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## FARMER GROUPS' CHARACTERISTICS INFLUENCING APPLICATION OF SOIL FERTILITY TECHNOLOGIES IN THE CENTRAL HIGHLANDS OF KENYA

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### ABSTRACT

Declining soil fertility is a major problem in East and Central Africa. Soil fertility enhancement (SFE) technologies have been developed, but their uptake has remained low. This first study assessed the influence of farmer groups' characteristics on the technology application. The study was carried out in Mbeere South and Maara sub-counties in Kenya. Interview schedules were administered to a total sample of 60 farmer groups. Data were analysed using SPSS software. Variables that influenced groups' application of animal manure were: group size ( $p=0.019$ ), frequency of group meetings ( $p=0.050$ ) and the number of females in the group ( $p=0.027$ ). Variables that influenced application of fertilizer included: Tropical livestock unit ( $p=0.045$ ), group formation prompt ( $p=0.098$ ) and qualification into group membership ( $p=0.028$ ). Variables that influenced application of a combination included: reason for applying a combination ( $p=0.003$ ), number of females in the group ( $p=0.067$ ) and group gender ( $p=0.056$ ). This information will be helpful to the groups, researchers, policy makers, farmers' training designers and other stakeholders wishing to disseminate technologies in natural resource management programmes.

**Key words:** *Farmers group, Group characteristics, SFE technologies, Animal manure, Inorganic fertilizers, Application*

### 1. INTRODUCTION

Smallholder farmers in Sub-Saharan Africa (SSA) face severe soil fertility crisis (Gonsalves et al., 2005). A survey in Kenya showed high amount of soil nutrient deficiencies caused by continuous cereal cultivation with limited use of fertility inputs (Gonsalves et al., 2005). Research on soil fertility improvement in Central Kenya highlands has generated recommendations for improving soil fertility on smallholder farms (Mugendi *et al.*, 2006). For instance, some herbaceous legumes, leguminous shrubs, cover crops, biomass transfer, and cattle manure technologies applied alone or combined with inorganic fertilizers have been identified as potential soil nutrient replenishment technologies due to their costs, effectiveness, appropriateness, simplicity, and multipurpose nature in meeting the needs of the resource poor farmers (Franzel et al., 2002; Mucheru, 2003).

Despite the obvious benefits of these soil fertility enhancement (SFE) technologies, the adoption rate has been slower than anticipated by the researchers as observed by Adiel (2004). On the other hand, if farmers can adopt these technologies, they can increase their farm productivity up to five-fold (Mugwe et al., 2009). Causes of low adoption may be attributed to the extension methods/approaches used in the dissemination of the soil fertility enhancement innovations among other reasons.

Farmers' groups is one of the approaches that have been used successfully to catalyze the participation of farmers as partners in research and development activities (CIAT, 2003; Sanginga et al., 2005), and target technology to specific groups (Reddy et al., 2010). Farmers' groups are community-based and their joint activities therefore have an out-scaling effect on the community (Wennink and Heemskerk, 2006). The smallscale farmers form these farmers' groups, which are key to up-scaling of technologies and they have self monitoring mechanisms to enforce collective actions through collective activities of the group (Bingen et al., 2003). For example, Peterson et al. (2004) found out that, group members who were not successful with their first attempt to test soil nutrient replenishment technologies (SNRT) continued to use the technologies after visiting other farmers and getting convinced. Kiptot (2007) however showed that the use of the village committee approach was misapplied as the approach assumed that groups are fully appropriate vehicles for technology development and dissemination.

The success of farmer groups depends on various factors which include small group sizes, group maturity and internal factors (common interests, group commitment and trustworthy leadership). Others are external factors (extension agents, researchers), structural social factors (roles, rules, procedures, social networks) and cognitive (norms, values, attitude and trust) social factors (Ostrom, 1992; Baland and Platteau, 1996; Uphoff and Wijayaratna, 2000; Agrawal, 2001; Haan, 2001; Johnson et al., 2002; Place et al., 2002; Jones, 2004). However, the cumulative effects of these factors and their direct influence on the application of technologies have not been well understood. For instance, Agrawal, (2001) found out that, like group size alone gave different results on group's success. Therefore, there is a need for more social-economic research to understand how farmer groups view and understand the technologies (Misiko, 2007; Kiptot et al., 2007). This calls for a study that focuses on factors that influence the application of the technologies by the groups.

## **2. MATERIALS AND METHODS**

### **2.1 Study Area**

The study was carried out in Mbeere South and Maara sub-counties in the Central highlands of Kenya. Mbeere South sub-county lies in the Agro-ecological Zone (AEZ) Lower midland 4 and 5 (LM 4 and LM 5), with an altitude of about 800m above sea level (Jaetzold et al., 2007). The average rainfall is between 600-800 mm per year, in a bimodal regime, where long rains come from mid March to June and the short rains from late October to December. The annual mean temperature is between 21.7 to 22.5°C. The sub-county experiences two cropping seasons per year, with the long rains season and the short rains season. The soils are predominantly Ferralsols and Acrisols (Jaetzold et al., 2007), and the predominant land uses are dry land farming and livestock production.

Maara sub-county on the other hand lies in the Agro-ecological Zone (AEZ) Upper Midland (UM2-UM3) (Jaetzold et al., 2007) on the eastern slopes of Mount Kenya, with an altitude of 1500 m above sea level. It receives an average rainfall of 1200-1400mm per annum with a bimodal regime where long rains come from March to June and short rains from October to December. The mean temperature is 20°C. Two cropping seasons are experienced in a year. The sub-county is predominantly maize/coffee growing zone with some dairy enterprises, ranging from 0.1 to 2 ha and an average of 1.2 ha per household. The soils are mainly humic Nitisols (Jaetzold et al., 2007).

### **2.2. Data collection**

A survey was conducted in Mbeere South and Maara sub-counties. Before the survey, enumerators were trained on how to go about data collection. Pre-testing of the survey tools was done on two groups per sub-county and field and direct observations were also used to collect the data.

### **2.3. Data Analysis**

Data cleaning and close examination was done to ensure completeness and consistency in the survey tool. The questions were coded, managed and the responses stored in MS Excel, and later transferred to SPSS software. SPSS, version 12 software, was used for data analysis. Descriptive statistical analysis was applied, involving the use of means, frequencies, percentages, standard deviation. For categorical variables, cross tabulation was carried out by testing for association using Pearson chi-square statistics. In the regression analysis, the group characteristics independent (explanatory) variables while the dependent variables were the farmers' groups' technology application. Results were presented in form of tables.

For logistic analysis, various factors were regressed upon the dependent variable "SFE technology application" in a binary logistic model. Such models are used when response variables are binary; that is, they have only two possible outcomes (Agresti & Finlay, 1997). The generic terms for the two possible outcomes are success and failure, and the

“odds” equal the probability of success divided by the probability of failure. A value of 0 was assigned if the farmer group did not apply and 1 if the farmer group applied, giving the regression of non-linear form. In this case a group was considered to have applied if over 80 % of its members had applied the technology and vice versa when 20 % and below of its members had applied the technology. All variables were transformed, coded and included into the Logit regression model to determine which factors/variables significantly influenced the application of animal manure, inorganic fertilizers and a combination of animal manure plus inorganic fertilizers (the soil fertility enhancement technologies) (Table 1).

### 3. RESULTS AND DISCUSSION

#### 3.1 The effect of farmer groups’ characteristics on the application of SFE technologies

##### 3.1.1 Group characteristics influencing the use of animal manure in Embu and Tharaka-Nithi Counties

The results of the Logit model are presented in (Table 2). The model was significant at  $p < 0.01$  and correctly predicted 78.3% of both that applied and those that did not apply animal manure. Group size ( $p = 0.019$ ), frequency of group meetings ( $p = 0.050$ ) and the number of females in the group ( $p = 0.008$ ) were significant in explaining the application of animal manure in Embu and Tharaka-Nithi counties (Table 2).

##### Number of Females in the Group

The number of females in the groups significantly ( $\beta = 0.197$ ,  $p = 0.008$ ) influenced application of animal manure (Table 2). This implies that an increase in the number of women in the groups increased the likelihood of application of animal manure. Explanation for this could be because manure is a resource that is easily available at the household level and hence does not require cash. Another is that manure application happens to be a labour-intensive exercise (Place *et al.*, 2005). Palm *et al.* (1997) also noted that processing and application of traditional organic materials such as crop residues and organic manure are labour intensive. Women are the main labour providers on the farms (Quisumbing and Pandolfelli, 2008). At the same time, women are known to talk a lot, share a lot and also influence each other easily. Manure application is not a knowledge-intensive exercise and therefore women could apply it with no problem as long as a demonstration on application is done. This agrees with Place *et al.* (2005) who reported that in Kenya, women who had less education than men excelled in the uptake of soil fertility replenishment technologies as long as explanations were given in the simplest terms possible.

**Table1: Definition of study variables**

Variables	Definition
<b>Dependent variables</b>	
Application (Manure, inorganic fertilizer, manure + fertilizer)	0 Not applied, 1 Applied
<b>Independent variables</b>	
Group age	Continuous variable
Group size	0 Small, 1 Large
Group gender	1 Male, 2 Female
Educated group	3 Mixed 0 Not educate, 1 Educated
Ages of group members	0 Young 1 Old
Frequency of group meetings	1 Weekly 2 Fortnightly 3 Monthly
Meeting venues	0 Members’ homes/farms 1 Public places
Tropical Livestock Unit (TLU)	Continuous variable
Common agenda during group meetings	1 Planning for trainings 2 Contributions / Benefits 3 Group investments
Number of males/females in the group	Continuous variable
Prompt for group formation	0 External influence 1 Internal influence

Qualification of group membership	1 Character / behaviour 2 Family relations 3 Ability to contribute financially
Reason for applying animal manure	1 Soil fertility & structure 2 High cost of fertilizers 3 Availability
Reason for applying inorganic fertilizer	1 Ease of application 2 Fast growth & maturity 3 High yields
Reason for applying a combination	1 High yields 2 Soil fertility & structure 3 Fast growth & maturity
Number of beneficiaries from agricultural activities	Continuous variable
Rating of participation in group activities	1 Fair, 2 Good, 3 V. good

**Table 2: Group characteristics influencing application of animal manure technology by groups in the Embu and Tharaka-Nithi Counties**

Independent variables	B	S.E.	Wald	Sig.	Exp(B)
Group age	0.131	0.083	2.497	0.114	1.140
No of females in the group	0.197**	0.074	7.045	0.008	1.218
Frequency of group meetings	-0.920*	0.470	3.834	0.050	0.399
Participation rate	1.068	0.665	2.575	0.109	2.908
Tropical Livestock Unit	0.120	0.511	0.056	0.814	1.128
No of males in the group	0.076	0.061	1.583	0.208	1.079
Group size	-3.898**	1.657	5.535	0.019	0.020

N=60, \*\*Significant at 5% probability level, \*Significant at 10% probability level

Less educated women were found to excel in adopting new technologies as long as explanations were provided in simple language and that this could explain why women were enthusiastic of soil fertility replenishment technologies and decided to adopt such techniques (Place *et al.*, 2005). That means that once they understand and have the numbers, they can influence each other in to adoption.

A study carried out in Ghana by Quisumbing and Pandolfell (2008) showed that the adoption of cocoa farming increased women's labour burdens, but also increased their control over land as husbands transferred land to their wives in exchange for their wives' labour in their fields. This is however contrary to the findings of Mwangi *et al* (2011) who found that higher proportions of females in user groups, and especially user groups dominated by females perform less well than mixed groups or male dominated ones. Simply adding women to groups does not lead to greater effectiveness. Women's inclusion in collective action needs to be accompanied by measures to strengthen their capacities for assuming active roles in leadership positions (Quisumbing and Pandolfell, 2008).

### Frequency of group meetings

The frequency of group meetings negatively ( $\beta = -0.920$ ,  $p = 0.050$ ) influenced application of animal manure (Table 2). This implies that the less the frequency of the group meetings, the more the likelihood of groups applying animal manure. That means that groups that meet monthly are more likely to adopt soil fertility technologies more than those that meet weekly. The reason for this could be that agricultural activities that involve soil inputs application are normally seasonal, and monthly meeting can address agricultural issues such as soil fertility replenishment which is once a season activity. On the other hand, most groups that meet weekly address resource issues such as merry-go-round, household items and credit issues. Where groups have accessed loans from their revolving fund or from outside, and repayments are mostly weekly or fortnightly, forcing the group to meet for loan repayment. Davis and Negash (2007) reported that the "poor" are the ones participating in many of the groups, and that they naturally come together because they have needs and togetherness may marginally reduce the resource poverty they experience.

Less frequent meetings allow group members to assist on each other's farms and this provides a learning experience forum for each one of them. These visits in each others' farms provide opportunities for them to have an experience

with soil fertility technologies, especially if they had not succeeded on their farms during their first attempt (Peterson *et al.*, 2004). This agrees with Cramb (1999) who reported that farmers group themselves work on each others' farms on a rotation basis. This not only assists in labour sharing but also hastens adoption of SFE technologies. In the study, Meinen-Dick and Di-Gregorio (2004) noted that the number of meetings may be a convenient indicator because it is relatively easy to measure, but it is not clear whether meetings are a transaction cost of collective action or an indication of effectiveness.

### Group size

Group size negatively ( $\beta = -3.898$ ,  $p = 0.019$ ) influenced application of animal manure (Table 2). This implies that the smaller the group sizes the higher the likelihood of using animal manure. This is probably because members of smaller groups are able to interact and share closely as opposed to members of large groups. According to Howard (2002), larger groups are less likely to achieve their goals than smaller groups because smaller groups are more viable since the costs of organization are less, and each member receives a more substantial portion of the collective good. Davis (2004) noted that cohesion was assisted by small group size, homogeneity of members and member accountability. Pretty (2003) and Sanginga *et al.* (2001) also noted that groups of less than 20 farmers can also function well. Small groups maintain a greater sense of solidarity and mutual responsibility (Uphoff and Wijayaratra, 2000). Large groups on one hand gain a wide range of experiences due to numbers and are likely to include persons from various farmer categories. On the other hand, such large groups are sometimes characterized by a less intensive exchange of experiences among themselves; they tend to be more subject to social problems and are often difficult to manage, therefore requiring strong leadership (Kampen and Shapland, 2004). Group sizes are determined by the members themselves (Heemskerk *et al.*, 2003). Mavedzenge Blasio *et al.* (1999) also reported that for adaptability analysis, an optimal common interest group size for development of flexible recommendations is a minimum of 15 members.

### 3.1.2 Characteristics influencing application of inorganic fertilizers in Embu & Tharaka-Nithi Counties

The results of the Logit model are presented in (Table 3). The model was significant at  $p < 0.01$  and correctly predicted 86.8% of both that applied and those that did not apply inorganic fertilizer. Qualification of group membership ( $p = 0.028$ ), prompt of group formation ( $p = 0.098$ ) and the Tropical Livestock Unit (TLU) ( $p = 0.045$ ) were significant in explaining the application of inorganic fertilizer in Embu and Tharaka-Nithi counties (Table 3).

**Table 3: Group characteristics influencing application of inorganic fertilizer technology by groups in the Embu and Tharaka-Nithi Counties**

Independent variables	B	S.E.	Wald	Sig.	Exp(B)
No of beneficiaries of agric activities in the group	0.134	0.109	1.507	0.220	1.144
Tropical Livestock Unit	1.926**	0.963	4.000	0.045	6.859
Group formation prompt	1.891*	1.143	2.736	0.098	6.624
Membership qualification	1.624**	0.741	4.802	0.028	5.073
Ages of group members	0.686	1.202	0.326	0.568	1.986
Educated group	0.222	0.231	0.925	0.336	1.248
No of females in the group	-0.336	0.275	1.499	0.221	0.714
No of males in the group	-0.395	0.281	1.979	0.160	0.674
Frequency of group meetings	0.250	0.658	0.144	0.704	1.284

N=60, \*\*Significant at 5% probability level, \*Significant at 10% probability level

### Tropical Livestock Unit (TLU)

The Tropical Livestock Unit (TLU) significantly ( $\beta = 1.926$ ,  $p = 0.045$ ) influenced the application of inorganic fertilizer (Table 3) which implies that an increase in the TLU increases the likelihood of farmers to make decision to apply inorganic fertilizer. Ownership of domestic animals is assumed to generate increased income through sales of the animals or their products and is thus hypothesized to accelerate adoption of inorganic fertilizers (Odendo *et al.*, 2010). This agrees with Davis (2004) who found out that there was a positive correlation between wealth level and the number of animals. These animals could either be a source of wealth or capital through their sales or manure sales. Ajayi *et al.*, (2007) noted that animal manure was becoming scarcer because most farmers had too few animals to produce adequate quantities of manure.

Sanginga and Woolmer (2009) also found that livestock rearing is a near-universal smallholder enterprise that serves to accumulate wealth, generate income, improve household nutrition and provide sources of soil organic inputs as waste products. In addition, households that were not selling produce or animal products found it difficult to afford mineral fertilizers, even at rates well below recommended levels (Hartemink, 2003). Mugwe *et al.* (2009) also reported that birds (poultry) are not only seen as a source of wealth but also manure providers. Birds or manure sales could provide capital to invest in inorganic fertilizers. Resource poor households were also found to occupy smaller farms, practice fewer farm enterprises, own fewer domestic animals and use less mineral fertilizers according to Sanginga and Woolmer (2009).

### Reason for Group Formation

The reason that prompted the group to start significantly ( $\beta = 1.891, p = 0.098$ ) influenced the application of inorganic fertilizer (Table 3). Results show that a majority (84.4%) of the groups that applied inorganic fertilizer were prompted to start by internal issues. These issues include inadequate financial resources, social support, agricultural marketing and risk coping strategies. Davis and Negash (2007) also reported that the “poor” will naturally come together because they have needs and togetherness may marginally reduce the resource poverty they experience. This means that if ‘poor’ farmers realized that they had soil fertility need, they would come together on top of joining many groups. This is in line with Stringfellow *et al.* (1997) who noted that donors and NGOs wanting to promote farmer cooperation need to refrain from pushing the process of group formation. This deprives the group members of their responsibility of taking charge of their situations. Farmers should instead be encouraged to develop their own forms of group organizations after analyzing their circumstances and the resources at their disposal.

### 3.1.3 Group characteristics influencing application of animal manure + fertilizers in the two Counties

The results of the Logit model are presented in (Table 4). The model was significant at  $p < 0.01$  and correctly predicted 80.7% of both that applied and those that did not apply manure plus fertilizer. Number of females in the group ( $p = 0.067$ ), reason for applying combination ( $p = 0.003$ ) and group gender ( $p = 0.056$ ) were significant in explaining the application of inorganic fertilizer in Embu and Tharaka-Nithi counties (Table 4).

**Table 4: Group characteristics influencing application of a combination of manure + fertilizer technology by groups in the Embu and Tharaka-Nithi Counties**

Independent variable	B	S.E.	Wald	Sig.	Exp(B)
Group age	-0.090	0.091	0.973	0.324	0.914
No of females in the group	-0.142**	0.078	3.349	0.067	0.867
Educated group	0.128	0.098	1.726	0.189	1.137
Age of group members	0.683	0.949	0.517	0.472	1.980
Venue of group meeting	0.977	0.879	1.236	0.266	2.657
Tropical Livestock Unit	0.294	0.487	0.364	0.546	1.342
Reason for combination	-1.848*	0.623	8.793	0.003	0.158
Group gender	1.577**	0.825	3.655	0.056	4.839

N=60, \*\*Significant at 5% probability level, \*Significant at 10% probability level

### Number of Females in the Group

The number of females in the groups negatively ( $\beta = -0.142, p = 0.067$ ) influenced the application of combination of manure plus fertilizer (Table 4). That means that an increase in the number of females in a group decreases the group’s application of the combination of manure plus fertilizer. This is especially in mixed gendered groups. Normally, women have been treated as physically weaker sex and when they are in mixed groups, they could take advantage of that and leave most of the application work to the men in the group. This agrees with Mwangi *et al.* (2011) who found that higher proportions of females, and especially user groups dominated by females perform less well than mixed groups or male dominated ones. Simply adding women to groups does not lead to greater effectiveness. Women’s inclusion in collective action needs to be accompanied by measures to strengthen their capacities for assuming active roles, including leadership positions (Quisumbing and Pandolfell, 2008).

### Reason for Using Combination

The reason for using a combination of manure plus fertilizer significantly influenced the application of combination of manure plus fertilizer (Table 4). Cross tabulation results showed that the reason for applying a combination of manure + fertilizer by the group significantly ( $p = 0.022, \chi^2 = 7.673$ ) influenced application of manure + fertilizer. A

majority (85.7 %) of the groups that applied a combination did so because of its association with high yields while 44.4% of groups that applied the combination did so because of its association with fast crop growth and maturity. This implies that an increase in the application of the combination is influenced by its association with high yields. This could be because most groups never felt that manure was unavailable, now that they just collect it from their cattle sheds, and combining it with fertilizer gave high yields. Combination of manure plus fertilizer has also been reported to give the highest yields. This agrees with Makinde *et al* (2001) and Bayu *et al* (2006) who reported that high and sustained crop yield could be obtained with judicious and balanced NPK fertilization combined with organic matter amendments. Place *et al* (2005) also noted that the use of manure and fertilizer has increased steadily over the last few years, partly due to some users' strong belief in fertilizers. Combining organic amendments and mineral fertilizers is often the best strategy for maintaining or even increasing soil fertility (Wopereis *et al.*, 2009)

### **Group Gender**

Group gender influenced ( $\beta= 1.577, p=0.056$ ) the application of a combination of manure plus fertilizer (Table 4). Results showed that 82.5% of the groups that applied a combination were mixed gendered (N=40), while 66.0% of the groups that applied a combination were male gendered (N=3). This implies that when men and women are mixed, there is synergy from both gender and the results are better. When the two genders are in the same group, it shows that they have accepted each other with their different contributions. A study carried out in Zimbabwe reported that women indicated that it was not necessary to have separate women's groups since their needs were the same as the men's (Jiggins *et al.*, 1992). According to Sanginga *et al.* (2005) men make decisions, organize group activities and maintain discipline in groups. They are also better placed to establish contacts with external institutions and to voice their needs and demands, while Kaaria and Ashby (2000) reported that the higher participation of women can be explained by their dormant roles and responsibilities in crop production.

While investigating the gender variable, Mwangi *et al.* (2011) found out that user groups dominated by females, perform less well than mixed groups or male dominated ones as far as technology access and dissemination was concerned. Mixed-sex groups were also found to be more effective at meeting project objectives, especially when women and men are both key users of a resource (Quisumbing, 2009). Kariuki and Place (2005) during their study in the central highlands of Kenya also reported that men express more satisfaction with how group finances are managed in mixed-sex groups than they do in all-male groups, because men are perceived as being more vulnerable to corruption. On the other hand however, Varughese and Ostrom (2001) found that heterogeneity in groups was not an important predictor of outcomes in collective action such as farmers' groups.

## **4. CONCLUSION**

The objective was to assess the effect of farmer groups' characteristics on the choice of soil fertility enhancement technologies by individual members. Results showed that group characteristics that significantly influenced application of manure were: group size, frequency of group meetings and the number of women in the group while, Tropical Livestock Units (TLU) and group formation prompt were the likely factors that influenced the application of fertilizer. On the other hand, the number of females in the group, reason for applying the combination and gender of the groups influenced the application of combination. This implies that groups should be of manageable sizes, hold timely and regular meetings, have some livestock, be self motivated by their objectives, have some knowledge on the effects of the technology application and if possible have mixed gender in order to benefit from their interactions and synergies

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## **REFERENCES**

- Adiel, R.K. 2004. Assessment of factors affecting adoption of soil fertility improvement technologies in Eastern Kenya: The case of Kirege location, Chuka division. M.Sc. thesis, Kenyatta University, Nairobi Kenya.
- Agrawal, A. 2001. Common property institutions and sustainable governance of resources. *World Development* 29:1649–1672.
- Agresti, A. and Finlay, B. 1997. *Statistical Methods for Social Sciences* (3<sup>rd</sup> edn.). Upper Saddle River, New Jersey: Prentice Hall.

- Ajayi, O., Akinnifesi, F. and Sileshi, G. 2007. Adoption of renewable soil fertility replenishment technologies in the southern African region: Lessons learnt and the way forward. *Natural Resources Forum*, 31:306-317.
- Baland, J. and Platteau, J. 1996. Halting degradation of natural resources: Is there a role for rural communities? New York: Food and Agricultural Organization of the United Nations; Oxford: Clarendon Press; New York: Oxford University Press.
- Bayu, W., Rethman, N., Hammes, P. and Alemu, G. 2006. Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield and nitrogen use in a semi-arid area of Ethiopia. *J. Plant Nutrition*, 29(2):391-407.
- Bingen, J., Serrano, A. and Howard, J. 2003. Linking farmers to markets: Different Approaches to Human Capital Development. *Food Policy* 28:405-419.
- CIAT, 2003. Farmer research groups' dynamics in Eastern Africa
- Cramb, R.A. 1999. Processes Influencing the Successful Adoption of New Technologies by Smallholder
- Davis, K.E. 2004. Technology Dissemination Among Small-Scale Farmers in Meru Central District of Kenya: Impact of Group Participation. Doctor of Philosophy Thesis. University of Florida.
- Davis, K.E. & Negash, M. 2007. Gender, wealth, and participation in community groups in Meru Central District, Kenya. *October*, (65).
- Franzel, S., Arimi, H.K. and Mureithi, F.M. 2002. *Calliandra calothyrsus*: Assessing early stage of adoption potential of a fodder shrub in the highlands of Eastern Kenya. In: (Franzel S. and Scherr S.). *Trees on the Farm: Assessing the Adoption Potential of Nutrient Replenishing Technologies in Africa*. CABI. Wallingford, UK & ICRAF.
- Gonsalves, J., Becker, T., Braun, A., Campilan, D., De Chavez, D., Fajber, E., Kapiriri, M., Rivaca-Caminade, J., and Vernooy, R., (eds.). 2005. Participatory Research and Development for Sustainable Agriculture and Natural Resource Management: A Sourcebook. Volume 3: Doing Participatory Research and Development. International Potato Center-Users' Perspectives With Agricultural Research and Development, Laguna, Philippines and International Development Research Centre, Ottawa, Canada.
- Haan, N. 2001. Of goats and groups: A study on social capital in development projects. *Agriculture and Human Values* 18:71-84
- Hartemink, A.E. 2003. Soil Fertility Decline in the Tropics with Case Studies on Plantations. International Soil Reference and Information Centre. Wageningen, Netherlands and CAB International, Wallingford, UK.
- Howard, P. 2002. Reading Summary for Network Organizations, Theories of Collective Action. Large groups. January 4, 2002.
- Jaetzold, R., Schmidt H., Hornet Z.B. and Shisanya C.A. 2006. Farm Management Handbook of Kenya. Natural conditions and farm information. 2<sup>nd</sup> Edition. Vol.11/ C. Eastern Province. Nairobi, Kenya, Ministry of agriculture/GTZ.
- Jiggins, J. and de Zeeuw, H. 1992. Participatory Technology Development in Practice: Process and Methods, 135-162. In: Reijntjes, C., Haverkort, B. and Waters-Bayer, A. (ed.). *Farming for the future: An Introduction to Low-External- Input and Sustainable Agriculture*, London, MacMillan.
- Johnson, N., Suarez, R. and Lundy, M. 2002. The importance of social capital in Colombian rural agro-enterprises. Paper Presented at the 25<sup>th</sup> International Conference of Agricultural Economists, Durban, South Africa.
- Kampen J. and Shapland B. 2004. Building social capital for Agricultural Innovations. Experiences with farmer groups in Sub-Saharan Africa. 2004 KIT. Amsterdam, The Netherlands. Accessed on 1<sup>st</sup> November 2010 from: [www.kit.nl/publishers](http://www.kit.nl/publishers)
- Colombian rural agro-enterprises. Paper Presented at the 25<sup>th</sup> International Conference of Agricultural Economists, Durban, South Africa.
- Heemskerck, W., N. Lema, D. Guindo, C. Schouten, Z. Semgalawe, H. Verkuyl, B. de Steenhuijsen Piters and P. Penninkhoff, 2003. A guide to demand-driven agricultural research. The Client-Oriented Research Management Approach, Institut d'Economie Rurale, Department of Research and Development, Tanzania; Royal Tropical Institute (KIT), Amsterdam. KIT-Publishers, Amsterdam, December 2003.
- Jones, E. 2004. Wealth-based trust and the development of collective action. *World Development* 32:691-711.
- Kaaria, S. and Ashby, J.A. 2000. Women and Technology Initiative. The resources-to-consumption model. PRGA Working Document 13. CGIAR Systemwide Programme on Participatory Research & Gender Analysis (PRGA), CIAT, Cali, Colombia.
- Kiptot, E. 2007. Seeing beyond fertiliser trees. A case study of community based participatory approach to agroforestry Research and development in Western Kenya. Ph.D. Thesis, Wageningen University.
- Kiptot, E., Hebinck, P.G.M., Franzel S., Richards, P. 2007. Adopters, testers or pseudo-adopters? Dynamics of the use of improved tree fallows by farmers in western Kenya. *Agricultural Systems* 94:509-519.

- Meinzen-Dick, R. and Di Gregorio, M. 2004. Collective Action And Property Rights For Sustainable Development Overview. International Food Policy Research Institute 2033 K Street, N.W. Washington, DC, U.S.A.
- Makinde, E.A., Akande, M.O. and Agboola, A.A., 2001b. Effects of Fertilizer Type on Performance of Melon in a Maize-melon Intercrop. *ASSET Series*, A(2):151-158.
- Mavedzenge, Blasio, Z., F. Murimbarimba and C. Mudzivo. 1999. Experiences of farmer participation in soil fertility resesarch in southern Zimbabwe. *Managing Africa's Soils* No. 5. February 1999.
- Misiko, M. 2007. Fertile ground? Soil fertility management and the African smallholder. Ph.D. Thesis Wageningen University, Netherlands.
- Mucheru, W.M. 2003. Soil Fertility Technologies for Increased Food Production in Chuka, Meru South District. Masters Thesis, Kenyatta University, Nairobi, Kenya
- Mugendi, D.N., Mucheru-Muna, M.W. and Mugwe, J.N. (Eds.). 2006. Soil fertility: Enhancing community extension, Manilla publishers, Nairobi, Kenya
- Mugwe, J., Mugendi, D., Mucheru-Muna M., Merckx R., Chianu J. and Vanlauwe B. 2009. Determinants of the Decision to Adopt Integrated Soil Fertility Management: Practices by Smallholder Farmers in the Central Highlands of Kenya. *Expl Agric.*, 45:61–75.
- Mwangi, E., Meinzen-Dick, R. and Sun, Y. 2011. Gender and sustainable forest management in East Africa and Latin America. *Ecology and Society* 16(1):17. [online] URL: <http://www.ecologyandsociety.org/vol16/iss1/art17/>
- Odeno, M., Obare, G. and Salasya, B. 2010. Determinants of the speed of adoption of soil fertility- enhancing technologies in Western Kenya
- Ostrom, E. 1992. The rudiments of the theory of the origins, survival, and performance of commonproperty institutions. In: Bromley, D.W. (Ed.), *Making the Commons Work: Theory, Practice and Policy*. ICS Press, San Francisco, CA, USA.
- Palm, C.A., Myers, R.J.K. and Nandwa, S.M. 1997. Organic-Inorganic Interactions in Soil Fertility Replenishment in Replenishing Soil fertility in Africa, p. 193-218 Buresh, R.J., Sanchez, P.A. and Calhoun, F. (Eds.). Soil Science Society of America Special Publication No. 51, Madison WI.
- Peterson, J., Kwesiga, F.R., Franzel, S., Phiri, D. and Gladwin, C. 2004. Improved fallows in Eastern Zambia. In: Eillita, M., Mureithi, J., Derpsch, R. (eds.). *Green manure/cover systems of smallholder farmers; Experience from Tropical and Subtropical Regions*. The Netherlands, Kluwer Publishers.
- Place, F., Adato, M., Hebinck, P., and Omosa, M. 2005. The impact of agroforestry based soil fertility replenishment practice on the poor in Western Kenya. Research Report No. 142. International Food Policy Research Institute/World Agroforestry Centre Washington/Nairobi.
- Place, F., Kariuki, G., Wangila, J., Kristjanson, P., Makauki, A. and Ndubi J. 2002. Assessing the Factors Underlying the Differences in Group Performance: Methodological Issues and Empirical Findings from the Highlands of Central Kenya, November 2002.
- Pretty J. 2003. Social capital and connectedness: Issues and implications for agriculture, rural development and natural resource management in ACP countries. Review paper for CTA. CTA Working Document Number 8032. December 2003.
- Quisumbing, A. and Pandolfelli, L. 2008. Promising Approaches to Address the Needs of Poor Female Farmers. International Food Policy Research Institute. Note 13.
- Quisumbing, A. and Pandolfelli, L. (2008). Promising Approaches to Address the Needs of Poor Female Farmers. International Food Policy Research Institute. Discussion Paper, 00882.
- Reddy, S.K, Mohanty, M., Rao, D.L.N., Rao, S.A., Pax C Blamey, F., Dalal, R.C., Dixit, S.K., Pandey, M. and Menzies, N.W. 2010. Development of farmers' participatory integrated nutrient management technology using the Mother-Baby Trial Approach, 19<sup>th</sup> World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010, Brisbane, Australia.
- Sanginga, P.C., Lilja, N.K. and Tumwine, J. 2005. Assessing the quality of participation in farmers' research groups in the highlands of Kabale, Uganda. PABRA Millennium Workshop. Tanzania.
- Sanginga, P.C., Lilja, N.K. and Tumwine, J. 2001. Assessing the quality of participation in farmers' research groups in the Highlands of Kabale, Uganda PRGA; *CGIAR, Future Harvest*. Working document/PRGA No. 19.
- Sanginga, N. and Woomer, P.L. (eds.). 2009. *Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process*. Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture. Nairobi. 263 pp.
- Stringfellow, R., Coulter, J., Lucey, T., Mc Kone C. and Hussain, A. 1997. Improving the access of smallholders to agricultural services in Sub-Saharan Africa: Farmer cooperation and the role of the donor community, Natural Resource Perspectives. Overseas Development Institute.

- Uphoff, N., Wijayaratna, C. 2000. Demonstrated benefits from social capital: The productivity of farmer organizations in Gal Oya, Sri Lanka. *World Development* 28:1875–1890.
- Varughese, G. and Ostrom, E. 2001. The contested role of heterogeneity in collective action: Some evidence from community forestry in Nepal. *World Development*, 29(5):747-765.
- Wennink, B. and Heemskerk, W. (Eds.). 2006. *Farmers' Organizations and Agricultural Innovation. Case studies from Benin, Rwanda and Tanzania*. Royal Tropical Institute (KIT), Amsterdam, The Netherlands. Bulletin 374. 2006.
- Wopereis et al. 2009. *PLAR–IRM Curriculum: Technical Manual*.