ADOPTION OF SOIL FERTILITY IMPROVING TECHNOLOGIES BY MALE AND FEMALE HEADED HOUSEHOLDS IN CENTRAL KENYA

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ABSTRACT

Understanding gender differentials in adoption of soil nutrient replenishment technologies is critical to their successful implementation by farmers. This study was conducted to examine gender differentials in choices of soil fertility management technologies adopted by male and female-headed households; and lastly, to investigate socio-economic, institutional, farm and demographic factors influencing their adoption. The results indicated gender differences in the choice of cattle manure and in organic fertilizer. A logistic regression model developed revealed that different factors influenced adoption at household level. In male-headed households, adoption was significantly and positively influenced by; number of cattle owned, access to credit, number of adults working on farm and farmer group membership. For female-headed households, adoption was positively influenced by area under cash crops, number of goats owned, number of adults working on farm, participation in project activities, and farmer group membership. Based on these findings, there is a clear need for strategies and policy to address gender disparities in adoption of soil improvement technologies in Central Kenya.

Key words: *adoption, choice, gender, soil, technologies*

INTRODUCTION

Africa South of the Sahara is the only remaining region of the world where per capita food production lags far behind that in other regions of the world. Africa's food insecurity is directly related to insufficient total food production. Depletion of soil fertility has been noted as the major biophysical cause of low per capita food production in Africa (Bationo *et al*., 2006).

In the Central Kenya, low soil fertility is a major constraint to food crop production and is caused by continuous cropping without adequate fertilizers and/or manure (Sanchez and Jama 2000). Among the most promising soil fertility replenishment practices introduced to solve this problem are animal manure, compost, in organic fertilizers and biomass transfer using nitrogen fixing tree fallows (Place *et al*., 2003). There is substantial literature based on cross-sectional analysis of adoption of these technologies in Kenya. However, there has been little accompanying exploration of the reasons for disadoption (i.e., abandonment after experimentation) of these techniques, especially over a period of many years. Gender of the household head has been found to influence adoption significantly (Marenya and Barrett 2007).

The criticality of gender issues in adoption of soil fertility improving innovations is increasingly gaining recognition and there is a strong call for its integration in development projects and programs (Moser and Barrett, 2006). This study thus sought to examine choices of soil fertility improvement technologies adopted by male and female-headed households and factors influencing their adoption.

MATERIALS AND METHODS

Study area

The study was carried in November 2006, in fourteen villages in Mukuuni location, Chuka division, Meru South district of Central Kenya. The area is located in Upper Midland 2 and 3 (UM2 and UM 3), a predominantly maize growing area, which is also referred to as a coffee agro-ecological zone (Jaetzold and Schmidt, 1983). The altitude is 1200-1600M above sea level with an annual mean temperature of 20^0 C, with annual rainfall varying between 1200 and 1400mm. The rainfall pattern is bimodal, falling in two seasons, with the long rains between March and June and short rains between October and December. The soils are mainly Humic Nitisols (Jaetzold and Schmidt, 1983). The farming system in the area is characterized by integration of both crops and animals. Maize is the main staple food, which is cultivated from season to season

Study design

As a result of soil fertility decline leading to low yields and food insecurity, a project was initiated by Kenyatta University in the area in 2002. One of the objectives of this project was to promote adoption of newly introduced soil fertility improvement technologies. The mother baby and participatory rural appraisal approaches were used. Demonstration trials were set up and the technologies were demonstrated to farmers during field days and village training workshops that were organized every growing season. The demonstration trials comprised soil fertility improvement technologies, such as; *Tithonia diversifolia, Calliandra calothyrsus, Leucaena trichandra*, and improved management of in organic fertilizers and cattle manure. The farmers then practiced the technologies as taught in the demo-trials in their farmers. By the time the study was conducted in November 2006, farmers had visited the demonstration plots eight times during the short and long rains seasons and 160 households had adopted at least one technology. For purposes of this study, an adopter was considered as a farmer who had been using one or more of the introduced technologies for the four years the project had been in existence.

Sample procedure and sample size

A sampling frame of all 350 households in the area was obtained from the provincial administration office, and availed by the area chief. Ninety of the households were female-headed households while 260 were male-headed households. From these records, 160 households had adopted at least one of the technologies by the time the study was conducted. Of these, 108 and 52 male and female-headed households had adopted at least one technology respectively. A sample size of 140 households was used, 70 of whom were adopters and another 70 non-adopters. This was further stratified into 35 were male-headed households and 35 female-headed households for both adopters and non-adopters. For purposes of this study, selected female-headed households were *de jure* in nature, where the headship was by a single, divorced, separated or widowed female. Male-headed households were sampled by use of simple random sampling while female-headed households were purposively sampled because they were fewer in number.

Data collection

This study was a household survey. Data was collected from both primary and secondary sources. Primary sources were semi-structured interview schedules, which were self-administered. Secondary sources comprised journals, newsletters and articles on the topic of research.

Data analysis procedures

The data collected was analyzed using the Statistical Package for social scientists (SPSS). Descriptive statistics such as frequencies, means and tables were applied. Chi-square tests at ($p<0.05$) were run to determine choices of technologies adopted by male and female headed households. The logistic regression model was also run to determine variables that significantly influenced adoption by male and female-headed households.

The logistic regression model

The logistic regression model was used to analyze the gender differences in factors influencing adoption of soil nutrient replenishment technologies in order to have a predictive understanding of adoption patterns in the region. The logistic regression model is a non-linear regression model that has a binary response variable. It represents the probability of the number of events being successful. It is an index reflecting the combined effects factors that predict adoption. According to Pampel, (2000), the model equation is as: Logit (E □Y□) = Logit (P) =X^T □

Where:

Logit (E □Y□) = is the binary response/independent variable

Logit (P) = the natural log of the odds of success

X^T = the explanatory/dependent variables

□ = is the regression co-efficient

The dependent variable was a dichotomous variable depicting adoption of a technology and took the value of 1 if the farmer had adopted at least one technology and 0 if none. The independent variables included demographic, socio-economic, farm characteristics and institutional factors. The hypothesized effects of these factors on adoption are as shown in the following table.

Table 1: Hypothesized results of variables under study

Variable	Description	Type	Hypothesis
Demographic Factors			
HHSIZE	House hold size	Continuous	Positive
ADULT	No. of adults working on farm	Continuous	Positive
AGE	Age of household head	Continuous	Positive/ Negative
Farm Characteristics			
FARM SIZE	Farm size in hectares	Continuous	Positive
FOOD	Area under food crops	Continuous	Positive
CASH	Area under cash crops	Continuous	Positive
CATTLE	Number of cattle owned	Continuous	Positive
GOATS	Number of goats owned	Continuous	Positive
SHEEP	Number of sheep owned	Continuous	Positive

Socio-economic Factors			
EDU	No. of years spent in school	Continuous	Positive
PART	Participation in project activities	Categorical	Positive
PERCEPT	Perception of soil fertility problem	Categorical	Positive
EMPLOYMENT	Off farm employment	Categorical	Positive
Institutional Factors			
CREDIT	Access to credit	Categorical	Positive
EXTENSION	Access to extension services	Categorical	Positive
GROUP	Group membership	Categorical	Positive

RESULTS AND DISCUSSION

Choices of technologies for adoption disaggregated by gender

The findings indicated significant gender differences in the adoption of cattle manure and in organic fertilizer. Adoption of cattle manure and inorganic fertilizers was higher among male-headed households in comparison to female-headed households (Table 2). These results are corroborated in a study by Place *et al* (2003), who reported women's lack of animal and pastureland limit their access to manure, and although organic fertilizer is important for maize in addition to inorganic fertilizer, women can rarely use it as they lacked animals as well as cash to procure it**.** However, no significant gender differences were found in adoption of *Tithonia diversifolia, Calliandra calothyrsus and Leucaena trichandra*.

Table 2: Choices of soil nutrient replenishment technologies for adoption by farmers disaggregated by gender in Central Kenya as of April 2007

Technology adopted	MHHs (N=35)	FHHs (N=35)	Chi-square value
	Adopters (%)	Adopters (%)	
Cattle manure	**65.7**	**40**	**4.644****
Tithonia	**82.9**	**80**	**0.094 ns**
Leucaena	**22.9**	**17.1**	**0.357 ns**
Calliandra	**71.4**	**54.3**	**2.203 ns**
Inorganic fertilizer	**74.3**	**37.1**	**9.785*****

Note*: ns = not significant; * = significant at p<0.1; ** = significant at p<0.05; *** = significant at p<0.01= significance at p<0.01*

Table 3: T-test results of farmers' characteristics disaggregated by gender in Central Kenya as of April 2007

	Male headed households (N=70)			**Female headed households (N=70)**		
Variables	**Non-adopters**	**Adopters**		**Non-adopters**	**Adopters**	
	Mean		**t-statistic**	**Mean**		**t-statistic**
Farm size (hectares)	2.6	3.3	2.9 **	1.9	2.0	0.9 ns
Land under food crops	1.3	1.6	1.5 ns	1.0	1.3	1.4 ns
Land under cash crops	0.5	0.6	1.6 ns	0.1	0.3	3.2 ***
Age	45.2	46.9	0.7 ns	47.5	47.1	1.5 ns
Household size	3.3	4.9	4.2 ***	3.5	3.2	1.2 ns
Number adults	1.9	2.7	4.9 ***	1.2	1.7	4.1 ***
Number of cattle	2.8	4.1	4.5 ***	1.9	2.2	1.5 ns

Number of goats	9.3	10.9	1.4 ns	4.1	5.9	2.7 ***
Number of sheep	1.6	1.7	0.3 ns	1.1	1.4	1.1 ns

***Legend**: NS= not significant; * = significant at p<0.1; ** = significant at p<0.05;*
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Analysis of sample characteristics

Results revealed gender differences in demographic, farm, socio-economic, and institutional characteristics between adopters and non-adopters as shown in table 2 and 3. In male-headed households, factors that were found to be significantly influencing adoption were farm size, household size, number of cattle owned, number of adults working on farm, group membership and participation in project activities. In female-headed households significant factors were land under cash crops, number of adults working on farm, number of goats owned, participation in project activities and group membership.

Table 4: Chi-square test results of farmers' characteristics disaggregated by gender in Central Kenya as of April 2007

	Male headed households (N=70)			**Female headed households (N=70)**		
Variables	**% of Farmers**		**χ^2 value**	**% of Farmers**		**χ^2 value**
	Adopters	**Non-adopters**		**Adopters**	**Non-adopters**	
Labour availability	77.1	68.6	0.65 ns	71.4	68.6	0.07 ns
Soil fertility problem	82.9	88.6	0.07 ns	71.4	74.3	0.40 ns
Control of land	94.3	91.4	0.40 ns	85.7	88.6	0.13 ns
Participation	51.4	77.1	5.04 **	42.9	77.1	8.57 ***
Education	97.1	100	0.51 ns	77.1	80	0.70 ns
Off farm employment	22.9	31.4	0.35 ns	20	25.7	0.32 ns
Extension services	82.9	82.9	0.10 ns	71.4	74.3	0.28 ns
Access to credit	17.1	57.1	9.13 ***	20	37.1	2.52 ns
Group membership	74.3	22.9	18.53 ***	31.4	71.4	20.70 ***

Legend: *NS= not significant; * = significant at p<0.1; ** = significant at p<0.05;*
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Logistic regression results of factors influencing adoption in female-headed households

The logistic regression model was significant at p<0.05 and correctly predicted 84.3 % for both adopter and non-adopter female headed households. This implies that the model predicted 84.3% of the total variations in adoption of soil nutrient replenishment technologies and was therefore very reliable (Table 5). The Exponential beta (**β**) or odds ratio indicated the proportion with which adoption could occur, while the beta (**β**) sign predicted whether the variable influenced adoption decisions positively (+) or negatively (-). The results indicate that adoption by female-headed households was significantly influenced by the number of goats owned, membership in a group, area under cash crops, participation in project activities and the number of adults working on the farm.

Table 5: Logistic regression parameter estimates for female-headed households.

Variables	β	S.E	Wald	P-value	Exp (β)
Number of adults	2.67	0.83	10.19	0.001	14.25
Group membership	2.12	0.79	7.26	0.007	8.30
Number of goats	0.32	0.15	4.67	0.031	1.37
Land under cash crops	3.14	1.68	3.49	0.062	23.16
Participation	1.45	0.721	4.03	0.045	4.25
Constant	-7.94	2.01	15.62	0.000	0.000

Key: β (odds ratio); S.E: (standard error); Exp (**β**): (exponential beta); Wald: wald statistic; df: degree of freedom
Source: field data results

The number of goats owned influenced adoption positively. The model predicted that a unit increase in the number of goats owned by a female household head was likely to increase adoption of soil nutrient replenishment technologies. This may have been so because most female household heads could not afford cattle and mainly fed their legume technologies to goats. A farmer's membership into a group increased the chances of adoption. The more farmer's that joined groups, the higher the possibility of taking up technologies. This may have been because farmers were able to access legume seedlings and receive adequate training and skills in groups. Farmers with larger areas of land under cash crops were more likely to adopt than those with smaller areas.

Indeed, a unit increase in the area of land under cash crops significantly affected adoption. Farmers' participation in project activities significantly and positively influenced adoption. This was attributed to the fact that through participation, farmers became aware of the technologies, were trained and could visit demonstration plots to learn more. An increase in the number of adults working on the farm had a resultant increase in adoption. This was because most households in the area relied on family labour and with the free primary education initiative by the government; labour from children was unreliable as more children enrolled in schools.

Logistic regression results of factors influencing adoption in male-headed households

The logistic model estimate was significant $p<0.05$ and correctly predicted at 90% for both adopter and non-adopter male headed households, suggesting that the model's precision in prediction was very high, at 90% and was thus dependable. The results revealed that number of adults working on farm, access to credit, member in a farmer's group and number of cattle owned significantly and positively influenced adoption (Table 6).

Table 6: Logistic regression parameter estimates for male-headed household

Variables	β	S.E.	Wald	P-Value	Exp (β)
Number of adults	**2.10**	**0.75**	**7.78**	**0.005**	**8.19**
Access to credit	**2.48**	**1.10**	**5.06**	**0.024**	**11.88**
Membership in group	**3.11**	**1.08**	**8.35**	**0.004**	**22.36**
Number of cattle	**1.32**	**0.44**	**9.18**	**0.002**	**3.75**
Farm size in hectares	**0.31**	**0.44**	**0.49**	**0.485**	**1.36**
Participation in project activities	**1.38**	**1.01**	**1.91**	**0.167**	**4.01**
Constant	**-13.34**	**3.42**	**15.21**	**0.000**	**0.000**

Key: β (odds ratio); S.E: (standard error); Exp (**β**): (exponential beta); Wald: wald statistic; df: degree of freedom
Source: field data results

A unit increase in the number of adults working on farm was found to increase adoption. This may have been due to the fact that most households in the area mainly relied on family labour, which was readily available and cheap. Farmers who accessed credit were more likely to adopt than those who did not. This was because financial access translated to access to purchasable inputs, including hired labour. A farmer's membership into a group was a motivation for adoption. A unit increase in group membership was found to possibly increase the adoption significantly. The reasons for this may have been that farmers who were group members could access legume seedlings, receive training and short loans with which they could purchase inputs. Farmers who owned more cattle were likely adopters in comparison to those who did not own as many. The explanation for this was that cattle ownership was a sign of wealth and thus well-to-do farmers could also afford to buy other farm inputs and also hire labour.

CONCLUSIONS AND RECOMMENDATIONS

This study affirms the need for gender consideration in adoption of soil nutrient replenishment technologies. The choices of technologies for adoption were differentiated by gender, with female-headed household adopting fewer technologies than male-headed households. Significant gender differences were observed in the choices of cattle manure and in organic fertilizers for adoption, with female-headed households using these technologies at lower numbers in comparison to male-headed households.

Factors significantly influencing adoption in male-headed households were found to be access to credit, membership in a farmer's group, number of adult household members working on farm, and the number of cattle owned. Those that significantly influenced adoption in female-headed households were found to be participation in project activities, membership in a farmer's group, area of land under cash crops, number of goats owned, and the number of adult household members working on farm.

Based on these findings, future success in adoption of soil fertility replenishment technologies requires deliberate and pragmatic efforts from project implementers, farmers, policy makers, and extension agents. The results of this study indicate that adoption of cattle manure and inorganic fertilizers was lowest in female-headed households. Project implementers, researchers, development agents and the government ought to implement measures and strategies that will increase access to cattle manure and inorganic fertilizers by female-headed households especially in scenarios where this would prove profitable. As well, owing to the fact that this study has designed a predictive understanding of factors influencing adoption of soil nutrient replenishment technologies by male and female-headed households, this can be applied to predict adoption patterns in the study area and Central Kenya in general. Efforts geared towards strengthening these factors with a view to increasing adoption would be a plus for successful project implementation. Scientists also need to consider gender-targeted design of technologies so as to meet the needs of both male and female farmers and design technologies that would not unnecessarily overburden women. Future researchers interested in studying adoption patterns should also consider investigating gender differentials in adoption of soil nutrient replenishment technologies by *de facto* female-headed households, which was not investigated, in order to make comparisons with results obtained by this study.

Finally, policy makers, extension personnel, researchers and project implementers require sensitization on the need to be gender literate in order to ensure that male and female household needs are taken into account in policy making, design and dissemination of soil fertility replenishment technologies and in the formulation and implementation of soil and agriculture related projects.

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