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Does Soil Conservation Pay? Evidence from Machakos and Kitui Districts, Kenya

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Abstract: Using data from a 2000 household survey in Machakos and Kitui districts in Kenya, the factors that influence the rates of return in soil conservation are examined. A Cobb-Douglass regression analysis is employed. The results show that land tenure; slope besides other factors explain the pattern of natural resource management in semi-arid areas. The policy implication hinges on better access to markets, improvement of land tenure security, increasing yields and better crop choice.

Key words: Incentives, soil conservation, agriculture, sustainability, marginal areas

INTRODUCTION

About 80% of the total land area in Kenya is marginal for agricultural production. This area is faced with frequent food shortages, is ecologically vulnerable and receives irregular and low amounts of rainfall. Marginal areas also face very serious problems of environmental degradation such as soil erosion and soil mining. Soil erosion and degradation of agricultural land present serious threat to food security and sustainability of agricultural production. Land degradation defined here as a decline in the land's actual or potential productivity[1] contributes to rural poverty, poor agricultural performance and general stagnation of the Kenyan economy. Poverty, market imperfections and policy failures among others hinder smallholders' incentives to invest in conservation practices[2,3]. As the population increases in these areas due to immigration and births, the situation is bound to get worse.

Nevertheless, these marginal areas can be very productive if farmers make substantial investments on their land. Such investments include terracing, application of manure, planting of trees, among others. These investments conserve water and the soils at the farm household level. Once these investments are undertaken, the food security situation will improve and other national objectives, notably poverty alleviation and employment generation, will also be met. Moreover, soil conservation also raises the long-term sustainability of farming systems.

Investments into soil conservation may be undertaken when sufficient returns are expected in comparison with the situation when no such investments are made. In this study the returns to soil conservation are examined. The analysis focuses on farmers' incentives to conserve soil and water in marginal areas.

Soil conservation benefits: Benefits of soil conservation are the crops grown and the yields obtained after terracing has been carried out. Investment in terraces will mean higher and stable yields from a given piece of land[4-9] The value of this benefit then depends on how much of this yield gets to the market and how much value is realised when it gets there. There are several factors at work such as transaction costs to the market, search costs for finding a buyer, distance from the crop fields to the homestead and household characteristics among others.

Information was thus sought to make it possible to estimate these factors and thereby construct a valuation of the net benefits from investment as a function of these factors. With this, one would be able to tell whether or not farmers respond to incentives and, more importantly identify which factors such as wealth, family size and transaction costs affect the response to incentives.

In the construction of soil conservation benefits, it is noted that there are other inputs to farming other than land and labour and differences in these would need to be accounted for in comparing various investment alternatives. Also, the investment problem is intertemporal (benefits coming for several years after costs are sunk) so benefits and costs need to be represented as discounted present values:

$$NPV = (1+r)^{-1} \sum_{t} Y_t P_t - C_t$$

where:
Y = Agricultural yields (maize and beans) in Kg ha^{-1}
P = Price of maize and beans per kilogram

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C = Costs incurred which consists of labour, fertiliser and manure
t = Number of years, representing the chosen time horizon
r = Social discount rate

Application of the above approach requires the adoption of a locally relevant universal soil loss equation (USLE) to estimate soil losses and then relate soil losses to yield decline using an experimental derived relationship between topsoil loss and yields. In a long-term experiment at Katumani Agricultural Research Station in Agro-Ecological Zone IV, Kilewe[10] estimated the USLE parameters. According to Pagiola[11], the yield soil loss equation of maize is given as:

$$\text{Yield} = \underset{(0.14)}{1.93} - \underset{(0.01)}{0.13}\ \text{Soil loss}$$

Adj. R Square = 0.97

There are other various functional forms that have been used. For instance, Shiferaw and Holden[12] use a translog, Mitchell[13] use linear, while Walker[14] and Ekbom[15] use variations of the general exponential form. Our borrowing from Pagiola[11] is dictated by the fact that it is in the same study area and thus have access to the same data. The limitation is that soil loss-yield relationship is often considered non-linear.

The data used for the above equation is derived from Kilewe[10] in which an artificial desurfacing experiment was carried out at Katumani to simulate long-term losses from erosion on maize yields. The results for the treatment closely approximate on-farm practices. In this simulation, neither manure nor fertilizer was used. As the equation above shows, a linear specification provides an excellent fit as the high R^2 indicates. The yield decline per unit of soil loss estimated is then converted to a proportional annual yield decline.

However with beans, there have been no experiments of artificial desurfacing to simulate long-term losses from soil erosion on yields. We also do not have sufficient information to re-construct the soil loss-yield relationship for beans. In any case, beans provide a better cover crop than maize. It follows that soil loss under bean crop is lower for a farm that has no terraces. It was assumed a similar soil loss-yield relationship for beans as for that of maize, as Pagiola[11] did. We assume pure crop stands due to insufficient data. Allowing for intercropping would complicate the analysis especially in handling the interactions of the crop enterprises.

With unterraced fields, we assume that input use such as manure, fertilizer and labour decline at about 25% every year corresponding to the yield decline. As for terraced fields, yields are assumed to remain stable over a number of years as well as the level of factor use. This is naturally a simplification, but a necessary one since no data is available on yield and input response of land changes over time. Studies have shown that crop yields on terraces less than 10 years since being constructed are higher than yields from terraces more than 10 years. Nevertheless, the differences are not significant or yields are rather stable especially when periodic maintenance is adequate[7,8]. Crop production costs are thus assumed to remain unchanged over time, but farmers would have to face the initial cost of terracing and the recurrent cost of terrace maintenance including nutrient investment. It was also assumed that there is no yield penalty from terracing due to terracing structures. This is because terraces are a form of insurance due to crop diversification. Instead of penalties, it should bring about some form of security to farmers. The argument is that in practice, the area devoted to production is not entirely lost, since terrace edges can be planted with grass crops for use as fodder or with trees or bananas. Some farmers plant root crops such as cassava in the terrace edges.

A 2% real discount rate was used in this study. This is considered appropriate due to the bequeath motives of farmers; and that real interest rates in Kenya have been negative on average[6] before liberalization in 1992. In addition, the economic or population growth ratio has been declining over the years showing the need for increased future savings, necessitating a low discount rate[16]. Discount rates are those appropriate for discounting future well-being[6,15-17].

The relevant time period or horizon is taken to be a 100 years. This is because the benefits of terracing can accrue to one's children and even grand children as farmers rarely sell land. Generally the land market in Sub-Saharan Africa is inactive[18,19]. Moreover, land acquisition in the study area is predominantly through inheritance[20].

The best would have been the relevant time the soil conservation structures have a productive effect on the farm. But with periodic and timely maintenance, this time period can extend to positive infinity. Shiferaw and Holden[12] argued where the soil conserving technology may arrest the degradation process and sustain production, the terminal time period may approach infinity. For our case, any time period ranging from 50 to 100 is still fine. This follows from earlier benefit-cost studies, which show that farmers break-even after 48 years[11].

Taking a longer time horizon than 48 years will not in any way change or bias the results. The time horizon would only affect the results if it were shorter than the minimum time required to repay the investment in soil conservation. Even though longer periods are essentially problematic since technologies change over farm family generations, simulation of benefits is often done under the assumptions that the same state of affairs will exist for a considerable period of time.

Borrowing also from Pagiola[11] we take an average annual soil loss of 20.65 tons per acre; which is equivalent to an annual reduction of 3 mm in topsoil depth. This will cause an annual decline in yield of 22 kg for maize and 15 kg for beans. Within 10 years, yields will have declined by 20%; within 20 years they will drop by more than 40%, assuming no intervention measures are taken to arrest the degradation of the land asset.

Consideration of yield decline alone is not sufficient to determine whether investment in conservation would be profitable from the farmer's perspective. Conservation would only pay if the costs of such investment were lower than the value of averted damage. Although costs decline slightly as lower yields reduce labour requirements for harvesting, revenues decline at a faster rate, so that net returns fall continuously.

We optimally employed a Cobb Douglas functional form as it provided the best fit to the data.

$$\ln B = a + \sum_{i=1}^{n} B_i \ln X_i$$

where, B and X_{ij} are the net benefits of soil conservation and factors considered, respectively. All the variables are described in Table 1.

Data setting: The data used in this study comes from a survey of rural households in Machakos and Kitui Districts during 1999-2000 cropping season. Four sub-locations were chosen in each district on the basis population density and distance to Nairobi. Two sub-locations with fairly high population density but far and near Nairobi were selected in each district. Likewise, two sub-locations with low population density but far and near Nairobi were also selected. A village was then selected from each of the sub-locations that showed recent signs of transition to sustainable agriculture. The villages selected in Machakos District were Kisaki, Musoka, Ngalalia and Ngumo; while in Kitui District these were Mwanyani, Kitungati, Utwiini and Kyondoni. The survey involved 105 house holds in each district with about 25 households in each village.

The study areas were in agro-ecological zone 4[21]. This zone is a transition between semi-arid and semi-humid, depending on altitude. It is characterised by having between 115 and 145 growing days (medium to medium/short growing season) and annual mean temperature between 15 and 18°C in the Lower Highland zone. The Upper Midland zone has between 75-104 growing days (short to very short growing season) and a mean annual temperature of between 21 and 24°C. Cattle and sheep keeping and the growing of barley are recommended in the Lower Highland zone, while sunflower and maize are recommended in the Upper Midland zone.

Table 1: Description, measurement and expected signs of variables

Variables	Description	Measurement	Expected sign
Slope	Slope of land parcel	Simple scale: flat (1), medium slope (2), steep slope (3)	+Ve
Tenure	Land tenure regime	Simple scale of increasing tenure security	+Ve
Loc	Location	Kitui(1), Machakos (0)	-Ve
Disth	Distance from homestead to crop fields	Metres	-Ve
Lcropac	Lagged crop output	In Kilograms and in value terms	+Ve
Cropac	Crop output	In Kilograms and in value terms	?
Searco	Search costs	Kenya shillings	-Ve
Educ	Education of household head	Simple scale: 0 no education, 1 primary, 2 secondary, etc.	+Ve
Wealth	Wealth of the household	Number of rooms in main house	+Ve
Gender	Whether household head is male or female	Male (1), female (0)	+Ve
Faror	Degree of farm orientation	Fraction of off-farm income	+Ve
Shh	Household size	Number of persons	+Ve
Farmca	Farm size per capita	Hectares per person	-Ve
Inc	Household income	Kenya shillings	+Ve
Age	Age of household head	Number of years	+Ve
Acescos	Access costs to markets	Kenya shillings	-Ve
Erode	Farm eroded or not	Eroded (1), otherwise (0)	+Ve
Terrace	Length of terrace	Metres per hectare	
Lab	Labour use	Man-days per hectare	
Fert	Fertilizer use	Kilograms per hectare	
Man	Manure use	Kilograms per hectare	
Benefits	Net benefits of soil conservation	Ksh per hectare	
Posneg	Whether benefits are positive or not	Positive (1), otherwise (0)	
Fertil	Land quality	Simple scale of increasing land quality	
Selfemp	Whether engaged in self employment or not	Yes (1), otherwise (0)	

RESULTS AND DISCUSSION

First some descriptive statistics were carried out with the benefits of soil conservation. The total sample size of maize farmers was 125 while for beans the sample size was 47. It is found that 34.4% of the sampled farmers had negative benefits of soil conservation on maize crop. These results contrast sharply with those of past studies [11,15,16] that just carried out cost-benefit analysis and found that it was indeed positive. Perhaps this was because they focussed on a representative or model farmer that was far from reality. The farmers (in this study) that had positive benefits of soil conservation on maize crop were 65.6%. As for beans, 34% of sampled farmers had negative net soil conservation benefits, while 66% had positive net soil conservation benefits. Thus a significant proportion of farmers have negative soil conservation benefits. The results of cost benefit analysis by Shiferaw and Holden[12] on work done in Ethiopia seem to lend credence to present results. However, our work is a step further for we are able to carry out some econometric analysis of the benefits as a function of household characteristics and transaction costs among others.

Appendix 1 and 2 show clearly some characteristics of these two groups of farmers (those that have negative benefits and those that have positive benefits). The difference in some characteristics between these two groups is significant. It is difficult to understand why some farmers have negative soil conservation benefits. It suggests that farmers terracing drives are sometimes influenced by social status rather than economic reasons. In addition, there are some other benefits of soil conservation that were not valued and therefore not included such as scenic beauty (intangible benefits). Their inclusion if possible might give a different picture.

Later some t-tests on some of the characteristics of these two groups of farmers were carried out and a number of peculiarities were noted. There is a higher and a significant use of manure and labor on fields of those farmers having negative benefits. In addition to that, their terrace length per hectare, search costs and household income are also significantly higher (Appendix 1). This seems to suggest that negative soil conservation benefits are not an indication of rampant poverty among the population but rather perhaps non-economic inclined.

It is related to over investments and low value of production. It is likely that due to the fragile ecosystem, the preoccupation of conservation cannot be assessed solely on crop value. Intangible benefits such as scenic beauty, moisture conservation and social status may need to be considered. This suggests that preferences of a community or group affect the preferences of individual farmers, in particular, if there are social norms as to what amounts to being a 'good farmer'. If deviation from this norm entails private costs to the farmer, for instance in the form of social sanctions, guilt feelings, low self-esteem or loss of prestige, over investment is plausible.

It is posited that the farmer may never know his or her real costs considering that soil conservation investments are made over a number of years. In addition and more importantly, if costs of acquisition of food from the market are considered along with risks associated with its adequate availability, cash flow problems of farmers and

Appendix 1: Independent samples test for maize

	Levene's test		T-test	
Variables	F	Sig.	t	Sig.
Slope	1.293	0.258	-0.056	0.955
Tenure	0.020	0.889	0.255	0.799
Disth	2.351	0.128	-0.804	0.423
Lcropac	0.126	0.723	-0.282	0.778
Searco	7.674	0.006	-1.786	0.077
Educ	0.624	0.431	0.457	0.649
Wealth	0.109	0.742	1.083	0.281
Faror	0.843	0.360	0.865	0.388
Shh	1.515	0.221	0.463	0.644
Farmca	1.623	0.205	0.427	0.670
Inc	2.503	0.116	-1.566	0.120
Age	0.572	0.451	0.578	0.564
Acescos	0.151	0.699	-1.320	0.189
Terace	16.162	0.000	3.803	0.000
Lab	25.544	0.000	3.408	0.001
Fert	4.746	0.031	1.288	0.200
Man	31.286	0.000	3.387	0.001
Cropac	0.753	0.387	-0.238	0.813
Area	1.420	0.236	0.346	0.730
Benefits	8.593	0.004	-11.207	0.000

Source: Field survey, 2000

Appendix 2: Independent samples test for beans

	Levene's test		T-test	
Variables	F	Sig.	t	Sig.
Slope	0.256	0.615	-0.421	0.676
Tenure	0.778	0.382	-1.469	0.149
Disth	3.736	0.060	-1.443	0.156
Lcropac	3.423	0.071	-1.243	0.220
Searco	0.204	0.654	0.593	0.556
Educ	0.003	0.957	0.242	0.810
Wealth	2.265	0.139	-0.913	0.366
Faror	0.441	0.510	-0.522	0.604
Shh	0.025	0.874	-0.940	0.352
Farmca	3.391	0.072	-1.518	0.136
Inc	1.224	0.275	0.543	0.590
Age	0.430	0.515	-2.015	0.050
Acescos	0.030	0.864	1.125	0.267
Terrace	8.393	0.006	2.089	0.042
Lab	6.348	0.015	1.984	0.053
Fert	3.091	0.086	0.797	0.429
Man	11.860	0.001	1.794	0.080
Cropac	8.452	0.006	-2.428	0.019
Area	0.139	0.711	0.390	0.699
Benefits	3.542	0.066	-6.696	0.000

Source: Field survey, 2000

information flow problems, it is likely that all costs linked to import substitution are lower. This points out to the underdevelopment of the marketing system in Kenya.

This suggests that the market or trading system cannot process adequately the quantities and qualities of commodities demanded in various markets. Further, this is a region prone to high levels of food insecurity implying that self-sufficiency may override other objectives given that agriculture is the mainstay of the economy. Agricultural incomes are very uncertain due to drought besides the market. Given this observation, it is not puzzling to find that some farmers have negative soil conservation benefits on maize fields. Since terraces are expensive mechanical structures, planting high value crops is one way of increasing soil conservation benefits. However, for the case of marginal areas, prevailing food insecurity makes farmers to focus on maize and beans, which are low value crops. This rather explains the apparent negative benefits of soil conservation investments.

Moreover, most people are poor who almost live from hand to mouth and with no "reserve" funds for tomorrow. Thus when transaction costs and risk considerations are incorporated into efficiency calculations, the livelihood strategies employed by the poor can be understood as economically rational.

On bean crop (Appendix 2), significant differences are noted in labor and manure use, length of terraces per hectare, age of principle household members, bean yields, farm size per capita, tenure and distance to crop fields. Farmers with positive net soil conservation benefits have higher levels of distance to crop fields, more tenure security, higher farm size per capita, are much older and have higher bean yields. They also have at the same time, lower use of manure and labor and lower terrace length levels. The emerging picture with beans is generally similar to that of maize, with the exception of higher distance to crop fields. This once more suggests that though both maize and beans are food crops, with the former playing a dominant role.

Nevertheless, the existence of farmers with negative soil conservation benefits on bean fields is still puzzling considering that beans do not constitute the predominant food crop. We are of the view that a number of factors are at play as farmers engage in soil conservation. There appears to be policy-induced distortions or market failure. This point towards the rather heavily emphasized government policy of self-sufficiency and food security. Recent evidence suggests that typical policy distortions in developing countries tend to encourage degradation[22]. Farmers may feel thus obligated to do anything that might further this objective whose end result is inefficiency. Moreover, coupled with poverty and risk objectives, farmers tend to realize sub-optimal outcomes.

Appendix 3 shows the descriptive statistics for some selected variables for maize crop, while Appendix 4, the descriptive statistics for bean crop. All these variables were represented in the econometric model. Most of the variables have low variability with the exception of distance to the crop fields and search costs. The high standard deviation is as a result of the wide variation between minimum and maximum sample values. This high variability will reduce the precision of the estimated coefficients.

Table 2 below shows the regression results of a Cobb-Douglas type of a functional form for soil

Appendix 3: Descriptive statistics of some selected variables used in the analysis for maize soil conservation benefits in Machakos and Kitui Districts, Kenya, 2000

Variables	Minimum	Maximum	Mean	Std. Dev.
Slope	0.21	05.00	02.26	00.96
Tenure	0.60	09.60	01.89	01.11
Disth	1.00	44020.00	1414.06	4691.33
Seacos	0.25	3000.00	339.72	428.22
Educ	1.0	05.00	03.08	01.05
Wealth	1.0	08.00	03.05	01.55
Shh	2.00	18.00	06.91	02.75
Acescos	31.25	200.00	107.00	36.04

N=125, Source: Authors own computation from survey data

Appendix 4: Descriptive statistics of some selected variables used in the analysis for beans soil conservation benefits in Kitui and Machakos Districts, Kenya, 2000

Variables	Minimum	Maximum	Mean	Std. Dev.
Slope	0.60	05.00	02.17	01.04
Tenure	1.00	06.30	01.84	01.02
Disth	0.30	5000.00	467.15	895.23
Seacos	2.00	1100.39	292.79	305.02
Educ	1.00	05.00	03.26	01.15
Wealth	1.00	08.00	03.24	01.83
Shh	2.00	12.00	06.79	02.48
Acescos	50.00	200.00	110.34	36.49

N=47, Source: Authors own computation from survey data

Table 2: Cobb-Douglas regression results of determinants of soil conservation benefits for beans in Machakos and Kitui Districts, Kenya, 2000

Variables	Coefficient	t-statistic
Slope	1.826	1.771*
Tenure	1.538	1.520
Loc	0.529	0.716
Disth	0.145	0.932
Seacos	0.311	1.269
Shh	-1.025	-1.487
Inc	0.397	1.201
Age	2.228	1.566
Acescos	-0.242	-0.223
Erode	0.992	1.540
Fertil	0.846	1.497
Selfemp	-1.320	-2.082**
Posneg	0.972	1.371
(Constant)	-2.675	-0.397
R^2	0.242	
N	47.000	

*significant at p<0.10, **significant at p<0.05, ***significant at p<0.01
Source: Estimates from field survey, 2000

conservation benefits on bean fields. All the variables are in natural logs with the exception of the dummy variables. The most significant variables are slope and whether one is engaged in self-employment or not. Other variables such as tenure, age of principle household member, erosion status of the fields and fertility of the fields were however significant under transaction costs to Nairobi (Appendix 5).

First, it is noted that the coefficient for slope bears a positive sign. The implication is that as slope increases so are the benefits of soil conservation. This is because averted damages increase as slope increases. Unconserved farms on steeper slopes face higher rates of erosion. As a result, yields decline rapidly. On lowerslopes, the cost of terracing outweighs the relatively small benefits of avoiding a low rate of erosion. As slope increases, however, the damages caused by erosion increase faster than the cost of terracing and conservation becomes increasingly profitable.

Tenure, although not significant at 10%, is significant at 13.8%. As Quisumbing *et al.*[23] argued, land tenure rules affect the expected future benefits to those who invest in land improvement. The results show that as property rights improve, soil conservation benefits increase because of the long gestation period of the investments. Farmers are thus able to recoup their benefits with secure tenure. The length of time required to break even provides an important indicator of the likely severity of tenure insecurity. Farmers with insecure tenure may doubt that they will be able to enjoy the benefits of adopting conservation measures that will accrue in the distant future. As Pagiola[11] argues, it takes 48 years to breakeven once soil conservation structures are constructed. A tenure regime that ensures uninterrupted

Appendix 5: Cobb-Douglas regression results of determinants of soil conservation benefits for beans and maize with transaction costs to three market outlets, in Machakos and Kitui Districts, Kenya, 2000

	Beans			Maize		
Variables	Nairobi	District	Division	Nairobi	District	Division
Slope	1.663	1.826	1.812			
	(1.624)	(1.771)*	(1.770)*			
Tenure	1.798	1.538	1.468			
	(1.763)*	(1.520)	(1.476)			
Loc	1.562	0.529	0.739			
	(1.319)	(0.716)	(0.982)			
Disth	0.170	0.145	0.150	-7.84E-02	-7.45E-02	-6.86E-02
	(1.115)	(0.932)	(0.982)	(-1.726)*	(-1.573)	(-1.494)
Seacos	0.355	0.311	0.307	-8.02E-02	-9.38E-02	-0.103
	(1.485)	(1.269)	(1.296)	(-0.917)	(-1.024)	(-1.174)
Educ				0.513	0.436	0.455
				(1.993)**	(1.673)*	(1.753)*
Wealth				-0.333	-0.334	-0.329
				(-1.389)	(-1.333)	(-1.348)
Gender				1.196	1.116	1.095
				(3.076)***	(2.8)***	(2.797)***
Shh	-1.056	-1.025	-1.130	0.579	0.533	0.500
	(-1.456)	(-1.387)	(-1.507)	(2.108)**	(1.895)*	(1.774)*
Inc	0.525	0.397	0.266	-0.186	-0.136	-0.116
	(1.664)	(1.201)	(0.856)	(-1.691)*	(-1.233)	(-1.043)
Farmca				0.211	0.157	0.144
				(1.523)	(1.127)	(1.034)
Age	1.973	2.228	2.552			
	(1.407)	(1.566)	(1.773)*			
Acescos	-2.675	-0.242	0.454	-1.002	-0.230	-0.262
	(-1.123)	(-0.223)	(0.715)	(-2.241)**	(-0.631)	(-1.191)
Erode	1.130	0.992	0.873	0.378	0.345	0.358
	(1.765)*	(1.540)	(1.353)	(1.704)*	(1.529)	(1.592)
Fertil	1.060	0.846	0.784			
	(1.802)*	(1.497)	(1.390)			
Selfemp	-1.411	-1.320	-1.250	0.511	0.402	0.371
	(-2.245)**	(-2.082)**	(-1.962)*	(1.880)*	(1.476)	(1.366)
Posneg	0.992	0.972	1.077	0.999	0.895	0.852
	(1.430)	(1.371)	(1.511)	(4.039)***	(3.615)***	(3.452)***
Constant	9.591	-2.675	-5.520	19.260	14.675	14.652
	(0.745)	(-0.397)	(-0.913)	(7.071)***	(7.637)***	(10.494)***
R^2	0.269	0.242	0.253	0.198	0.165	0.172
N	47	47	47	125	125	125

*significant at P<0.10, ** significant at P<0.05, *** significant at P<0.01 Source: Estimates from field survey, 2000 and exclusive benefits of soil conservation for at least 48 years implies that it is secure. Further, there are the bequest motives of many farmers that can only be achieved through secure tenure. Tenure that lasts less than the expected repayment periods imply lower soil conservation benefits. In such a scenario, farmers are unlikely to undertake such investments. Conditions under which adoption of soil conservation practices is less profitable also have increasingly long repayment periods. Insecure tenure or uncertain tenure may also imply a high discount rate leading to low soil conservation benefits. The converse is true, that secure tenure strongly suggests a low discount rate leading to higher net soil conservation benefits.

Another plausible explanation is offered by Besley[24]. Who argues that it is reasonable to postulate that work effort is critically affected by land tenure security, which influences the expected future benefits of soil conservation investments (for our case). Thus if one controls for quality of land, the difference in residual net benefits among different tenure regimes, if any, can be attributed to the incentive effects of land tenure institutions on work effort. Which implies a greater labour productivity both on soil conservation investments and crop production, with a consequent higher net soil conservation benefits. Tenure security also influences cultural attachment to the land as well as economic considerations[24].

Erosion status of the fields is positive but only significant at 13.3%. The implication is that marginal returns to soil conservation are higher on eroded fields than those that are not. This is because averted damages on eroded fields are higher. The results also show that age is an important variable. It is significant at 12.7%. As argued earlier, older people have more farming experience and have accumulated wealth. Moreover, it does also indicate that the older one is, the likelihood of recouping all the benefits of soil conservation. Further, this may be associated with strategic behaviour, where some farmers not wanting to incur costs of learning- by-doing would wait to acquire information from their neighbours. Thus, an older farmer may become more proficient with his technology as he accumulates information[25]. These reasons coupled with bequeath motives of farmers tend to lower the discount rate therefore leading to higher net benefits of soil conservation investments.

Fertility is also another important factor, showing that returns to soil conservation are higher on fertile soils than those that are not. The variable is however significant at 14.4%. Fertile fields have less costs involved especially in fertilizer application and also that crop yields are likely to be higher. Therefore, the pay-offs of soil conservation are higher on fertile parcels of land. The dummy variable Posneg shows that farmers with positive and negative soil conservation benefits are essentially different or have different characteristics. As has been shown by t-tests, farmers with negative soil conservation benefits use more inputs such as manure and fertilizer and yet their productivity is not significantly higher. This might be resulting from a drive by farmers to receive social approval and also to be food secure irrespective of the attendant costs. In fact, about 95% of the sampled farmers believe crop yields fall significantly if land is not terraced. Another dummy variable Selfemp (whether involved in self-employment or not) is negative and significant. A possible explanation is that engaging in self-employment potentially competes (as a destination) for resources such as capital and labour with farming leading to lower crop yields with consequent lower soil conservation benefits.

It is found that transaction costs, access costs (Acescos) are generally negative as expected although not significant. Transaction costs are reflected in lower returns to conservation to the extent that they affect the effective prices faced by farmers. This suggests that transaction costs to the market reduce incentives for soil conservation. As transaction costs increase, there is a dis-incentive to undertake soil conservation investments. The lack of significance may imply that farmers have copying strategies of reducing transaction costs so that eventually the effect may not be that substantial. Moreover, the supply and demand curves for staple crops are usually fairly inelastic due to cash needs of households and the absence of adequate storage facilities. But the fact that the sign is the expected one-negative-illustrates that transaction costs have a negative influence on incentives for soil conservation.

It is also possible that when farmers decide on soil conservation investments, they base their decision on a large information set, potentially larger than contained in the data set at hand. It is therefore possible that we are unable to control for all variables that are part of the farmer's information set. It might even be possible that an unobserved systematic pattern over the whole sample is inflicting our farmer's decision.

Now turn to soil conservation benefits for maize fields (Table 3). It is found that there are relatively many significant variables comparatively four. It is also found that household size, education, gender and a dummy whether benefits are negative or not, are significant. Access costs, search costs and distance to the crop fields are negative as expected. As distance to the crop fields' increase, returns to soil conservation decrease. This variable is significant at 11.9% but with transaction costs to Nairobi, it is significant at 10%. Distance to the crop

Table 3: Cobb-Douglas regression results of determinants of soil conservation benefits for maize in Machakos and Kitui Districts, Kenya, 2000

Variables	Coefficient	t-statistic
Disth	-7.45E-02	-1.573
Seacos	-9.38E-02	-1.024
Educ	0.436	1.673*
Wealth	-0.334	-1.333
Gender	1.116	2.8***
SHH	0.533	1.895*
Farmca	0.157	1.127
Inc	-0.136	-1.233
Acescos	-0.230	-0.631
Erode	0.345	1.529
Selfemp	0.402	1.476
Posneg	0.895	3.615***
Constant	14.675	7.637***
N	125.000	
R^2	0.165	

*significant at p<0.10, **significant at p<0.05, ***significant at p<0.01
Source: Estimates from field survey, 2000

fields works through reduced input use at fields far away from the homestead because effective input costs have increased. The benefits of terracing which are the yields of the crops also decrease due to low input usage. It is also less profitable to cultivate distant parcels of land. All these tend to reduce soil conservation benefits.

Search costs are equally negative although not significant, also showing that they tend to lower soil conservation benefits. As argued previously, the benefits of soil conservation are the crops grown. If the search costs are high, then the expected revenue will fall implying lower soil conservation benefits. Access costs to the market are negative as expected although not significant [however, using transaction costs to Nairobi market outlet, the variable was found to be significant, (Appendix 5)]. This is likely to be related to food security (that is subsistence) objectives of farming households. Even though the effect of transaction costs is weak, soil conservation investments are further reduced by the expected lower soil conservation benefits. The low value for maize does not necessarily imply misspecification but may simply point out a very narrow range of variation in soil conservation benefits with respect to the explanatory variables. Thus suggesting or alluding to subsistence objectives with regards to maize.

Household size turns out as expected with a positive sign. It has a significant effect on net benefits of soil conservation. An increase in household size increases labour available for both soil conservation and crop production. Family labour is relatively cheap, as it does not face incentive and motivational problems. Moreover, it does not necessarily require supervision. As a result, soil conservation benefits increase. Gender also has a positive influence on benefits. Men are physically strong and thus use more manure, which is relatively cost-effective and thus able to obtain higher crop yields. Likewise, education has a positive impact on soil conservation benefits. Education improves resource allocation and reduces a lot of information problems resulting in higher soil conservation benefits. Moreover, one would be able to make the terrace layout without the need of a soil conservation officer or hiring an expert at a fee. In addition one is likely not to over invest in soil conservation measures. Thus, we anticipate that it might be difficult to optimise on all accounts for a poor, relatively uneducated household suffering from inadequate information. There are unexpected signs however with wealth and household income. Nevertheless, they are not significant.

In general were observed substantial differences on soil conservation benefits between beans and maize. There are many significant variables with maize but much less with beans. This may springs from the fact that maize is the most dominant staple (that is, food security crop) in which case, there is an interaction between pure soil conservation benefits and subsistence incentives. It is this interaction that is much pronounced in maize compared to beans. It appears that beans are not paramount as far as food security is concerned.

Conclusions and policy implications: With a discount rate of 2% and a time horizon of 100 years, the net present value of soil conservation benefits was computed for both maize and beans crop enterprises. The results indicate that about 66% of the farmers had positive benefits while 34% had negative benefits. This may be explained by social status, good farmership, import substitution, cash flow problems, underdeveloped marketing system and food insecurity

Using a Cobb-Douglas regression function, the results show that transaction costs have a negative influence of soil conservation benefits for maize and beans. The lack of significance may arise from the fact these crops are food security crops. With bean enterprise, other important factors include slope, tenure, household size, involvement in self-employment, fertility and erosion status of fields. While for maize enterprise, other key factors include: distance to crop fields, household size, educational level and gender of principle household member, erosion status of the fields, involvement in self-employment and a dummy variable for positive and negative soil conservation benefits.

The policy implications are varied. First efforts to develop conservation practices with lower costs or higher net returns should continue to be encouraged. Conservation investments are likely to be made (ceteris paribus) if they are less costly to farmers, both in terms of monetary costs as well as labour and animal power requirements. This is true regardless of the nature of factor markets; however, if credit or labour constraints are binding, such costs may prohibit even highly profitable investments from occurring. Similarly, sustained efforts to improve crop productivity, which include the growing of high value crops or use of improved crop varieties, should be encouraged. This is envisaged to continuously cut down production costs.

Besides, transaction costs to the market need to be significantly reduced. One of the strategies is the generic policy of improvement of rural road infrastructure and market information systems. This is likely to create economies of scale which may be in the form of reduced transaction costs, lower operation and maintenance costs of equipment, enhanced diffusion of technology; new mixes of inputs and outputs; favorable input and output prices at the farm level; and increased specialization and commercialization.

However, with the severe budgetary constraints faced by the government, the answer lies in the identification and mobilization of a number of stakeholders in the provision of rural road infrastructure. For instance, with the assistance from government institutions and non-government organizations, rural communities can be mobilized to grade or upgrade and maintain rural access roads. Communally upgraded and maintained rural roads will reduce transaction costs and thus increase farm gate prices, often for more sustainable crops. They also connect people with new ideas and extension agencies, thus raising their range of known land use options; besides improvement in farmers' marketing margins. Improved marketing margins will attract private input traders, leading to a more competitive and input supply system [26,27] and thus increasing the choice of markets and inputs for rural enterprises[28]. The expected result will be enhanced soil conservation in marginal areas.

Transaction costs can also be reduced by increasing social capital. This can be done through support for and active participation in, formation and functioning of farmers' associations[29]; support for and active participation in, formation and functioning of trader associations[30]; support for and active participation in, formation and functioning of industry associations, comprising not only producers (farmers) but also traders, manufacturers (processors) and scientists[31]; support for organizations that link farm input supply with information dissemination[32].

The other policy measure is to improve education levels through effective extension service by the government and complemented by non-governmental organizations. In the view that the extension service is now demand driven, some copying mechanisms have become essential. Field days, public meetings and women groups are now becoming entry points of the extension service. Through these, they manage to reach many people at the same time. The demand driven approach envisages a market for extension services. However, its efficacy is in doubt given the current experience with agricultural market liberalization under conditions of poor infrastructure, weak institutions and poverty[33].

Hand in hand with extension, the government should ensure that constraints such as insecure tenure do not prevent farmers from adopting soil conservation measures. However, equating land titles with secure tenure and thus with increased investment is too simplistic. Unless numerous improvements are made to the legal system and government institutions, land titles often prove to be too costly to obtain or enforce for most farmers. Moreover, unless access to credit is improved for farmers holding titles, the desired investment effect may not materialize.

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