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Full Length Research Paper

Assessing impact of soil management technologies on smallholder farmers' livelihoods in North Western Kenya

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Soil nutrient depletion is a major constraint to agricultural production on smallholder farms in Kenya. Intervention in the depletion through soil management project (SMP) was initiated in 1994 through 2004. Phase one involved development of low cost technologies while phase two was designed to upscale the technologies. An impact assessment of the SMP project on the livelihoods of target beneficiaries was carried out in 2006 to determine the effects of the project of target community. A semi structured questionnaire jointly developed by stakeholders after identifying progress indicators was administered to 192 respondents who were randomly selected using simple random sampling technique. The farmers were stratified into participating and control or counterfactuals. The results showed that there was significant impact on target communities and other stakeholders who were involved in the project. The crop yields food supply and household earnings increased. A number of farmers, extension agents and researchers were trained on integrated soil fertility management technologies and extension methodologies. Long term impact indicated that there were increased crop and livestock yields, enhanced food availability and improved access to agricultural information. However, there is demand to sustain the interaction between change agents and farmers.

Key words: Impact, assessment, soil, technologies.

INTRODUCTION

Land degradation will remain an important global concern because of its adverse impacts on agricultural production, food security, poverty and the environment (FAO, 2001; AusAID, 2004). Inappropriate land management, particularly in areas with high population densities and fragile ecosystems, further increases loss of productivity of resource poor farmers (Shyamsundar, 2002). This in turn affects farmers' livelihoods in rural settings. Poverty and food insecurity are major concerns among stakeholders along agricultural product value chain in not only in Kenya (Kenya 2004a, 2005, Mwangi, et al., 2001) but also other Sub-Saharan African (SSA) countries (IRDC, 1995; Welch et al., 2000; Chopra, 2004; FAO, 2007, Tchale et al., 2004). Despite the diverse interventions, the same development indicators have shown a declining trend in the past two decades. The per capita food production is progressively declining due to increasing human population, majority of who reside in rural settings. This was attributed to declining agricultural productivity due to nutrient mining that negatively impact on agriculture sector (De Jaeger et al., 1998; Chopra, 2004). Agriculture continues to play a significant role in Kenyan economic growth as it contributes approximately 26% of GDP, employing 75% of the national labour force (Kenya, 2007a; 2007b). Over 80% of the population lives in rural areas and make a living, directly or indirectly, from agriculture (Kenya, 2004a). Therefore, appropriate agricultural technology generation and dissemination is widely recognized as one of the major determinants of economic growth. In the past two decades, substantial progress has been made by research institutions in

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Table 1. Location, agro-ecological zones (AEZ) and population density of the study districts.

Greater district	Elevation (meters above sea level)	Agro-ecological zone	Mean annual rainfall (mm)	District coordinates	Population density (persons/km²)
Uasin Gishu (1439 km²)	1135 - 1350	LH	750-1250	0°03S′ - 0°55′N, 34°50′ - 35°37′ E	278
Marakwet (1190 km²)	2700 - 3350	UH; TA	750-1000	0°20’ - 1°30′N, 35°0′E - 35°45′ E	241
Keiyo (1190 km²)	1135 - 1300	UH; TA; UM; LM	750-1000	0°1' - 0°46' S, 33°54' - 34° 26' E	
West Pokot (4931 km²)	1200 - 3365	LM; IL	1200-1700	0°1' - 0°46' S, 33°54' - 34° 26' E	104
Trans Nzoia (1559 km²)	1800 - 1900	UH; UM; TA	1000-1200	0°52´ - 1°18´S, 34°38´ - 35°23´E	521

LH= Lower highland; UH= Upper highland; TA= Tropical alpine; UM= Upper midland; IIL= Inner lowland; LM = Lower midlands.

developing and disseminating low cost soil management technologies to smallholder farmers that was aimed at contributing towards improving livelihoods of rural folk (Mureithi et al., 2000).

The Soil Management Project (SMP) funded by The Rockefeller Foundation and Kenya Agricultural Research Institute (KARI) is one such project which developed and disseminated low cost integrated soil fertility management (ISFM) technologies to mitigate the declining soil fertility aimed at improving welfare of low resource-based household. Phase one (1994 - 2000) involved technology development while phase two (2000 - 2005) was tailored to technology dissemination. The best-bet low cost technologies were up-scaled through participatory methodologies/approaches which included farmer participatory research (FPR) and farmer field school (FFS) approaches. These approaches were advocated because they were perceived to be not only effective but also efficient in technology dissemination (Allen and Manyong, 2006). In addition conventional extension (CE) was also used.

Since the inception of the project there was no follow-up to assess the impact of the project on the livelihoods of farmers and other stakeholders. This study was designed to contribute to this information gap with the objective of assessing the SMP project impact on the livelihoods of target beneficiaries. The livelihood indicators identified included: stakeholder partnerships (associations) and linkages, formation of social networks, food security, income generation and resource sustainability. In particular, the measurable indicators of food security were the crop yields and the time taken for various food items to be stored. This was perceived to give evidence on the success and constraints of the project for development of future interventions.

MATERIALS AND METHODS

Description of study sites

The study was carried out in 2006 in two clusters of Matunda in Trans Nzoia (with poverty incidence of 54%) and Chobosta in Uasin Gishu (with poverty incidence of 42%) administrative regions of northwestern Kenya. The region lies in low highland (LH), upper midland (UM) and upper highland (UH) agro-ecological zones which are highly favourable for agricultural production (Jaetzold et al., 2005). Farmers practice mixed farming system. The dominant soil types are the nitisols, ferralsols and cambisols. These regions are major net exporters of maize grains in the country (Wangia et al., 2002; KFSSG, 2008) with relatively high maize technology adoption (Hassan, 1988.). However, maize yields and those of other crops (pulses, fodder, wheat, local and exotic vegetables) are progressively declining due to poor farm management practices. The small-scale farmers who are also food-poor in the region account for more than 80% of the farming community and their numbers are progressively increasing due to sub-division of large scale farms. The regions covered the following agro-ecological zone upper midland zone (which is maize-sunflower of Trans Nzoia district); lower highlands (which is wheat/maize and barley of Uasin Gishu, West Pokot, Keiyo and Marakwet districts) and L (Table 1). The major soils are Nitosols, Ferralsols, Cambisols, Acrisols and Regosols (Table 2).

Integrated soil fertility management (ISFM) technologies

During phase one of the project, the technologies developed and subsequently up-scaled in phase two included: inorganic planting fertilizers at the rates of 60 kg P_2O_5 ha^{-1} and top-dress with 60 kg ha^{-1} applied on maize crop (Mureithi et al., 2000). In addition, organic-inorganic combinations for maize at the rate of 30 kg P_2O_5 + 30 kg N + 5 tones of farm yard manure (FYM) or compost ha^{-1} were also recommended. Some legumes (like soy beans and dry beans) were promoted for food and soil fertility improvement through nitrogen fixation. *Dolichos lablab* which was also part of the (Integrated soil fertility management (ISFM) strategy as green manure for incorporation in the soil at an appropriate growth stage

Table 2. Major soil types by AEZs in mandate districts (ranking and acreage).

Soil types	Major soil types (ha) by AEZ						ALL (ha)	Ranking
	TA	UH	LH	UM	LM	IL		
Nitosols	0	257,600	164,600	108,850	3100	0	534,150	1
Ferralsols	0	6250	155,850	150,900	42,000	0	355,000	2
Cambisols	40,000	31,800	66,400	47,500	97,500	7500	290,700	3
Acrisols	0	0	4000	59,100	101,250	0	164,350	4
Regosols	100	46,250	21400	20,450	25,600	45000	158,800	5
Solonetz	0	0	0	0	9000	100,000	109,000	6
Lithosols	2600	30,000	21,400	11,700	2000	2500	70,200	7
Gleysols	0	0	51,800	6700	1000	0	59,500	8
Luvisols	0	0	8100	37,100	10,350	0	55,550	9
Vertisols	0	0	0	4200	1000	0	5200	10
Rankers	20,000	0	0	0	0	0	20,000	11

Source: Computed from Jaetzold and Schmidt (1983).

was also recommended. The later is also a rich livestock feed (Nyambati et al., 2009).

Compost manure

To prepare compost, the ground has to be loosened and dry materials (e.g. chopped maize stover, bean hulms and dry leaves) are then placed followed by a thin layer of plant materials followed in turn by a thin layer of soil (or FYM) if available and ash. The layering is repeated until the heap is about 1 m high. After placing soil, it is always advisable to add water in order to increase moisture levels for effective decomposition to take place. The whole heap is then covered with soil. A stick (thermometer) is then placed in the middle to check for the degree of decomposition to check on decomposition process. The heap is then shaded to avoid nutrient leaching due to rains. After full decomposition, the compost is then placed in the planting holes of the crop in question. For maize, 5 or 10 ton ha $^{-1}$ is applied.

Farm yard manure (FYM)

A collected mixture of dung and stover from a cattle boma piled under shade was used as control for nutrient loss. The material is stored in the shade until the mixture is fully decomposed. A fully decomposed FYM changes colour and friable texture when applied in planting holes at the rate recommended for each crop; for maize, 5 or 10 ton ha^{-1}.

Inorganic fertilizers

The commonly used inorganic basal fertilizer are diammonium phosphate (18:46:0), mono-ammonium phosphate (MAP) while tp-dress fertilizers are calcium ammonium nitrate (0:26:0) and urea (0:46:0). For planting fertilizers placed in planting holes 60 kg P_2O_5 ha^{-1} and top-dress with 60-kg ha^{-1} was applied when maize crop is about six weeks after germination.

Organic manure - Inorganic fertilizer combinations

This includes application of organic resources of animal or plant origin in combination with mineral inputs to maximize input use efficiencies and return to investments. The combination was perceived to solve the problem of increasing cost of inorganic fertilizers (Ariga et al., 2006, 2007). After testing a number of treatments, the recommended rates of organic/inorganic combinations for maize was 30 kg P_2O_5 + 30 kg N + 5 tonnes of FYM or Compost ha^{-1}.

Other soil nutrient sources

Integration of cover crop and multi-purpose, woody and herbaceous legumes in existing cropping systems was also developed and disseminated. This was aimed at increasing the availability of organic resources and consequently to improve crop yields and farm profits. One of the cover crop crops was *D. lablab.* These crops can also be used as a livestock feed.

Conceptual framework

Impact evaluation establishes whether the project had a welfare effect on target population and whether the effects can be attributed to the project. We develop an impact assessment conceptual framework that leads to specification of models for empirical analyses of SM project effects. This framework draws on the related existing impact evaluation literature and particular that of Maluccio (2005). It was hypothesized that there would be improved lively-hoods of all farmers who participated in the SM project through the enhanced agricultural outputs through adoption of ISFM technologies. This was achieved through participatory approaches of technology development and transfer. Farmers were involved in all stages of technology generation continuum and therefore expected effects on livelihoods of farmers and other actors were high. Livelihoods connote the means, activities, entitlements and assets by which people make a living (Devereux et al., 2004). Assets, in this context, were defined as; natural or biological (land degradation), social (community associations and social networks, participation in projects, empowerment through training and income acquisition), human (knowledge creation through skills acquired) and physical (that is, household assets, farm produce etc). Thus, a livelihood comprises the capabilities, assets (including both material and social resources like skills) and activities (adoption of ISFM strategies) required for a means of living (Chambers and Conway, 1992; Adato and Dick, 2002). Livelihood assessment is a way of looking at how an individual, a household, or a community behaves

Table 3. Selection criteria for the counterfactual groups in SMP impact assessment study.

Study sites	AEZs potential	Ethnicity	Farm systems	Remoteness	Farm sizes	Change agents
Matunda/Weonia-Target	High	Luyha	Mixed/sedentary	Low	Small	Medium
Birunda-Counterfactual	High	Luyha	Mixed/sedentary	Low	Small	Medium
Chobosta-Target	High	Nandi	Mixed/sedentary	Low	Medium	Medium
Merewet-Counterfactual	High	Nandi	Mixed/sedentary	Low	Medium	Medium
Yuya-Target	High	Luyha	Mixed/sedentary	Low	Small	Medium

under specific frame conditions (Ashley and Hussein, 2000). One of the ways to understand livelihood systems is to analyze the coping and adaptive strategies pursued by individuals and communities as a response to external shocks (poverty and hunger) and stresses such as land degradation (decline in soil fertility) and policy failures (Ashley and Carney, 1999; Brown, et al., 2006). This study looks at how the SM project intervention through development and dissemination of low cost technologies influenced the farmers' livelihoods.

Survey design

We have *ex ante* impact assessment (IA) which is carried out before the project starts and *ex post* impact assessment which is carried out after the completion of the project (Alston et al., 1995). This study addressed the *ex post* IA. To estimate the true treatment effect of ISFM technologies on livelihood indicators of target population, two groups of farmers were identified; the 'treated' which included those who benefited from the technologies and those who did not (non-treated). The impact estimation was done by generating panel data for two periods; before project implementation (baseline data) and after project implementation in 2006. Both primary and secondary data were utilized. Secondary data was collected from project monitoring and evaluation records using a checklist. The data were collected on key livelihood indicators 'before' and 'after' the implementation of the project for both the treatment group and the comparison group. The livelihood related observations were made on food security, poverty, social capital and natural resource (soil fertility) assets.

The baseline data were collected in 2000 before the up-scaling intervention began. This was done through personal interviews using a semi-structured questionnaire. A checklist was used to rate contribution of stakeholders on the project. Multistage sampling technique was used to select divisions, villages and respondents. After establishing a sample frame for treated and control clusters, a composite sample size of 192 households (120 participants and 70 non-participants) was randomly selected using simple random sampling technique. The sample frame for the control group was developed with theA collected mixture of dung and stover from a cattle boma piled under shade was used as control for nutrient loss. The material is stored in the shade until the mixture is fully decomposed. A fully decomposed FYM changes colour and friable texture when applied in planting holes at the rate recommended for each crop; for maize, 5 or 10 ton ha^{-1}.

Data analysis

The quantitative evaluations were undertaken to establish the average effect of the soil management (SM) project on a number of indicators at the household level. The difference-in-difference (or double difference) model (Maluccio, 2005) and descriptive statistics were used to assess the impact of the project on the selected indicators (Livelihood assets, food security, income generation and social capital) in approaches of up-scaling technologies. Despite the limitations, DD is a popular approach to non-experimental evaluations in the IA literature (Nkonya et al., 2008). In this model comparison is made between treatment (target) and comparison (counterfactual) groups in terms of outcome changes over time relative to the outcomes observed for a pre-intervention baseline. Thus, DD requires quality baseline study on specified indicators which was conducted in 2000 just before the up-scaling work was initiated.

The model allows for conditional dependence in the levels arising from additive time-invariant latent. The difference-in-difference (or double difference) method entails comparing observed changes in outcome before and after the project for a sample of participants and non-participants. Outcome data was collected on both participants and non-participants using a baseline survey before the program. This was repeated through a survey in 2006 after the program was implemented. This repeat survey was highly comparable with the baseline survey of the progress indicators. The mean project impact was estimated by comparing the mean difference in outcomes "after" and "before" the SM project intervention between the participants and non-participant groups. The assumption of the DD approach is that project participants have the same outcomes as individuals in the comparison group in the absence of the project. Thus, difference between 'before' and 'after' periods in the comparison group was a good counterfactual for the treatment group. This was done by computing the difference before-after for the comparison group (Equation 1) and the difference before-after for the treated group (Equation 2). The overall impact (double difference or difference in difference) was as shown in Equation 3. The key advantage of the double-difference estimator is that it nets out the effects of any observable or unobservable additive factors that have fixed (time-invariant) impacts on the outcome indicator, or that reflect common trends affecting project participants and non-participants equally (such as changes in prices or weather (Maluccio, 2007).

$$\bar{y}_{C1} - \bar{y}_{C0} = \frac{1}{N_C}(\bar{y}_{j1} - \bar{y}_{j0}) \tag{1}$$

$$\bar{y}_{T1} - \bar{y}_{T0} = \frac{1}{N_T}(\bar{y}_{i1} - \bar{y}_{i0}) \tag{2}$$

$$net - impact = (\bar{y}_{T1} - \bar{y}_{T0}) - (\bar{y}_{C1} - \bar{y}_{C0}) \tag{3}$$

Where y_{T1} = outcome (e.g., income, food supply) of beneficiaries after the project started; y_{T0} = outcome of beneficiaries before the project started; y_{C1} = outcome (e.g., income, food supply) of non-beneficiaries after the project started; and y_{C0} = outcome of non-

Table 4. Impact of SM project on food crop yields in northwest Kenya.

Crop	Yield, 90-kg bags per acre						
	Counterfactuals n = 70			Participating n = 120			
	Before	After	Impact	Before	After	Impact	Net impact
	$(\bar{y}_{C0})$	$(\bar{y}_{C0})$	$(\bar{y}_{C0} - \bar{y}_{C0})$	$(\bar{y}_{C0})$	$(\bar{y}_{C0})$	$(\bar{y}_{C0} - \bar{y}_{C0})$	$(\bar{y}_{C0} - \bar{y}_{C0})-(\bar{y}_{C0} - \bar{y}_{C0})$
Maize	12.4	13.2	1.2	11.6	15.5	3.9	2.7
Beans	0.98	1.52	0.55	1.34	1.67	0.33	-0.22
Soy beans	0	0	0	0	1.3	1.3	1.3*
Finger millet	4.4	3.63	0.77	3.03	1.4	1.63	0.86
Ground nuts	0	0	0	0	0.18	0.18	0.18*
Sorghum	0.20	0	0.2	0.36	0.68	0.32	0.12
Sweet potatoes	7.0	10.0	3.0	8.7	17.4	8.7	5.7

* New crop introductions in the farming systems.

beneficiaries before the project started; N_c is the sub sample of counterfactual and N_T is that of beneficiaries (treated group).

RESULTS AND DISCUSSIONS

Effects at household level on production levels (physical assets)

One of the key progress indicators of soil fertility productivity enhancing technologies which were accompanied by agronomic packages for the test crops was the yield changes which also shifts production frontier of targeted farm enterprises. The target crops were those commonly grown by farmers and they included maize, beans, sweet potatoes, and vegetables. However, a few were new introductions (soy beans, groundnuts) that were demanded by farmers after project tours in other farming communities. From Table 4, there was an overall net improvement in maize (*Zea mays*) yield of 2.7 90-kg bags per acre which can be attributed to the project. The other enterprises with net increase in yields included: soy beans *(Glycine max =Glycine soja)* finger millet *(Eleusine sp)* (0.86), ground nuts, sorghum (0.12) and sweet potatoes (*Ipomea batatus*) (5.7).

However, soy beans and ground nuts *(Arachis hypogaea)* were new introduction in the target farming systems and were only planted by treated or participating farmers. Soybeans and groundnuts were new crops introduced in the target areas. One of the three components of food security is food availability which has to do with the supply of food. Thus, yield increase may have contributed to this aspect of the household who accessed the ISFM technologies and practiced them. This demanded enhanced up-scaling of the relevant technologies in order to increase and sustain productivity for the farming communities. Since the target population was low, resource-based smallholder farmers, accessing the technologies would enhance farm produce supply and subsequently improve food security in the regions.

Effects of farmer level on human capital

FFS members who practiced ISFM technologies focused on social and participatory processes that led to increased social capital accumulation. The progress indicators for human capital were the number of stakeholders trained, skills and confidence acquired and confidence acquired from SM project activities. Capacity building was one of the project objectives particularly when initiating participatory approaches in research and extension activities using FFS and FPR approaches. Researchers, extension staff and farmers were trained and fully sensitized on project implementation and progress monitoring of indicators. A total of 38 officers, 21 males and 17 females from all disciplines and programs were trained on procedures participatory monitoring and evaluation of project activities (PME) (Figure 1). In addition, through the project monitoring unit, it was found out that FFS was more superior than FPR and CE in disseminating the technologies to farmers. This is because the number of farmers who adopted the technologies using FFS rose from 192 in year 2001 to 1068 in 2004 while that of FPR and CE rose from 330 to 770 and 108 to 110 respectively during the same period. These farmers were also used as technology disseminators to complement other government and non-governmental extension staff. This implies that the use of multiple approaches that are synergistic enhances the adoption rates.

Effects at household level on social capital

Participation in the SM project was hypothesized to affect human and social capital directly through enhanced capacity to disseminate ISFM technologies through result demonstrations and experimentation. In addition to

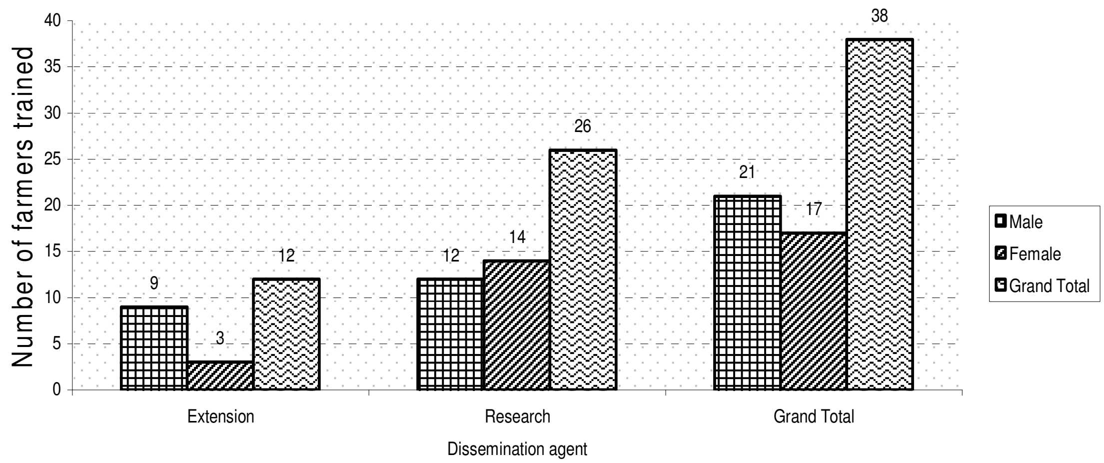

Figure 1. Actors along the value chain trained on monitoring project benefits.

Table 5. Farmer rating of selected social capital aspects attributed to SMP.

Social capital aspects	Farm category	n	Mean	SD	SE	t-value
Demonstration level of ability	Counterfactual	70	2.50	1.18	0.37	10.73***
	Contact	120	2.37	1.10	0.20	
Communication level of ability	Counterfactual	70	3.50	0.93	0.33	14.63***
	Contact	120	2.84	1.11	0.20	
Relate to other farmers level of ability	Counterfactual	70	2.68	1.01	0.18	13.87***
	Contact	120	2.60	1.07	0.34	
Relate to extension's level of ability	Counterfactual	70	1.89	1.07	0.20	9.01***
	Contact	120	1.80	0.42	0.13	
Relate to researchers level of ability	Counterfactual	70	1.42	0.90	0.18	6.15***
	Contact	120	1.00	0.00	0.00	
Decision making process	Counterfactual	70	2.97	1.02	0.19	20.38***
	Contact	120	2.70	0.48	0.15	

Rating 1= very high, 2=high, 3=moderate, 4=low, 5=very low

demonstration, participation would strengthen communication skills, ability to relate to change agents (research and extension), other farmers and analytical skills in decision making process (problem solving skills). Table 5 shows that the contact groups rating social capital aspect was higher than counterfactual. The farmers' ability to conduct and explain the SM technology demonstrations was rated higher project participants (2.7) than the non-participants (3.5). This could be attributed to the fact that through the FFS and FPR approaches, farmers were engaged in group collective activities of conducting demonstrations.

These activities further strengthened their ability to work together and share information through set out new rules and norms which were to be followed for group management. For example during open days that were held at least once a year in each FFS. In addition, farmers' ability to communicate was rated higher by participants (2.3) than non-participant (2.50). The farmers were also encouraged to make presentations after (agro-ecosystem analysis (AESA) during FFS training sessions and also during open days where the farmers were hosting others. The relationship between farmers and researchers including extension were rated higher by project participants than non-participants. Social capital which is an important aspect in community development relates to the following aspects among group members: adherence to rules and norms, collective responsibility, group cohesiveness, attitudes, innovativeness, and degree of heterogeneity of group members. In addition, it may refer to networking with other institutions. All these aspects were integrated in SMP activities through the

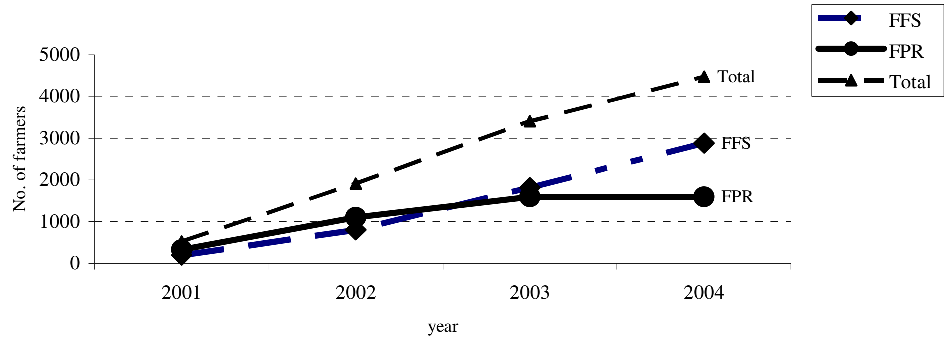

Figure 2. Total number of farmers trained under the project.

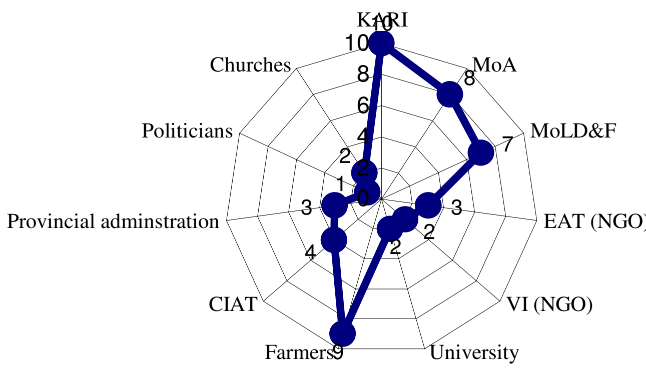

Figure 3. Stakeholder rating of their contribution to project.

FFS processes. Contact farmers had increased self-esteem and confidence in disseminating technologies and also taking up leadership roles in the group and wider community responsibilities. From about 45 FFSs there was at least one farmer popularly known as farmer teacher facilitator from each group who was training other farmers during field days and exchange visits; majority (>50%) of the farmers. Despite the fact that about60% of the total FFSs established through the project sustained the groups, others did not. Local and supra-levels groups were also formed during and after project completion. For example there were efforts to establish district FFS network. The groups also came up with proposals to attract funds in other projects and micro-financial institutions.

Assessing partnership and linkages of stakeholders

Farmers were asked to rate the contribution of various stakeholders to the project on a scale of 1 - 10. Figure 1 shows the degree of contribution (computed scores) and linkages among stakeholders involved in the soil management project. On a scale of 1 to 10 stakeholders were rated based on their contribution to the project activities. From the results, research through Kenya Agricultural Research Institute (KARI), farmers and Ministry of Agriculture contributions were higher than the rest (Figure 3). The research-farmer and research-extension linkages established through the project still exist within specific areas. These linkages need to be expanded, strengthened further and sustained for enhanced and perceptible impact to continue.

Effects of farmer level on enhanced food security

A proxy indicator to food security impact was the number of months the food stayed in store *ceteris paribus*. Table 6, shows the food security situation using the number of months a given type of food crop harvested by the household stayed in store as a proxy indicator. From all the target enterprises, the number of months harvested food stayed in the store for maize and sweet potatoes decreased among the counterfactuals while it increased for the contact farmers. The net impact of all the crops was an increased number of months the food stayed in stores. This implies that the project had a positive effect on the food situation of the target farming community.

Impact at farmer level on financial capital

Proxies to poverty alleviation through income generation

Table 6. Period (in months) food lasts in the store for households in North West Kenya.

Crop	Number of months						
	Counterfactuals n = 70			Participating n = 120			Net impact
	Before (a)	After (b)	Impact (b-c)	Before (d)	After (e)	Impact (e-d)	[(e-d)-(b-c)]
Maize	5.6	4.9	-0.7	3.8	7.1	3.3	4.0
Beans	5.5	4.3	-1.2	1.8	6.2	4.4	5.6*
Finger millet	4.8	6.4	1.6	3.4	6.2	2.8	1.2
Ground nuts	2	2	0	0.9	6	5.6	5.6**
Sorghum	1	6.5	5.5	6.6	7.6	1.0	4.5
S/potatoes	6.6	6.5	0.1	4.0	5.9	1.9	1.8
Vegetables	7.7	7.0	0.7	2.6	7.6	5.0	4.3

*1% and **5% significant level, respectively.

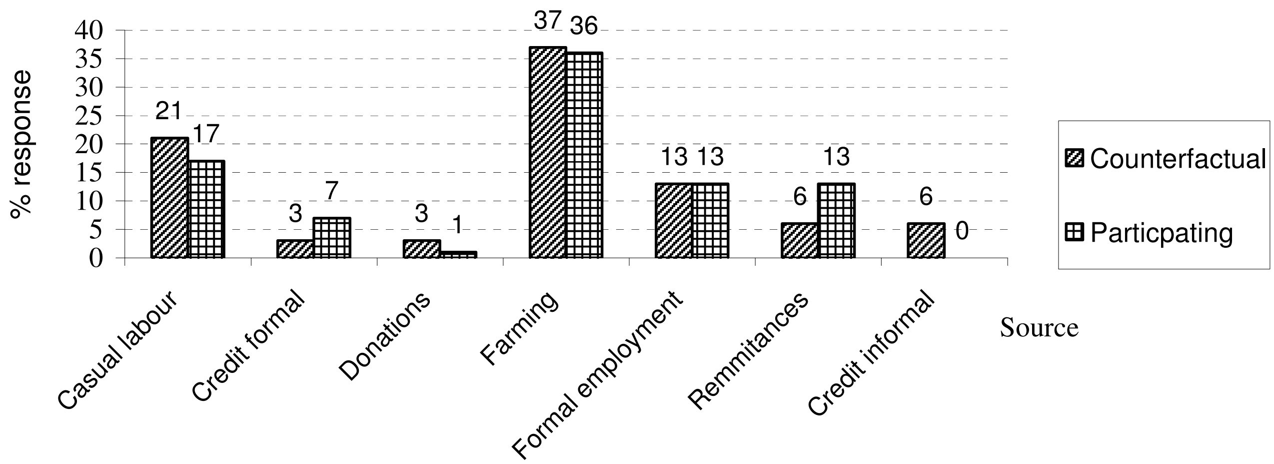

Figure 4. Sources of income for participating and counterfactual groups.

were the different household income sources. The main sources of income for participating and counterfactual groups were farming with casual labour being the second (Figure 4). However, 21% of counterfactuals group depended on casual labour as a source of income while the proportion for the contact was 17%. This may imply that the farmers who had adopted the ISFM technologies spend more time on their farms to increase farm earnings instead of selling their labour services to other households. This was because casual labour was a common practice among the farming communities in these regions in exchange for cash to meet their household financial obligations. The same trend was reported in engaging in farming and donations except for the case of remittance from friends and relatives, which was less in counterfactuals (7%) than in participating group (13%). This implies that there was an improvement in farming as a source of income among the contact farmers. The demand for credit (both formal and informal) among the participants was higher compared to the counterfactual. This is because farmers were encouraged to design projects that would assist them get funds from other financiers. For example some groups could have accessed funds from micro-financial institutions like K-rep, Faulu Kenya and Equity bank among others. In addition, groups formed during and post SM project implementation had their own merry-go-round not only for lending among the group members but also to buy other household assets.

Farmer perception to soil fertility enhancement using weeds

Effects at plot were also collected targeting natural resource aspects. Farmers were asked what they used as indicator to soil fertility improvement and they said that other than yield, they used weeds and soil colour as proxy indicators. Subsequently, among the indicators for land resource, conservation and sustainability identified, was a soil fertility change using weeds as surrogate indicators of soil fertility changes (De Jager et al., 2001, 1998). The impact of the project on soil fertility enhancement using the proxy indicator as weeds

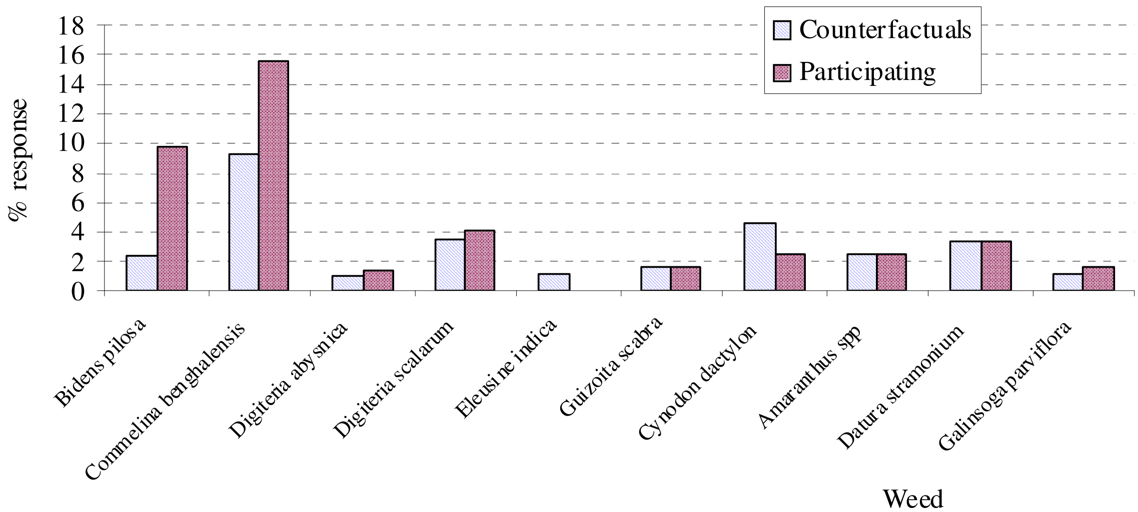

Figure 5. Responses on surrogate weeds indication of soil fertility changes.

types growing on the farm before and after adoption of the soil amendment technologies was variable. Some of the weeds that indicated increased soil fertility included *Commelina benghalensis, Digitaria scalarum, Bidens pilosa, Cynodon dactylon, Guizoita scabra and Eleusine indica* (Figure 5). As indicated by respondents, in some plots there were net increases in population of increased fertility weed indicators.

Constraints encountered in the project implementation

Despite the fact that the project was smoothly implemented in almost ten years with steady financial flows, there were some limitations. Farmers and other stakeholders were asked what constraints they perceived, threatened the successful implementation of the project. Majority of farmers (>65%) in the project indicated that the weaning off period of project activities was abrupt. This could have been attributed to the fact that farmers had sustained contact with the change agents for about ten years without interruptions and most of them would have wished the process to continue. The active participation of extension agents coupled with the training they were given was expected to sustain the contacts among stakeholders in the project. In addition some sub-activities like tours, and establishment of networks among the FFSs were not undertaken as scheduled. Lack of implementation of the activities was attributed to poor communications among the project managers, farmers and other stakeholders. To support other activities some inputs were given, however, some farmers thought that it was a continuous process. The linking of farmers to markets was not well integrated in the project activities and farmers were finding it difficult to sell some surplus outputs.

Conclusion and Recommendations

From the results the project had a positive impact in terms improving food availability, enhanced human and social capital accumulation. Enhanced social capital among stakeholders was realized through training of stakeholders in the project and identifying and strengthening linkages among them. On the demand side, farmers were sensitized to demand for agricultural and financial services from the change agents and financial institutions respectively. There was enhanced impact on food availability, income generation and improved soil fertility in the contact cluster sites compared to non-contact sites. However, there was need to enhance and sustain the network among the value chain stakeholders who were involved in the project as some of the partners were lowly rated as regards the contribution to the project. The project would have also looked at the input-output aspects in order to motivate farmers to continue practicing the soil management intervention. Targeting interventions can enhance the livelihoods of low resource base farmers as indicated by (Kraybill and Bashaasha, 2006). Continued investment in agricultural production will depend on the incentives farmers get from policy makers. However, other projects need to emulate the SMP in the design and implementation approaches for enhanced, improved and sustainable agricultural productivity.

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