	Tharaka (N=81)	Embu (N=93)	Meru (N=81)	Siaya (N=143)
Grew maize	100.0	97.5	100.0	96.3	93.0
Improved hybrid	88.3	92.4	82.3	88.8	39.2
Improved OPV	0.0	0.0	10.4	3.8	0.0
All improved (hybrid/OPV)	88.3	92.4	87.5	91.3	39.2

From the gender perspective, the descriptive statistics showed that male headed households had the highest proportion of households that had adopted the improved maize varieties compared to female headed households. While almost 80% of the male headed households had adopted improved maize varieties, less than 60% of the female headed households were found to have adopted improved maize varieties (Figure 3.6). On the other hand, about 78% of the male headed households had adopted improved hybrid maize varieties compared to 58% of the female headed households. About 3% of the male headed households had adopted improved OPVs while only 1% of the female headed households had adopted this category of improved maize varieties (Figure 3.6). Therefore, the adoption spread of improved maize varieties by gender showed that low adoption spread among female headed households and this could be caused by several factors. One of the reasons for low adoption rates f improved maize varieties among female headed households could be that improved seeds of maize varieties are capital intensive and female headed households could be disadvantaged in term of capital compared to male headed households. Also, seeds of improved maize varieties could be only found with stockists usually located in main markets that are in many cases at far distances from markets. Since female farmers might be constrained more than male farmers in accessing these markets in terms of transportation, (male farmers could ride bicycled themselves to these markets), female farmers might not be able to access improved seeds easily. Therefore, policies or interventions that could increase the input distributional networks in rural areas could be important in enabling female headed households' access these important inputs.

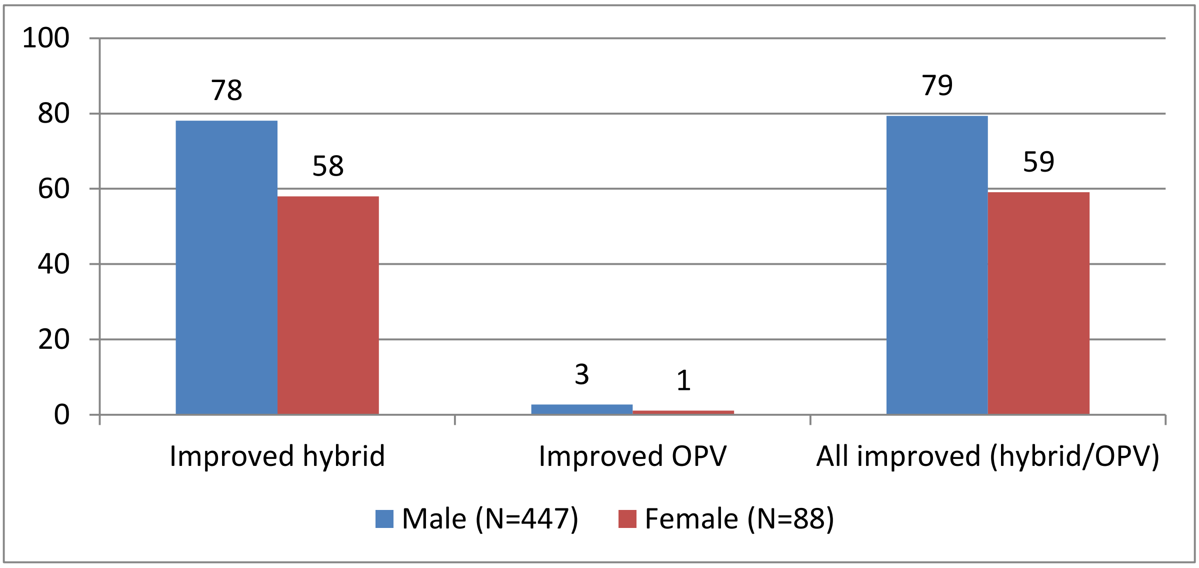

Figure 3.6 Adoption spread of maize varieties by gender of the household head (% households)

For specific improved maize varieties, the descriptive analysis showed that the top four most widely adopted improved maize varieties in Kenya were DUMA43, H513, DK8031 and WS505 in that order of reducing importance (Figure 3.7). About 29% of the total sampled households grew DUMA43; followed by a distant 12% that grew H513, ten 11% who grew DK8031 and lastly 8% growing WS505. All these for top most widely adopted improved maize varieties are hybrids – a clear indication that OPVs are not very popular among the surveyed households. Reasons for preference of hybrids over OPVs are not clear and need further investigations. Similarly, more rigorous analysis of data is needed to tease out the reasons why DUMA43 is more widespread among the surveyed households i.e. could it be a market failure problem or special intrinsic variety specific traits.

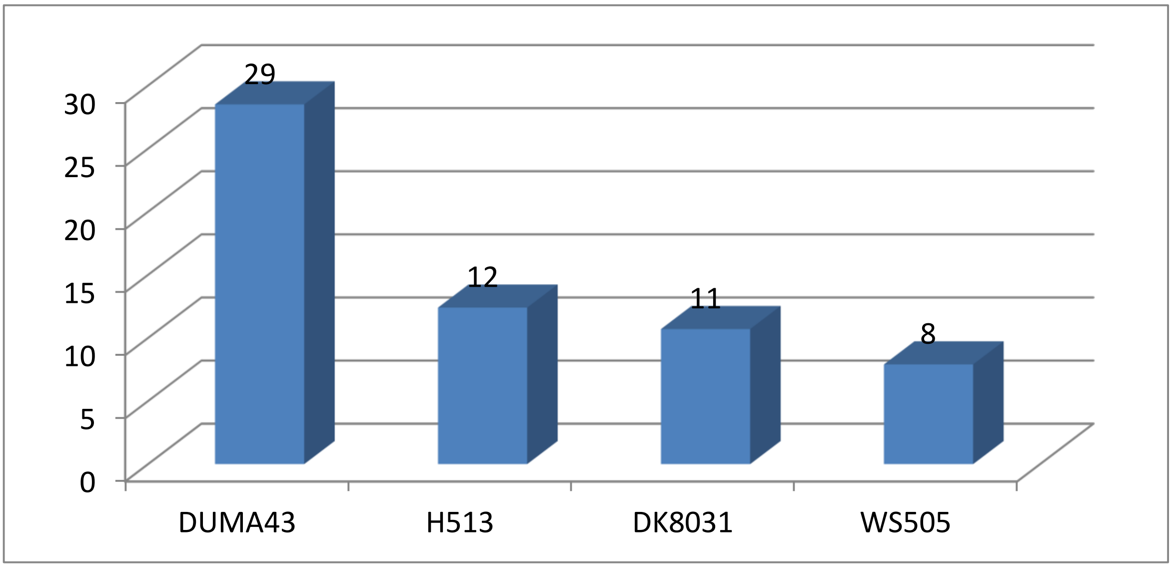

Figure 3.7 Adoption of the most widespread improved maize varieties (% households) – N=535

Across the surveyed counties, the most popular improved maize variety, DUMA43, was more widely adopted in Tharaka County (58%) followed by Embu County (57%), Meru County (41%) and then Siaya County (13%). There was no adoption of DUMA43 in Bungoma County (Table 3.3a). This means that DUMA43 is mainly grown in eastern Kenya Counties compared to western Kenya counties. On the other hand, H513 was grown in all the five sampled counties with the highest proportion of farmers in Meru County growing this variety (35%) followed by Bungoma County (12%), Tharaka County (9%), Siaya County 8% and then Embu County (3%). Siaya county had the histe proportion of households that grew DK8031 (15%) followed by Tharaka and Meru County at about 14% each, Embu County at 12% and Bungoma County at less than 2%. WS505 was almost entirely grown in Bunoama district only. Almost 28% of the households sampled from Bungoma district grew WS505 while just a paltry 1% of those from Embu County grew this variety and no households from the other remaining three counties Table 3.3. The variation in adoption of specific varieties across the counties could be associated with micro-climatic factors in those areas and or seed and other market infrastructure related reasons i.e. seed companies in Kenya could be targeting certain areas with their products more than other areas in the country for some economic/business reasons.

Table 3.3 Adoption spread of most popular improved maize variety by county (% households)

Maize variety	Bungoma (N=137)	Embu (N=93)	Tharaka (N=81)	Meru (N=81)	Siaya (N=143)
DUMA43	0.0	57.0	58.8	40.7	13.3

H513	12.4	3.2	8.8	34.6	7.7
DK8031	1.5	11.8	13.8	13.6	15.4
WS505	27.7	1.1	0.0	0.0	2.1

3.5.2 Adoption intensity of improved maize varieties

Adoption intensity was analyzed in term s of how much land resources the household had put under different maize varieties. From the results presented in Table 3.4a, almost 60% of the land cultivated by the surveyed households was under maize. Siaya district had the highest proportion of cultivated land that was under maize (72%) followed by Embu County (60% and then Bungoma County (56%), Meru County (47%) and lastly Tharaka County (42%). However, despite having the highest proportion of land under maize among the five surveyed counties, Siaya district had the lowest proportion of maize area that was under improved hybrid maize varieties across the five sampled counties (Table 3.4a). While the overall adoption intensity of improved hybrid maize varieties among the surveyed households was about 68% of the total maize area, Siaya district had only 31% of its maize area under I improved hybrid maize varieties. The highest adoption intensity of improved hybrid maize varieties was in Meru County (85%) and Bungoma County (84%). As expected, adoption intensity of OPVs was very low i.e. only 1.7% of the total maize area among the surveyed households was under OPV.

Table 3.4a Adoption intensity of maize varieties by county

Intensity variable	Bungoma (N=137)	Embu (N=93)	Tharaka (N=81)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Percent cultivated area under maize (%)	56.1	60.4	42.3	47.2	72.2	57.7
Percent maize area under hybrid varieties (%)	84.3	76.6	81.6	84.7	31.3	68.4
Percent maize area under OPV varieties (%)	0.0	6.9	3.0	0.0	0.0	1.7
Percent maize area under improved varieties (%)	84.3	83.5	84.7	84.7	31.3	70.1

However, the broad analysis of improved maize varieties revealed that about 70% of the maize area among the sampled households was under improved varieties (either hybrids and or OPVs). Highest improved maize adoption intensities were in eastern Kenya counties with Tharaka and Meru Counties having the highest adoption intensity of about 85% followed by Bungoma County at 84%, Embu County at just slightly more than 83% and then lastly Siaya County at just above 30% (Table 3.4a). Therefore the big question here is that why Siaya district has the highest proportion of cultivated land under maize yet it has the lowest proportion of cultivated land under improved varieties? If there are productively more superior improved varieties suitable for Siaya agro-ecological zones, then why is the adoption of these varieties very low in Siaya? Probably maize could be acting as a cash crop in Siaya County thus the high allocation of its land to it. On the contrary, in the other four counties, there are alternative cash crops. For example, in Bungoma district, the most widely adopted cash crop is sugar cane grown under contract with Nzoia and Mumias sugar companies. On the other hand, coffee and tea are very popular cash crops in the three eastern Kenya Counties of Embu, Meru and Tharaka.

At the gender level, female headed households allocated more of their cultivated land to maize than male headed households i.e. while female headed households allocated almost 70% of their cultivated land to maize, male headed households allocated only 55% of their cultivated land to maize (Table 3.4b). One outstanding implication of this finding is that female headed households give priority to food security and thus allocate more of their cultivated land to the main food staple, maize, than male headed households. On the other hand, male headed households are more risk takers and they allocate more land to cash crops like sugar cane in Bungoma County of western Kenya and tea and coffee in Embu, Meru and Tharaka Counties in eastern Kenya.

Table 3.4b Adoption intensity of improved maize varieties by gender of the household head

Intensity variable	Male	Female
Percent cultivated area under maize (%)	55.2	69.5
Percent maize area under hybrid varieties (%)	71.8	54.4
Percent maize area under OPV varieties (%)	1.8	1.0
Percent maize area under improved varieties (%)	73.6	55.4

However, in terms of adoption intensity of improved maize varieties, again male headed households adopted improved maize varieties more intensively than female headed households. About 74% of the maize area under male headed households was under improved maize varieties compared to 55% of the maize area under female headed households that was under improved maize varieties (Table 3.4b). Similarly, for improved hybrid maize varieties, about 72% of the maize area under male headed households was under improved hybrid maize varieties while about 54% of the maize area under female headed households was under improved hybrid maize varieties. Lastly, male headed households had also a higher adoption intensity of improved OPVs (2%) compared to female headed households (1%).

This later finding on maize adoption intensity by gender also has far reaching implication on overall national production of maize and by extension national food security. The implication is that if high yielding maize varieties can be availed to female headed households, then national maize production levels are likely to increase given the fact that female headed households put a higher proportion of their cultivated land under maize production than their male counterparts (Table 3.4b).

3.6 Maize productivity

As a main food crop in Kenya, maize productivity should keep pace with increase in demand that is usually driven by population growth. Descriptive analysis of productivity of this crop by variety type, county surveyed and gender of the household head was carried out and results presented and discussed in this section.

The results showed that the overall maize productivity (yield) among the surveyed households was about 1.4 t/ha. Among the improved maize varieties, hybrid maize varieties were higher yielding than OPVs. The average yield for hybrid maize varieties was about 1.6 t/ha while that of OPVs was about 1.4 t/ha (Figure 3.8). Similarly, comparing the overall improved maize productivity with local varieties showed that the former had a superior yield than the latter. While the improved maize varieties yield was about 1.6 t/ha, local maize varieties had a yield of about 0.9 t/ha (Figure 3.8). The implication of these results is that there is need for concerted effort to popularize and promote the diffusion of improved maize varieties among the sampled farmers in order to increase maize production and address the food security problems affecting much of the rural farming households in the surveyed counties.

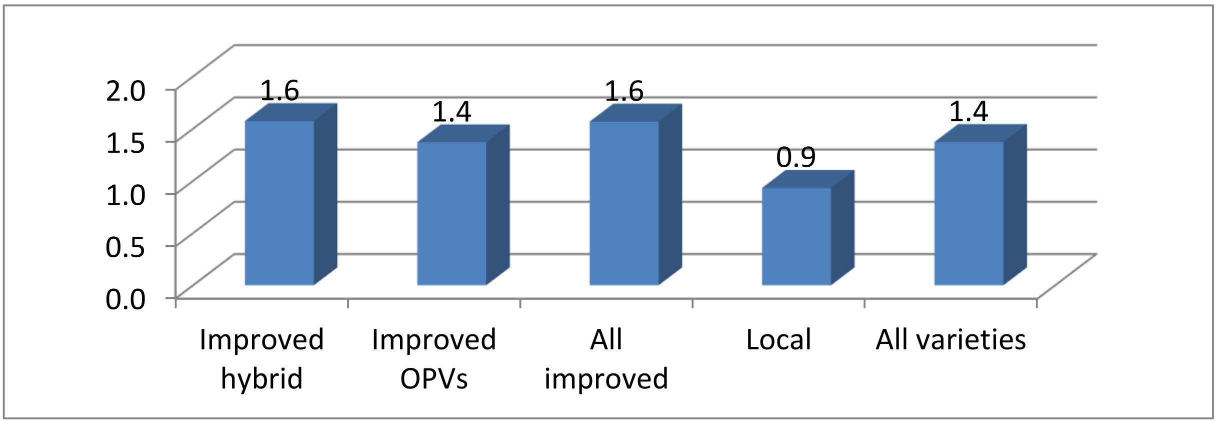

Figure 3.8 Maize productivity by variety type (t/ha)

Across, the surveyed counties, the descriptive statistics showed that Meru County had the highest maize productivity (yield) at about 1.8 t/ha followed by Bungoma County and Tharaka County with 1.5 t/ha each, Embu County with 1.4 t/ha and Siaya County with the least maize yield of just about 1 t/ha (Table 3.5a). Except the local maize varieties, Meru County had the highest yield for all improved maize varieties than any other sampled county. On the other hand, Siaya County had the lowest maize yield for all improved maize varieties except the local varieties. The yield difference between improved and local varieties is highest in Meru County and Bungoma County while it is lowest in Siaya County and Tharaka County (Table 3.5a). The low yield difference between improved and local maize varieties could be one of the contributing factors for low adoption spread and intensity of improved maize varieties in Siaya County. Probably, improved maize varieties have a higher yield than local variety when the production risks are low e.g. optimum rainfall, but the downside yield risk in the event of the risk occurring is so high in improved maize varieties compared to local maize varieties. This could be the reason that has forced maize farmers in Siaya to continue growing local maize varieties as compared to farmers from the other sampled four counties. In fact, Siaya County has the lowest annual average rainfall and is more prone to drought compared to the other four counties (Tongrukswattana *et al.*, 2015).

Table 3.5a Maize productivity by county (t/ha)[a]

Maize variety	**Bungoma**	**Tharaka**	**Embu**	**Meru**	**Siaya**	**Total**
Improved hybrid	1.6	1.6	1.5	1.9	1.2	1.6
Improved OPVs	na	na	1.3	1.7	na	1.4
All improved	1.6	1.6	1.5	1.9	1.2	1.6
Local	0.9	1.3	1.0	0.4	0.9	0.9
All varieties	1.5	1.5	1.4	1.8	1.0	1.4

a/: na means not applicable i.e. the variety was not grown in that particular county

At the gender level, the descriptive statistics showed that compared to female headed households, male headed households had on average better maize yield on all varieties. The overall maize productivity for male headed households was about 1.5 t/ha while that of female headed households was just 0.9 t/ha. For the hybrid maize varieties, the yield of male headed households was about 1.7 t/ha compared to 1.1 for female headed households. Similarly, for the OPVs, the yield of male headed households was about 1.6 t/ha while that of female headed households was less than 0.5 t/ha (Table 3.5b). On average, improved maize productivity for male headed households was 1.6 t/ha while female headed households was just 1 t/ha. The low maize productivity among female headed households as compared to male headed households could be associated with the low levels of improved maize adoption among female headed households as compared to male headed households (Figure 3.6).

Table 3.5b Maize productivity by gender of the household head (t/ha)

Maize variety	Male	Female	Total	t-statistic	p-value
Improved hybrid	1.7	1.1	1.6	3.927	0.000
Improved OPVs	1.6	0.4	1.4	1.100	0.284
All improved	1.6	1.0	1.6	4.105	0.000
Local	1.0	0.8	0.9	2.359	0.019
All varieties	1.5	0.9	1.4	5.632	0.000

3.7 The economics of maize production

Farmers expend their resources in the process of producing maize. This maize produced is used mainly for home consumption among smallholder farmers though sometimes they sell surpluses at some given point in time. It is therefore proper for an in-depth analysis of costs incurred in maize production process compared to the value of the grain harvested to ascertain the economic attractiveness of maize production. The costs that go into the production process are both fixed and variable (proportional) costs. In this section, we only consider variable costs that will enable us to establish gross margins of maize production in the framework of returns to land and family labour. Only cash purchased costs were considered.

The descriptive statistics of maize gross margins across the five sampled counties were as presented in Table 3.6a. The average gross margin of maize across the counties was about KSh. 32,529 ha^{-1}. Bungoma County had the highest gross margins of about KSh. 47,000 ha^{-1} while Meru district had the lowest gross margins of about KSh. 21,587 ha^{-1}. Though Siaya County had the lowest maize productivity and thus the lowest value of maize produced per hectare of area under maize, this county had the third highest maize gross margins, beating Embu and Meru counties. The implication of this result could be that though Meru and Embu had higher yields of maize, the yields in these two districts come with a heavy capital outlay in terms of yield enhancing inputs like improved seeds and fertilizers. In fact, the total variable costs of the three eastern Kenya counties (Embu, Meru and Tharaka) were almost 4 times that of Siaya County (Table 3.6a). A striking observation wothy highlighting is that herbicide and pesticide use on maize crop is more popular in eastern kenya counties compared to western kenya copunties. On the other hand, hiriong of oxen in maize production was more popular in western kenya than eastern Kenya (Table 3.6). The latter finding is in line with the earlier finding where a higher proportion of households from western Kenya were found to have owned ox-ploughs and oxen than their counterparts from eastern Kenya.

Table 3.6a Maize gross margins by county (KSh/ha)

Variable	Bungoma (N=137)	Embu (N=92)	Tharaka (N=75)	Meru (N=78)	Siaya (N=133)	Total (N=515)
Maize value	60,171	45,392	54,180	42,366	34,230	47,263
Seed	4,220	6,122	4,025	3,943	1,723	3,845
Fertilizer	4,605	7,658	9,046	7,539	1,291	5,386
Manure	9	143	0	21	0	31
Herbicides	18	98	549	45	1	109
Pesticides	88	730	911	516	14	368
Hired oxen	1,787	109	529	168	1,001	856
Hired tractor	460	51	580	9	121	249
Hired labour	1,982	4,803	5,164	8,538	1,779	3,890
TVC	13,169	19,716	20,804	20,779	5,930	14,734
Gross margins	47,002	25,677	33,376	21,587	28,300	32,529

Gender analysis of maize gross margins showed that male headed households had higher maize gross margins than their female counterparts. While the average maize gross margins by female headed households was about KSh. 19,684 ha^{-1}, male headed households had maize gross margins of about KSh. 35,547 ha^{-1} (Table 3.6b). The t-test for this difference in maize gross margins across the gender of the household heads was statistically significant at 1%. Despite male headed households having higher average total variable costs, they still returned a higher gross margins than female headed households and this clearly indicates that former had a superior maize yield that the latter. It is also important to note that fem ale headed households had the lowest proportion of households that had adopted improved maize varieties and this could have contributed to their poor yields that translated into poor gross margins as seen in Table 3.6b

Table 3.6b Maize gross margins by gender of the household head (KSh/ha)

Variable	Female (N=98)	Male (N=417)	Total (N=515)
Total value of maize produced	31,428	50,984	47,263
Seed	3,278	3,978	3,845
Fertilizer	3,885	5,738	5,386
Manure	4	37	31
Herbicides	110	109	109
Pesticides	282	388	368
Hired oxen	775	875	856
Hired tractor	240	251	249

Hired labour	3,168	4,060	3,890
TVC	11,743	15,437	14,734
Gross margins	19,684	35,547	32,529

Further analysis of the significance of particular cost items was conducted and results were as presented in Figure 3.9. Fertilizer constituted the highest proportion of total maize variable costs among the surveyed households. About 37% of the total maize variable costs were fertilizer followed by seed and hired labour at about 26% each (Figure 3.9). These results points to the fact that for maize to become more profitable, then fertilizer costs has to be minimized significantly. Therefore, the use of less capital intensive productivity enhancing technologies like maize/legume intercropping and rotation, crop residue retention and other approved CA techniques becomes hand in making maize more profitable to smallholder farmers in Kenya.

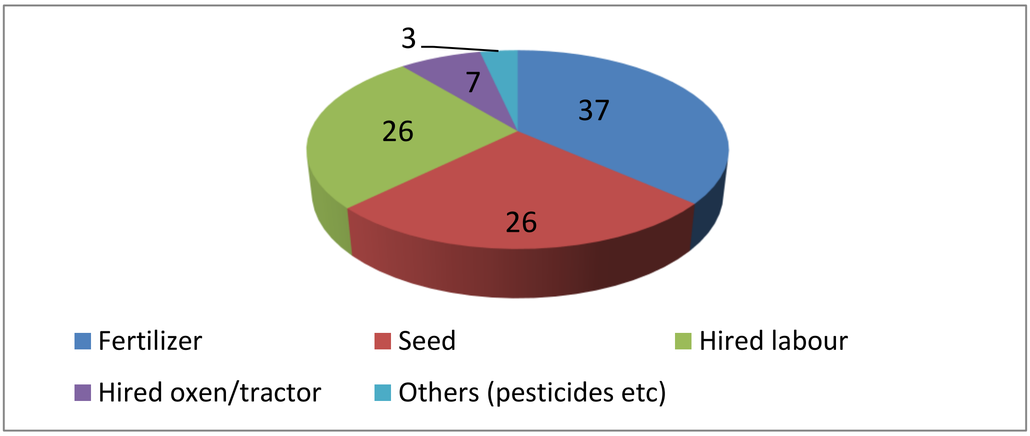

Figure 3.9 Variable costs contribution (%)

3.8 Adoption of inorganic fertilizer

Due to deteriorating soil fertility as a result of continuous cultivation of plots, fertilizer application has been used for a long time as a way to restore soil fertility and thus increase or maintain crop productivity. Despite this obvious benefit, adoption spread and adoption intensity of fertilizer in sub-Saharan African countries like Kenya is still low compared to other developing and developed countries in the world. Like in the previous section on maize adoption, fertilizer adoption spread was analyzed by getting the proportion of the surveyed households that had used fertilizer. On the other hands, fertilizer adoption intensity was the amount of fertilizer that was used per given area. Analysis of adoption intensity of fertilizer was extended to unconditional and conditional adoption intensities. Unconditional intensity is where all cultivated area was considered as the denominator while conditional adoption intensity is where only plots that had applied fertilizer were used as denominators.

3.8.1 Fertilizer adoption spread

Almost 87% of the surveyed households in the five counties had adopted fertilizer. The highest adoption spread was mainly in eastern Kenya counties compared to the western Kenya counties. Embu County had the highest proportion of sampled households that had adopted fertilizer (96%) followed by Meru county (93%) and Bungoma County (91%). Siaya County had the lowest proportion of households that had adopted fertilizer in their crop production activities at 79% (Table 3.7a). A higher proportion of the surveyed households had adopted basal fertilizer (85%) compared to top dressing (62%). Basal fertilizer adoption was higher in the eastern Kenya counties (Embu, Meru and Tharaka) compared to western Kenya counties (Bungoma and Siaya). Overall, Siaya district had the lowest adoption of both basal and top dressing fertilizers among the five surveyed counties (Table 3.7a).

Table 3.7a Adoption spread of fertilizer by county (% households)

Fertilizer type	Bungoma (N=137)	Tharaka (N=79)	Embu (N=96)	Meru (N=80)	Siaya (N=143)	Total (N=535)
Planting (basal)	83.9	84.8	92.7	87.5	77.6	84.5
Top dressing	73.7	69.6	71.9	83.8	29.4	62.4
All	90.5	89.9	95.8	92.5	79.0	88.6

From a gender perspective, a higher proportion of male headed households adopted fertilizer compared to the proportion in female headed households. Whereas 90% of the male headed households had adopted fertilizer, only 81% of the female headed households had adopted fertilizer (Table 3.7b). The proportion of female headed households who had adopted basal and top dressing fertilizer was lower than that of male heeded households and particularly for the top dressing fertilizers. The low adoption of fertilizer among female headed could be associated with high capital outlay that is required for a household to adopt fertilizer. It could also be associated with the bulkiness of fertilizer thus disadvantaging female heeded household to transport it to their farms.

Table 3.7a Adoption spread of fertilizer by gender of the household head (% households)

Fertilizer	Male (N=447)	Female (N=88)	Total (N=535)
Planting (basal)	85.2	80.7	84.5
Top dressing	66.7	40.9	62.4
All	90.2	80.7	88.6

3.8.2 Fertilizer adoption intensity

Considering all cultivated area, the unconditional fertilizer adoption intensity was computed by sampled county and by gender of the household head. The overall unconditional adoption rate of fertilizer among the surveyed households was about 90 kg/ha. Embu County had the highest adoption rate of about 126 kg/ha followed by Bungoma County at about 107 kg/ha (Table 3.8a). On the other hand, Siaya County had the lowest unconditional fertilizer adoption rate of just about 34 kg/ha. These results show that the county with the highest adoption rate applies more than three times what the lowest county applies. For specific fertilizer types, the descriptive statistics showed that the average adoption rate of planting (basal) fertilizer was about 60 kg/ha while that of top dressing was about a half of the basal i.e. 30 kg/ha (Table 3.8a). Siaya district had the lowest adoption rates for both basal and top dressing among the five surveyed counties. The unconditional adoption rate for top dressing fertilizer was particularly low for top dressing fertilizer in Siaya County compared to Bungoma County that had the highest rate of applying top dressing fertilizer (Table 3.8a).

Table 3.8a Unconditional fertilizer adoption intensity by county (kg/ha)

Fertilizer	Bungoma (N=574)	Tharaka (N=561)	Embu (N=586)	Meru (N=519)	Siaya (N=641)	Total (N=2881)
Planting (basal)	59.5	59.6	88.9	69.4	26.0	59.8
Top dressing	47.1	26.8	37.0	34.6	8.3	30.2
All	106.5	86.4	125.9	104.0	34.3	90.0

Further descriptive analysis of the unconditional fertilizer application rates at the gender of the household head was conducted and the results were as presented in Table 3.8b. Overall, female headed households applied unconditionally low rates of fertilizer compared to male headed households. While male headed households had on average unconditional fertilizer application rate of about 93 kg/ha, female headed households had about 72 kg/ha. Similarly, male headed households had a higher rate of applying both planting (basal) and top dressing fertilizer than female headed household though the difference in top dressing was lower compared to that of the basal fertilizers. Both male and female headed households almost applied twice as much planting (basal) fertilizer as they did with top dressing fertilizer (Table 3.8b).

3.8b Unconditional fertilizer adoption intensity by gender of the household head (kg/ha)

Fertilizer	Male (N=2467)	Female (N=414)	Total (N=2881)
Planting (basal)	62.1	45.7	59.8
Top dressing	30.8	26.4	30.2
All	93.0	72.1	90.0

Adoption intensity of fertilizer was also analyzed conditional on having applied fertilizer on that particular plot i.e. by considering only plots that had fertilizer applied on them. The overall results in this analysis showed that the rate of applying fertilizer was about 212 kg/ha up from 90 kg/ha when all cultivated plots were considered (Table 3.8c and Table 3.8a, respectively). At county level, conditional adoption intensity results showed that Bungoma had the highest rate of about 283 kg/ha compared to just about 107 kg/ha when all cultivated plots were considered in Table 3.8a. Therefore, while Embu County had the highest unconditional adoption rate among the sampled counties, Bungoma County had the highest conditional adoption rates. At this point, it is important to note that Bungoma County could be having high conditional adoption rates due to fertilizer credit facility availed by Nzoia Sugar Company for application of the same on sugar cane by the contracted farmers. On the contrary, the other four sampled counties might be having such kind of arrangements.

Table 3.8c Conditional fertilizer adoption intensity by county (kg/ha)

Fertilizer	Bungoma	Tharaka	Embu	Meru	Siaya	Total
Planting (basal)	183.7	162.1	157.1	154.2	120.4	154.6
Top dressing	175.1	92.0	94.8	93.3	112.7	115.6
All	283.0	209.5	204.8	209.9	153.7	212.3

Similar analysis of conditional adoption rates of fertilizer was conducted for male and female headed households and results presented in Table 3.8d. The results still showed that male headed households had a higher fertilizer adoption rates than female headed households. For instance, male headed households had overall conditional fertilizer application rate of about 217 kg/ha up from 93 kg/ha compared to about 180 kg/ha up from 72 kg/ha for female headed households (Table 3.8b and Table 3.8d, respectively).

3.8d Conditional fertilizer adoption intensity by gender of the household head (kg/ha)

Fertilizer	Male	Female	Total
Planting (basal)	159.6	123.1	154.6
Top dressing	114.4	125.6	115.6
All	217.4	179.5	212.3

3.9 Fertilizer application on maize crop

Maize productivity is very important in determining national food security in Kenya. A part from providing food, maize is also an important source of cash income for smallholder farmers who manage to produce surplus for the market. Therefore enhancing its productivity is very critical for national poverty eradication and enhanced food security. To achieve higher productivity of maize, use of improved seed and fertilizer has been promoted by both public and private efforts. Use of improved maize was discussed in details in section 3.5. In this section, we present and discuss the results of use of fertilizer on maize crop among the surveyed households.

About 69% of the surveyed households applied some fertilizer on their maize crop. Fertilizer application on maize crop was more prevalent among the households in eastern Kenya counties of Embu, Tharaka and Meru compares to farmers from western Kenya counties of Bungoma and Siaya (Table 3.9a). Embu County had the highest proportion of households that applied fertilizer on their maize crop at almost 94% followed by Meru County at 86%, Tharaka County at almost 85% and Bungoma County at about 61%. Siaya County had the least proportion of the households that applied fertilizer on their maize crop at just about 422% (Table 3.9a). About 65% of the households in the five surveyed counties had used some planting (basal) fertilizer on their crop compared to about 50% who had used top dressing fertilizer on their maize crop. Across all the surveyed counties, there were more households that used planting (basal) fertilizer on their maize crop than those who used top dressing fertilizer (Table 3.9a).

Table 3.9a Adoption spread of fertilizer on maize crop by county (% households)

Fertilizer	Bungoma (N=137)	Tharaka (N=79)	Embu (N=96)	Meru (N=80)	Siaya (N=143)	Total (N=535)
Planting (basal)	51.8	78.5	91.7	82.5	40.6	64.5
Top dressing	48.9	65.8	65.6	73.8	17.5	49.7
All	60.6	84.8	93.8	86.3	42.0	69.0

Similarly, a higher proportion of male headed households had adopted fertilizer on their maize crop than the proportion among the female headed households. Overall, whereas almost 71% of the male headed households had adopted fertilizer on their maize crop, only 59% of female headed households had adopted fertilizer on their maize crop (Table 3.9b). A higher proportion of both male and female headed households adopted planting (basal) fertilizer on their maize crop compared to top dressing fertilizer. In fact, the proportion of female headed households that applied planting (basal) fertilizer on their maize crop is almost double that one that applied top dressing (Table 3.9b).

Table 3.9b Adoption spread of fertilizer on maize crop by gender of the household head (% households)

Fertilizer	Male (N=447)	Female (N=88)	Total (N=535)
Planting (basal)	66.0	56.8	64.5
Top dressing	52.8	34.1	49.7

All	70.9	59.1	69.0

Fertilizer application intensity (rates) on maize crop was analyzed and results presented in Table 3.10a – 3.10d. Unconditional application rates of fertilizer to maize crop showed an overall application rate of about 114 kg/ha among the surveyed households. It was clear from these results that unconditional fertilizer application rates on maize were higher in eastern Kenya counties than western Kenya counties. This higher adoption intensity in eastern Kenya could be associated with the fact that more households use fertilizer on their crop in eastern than western Kenya as shown in Table 3.9a. The amount of planting fertilizer used on maize crop was more than twice the top dressing fertilizer. An average of about 9 kg/ha of top dressing fertilizer was unconditionally applied to maize crop compared to about 21 kg/ha for the planting (basal) fertilizer. However, the difference in unconditional top dressing and basal fertilizer application rates on maize in Bungoma County was not that big like in the other four sampled counties (Table 3.10a).

Table 3.10a Unconditional adoption intensity of fertilizer on maize crop by county (kg/ha)

Fertilizer	Bungoma (N=574)	Tharaka (N=561)	Embu (N=586)	Meru (N=519)	Siaya (N=641)	Total (N=2881)
Planting (basal)	64.3	93.5	121.6	98.5	21.3	73.1
Top dressing	51.9	48.9	53.5	64.9	8.7	40.9
All	116.3	142.4	175.2	163.4	30.1	114.0

At the gender, level, male headed households had a higher unconditional fertilizer application rate compared to female headed households among the surveyed households. Whereas female headed households had an average of about 84 kg/ha, male headed households had almost 121 kg/ha (Table 3.10b). Similarly, female headed households had consistently lower unconditional application rates of planting (basal) and top dressing fertilizers compared to their male headed counterparts.

Table 3.10b Unconditional adoption intensity of fertilizer on maize crop by gender of household (kg/ha)

Fertilizer	Male (N=2467)	Female (N=414)	Total (N=2881)
Planting (basal)	77.2	53.9	73.1
Top dressing	43.3	29.7	40.9
All	120.5	83.7	114.0

For the conditional analysis, the descriptive statistics showed that the average overall fertilizer application rate on maize crop was about 187 kg/ha up from 114 kg/ha (Table 3.10c and Table 3.9c, respectively). Bungoma district had the highest conditional fertilizer application rates on maize crop (239 kg/ha) while Siaya County had the lowest (102 kg/ha). This means that among the five surveyed counties, maize production is more seriously undertaken in Bungoma County where farmers undertake heavy capital outlays in terms of buying fertilizer just to improve the productivity of this crop. The general higher fertilizer application rates observed in eastern Kenya counties (table 3.8c) could be associated with the fact that they apply most of that fertilizer in cash crops like coffee and tea or in other high value crops other than maize. The conditional planting (basal) and top dressing fertilizer application rates showed higher rates for the former than the later i.e. about 97 kg/ha of top dressing fertilizer was applied to maize crop on average compared to about 129 kg/ha for the planting (basal) fertilizer (Table 3.10c).

Table 3.10c Conditional adoption intensity of fertilizer on maize crop by county (kg/ha)

Fertilizer	Bungoma	Tharaka	Embu	Meru	Siaya	Total
Planting (basal)	157.7	133.5	145.1	120.7	74.3	129.0
Top dressing	145.5	87.0	88.5	89.6	83.6	97.5
All	239.1	189.6	199.1	186.6	101.9	187.0

On the other hand, male headed households had a higher conditional fertilizer application rate on maize compared to female headed households. About 190 kg/ha of fertilizer was applied to maize crop by male headed households while about 168 kg/ha was applied to maize by female headed households (Table 3.10d). Male headed households had consistently higher conditional application rates of both planting (basal) and top dressing fertilizers compared to female headed households.

Table 3.10d Conditional adoption intensity of fertilizer on maize crop by gender of household (kg/ha)

Fertilizer	Male	Female	Total
Planting (basal)	131.9	112.2	129.0
Top dressing	97.0	101.7	97.5
All	190.2	168.0	187.0

3.10 Determinants of technology adoption: Multivariate probit regression estimates

The descriptive results of the multivariate Probit model variables are presented in Table 3.11 and the econometric results in Table 3.12. The econometric results indicate that social economic and plot characteristics such as age, education, fertility, slope, depth and soil colour significantly influence technology adoption. The probability of adopting herbicide use and minimum tillage technologies reduces with education. More educated farmers showed a higher probability of adopting knowledge intensive technologies and ones that require considerable input in terms of management such as improved seed and soil and water conservation similar to findings by Pender & Gebremedhin (2007). Again, educated farmers may also be more aware of the benefits accrued to adoption of modern technologies and more able to search for appropriate technologies to alleviate constraints in production (Pender & Gebremedhin, 2007, Kassie et al. 2011).

The probability of adopting animal manure and legume intercrop increased with age. Older farmers have accumulated much experience in farming to understand the substitution of fertilizer with manure. They also adopt legume intercrop as a risk diversifying strategy especially in some parts of eastern region. Farmers who perceived their plots as good or moderately good in terms of fertility did not adopt fertilizer use, soil and water conservation and minimum tillage. These two technologies are mainly adopted with an intent to improve the fertility of the soil and hence less likely that they are adopted in relatively fertile soils. Plots in Eastern region which is the reference were more likely to adopt improved seed, minimum tillage, fertilizer and pesticide use but less likely to adopt legume intercrop. Sub plot distance significantly influenced adoption of fertilizer, improved seed, soil and water conservation and animal manure. Distance which is a proxy for accessibility can influence the use of inputs, availability of information as well as opportunity cost of labour (Jansen et al. 2006; Wollni et al. 2000; Pender & Gebremedhin 2007). Distance increases the amount of labour by raising the output input price ratios (Shiferaw et al. 2012).

Table 3.11: Description and measurement of variables

Dependent variables	Description and measurement of variables	Mean	Std. Dev.
Fertuse	Plot received fertilizer (1=yes; 0= no)	0.76	0.42
Pestuse	Plot received pesticide (1=yes; 0= no)	0.27	0.44
Herbuse	Plot received herbicide (1=yes; 0= no)	0.04	0.20
Impseed	Plot received improved seed (1=yes; 0= no)	0.75	0.43
Mintill	Plot received minimum tillage (1=yes; 0= no)	0.09	0.29
Swatercons	Plot received soil water conservation (1=yes; 0= no)	0.54	0.49
Animan	Plot received animal manure (1=yes; 0= no)	0.39	0.48
leg_interc_p	Plot received legume intercropping (1=yes; 0= no)	0.20	0.40
Legcrrop	Plot received legume crop rotation (1=yes; 0= no)	0.16	0.36
Independent variables		Mean	Std. Dev.
Mzyieldpacre	Maize yield per acre in kilograms	147.75	925.33
Age	The age of the farmer (years)	51.28	14.46
Educ	Education level of the farmer in years of schooling	7.93	7.47

Season	Farming season during the year (1=long rains 0=short rains)	0.47	0.499
Subplotdist	Distance to the subplot from home in kilometers	6.96	25.14
Subplotarea	Area of the subplot in acres	0.33	1.09
Howmanycrops	Number of crops grown on the subplot	1.83	0.73
Goodffertpt	Farmer perceives soil fertility to be good (1=yes; 0= no)	0.16	0.37
Modffertpt	Farmer perceives soil fertility to be moderate (1=yes; 0= no)	0.48	0.49
porffertpt (reference)	Farmer perceives soil fertility to be poor (1=yes; 0= no)	0.08	0.27
flatsloplt (reference)	Farmer perceives soil slope to be flat (1=yes; 0= no)	0.33	0.47
Modsloplt	Farmer perceives soil slope to be moderate (1=yes; 0= no)	0.34	0.47
Steepsloplt	Farmer perceives soil slope to be steep (1=yes; 0=no)	0.053	0.22
shallow_depthplot (reference)	Farmer perceives soil depth to be shallow (1=yes; 0=no)	0.09	0.28
mod_depthplot	Farmer perceives soil depth to be moderate (1=yes; 0=no)	0.23	0.42
deep_depthplot	Farmer perceives soil depth to be deep (1=yes; 0=no)	0.39	0.48
blacksoil (reference)	Farmer perceives soil type to be black (1=yes; 0=no)	0.10	0.31
Brownsoil	Farmer perceives soil type to be brown (1=yes; 0=no)	0.40	0.49
Redsoil	Farmer perceives soil type to be red (1=yes; 0=no)	0.16	0.37
Greysoil	Farmer perceives soil type to be grey (1=yes; 0=no)	0.04	0.19
Residue	Crop residues & stubble were left on sub-plot from previous season (2011/12) (1=yes; 0=no)	0.42	0.55
age_sq	Age squared	2839.61	1573.74
stress_inc_e	The farmer experienced stress incidence (1=yes; 0= no)	0.69	0.46
western (reference)	Region of residence (1=yes 0=no)	0.49	0.50
Eastern	Region of residence (1=yes 0=no)	0.50	0.50
Decfemales	Female is the decision maker in cropping activities (1=yes; 0=no)	0.15	0.35
decmales	Male is the decision maker in cropping activities (1=yes; 0=no)	0.12	0.32
joint_decsn	Joint decision making in cropping activities (1=yes; 0=no)	0.50	0.50
extmaz	Farmer had access to extension services (1=yes; 0= no)	0.46	0.49
Lnincome	Log of farmers income	10.98	1.31

Table 3.12: Multivariate probit model parameter estimates across SAI packages

Variable	Fertilizer (FT)		Pesticide (PT)		Herbicide (HB)	
	Coef	Std. Err	Coef	Std. Err	Coef	Std. Err
Mzyieldpacre	0.0002*	0.0001	0.0001***	0.00002	-0.00003	0.0001
Age	-0.008	0.009	0.002	0.006	-0.008	0.013
Educ	0.011	0.028	0.005	0.017	-0.083	0.045
Season	-0.185	0.170	-0.295**	0.138	-0.338	0.240
Subplotdist	0.018*	0.010	0.0001	0.005	-0.0002	0.009
Subplotarea	0.025	0.062	-0.023	0.030	0.024	0.052
Howmanycrops	0.130	0.145	0.220**	0.101	-0.156	0.191
Goodffertpt	-0.161	0.358	-0.023	0.291	0.460	0.472)
Modffertpt	-0.068	0.304	-0.067	0.238	-0.474	0.403
Modsloplt	0.397*	0.217	0.009	0.163	0.257	0.317
Steepsloplt	-0.416	0.427	-0.436	0.323	0.420	0.463
mod_depthp_t	-0.177	0.322	-0.315	0.234	0.182	0.421
deep_depth_t	-0.152	0.284	-0.587***	0.216	-0.111	0.398
Brownsoil	0.195	0.285	0.725***	0.267	-0.135	0.451
Redsoil	0.265	0.333	1.462***	0.293	0.471	0.491
Greysoil	1.083**	0.547	0.214	0.407	0.131	0.600
Residue	0.195	0.162	0.213**	0.086	-0.506*	0.281
age_sq	0.000	0.0001	-0.0001	0.0001	-0.0002*	0.0001
stress_inc_e	-0.124	0.199	-0.259	0.159	-0.036	0.298
Eastern	0.623***	0.200	1.146***	0.167	0.725**	0.302
fem_decsn	5.021	131.5	-0.478**	0.213	-0.493	0.504
joint_decsn	-0.298	0.191	0.067	0.167	0.532	0.356
Extmaz	-0.111	0.197	-0.193	0.161	0.418	0.280
Inincome	0.104	0.070	0.084	0.057	0.051	0.120

Variables	Improved seed (IS)		Minimum Tillage (MT)		Soil Water Conservation (SWC)	
	Coef	Std Err	Coef	Std Err	Coef	Std Err
mzyieldpacr	0.0001	0.0001	0.000	0.000	0.0000	0.000
Age	-0.0001	0.007	-0.016*	0.010	0.0070	0.004
Educ	-0.016*	0.013	-0.051**	0.025	0.023*	0.015
Season	-0.239*	0.124	-0.080	0.153	0.036	0.112
subplotdist	0.014*	0.007	0.001	0.007	-0.013**	0.005
subplotarea	0.042	0.064	-0.055	0.113	0.053	0.045
howmanycro	-0.052	0.107	0.084	0.121	0.186**	0.091
goodffertpt	-0.063	0.264	-	0.3145	0.448*	0.236

			0.831***			
modffertpt	-0.201	0.213	-0.889***	0.246	0.096	0.195
modsloplt	0.300**	0.151	0.750***	0.195	0.181	0.136
steepsloplt	0.010	0.334	0.193	0.431	0.2913	0.292
mod_depthp_t	-0.0407	0.229	-0.018	0.273	-0.2960	0.205
deep_depth-	-0.226	0.205	-0.064	0.243	-0.077	0.183
brownsoil	0.198	0.188	0.160	0.283	-0.057	0.176
Redsoil	0.345	0.230	0.914**	0.306	-0.178	0.209
Greysoil	-0.348	0.284	-0.215	0.472	-1.111***	0.309
Residue	-0.125	0.091	0.232**	0.103	-0.174*	0.093
age_sq	0.000	0.0001	-0.0001	0.0001	0.0000	0.0001
stress_inc_e	0.125	0.145	-0.036	0.186	-0.127	0.133
Eastern	0.380***	0.142	0.503**	0.177	0.067	0.129
fem_decsn	-0.260	0.175	-0.059	0.253	-0.278*	0.162
joint_decsn	0.033	0.161	0.560**	0.211	0.061	0.143
Extmaz	-0.092	0.138	0.066	0.178	0.246*	0.128
lnincome	0.027	0.051	0.1023	0.069	0.041	0.047

Variables	Animal Manure (AM)		legume intercrop rotation(LI)		legume crop rotation(LCR)	
	Coef	Std Err	Coef	Std Err	Coef	Std Err
Mzyieldpacre	0.000	0.00002	0.0000	0.00002	0.000	0.0001
Age	0.011*	0.006	0.017**	0.007	-0.017**	0.007
Educ	0.012	0.008	0.0008	0.017	0.006	0.018
Season	-0.125	0.113	-0.106	0.128	-0.104	0.151
subplotdist	-0.022***	0.006	0.006	0.006	-0.012	0.008
subplotareaH	-0.025	0.027	-0.020	0.029	0.021	0.034
howmanycrop	0.053	0.092	0.369***	0.101	-0.197	0.117*
goodffertpt	0.007	0.235	0.357	0.260	0.319	0.310
modffertpt	-0.275	0.196	0.245	0.216	0.250	0.267
modsloplt	0.171	0.137	0.094	0.153	-0.111	0.184
steepsloplt	0.124	0.306	-0.307	0.325	0.713**	0.316
mod_depthp_	-0.078	0.206	0.064	0.226	-0.487	0.256
deep_depth_t	-0.067	0.182	-0.125	0.201	-0.464**	0.235
brownsoil	0.234	0.184	-0.459**	0.219	0.311	0.268
Redsoil	0.287	0.214	-1.020***	0.248	0.795***	0.286
Greysoil	-0.272	0.298)	-0.092	0.358	-0.452	0.519

Residue	0.010	0.0871	-0.023	0.093	-0.015	0.126
age-sq	0.0001**	0.00005	-0.0001*	0.00006	0.0000	0.00007
stress_inc_e	0.278**	0.136	-0.067	0.152	-0.065	0.173
Eastern	-0.202	0.131	-0.354**	0.144	0.038	0.172
fem_decsn	-0.163	0.1655	0.102	0.197	-0.439*	0.224
joint_decsn	0.341**	0.146	-0.442***	0.164	-0.038	0.180
Extmaz	-0.284**	0.129	0.162	0.147	-0.013	0.168
lnincome	0.026	0.047	-0.037	0.054	-0.067	0.062

Notes: Coef means coefficient

***, ** and * denote statistical significance at 1%, 5% and 10% confidence levels, respectively.

3.11 SAI Packages use across maize, beans and maize-bean intercrop sub-plots

The SAI package combinations are presented on Table 3.13 and the multinomial regression results on package used combinations

Table 3.13: SAI packages used on pure maize and bean stands and maize bean intercrop plots

Choice *j*	Binary quadruplet (package)	Improved Seed (S)		Organic Fertilizer (F)		Animal Manure(M)		Pesticide (P)	
		S_1	S_0	F_1	F_0	M_1	M_0	P_1	P_0
1	S_1 F_0 M_0 P_0	√			√		√		√
2	S_0 F_1 M_0 P_0		√	√			√		√
3	S_0 F_0 M_1 P_0		√		√	√			√
4	S_0 F_0 M_0 P_1		√		√		√	√	
5	S_1 F_1 M_0 P_0	√		√		√			√
6	S_1 F_0 M_1 P_0	√			√	√			√
7	S_1 F_0 M_0 P_1	√			√		√	√	
8	S_0 F_1 M_1 P_0		√	√		√			√
9	S_0 F_1 M_0 P_1		√	√			√	√	
10	S_0 F_0 M_1 P_1		√		√	√		√	
11	S_1 F_1 M_1 P_0	√		√		√			√
12	S_1 F_1 M_0 P_1	√		√			√	√	
13	S_1 F_0 M_1 P_1	√			√	√		√	
14	S_0 F_1 M_1 P_1		√	√		√		√	
15	S_1 F_1 M_1 P_1	√		√		√		√	

NOTE: The binary quadruplets represent the possible SAI combinations. Each element in the quadruplet is a binary variable for adoption of improved seed (S), organic fertilizer (F), animal manure (M) and pesticide (P) and 0 = otherwise.

3.12 Factors explaining the adoption decision of SAI packages

The results from multinomial logit model presented in Table 3.14 are compared to the reference package of fertilizer and improved seed ($S_1F_1M_0P_0$). The education level of farm decision maker positively influence uptake of ($S_0F_1M_1P_1$) and ($S_1F_1M_1P_1$) packages but has a negative effect on adoption of ($S_1F_1M_0P_1$) and ($S_1F_0M_1P_1$) packages. This might be because a package combining use of fertilizer, improved seed and pesticide is relatively knowledge intensive and requires considerably higher management skills. Highly educated farmers are able to search for information and interpret extension services. SAIs are knowledge intensive and requires considerably higher management skills

The age of household head positively influence adoption of packages ($S_1F_1M_1P_0$), ($S_1F_1M_0P_1$), ($S_0F_1M_1P_0$,), ($S_0F_1M_0P_0$,) and ($S_1F_0M_0P_0$), but negatively related to the adoption of ($S_1F_0M_1P_1$) package. Age being a proxy for experience in farming, the elderly tend to adopt more of fertilizer and manure packages.

There is a strong positive correlation between sex of plot decision maker and adoption of ($S_1F_0M_1P_0$) package. Similarly adoption of ($S_1F_1M_0P_1$) and ($S_1F_0M_0P_0$) packages are also positively influenced by sex of plot decision maker. Male farmers tend to adopt more of improved seed and fertilizer.

The results further indicate the importance of soil fertility in determining adoption of ($S_0F_1M_0P_0$) and ($S_0F_1M_0P_1$) packages. This could be because when the soil fertility is good farmers do not use fertilizer. Farmers who perceive their plots to be fertile have low adoption of packages containing fertilizer. With good soil fertility there is little use of fertilizer.

The adoption of ($S_1F_1M_1P_1$), ($S_0F_1M_1P_1$), ($S_1F_0M_1P_1$) and ($S_1F_1M_1P_0$) packages is negatively influenced by the area of farmer's sub plot. Farmers who have small pieces of land use more than two technologies on their sub plots, probably because they intend to increase production so as to have adequate food for their families. Farmers who have small pieces of land use more than two technologies on their sub plots.

Farmers' income positively influences uptake of ($S_1F_1M_1P_1$), ($S_0F_1M_1P_1$), ($S_1F_0M_0P_1$) and (S_1F_0 M_0 P_1), but negatively influence uptake of ($S_0F_1M_1P_0$) packages. Farmers' income influences uptake of more SAI technologies more so those that had fertilizer.. This can also be attributed to the fact that most farmers pointed out the prices of fertilizer and improved seed to be a major challenge.

Availability of labor was found to be crucial in adoption of ($S_0F_0M_1P_0$), ($S_0F_1M_1P_0$), ($S_0F_1M_0P_1$) and ($S_1F_1M_1P_1$) Packages. This could be because packages containing fertilizer, manure and pesticide tend to use more labor. Probably because they are labor intensive.

Table 1: Factors explaining the adoption decision of SAI packages

Variable	F	S	M	SM	SP	FM	FP	MP	SFM	SFP	SMP	FPM	SFMP
Education level	0.002	-0.024	-0.062	-0.050	-0.038	0.007	0.029	0.158	0.003	-0.043*	-0.720***	0.033*	0.023**
	(0.013)	(0.053)	(0.071)	(0.065)	(0.140)	(0.017)	(0.035)	(0.225)	(0.013)	(0.024)	(0.347)	(0.019)	(0.011)
Age	0.014**	-0.010	0.038**	0.033	0.010	0.017*	0.045	0.024	0.020***	0.018***	-0.02***	0.008	0.018
	(0.007)	(0.014)	(0.017)	(0.016)	(0.036)	(0.010)	(0.029)	(0.063)	(0.06)	(0.007)	(0.043)	(0.018)	(0.007)
Sex of plot decision maker	-0.2418**	0.826***	1.599	1.146***	0.714	-0.246	1.051	0.475	0.134	0.253**	2.990	0.290	0.048**
	(0.104)	(0.298)	(0.528)	(0.394)	(0.754)	(0.157)	(0.742)	(0.788)	(0.092)	(0.109)	(1.452)	(0.312)	(0.108)
Subplotdistance	-0.013*	-0.001	-0.099	-0.096	-0.050	0.004	0.027*	-0.011	-0.001	0.001	-0.090	-0.041	-0.005
	(0.008)	(0.011)	(0.066)	(0.055)	(0.072)	(0.006)	(0.015)	(0.059)	(0.004)	(0.004)	(0.394)	(0.047)	(0.006)
Soil fertility	0.414***	-0.365	-0.017	-0.757	-0.262	0.307	0.562	0.361	-0.255	0.093	3.264	-0.185	-0.217
	(0.154)	(0.322)	(0.410)	(0.394)	(0.856)	(0.238)	(0.749)	(1.257)	(0.131)	(0.150)	(1.988)	(0.433)	(0.156)
Group membersh	0.036	-0.188	-0.826	0.145	-14.912	-0.060	0.767	0.616	-0.058	-0.186	-1.290*	-0.448	-0.337
	(0.185)	(0.364)	(0.510)	(0.476)	(899.17	(0.278)	(0.899)	(0.037)	(0.155)	(0.181)	(0.800)	(0.510)	(0.184)
Subplot tenure	-0.020	-1.085	0.021	0.699**	0.796***	-0.938**	-1.885	-1.402	-0.442**	0.229	-14.610*	-1.523	-0.666
	(0.176)	(0.737)	(0.568)	(0.292)	(0.473)	(0.478)	(0.260)	(0.958)	(0.185)	(0.148)	(0.300)	(0.876)	(0.259)
Subplotarea	-0.013	0.100	-0.097	-0.043	-0.393	0.071	-1.354	0.082	-0.030**	0.048	-2.943**	-1.511*	-0.050***
	(0.116)	(0.116)	(0.318)	(0.233)	(0.965)	(0.116)	(1.075)	(0.296)	(0.077)	(0.085)	(2.658)	(0.806)	(0.113)
Income	0.430***	-0.173	-0.106	-0.100	0.258	0.078***	-0.008**	0.202	-0.075	0.003	-0.063	0.774*	0.117**
	(0.106)	(0.159)	(0.233	(0.221)	(0.479)	(0.160)	(0.659)	(0.769)	(0.093)	(0.007)	(0.774)	(0.334)	(0.210)
Labour	-0.005	-0.016	-0.050**	-0.020	-0.011	-0.001*	0.020**	-0.014	0.004	-0.133	0.037	0.023	0.021*
	(0.007)	(0.012)	(0.023)	(0.016)	(0.033)	(0.009)	(0.009)	(0.052)	(0.005)	(0.113)	(0.032)	(0.010)	(0.005)
_cons	-1.943***	-1.272	-5.936***	-4.743***	-5.298	-2.108**	0.238	-1.020	-0.689	-2.080***	0.463	1.879	-0.534
	(0.553)	(1.396)	(1.937)	(1.579)	(3.240)	(0.912)	(0.29o)	(0.662)	(0.478)	(0.598)	(0.300)	(0.877)	(0.559)
Number of observations							3,449						

Note: Standard errors are in parenthesis. Fertilizer and Improved seed (FS) is the reference package. S= improved seed, F= organic fertilizer, M= animal manure, P= pesticide

***, ** and * denote statistical significance at 1%, 5% and 10% confidence level.

Group membership influenced the adoption of ($S_1F_0M_1P_1$) package .This is attributed to the fact that farmers in groups get more information easily and share them among themselves. With limited or inadequate information sources and imperfect markets, including insurance market and social networks could facilitate the exchange of information hence aid farmers to get inputs on time and overcome other challenges including credit constraints.

3.13 Impact of farmers' choice of SAI technology combination on labour use and income

With regard to SAI uptake on labor use, results reveal that farmers who adopted SAI packages significantly demand more labor than it would have been if they had not adopted the specified SAI packages as shown on Table 3.15. Similarly adoption of packages containing three or four technologies per plot demanded more labor than packages that had one or two technologies. The results further showed that packages containing manure and pesticide use demanded the highest amount of labor. This is probably because manure use and pesticide application is labor intensive.

On the other hand, adoption of packages contained minimum tillage and soil and water conservation significantly decreased labor demands. This result contradicts the findings by Hailemariam *et al.* (2013) who analyzed the impacts of cropping system diversification, conservation tillage and modern seed adoption on household income, agrochemical use and demand for labor in Ethiopia, and found that conservation tillage increased pesticide application and labor demand. This is probably due to the fact that initial costs of putting up ridges and farrows for minimum tillage could be very high and very low cost if any in the consecutive years. Hence the costs of maintaining minimum tillage and soil and water conservation are very minimal in the consecutive years resulting to decreased labor demands.

Concerning the impact of farmers' choice of SAI technology combination on income, results generally reveal that adoption of SAI practices in combination increases farmer’s income than adoption in isolation. The highest proceeds are achieved when SAI practices are adopted in combination rather than in isolation.

The results also show that adoption of packages that contain soil and water conservation and minimum tillage gives the highest income. Previous studies have shown that conservation tillage can lead to substantial ecosystem service benefits by reducing soil erosion and nutrient depletion and conserving soil moisture (Fuglie, 1999; Woodfine, 2009).

Table 2: Impact of SAI practices combinations on labor use in man days and income.

ATT	SAI	Mean of labor use	Mean of income
	SF	26.402(0.605)	46794(1780)***
	SM	27.758(0.857)	34852(1345)
	SP	28.630(0.981)	37968(1704)
	FM	27.378(0.814)	34310(1260)***
	FP	26.878(0.628)	45344(1964)***
	MP	28.527(0.584)	36091(781)
	SFM	30.168(1.373)	36948(3406)
	SFP	28.693(0.991)	37444(1638)
	SMP	30.219(1.360)	37069(3365)
	SMFP	30.168(1.373)	39588(3366)**
	WT	24.702(2.186)	45919(3871)
	ST	26.170(1.785)	52437(7885)*
	WTS	24.787(1.458)*	45071(3817)
	WTH	25.950(0.611)*	47879(1249)**
	WTM	25.028(0.995)*	37868(2055)
	WCT	25.317(0.755)	32893(1436)***
	WTFM	26.629(0.819)	43945(4180)***
	WTCS	25.317(0.755)**	32893(1436)***
	WTPF	26.395(0.258)	43945(4180)***
	WTCSF	24.357(0.768)**	48003(1469)***
ATU	SF	21.749(0.881)***	33794(1780)***
	SM	27.758(0.857)	34852(1345)
	SP	23.856(0.574)**	37968(1704)
	FM	24.336(0.666)	34310(1260)***
	FP	21.681(0.897)***	49344(1964)***
	MP	20.444(1.036)**	36091(781)
	SFM	24.651(0.556)	36948(3406)
	SFP	23.897(0.574)**	37444(1638)
	SMP	24.627(0.557)	37069(3365)
	SMFP	24.651(0.556)	39588(3366)**
	WT	21.682(1.790)***	45919(3871)
	ST	20.931(0.770)***	52437(7885)*
	WTS	22.505(0.513)*	45071(3817)
	WTH	25.369(0.709)	44219(1249)**
	WTM	24.518(0.660)	37868(2055)
	WCT	26.212(0.671)	32893(1436)***
	WTFM	22.107(1.893)*	43945(4180)***
	WTCS	26.212(0.671)	32893(1436)***

WTPF	25.797(1.621)	43945(4180)***
WTCSF	20.994(0.667)	43003(1469)***

Note: Standard errors are in parenthesis. S= improved seed, F= organic fertilizer, M= animal manure, P= pesticide, C=Intercrop, T=Minimum tillage, W =Soil and water conservation.

***, ** and * denote significance at 1%, 5% and 10% confidence level.

The highest income of 52437 Kenya shillings is achieved when improved seed variety is used under minimum tillage followed by use of improved seed, minimum tillage, fertilizer, soil and water conservation and intercropping package that gave 48003 Kenya shillings. However, it also appears that use of fertilizer and improved seed variety enables farmers to earn higher income from their farm produce.

The uptake of package containing minimum tillage, soil and water conservation and herbicide also gives a higher output of farm produce. Perhaps, because conservation agriculture may necessitate application of herbicides to kill weeds before planting under minimum tillage systems. This is in-tandem with other studies which have revealed that system diversification helps to maintain soil biodiversity, which can reduce pest and weed infestations that otherwise must be controlled by pesticides and/or additional labor (Hajjar *et al*., 2008; Tilman *et al*., 2002).

Most packages that farmers use that contain use of improved seed varieties also contain the use of pesticide. Besides, past studies have related the use of more pesticides in the package that contains improved seed to the fact that farmers would like to avoid risk, as high yielding varieties are prone to pest outbreaks (Jhamtani, 2011: Hailemariam *et al.*, 2013).

As shown on Table 3.16, the average labor demand both for females and males is significantly higher than it would have been if the adopters had not adopted. Adoption of SAI packages increases women workload contributed to both family and hired labor compared to their male counterparts. This puts different effects on male and female labor time allocation. In nearly all cases, adoption of SAI packages leads to more time spent working on the farm for females than for males. This may negatively affect larger households by diverting time from other activities such as food preparation and childcare, as women are usually responsible for routine care of the household. This is consistent to the findings by Njeri, (2007) who noted that in Kenya, women supply about 70-75 percent of agricultural labor in agriculture. Unlike men, women lack access and control over production resources such as land, information and credit.

In general, adoption of SAI packages increases women workload contributed to both family and hired labor compared to their male counterparts. More women depend on agriculture wage labor as a source of livelihood. This is in line with the findings of Njeri (2007) who found that in African societies, women are responsible for feeding their families hence crops produced for subsistence are associated with women, while men grow cash crops because they are responsible for providing cash income for the family.

Table 3.163: Impact of SAI practices combinations on labor use in man days by gender

		Family labor Women	**Family labor Men**	**Hired labor Women**	**Hired labor Men**
ATT	SF	9.970(0.252)	6.799(0.226)	2.413(0.071)***	1.390(0.042)***
	SM	10.655(0.289)	6.914(0.264)**	2.849(0.103)**	1.636(0.076)
	SP	11.309(0.348)**	7.039***	2.854(0.125)	1.722(0.091)
	FM	10.626(0.265)***	6.779(0.241)***	2.759(0.092)**	1.551(0.078)
	FP	9.229(0.250)***	7.571(0.264)***	2.360(0.078)***	1.492(0.039)***
	MP	9.742(0.224)***	7.486(0.282)***	3.226(0.113)***	1.651(0.050)
	SFM	11.239(0.589)**	6.871(0.488)	3.283(0.228)*	1.802(0.156)
	SFP	10.007(0.395)***	6.311(0.341)***	2.861(0.125)	1.719(0.091)
	SMP	10.082(0.557)**	6.970(0.477)	3.243(0.227)*	1.809(0.155)
	SMFP	9.270(0.551)***	8.347(0.590)	3.283(0.228)*	1.802(0.156)
ATU	SF	9.521(0.420)***	5.302(0.341)**	2.236(0.130)	1.180(0.075)***
	SM	9.490(0.233)***	5.670(0.209)	2.531(0.083)***	1.769(0.070)***
	SP	9.221(0.204)*	5.829(0.178)	2.568(0.085)	1.585(0.055)***
	FM	9.578(0.231)	5.699(0.201)	2.529(0.082)***	1.732(0.075)**
	FP	9.469(0.437)***	5.346(0.351)**	2.261(0.133)	1.177(0.071)***
	MP	9.311(0.479)*	4.985(0.465)	2.455(0.185)***	1.036(0.074)***
	SFM	9.592(0.271)	6.164(0.194)	2.552(0.123)*	1.582(0.076)
	SFP	9.507(0.252)**	5.885(0.218)	2.548(0.084)	1.575(0.054)***
	SMP	9.713(0.227)	6.158(0.195)	2.562(0.128)*	1.589(0.075)
	SMFP	9.145(0.236)*	6.452(0.241)**	2.552(0.123)*	1.582(0.076)

Note: Standard errors are in parenthesis.

1 man day = 8 working hours; S= improved seed, F= organic fertilizer, M= animal manure, P= pesticide.

***, ** and* denote significance at 1%, 5% and 10% confidence level.

Source: Adoption Pathways Survey data, 2013

3.14 Relationship between farm size, family size and SAI intensity

The relationship between farm and family sizes, and SAI practices' uptake intensity is given in Figure 23. The results show that Bungoma County report the highest family size on average, followed by Siaya County with a mean of 7 and 6 persons per household, respectively. Embu County has the least household size with a mean 4 persons per household. In Tharaka Nithi and Meru Counties households have an average of 5 persons.

Farmers from Siaya County have the largest parcels of land followed by Meru County with an average of 5.14 and 5.06 acres per household. Embu County has small pieces of land with an average of 2.95 acres per household.

On the contrast, Bungoma County reported the lowest number of plot SAI practices intensity with a mean adoption rate of 3.99 per plot. Generally farmers use a package of four SAI technologies per plot across the five Counties.

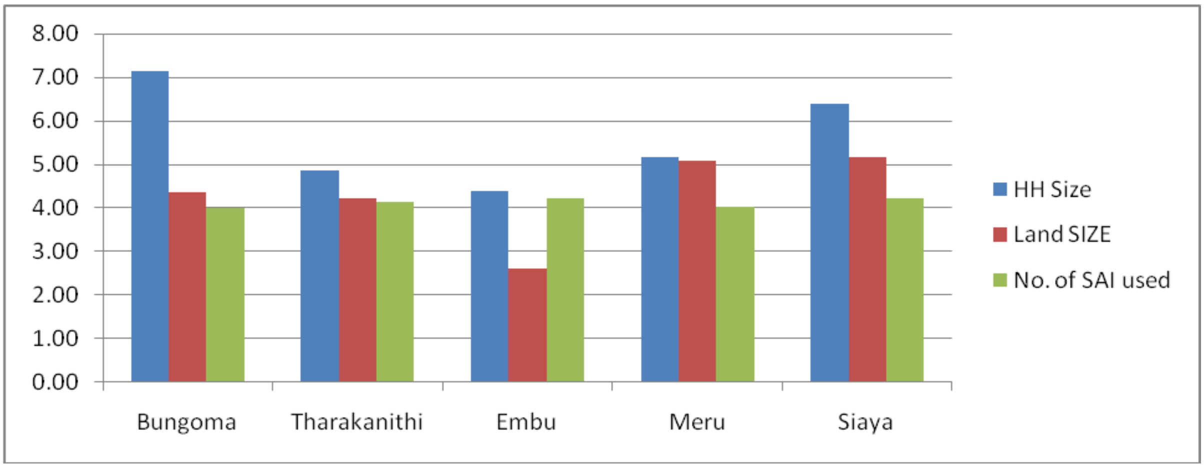

Figure 3.10: Relationship between farm size, family size and SAI intensity

3.15 Correlation of maize yield per acre with SIMLESA technologies

In Figure 24, the correlations between maize yields and the intensity of SAI practices are presented. The results show that maize yield hectare and the use of improved seed variety were highly correlated compared to all other SIMLESA technologies. This is expected since the use improved maize varieties and fertilizer are relatively inseperable considering that two constitute a package in the pursuit of the green revolution benefits.

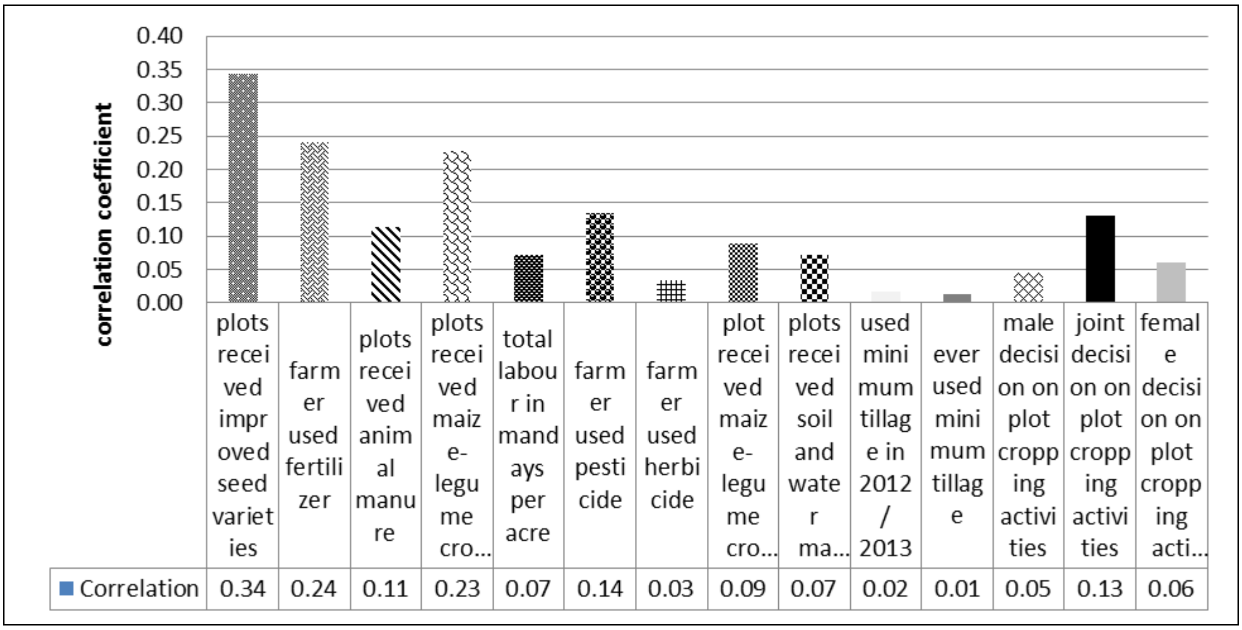

Figure 3.2: Correlation of maize yield per acre with SIMLESA technologies

The correlation coefficient of 0.34 is significantly different from zero implying that adoption of improved seed technologies is linearly linked with increased maize yield per unit area. Minimum tillage and herbicide use technologies had minimum but positive correlation with maize yield. However the coefficients are not significantly different from zero indicating that though the correlation is positive, the degree of covariability is relatively negligible.

CHAPTER FOUR: AGRICULTURAL INPUT USE

4.1 Proportion of female labour in different crop production activities

The effects of SAI practices and labour use intensity is one of the issues that is not yet clear cut in comparison to the conventional agricultural land use practices, especially when the gender dimension and labour use is considered. In Table 4.1, a mean comparison of labour use by gender is presented. The *t* test statistic shows significant differences between means for labor man days provided by males and females in all farming activities. Females provided bulk of family labor in the plots than males.

Table 4.1: Means of labor contribution by gender

Variable	Female N=4298	Male N=4298	*t*
Total labor man days	5.41 (9.10)	3.95 (8.29)	7.75*
Land preparation and planting	1.27 (1.18)	1.07 (1.00)	3.08*
Weeding	1.70 (3.86)	0.98 (2.71)	10.11*
Harvesting	1.50 (3.64)	1.30 (4.67)	2.17**
Threshing	0.95	0.61	7.64*

Notes: Figures in parenthesis are standard deviations.

** and * denote significant at 5% and 10% confidence levels, respectively.

4.2 Maize seed sources and recycling between hybrids and OPVs and overall in maize as a crop

Figure 4.1 show the sources of maize seed that farmers use in their fields. The results show that a majority of the farmers in all the sampled counties sourced their first maize seed from agro dealers and agro-vets. No maize seeds were sourced from extension demo plots and on farm trials in Siaya and Bungoma counties. Likewise, farmers never soured seeds from research centres in Meru and Bungoma counties.

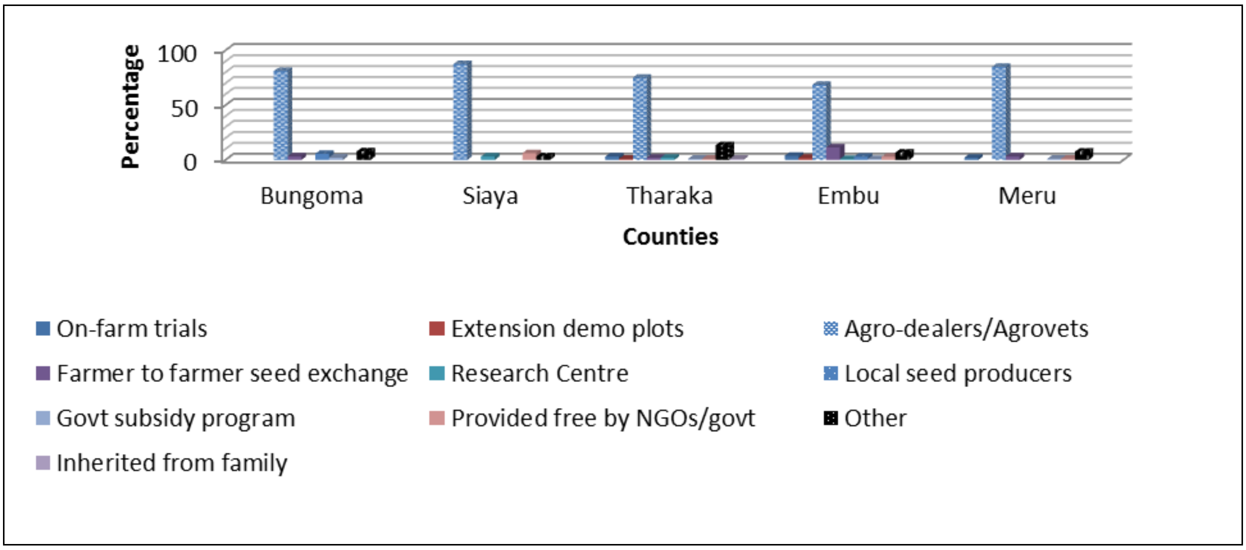

Figure 4.1: Sources of maize seeds

Seeds supply to farmers by the government is observed in all counties being more prominent in Siaya County at 6.25%. Farmer to farmer seed exchange is popular in Embu County with 11.43% of the farmers getting their seeds from this source. Local seed producers supplied seeds to farmers in Embu and Bungoma counties compared to none in the other three counties sampled.

4.3 Sources of information on new seed varieties by Gender and County

Majority of information among farmers on new seed varieties is obtained from fellow neighboring farmers and other farmer relatives. Although agro dealers supplied majority of seeds to farmers in all the counties, they conveyed very limited information on seed varieties. However, they conveyed a proportion of this information in at least all the counties sampled. Electronic and print media is the second most reliable source of this information in all the counties sampled while farmer groups form of collective action failed to convey any information in Siaya and Tharaka Nithi counties. Close to 17%, 10% and 11% of farmers in

Tharaka Nithi, Bungoma and Meru counties obtained this information from government extension while failing to provide any information in Siaya and Embu counties.

4.4 Overview of main legumes grown across the survey counties (% households growing)

Among the five major legumes grown in Kenya, beans were the most popular legume grown in the five counties (Figure 4.2 and Figure 4.3)). Tharaka Nithi, Embu and Meru Counties recorded high percentage of farmers growing beans in their households. Beans adoption rate was relatively lower counties in western Kenya that is Bungoma and Siaya. Very few farmers adopted soy, pigeon peas, groundnuts and cowpeas across the five counties.

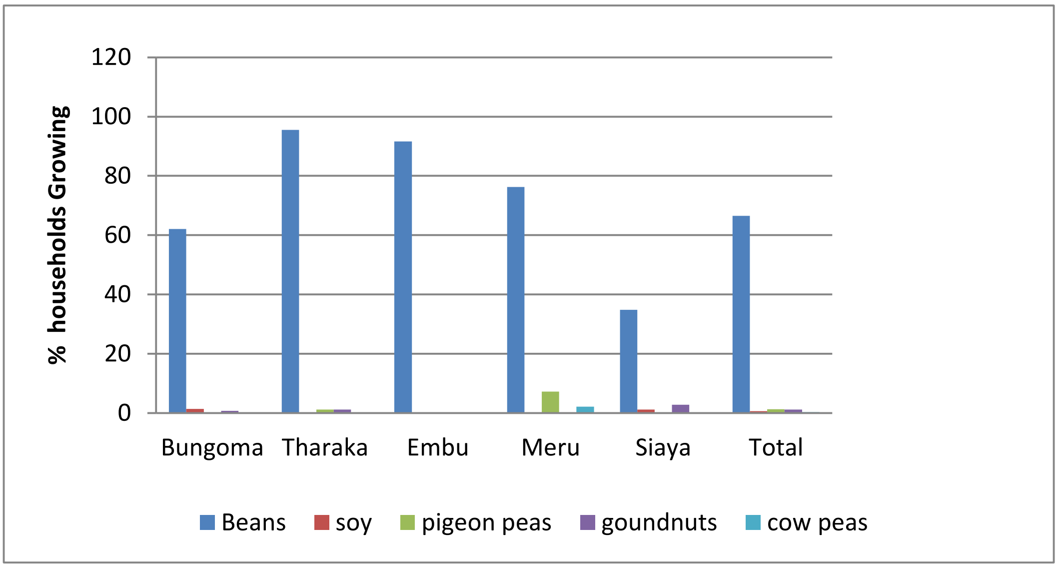

Figure 3: Main legumes grown across the counties

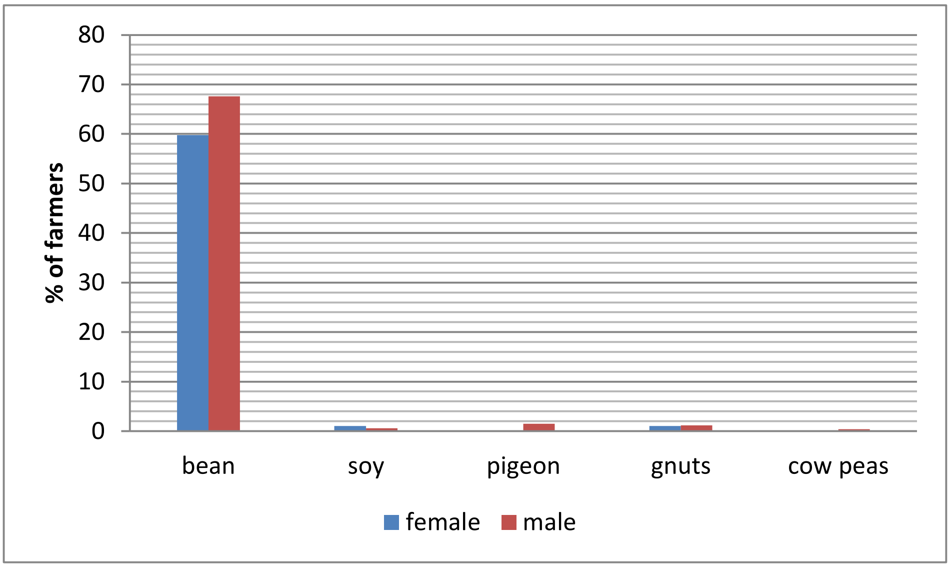

Figure 4.3: Main legumes grown by gender of household head

Further analysis of legume grown across the counties based on gender reveal that more male headed households adopted the legumes compared to female headed households.

4.5 Adoption of different varieties of the main legume grown in the country

Bean was the major legume grown across all the counties (Figure 4.4). In terms of adoption of the bean varieties Mwitemania bean variety was the most popular followed by Rosecoco and Wairimu the other three varieties Nyayo, Gacera Gacugu were not popular in all the Counties. Mama safi bean variety was adopted by quite a number of farmers Embu only. Mwitemania was not popular in western Kenya with Bungoma County recording few households growing while in Siaya no farmer had adopted the variety. Majority of the farmers in Siaya grew the Rosecoco beans variety.

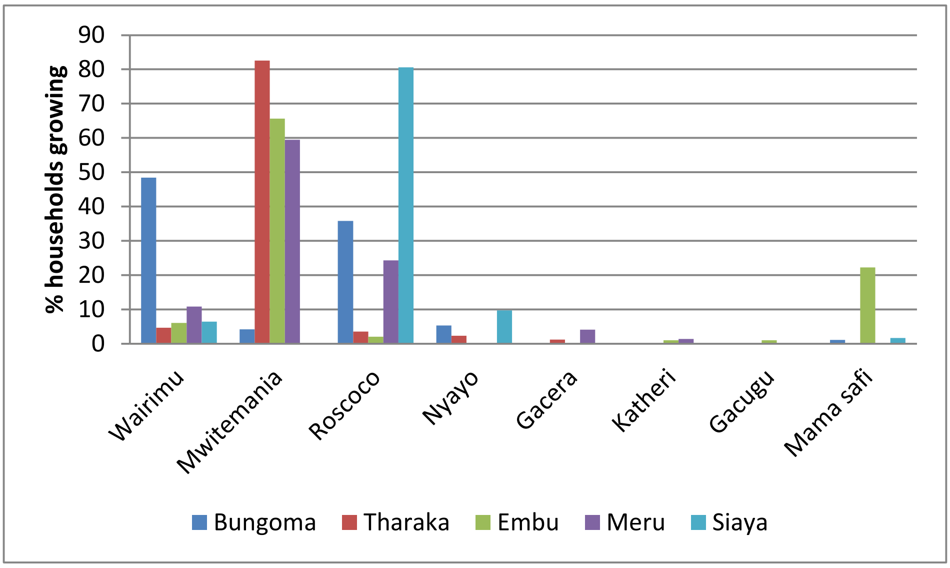

Figure 4.4: Main bean varieties grown across the counties

Analysis of beans varieties grown by gender reveal that Wairimu, Mwitemania, Gacera and Katheri were adopted more by male headed households while Rosecoco ,Nyayo,Gacugu and Mama Safi was popular in female headed households (Figure 4.5).

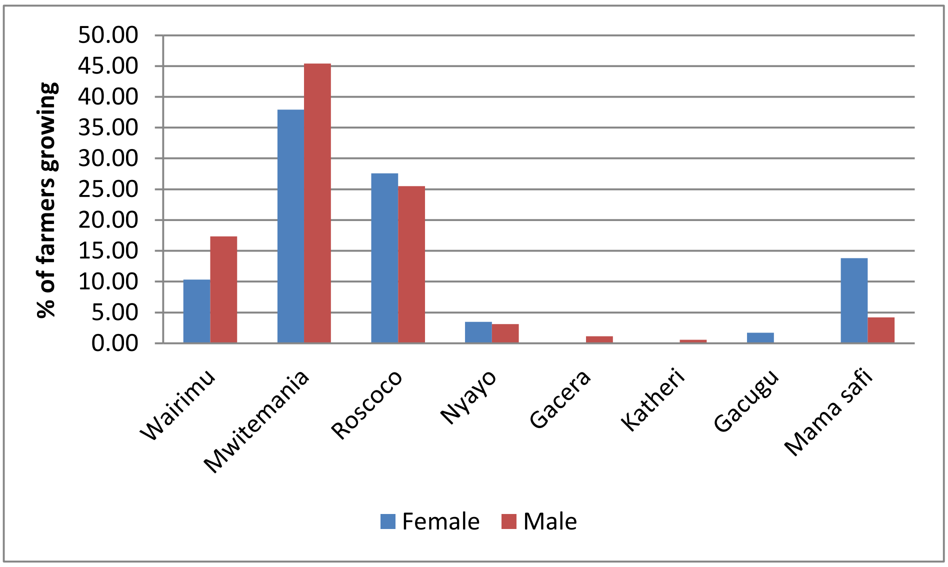

Figure 4: Main bean varieties grown by gender of household head%

4.6 Main source of information of beans varieties

Source of information on major on agricultural technology is an important aspect in it enhancing technology diffusion and uptake. The majority of the farmers in the five counties received information on bean varieties from neighbors and relatives (Figure 4.6). Surprisingly, major key institutions such as government extension, farmer groups, research organizations were mot been used by farmers to get accurate information on the available varieties

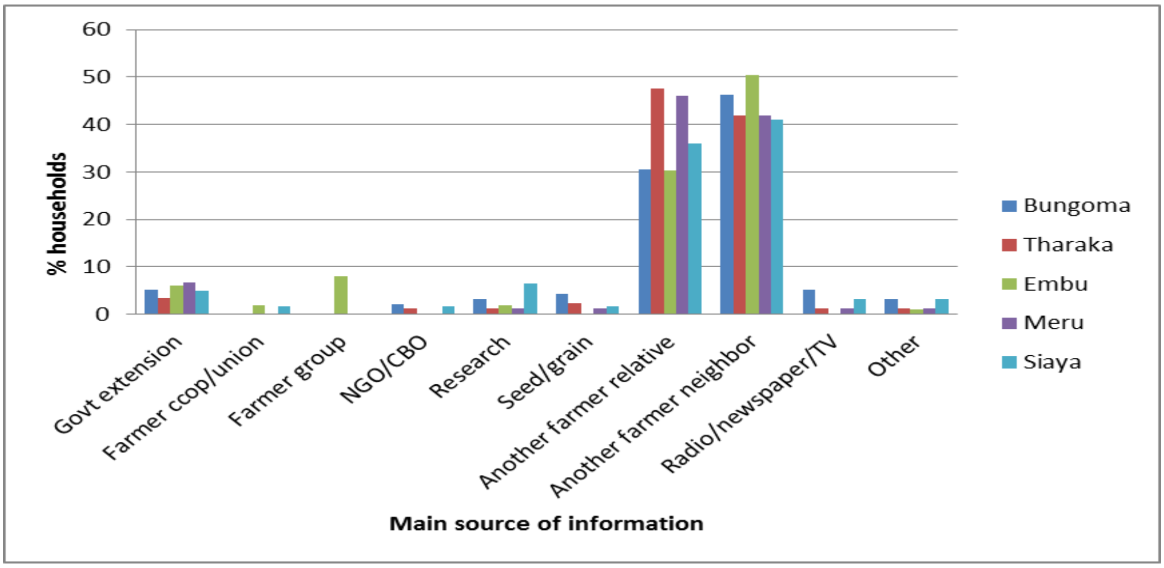

Figure 4.6: Main source of information of beans varieties

4.7 Main source of information of beans varieties by gender of household head (%households)

A further look at the households sources of information on bean varieties from a gendered perspective indicate that majority of the female headed household preferred accessing information from a neighboring farmer who is not a relative (Figure 4.7)

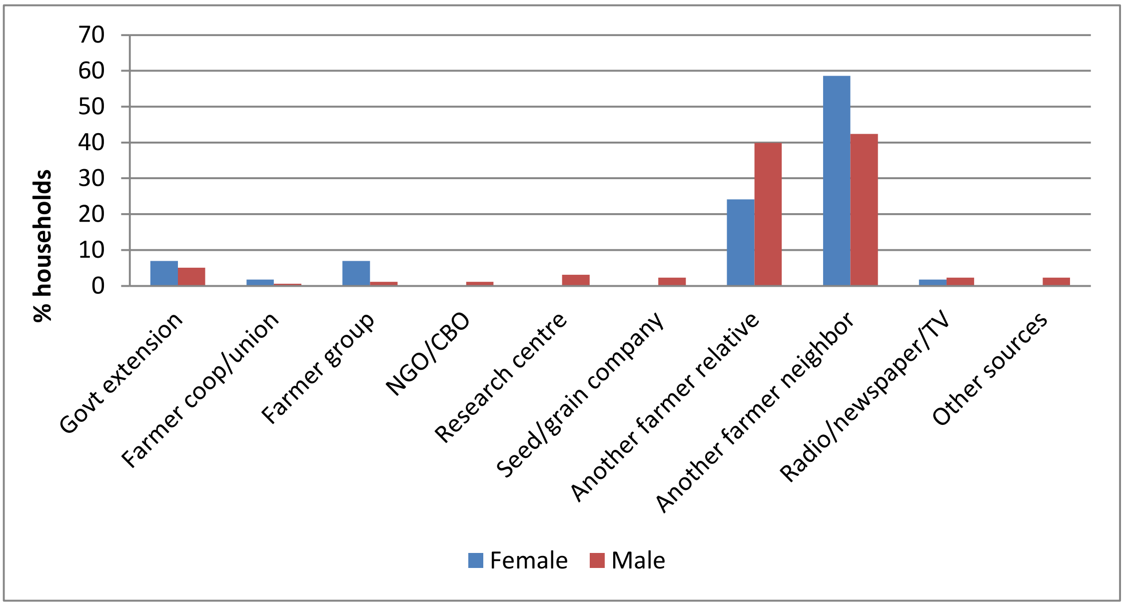

Figure 5: Main source of information of beans varieties

Similarly as in maize production, high fertilizer prices and availability are a major constraint highly ranked among the farmers sampled as a key issue in legume production (Figure 4.8). Constraints in output and input market were observed in 6% and 8% of the sampled farmers and were ranked between 6 and 7 in terms of concern to farmers with regard to other constraints. Availability of credit to buy fertilizers and improved legume seeds were also observed in 10% of the farmers. Timely availability of improved seed is a constraint to only 4% of the farmers sampled compared to 6% in maize production.

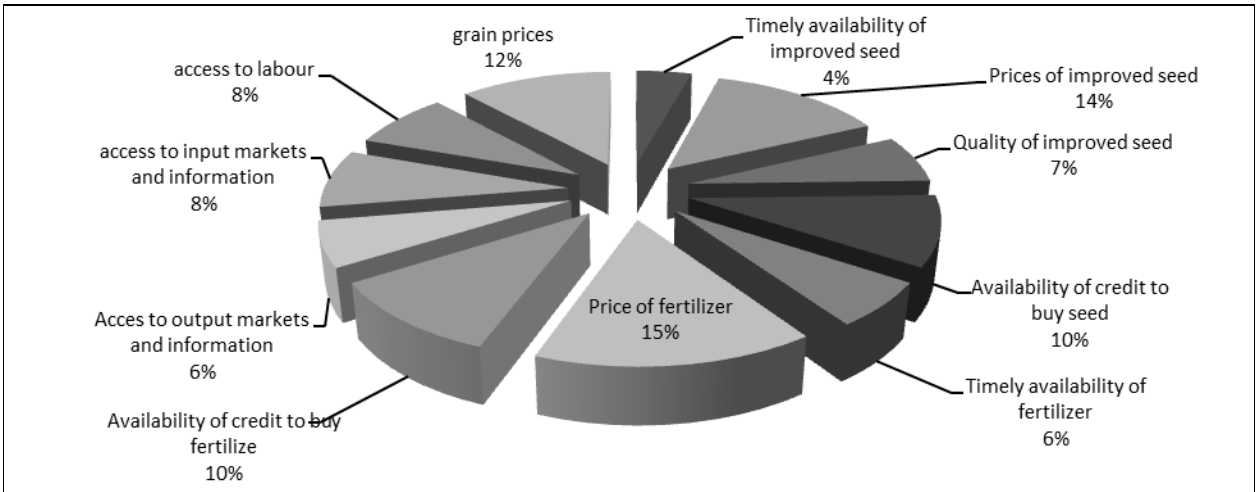

Figure 4.8: Constraints in accessing key inputs in legume production

CHAPTER FIVE: HOUSEHOLD WELFARE OUTCOME

5.1 Household food security

The subjective own assessment of household food security status was carried out during the survey at household level. The descriptive statistics showed that about59% of the surveyed household felt that they were food secure i.e. they had either food surplus or were at break-even (no shortage and no surplus). Specifically, about 14% of the surveyed households reported that they had food surplus while almost 45% were at the break-even point in terms of food security (Figure 5.1). On other hand, about 37% of the sampled households reported that they were having transitory food insecurity with almost 4% facing acute/chronic food insecurity.

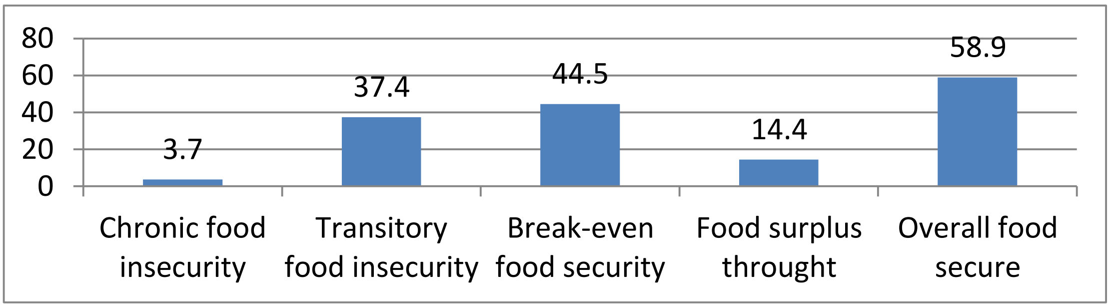

Figure 5.1 Household food security (% households

Across the five sampled counties, the descriptive statics of food security showed that eastern Kenya counties had the highest proportion of the households that were food secure compared to western Kenya counties (Table 5.1). The county with the highest proportion of the households that were food secure was Tharaka (almost 79%) while Bungoma County had the lowest proportion of the households that felt that they were food secure (41%). It is important to remember that these were own subjective assessments of food security by the main household respondents in the survey and should be interfered from that perspective.

Table 5.1 Household food security by county (% households)

Maize variety	Bungoma (N=137)	Tharaka (N=79)	Embu (N=96)	Meru (N=80)	Siaya (N=143)
Chronic food insecurity	5.8	1.3	4.2	2.5	3.5
Transitory food insecurity	53.3	20.3	30.2	27.5	42.0
Break-even food security	34.3	54.4	45.8	50.0	44.8
Food surplus throughout	6.6	24.1	19.8	20.0	9.8
Overall food secure	40.9	78.5	65.6	70.0	54.5

From a gender analysis perspective, the descriptive statistics of household food security showed that male headed households were generally more food secure than female headed households. About 60% of the male headed households were food secure compared to about 51% of the female headed households (Figure 5.2). Specifically, while a higher proportion of male headed households were food surplus and break-even, a higher proportion of female headed households were facing chronic and transitory food insecurities (Figure 5.2).

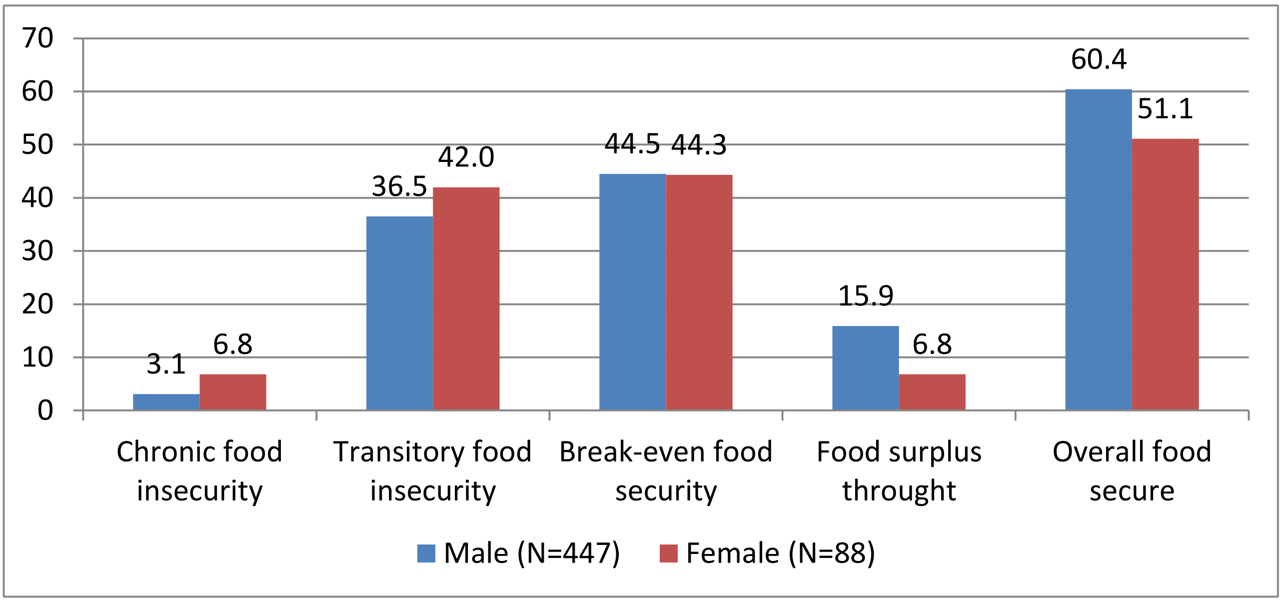

Figure 5.2 Household food security by gender of the household head (% households)

CHAPTER SIX: HOUSEHOLD INCOMES, RISKS AND LIVELIHOOD SHOCKS

6.1 Household incomes

Rural farm households derive incomes to support their livelihoods from various sources. Due to the risky environment in which they operate, they keep a portfolio of incomes ranging from farming (crop and or livestock) to other non-farm activities like wage earning engagements and business. Descriptive analysis was conducted first to ascertain the level of household incomes by Survey County and by gender of the household head. The overall average household annual income excluding income derived from livestock sales was about KSh. 156,000. The eastern Kenya counties of Embu, Meru and Tharaka had the highest level of average household income compared to western Kenya counties of Bungoma and Siaya (Figure 6.1). Embu County had the highest level of average annual household income at about KSh. 229,000 while Siaya district had the lowest average annual household income of about KSh. 106,000. Therefore the county with the highest average annual household income (Embu) had an average household average income that was more than twice that one of the lowest county (Siaya).

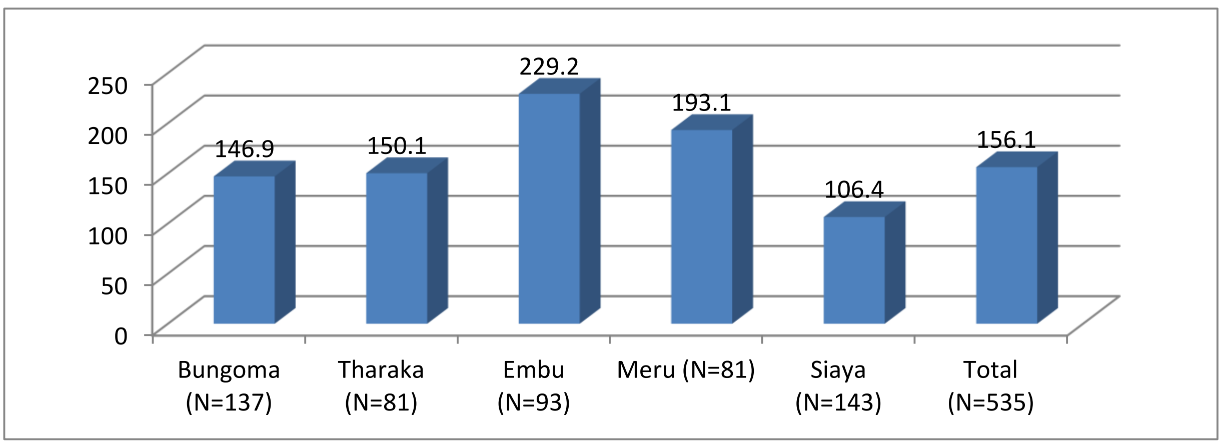

Figure 6.1 Total household income excluding livestock (1,000 KSh)

Male headed households on the other had had a higher level of average household annual income compared to female headed households. Whereas female headed households had an average annual household income of about KSh. 94,000, male headed household had an average of about KSh. 170,000 (Figure 6.2). This means that male headed households had an income that was about twice that of female headed households. The implication of such huge income disparities between male headed and female headed households is that the former are greatly disadvantaged in access key resources to improve their livelihoods. These livelihood improving resources include agricultural productivity inputs like purchased improved seed and fertilizer as seed in the preceding sections of this report.

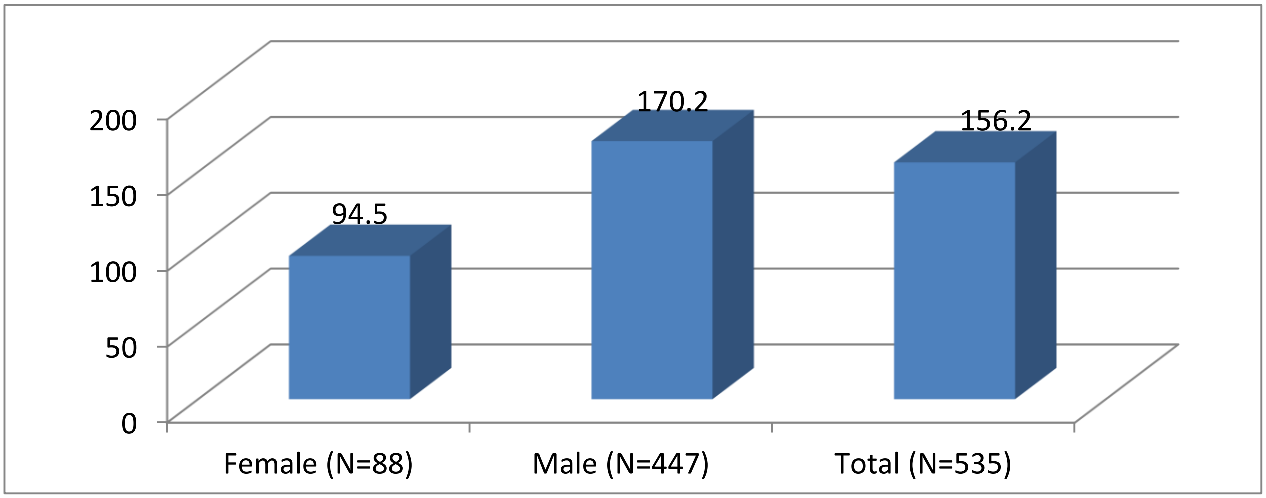

Figure 6.2 Household incomes by gender of the household head (1,000 KSh)

Further analysis to gain more insight on the importance of different income portfolios in household income was carried out. The results showed that overall, crop income accounted for the largest share in in total household annual income among the surveyed households followed by self-employment. About 40% of the total annual household income was from crops and 22% was from self-employment (Figure 6.3). These results clearly indicate that crop enterprises among the surveyed smallholder farmers are of great importance in their livelihoods. Therefore, interventions aimed at improving on-farm productivity of crops are likely to go a long way in reducing poverty and food insecurity among the rural farming communities in Kenya.

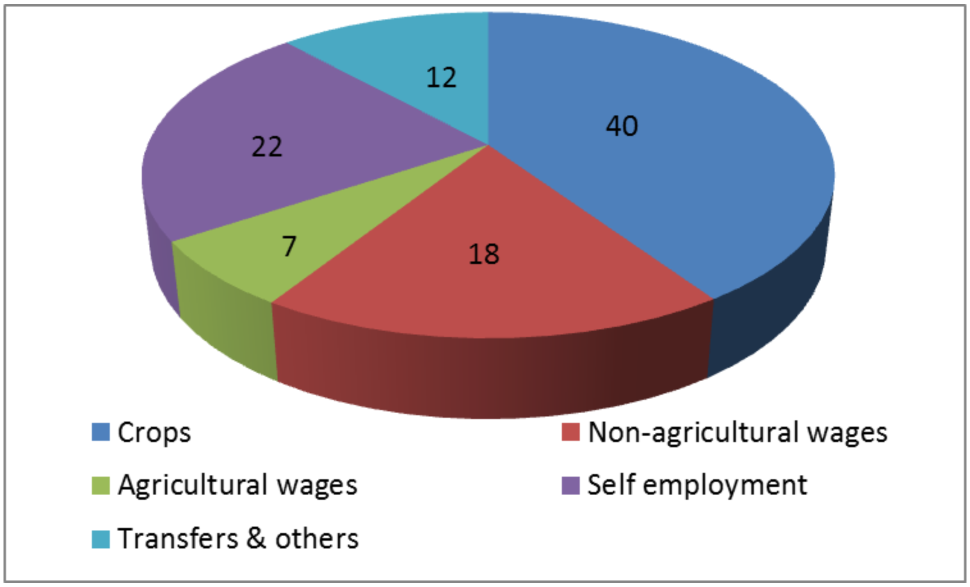

Figure 6.3 Household income shares (% share in total annual income)

Crop income still accounted for the highest proportion of total annual household incomes in all the five surveyed counties. It was particularly important in Embu County where almost 70% of the total household annual income was derived from crops (Table 6.1). On the other hand, Siaya County had the lowest proportion of crop income in total annual household income at just 22%. Generally, a comparison across the five districts reveals that crop income is more important in the household incomes of the eastern Kenya households compared to western Kenya (Table 6.1). Western Kenya households had the highest contribution on income from self-employment and transfers compared to eastern Kenya households. It is also worth noting that higher proportions of household incomes coming from transfers among the western Kenya households could be a pointer to the fact that there is high dependence ration of western Kenya households on incomes from those household members who have out-migrated in search of better opportunities elsewhere. The low contribution of crop income in household income among Siaya households could also be an indicator that the agro-ecological zones in this county are not favorable for crop farming/production compared to the other sampled counties.

Table 6.1 Household income sources by county (% share in total income)

Source	Bungoma (N=137)	Tharaka (N=81)	Embu (N=93)	Meru (N=81)	Siaya (N=143)	Total (N=535)
Crops	29	49	69	48	22	40
Non-agricultural wages	25	19	9	19	16	18
Agricultural wages	6	13	5	5	5	7

Self-employment	25	12	11	20	33	22
Transfers & others	13	6	4	4	22	12

Gender analysis of the income shares of different sources revealed that male headed households derived a higher proportion of their income from crops compared to female headed households i.e. about 42% of the male headed households'' income was from crops compared to 32% for women headed households (Figure 6.4). Several reasons could be at play in explaining why male headed households had a higher proportion of their income coming from crops than female headed households. These reasons could include but not limited to accessibility to crop production assets like land and other productivity enhancing inputs like improved seed and fertilizer. Female headed household could be disadvantaged in accessing these assets. Male headed households also had a higher proportion of income derived from agricultural wages, self-employment and transfers compared to that of female headed households (Figure 6.4). It is also worth noting that female headed households had a higher proportion of income coming from non-agricultural wages than male headed households.

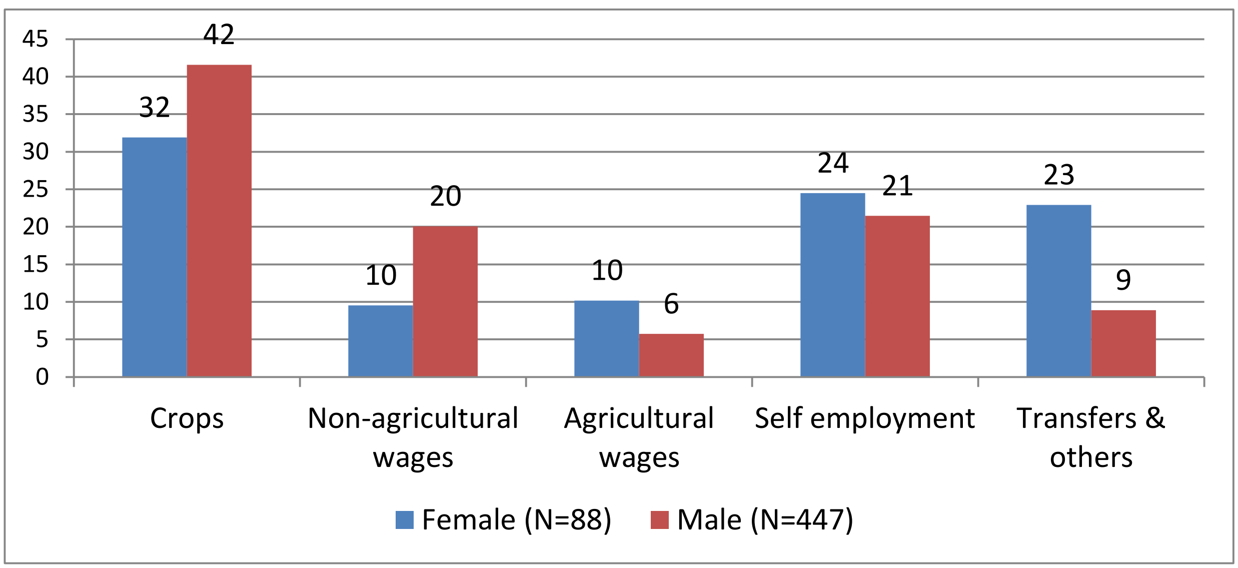

Figure 6.4 Household income shares by gender of the household head (% shares in total income)

6.2 Household risks and livelihood shocks

The frequency of shocks as reported by the sample farmers across gender are reported in Figures 6.5 – 6.13. With regard to drought in the past ten years most female headed household were affected two times more male headed households and this difference was statistically significant. High incidences of hailstorms were recorded in Bungoma and Siaya counties. The incidence in most cases occurred once in the past ten years.

High incidences of pests and diseases were recorded in Bungoma and Siaya counties. Pests and diseases in most cases affected households once in the past ten years. High incidences of too much rains and floods were recorded in Tharaka Nithi and Siaya counties. Too much rains and floods in most cases affected households once in the past ten years. High incidences of drought were recorded in Tharaka Nithi, Embu and Meru counties. Drought in most cases affected households once in the past ten years but for those households in siaya the frequency of occurrence for drought was more than to times.

Frequency of increase in food prices (past five years) by gender of the household head is presented in Figure 6.11. High incidences of increase in food prices were recorded in Bungoma County. Increase in food prices in most cases affected households once in the past ten years in Embu and Meru while Tharaka Nithi and Siaya recorded more than two times.

Frequency of increase in input prices (past five years) by gender of the household head is presented in Figure 6.12. Increase in input prices in most cases affected households once in the past five years in with exemption of siaya recorded more than two times. Frequency of decrease in output prices (past five years) by gender of the household head is presented in Figure 6.13. Risk of decrease in output prices was higher in Tharaka Nithi, Embu and Meru and low in Siaya and Bungoma counties.

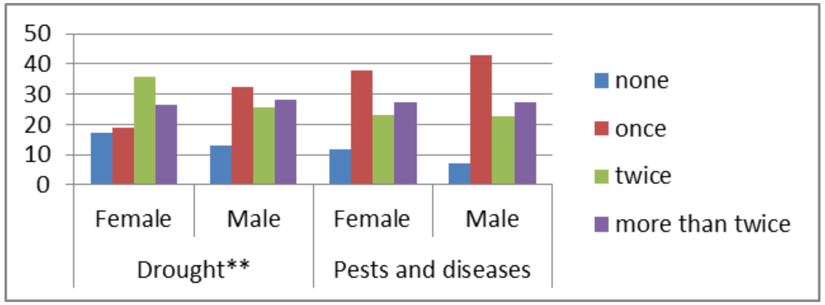

Figure 6.5: Frequency of drought (past ten years) and crop pest/disease (five years) by gender of the household head

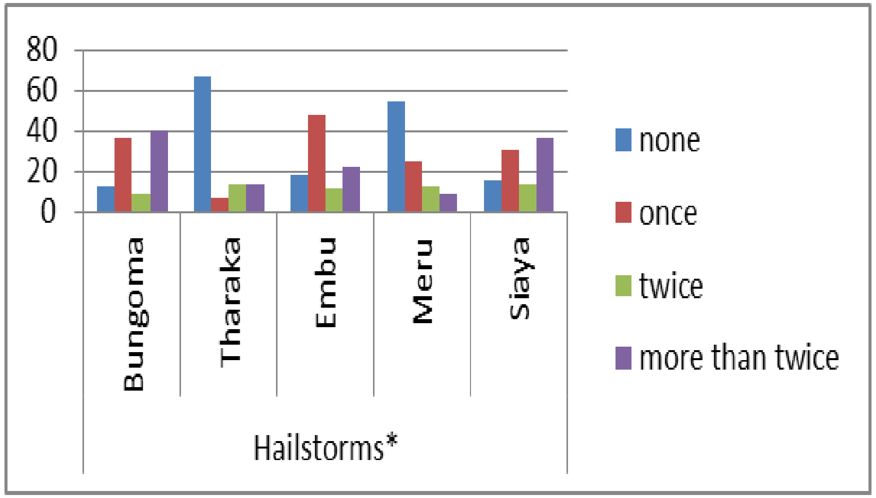

Figure 6.8: Frequency of hailstorm (past ten years) across study area counties

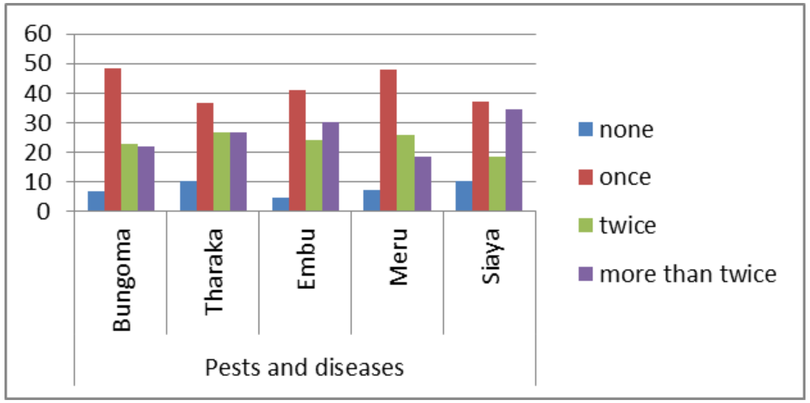

Figure 6.7: Frequency of pest and diseases (past ten years) across study area counties

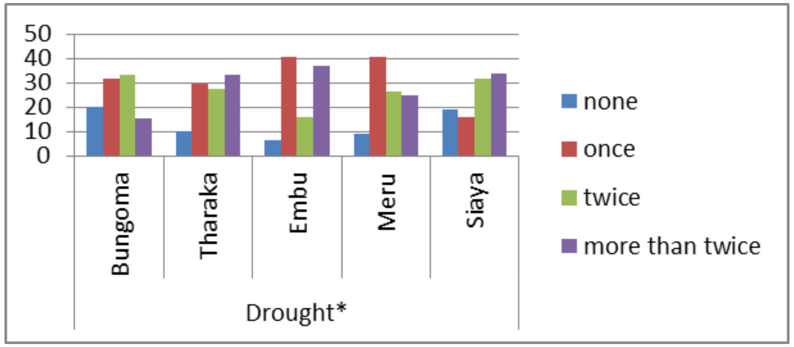

Figure 6.10: Frequency of drought (past ten years) across study area counties

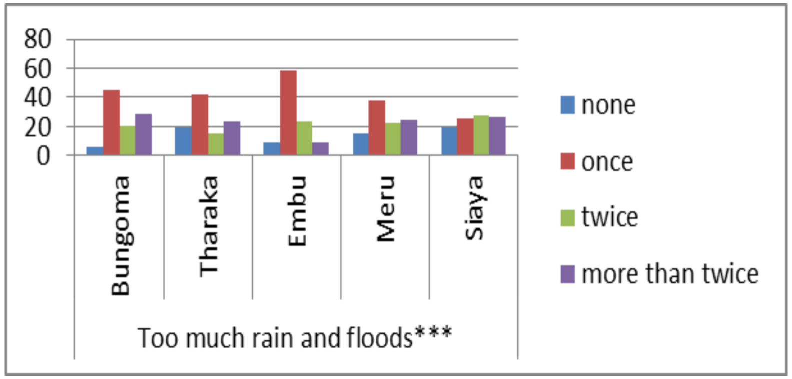

Figure 6.9: Frequency of too much rains and floods (past ten years) across study area counties

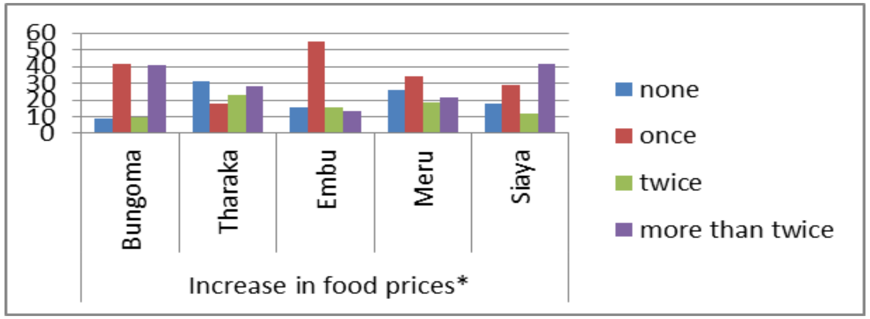

Figure 6.12: Frequency of increase in food prices (past five years) across study area counties

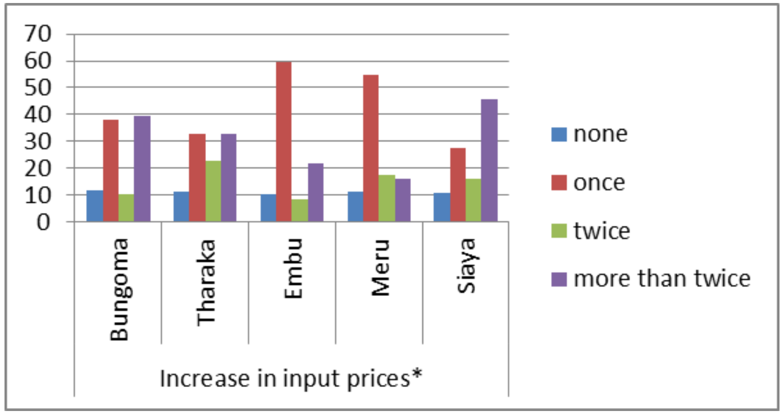

Figure 6.11: Frequency of increase in input prices (past five years) across study area counties

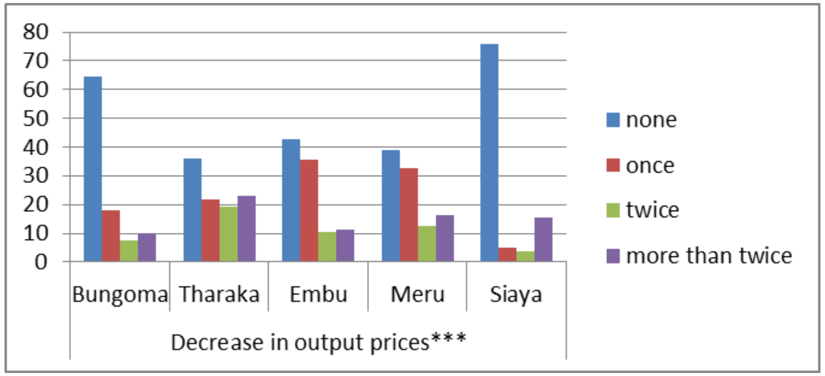

Figure 6.13: Frequency of decrease in output prices (past five years) across study area counties

Percent reduction of main crop production and overall incomes due to risks across counties are given in Figure 6.14 (refer figure below) . The results suggest that percent reduction of either main crop production or overall household income by drought is generally higher. Percent reduction on crop yields due to drought is highest in Embu and Bungoma and on income is highest in Tharaka Nithi and Embu. Hailstorms highly reduced crop yields in Tharaka Nithi.

Percent reduction of main crop production and overall incomes due to risks across according to the gender of the household head is presented in Figure 6.15 (refer figure below). The results indicate that percent reduction of either main crop production or overall household income as a result of risks is higher in female headed households. Percent reduction on crop yields and income due to drought is higher.

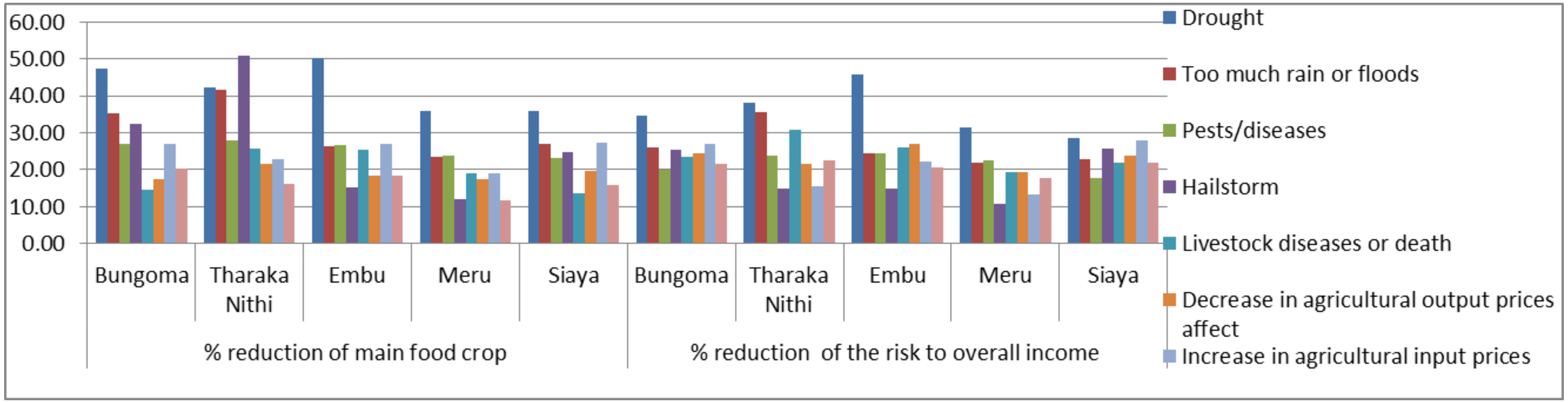

Figure 6: percent reduction of main crop production and overall incomes due to risks across counties

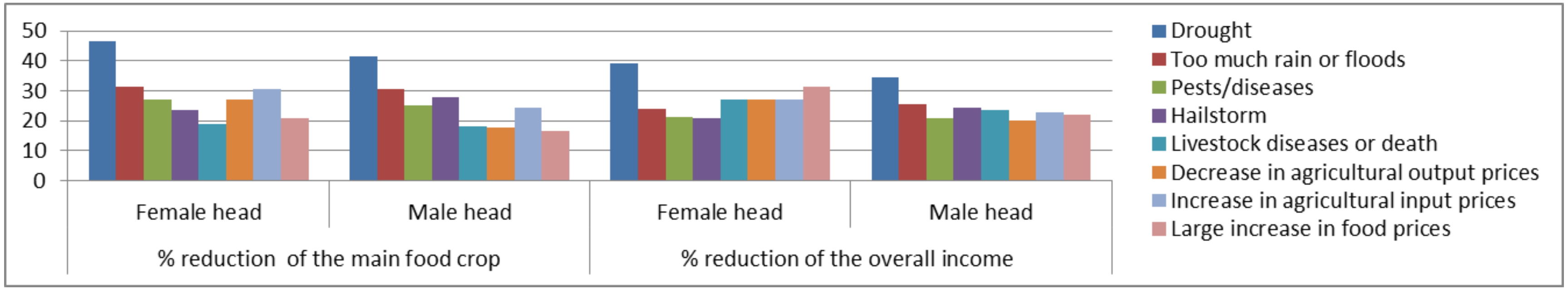

Figure 6.15: Percent reduction of main crop production and overall incomes due to risks by gender of the household head

CHAPTER SEVEN: HOUSEHOLD GENDER DIMENSIONS IN DECISION MAKING

7.1 Household decision making

Men own more assets than women but t-test results show no significant difference between the two. Women make significantly more decisions with regard to giving away assets. Men will keep majority of the assets in case of divorce. Decision to sell, mortgage or regarding new purchase was insignificantly different as shown in Table 7.1.

Table 7.1: Decision making by gender

	Gender	Observations	Mean	*t*
Ownership of most assets	Female	2678	1.34(0.009)	-1.05
	Male	2485	1.36(0.009)	
Decision to sell	Female	2663	1.34(0.47)	-0.65
	Male	2410	1.35(0.48)	
Decision to give away	Female	2557	1.32(0.47)	-3.07***
	Male	2272	1.36(0.48)	
Decision to mortgage	Female	2673	1.35(0.47)	-1.56
	Male	2446	1.37(0.48)	
Keep majority in case of divorce	Female	1656	1.59(0.70)	6.41***
	Male	2073	1.43(0.71)	
Decision regarding new purchase	Female	2443	1.32(0.46)	-0.01
	Male	2173	1.32(0.46)	

Standard deviation in parenthesis

7.2 Decision making on credit use

Generally, most farmers in all the five counties received the amount of credit they need with the male farmers from Tharaka Nithi getting 100%. In Embu and Siaya counties more than 18% of the farmers did not received credit. Less than 10% of the famer's spouses do make decision on credit use across all the counties, with very few decision (less than 5%) in all the five counties made by other household members. Majority of the farmers in Siaya County make decision on credit use independently, which is contrary to Meru County with more than 60% of the farmers making decision on credit use jointly as spouses. More than 70% of the female farmers make decision on credit use jointly with their spouses in Meru and Tharaka Nithi County.

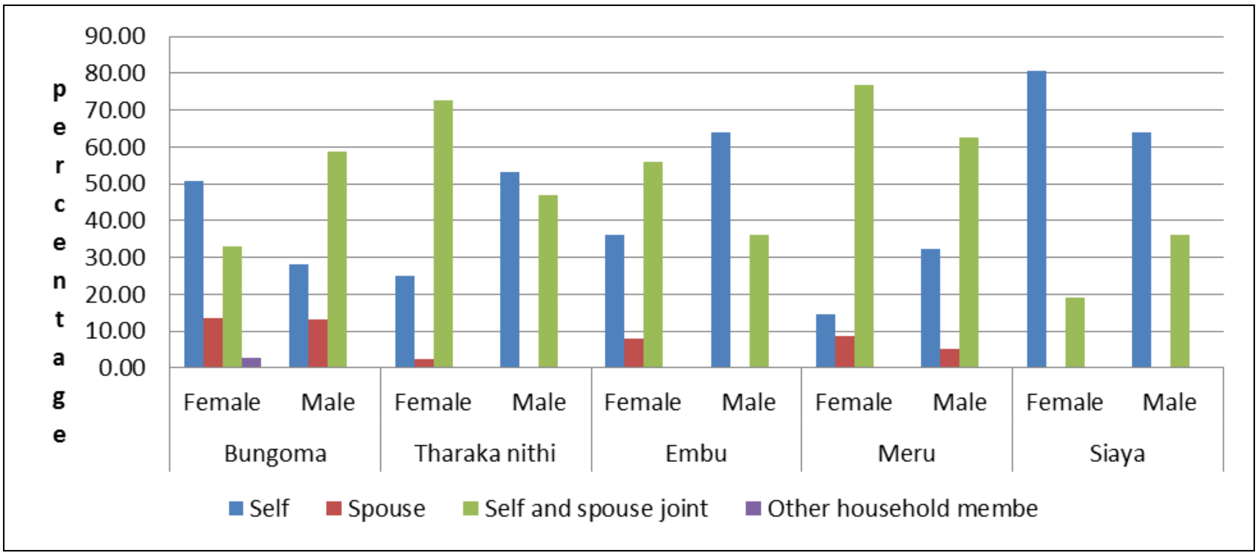

Figure 7.1: Decision making on credit use

The respondents made more decisions regarding saving on their own than they did it jointly. Female respondents in Bungoma, Embu and Meru counties, made more decisions on their own compared to male respondents (Figure 7.1).

7.3 Decision making on use of savings by county

Household decisions regarding the use of savings were more of jointly than self in Tharaka Nithi and Meru counties (Figure 7.2). The majority of the decisions in Siaya County were made by the respondents more than any other county. Very limited decisions on use of savings were made by the spouses in all counties sampled.

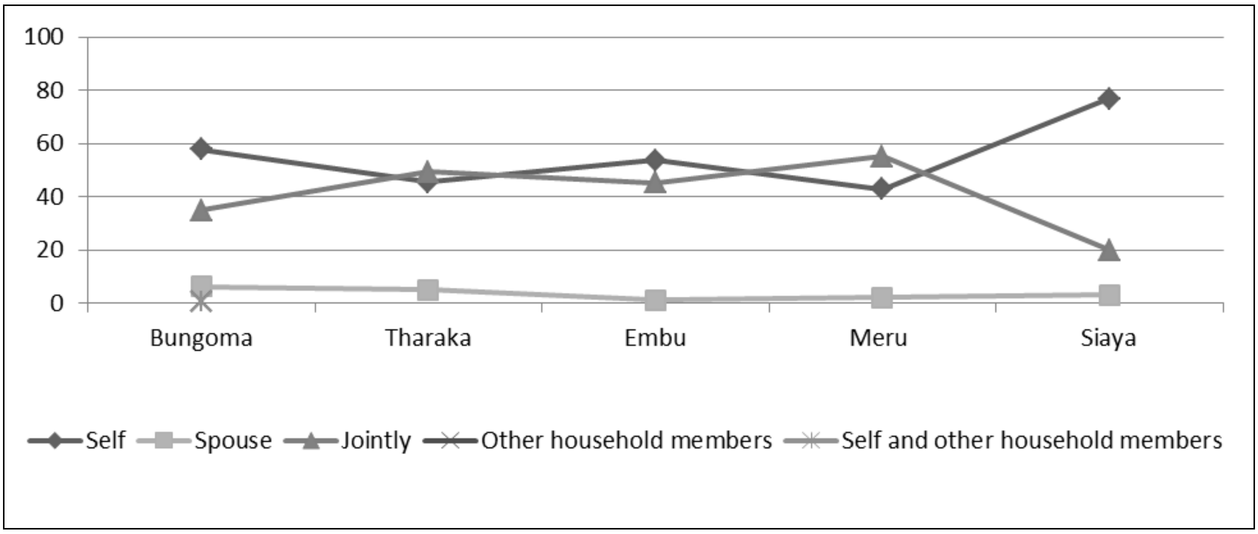

Figure 7.2: Decision making on use of savings by county

7.4 Household influence in community projects

Households influence developments projects by suggesting priory projects to be undertaken within their community. Generally, a participatory approach where stakeholders are involved is always desirable. Majority of the households had confidence in speaking publicly about what projects they want implemented in their respective counties (Figure 7.3). Households in Meru and Tharaka Nithi felt they were very comfortable as compared to Siaya and Bungoma Counties.

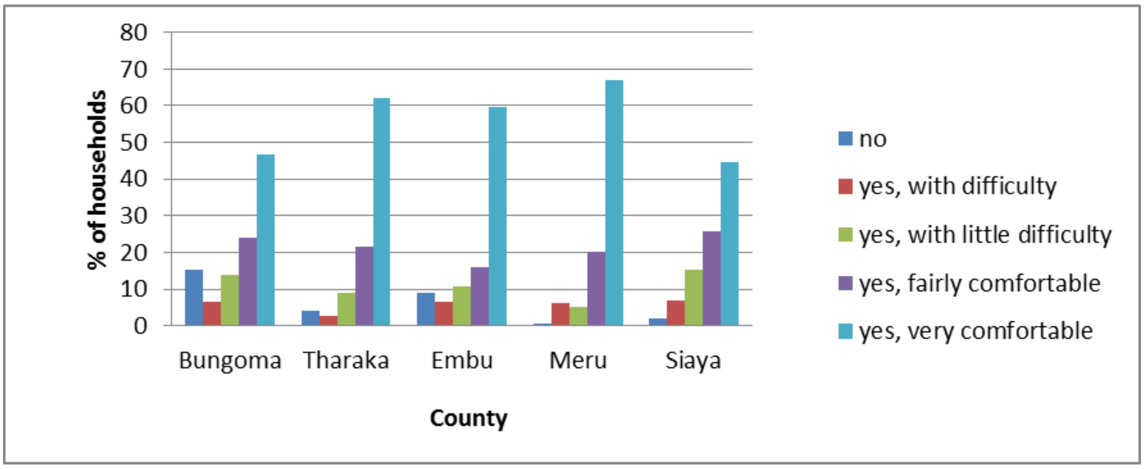

Figure 7.3: Household influence in community projects across counties

On the households' response on decisions concerning community projects from a gender perspective males were very comfortable speaking publicly as compared to women (Figure 7.4). A majority of the women felt there were able to speak though with some difficulty this can be attributed to the fact that in Kenya majority of the households' decisions are made by male.

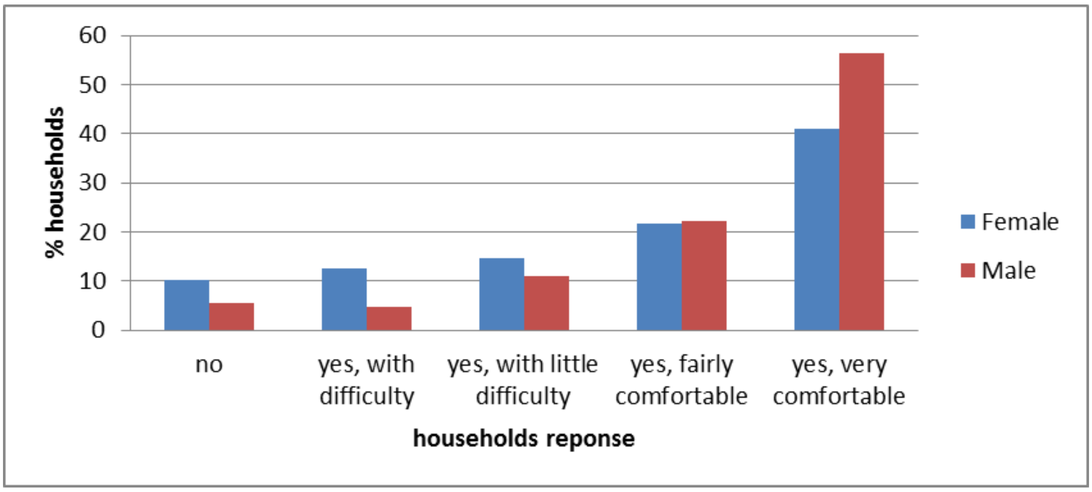

Figure 7.4: Household influence in community projects across counties

7.5 Household influence in community in respect to wages

Household's decision making with respect to decion on wages to be paid to laboures reveal that majority of of the hosuehold were very comfortable speaking in public (Figure 7.5).

Houseolds in Embu, Meru and Tharaka counties were more comfortable compared to siaya and bungoma counties

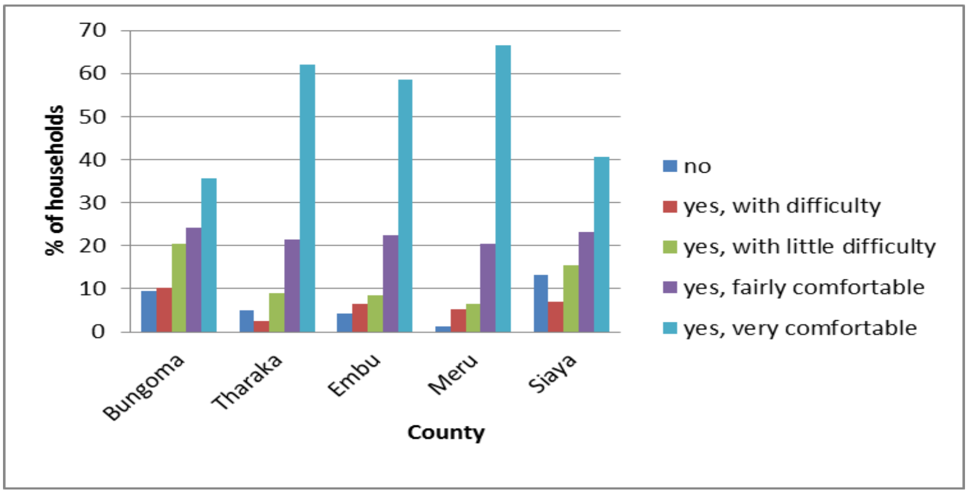

Figure 7.5: Household influence in community in respect to wages across counties

With regard to decisions on wages to be paid from a gender perspective results show that males were more comfortable speaking about it as compared to females in all the counties (Figure 7.6).

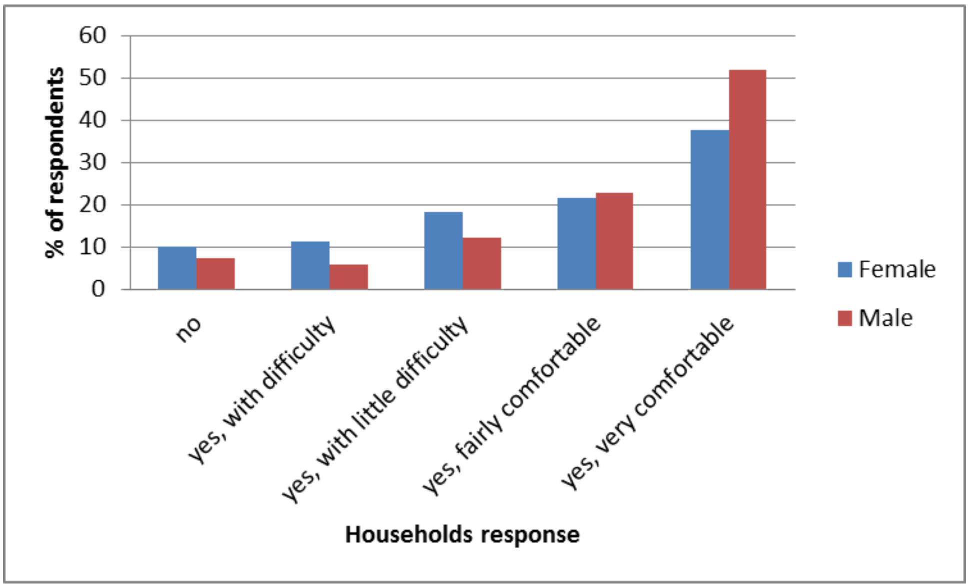

Figure 7.6: Household influence in community decisions regarding wages from a gender perspective

CHAPTER EIGHT: CONCLUSIONS AND POLICY IMPLICATIONS

Considering that agriculture is the main source of livelihoods for farmers and that the majority of decision makers on general agricultural production activities are males, yet the majority of those who report agriculture as the main primary occupation are females, it might be appropriate to generally design strategies that empower women on agricultural production decision making process. This would complement their dominant role on plot level decision making.

Education stock promotes intensified use of fertilizer, pesticide and manure use, but it is negatively associated with herbicide, minimum tillage, soil and water conservation, and legume-crop rotation use. Combining education stock for better management skills and enhanced advocacy for increases in the uptake of SAI practices is likely to benefit the famers more in response climate and policy variability.

The majority of households own mobile phones, radio and bicycles. These assets can be meaningfully used in dissemination information on the importance of SAI practices by way of reducing transaction costs (arising out of search costs) in combination with mitigating the effects of high transport costs in input and output deliveries to sales makes (by way of use of bicycles). These are opportunities that can be explored and exploited in outscaling the uptake of SAI practices.

There is gender disparity regarding decisions on assert use and disposal with respect giving asset away which favours women whereas the decision to keep assets in case of divorce is entirely male-dominated. This suggest that women are more philanthropic in their association with assets while men are more disposed to economic empowerment. This unequal economic imbalance is likely to have implication on productivity – considering that women make dominate males on plot level decisions on agricultural activities that are undertaken thereof. There is a need therefore to equalize economic empowerment across gender and this is a policy question. Furthermore, livestock, mortgaging or selling, hiring out, keeping assets in case of divorce, and on new purchased is male dominated, which further disempowers women economically. The implication is that women are most unlikely to adopt packages, including SAI, that expenditure intensive.

Considering that a majority of households have memberships in merry-go-rounds and increasingly in farm-crop marketing groups, this type of social capital can be exploited in bridging information gaps on the benefits of SAI practices. Furthermore, they can be used as a vehicle of empowering women economically. This means that it is critical to promote and enhance the effectiveness of such groups particularly for enhancing the uptake of SAI practices.

The perception on soil fertility indicators and characteristics vary according to gender. Furthermore, males use relatively more improved maize seed varieties than females. This means that there is scope for improvements in the use of hybrid seeds. Moreover, it is apparent that improved OPVs are seldom adopted across counties. This provides an opportunity for their improved use, especially if it is confirmed that they are appropriate in mitigating low yield effects resulting from climate variability and downstream shocks.
It is apparent that the use of SAI practice in combination generates positive benefits on income and labor use. However, the intensity of use of these practices is determined by among others farm inputs, access to information and access and availability of credit. It is also evident that farmers in organized groups tend to adopt more of improved seed variety and fertilizer, while the elderly used more fertilizer and manure packages. It was also shown that those farmers with small land sizes use more than two SAI practices on their sub plots. All these factors provide avenues for policy intervention in favour of increasing the use SAI practices. In general the highest returns from farming are achieved when SAI practices are adopted in combination rather than in isolation, which implies also that farmers need to be encouraged to use a combination of these practices in order to maximize on the associated benefits.

There is strong evidence the quantity of labor required increase with the number of SAI practices adopted, yet considering the “abundance” of labour in the rural areas, this may be a panacea to rural agricultural employment with the intensified use of SAI practices. This is as long as they generate positive benefits and it is relatively clear that they are beneficial. The predominance of small sized land holding also seem to incentivize the uptake of SAI practices. Yet, these benefits are unlikely to be realized unless access to appropriate information through the extension service providers is not guaranteed. In particular, crop rotation and use of improved seed varieties seem to generate substantial returns to SAI technology investments followed by the use minimum tillage and soil and water conservation for maize and beans inter-crop. The latter appear to improve to lead to improved yield. These practices need to be promoted aggressively so that the farmers can adopt them.

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APPENDIX

Risk	% reduction of main food crop				
	Bungoma	Tharaka Nithi	Embu	Meru	Siaya
Drought	47.31	42.41	50.39	36.00	35.90
Too much rain or floods	35.22	41.71	26.31	23.51	27.07
Pests/diseases	26.95	28.00	26.58	23.73	23.29
Hailstorm	32.36	51.00	15.08	12.10	24.62
Livestock diseases or death	14.51	25.65	25.45	19.00	13.61
Decrease in agricultural output prices affect	17.33	21.55	18.28	17.30	19.56
Increase in agricultural input prices	26.85	22.81	26.98	19.11	27.34
Large increase in food prices	20.39	16.14	18.41	11.57	15.94
	% reduction as a result of risk to production of main food crop of the household			% reduction as a result of risk to overall income of the household	
Risk	Female	Male	χ^2	Female	Male
Drought	46.57868	41.54589	1.18	39.24528	34.5916

			37		
Too much rain or floods	31.14898	30.53855	0.163	24.06122	25.37302
Pests/diseases	27.15873	25.20013	0.6707	21.12281	20.75768
Hailstorm	23.51122	27.96649	-1.1249	20.925	24.15135
Livestock diseases or death	18.72973	18.16667	0.1467	26.89189	23.38857
Decrease in agricultural output prices	26.92593	17.68229	2.663***	27.06897	20
Increase in agricultural input prices	30.50685	24.31383	2.688***	27.13514	22.94072
Large increase in food prices	20.71429	16.42331	1.776*	31.14925	21.78886
	% reduction of the main food crop		% reduction of the overall income		
Risk	Female head	Male head	Female head	Male head	
Drought	46.57868	41.54589	39.2453	34.5916	
Too much rain or floods	31.14898	30.53855	24.0612	25.37302	
Pests/diseases	27.15873	25.20013	21.1228	20.75768	

Hailstorm	23.51122	27.96649	20.9 25	24.15135	
Livestock diseases or death	18.72973	18.16667	26.8 919	23.38857	
Decrease in agricultural output prices	26.92593	17.68229	27.0 69	20	
Increase in agricultural input prices	30.50685	24.31383	27.1 351	22.94072	
Large increase in food prices	20.71429	16.42331	31.1 493	21.78886	

Frequency in past ten years	Pests and diseases					
	Bungoma	Tharaka	Embu	Meru	Siaya	
none	6.666666667	10.20408163	4.545455	7.407407	10.08403	
once	48.57142857	36.73469388	40.90909	48.14815	36.97479	33.774
twice	22.85714286	26.53061224	24.24242	25.92593	18.48739	
more than twice	21.9047619	26.53061224	30.30303	18.51852	34.45378	
Frequency in past ten years	Hailstorms*					
	Bungoma	Tharaka	Embu	Meru	Siaya	
none	12.38938053	66.66666667	18.51852	54.16667	15.45455	
once	36.28318584	6.666666667	48.14815	25	30.90909	71.582*
twice	8.849557522	13.33333333	11.11111	12.5	13.63636	
more than twice	39.82300885	13.33333333	22.22222	8.333333	36.36364	

	Livestock diseases/ deaths		
Frequency in past five years	Female	Male	
none	54.0229885	57.0135747	
once	24.137931	23.9819005	2.8062
twice	8.04597701	9.2760181	
more than twice	13.7931034	9.72850679	
	Decrease in output prices		
Frequency in past five years	Female	Male	
none	65.5172414	53.5307517	
once	12.6436782	21.8678815	7.5444
twice	8.04597701	9.79498861	
more than twice	13.7931034	13.8952164	
	Increase in input price		
Frequency in past five years	Female	Male	
none	12.6436782	10.7865169	
once	37.9310345	41.3483146	12.1645
twice	10.3448276	15.2808989	
more than twice	36.7816092	30.3370787	
	Increase in food prices		
Frequency in past five years	Female	Male	
none	18.3908046	18.2844244	
once	34.4827586	35.8916479	5.6293
twice	14.9425287	14.6726862	
more than twice	32.183908	29.5711061	

Frequency in past ten years	Drought**		
	Female	Male	
none	17.1875	13.1147541	
once	18.75	32.4590164	18.587**
twice	35.9375	25.5737705	
more than twice	26.5625	28.1967213	
	Too much rains/ floods		
Frequency in past ten years	Female	Male	
none	15	11.6438356	
once	43.3333333	40.0684932	3.5921
twice	23.3333333	22.9452055	
more than twice	18.3333333	25.3424658	
	Pests and diseases		
Frequency in past ten years	Female	Male	
none	11.5942029	7.12074303	
once	37.6811594	43.0340557	3.442
twice	23.1884058	22.6006192	
more than twice	27.5362319	27.244582	
	Hailstorms		
Frequency in past ten years	Female	Male	
none	16	21.33891213	
once	40	31.38075314	5.0162
twice	10	11.71548117	
more than twice	34	35.56485356	