An Analysis of Returns to Integrated Soil Conservation Practices in the Lake Naivasha Basin, Kenya

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Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia

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ABSTRACT

The current study seeks to assess the private benefits associated with integrated soil conservation practices (ISCPs) by estimating the marginal value of crop production that can be attributed to such practices. In areas where land degradation associated with soil erosion causes serious agri-environmental challenges such as loss of land fertility, siltation and eutrophication, an integrated approach to soil conservation is neccessary. However, notwithstanding efforts to encourage adoption of such practices, their uptake remains generally low. Understanding this deplorable status therefore warrants keen investigations on the effect of ISCPs on crop productivity. To achieve the objective, the current study applied propensity score matching and exogenous switching regression techniques to cross-sectional data collected from a random sample of farm households located in Lake Naivasha basin, Kenya. Results indicate that there is a significant positive effect of implementing integrated soil consercvation practices on crop productivity. However, we note that whether the additional benefits will cover the opportulity costs associated with the implementation of these practices will depend on farm specific attributes. In cases where marinal benefits are not substantial to over private incentives for implementation of soil conservation practices, intrinsic or external incentives could be necessary.

Key Words: Propensity Score Matching; Exogenous Switching Regression; Integrated Soil conservation practices

1 INTRODUCTION

Land degradation is recognized as a major threat to agricultural land quality and productivity and, therefore, to food security in many developing countries (Bewket, 2007; Kassie et al., 2008; Mazvimavi and Twomlow, 2009). Land degradation is mainly attributed to soil erosion, deforestation, soil contamination and all other activities and processes that reduce the economic and ecological productivity of land (OECD, 2012). Particularly, soil erosion has been identified as a key problem because of the many negative impacts it causes to the environment and to agricultural productivity. Besides reducing the productivity of land on-site, soil erosion also causes off-site effects such as eutrophication and siltation (Mbaga-Semgalawe and Folmer, 2000). Soil erosion also threatens species in both terrestrial and aquatic ecosystems through the degradation and pollution of their habitats. Due to the myriad negative effects caused by soil erosion, it is without doubt that activities aimed at soil conservation provide both private and social benefits; private gains in terms of increased crop productivity and improved land quality, and social benefits in terms of better ecology (Miller et al., 2008) . For this reason, significant amount of efforts have been made by governments and development agencies to promote soil and water conservation technologies among farmers in developing countries (Bekele, 2005; Kassie et al., 2008). However, despite these efforts, the adoption of soil conservation practices have been below expectations (Khisa et al., 2007; van Rijn et al., 2012). This gives rise to the question whether and to what extent soil conservation practices are indeed capable of generating private benefits to farmers.

Studies conducted previously in different countries to analyze the impact of various soil conservation technologies (SCTs) on crop productivity have yielded sundry results. Some studies (for example Bekele, 2005; Kassie et al., 2008; Otsuki, 2010; Pender and Gebremedhin, 2007; Shively, 1998; Vancampenhout et al., 2006) have come to the conclusion that, generally, SCTs helped to enhance cropland productivity on degraded lands. If appropriately selected and given sufficient time, soil conservation practices (SCPs) are expected to reduce soil erosion rates, improve agricultural land quality and enhance crop yields (Lutz et al., 1994; Shively, 1998). The issue of selection of appropriate soil conservation practices is particularly important because the success of a particular technology or set of technologies will depend on farm attributes such as topography and soil characteristics which are highly heterogeneous across farms and sometimes even within the same farm. Due to this heterogeneity, it is necessary sometimes to even combine multiple soil conservation technologies within the same farm so as to generate substantial benefits, especially considering that for example due to their land requirements soil conservation practices may even lead to a decline in crop yields. Thus, studies by Kassie et al., (2011) and Shiferaw and Holden (2001) found that under certain circumstances, some soil conservation practices such as *Fanya Juu* terraces may not necessarily be ‘win-win’ since they are deemed inefficient from a farmer’s perspective and have a negative effect on crop productivity. Nevertheless, even when yields can be increased through adoption of soil conservation technologies, farmers may still fail to implement them. This could be partly because of behavioral and social aspects as highlighted by Lynne et al., (1988) and Willy and Holm-

Mueller, (2013) and partly because the costs associated with these practices outweigh the net benefits created. Farmers are particularly concerned by high labor and land requirements for implementation and maintenance of some soil conservation technologies since these resources are usually the most limited among low-income farmers (Shiferaw and Holden, 2001). The private benefits generated from soil conservation technologies must therefore be substantial to off-set the opportunity costs if they have to make economic sense to farmers.

In the current study we hypothesize that integrated soil conservation, a practice where farmers implement more than one soil conservation practices on their farms create substantial private benefits in-terms of higher crop productivity. Therefore, the research question we seek to explore is whether the net value of crop production for farmers who have implemented integrated soil conservation practices are higher than those of the farmers who have not. This is motivated by the tenet that farmers are likely to sustain conservation practices on their farms partly if they create substantial incentives in the form of improved crop and livestock productivity and the production foregone by implementing such technologies can be offset by productivity increase from using SCTs (Shiferaw and Holden, 2001). Therefore identifying returns to soil conservation practices may contribute vital inputs into promotion of SCTs among smallholder farmers.

The main goal of this study is to estimate the effect of implementing integrated soil conservation practices (ISCPs) on the value of crop production among smallholder farmers in the lake Naivasha basin, Kenya. This helps us to evaluate the returns to the entire soil conservation package as opposed to assessing returns to individual soil conservation practices an approach used in many studies focusing on this topic. Six practices were considered in this study namely: Tree Planting, *Fanya Juu* Terraces, Grass Strips, Napier Grass, Contour farming and Cover crops. The study uses Propensity Score Matching (PSM) to analyze matched observations of farmers who have implemented integrated soil conservation practices and those who have not.

The rest of the paper is structured as follows: the next section summarizes previous research on returns to soil conservation practices. Section 3 then describes the methodology employed in this study, including data collection and sampling methods and analytical techniques. Results and discussions are presented in section 4, while section 5 concludes and draws policy implications.

2 LITERATURE ON RETURNS TO SOIL CONSERVATION PRACTICES

As has already been mentioned, despite the unanimous agreement in literature that most soil conservation technologies control erosion and generate off-site positive effects, such technologies remain poorly adopted in many developing countries (Khisa et al., 2007; Pretty et al., 1995; van Rijn et al., 2012). This state of affairs has been the driving force behind many government efforts to promote soil conservation and has also received substantial focus in research. Studies in this area have focused on assessing the effect of soil conservation practices on crop productivity using either econometric approaches (for example Bekele, 2005; Kassie et al., 2008; Nyangena and Köhlin, 2009; Otsuki, 2010; Pender and Gebremedhin, 2007; Shively, 1998) or Cost Benefit Analysis(CBA) (for example Araya and Asafu-Adjaye, 1999; Ellis-Jones and Tengberg, 2000; Lutz et al., 1994; Posthumus and De Graaff, 2005; Shiferaw and Holden, 2001; Tenge, 2005). Regardless of the method used, most findings converge to one agreement that the effect of soil conservation on crop productivity is context specific and depends on a number of factors. The current study seeks to advance the debate by looking at how the combination of multiple soil conservation practices may influence crop productivity.

A study by Kassie et al. (2008) analyzed the impact of stone bunds on the value of crop production in Ethiopia and revealed that their effects on crop productivity differed with agro-ecological settings. Implementing stone bunds increased crop productivity in low rainfall areas whereas in the high rainfall areas this was not the case. Beside the agro-ecological conditions, studies conducted in Kenya by Nyangena and Köhlin (2009) and Otsuki (2010) found that the erosion status of the farm was a major determinant of the effect of agro forestry, bunds and terracing on crop productivity.

A study by Araya and Asafu-Adjaye (1999) in Eritrea found that plots where stone and soil bunds, *Fanya Juu* terraces and double ditches were implemented yielded negative net present values (NPVs) . However, when the authors accounted for social benefits, the NPVs were positive, emphasizing on the fact that even when SCTs are not economically viable for individual farmers, the net gain to the society can be positive. This finding is confirmed by Shiferaw and Holden (2001) who applied a different approach to Ethiopian small-holder farms and concluded that unless farmers did not discount future benefits from conservation at all or used very low discount rates, the soil conservation practices did not yield positive benefits. A similar study conducted by Tenge(2005) among smallholder farmers in the West

Usambara Highlands in Tanzania estimated the financial efficiency of bench terraces, *Fanya Juu* terraces and Grass Strips and revealed that profitability of these SCPs depended on soil type, slope and opportunity costs of labor and farmers' subjective discount rates. For instance, Fanya Juu terraces constructed on both moderate and steep slopes were economically viable only for farmers with low opportunity costs of labor, whereas farmers with high opportunity costs could only benefit from the practice if it was constructed on gentle slopes. Similarly, implementation of grass strips on steep slopes with both stable and unstable soils for farmers with high opportunity costs would yield negative NPVs and Internal Rate of Return (IRR) below the market discount rate (Tenge, 2005). However, soil erosion is often present on steep slopes with unstable soils that accelerate soil surface movement and run-off. Consequently, smallholder farmers with farms located on extremely sloped areas would need additional incentives to make soil conservation technologies economically attractive for them. A study by Posthumus and De Graaff, (2005) among Peruvian farmers arrives at similar findings, and also finds the type of crop enterprise an important determinant of the profitability of soil conservation practices.

Most of the studies highlighted here analyze soil conservation practices in isolation not taking into account the possible effect that may result from integrating more than one soil conservation practices in one farm/plot. Further, as Kassie et al., (2011), Kassie et al. (2008) and Shively, (1998) indicate, any analysis on the effect of soil conservation technologies on the value of crop production that ignores the presence of self selection may yield biased estimates. Self-selection problem arises because farmers are not randomly assigned to the groups of adopters and non-adopters, but they choose themselves to adopt a soil conservation technology based on their individual attributes which influence their adoption behavior. Consequently the counterfactual effect, that is, the production level that farmers would have achieved had they not implemented integrated soil conservation technologies, is not observable (Kassie et al., 2011). Therefore, a mere comparison of the difference in crop productivity between implementers and non-implementer of integrated soil conservation technologies would yield biased estimates of the effect of ISCPs on crop production, because this effect is likely to be correlated with farm- and farmer-specific unobserved characteristics (Shively, 1998). Further, unobservable variables that simultaneously affect the technology choice variable (level of implementing integrated soil conservation practices) and the outcome variable (value of crop production) may cause hidden bias (Rosenbaum, 2002). The current study seeks to address the three shortcomings by analyzing the effect of integrated soil conservation practices on the value of crop production using the Propensity Score Matching (PSM) and exogenous switching regression approach, an approach also applied by Kassie et al., (2008).

3 METHODS, DATA TYPES AND DESCRIPTION OF VARIABLES

3.1 Description of the study area and data

Lake Naivasha is a freshwater lake located within the Kenyan Rift Valley at 0º30′ S- 0º55' and 36º 09′ E- 36º24' E. The Lake lies 80km north-west of Nairobi and consists of three parts: the main lake, Sonachi (or Crater Lake) and Oloiden and has a catchment area of approximately 3400 square kilometers. In 1995 an area of 30 000 ha around the Lake Naivasha was designated as a "wetland of international importance" (RAMSAR convention, 2011). The basin is home to about 650 000 people that depend on the natural resources within the basin for their livelihood directly or indirectly (WWF, 2011). The main economic activities in the basin include: tourism, small holder farming and pastoralism, fishing and geothermal power production in the south of the lake, horticulture and floriculture (Chiramba et al., 2011). Kenya is a top exporter of fresh cut flowers and vegetables to UK and Europe, 75% of which is supplied by Naivasha. The area of 50 square kilometers around the lake is intensively used by horticulture and floriculture farms abstracting water from the lake for irrigation and who were than claimed as responsible for lake's decreasing water level (Becht et al., 2005; Chiramba et al., 2011). The area in the upper catchment (approximately 18 000 ha) is occupied by smallholder farms producing mainly Irish Potatoes, maize, beans, vegetables and other crops (Mekonnen and Hoekstra, 2010). This part of the basin has also faced increased pressure on natural resources due to population growth over last 50-60 years. Within this period, substantial land cover and land use changes have occurred, especially involving conversion of forests into crop fields causing a direct impact on surface and ground water quality and quantity(WWF, 2011). Soil erosion caused by unsustainable agricultural practices accelerated land degradation in the upper catchment and has contributed to the siltation of the lake through the increased sediment load (Becht et al., 2005 and Willy and Holm-Mueller, 2013). Therefore, analyzing soil conservation practices is a crucial contribution to the debate on how to make farming practices sustainable and minimize negative agri-environmental effects in the lake Naivasha basin and other similar regions elsewhere in the world.

This study is based on primary cross-sectional data that was collected within the framework of the "Resilience, Collapse and Reorganization in socio-ecological systems of African Savannas" (RCR) project funded by the German Research Foundation (DFG). The data was collected through structured interview schedules administered to 308 farm households drawn from eight Water Resource Users Associations (WRUAs). The sample was drawn through a stratified random sampling procedure, where the WRUAs served as strata. Data was captured on the soil conservation practices implemented, crop and livestock enterprises and other household socio-economic and demographic attributes.

3.2 Analytical framework

This paper utilized Propensity Score Matching (PSM) technique to assess the effect of implementing integrated soil conservation practices on the value of crop production. Exogenous switching regression was then applied to check the robustness of the PSM results following Kassie et al., (2008). The idea of estimating propensity scores was initiated by Rosenbaum and Rubin, (1983) who proved that self-selection bias can be removed through adjustment using propensity scores of treated and non-treated groups. The method has then found wide application in medical and economic research (Caliendo and Kopeinig, 2008; Dehejia and Wahba, 2002) to address self-selection problems. Self-selection bias is likely in the current study because assignment of treatment (whether to implement integrated soil conservation or not) is not random. Rather, individuals choose themselves to receive a treatment or not based on various farm- and farmer-specific characteristics, economic and institutional factors. Therefore, those who implement integrated soil conservation technologies might be systematically different from each other and from those who don't implement. To calculate the effect of soil conservation practices on crop productivity (treatment effect), this self-selection problem has to be addressed for (Kassie et al., 2008; Mendola, 2007) and PSM which involves computation of a propensity score for each individual helps to achieve this objective.

A propensity score is the conditional probability of taking a treatment given a vector of explanatory variables as indicated in equation (1) (Rosenbaum and Rubin, 1983).

$$p(x) = Pr[D = 1|X = x] \tag{1}$$

where p(x) is a propensity score, and Pr is the probability of implementing integrated soil conservation efforts (taking a treatment, D=1) conditional on the vector of observed covariates, x. In our case the dummy variable indicating the treatment effect takes the value of 1 if a farmer has implemented at least two soil conservation practices and 0 if the farmer has implemented only one soil conservation practice. The explanations on how the treatment variable was generated are offered in the next section.

A probit model was applied to estimate the predicted probabilities (propensity scores) of implementing integrated soil conservation efforts. The probit model is as specified in Equation (2) (Greene, 2003 and Verbeek, 2008):

$$\Pr(D = 1|X) = G(z) = \int_{-\infty}^{X'\beta} \phi(z)dZ = \Phi\,(X'\beta) \quad (2)$$

where $G(z)$ is a function taking values between 0 and 1, $\Phi(z)$ is the standard normal cumulative distribution function, z is the vector of covariates and $\phi(z)$ is the standard normal density function. The probabilities were estimated using the method of maximum likelihood which maximizes the log-likelihood function:

$$\ln L = \sum_{y_i=0} ln\left[1 - \Phi\left(X_i'\beta\right)\right] + \sum_{y_i=1} ln\,\Phi\left(\mathrm{X}_i'\beta\right) \quad (3)$$

The empirical probit model estimated is specified in Equation (4):

$$Y_i^* = \;+u_i,\; u_i \sim N(0,1), i = 1, \ldots, N \text{ and } Y_i = \begin{cases} 1\; if\; Y_i^* > 0 \\ 0\;\; if\; Y_i^* < 0 \end{cases} \quad (4)$$

where Y_i^* is a latent variable representing the decision to implement integrated soil conservation practices and Y_i is observed status of implementing integrated soil conservation technologies for each household, X is a matrix of explanatory variables which include farmer and farm characteristics, institutional and socio-economic factors, the βs are the parameters to be estimated and u_i is a normally distributed error term.

The predicted probabilities obtained by estimating equation (4) are used as propensity scores for matching the samples of implementers of integrated soil conservation practices and non implementers. After propensity score estimation, a matching algorithm to match each adopter with a non-adopter with similar propensity scores is used. In this study, we used the nearest neighbor matching (NNM) method with caliper after imposing non replacement and common support conditions. A caliper or a tolerance level on the maximum propensity score distance allowed was imposed to improve the matching quality (Caliendo and Kopeinig, 2008).The no replacement condition - where every untreated observation is considered only once- was made to avoid an increase in the estimator variance that occurs when replacement is allowed. The common support condition implies that only comparable observations from the treated and non-treated groups are entered into the analysis, for which a researcher has to define the *region of* common support (Caliendo and Kopeinig, 2008). All the observations that are outside the common support are excluded from the analysis. It was also necessary to check the balancing property of the sample, which ensures that households within the treated and control groups have similar propensity score that is, they should have the same distribution of covariates (Mendola, 2007). The balancing property shows how well the samples were matched (matching quality). In this study, the quality of matching was checked using the standardized bias method. This method calculates bias in mean differences of covariates for treated and control groups after matching. An average bias in mean difference less than 5% is considered tolerable (Caliendo and Kopeinig, 2008). After estimating the propensity scores, the causal effect of integrated soil conservation on crop productivity can be calculated. This effect is called Average Treatment Effect on the Treated (ATT) and is represented as follows (Grilli and Rampichini, 2011).

$$ATT = E[Y(1) - Y(0)|\, D = 1] \tag{6}$$

where Y is the outcome variable on which the technology effect has to be estimated. In our case, this is the value of crop production per hectare. $Y(1)|D=1$ is the observed value of crop production for treated and $Y(0)|\ D=1$ indicates what would happen to the treated had they not received the treatment (counterfactual). In reality, $Y(0)|\ D=1$ is not observed, so we use the best substitute, the control group of non-treated that are similar in distribution of covariates to the adopters (Mendola, 2007). ATT is then calculated as the difference in outcome variables between groups of treated and non-treated that are matched according to their propensity to implement integrated soil conservation technologies. Thus, PSM ensures that the estimated technology effect is only due to the treatment and not because of other covariates by taking care of self-selection bias. However, the estimated treatment effect could have hidden bias as a result of unobserved heterogeneity. To test the sensitivity of the ATT to unobserved heterogeneity, we used the Rosenbaum, (2002) bounds test. The bounds test establishes the point at which the estimated results would no longer hold or in other words how the ATT is robust to unobserved heterogeneity. PSM techniques might yield inconsistent estimates especially due to unobserved heterogeneity. Therefore, to ensure consistency and robustness of the PSM results, we used exogenous switching regression a complementary method to PSM following Kassie et al (2008). After running PSM, two samples are generated and used in estimating the exogenous switching regression models. One sample consists of treated individuals who are on common support and for whom a match was found among the untreated individuals. The other sample consists of untreated individuals who are both on common support and are also matching those in the treated sample. The general exogenous switching regression model can be described in equations (7-8).

$$lnZ_{i1} = W_i\beta_{i1} + v_{i1} \ \ (\ if \ \ Y_i = 1) \qquad (7)$$

$$lnZ_{i0} = W_i\beta_{i0} + v_{i0} \ \ (\ if \ \ Y_i = 0) \qquad (8)$$

$$Y_i^* = \ X\alpha + u_i \qquad and \qquad Y_i = \begin{cases} 1 \ if \ Y_i^* > 0 \\ 0 \ \ if \ Y_i^* < 0 \end{cases} \qquad (9)$$

where Z_i is the value crop production per ha for each household i, W_i is a vector of explanatory variables that are hypothesized to influence the value of crop production; β_i and α are vectors of regression coefficients, and u_i and v_i are the random unobserved attributes. Note that Y_i^* is the selection equation signifying whether a farmer has implemented ISCPs or not and is the same equation used in estimating propensity scores. It is assumed that the unobserved characteristics affecting Z_{i1} (or Z_{i0}) are uncorrelated with those affecting Y_i^*, that is, the error terms of the outcome equations are independent from those of the selection equation.

3.3 Description of dependent and explanatory variables

Table 1 presents summary statistics of dependent and explanatory variables used in the binary probit model that was used to estimate propensity scores. Construction of the dependent variable was done considering the fact that most of the soil conservation technologies require certain time period and need to be implemented on substantial area of land for their effect on crop productivity to be visible. De Graaff et al. (2008) claimed that “actual adopters” are those farmers undertaking significant amount of efforts to conserve their land from degradation. The following composite criterion was developed and used to determine who qualified to be implementers of ISCPs and those who did not.

The first criterion was that each of the six soil conservation practices considered in the study must have been consistently implemented for at least 2 years. In total, 6 soil conservation technologies mostly used by farmers in the lake Naivasha Basin were considered in this study: Tree Planting, *Fanya Juu* Terraces, Grass Strips, Napier Grass, Contour farming, and Cover crop practices. Second, the soil conservation practices must have been implemented at a substantial extent, a criteria also used by Willy and Holm-Mueller (2013) and third, a farmer will count as having implemented integrated soil conservation practices if (s)he had implemented two or more of the soil conservation practices. The choice of explanatory variables was based on literature review on adoption of soil conservation practices and the covariates used in the current study are self explanatory.

Table 1: Description of covariates used in generating propensity scores before matching

Variable	Implementers of ISCPs	Non implementers of

	(N= 203)		ISCPs (N=92)	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Gender of household head (Male=1)	0.88	0.324	0.82	0.390
Age of household head (years)	56.55	13.908	52.07	13.821
Farm size (ha)	2.41	2.889	3.26	5.462
Square of farm size (ha)	14.12	50.206	40.16	172.597
Dummy for primary education[1] (1=Yes)	0.45	0.499	0.48	0.502
Dummy for secondary education[1] (1=Yes)	0.26	0.438	0.28	0.453
Dummy for post secondary education[1] (1=Yes)	0.06	0.245	0.03	0.179
Number of adults in the household	3.29	1.506	3.30	1.765
Dummy for attending training (1=Yes)	0.28	0.448	0.26	0.442
Distance to the river (Kms)	2.27	3.377	1.75	2.325
Household asset ownership (value)	0.37	0.120	0.31	0.114
Proportion of marketed output (%)	0.46	0.291	0.47	0.299
Perceives soil erosion as a problem in the region (1=Yes)	0.53	0.500	0.45	0.500
Dummy for cattle ownership (1=Yes)	0.95	0.217	0.87	0.339
Dummy for secure land tenure (1=Yes)	0.67	0.471	0.54	0.501
Dummy for access to extension (1=Yes)	0.47	0.500	0.42	0.497
Dummy for location in Kianjogu WRUA[3] (1=Yes)	0.15	0.356	0.07	0.248
Dummy for location in Lower Malewa WRUA[3] (1=Yes)	0.10	0.305	0.10	0.299
Dummy for location in Middle MalewaWRUA[3] (1=Yes)	0.19	0.395	0.18	0.390
Dummy for location in Upper Malewa WRUA[3] (1=Yes)	0.11	0.318	0.11	0.313
Dummy for location in Mkungi Kitiri WRUA[3] (1=Yes)	0.11	0.312	0.13	0.339
Dummy for location in Upper Gilgil WRUA[3](1=Yes)	0.10	0.305	0.15	0.361
Dummy for location in Upper Turasha WRUA[3] (1=Yes)	0.14	0.351	0.11	0.313
Log of off-farm income per year	4.72	5.094	3.06	4.963

2. No education is the reference category 3. Wanjohi WRUA is the reference category.

Descriptive statistics of the outcome variable and covariates used in the exogenous switching regression models are presented in Table 2. The dependent variable was computed by multiplying the output (in Kgs) of each commodity produced at the farm with average regional prices of that commodity. The average value of crop production per hectare for each household was then computed by aggregating the values of all commodities produced and dividing the outcome with the total land under crops. For statistical reasons (skewed distribution of the outcome variable) the natural log of the value of crop production was used as a dependent variable in the exogenous switching regression models.

Table 2: Summary statistics of variables used for exogenous switching regression

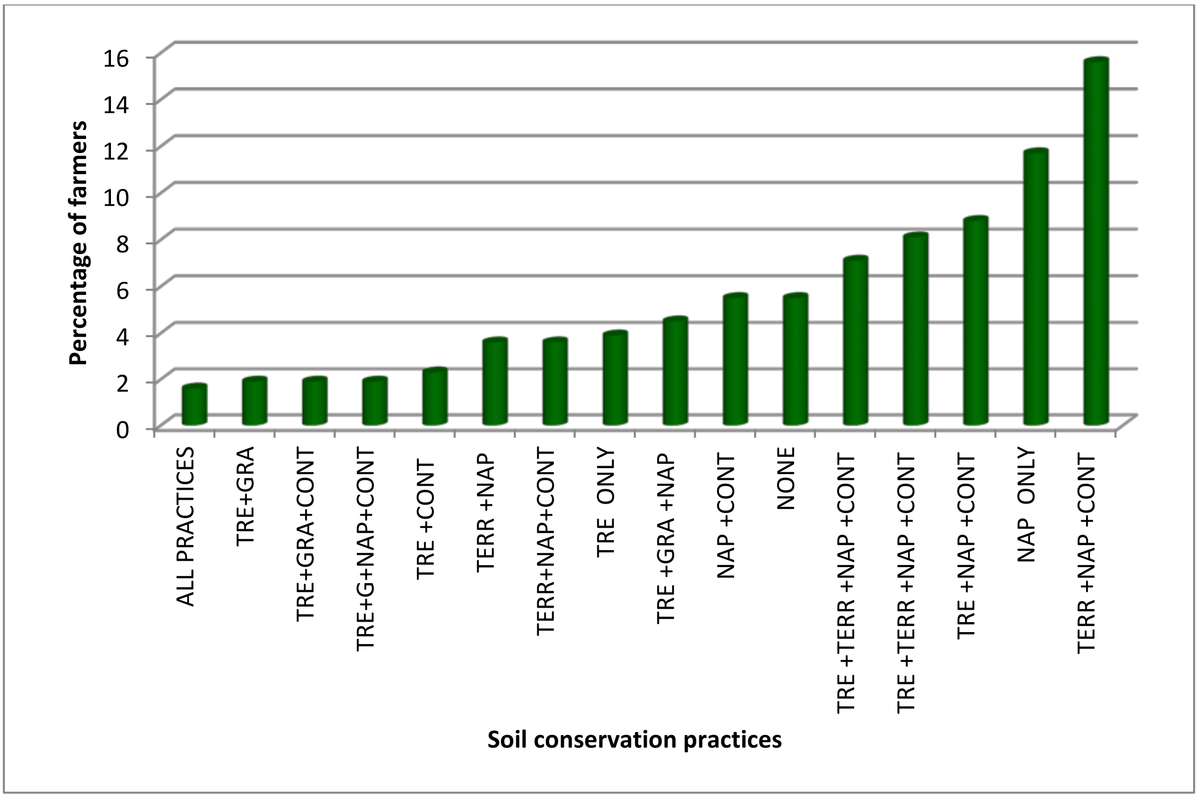
Variable	**Treated sample (N=82)**		**Control sample (N=93)**	
	Mean	Std. Dev.	Mean	Std. Dev.
Value of crop production in Ksh. per ha	192,344	166,222	169,612	157,833

Log of Value of crop production per ha	11.85	0.837	11.34	2.050
Number of adults in the household	3.26	1.497	3.29	1.761
Years of living in the community	31.10	13.121	24.88	15.187
Number of credit sources accessed	1.21	0.797	1.24	0.772
Land under crops (ha)	1.07	0.701	1.24	1.931
Distance to the river (kms)	1.59	2.678	1.74	2.315
Dummy for farm experiencing erosion (1=Yes)	0.72	0.452	0.63	0.484
Dummy for engagement in exchange of materials (1=Yes)	0.89	0.315	0.85	0.360
Dummy for membership in farmers group(1=Yes)	0.17	0.379	0.17	0.379
Dummy for attainment of primary education(1=Yes)	0.51	0.503	0.48	0.502
Dummy for secondary education(1=Yes)	0.22	0.416	0.28	0.451
Dummy for post secondary education(1=Yes)	0.01	0.110	0.03	0.178
Dummy for subjective norms(1=Yes)	0.57	0.498	0.57	0.498
Dummy for ownership of mobile phone(1=Yes)	0.94	0.241	0.94	0.247
Dummy for ownership of radio(1=Yes)	0.93	0.262	0.92	0.265
Dummy for membership in religious group(1=Yes)	0.02	0.155	0.03	0.178
Dummy for membership in village group(1=Yes)	0.23	0.425	0.23	0.420
Dummy for membership in water project	0.73	0.446	0.62	0.487
Age of household head (years)	54.06	13.845	52.31	13.950
Log of off-farm income per year	3.39	4.690	3.15	5.004
Dummy for manure application	0.43	0.498	0.35	0.481
Dummy for use of hired labour	0.39	0.491	0.26	0.440
Log of fertilizer cost per year	8.84	2.921	8.67	2.853
Household located in the Kinangop plateau	0.44	0.499	0.39	0.490
Distance to nearest tarmac road (kms)	7.27	22.484	4.54	3.866

4 RESULTS AND DISCUSSIONS

4.1 Descriptive statistics and opportunity costs of Soil conservation practices

Figure 1 presents some descriptive statistics on implementation of integrated soil conservation practices in the Lake Naivasha basin. The most popular type of integration observed in the study area was that combining terraces, Napier grass and contour farming, which had been implemented by close to 16% of the households. Only a small proportion (1.6%) had implemented the entire package of soil conservation practices.



TRE=Tree planting; GRA=Grass strips; CONT=Contour farming; NAP=Nappier grass; TERR= Terraces

Figure 1: The major combinations of soil conservation practices

The choice by each farmer on the specific combination of practices to implement is usually determined by farmer and farm attributes. This is a non trivial issue but will not be discussed since it is beyond the scope of this paper. However, we consider that some soil conservation practices will involve investment of scarce farm resources such as land and labour and therefore opportunity costs could be a major consideration in their implementation. As elaborated by Ellis-Jones and Tengberg (2000), opportunity costs in implementation and maintenance of soil conservation practices arise from two main components. First, it is the crop production foregone by allocating part of the scarce household land to soil conservation practices such as Terraces, Tree planting and Napier grass growing. This component is estimated using the gross margins of the crops that would have been grown on that land. The second component involves off-farm income generating opportunities foregone by allocating household labour hours to implementation of soil conservation practices. The wage rate in the area is the best estimator of the opportunity cost of labour. However, the opportunity costs are unique for every region and could also differ even for every farmer because they depend on farm and farmer circumstances such as the slope of the farm, the prevailing wage rates for the off-farm employment opportunities that each farmer has access to and the gross margins of the enterprises that each farmer has, which is in turn dependent on prices. For our arguments we use the opportunity costs estimated by Zhunusova (2012). According to the author, for a farmer with a moderately sloping farm the opportunity costs for implementing *Fanya Juu* terraces in the Lake Naivasha basin were in the range of Kshs. 7,800 and Kshs. 30,400 per ha while those of implementing grass strips ranged between Ksh. 3,000 and Ksh. 10,500 per ha depending on the slope of the farm. The extremely sloping farms had higher opportunity costs. These costs will be taken as indicative for the area and compared with the effect of implementing ISCPs in the next section.

4.2 Propensity score matching (PSM) results

Tables 3 present the results of propensity score matching (PSM) generated using the psmatch2 command Stata module developed by Leuven and Sianesi (2003). According to the Log likelihood test, the probit model used in the estimation of propensity scores is significant at the 0.01 level ($p<0.01$). The Pregibon's linktest (Pregibon, 1980) used to check model misspecification, rejects the null hypothesis that the model is mispecified. The prediction power of the model is also strong as indicated by the percentage of correct predictions (77.9%). Table 3 indicates that farm size, gender of household head, asset ownership, regional dummies and the proportion of marketed output had statistically significant effects on the behavior of farmers in terms of undertaking integrated soil conservation practices. Since this model was used merely as a statistical tool to estimate the propensity scores, no behavioral interpretation to the results will be offered here.

We conducted t-tests to assess the quality of the matching to ensure that the distribution of covariates is equal between the treated and control samples independent of the treatment. The t-statistics obtained ($p>0.1$) indicates that satisfactory matching quality was achieved for all covariates included in the model. The test of the balancing property was done considering only those observations that were on common support.

Table 3: Results of the probit model used in propensity Scores

Covariates	Coefficients	Std. Err.	Marginal effects
Gender of household head (Male=1)	0.38	0.258	0.13
Age of household head (years)	0.01	0.008	0.00
Farm size (ha)	-0.12**	0.062	-0.04
Square of farm size (ha)	0.00	0.003	0.00
Average Household education level (years)	-0.01	0.031	0.00
Number of adults in the household	-0.05	0.056	-0.02
Dummy for attending training (1=Yes)	-0.05	0.204	-0.02
Distance to the river (kms)	0.02	0.034	0.01
Household asset ownership (0-1 index)	4.63***	1.101	1.51
Perception on soil erosion as a problem in the area	0.27	0.177	0.09
Dummy for cattle ownership (1=Yes)	0.41	0.376	0.15
Dummy for secure land tenure(1=Yes)	0.11	0.209	0.04
Dummy for access to extension(1=Yes)	0.30	0.202	0.10
Natural log of off-farm income per year	0.03	0.019	0.01
Dummy for location in Kianjogu WRUA (1=Yes)	1.33***	0.511	0.26
Dummy for location in Lower Malewa WRUA (1=Yes)	0.82**	0.414	0.20
Dummy for location in Middle Malewa WRUA (1=Yes)	0.37	0.352	0.11
Dummy for location in Upper Malewa WRUA (1=Yes)	0.51	0.391	0.14
Dummy for location in Mkungi Kitiri WRUA (1=Yes)	0.11	0.321	0.04
Dummy for location in Upper Gilgil WRUA (1=Yes)	0.02	0.328	0.01
Dummy for location in Upper Turasha WRUA (1=Yes)	0.26	0.299	0.08
Proportion of marketed output (%)	-0.60**	0.327	-0.20
Constant	-2.39***	0.658	
Model summary statistics			
Number of observations	293		
LR χ^2 (24)	70.24***		
Pseudo R^2	0.19		
Log likelihood	-145.61		
% of correct predictions	77.9		

*,**,*** indicate significance at 0.1, 0.05 and 0.01 levels respectively.

Estimates of average effect of implementing integrated soil conservation technologies on the value of crop production per hectare (ATT) generated through the nearest neighbor (with caliper) method are presented in Table 4. When only the land under crops is used in computing the outcome variable, the results indicate that farmers who had implemented integrated soil conservation practices had a 34.45% higher value of crop production than those who did not. That would imply that for an average farmer in the sample, implementing ISCPs would create Kshs. 20,000 (€ 180) per ha per year more than their non implementing counterparts. When we included the degraded land in computing the outcome variable, the effect of implementation on the value of crop production was unsurprisingly higher. In the second model, implementation of ISCPs yielded a 35.5% higher value of crop production or Kshs. 21,500 (€195) for an average farmer. The implication is that ISCPs will have a higher impact on degraded land because of the potential of such lands to benefit from improved conservation. We also note that the expected value of crop production before matching is substantially lower than after matching. These results imply a presence of positive self selection bias which means that farmers who had low crop productivity are more likely to self select into implementation of ISPs.

Table 4: Effect of implementing integrated soil conservation technologies

	MODEL 1[a]		**MODEL 2**[b]	
	Value of crop production per hectare	**Log of value of crop production per hectare**	**Value of crop production per hectare**	**Log of value of crop production per hectare**
Before matching				
Mean difference	6,000	0.181	2,339	0.182
t-stat	0.36	1.416**	0.15	1.419**
After matching				
ATT	13,627	0.296[a]	12,928	0.303[b]
t-stat	0.61	1.89**	0.58	1.89**
Balancing property				
Attained?	YES	YES	YES	YES
Standardized mean bias	5.2%	5.2%	5.2%	5.2%
Common support condition				
Imposed?	YES	YES	YES	YES
N on common support	170	170	170	170
Number of observations				
Total	293	293	293	293
Treated	80	80	80	80
Controls	90	90	90	90

** Value statistically significant at the 0.05 level.

a- The outcome variable was computed by dividing the total value of crop production by the land under crops

b- The outcome variable was computed by dividing the total value of crop production by the land under crops plus the degraded land that was not usable

4.3 Robustness and sensitivity analysis of the ATT

Exogenous switching regression analysis based on matched observations of implementers and non implementers of integrated soil conservation practices was used to check the robustness of results obtained through the PSM method. Table 5 presents the results of exogenous switching regression models. F-tests show that both models are significant at the 0.05 level.

The results in Table 5 indicate that the coefficients of the cost of fertilizers, the size of crop land and proportion of marketed output were consistent in sign and significance for both implementers and non implementers of ISCPs. The positive influence of fertilizer use on crop productivity is obvious and also the negative effect of land under crops is consistent with the theory that farmers with smaller parcels of land are able to optimize their production better and receive higher yields compared to those with larger parcels. Otsuki (2010) claimed that smaller plots tend to be more productive than larger plots in the case when households employ mostly family labor for crop production. Farmers who are commercial oriented are also most likely to have higher productivity as confirmed by the results since they are also likely to use more purchased inputs. The crop output for the implementers of ISCPs however seemed to be more responsive to external inputs as indicated by the significant coefficients of use of pesticides and manure in the model for implementers of ISCPs. Against expectation, more educated implementers of soil conservation practices were found to have lower value of crop production. Likewise, access to extension services was found to negatively influence the value of crop productivity.

Table 5: Exogenous switching regression results on the determinants of value of crop productivity

Explanatory variables	**Implementers of ISCTs**	**Std. Err.**	**Non Implementers of ISCTs**	**Std. Err.**
Dummy for engagement in off-farm activity	0.39**	0.172	0.15	0.180
Dummy for use of hired labour	0.27	0.160	0.15	0.223
Land under crops	-0.37***	0.112	-0.39***	0.094
Cost of fertilizer per year (Ksh.)	0.0001**	0.0002	0.0001**	0.0003
Age of household head (years)	-0.01*	0.006	0.00	0.008
Soil erosion perceived present (1=Yes)	-0.32*	0.169	-0.14	0.195
Dummy for engagement in exchange of materials	0.30	0.240	0.32	0.289
Dummy for use of pesticides	0.32*	0.187	0.08	0.222
Livestock ownership (TLU)	0.02	0.020	-0.01	0.023
Distance to nearest tarmac road	0.02	0.019	0.02	0.027
Dummy for post secondary education	-0.90*	0.497	0.30	0.514
Dummy for use of manure	0.37**	0.156	-0.03	0.191
Proportion of marketed output	0.86***	0.353	1.85**	0.376
Number of interacted with by household	0.001	0.001	0.00	0.001
Dummy for practicing irrigation	0.24	0.190	0.28	0.237
Access to extension services	-0.38*	0.200	0.13	0.218
Dummy for location of household	-0.13	0.198	0.04	0.208
Slope of the farm (1=Extremely sloping)	-0.32	0.272	-0.29	0.307
Constant	10.71***	0.588	10.18**	0.628
Model summary statistics				
Number of Observations	80		90	
F-test	$F_{18,61} = 7.99$***		$F_{18,71} = 4.55$***	
R-squared	0.70		0.54	

*,**,*** indicates parameters are significant at the 0.01, 0.05 and 0.1 levels respectively.

Table 6 presents mean differences in predicted value of the log of crop production per hectare. The results indicate a significant positive influence of implementing integrated soil conservation practices on the value of crop production per hectare. In general, results of the exogenous regression analysis are consistent with those obtained with Propensity Score Matching (PSM). The mean difference of the predicted value of the log of value of crop production was 0.29, which implies that implementers of ISCPs had 33.6 % more value of crop production compared to non implementers. This would imply that the additional value of crop production for an average farmer as a result of implementation of ISCPs is Kshs 20,468. Both PSM and exogenous switching regression show a significantly higher value of crop production for individuals who had implemented ISCTs.

Table 6: Differences in means of predicted logarithm of the value of crop production per hectare

	Number of observations	Mean	Std. error
Implementers	80	11.98	0.080
Non-Implementers	90	11.27	0.089
Mean difference		0.29	0.120
T-test		2.428***	

*** indicates statistics are significance at the 0.01 level

The sensitivity of the ATT to unobserved heterogeneity was assessed using the Rosenbaum (2002) bounds test. The results on Table 7 indicate that the treatment effects are not very sensitive to hidden bias caused by unobserved heterogeneity because of unobserved covariates - such as individual skills or personal abilities - that might simultaneously affect the treatment and outcome variables. The upper bound of the p-value (p+) becomes insignificant when the sensitivity parameter (Γ) is equal to 1.2. This implies that the probability of receiving treatment by two individuals with the same observed covariates can differ by up to 20% without altering the inference on the treatment effect. These results indicate a relatively low sensitivity of the ATT to hidden bias, and therefore the estimated effect is a result of implementation of integrated soil conservation practices.

Table 7: Bounds test results on sensitivity of treatment effects to hidden bias

Sensitivity parameter (Γ^*)	Level of significance (p^+)	Level of significance $(p)^-$	*Confidence interval*	
1	0.026	0.026	-0.001	0.634
1.05	0.040	0.016	-0.048	0.659
1.1	0.058	0.010	-0.076	0.690
1.15	0.080	0.006	-0.111	0.722
1.2	0.107	0.004	-0.137	0.747
1.25	0.139	0.002	-0.158	0.769
1.3	0.174	0.001	-0.175	0.799
1.35	0.214	0.001	-0.210	0.821
1.4	0.256	0.001	-0.232	0.847
1.45	0.300	0.000	-0.261	0.870
1.5	0.346	0.000	-0.286	0.897

*This parameter represents the odds ratio and measures the degree of departure from equal treatment between observations. A value of 1 implies that the odds ratio of treatment is the same and therefore the study is free from hidden bias.

Using the two approaches, we find consistent results indicating a positive effect of implementing integrated soil conservation practices on the value of crop production. However, the estimated gains as a result of implementing ISCPs averaging at Ksh. 20,000 (€180) are not substantially large enough to cover the opportunity costs associated with the implementation of these practices which as indicated earlier, especially in the extremely sloped farms where such opportunity costs are upto Ksh. 34,000 (€309) per ha. Therefore, implementation of ISPs might not necessarily yield positive private benefits, but as indicated by Araya and Asafu-Adjaye (1999), these practices might yield net positive effects if social benefits are taken into consideration. However, a dynamic approach that incorporates time preference considerations in the assessment of the effects of ISCPs on crop productivity will be a valuable contribution in this debate. The difference between the value of crop production between implementers and non implementers of ISPCs might become bigger because the farms without soil conservation measures will continue to be eroded, further depressing yields. We recommend this as a focus for future research.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The main objective of this paper was to estimate benefits of implementing integrated soil conservation practices. Using data obtained from smallholder farmers in Lake Naivasha basin, Kenya, the study employed Propensity Score Matching (PSM) to estimate the additional value of crop productivity that can be attributed to implementation of ISCPs. Investigating returns to soil conservation technologies is of crucial importance for successful promotion of soil conservation technologies because farmers seem to continiously use SCPs mostly if they believe that technologies are profitable. PSM was used to address self-selection bias and evaluate conservation technology effect on the value of crop production. Consistency of the resulst was checked using exogenous switching regression models and t-tests, while sensitivity of the results to unobserved heterogeinity was checked using bounds test. From the PSM, matched samples of implementers and non implementers of ISCPs were obtained to ensure uniformity in the samples such that the individuals who were compared differed only in the treatment.

Estimated average treatment effects (ATT) obtained through PSM method show that implementing ISCPs yields positive significant effects on the value of crop production per hectare. The results obtained through exogenous switching regression confirmed these results. However, although our findings reveal that integration of several soil conservation practices is beneficial, the marginal benefits are not substantially high to cover the opportunity costs associated with the implimantation of ISCPs, especially in extremely sloped fields. In cases where marinal benefits are not substantial to over private incentives for implementation of soil conservation practices, intrinsic or external incentives could be necessary. Previous studies which evaluated the effect of individual soil conservation practices such as terraces (Kassie et al., 2011) or stone bunds (Araya and Asafu-Adjaye, 1999) had a negative effect on crop productivity. However, as revealed in the current study, when such a practice in used within an integrated soil conservation package, the overall effect is positive. This result highlights the importance of using the approach of assessing the complementary effects of different soil conservation practices such as the one used in the current study. Given these findings, we encourage policies that emphasize on integrated approaches to soil conservation, where comprehensive soil conservation packages that suit each farmers' local conditions are promoted. This will ensure that beside the social benefits associated with soil conservation practices, there is also a sufficient flow of private benefits, an incentive for farmers to sustain soil conservation practices. We recommend future research using a dynamic assesment that incorporates time preference considerations in the assessment of the effect of soil conservation practices on the value of crop productivity.

REFERENCES

Araya, B., Asafu-Adjaye, J., 1999. Returns to Farm-Level Soil Conservation on Tropical Steep Slopes: The Case of the Eritrean Highlands. Journal of Agricultural Economics 50, 589–605.

Becht, R., Odada, E.., Higgins, S., 2005. Lake Naivasha : experience and lessons learned brief, in: Lake Basin Management Initiative : Experience and Lessons Learned Briefs. Including the Final Report: Managing Lakes and Basins for Sustainable Use, a Report for Lake Basin Managers and Stakeholders. International Lake Environment Committe Foundation (ILEC), Kusatsu, pp. 277–298.

Bekele, W., 2005. Stochastic Dominance Analysis of Soil and Water Conservation in Subsistence Crop Production in the Eastern Ethiopian Highlands: The Case of the Hunde-Lafto Area. Environmental and Resource Economics 32, 533–550.

Bewket, W., 2007. Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: Acceptance and adoption by farmers. Land Use Policy 24, 404–416.

Caliendo, M., Kopeinig, S., 2008. Some Practical Guidance for the Implementation of Propensity Score Matching. Journal of Economic Surveys 22, 31–72.

Chiramba, T., Mogoi, S., Martinez, I., Jones, T., 2011. Payment for Environmental Services pilot project in Lake Naivasha basin, Kenya – a viable mechanism for watershed services that delivers sustainable natural resource management and improved livelihoods. Presented at the Water in the Green Economy: Towards Rio+20, Zaragoza, Spain.

De Graaff, J., Amsalu, A., Bodnár, F., Kessler, A., Posthumus, H., Tenge, A., 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. Applied Geography 28, 271–280.

Dehejia, R.H., Wahba, S., 2002. Propensity Score-Matching Methods for Nonexperimental Causal Studies. Review of Economics and Statistics 84, 151–161.

Ellis-Jones, J., Tengberg, A., 2000. The impact of indigenous soil and water conservation practices on soil productivity: examples from Kenya, Tanzania and Uganda. Land Degrad. Dev. 11, 19–36.

Greene, W., 2003. Econometric Analysis, 5th ed. Prentice Hall, Upper Saddle River, New Jersey.

Grilli, L., Rampichini, C., 2011. Propensity scores for the estimation of average treatment effects in observational studies. Bristol.

Kassie, M., Köhlin, Gunnar, Bluffstone, R., Holden, S., 2011. Are soil conservation technologies "win-win?" A case study of Anjeni in the north-western Ethiopian highlands. Natural Resources Forum 35, 89–99.

Kassie, M., Pender, J., Yesuf, M., Kohlin, G., Bluffstone, R., Mulugeta, E., 2008. Estimating returns to soil conservation adoption in the northern Ethiopian highlands. Agricultural Economics 38, 213–232.

Khisa, P., Gachene, C.K.., Karanja, N.., Mureithi, J.., 2007. The effect of post harvest crop cover on soil erosion in a maize-legume based cropping system in Gatanga, Kenya. Journal of Agriculture in the Tropics and Subtropics 103, 17–28.

Leuven, E., Sianesi, B., 2003. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing (Statistical Software Components No. S432001), Statistical Software Components. Boston College Department of Economics, Boston.

Lutz, E., Pagiola, S., Reiche, C., 1994. The Costs and Benefits of Soil Conservation: The Farmers' Viewpoint. The World Bank Research Observer 9, 273–295.

Lynne, G.D., Shonkwiler, J.., Rola, L.., 1988. Attitudes and farmer conservation behaviour. American Journal of Agricultural Economics 12, 12–19.

Mazvimavi, K., Twomlow, S., 2009. Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. Agricultural Systems 101, 20–29.

Mbaga-Semgalawe, Z., Folmer, H., 2000. Household adoption behaviour of improved soil conservation: the case of the North Pare and West Usambara Mountains of Tanzania. Land Use Policy 17, 321–336.

Mekonnen, M.., Hoekstra, A.., 2010. Mitigating the Water Footprint of Export Cut Flowers from the Lake Naivasha Basin, Kenya (Value of Water Research Report Series No. 45), Value of Water Research Report Series. UNESCO-IHE, Delft, The Netherlands.

Mendola, M., 2007. Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. Food Policy 32, 372–393.

Miller, M.J., Mariola, M.J., Hansen, D.O., 2008. EARTH to farmers: Extension and the adoption of environmental technologies in the humid tropics of Costa Rica. Ecological Engineering 34, 349–357.

Nyangena, W., Köhlin, G., 2009. Estimating Returns to Soil and Water Conservation Investments - An Application to Crop Yield in Kenya (Working Papers No. 402), Working Papers in Economics. School of Business, Economics and Law at University of Gothenburg, Göteborg , Sweden.

OECD, 2012. Glosary of Statistical Terms [WWW Document]. URL http://stats.oecd.org/glossary/download.asp (accessed 8.31.12).

Otsuki, T., 2010. Estimating Agroforestry's Effect on Productivity in Kenya: An Application of a Treatment Effects Model (Discussion Paper No. DP - 20 10 - E - 001), OSIPP Discussion Papers. The Osaka School of International Public Policy, Osaka University, Osaka, Japan.

Pender, J., Gebremedhin, B., 2007. Determinants of Agricultural and Land Management Practices and Impacts on Crop Production and Household Income in the Highlands of Tigray, Ethiopia. Journal of African Economies 17, 395–450.

Posthumus, H., De Graaff, J., 2005. Cost-benefit analysis of bench terraces, a case study in Peru. Land Degrad. Dev. 16, 1–11.

Pregibon, D., 1980. Goodness of link tests for generalized linear models. Appl Stat 29, 15–24.

Pretty, J.N., Thompson, J., Kiara, J.., 1995. Agricultural regeneration in Kenya: The catchment approach to soil and water conservation. Ambio. Stockholm 24, 7–15.

RAMSAR convention, 2011. The Annotated Ramsar List: Kenya [WWW Document]. The Annotated Ramsar List: Kenya. URL The Annotated Ramsar List: Kenya

Rosenbaum, P.R., 2002. Observational Studies, Second Edition. ed. Springer, New York, USA.

Rosenbaum, P.R., Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70, 41–55.

Shiferaw, B., Holden, S., 2001. Farm-level benefits to investments for mitigating land degradation: empirical evidence from Ethiopia. Environment and Development Economics 6, 335–358.

Shively, G.E., 1998. Modelling Impacts of Soil Conservation on Productivity and Yield Variability: Evidence from a Heteroskedastic Switching Regression, in: American Proceedings of the Annual Meeting of the Agricultural Economics Association Annual. Presented at the Annual meeting of the American Agricultural Economics Association, 2-5 August, Salt Lake City, Utah.

Tenge, A., 2005. Participatory appraisal for farm-level soil and water conservation planning in West Usambara highlands, Tanzania. [s.n.], [S.l.].

Van Rijn, F., Bulte, E., Adekunle, A., 2012. Social capital and agricultural innovation in Sub-Saharan Africa. Agricultural Systems 108, 112–122.

Vancampenhout, K., Nyssen, J., Gebremichael, D., Deckers, J., Poesen, J., Haile, M., Moeyersons, J., 2006. Stone bunds for soil conservation in the northern Ethiopian highlands: Impacts on soil fertility and crop yield. Soil and Tillage Research 90, 1–15.

Verbeek, M., 2008. A Guide to Modern Econometrics, 3rd Edition. ed. John Wiley & Sons, Chichester.

Willy, D.K., Holm-Mueller, K., 2013. Social influence and collective action effects on farm level soil conservation effort in rural Kenya. Ecological Economics 90, 94–103.

WWF, 2011. Shared Risk and Opportunity in Water Resources: Seeking Sustainable Future for Lake Naivasha (WWF Report 2011), WWF Reports. WWF.

Zhunusova, E., 2012. Marginal Benefits and Opportunity Costs of Environmentally Friendly Technologies Employed by Small-Holder Farmers in the Lake Naivasha Basin, Kenya (Master Thesis). University of Bonn, Bonn, Germany.