Research Application Summary

Determinants of adoption and utilisation of integrated soil fertility management by small holders in Central Kenya

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Abstract

Per capita food production in Africa has been declining over the last two decades, contrary to global trends due to soil fertility decline. The study sought to determine factors that influence adoption and utilization of integrated soil fertility management (ISFM) technologies by smallholder farmers in central Kenya. Two hundred and forty (240) farmers were randomly sampled and data collected through face-to-face interviews. Data were subjected to binary logistic regression to determine factors that could explain adoption and utilization of the ISFM technologies. Results showed that in regard to combined organic and inorganic fertilizers utilisation, positive associations were detected with occupation, farming experience, perception of soil degradation, external assistance, off-farm income, perception of food and cash security, tropical livestock units, and house-hold size. The study concludes that there is need to examine the critical role that socio-economic variables contribute in the farming system during the development of ISFM.

Key words: Kenya, socio-economic factor, soil improvement technologies, tithonia

Résumé

La production alimentaire par habitant en Afrique a diminué au cours de deux dernières décennies, contrairement aux tendances mondiales, suite à la baisse de la fertilité du sol. L'étude visait à déterminer les facteurs qui influencent l'adoption et l'utilisation des technologies de gestion intégrée de la fertilité des sols (GIFS) par les petits exploitants agricoles au Kenya central. Deux cent quarante (240) agriculteurs ont été échantillonnés au hasard et les données recueillies grâce aux interviews de face-à-face. Les données ont été soumises à la régression logistique binaire pour déterminer les facteurs qui pourraient expliquer l'adoption et l'utilisation des technologies de GIFS. Les résultats ont montré qu'en ce qui concerne l'utilisation combinée des engrais organiques et inorganiques, des associations positives ont été décelées avec la profession, l'expérience acquise dans l'agriculture, la perception de la dégradation des sols, l'aide extérieure, le revenu hors-ferme, la perception de la sécurité alimentaire et monétaire, les unités du cheptel tropical, et la taille du ménage. L'étude conclut qu'il est nécessaire d'examiner le rôle essentiel que les variables socio-économiques contribuent au système agraire lors de l'aménagement de la GIFS.

Mots clés: Kenya, facteur socio-économique, technologies d'amélioration des sols, tithonia

Background

Per capita food production in Africa has been declining over the last two decades, contrary to the global trends. The growth rate for cereal grain yield is about 1%, while population growth is about 3 % (Bationo *et al*., 2004). Soil nutrient depletion in sub-Saharan Africa, a phenomenon that has ultimately led to soil degradation and reduced per capita food production, is one of the main factors causing declining food production. The humid highlands of central Kenya are characterized by high population pressure and intensively cultivated farmlands, which has led to increased soil fertility degradation. Farmers in this region use insufficient amounts of inorganic fertilizers and other sub-optimal inputs (Woomer and Muchena, 1996) partly due to lack of knowledge (Okalebo, 2000; Makokha *et al*., 2001). Past research in Kenya shows that adoption of new agricultural technologies, including soil management practices among the small-holder farmers has generally lagged behind scientific and technological advances, and hence the impact on agricultural production has been low (Okurro *et al*., 2002). Several Integrated Soil Fertility Management (ISFM) technologies have been introduced in central Kenya, but there is poor information, data and knowledge on how farmers have adopted ISFM technologies. There is also lack of scientific understanding of ISFM adoption behaviour among farmers. The aim of this study was to determine factors that influence ISFM (fertilizers, manure, and a combination of organic and inorganic soil inputs) adoption and utilization in central Kenya.

Methods

Study area description. This study was conducted in Meru South and Mbeere Districts of Kenya. Meru South District of Kenya lies between latitudes and longitudes 00°03¢47¢¢ N and 00°27¢28¢S 37°18¢24¢¢ E and 28°19¢12¢¢ E. The district covers an area of about 1035 km^2. According to agro-ecological conditions, the area lies in the Upper Midland Zone (UM2-UM4) (Jaetzold *et al*., 2006) on the eastern slopes of Mt. Kenya with an annual mean temperature of 20° C and a bimodal rainfall pattern totaling 1200–1400 mm. The rainfall comes in two seasons; the long rains (LR) lasts from March through June, while short rains (SR) commences in October through December. According to the Kenya 2009 census report (Kenya National Census, 2009), the population density in Meru South district was 205 persons/ km^2, while the population density in Mbeere district was 105 persons/km^2.

Meru South district is dominated by farming systems with a complex integration of crops and livestock, and smallholder farms that are intensively managed (Mairura *et al*., 2007). Land sizes are small ranging from 0.1 to 1.5 ha (mean=1 ha), and slope cultivation is widespread. The main cash crops are coffee and tea, while the main staple food crop is maize, which is cultivated from season to season mostly intercropped with beans. Other food crops include potatoes, bananas and vegetables that are mainly grown for subsistence consumption. Improved dairy farming is a major enterprise. Other livestock in the area include sheep, goats and poultry.

Mbeere District has an altitude of approximately 1028 m above sea level, and annual mean temperature ranging between 23.9-21.7 ^{o}C (Jaetzold *et al*., 2006). The rainfall is bimodal, falling in two seasons, the long rains (LR) lasting from March to June and short rains (SR) from October to December. The total rainfall is however unreliable, with a mean annual rainfall of 800-900 mm (Government of Kenya, 1997; Jaetzold *et al*., 2006). The soils are sandy-clay-loam, blackish grey or reddish brown, classified as the Nitro-rhodic Ferralsols, mainly low in fertility and must be intensively manured and fertilized season after season (Jaetzold *et al*., 2006). The soils are shallow (about 1 m deep) and lose their organic matter, including nutrient rich aggregates within 3-4 years of cultivation without adequate internal/external organic material inputs and soil protection from water erosion (Warren, 1998; Micheni *et al*., 2004).

Sample size description and data collection. There were five villages sampled in both Meru South and Mbeere districts, with a total sample of 240 farmers (Fig. 1).

The farmers interviewed in Meru South were 120 comprising of 24 (10%) from Ntatua village, 24(10%) from Mbironi village,

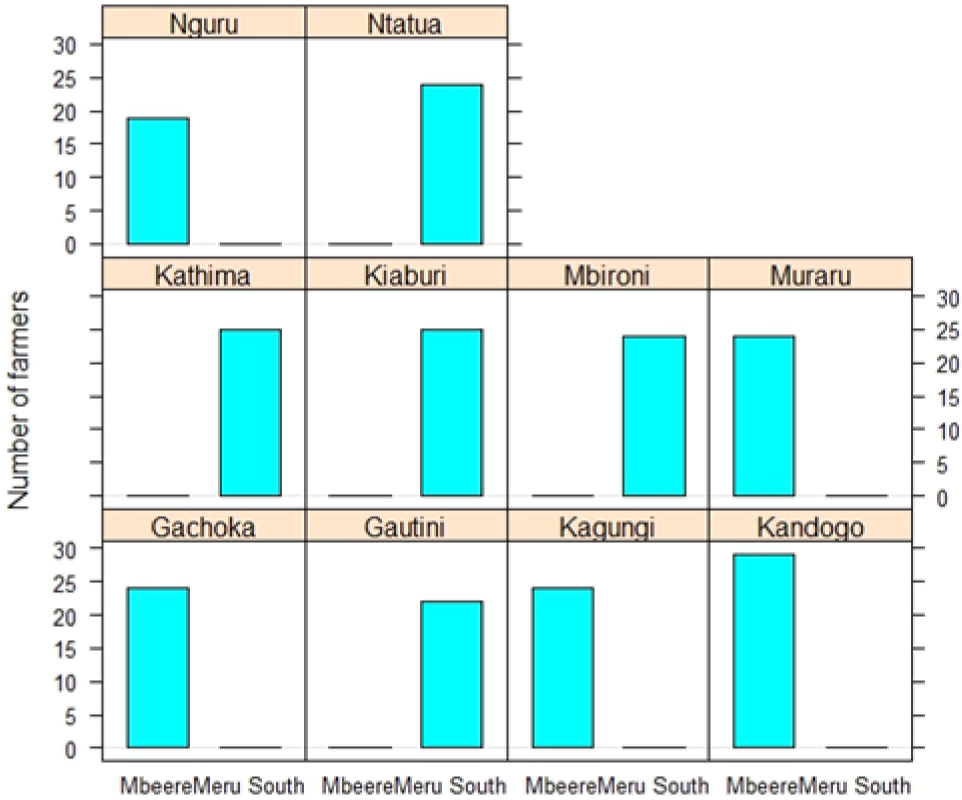


Figure 1. Sample size distribution in central Kenya.

25 (10.4%) from Kathima village, 22 (9.2%) from Gautini village and 25 (10.4%) from Kiaburi village. In addition, 120 farmers were sampled from five villages in Mbeere which comprised of 24 (10%) from Gachoka village, 29 (12.1%) from Kandogo village, 19 (7.9%) from Nguru village, 24 (10%) from Muraru village and 24 (10%) from Kangungi village (Fig, 1). Before the survey was conducted, enumerators were trained on how to go about the exercise, pretesting of tools was done and field and direct observations were used to collect the data.

Data analysis and management. Data was entered in SPSS software and subjected to cleaning and data exploration. Logistic regressions were conducted to determine factors affecting ISFM adoption and utilization. Factors analysis was conducted to determine farmers' behavior patterns underlying community participation. Prior to factor analysis data was log-transformed. Livestock data was transformed into tropical livestock units using FAO conversion factors for *Sub-Saharan* Africa livestock (see Chilouda and Otte, 2006).

Description of logistic regression parameters. Table 1 shows a description of key regression variables that were included to explain adoption of fertilizers, manure, and combined inorganic fertilizer and manure use. The variables included the location variable (District of residence), gender, occupation, age education, years of farming experience, whether soil fertility is a constraint, whether farmers have received external assistance with agricultural problems, off-farm income, remittances, food and cash security, extent of soil degradation, livestock income, tropical livestock unit and household size (Table 1).

Results

Socio-demographic farm characteristics. In Meru South, males composed of 89% of the sample, while female farmers were 14.2% (Table 2). In Mbeere district, males and females comprised of 68.8% and 22.2% of the sample, respectively (Table 2). The main occupation of the household head was farming, where 79% of the farm households were involved (Table 2). A higher percentage of farmers were involved in farming in Meru South, than in Mbeere district.

In Meru South and Mbeere, the mean age across farmers was 49 years, ranging from 25 to 91 years, with minimal differences between districts (Data not shown). The survey showed that the population structure in Mbeere was different from the distribution in Meru South district (Fig. 2).

Livestock ownership and livestock income. In relation to livestock income, the mean livestock income was larger Meru South than in Mbeere district, however, the mean TLU in Mbeere (2.1) was larger than in Meru South. The mean livestock income in male-managed households was also larger than in female-managed households. Meanwhile, the average TLU for female-managed households was larger than in males (Table 3).

Utilization of ISFM by farmers in central Kenya. In regard to manure, there was an almost equal proportion of farmers with knowledge, use, and perceived sufficiency (Table 4). There was also an equal proportion in both districts who believed that use of different fertilizers other than manure can improve production. In regard to crop residues, there was a higher level of use and sufficiency in Meru South compared to Mbeere (Table 4). There was also a higher percentage of farmers in Meru south (57%) compared to Mbeere (43%), who used crop residues. Meanwhile, a higher percentage of farmers in Meru

Table 1. Description of variables influencing adoption of ISFM by farmers in central Kenya.

Observations	Variable description	Variable type	Levels	Expected sign
Dependent variables				
Fertiliser use	Whether farmers used fertilisers or not	Binary	1=Yes, 0=No	NA
Manure use	Whether farmers used manure or not	Binary	1=Yes, 0=No	NA
Combined inorganic fertilizers and Manure use	Whether farmers used a combination of fertilizers and manures or not	Binary	1=Yes, 0=No	NA
Independent variables				
District	District of residence (Mbeere is an arid zone, while Meru South is a humid zone in central Kenya)	Categorical	1=Mbeere, 0=Meru South	+
Gender	Gender of household heads	Binary	1= Male, 0= female	-,+
Occupation	Occupation of household heads	Categorical	1= Farming, 2= Business, 3= Other	+
Age	Age of household heads	Continous		-,+
Education	Educational attainment of household heads	Categorical	1=None, 2= Primary, 3= Secondary, 4=Tertiary	+
Years of farming experience		Continous	NA	+
Whether soil fertility is a constraint		Binary	1=Yes, 0=No	+
Assistance with agricultural problems	Assistance with agricultural problems	Binary	1=Yes, 0=No	+
Off-farm income	Whether farmers have some off-farm income	Binary	1=Yes, 0=No	+
Remittances	Whether farmers receive remittances	Binary	1=Yes, 0=No	+
Food and cash security	Perception of food and cash security	Categorical	1=Poor, 2=Fair, 3=Good	-,+
Extent of soil degredation	Extent of soil degredation	Categorical	1= Very high, 2= High, 3=Medium, 4= Low, 5=Very low	-
Livestock income	Livestock income	Continous	NA	+
Tropical livestock unit	Tropical livestock unit	Continous	NA	+
Household size	Household size	Continous	NA	+

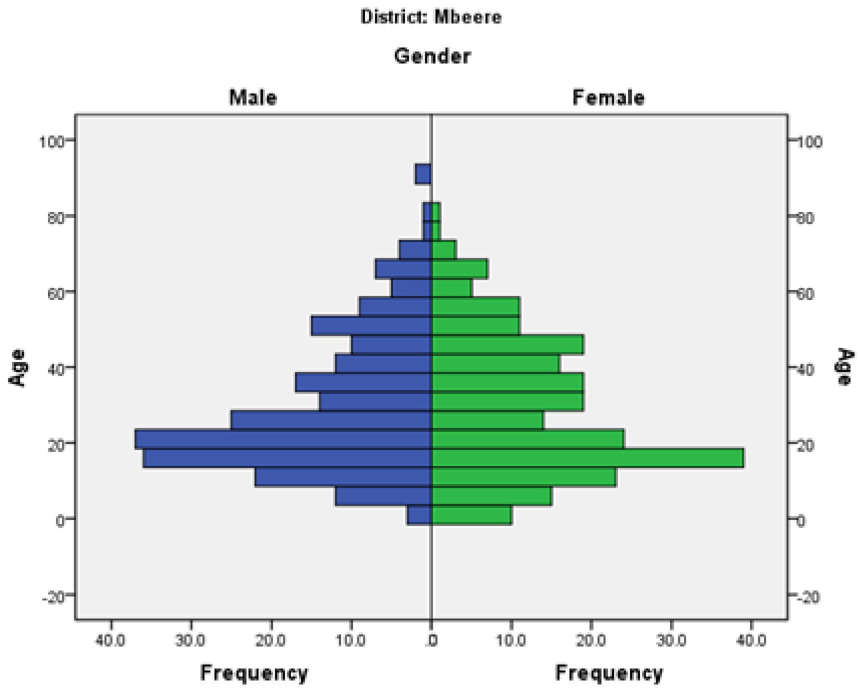
Table 2. Distribution of gender, occupation and education of household heads by district.

Gender	District		Total
	Meru South	Mbeere	
Male	103 (88.9)	62 (51.7)	165 (68.8)
Female	17 (14.2)	58 (48.3)	75 (22.2)
Total	120 (100)	120 (100)	240 (100)
Occupation of household head			
Farming	101 (84.9)	86 (72.3)	187 (78.6)
Business	17 (14.3)	13 (10.9)	30 (12.6)
Others	1 (0.8)	20 (16.8)	21 (8.8)
Total	119 (100)	119 (100)	238 (100)
Education			
None	8 (6.7)	26 (21.7)	34 (14.2)
Primary	59 (49.2)	57 (47.5)	116 (48.3)
Secondary	30 (25)	17 (14.2)	47 (19.6)
Tertiary	23 (19.2)	20 (16.7)	43 (17.9)
Total	120 (100)	120 (100)	240 (100)
Off-farm income			
Yes	73 (60.8)	66 (55.5)	139 (58.2)
No	47 (39.2)	53 (44.5)	100 (41.8)
Total	120 (100)	119 (100)	239 (100)

Values are counts, and column percentages.

South (55%), knew crop residues. A higher proportion of farmers in Mbeere district thought that the use of other inputs apart from crop residues would increase production. There was a higher proportion of farmers using green manures in Meru South, than in Mbeere district, by more than 15%. However, 66% of farmers believed that the use of other inputs apart from green manures would enhance soil fertility, compared to 35% of the farmers in Meru South. Compost use and sufficiency was higher in Meru South district almost as twice as much compared to Mbeere district.

Factors affecting ISFM adoption. Results of the logistic regression was conducted to determine the factors that influenced ISFM adoption (Table 5). In relation to fertilizer use, occupation (1=farming, 2=business) represented a coding direction quantifying farming based occupation at the lower end of the scale to business based occupation. Use of fertilizers



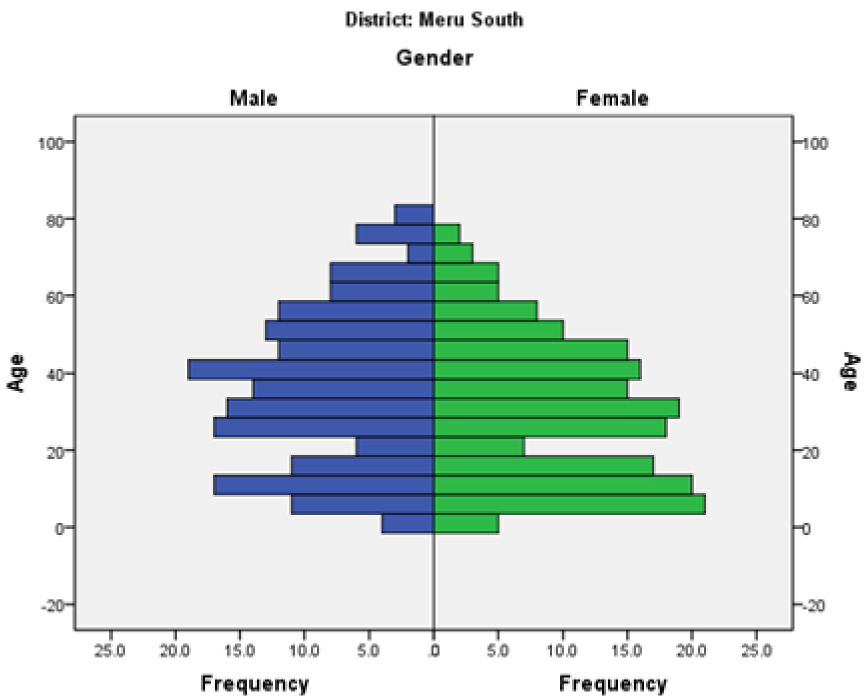


Figure 2. Population structure in Mbeere and Meru South districts.

Table 3. Mean livestock income and TLU (Tropical livestock units) by district and gender.

Categories	Livestock parameters	
District	Income (Kshs)	TLU
Mbeere	12953.8 ± 12727.10 (67)	2.1± 1.90 (108)
Meru South	17196.3 ±13653.60 (120)	1.4±1.00 (120)
Total	15676.26 ± 13450.17 (187)	1.76 ± 1.52 (228)
Gender		
Male	16188.8 ± 14075.46 (138)	1.71 ± 1.58 (162)
Female	14232.7 ±11518.18 (49)	1.9 ± 1.36 (66)
Total	15676.26 ± 13450.17 (189)	1.76 ±1.52 (228)

Values are arranged as means, followed by standard deviations and number of cases.

Table 4. Utilisation of organic soil resources in central Kenya by district.

ISFM	District	Knows ISFM	Uses ISFM	ISFM is sufficient	Use of different a different input will improve production
Manure	Mbeere	117 (50)	99 (48.1)	52 (50.5)	118 (51.3)
	Meru South	117 (50)	107 (51.9)	51 (49.5)	112 (48.7)
	Total	234 (100)	206 (100)	103 (100)	230 (100)
Crop residue	Mbeere	60 (45.1)	42 (42.9)	17 (34.7)	92 (54.4)
	Meru South	73 (54.9)	56 (57.1)	32 (65.3)	77 (45.6)
	Total	133 (100)	98 (100)	49 (100)	169 (100)
Green manure	Mbeere	12 (52.2)	3 (42.9)	1 (25)	76 (65.5)
	Meru South	11 (47.8)	4 (57.1)	3 (75)	40 (34.5)
	Total	23 (100)	7 (100)	4 (100)	116 (100)
Compost	Mbeere	30 (47.6)	4 (36.4)	1 (25)	77 (62.6)
	Meru South	33 (52.4)	7 (63.6)	3 (75)	46 (37.4)
	Total	63 (100)	11 (100)	4 (100)	123 (100)
Others	Mbeere	-	-	-	1 (33.3)
	Meru South	-	-	-	2 (66.7)
	Total	-	-	-	3 (100)
Total	Mbeere	219 (48.3)	148 (46)	71 (44.4)	364 (56.8)
	Meru South	234 (51.7)	174 (54)	89 (55.6)	277 (43.2)
	Total	453 (100)	322 (100)	160 (100)	641 (100)

Values in parenthesis are column percentages. Counts are more than the sample size because data on utilization was based on several inputs.

Table 5. Logit regression of factors influencing ISFM adoption in central Kenya.

Parameters (x's)	ISFM components (y's)		
	Fertilizer use	Manure use	Combined Inorganic fertilizer and Manure use
District	-0.009 (ns)	1.737 (ns)	-46.991 (ns)
Gender	-0.536 (ns)	-1.242 (ns)	-65.769 (ns)
Occupation	0.762 (ns)	0.221 (ns)	36.645 (ns)
Age	0.028 (ns)	0.194 (ns)	-2.091 (ns)
Education	0.693 (0.06)	-0.742 (ns)	-14.671 (ns)
Years of farming experience	-0.043 (ns)	-0.198 (ns)	1.336 (ns)
Whether soil fertility is a constraint	-0.135 (ns)	1.466 (ns)	55.135 (ns)
Assistance with agricultural problems	0.739 (ns)	3.967 (0.02)	26.022 (ns)
Off-farm income	-0.277 (ns)	-1.319 (ns)	46.65 (ns)
Remittances	-1.11 (0.05)	-1.908 (ns)	-55.697 (ns)
Food and cash security	1.464 (0.001)	-0.001 (ns)	41.8 (ns)
Extent of soil degradation	-0.126 (ns)	-0.09 (ns)	-5.178 (ns)
Livestock income	0.000 (ns)	0.000 (ns)	-0.001 (ns)
Tropical livestock unit	0.361 (ns)	2.963 (0.025)	34.795 (ns)
Household size	-0.097 (ns)	-0.044 (ns)	14.876 (ns)
Constant	-2.247 (ns)	-7.355 (ns)	77.703 (ns)
-2 Log likelihood	85.2	45.1	0.000
Cox and Snell R Square	0.268	0.296	0.157
Nagelkerke R Square	0.491	0.652	1.000
% Correct predicted	88	97.8	100

showed positive associations with occupation, age, education, external assistance, perception of food and cash security, tropical livestock units positively influenced fertilizer adoption.

For manure use, district of residence had a positive association, with farmers in Meru-South more likely to use manure than their counterparts in Mbeere district, a drier agro-ecozone (Table 2). In regard to combined organic and inorganic fertilizers, positive associations were detected with occupation, farming experience, perception of soil degredation, external assistance, off-farm income, perception of food and cash security, tropical livestock units, and house-hold size (Table 5).

Community participation at village level. The following section reports the patterns of community participation at village level using factor analysis on scored data (Table 6).

Twelve parameters related to the assessment of community participation in agricultural activities were reduced to three main parameters. The factors explained 64% of the total variance. The first factor was related to participation participation in

Table 6. Rotated component matrix of selected community participation parameters rated by farmers in central Kenya.

Parameters	Component			Communalities
	1	2	3	
Participation in community activities	0.830	-	-	0.770
Cooperation among people	0.828	-	-	0.755
Extent of exchange of gifts	0.792	-	-	0.696
Extent of trust	0.746	-	-	0.741
Financial contribution	0.677	-	-	0.583
Men participation	0.647	-	-	0.639
Training in agricultural courses	-	0.797	-	0.641
Soil fertility management	-	0.612	-	0.613
Visits by extension officers	-	0.612	0.572	0.704
Credit facilities	-	-	-0.774	0.666
Women participation	-	-	0.548	0.353
Helping others	-	-	0.544	0.513
Eigen values	3.731	2.013	1.932	
% variance	31.1	16.8	16.1	
Cumulative variance	31.1	47.9	64.0	

Kaiser-Meyer-Olkin measure of sampling adequacy = 0.801; Bartlett's test of sphericity: (X^2= 1230.012, Sig = 0.000). The cut point for displaying loadings was set at L=0.5.

community activities by farmers, which included co-operation, gift exchange, trust and the degree of participation by men. The parameters in this dimension were highly correlated. The second factor was related to agricultural training, extension visit, and soil fertility management. The third factor was related to the extent of credit access and women participation. The third factor can be interpreted as a contrast between access to credit and women participation, because of the negative loading of credit on component 3. In regard to farmer participation in community and social activities at village level, the main patterns of farmer involvement can be decomposed into the three broad facets, including social welfare, credit access (or economic development) activities. In the third factor, activities related to credit development were negatively associated with social participation and community support activities.

Discussion

Most household heads were involved in farming as a major activity. In Meru- South, a higher proportion of farmers were involved in business, compared to Mbeere district, indicating that Meru South district has more economic activity, compared to Mbeere district. This shows that farmers in Meru-South had higher agricultural and market opportunities than farmers in Mbeere district. This was expected due to better agro-climatic characteristics, and possibly better market opportunities. Majority of males fell in the middle wealth category, with male-managed farms in both divisions, being more profitable than female-managed farms. More of the farmers in Meru South district had land tenure security, compared to Mbeere district as expected. However, a higher proportion of female plots were under cultivation than male plots, highlighting the important role that female farmers contribute to agriculture, which is usually under-estimated. The higher proportion of rented plots in Meru South compared to Mbeere indicates that Meru South is more economically oriented than Mbeere, because most farmers renting farms, are likely to do so with potential economic opportunities.

Livestock income from male managed households was larger than in female-managed households. The proportion of male and female who received remittances was almost equal, this tallied with the findings of Bonabana-Wabi (2002), who did not find any association between gender and remittances. The main constraint to the use of organic fertilizers (by farmer frequency) by farmers was high cost as expected. Farmers in Mbeere also faced more agricultural constraints in relation to input use and production compared to Meru South. There was a higher use frequency of major fertilizers among male- headed households as compared to female-headed households possibly because male have more access to resources and decision-making in the use of inputs. Male managed farms had higher levels of knowledge, use and sufficiency of most major fertilizers than female-managed farms. The study has shown that males contributed most to ISFM related labour, and as a result, their role needs to be further examined in relation to ISFM adoption. The role of gender was more important as a determinant than location, in ISFM adoption and utilization.

The effect of farm size on technology adoption has been variously found to be positive (Kasenge, 1998), negative (Yaron, Dinar and Voet, 1992) or neutral to adoption (Mugisa-Mutetikka *et al*., 2000). Farm size affects adoption costs, risk perceptions, human capital, credit constraints, labor requirements, tenure arrangements and more. With small farms, it has been argued that large fixed costs can become a constraint to technology adoption (Abara and Singh, 1993). With some technologies, the speed of ISFM adoption may be different for farmers in different wealth.

The availability of time is an important factor affecting technology adoption. It can influence adoption in either a negative or positive manner. Practices that heavily draw on farmer's time may inhibit adoption (Mugisa-Mutetikka *et al*., 2000). However, practices that leave time for other sources of income accumulation may promote adoption. In such cases, as well as in general, income from off-farm labor may provide financial resources required to adopt the new technologies.

Age is another factor thought to affect adoption. Age is said to be a primary latent characteristic in adoption decisions. However there is contention on the direction of the effect of age on adoption. Age was found to positively influence adoption of sorghum in Burkina Faso (Adesiina and Baidu-Forson, 1995). In central Kenya, age had a positive effect on adoption. The effect is thought to stem from accumulated knowledge and experience of farming systems obtained from years of observation and experimenting with various technologies. In addition, since adoption pay-offs occur over a long period of time, while costs occur in the earlier phases, age (time) of the farmer can have a profound effect on technology adoption. However age has also been found to be either negatively correlated with adoption, or not significant in farmers' adoption decisions (see Green and Ng'ong'ola, 1993; Baidu-Forson, 1999). Older farmers, perhaps because of investing several years in a particular practice, may not want to jeopardize investments by trying out a completely new method. In addition, farmers' perception that technology development and the subsequent benefits, require a lot of time to realize, can reduce their interest in the new technology because of farmers' advanced age, and the possibility of not living long enough to enjoy it (Caswell *et al*., 2001). Furthermore, elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt an income-enhancing technology. As a result, it is expected that the old that do adopt a technology do so at a slow pace because of their tendency to adapt less swiftly to new ideas (Tjornhom, 1995). In this study, farming experience, which is connected to age was negatively associated with ISFM adoption.

Education had a negative effect on the adoption of ISFM, which was not expected. Jera and Ajayi (2008) found a negative association in the adoption of tree-based fodder technologies in Zimbabwe. Jera and Ajayi (2008) showed that formal education may not have played an important role in tree-fodder adoption, because adoption of tree fodders was more likely to be associated with farmer experiences rather than education. Fodder knowledge, including ISFM is not taught in formal junior level syllabi (Jera and Ajayi, 2008). As a result, the role of education in ISFM needs further examination. Studies that have sought to establish the effect of education on adoption in most cases relate it to years of formal schooling (Tjornhom, 1995). Generally education is thought to create a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Caswell *et al*., 2001). ISFM is knowledge-intensive (Bationo *et al*., 2004). Education is thought to reduce the amount of complexity perceived in technology and may increase the likelihood of a technology's adoption, although mixed results in relation to education have been shown in other studies, similarly to this case.

Gender relationships with agricultural production and technology adoption have been investigated for a long time. Most show mixed evidence regarding the different roles men and women play in technology adoption. In the most recent studies, Doss and Morris (2001) in their study on factors influencing improved maize technology adoption in Ghana, and Overfield and Fleming (2001) studying coffee production in Papua New Guinea show insignificant effects of gender on adoption. Musaba *et al*., (2008) hypothesized the relationship between gender and adoption to be ambiguous, but turned out to be positively associated with male farmers. Good extension programs and contacts with outsiders are a key aspect in technology dissemination and adoption (IFPRI, 1998). Most studies analyzing this variable in the context of agricultural technology show its strong positive influence on adoption.

Off-farm income (Musaba, 2010), livestock income and TLU and group membership had a positive effect on ISFM adoption as was expected. Several researchers have reported a positive effect of off-farm income which creates extra income, thus increasing likelihood of adoption. Livestock resources are also considered major driving factors in ISFM adoption. Musaba (2010) reported a positive association between herd size and technology adoption. Apart from livestock income which may increase available finances, manures can lead to savings in purchases of fertilizers. The complementarities between livestock and fodder/crops are also advantageous to ISFM adoption.

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