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Analysis

Social influence and collective action effects on farm level soil conservation effort in rural Kenya

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ABSTRACT

This paper analyzes the effects of social influence and participation in collective action initiatives on soil conservation effort among smallholder farmers in Lake Naivasha basin, Kenya. We apply binary and ordered probit models in a two stage regression procedure to cross-sectional data collected through a household survey among randomly selected smallholder farmers. Smallholder farming systems in the research area are associated with practices that render farmlands susceptible to soil erosion causing negative impacts on land and the environment. Therefore, strategies that encourage soil conservation are likely to also offer solutions for dealing with agri-environmental challenges and poverty alleviation. Results indicate that social capital facilitates participation in collective action initiatives which then influence individual soil conservation efforts. Neighborhood social influences, subjective norms, gender, education level, farm size, access to credit and livestock ownership also emerge as key determinants of soil conservation effort. Policy implications drawn by this study encourage strategies to increase participation and effectiveness in collective action initiatives as a boost to soil conservation. Implementation of soil conservation practices could also be encouraged through awareness increasing instruments, facilitating access to agricultural micro-credit and paying attention to gender related challenges on knowledge access and rights over land and other natural resources.

1. Introduction

The agricultural sector plays a key role in livelihood support and economic development in Sub-Saharan African (SSA). However, statistics indicate that historically agricultural productivity growth in SSA has been lower than in the rest of the world (OECD and FAO, 2012). The stagnation in productivity growth can be attributed to suboptimal external input use, pests and diseases, soil degradation, frequent and prolonged droughts, and poor market integration among other challenges (World Bank, 2008). Soil degradation which occurs mainly through soil erosion and loss of soil fertility is a major challenge to SSA agriculture because it not only causes a decline in crop yields and desertification but also increases crop production costs in the long run. Smallholder farming systems in SSA are characterized by high rates of land fragmentation, intensive tillage of land, nutrient mining and extraction of crop residues to feed livestock. These practices accelerate soil degradation and soil erosion, making agriculture one of the most serious sources of non-point water pollution. In cases where rural agriculture has intensified, increased use of inorganic fertilizers leads to infiltration of nitrogen and phosphorous from agricultural fields to surface water bodies (Berka et al., 2001). Effective soil erosion control could therefore enhance long term productivity of farmers' most valuable physical asset—land, mitigate the negative impacts of soil degradation on crop yields and the environment and also boost efforts towards rural poverty alleviation.

Achieving substantial adoption and diffusion of soil and water conservation practices and other agricultural innovations in SSA has been a challenge in recent decades, a trend that authors attribute to low awareness, negative attitudes and insufficient financial capacity among other factors (Khisa et al., 2007; Pretty et al., 1995; van Rijn et al., 2012). However, it is noted that sometimes even when the right conditions prevail, adoption rates may still remain low. As Lynne et al. (1988) note, awareness, right perceptions and substantial capacity are necessary but not sufficient conditions for the adoption of soil conservation practices. This observation raises the question: Why would farmers not adopt a practice even when economic incentives seem sufficient?

To answer this question, we have to seek other factors beyond individual capacity and perceptions that could explain farmers' choices such as social factors. Given that soil and water conservation practices are associated with benefits that are partly public goods, one of the important aspects to consider is the effect of communal coordination mechanisms on individual adoption behavior. Collective action is cited as one of the most successful coordination mechanisms for natural resources management and also for increasing agricultural production (Meinzen-Dick et al., 2002; Ravnborg et al., 2000). Collective action can be defined as what happens when individuals voluntarily contribute to an effort towards achieving an outcome (Poteete and Ostrom, 2004) or when voluntary action is taken by individuals within a group to achieve a common goal (Meinzen-Dick and Di Gregorio, 2004). At community level, the effects

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of collective action are clear since individuals are able to mobilize local resources as an avenue for seeking solutions to societal problems, especially where isolated individual efforts to solve these problems are not tenable (Swallow et al., 2002). What is not clear is the indirect role of participation in collective action as a driver for individual efforts on soil and water conservation. Do individuals who participate in collective action acquire certain network externalities which enable them to implement better practices? To explain this we need to look at how collective action emerges and operates. Social networks and social participation which are important components of social capital enable individuals to engage in frequent interactions with others and facilitate the access to information and sharing of knowledge and better access to markets through collective bargaining. Reciprocity based on trust and trustworthiness is also an important feature that facilitates collective action since individuals within a social group may engage in informal exchanges with each other in the hope that the counterparts will reciprocate (Pretty and Ward, 2001). Through reciprocate exchanges; individuals are able to minimize costs associated with acquisition of inputs hence making technology adoption easier. Social networks and repeated interactions create mutual social influence between individuals within a group, a phenomenon that is manifested through subjective norms and neighborhood social influences. A subjective norm is defined as "a person's perception that most people who are important to him or her think (s)he should or should not perform the behavior in question" (Ajzen and Fishbein, 1975). Neighborhood social influences relate to the degree of prompting that an individual receives from peers. There is however limited evidence in the literature on the direct role of neighborhood social influences and subjective norms in determining soil conservation effort.

Against this backdrop, the current study seeks to analyze the effect of neighborhood social influence and participation in collective action initiatives on soil conservation effort among smallholder farmers in Lake Naivasha basin, Kenya. Soil conservation effort is measured by the number of soil conservation practices that a farmer has implemented among a variety of practices: terracing, Napier grass, contour farming and filter grass strips. The study seeks to ascertain whether social capital facilitates collective action which then enhances individual action and whether social control that may emerge from social networks within a community may substitute for pure economic incentives to undertake individual action on soil conservation. To achieve the stated objectives, we apply a two stage econometric estimation procedure to primary data collected during a household survey among 307 randomly selected small-scale farmers.

The rest of the paper is structured as follows: Section 2 presents our theoretical and conceptual frameworks and empirical models and Section 3 describes the study area and data collection methods. Section 4 presents and discusses descriptive and regression results, while Section 5 concludes and draws policy implications.

2. Theoretical and Conceptual Frameworks

2.1. Theoretical Framework

Following Fernandez-Cornejo (2007), our theoretical model modifies the agricultural household model (Singh et al., 1986) to accommodate participation in collective action initiatives and technology adoption decisions. The agricultural household model explains farm household optimization behavior by maximizing utility (U) as per the objective function:

$$\text{Max } U = (G, L, H, \varphi) \tag{1}$$

where G = purchased consumption goods, L = leisure, H = factors exogenous to the current decisions such as human capital, and φ = other household characteristics. Household utility is maximized subject to:

$$\text{Income constraint}: P_g G = P_q Q - W_x X' + WM' + I \tag{2}$$

$$\text{Technology constraint}: Q = Q[X(\tau), F(\tau), H, \tau, R], \tau \geq 0 \tag{3}$$

$$\text{Time constraint}: T = F(\tau) + M + L, M \geq 0 \tag{4}$$

where P_g and P_q denote the prices of purchased goods and farm output respectively, G and Q are quantities of purchased goods and farm output respectively; W_x and X are row vectors of price and quantity of farm inputs which is a function of the intensity of technology adoption (τ); I is exogenous income, $\mathbf{R}$ is a vector of exogenous factors that shift the production function; and T denotes the total household time endowments, which is split between off farm activities, M; Leisure, L and farm work, F which is a function of the intensity of technology adoption (τ) since some technologies are labor saving hence freeing some labor time for allocation to other activities. The technology constrained measure of household income is obtained by substituting Eq. (3) into Eq. (2) (Huffman, 1991):

$$P_g G = P_q Q[X(\tau), F(\tau), H, \tau, R] - W_x X(\tau)' + WM' + I. \tag{5}$$

The first order optimality conditions (Kuhn–Tucker conditions) are obtained by setting up the Langragian function (6) and maximizing $\mathcal{L}$ over (G, L) and minimizing the function over the Langrage multipliers (λ, μ):

$$\begin{aligned} \mathcal{L} = {} & U(G, L, H, \varphi) \\ & + \lambda\left\{P_q Q[X(\tau), F(\tau), H, (\tau), R] - W_x X(\tau)' + WM' + I - P_g G\right\} \\ & + \mu[T - F(\tau) - M - L]. \end{aligned} \tag{6}$$

Reduced form equations of the household model obtained from the Kuhn–Tucker conditions of Eq. (6) can be used to obtain optimizations for off farm participation decisions and decisions on adoption of technology. The household decision to participate in off-farm activities depends on the relation between the wage rate and the marginal product of farm labor. This relation can be used to obtain the demand functions for on-farm labor and leisure and eventually the supply function for off farm time. Non-zero optimum off farm time allocation occurs when marginal product of farm labor is equal to the wage rate, or when the wage rate exceeds the reservation wage (Fernandez-Cornejo, 2007). On the other hand, the optimal extent of adoption will occur when the value of marginal benefit of adoption is equal to the marginal cost of adoption, which includes the marginal cost of production inputs and the marginal cost of farm work brought up by adoption of the technology, valued at the marginal rate of substitution between leisure and consumption of goods. Fernandez-Cornejo (2007) suggests the use of implicit function theorem to derive expressions for off-farm labor supply and technology adoption as a function of wages, prices, human capital, non-labor income and other exogenous factors. These factors may be replaced in the reduced form representations of farm labor supply and technology adoption by observable farm and farmer characteristics. The following section reviews the literature on soil conservation to identify important variables that will be used in the empirical models to analyze household decision making in participation in collective action and implementation of soil conservation practices.

2.2. Conceptual Framework and Hypotheses

Adoption and diffusion of agricultural technologies have been studied extensively since the inaugural work by Ryan and Gross (1943) and Rogers (1962). Previous studies have identified key determinants of soil conservation technology adoption which can be categorized into personal characteristics such as age, gender and education level (Doss and Morris, 2001; Napier et al., 1984); economic factors like income, farm size and household asset ownership (Ervin and Ervin, 1982; Kabubo-Mariara et al., 2006; Marenya and Barrett, 2007; Nkonya et al., 2008); physical factors like slope, altitude, climate and soil quality

(Kabubo-Mariara, 2012); and social and institutional factors such as credit, access to extension services, land tenure and perceptions on existence of soil erosion problem and the benefits of engaging in soil conservation (Ervin and Ervin, 1982; Kabubo-Mariara, 2007, 2012; Meinzen-Dick and Di Gregorio, 2004; Migot-Adholla et al., 1991; Place and Swallow, 2000; Rogers, 1995; Shiferaw and Holden, 1998).

To understand individual decision making beyond a purely individual perspective, behavioral approaches have also been initiated by Lynne and Rola (1988) and Lynne et al. (1988) who applied the Theory of Reasoned Action (TRA) developed by Ajzen and Fishbein (1975) in the analysis of farmers' attitudes and conservation behavior. TRA links behavior to attitudes and social norms. An application of TRA to water conservation behavior by Lynne et al. (1995) finds a positive influence of community (subjective) norms on the likelihood and intensity of adoption. Technology adoption can be seen as a social process where individuals' decisions are conditioned by the social context within which they exist (Barrett et al., 2002). The social environment can be viewed as a complex pattern of a) individuals interacting and working together to achieve common goals and b) the possibilities of individuals influencing each other towards performing certain behaviors. The social influence–technology adoption link is expressed through subjective norms and neighborhood social influences which are embedded within social norms and social capital. Neighborhood social influences facilitate social learning, a process that helps to shorten the adoption process. Frequent interaction with potentially influential agents also creates network externalities (Foster and Rosenzweig, 1995; Kim and Park, 2011; Nyangena, 2006) and fosters the formation of social capital.

Social capital is a composite concept which encompasses *social participation*, *social support*, *social networks*, *reciprocity* and *trustworthiness* and enhances the ability of individuals to cooperate hence formation of collective action (Ostrom and Ahn, 2009) which can support or even make up for the lack of individual action in natural resources management. As Meinzen-Dick et al. (2002) indicate, participation in collective action initiatives is influenced by household and community characteristics such as distance to the market, level of social capital, location of a household within a resource supply system, group size and leadership quality. Participation in collective action may also be influenced by the perceived benefits of participation and attitudes on the usefulness of such participation. As Meinzen-Dick et al. (2002) note, the presence of other organizations facilitates participation in collective action since it provides an opportunity for boosting social capital and organizational density especially when an individual is also involved in the activities of these other organizations. The number of adults in a household and the number of years of living in a community may further enhance the capacity of a household to participate in collective action. Fig. 1 shows relationships between dependent and explanatory variables and hypothesized signs of these relationships.

2.3. Empirical Framework

To estimate the decisions to participate in collective action initiatives and soil conservation effort empirically, a two stage econometric model is specified to address self selection problems. Participation in collective action exhibits self selection because the households' decisions to participate in collective action are not random but rather individuals self select into participation depending on – among other attributes – specific household characteristics including their expected gains from participation and level of social capital. In the first stage, we used a binary probit model to regress participation in collective action initiatives on farmers' perceived benefits of participation, level of social capital and other personal attributes. A binary probit model was chosen because of the nature of the dependent variable which takes the value $Y_{1i} = 1$ if a farmer was participating in collective action initiatives and $Y_{1i} = 0$ otherwise. The observed decision (Y_{1i}) is however assumed to represent a latent variable Y_{1i}^* which represents farmers' utility acquired from participation in collective action. We observe Y_{1i} if the underlying latent variable Y_{1i}^* exceeds a certain threshold following the decision rule:

$$Y_{1i} = \begin{cases} 1 & \text{if } Y_{1i}^* > 0 \\ 0 & \text{if } Y_{1i}^* \le 0 \end{cases}.$$

Participation in collective action is specified as follows:

$$Y_{1i} = X_{1i}^{'}\beta_1 + \varepsilon_1$$

where Y_{1i} is a dummy participation variable, $X_{1i}^{'}$ is a vector of explanatory variables conditioning the decision to participation in collective action, which include the perceived benefits, level of social capital and other household characteristics. $\boldsymbol{\beta}_1$ is a vector of coefficients to be estimated and ε_1 captures stochastic disturbances, assumed to be normally distributed.

In the second stage, the effect of participation in collective action, neighborhood social influence and subjective norms on the soil conservation efforts was estimated. The inverse Mills ratio (Heckman, 1979) generated from the first stage entered the second model as an explanatory variable. The number of soil conservation practices that a farmer has implemented was used to represent the effort of soil conservation. Each farmer faces multiple choices on the number of soil conservation practices which they can implement, with a possibility of multiple

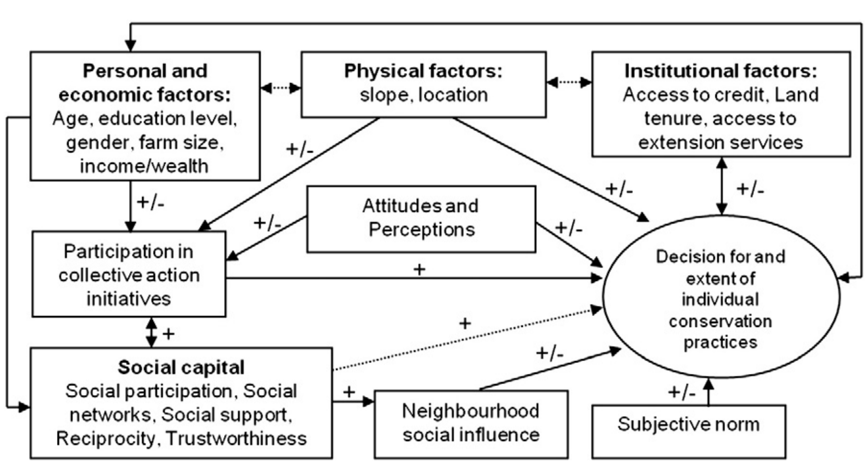

Fig. 1. Conceptual framework. This figure presents a conceptual link between the dependent variables and the explanatory variables.

adoptions. To account for the multiple adoption possibilities and the ordinal nature of the dependent variable, we used an ordered probit model. Among the four soil conservation practices considered in this study, we generate five possible choices: $Y_{2i} = 0$ (none of the practices implemented), $Y_{2i} = 1$ (only one practice implemented) $Y_{2i} = 2$ (two practices implemented); $Y_{2i} = 3$ (three practices implemented) and $Y_{2i} = 4$ (four practices implemented). However, since there were too few farmers (~2%) who had implemented all the four practices, this category was merged with the one with 3 practices, ending up with four categories. To model the four soil conservation effort outcomes we use an ordered response model:

$$Y^*_{2i} = X'_{2i}\beta_2 + \hat{Y}^*_{1i}\alpha + S_i\,\gamma + N_i\vartheta + \varepsilon_2; \varepsilon_1 \backsim NID\left(0, \sigma^2\right)$$

and

$$Y_{2i}\begin{cases} 0 \text{ if } Y^*_{2i} \le \theta_1, \\ 1 \text{ if } \theta_1 < Y^*_{2i} \le \theta_2, \\ 2 \text{ if } \theta_2 < Y^*_{2i} \le \theta_3, \\ 3 \text{ if } \theta_3 \le Y^*_{2i} \end{cases}$$

where Y^*_{2i} can be interpreted as the soil conservation effort, θ_1 are threshold parameters to be estimated simultaneously with the other coefficients: β_2,α,γ and ϑ. Y_{2i} is the number of soil conservation practices implemented by farmer i; X'_{2i} is a matrix of control explanatory variables, $\hat{Y}^*_{1i}$ are the inverse Mills ratio values obtained from the binary probit model in step one, S_i and S_i are row vectors representing households' subjective norm and households' neighborhood social influence index respectively and ε_2 are stochastic disturbances, assumed to be normally distributed. The parameters in both models were estimated using maximum likelihood in STATA 11.

3. Study Area, Data Collection and Analysis Methods

3.1. Description of the Study Area

The current study was conducted in the upper catchment of the Lake Naivasha basin located at 0°30′ S–0°55′ S & 36°09′ E–36°24′ E and covering 3400 km^2 (Fig. 2). The basin is characterized by forested landscapes and smallholder farm settlements in the upper catchment where households draw livelihood support by engaging in smallholder semi-subsistence farming. Large scale intensive floriculture and horticulture farms (mainly under green houses) and urban settlements dominate the lower reaches of the basin. Crop production in the study area is carried out following a cropping calendar of two rainy seasons occurring in March/April and October/November. The average mean annual rainfall is 1120 mm in the upper catchment and 985 mm in the lower catchment. Statistics from the current study indicate that on average, farm households in the upper catchment on average own 2.67 ha of land where they grow roots and tubers, maize, pulses and vegetables. Livestock production, mainly dairy cattle, sheep, goats and poultry, is also an important farm enterprise. Because of the seasonal cropping patterns and continuous land fragmentation caused by population pressure and land inheritance cultural practices the land is subjected to frequent tillage making the soil loose and susceptible to erosion. Soil erosion and fertilizer use in the basin have also been associated with siltation and eutrophication, major environmental challenges for Lake Naivasha. In the past 5 decades, sediment yield has increased from 1.3 tonnes ha^{-1} year^{-1} in 1947 to 8.9 tonnes ha^{-1} year^{-1} in 2006 (Stoof-Leichsenring et al., 2011) while the lake has become eutrophic (Kitaka et al., 2002). This has caused a load of 3.4 Mio. tonnes of sediments into the lake within a 50 year period with serious implications on water quality and biodiversity (Willy et al., 2012).

3.2. Data

The primary data used in this study was collected through a household survey conducted among 307 households in the Lake Naivasha basin in April–July, 2011, within the research project—Resilience Collapse and Reorganization in Socio-Ecological Systems of African Savannas (RCR) funded by the German Research Foundation (DFG). A multistage stratified random sampling procedure was used to sample households. In the first stage, we purposively selected 8 Water Resource Users Associations (WRUAs) to form our sampling strata. For each stratum a sampling frame was generated with the help of WRUA officials and village elders. A random sample of households was then drawn from each WRUA, proportional to size. A semi-structured interview schedule was then administered through personal interviews with household heads and/or their spouses as respondents. They were asked information about their soil conservation behavior, participation in collective action initiatives, level of natural, human and social capital,

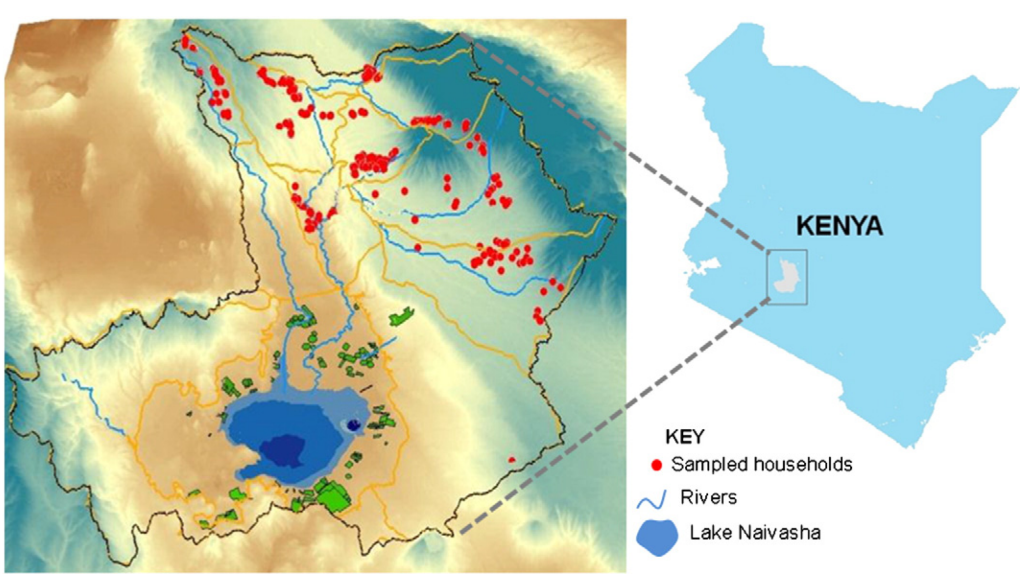

Fig. 2. Map of Lake Naivasha basin. This figure presents a map of the location of the research area in Kenya and an elaborate map of the Lake Naivasha basin.

attitudes and perceptions on soil erosion and household socio-economic and demographic characteristics. It was recognized that subjecting respondents to very long periods of recall especially on the year when soil conservation practices were adopted, which sometimes ran back to the 1960s could yield measurement errors. To minimize this potential error, sufficient probing was done during data collection.

The social capital indicators were further subjected to explorative factor analysis using Principal Components Analysis (PCA) to generate indices on the five components of social capital considered in this study: *social participation*, *social networks*, *social support*, *reciprocity* and *trustworthiness*. PCA was conducted in three steps: First, the respondents were asked specific questions that were used as indicators of each of the 5 components of social capital. Second, PCA with orthogonal rotation was carried out on these items. Sampling adequacy for the analysis was verified using Kaiser–Meyer–Oklin (KMO) statistics while Bartlett's test of sphericity was used to test whether correlations between items were large enough for PCA. Third, the components obtained from step 2 with eigenvalues greater than 1 were selected for further analysis. The factor scores in each PCA component were summed up for each social capital component to obtain a single score and normalized on a 0–1 scale. The final indices were taken to represent the level of each of the 5 social capital components and were used as explanatory variables in the regression model. The PCA results and complete list of the specific questions/indicators used in the PCA are provided in Appendix A1.

3.3. Description of Variables

Descriptions of the variables used in the estimations and their descriptive statistics are presented in Table 1. The dependent variable for the first model was participation in collective action initiatives (*CAPART*). In the study area, there are several collective action initiatives including community mutual support initiatives, maintenance of rural access roads, and maintenance of communal water infrastructure and collective efforts for managing natural resources such as community water supply organizations. Individuals may choose to engage in the communal collective action initiatives either by contributing finances or by allocating time to these activities or both. Participation was measured by asking respondents whether they had participated in any of the collective action initiatives in the community either through contribution of their time or financial resources. Individuals who had participated in at least one collective action initiative by either of the means were considered as participants.

The dependent variable in the second model was the number of soil conservation practices implemented (*SCEFFORT*). The respondents were asked to give information on the soil conservation practices they had implemented on their farms, the year when first adoption occurred and the extent of implementation of these practices. The farmers where considered as adopters only when the extent of implementation was above a certain threshold (these thresholds are presented in Table 3). An ordered dependent variable was then generated by counting the number of soil conservation practices that each farmer had implemented.

The explanatory factors considered in the participation in collective action initiatives model were as follows: the number of years a household has lived in the community (COMYEARS), number of adults in the household (ADULTS), distance to the nearest tarmac road as an indicator of access to markets (DSTAMAK), contacts with an external organization (EXTORG), whether a farmer thinks it is beneficial to participate in CA or not (PERCBEN), whether the household is located close to a river source or not (RIVPROX) and the level of social capital. Social capital was hypothesized to be an important precondition for participation in collective action. The role of social capital as a driver for

Table 1
Description of dependent and explanatory variables.

Variable	Description/measurement	Mean/proportion	Std. dev	Expected sign
Dependent variables				
CAPART	Participation in collective action initiatives (1 = yes)	0.49		
SCEFFORT	Soil conservation effort (ordered numbers: 0,1,2,3)	1.65	0.89	
Explanatory variables (binary probit)				
PERCBEN	Participation in CA beneficial? (1 = yes)	0.68		+
DISTTMK	Distance to the nearest tarmac road (km)	5.01	12.15	+
COMYEARS	Length of time household has lived in the community (years)	29.48	14.62	+
ADULTS	Number of adults in the household	3.28	1.57	+
ASSETINDEX[a]	Level of household wealth	0.35	0.12	+
SNETINDEX[a]	Intensity of social networks	0.19	0.14	+/−
SPARINDEX[a]	Intensity of social participation	0.31	0.18	+
SCSPINDEX[a]	Degree of social support	0.19	0.11	+
TRUSTINDEX[a]	Level of trustworthiness	0.45	0.33	+
RECINDEX[a]	Level of involvement in reciprocate exchanges	0.44	0.21	+
RIVPROX	Farm located close to river source (1 = yes)	0.24		+
EXTORG	Involvement with an external organization	0.26		+
Explanatory variables (ordered probit)				
FARMSIZE	Size of the farm (ha)	2.60	3.83	−
HHEDUC	Average years of schooling completed by household members	7.30	3.35	+
CREDTACES	Number of credit sources accessible to the household (number)	1.30	0.79	+
DSRIVER	Distance from the farm to the nearest river (km)	2.10	3.06	−
Inverse Mills ratio	Inverse Mills ratio	0.96	0.676	+
NEISOCINFL	Neighborhood social influences index (ratio with range 0–1)	0.669	0.179	−/+
GENDER	Gender of household head (1 = male)	0.86		+
SUBNORM	I would adopt a technology because those important to me think I should (1 = yes)	0.65		+
PECEROYES	Perception that soil erosion is a problem (1 = yes)	0.50		+
CATOWN	Ownership of cattle by household (1 = yes)	0.92		+
LANDTEN	Land owned with title deeds (1 = yes)	0.62		+
EXTSERV	Contact with extension service providers (dummy 1 = yes)	0.46		+
LOCDUMMY	Location of the household (1 = K-plateau)	0.36		+

[a] These variables are measured by an index, with values ranging from a minimum of 0 to a maximum of 1.

participation in collective action was assessed using the indices of the five components of social capital generated using PCA as explained in Section 3.2.

In the second model the personal attributes used as explanatory variables to estimate soil conservation effort included the following: gender of household head (GENDER), farm size (FARMSIZE) and household education level (HHEDUC). Institutional variables included land tenure (LANDTEN), access to extension services (EXTSERV) and access to credit (CREDTACES). Cattle ownership (CATOWN) was included in the model to control for direct benefits generated from soil conservation practices while perception that soil erosion is a problem (PECEROYES) was used to capture farmers' attitude and perceptions towards soil erosion. The inverse Mills ratio generated from the participation in collective action initiatives model was used as a proxy for the probability of participating in collective action on soil conservation effort.

A neighborhood social influence variable was included to represent the social pressure. A neighborhood social influence (NEISOCINFL) indicator for each farmer i located in village k with N individuals at time t was computed using the expression below as formulated by the authors:

$$NSI_{it} = \frac{\sum X_{it}}{\sum_{i=1}^{N-1} P_{kt}}$$

where X_i represents the behaviors performed by farmer i that are similar to those of their peers in the village (for example the number of technologies adopted or not adopted), P_{kt} are the behaviors performed by all other farmers within the village except i. Finally, the belief that individuals would adopt a technology just because those who are important to them think that they should was used to capture subjective norms (SUBNORM).

4. Results and Discussions

4.1. Participation in Collective Action

Results indicate that 49% of the sampled households were participants in collective action initiatives. Time expenditure on communal activities was split between the activities indicated in Table 2. On average, households spend about 43 h per year, ranging from 1 to 384 h on collective action related activities. A larger proportion of this time is spent on water related activities, since this is a major form of collective action in the area. Financial contribution to communal activities averaged at Kshs. 1758 (17€) ranging from Kshs. 100 (1€) to Kshs. 11,000 (110€) within the year 2010.

4.2. Trends on Implementation of Soil Conservation Practices in the Research Area

Farmers in the Lake Naivasha basin have been using various strategies to control soil erosion since 1960s. The most popular soil conservation practices are as follows: bench terraces, Napier grass, filter grass strips, contour farming, crop rotation, cover crops, planting of trees and inter-cropping. Among these practices, four practices were selected for in-depth analysis in this study because of their direct role in soil erosion control and permanent nature. Napier grass (*Pennisetum purpureum*) is a perennial plant native to Africa that is usually used as fodder. When planted on slopes, Napier grass controls soil erosion by formation of a natural barrier which obstructs soil movement. Napier grass has fibrous and rhizomatous roots with fast tillering characteristics which make it an effective medium for soil erosion control (Mutegi et al., 2008). However, this rooting characteristic also makes it a potential competitor with crops for nutrients. Bench terracing is a practice that involves construction of bunds along the contour by digging ditches and heaping the soil on the upper or lower part to form an embankment, suitable especially for farms with moderate and steep slopes (Chow et al., 1999). These embankments prevent soil erosion by holding rain water and preventing run-off. By trapping soil particles, bench terraces also reduce phosphorus transportation to water bodies. Although this is a good measure against soil erosion, some studies have indicated that bench terraces may cause low crop yields in the short run, especially in high rainfall areas (Kassie et al., 2008, 2011; Tang, 1998). Filter grass strips is a practice involving planting strips of grass along and/or across gullies and water ways to act as a sediment filter. The commonly used grasses in the study area for this purpose are cock's foot (*Dactylis glomerata*) and Elmba Rhodes grass (*Chloris gayana*) which are also used as fodder. Vetiver grass also (*Vetiveria zizanoide*) is suitable for soil erosion control (Dalton et al., 1996). Finally, contour farming involves tilling land across the slope and establishing crops on the furrows formed by tillage. The technique controls erosion by slowing down run-off and redirecting it around the hill-slope. The practice also prevents the movement of soil particles and fertilizer loss.

Table 3 presents summary statistics for the four soil conservation practices. Given the duration that these practices have been in use in the study area, the practices were mature at the time of the study; therefore we are not likely to generate biased and inconsistent parameter estimates that can be obtained if practices are studied when they have just been introduced (Marenya and Barrett, 2007).

The trends of long term diffusion of the soil conservation practices (Fig. 3) indicate that the penetration rate of these practices has been low, with only Napier grass having penetrated more than 50% of the potential adopters by 2011.

4.3. Binary and Ordered Probit Regression Results

Tables 4 and 5 present regression estimates from the binary and ordered probit regression models respectively. Both models are highly significant ($p < 0.01$), based on the likelihood ratio test for the null hypotheses that all the coefficients in each model are simultaneously equal to zero. Pregibon's link test for model specification (Pregibon, 1980) and Hosmer–Lemeshow statistics were used to assess the fit of the models. Given that $p > 0.1$ in both cases, we fail to reject the null hypothesis that the models accurately fit the data.

Participation in the collective action initiatives was found to be significantly influenced by all the components of social capital included in the model. Social participation, social support, reciprocity and trustworthiness had significant positive influences on participation in collective action. It is worth noting that the different components of social

Table 2
Household time expenditure on communal activities.

Communal collective action activity	% of households who participated	% time spend on activity
Water management activities	77.2	68.8
Tree planting	12.0	10.7
Access road maintenance	5.0	8.1
Soil erosion control	2.9	3.4
Construction of communal facilities	2.9	9.0

Source: Authors' survey data.

Table 3
Soil conservation practices implemented by sampled farmers.

Soil conservation practice	Adopters (%)	Extent of adoption			Threshold	Length of practice (years)	
		Mean	SD	Unit		Mean	SD
Napier grass	76.6	0.14	0.15	ha	2% of farm	12.6	11.22
Bench terraces	31.8	264.7	322.29	m/ha	50 m/ha	17.1	14.16
Contour farming	38.0	0.72	0.510	ha	10% of farm	17.9	13.96
Filter grass strips	20.5	267.1	314.59	m/ha	50 m/ha	12.7	12.83

Source: Authors' household survey data.

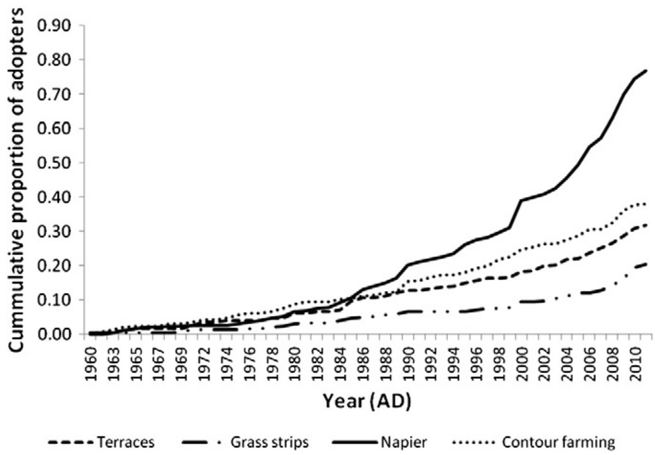

Fig. 3. Trends in diffusion of soil conservation practices in the Lake Naivasha basin: 1960–2011. The figure shows the trends in the diffusion of the four soil conservation practices that are covered in the study starting 1960 when the first settlements occurred in the area and 2011 when the survey was conducted.

capital are embedded and complement each other as indicated by their strong joint influence on participation in collective action (*Wald statistics* = 68.56, $p < 0.01$). For example, social participation, which was measured by the degree of household membership and active participation in communal groups and associations, provides opportunities for individuals to establish social networks and engage in repeated interactions hence form reputation and trustworthiness.

An increase in social participation by one unit increases the probability of participating in collective action initiatives by 41 percentage points. Trustworthiness was measured using indicators that required respondents to express to what extent they felt fellow community members could be trusted and was found to positively influence participation in collective action. A high level of trustworthiness creates trust among individuals in a community and enhances the tendencies of individuals to work together. Most collective action initiatives which involve reciprocate exchanges are built on trust, which "… involves opportunities for both trustor and trustee to enhance their welfare" (Ostrom and Ahn, 2009). For instance, a farmer will only lend their labor time to other farmers when he/she can trust that they will reciprocate in future. When trust is well established, it eliminates the need for costly monitoring and enforcement since individuals expect others to act in accordance with the shared norms.

A unit increase in the intensity of social networks reduces the probability of participating in collective action initiatives by 38.8 percentage points. One possible explanation for this result is that because this indicator included networks outside the community, community members with wider and stronger links outside the community may opt out of local communal initiatives and therefore reduce the likelihood of participating in local collective action. This result was supported by the positive influence of distance to the tarmac road indicating that the households in the interior with little access to the outsiders were more likely to participate in collective action initiatives at local level. As expected, households within WRUAs located closer to a river source had a higher probability of participating in collective action by initiatives 9.4 percentage points. Proximity to river sources makes it technically easier and cheaper for individuals to tap water for domestic and irrigation purposes collectively from a common intake, one of the most common forms of collective action in the area.

The estimated average marginal effects in Table 5 are interpreted as percentage changes on soil conservation effort when an explanatory variable changes by one unit. For a positive marginal effect, an increase in explanatory variable would cause an increase in the latent variable, hence the probability that $Y_i = 3$ will increase while the probability that $Y_i = 1$ will decrease.

Male gender, higher level of education and better access to credit had positive influence on the soil conservation effort as expected. Male headed households are 8.4 percentage points more likely to implement 3–4 soil conservation practices compared to female headed households. This finding is consistent with that of Marenya and Barrett (2007). Gender differences in soil conservation behavior are manifested through gender influences on access and control of resources (such as land and labor), and access to information and credit services, factors that are important in determining soil conservation effort. Consistent with human capital theory, increasing the average household education level by one year increases soil conservation effort by 1.1 percentage points.

Access to credit influenced the soil conservation effort positively. Access to credit relaxes the household cash constraint thereby facilitating the acquisition of inputs necessary for establishing soil conservation practices. Secure land tenure and access to extension services had the expected positive influence on soil conservation effort but the coefficients were insignificant. The coefficient of farm size was negative, against expectations. Although it is obvious that soil conservation practices vary with scale of operation, a possible explanation of this finding is that in the Lake Naivasha basin case, farmers with smaller farms could have higher incentives to implement more soil conservation practices to prevent soil erosion from further reducing their actual area of production.

Results indicate that households who perceived soil erosion as a problem in the area also had a higher soil conservation effort. This is in agreement with earlier work by Asafu-Adjay (2008), Ervin and Ervin (1982) and Rogers (1995) who identified perception on soil erosion as a key first step preceding decisions to adopt soil conservation practices. Ownership of cattle increased the soil conservation effort by 12.0 percentage points. Farmers are likely to implement soil conservation practices that have win–win benefits such as Napier grass and filter grass strips which provide fodder to complement those that only create long term benefits of soil erosion control and improved crop productivity such as terraces.

The marginal effect of the inverse Mills ratio was 0.044 and significant indicating the presence of a positive selectivity bias in the model. This

Table 4
Determinants of participation in collective action.

Variable	Coefficients	Std. error	Average marginal effects
Constant	-4.086^{***}	0.677	
Degree of social support	1.490^{*}	0.882	0.393
Intensity of social participation	5.354^{***}	0.693	1.411
Intensity of social networks	-1.474^{**}	0.698	−0.388
Level of participation in reciprocate exchanges	0.969^{*}	0.524	0.255
Level of trustworthiness	0.683^{**}	0.267	0.180
Farm located close to river source	0.356^{*}	0.207	0.094
Household asset ownership	0.512	0.730	0.135
Perceives participation as beneficial	0.138	0.246	0.036
Distance to tarmac road	0.010	0.009	0.003
Years of living in the community	0.008	0.006	0.002
Number of adults in the households	0.055	0.054	0.014
Involvement with an external organization	0.432^{**}	0.206	0.114
Model summary			
Number of observations	307		
Pseudo R^2	0.32		
LR χ^2 (12 d.f.)	136.95^{***}		
Log likelihood	−144.191		
% of correct predictions[a]	76.55		

[a] Model predictions based on the threshold, c = 0.5. *, **, and *** Coefficients are significant at the 0.1, 0.05 and 0.01, levels respectively.

Table 5
Determinants of soil conservation effort.

	Coefficients	Std. err.	Average marginal effects			
	β	S.E.	Prob ($Y_i = 0$)	Prob ($Y_i = 1$)	Prob ($Y_i = 2$)	Prob ($Y_i = 3$)
Explanatory variables						
Gender of household head	0.353**	0.188	−0.052	−0.070	0.038	0.084
Farm size	−0.051***	0.017	0.008	0.010	−0.005	−0.012
Education level of household	0.048**	0.021	−0.007	−0.010	0.005	0.011
Access to credit	0.229***	0.088	−0.034	−0.045	0.025	0.055
Distance to the river	0.039*	0.022	−0.006	−0.008	0.004	0.009
Subjective norms	0.408***	0.134	−0.060	−0.081	0.044	0.097
Perception that soil erosion is a problem	0.296**	0.127	−0.044	−0.059	0.032	0.071
Cattle ownership	0.500**	0.255	−0.074	−0.099	0.054	0.120
Land tenure	0.127	0.137	−0.019	−0.025	0.014	0.030
Access to extension services	0.042	0.134	−0.006	−0.008	0.005	0.010
Household located in the Kinangop Plateau	−0.025	0.146	0.004	0.005	−0.003	−0.006
Neighborhood social influence	−0.668*	0.357	0.099	0.133	−0.072	−0.160
Inverse Mills ratio	0.184*	0.104	−0.027	−0.037	0.020	0.044
Threshold parameters						
θ_1	−0.245	0.459				
θ_2	1.065	0.462				
θ_3	2.254	0.469				
Model summary						
No. of observations	307					
Pseudo R^2	0.087					
LR χ^2 (13 d.f.)	67.49***					
Log likelihood	−356.300					

*, **, and ***: Coefficients are significant at the 0.1, 0.05 and 0.01 levels, respectively.

implies that an individual with average sample characteristics who self selects into participation in collective action implemented more soil conservation practices compared to an individual with average set of characteristics drawn at random from the population. Participation in collective initiatives enhances soil conservation since it creates an opportunity for farmer-to-farmer exchange of planting materials, information and labor. Exchange of labor enables the household to overcome labor constraints and therefore improve their prospects to implement labor intensive soil conservation practices. Community collective action initiatives also boost soil conservation because of the possibility of collective learning, selection of appropriate soil conservation practices and accessing innovations that adapt soil conservation practices to local conditions.

Increasing neighborhood social influence intensity by one unit was found to decrease the soil conservation effort by 16.0 percentage points. Considering that neighborhood social influences could either be positive (encouraging soil conservation) or negative (discouraging soil conservation) this result implies that the negative neighborhood social influence among the sampled households is stronger. This may explain the observation that soil conservation effort was generally low. For example only 31.8% of the farmers had implemented terracing which is a more demanding soil conservation practice.

Finally, subjective norms had a significant positive influence on soil conservation effort. The subjective norm we considered in the analysis was the belief that individuals would adopt a technology (or not adopt) just because those important to them think they should do so. Individuals who held such belief had a higher soil conservation effort by 9.7 percentage points. As indicated by Ajzen and Fishbein (1975) subjective norms reflect some degree of social pressure and therefore the behavior of referent farmers may influence a farmer's intention on accepting a particular practice.

5. Conclusions and Policy Implications

This study used a two step econometric approach to assess the effect of participation in collective action initiatives, neighborhood social influence and other covariates on the soil conservation effort in Lake Naivasha basin in rural Kenya. In the first step we estimated participation in collective action initiatives using binary probit regression while in the second step, ordered probit regression was used to elucidate determinants of soil conservation effort.

Regression results indicated that four components of social capital: *social participation*, *social support*, *reciprocity* and *trustworthiness* had positive influences on the probability of participating in collective action while social networks had a negative influence. Location of households closer to sources of rivers and involvement with external organizations was found to also enhance participation in collective action. On the other hand, participation in collective action was found to enhance soil conservation efforts. Results also indicate that neighborhood social influence and subjective norms were significant determinants of soil conservation effort besides gender, education level, farm size, access to credit and livestock ownership.

From these findings we can draw three main policy implications. First, soil conservation could benefit from efforts to encourage participation in collective action and enhanced effectiveness of existing collective action initiatives. One possible approach to achieve this is through policies that recognize local groups and facilitate capacity building through training of trainers within the community to strengthen local knowledge, leadership and innovativeness. Further, community participatory approaches could be enhanced as an incentive for participation in collective action on management of natural resources. Also, strategies that encourage regional social capital formation such as creating an enabling environment for local groups to form and thrive may boost collective action, especially on soil conservation and management of other natural resources. Secondly, the existing extension policy needs to be strengthened to incorporate strategies that recognize the role played by neighborhood social influence and subjective norms in dissemination of information and technologies including soil conservation practices.

The results also suggest the need for strengthening of existing policies on access to agricultural credit and those that address gender related challenges on access to resources and information such as the law on affirmative action to encourage soil conservation among marginalized groups.

Appendix A1. Principle Components Analysis (PCA) Results on Social Capital Indicators

Table A1
Principal component analysis on social support variables.

	Rotated factor loadings			
	Community support	Mutual support	Organization support	Family support
Social support available from close family members	.179	.221	−.284	**.758**
Social support available from close relatives	.192	.324	−.276	**−.681**
Social support available from neighbors	**.686**	.038	.075	−.005
Social support available from mutual support groups	**−.766**	−.042	−.024	−.016
Social support available from religious groups	−.229	**.665**	.495	.079
Receives remittances	.183	**.769**	−.164	−.048
Social support available from NGOs	.176	−.047	**.817**	−.052
Summary statistics				
Eigenvalues	1.366	1.134	1.053	1.035
% of variance explained	17.757	17.038	15.755	14.988
Total % of variance explained	65.54			
Average overall score (0–1 scale)	0.22			
KMO statistics	0.513			
Bartlett's Test of sphericity				
χ^2 (45)	42.838			
p	.003			

Bold figures are used to emphasize the variables which were highly correlated with the extracted factors.

Table A2
Principal component analysis on social participation variables.

	Rotated factor loadings		
	Involvement in groups	Participation in water management	Participation in communal activities
At least one person in the household is a member of a group	**.820**	.103	.077
Holds leadership position in the group	**.869**	.119	.057
Frequency of active involvement in a group	**.559**	.096	−.042
No of household members in groups	**.923**	.051	.023
Membership in WRUA	.178	**.709**	.044
Membership in Community water project	−.079	**−.773**	−.102
Participation in communal water management	.056	**.739**	.120
Time spent in communal activities (h/year)	.066	−.018	**.896**
Participation in communal activities	−.016	.362	**.751**
Summary statistics			
Eigenvalues	2.97	1.80	1.09
% of variance explained	32.99	20.00	12.08
Total % of variance explained	65.07		
Average overall score (0–1 scale)	0.31		
KMO statistics	0.70		
Bartlett's test of sphericity			
χ^2 (36)	885.08		
p	0.000		

Table A3
Principal component analysis on social networks variables.

	Rotated factor loadings	
	Local networks	External networks
Years of household membership in groups	**.827**	.074
Intensity of social interactions (people contacted)	**.829**	.039
Number of household members working outside village	.011	**.794**
Number of months spend away from home	.098	**.771**
Summary statistics		
Eigenvalues	1.499	
% of variance	1.114	
Cumulative % of variance	65.33	
Average score (0–1 scale)	0.19	
KMO statistics	0.533	
Bartlett's test of sphericity		
χ^2 (6)	71.11	
p	0.000	

Table A4
Principal component analysis on trust variables.

	Rotated factor loadings	
	Perceived trust	Proven trust
A misplaced purse in the community is likely to be returned	**0.808**	.091
Community members more trusted than non community members	**0.818**	−.013
I can trust most people in my community with a loan	.002	**.731**
I have engaged in mutual exchanges with other community members	.068	**.727**
Summary statistics		
Eigenvalues	1.369	1.029
% of variance	34.224	25.716
Cumulative % of variance	59.939	
Average score (0–1 scale)	0.47	
KMO statistics	.508	
Bartlett's test of sphericity		
χ^2 (6)	40.225	
p	.000	

Table A5
Principal component analysis on reciprocity variables.

	Rotated factor loadings	
	Diffuse reciprocity	Simultaneous reciprocity
I get mutual benefit from communal water management activities	**.762**	.154
I benefit by being a member of the water project	**.813**	−.115
I benefit by being a member of a WRUA	**.652**	−.294
I don't benefit by participating in communal activities	**.539**	.354
My villagers help one another	−.081	**.685**
I have exchanged planting materials with other farmers in the past	−.053	**−.672**
Summary statistics		
Eigenvalues	1.965	1.170
% of variance	32.757	19.495
Cumulative % of variance	52.252	
Average score (0–1 scale)	0.44	
KMO statistics	.630	
Bartlett's test of sphericity		
χ^2 (21)	204.345	
p	.000	

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