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Rural Roads and Sustainable Agriculture in Semi-arid Areas: Evidence from Machakos and Kitui Districts, Kenya

[1]S.M. Mwakubo, [2]H.K. Maritim, [3]W.K. Yabann and G.A. Obare
[1]Department of Agriculture Economics, Egerton University, Box 536, Njoro, Kenya
[2]School of Business and Management,
[3]School of Environmental Studies, Moi University, Box 3900, Eldoret, Kenya

Abstract: Using data from a 2000 household survey, the effects of rural roads on sustainable agriculture was examined in selected semi-arid areas in Kenya. A Tobit model was used to establish the factors that influence the decision to invest in soil conservation measures and the level of investment in terracing and a Three Stage Least Squares (3SLS) method was used to determine the direct and indirect impact of road infrastructure on terracing. The study findings show that poor physical road infrastructure endowment, distance to crop fields and degree of farm orientation significantly influence the likelihood of reduced terracing intensity. However, slope, household wealth status, household size and erosion status of crop fields significantly influence the likelihood of intensified terracing. The direct effect of road infrastructure is not significant on maize though negative, while on beans it is negative and significant. Other factors that are significant include: degree of farm orientation, wealth, slope, distance to and erosion status of crop fields. Given the high costs of provision of roads, the policy challenge is to involve non-governmental organizations and local communities to upgrade and maintain rural roads.

Key words: Rural roads, sustainable agriculture, soil conservation, marginal areas, Kenya

INTRODUCTION

Investments in road infrastructure are said to have important positive effects on development[1,2] and are thought to favour the rural poor[3]. There is a broad consensus among economists that improvements in both transport and institutional arrangements are important[4]. A recent review of Sub-Saharan Africa's rural roads pointed out that the existing rural road network needs to be increased up to tenfold if the full potential of the region is to be realised[5]. Poor and inadequate roads tend to raise marketing costs of both inputs and outputs considerably.

Depending on the season and distance, marketing costs may determine a major part of prices of staples in food deficit areas. These costs result in a wide price band, representing the difference between farm gate prices and consumers. The price band explains why many subsistence farmers prefer production for home consumption and disregard access to profitable market opportunities. The higher the price band, the greater the number of market imperfections and missing markets[6]. This is more pronounced in marginal areas.

Furthermore, marginal areas are ecologically vulnerable and also face very serious problems of environmental degradation such as soil erosion and soil mining. At rising population densities, farmers are often caught into a 'malthusian' poverty trap of increasing environmental degradation. Consequently, food availability and accessibility of large population groups may be severely reduced in the near future[7].

Nevertheless, these marginal areas can be very productive if farmers make substantial investments on their land in terracing, application of manure and planting of trees among others. Investments into soil conservation may be undertaken if sufficient returns are expected in comparison with the situation when no such investments are made. The returns to the household of the investments would critically depend on what the household can do with the crops. These returns can be related to outside factors, but are influenced by the state of existing road infrastructure and the available modes of transport, which subsequently determine the level of access to input and output markets.

Various studies on the influence of road infrastructure on agricultural production have been carried out in Kenya. For example, easier access encourages the adoption of high value crops[8-11] and commercialisation of agriculture[12]. Rhodes[13] shows the

Corresponding Author: Dr. Samuel M. Mwakubo, Department of Agriculture Economics, Egerton University, Box 536, Njoro, Kenya

benefits of public infrastructure investments in rural road rehabilitation. In 1988, three regions of Tanzania lost 50% of their cotton, one region 80% of its rice and another region 50% of all its seeds and fertilizers and other chemicals when rural roads became impassable following heavy rains[14]. However, few or no studies have focused on the role of road infrastructure on soil conservation investments. Moreover, most studies on soil conservation are on benefit-cost analysis of terraces[15-17]. The objective of this study was to contribute to filling this gap using data from a 2000 survey of farming households in Kenya. We estimate a Tobit and 3SLS functions for two production enterprises through which the effects of rural roads can be established.

MATERIALS AND METHODS

In Machakos district, the classified road network in the district covers a distance of 1,562.9 km. The road network connects most of the market centres and also provides access to areas of agricultural importance. The distribution network by class and type of surface is given in Table 1.

There are also unclassified roads built and maintained by local communities. Despite the extensive network, the distribution is not even and the condition of the roads is not good throughout the year. The tarmac road network is linked by gravel and earth roads, most of them are impassable during the rainy seasons. The hilly terrain in Kangundo, Ndithini and Kalama Divisions has some of the worst roads. Due to the extensive nature of the district and also to the steep and rocky hill masses, the conditions of the roads deteriorate very fast. Kangundo, Kalama and Ndithini are the divisions greatly affected by poor road network.

With regard to Kitui District (Table 1), there are 3,373.1 km of classified and unclassified roads. These are international trunk road (A), national trunk road (B), secondary roads and motorable trucks (C). This road network covers only a small portion of the district. Central and Kabati divisions are fairly well covered by reasonable road network.

The data used in this study comes from a survey of rural households in Machakos and Kitui districts during 1999-2000 cropping season within agro-ecological zone 4[20]. Four sub-locations were chosen in each district on the basis of condition of road infrastructure and distance to Nairobi. Two sub-locations with fairly good road infrastructure but far and near Nairobi were selected in each district. Likewise, two sub-locations with poor road infrastructure 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 households in each district with about 25 households in each village. Data collection focused on maize and beans being the two most important staple crops in the region[21].

Here, we detail how we conceptualized, measured and applied the measure of road infrastructure and how this with a host of other explanatory factors were hypothesized to affect soil conservation at the household level. It is at this level that final decisions are made about resource use[22].

Conceptual framework: The soil conservation model (Fig. 1) below is adopted from Shiferaw and Holden[23]. This framework offers a holistic approach for assessing resources and assets that are available to households and how these are linked to the strategies that are used to reach desired household welfare outcomes. Rural roads is one of the important resources that maybe available to the household. The model illustrates how rural roads and other factors directly or indirectly influence terrace investments. Several factors are envisaged to influence

Table 1: Classified road network in Machakos and Kitui districts in kilometres

	Road type							
	Machakos				Kitui			
Class	Bitumen	Gravel	Earth	Total	Bitumen	Gravel	Earth	Total
A	108.6			108.6	48.8		94.2	143.0
B	35.5			35.5	6.5	147.6	9.6	163.7
C	151.9	82.7		234.6	25.5	110.7	74.3	210.5
D		207.3	69.8	277.1	4.2	871.9	162.1	1,038.2
E	44.7	107.5	519.6	671.8	1.0	63.2	1,182.6	1246.8
Rural access	4.1	2.3	12.7	19.1	0.0	537.1	30.4	567.5
GoK access		216.2		216.2	2.2		1.2	3.4
Total	344.8	616.0	602.1	1,562.9	88.2	1,730.5	1,554.4	3,373.1

Source: GoK[18,19]

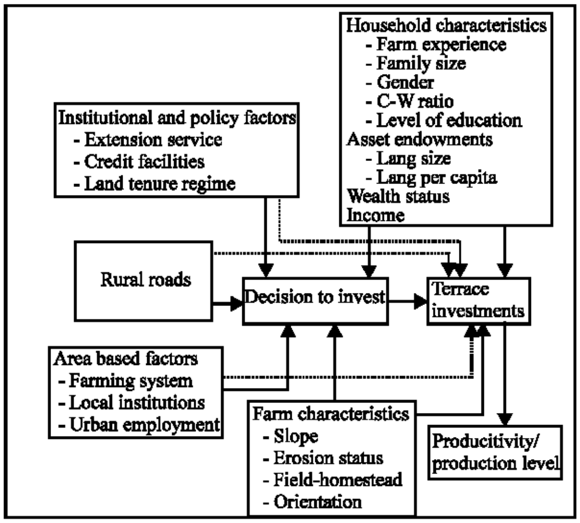

Fig. 1: Rural roads and soil conservation model

the decision to invest in soil conservation practices in the first stage. These factors include the state of the road infrastructure, the existing institutional and policy factors particularly at the macro level, household characteristics, location/area based factors and farm characteristics.

In the second stage, the household decides the level of investments to be made. We postulate that this will be a function of the state of the road infrastructure, consumer-worker ratio, education, age, land tenure security and access to credit among others. An increase in the consumer-worker ratio reduces the ability of households to meet the subsistence needs especially where land pressure is high[24] and may subsequently lead to a reduction in terrace investment. We also conjecture a positive relationship between education and terrace investments as education embodies acquisition of managerial skills.

Empirical evidence suggests that older farmers are more likely to reject conservation practices[25] and new productive practices[26]. Land tenure insecurity has been found to be a deterrent to investment in resource management and conservation[27,28]. Thus we conjecture farmers who perceive insufficient security of land tenure would be less willing to invest in terraces.

When credit markets are imperfect, farm size, when related to wealth may help ease the liquidity constraint to invest in land quality management. Since the type of the house variable is correlated with wealth and welfare of rural households, we expect it to influence soil conservation positively. The physical erosion potential has been shown to positively affect adoption decisions[25,29]. Consequently, we hypothesized the slope of cropland to be positively related to intensity of terrace structures.

The net effect of diversification out of agriculture on land quality investments is theoretically not clear[25,27]. Increased dependence on non-agricultural activities may lower the economic significance of the soil erosion problem. Alternatively, off farm income may ease the liquidity constraint for soil conservation investment or the purchase of soil fertility enhancing inputs.

According to Pagiola[30], poor farmers may have more incentives to adopt sustainable farming practices than other farmers because the future disutility of degrading a resource is potentially unbounded. Yet if we consider soil conservation in a form of terracing to be labour intensive, then we would expect wealthy farmers capable of overcoming the labour constraint, which will be reflected in a large quantity of terraces (hence high investments in terraces) ceteris paribus.

Our maintained hypothesis is that markets are important and that people produce for home consumption and also for the market. When there is no access to the market, returns to farm produce tend to be very low. As soon as there is connection (access to outside markets), returns are bound to rise as farmers search for high yielding technologies and for a better price for their produce. This access to the market in rural areas in most cases is through the road infrastructure. If it is poor, farmers face considerable costs and it therefore follows that the returns even with the market exchange are bound to be low. In such a scenario, there is no sufficient incentive to invest in soil conservation measures.

The level of accessibility to markets is a function of the mode of transport used, the physical distance and the state of road infrastructure. Consequently, a good measure for accessibility should incorporate these components for it to be adequate. In this study, time to the market is used as a proxy of road infrastructure. In any case, the mode of transport used, the physical distance and the state of road infrastructure all have an influence on the time it takes to reach the market. Such a variable is sufficient to measure the level of accessibility, when the existing stock of road infrastructure cannot be valued.

The condition of road infrastructure to the market will determine the type and quantities of inputs used in agricultural production and also the returns obtained. This will therefore have a profound influence on the investments made in soil conservation. Besides, the poorer the road infrastructure, the less competitive the marketing systems are likely to be and also the less information available is. This should be reflected in differential terrace adoption and terrace density since the predominant soil conservation investment in semi-arid areas in Kenya is terrace construction[21].

Table 2: Description and measurement of variables

Variables	Description	Measurement
TERRACE	Length of terrace	Metres per acre
SLOPE	Slope of land parcels	Simple scale: low flat (1), lower slope (2), mid slope (3), upper slope (4)
TENURE	Land tenure regime	Simple increasing scale of tenure security (1 to 7)
DISTH	Distance from homestead to crop fields	Metres
SELFHG	Involvement in self-help group activities	1 or 0
AREA	Size of crop fields	Acres
CROPAC	Crop output	In kilograms per acre
EDUC	Education of household head	Number of years in formal schooling
WEALTH	Wealth of household	Number of rooms in main house
SEX	Sex of household head	Male (1), female (0)
FAROR	Degree of farm orientation	Fraction of off-farm income in total household income
SHH	Household size	Number of persons
FAMCA	Farm size per capita	Acres per person
INC	Household income	Kenya shillings
AGE	Age of household head	Number of years
ACET	Access time to market per kilometre	Minutes per kilometre
SEARCO	Search costs for buyer	In Kenya shilling (Ksh)
ERODE	Farm eroded or not	1 or 0
LOC	Where household is located?	0 Kitui, 1 Machakos
FERT	Fertilizer use	Kilograms per acre
MAN	Manure use	Kilograms per acre
LAB	Labour use	Man-days per acre

Modelling adoption and investment levels

The description and measurement of variables are given in Table 2. In this study, the length of terrace per hectare proxed soil conservation investments while wealth of the household is by number of rooms of the main house in the homestead. The local people often build very good houses rendering the type of house as a poor indicator of wealth.

A Censored Tobit was used to model adoption of terracing technology and the intensity of terracing conditional of having decided to terrace in the first place. This is because information on the dependent variable from population is limited in its range[31,32]. The impact of productivity on terracing intensity and vice-versa may or may not be direct implying that some factors may simultaneously affect both productivity and the intensity of terracing. This simultaneity induces correlation between the regressors and error terms of each equation in the systems, thus causing OLS to be inconsistent in estimating parameters. As a result, the main estimating technique used was 3SLS [33].

Since infrastructure does not influence crops the same way, maize and beans were used as they are the dominant crops in the study area.

The models are specified as follows:

Tobit Equation:

TRACE = f (ACET, FAMCA, SHH, DISTH, SLOPE, TENURE, EDUC, FAROR, INC, AGE, WEALTH, SELFHG, ERODE, LOC, AREA, SEARCO) (1)

Three-Stage-Least squares system equations:

1. TRACE = f (ACET, FAMCA, SHH, DISTH, SLOPE, TENURE, EDUC, FAROR, INC, AGE, WEALTH, SELFHG, ERODE, LOC, AREA, SEARCO)
2. CROPAC = f (LAB, MAN, FERT, TERACE, LOC)
3. LAB = f (ACET, FAMCA, SHH, DISTH, TENURE, FAROR, INC, AGE, ERODE, LOC, SEARCO) (2)
4. MAN = f (ACET, FAMCA, DISTH, TENURE, FAROR, INC, AGE, ERODE, LOC, SEARCO)
5. FERT = f (ACET, FAMCA, DISTH, TENURE, EDUC, FAROR, INC, AGE, WEALTH, LOC, ERODE, SEARCO)

RESULTS AND DISCUSSION

Determinants of soil conservation investments: Application of Tobit regression: Table 3 shows the Tobit regression results using LIMDEP Econometric Package. We find that access time is negative and significant for beans. With maize, the variable is negative as expected, although not significant. Generally, the results show that access time reduces the probability of a farmer undertaking soil conservation investments and even the intensity. The lack of significance for maize may be linked to food security reasons. Maize is a predominant staple food crop implying that under high transaction costs to the market, farmers resort to import substitution in order to minimize food insecurity. Relying on the market for food supply is rather risky in the light of cash flow problems. As Mwakubo[21] argues, if the costs of food

Table 3: Tobit regression results for determinants of terracing levels

	Maize		Beans	
Variables	Coefficient	t-statistic	Coefficient	t-statistic
ACET	-59.364	-0.607	-183.773	-2.030**
FAMCA	-213.849	-0.525	-90.014	-0.430
SHH	78.502	0.927	91.684	2.184**
DISTH	0.460E-01	0.259	-0.257	-1.565
SLOPE	317.942	1.918*	187.374	1.875*
TENURE	-531.947	-1.720*	-204.129	-2.079**
EDUC	20.058	0.132	116.794	1.437
FAROR	-6.592	-0.889	-4.331	-1.002
INC	-0.505E-03	-0.218	0.109E-02	0.681
AGE	-14.921	-0.935	-5.725	-0.735
WEALTH	188.226	1.626*	57.241	0.989
SELFHG	361.031	1.026	-156.170	-0.430
ERODE	303.469	0.966	169.042	0.959
LOC	-99.071	-0.226	-52.400	-0.241
AREA	46.444	0.565	100.942	1.465
SEARCO	-0.309	-0.492	-0.203	-0.599
SIGMA(σ)	843.597	6.596***	454.034	7.443***
N	37.000		37.000	
Log L	-214.907		-233.8541	

* Significant at p<0.10, ** Significant at p<0.05, *** Significant at p<0.01.
Source: Field survey, 2000

acquisition from the market are considered along with risks associated with its adequate availability and information flow problems, it is likely that all costs linked to food import substitution are lower. Beans on the other hand is not a major staple crop and in some cases can be considered as an income crop; hence the negative and significant effects of access time.

Tenure is also found to have negative significant effects on the two crop enterprises. This is rather unexpected. Two possible reasons may explain this result. First, it may have to do with the distribution of parcels of land meaning that other unaccounted for factors such as soil fertility may be responsible. Secondly, both maize and beans are annual crops implying that tenure security is not very crucial although still important. The coefficient for distance to home is negative though not significant for beans; while for maize it is positive, but not significant. The analysis at the household level apparently shows that homestead to fields "kind of infrastructure" (i.e. total distance to the crop fields) is important. Thus the further the fields are the difficult it is to supervise, monitor and control. Hence, the less likely the odds of making investments in soil conservation measures. The vice-versa is true. Time to the district trading centre has the right expected sign and significant at 5% level of significance for beans. This implies that when the costs of access are high, given that farmers are price takers, farm returns reduce significantly thus depressing the incentive to invest in soil conservation measures. In other words, when the road infrastructure is poor, farmers are less likely to undertake terrace construction and even the level of terracing will be low.

Farmers' behaviour is therefore influenced by the expected profitability of any investment made. The returns to terrace construction are the crops grown after the investments have been undertaken. With poor road infrastructure, which implies high costs of access to the market, the net returns to the farmers are low depressing the incentive for further terracing. Prior to making any investments in soil conservation measures, farmers have an understanding of the costs of access to the market, implying that the decision to invest is arrived after taking into account costs of access. However, we note that road infrastructure variable is not significant for maize crop. This may be linked to the fact that maize is a staple crop, making infrastructure inelastic. Subsistence requirements are paramount here.

The results also show that slope is positive while tenure is negative but both are significant. The higher the slope, the greater the need to construct more terraces in order to reduce soil erosion. The sign for tenure is unexpected. This is surprising and contrary to expectations. A possible explanation may be linked to the distribution of tenure among the fields. It is likely that gentle slopes have more secure tenure as they are often relatively more fertile due to less erosion. As Pender and Kerr[34] argue, the impact of many variables are conditioned by the nature of factor markets, the extent of complementarics between those variables and other productive inputs and the nature of preferences of households.

Household size is found to be positive and significant for beans. This is an endowment for labour, which is likely to be used in terracing and also for crop production. This type of labour (own or family labour) faces very low transaction costs and most farmers fall back on it when transaction costs of outside labour are considerably high. Hired labour is expensive due to hiring, monitoring and has serious incentive problems. Moreover, this labour has a tendency to shirk[35]. However, where opportunity costs of family labour are high especially when there is plenty of well paying off-farm jobs in close proximity, the trade-off becomes complex. This is particularly true with better-educated household members, making their time have high opportunity costs.

Location is found not to be significant, giving a clear indication that there are no significant differences between Machakos and Kitui. However, the negative sign indicates that Machakos has higher terracing level compared to Kitui, which is probably by chance. This suggests that Machakos has perhaps unique factors from that of Kitui that are location specific[36,37].

Farm size per capita is negative and not significant. It appears that population pressure or land scarcity is not important in making farmers terrace their farms. However, this does not mean that land scarcity is not important in explaining the level of soil conservation investments. What the results mean is that it does not increase significantly the odds of making a decision to invest and the intensity of terrace investment. Whether land scarcity leads to a downward spiral or soil degradation and yield decline, or to farmers investing in soil improving measures, perhaps eventually triggering sustained growth in productivity and income as suggested by Boserup[38], might depend in part on the evolution of property rights over land and access to markets.

We also find that household income is negative though not significant for maize; while it is positive for beans. This is not surprising considering that returns to investment in agriculture compared to other enterprises are generally low. It does suggest that household income is not a prerequisite (i.e. driving force) for soil conservation investments but rather is facilitative. This explains some peculiar observations of rich households that have not yet terraced their farms.

Membership in a self-help group is positive and but not significant for maize fields. Self-help groups are very important in investment decisions and indeed represent social capital. This is some form of peer group pressure, which can be very helpful in investments in soil conservation. Moreover, we posit that this self-group involvement makes labour sourcing and supervision rather cheap for both terracing and crop production. This is because the owner of the farm is part of the group and hence ever present. Since there are other benefits from social interaction such as risk sharing, self-help labour has less opportunistic tendencies (i.e. less incentive to shirk). It appears that the focus on terracing seem to be on maize fields since the crop is the staple food. The primary concern is meeting the food security needs of households.

The wealth variable is positive and significant on terracing with maize fields. Wealth is important especially in the presence of imperfect credit markets[34]. It eases any financial constraints associated with labour hiring for terracing. The differential impact might be due to prestige of having better terraces on maize fields as compared to bean fields.

Determinants of soil conservation investments: A total of 5 equations were run simultaneously for each crop enterprise, using SHAZAM Econometric package. All the variables were in natural logs with the exception of the dummy variables LOC, SELFHG and ERODE. Equation 1 in both systems is of major interest. The results are presented in Table 4 and 5 for maize and beans, respectively.

For Eq. 1 of the 3SLS system of equations we find that road infrastructure, whether farm is eroded or not, distance to the fields from homestead, slope, degree of farm orientation, wealth and age are significant. Some of these variables are negatively related to the level of investment. The road infrastructure variable shows that a unit increase in time to the market as a result of deterioration of roads will decrease terrace investment by a factor of 0.864 for maize fields and a factor of 3.005 for bean fields. This implies in effect that with the improvement of road infrastructure, we expect significant investments in soil conservation especially on bean fields and thereby make land use in semi-arid areas sustainable.

The coefficient for road infrastructure is inelastic for maize and quite elastic for beans. Response of terraces on maize fields due to road improvement may thus be slight possibly due to the fact that maize is a predominant food staple. Farmers in such cases are driven by subsistence needs in terracing rather than access to the market. Thus some investments may be made with the purpose of meeting subsistence requirements. This kind of investment is called autonomous investment and may not be very much responsive to costs of access. Logically then, investment above the autonomous level becomes responsive to market access (i.e. we theoretically expect elasticity of costs of access with respect to investment to be elastic while below the threshold, to be inelastic). With beans, it appears that the crop though used as food, is often taken as a cash crop. Such crops often are more responsive to the quality and state of roads to the market.

This may point that road infrastructure which is felt in the form of low prices for farm produce becomes a decision variable once the autonomous or subsistence terrace investment threshold has been reached. Distance from homestead to the crop fields is negative and significant for beans. It implies that as the distance increases, effective price of inputs applied to the crop fields' increase. Farmers respond by reducing application hence the lower the terracing intensity. Moreover, Mwakubo[21] argues that farmers fear theft and pilferage of produce from parcels of land farther away, which is another form of transaction costs, hence less investments. For maize however, the coefficient is positive, although not significant. Its effect seems to be indirect through reduced manure use.

An increase in land availability appears not to influence terracing directly. It seems to indirectly affect through labour usage. However, other studies show this variable to be negatively correlated with soil conservation measures[39].

Table 4: 3SLS estimates of terrace investment for maize crop

Variable	Equation 1	2	3	4	5
dependent variable	(TERACE)	(CROPAC)	(LAB)	(MAN)	(FERT)
(CONSTANT)	15.589 (1.1695)	3.477 (2.024)**	-4.361 (-1.30)	0.317 (.357E-01)	2.670 (.712)
ln ACET	-0.864 (-0.9143)		0.177 (.480)	-0.725 (-.680)	-0.138E-02 (-.319E-02)
ln FAMCA	-0.379 (-0.636)		-0.634 (-2.764)***	-0.590E-01 (-.917E-01)	-0.174 (-.670)
ln SHH	1.019 (1.169)		-1.212 (-3.429)***		
ln DISTH	0.626E-01 (0.2974)		-0.225E-01 (-.270)	-0.411 (-1.715)**	0.222E-01 (.233)
ln SLOPE	0.772 (0.4454)				
ln TENURE	-1.699 (-0.8286)		0.701 (1.026)	0.720 (.376)	-0.358 (-.447)
ln EDUC	-0.236 (-0.2800)				0.631 (1.604)**
ln FAROR	-1.521 (-1.866)**		0.779 (2.314)**	-0.683E-01 (-.742E-01)	-0.516 (-1.432)**
ln INC	-0.330 (-0.7907)		0.450 (2.636)***	-0.653E-01 (-.144)	-0.108 (-.620)
ln AGE	-1.335 (-0.7025)		0.920 (1.389)*	1.438 (.793)	0.399 (.474)
ln WEALTH	2.373 (3.520)***				0.432 (1.396)*
SELFHG	0.246 (0.3509)				
ERODE	1.079 (1.582)*		0.167 (.597)	-0.442E-01 (-.546E-01)	-0.378 (-1.211)
LOC	-.582 (-0.6894)		-0.366 (-1.150)	0.127 (.139)	-0.0204 (-.0535)
ln SEARCO	-.476E-03 (-0.00156)		0.448E-01 (.378)	-0.136E-01 (-.406E-01)	-0.558E-02 (-.421E-01)
ln LAB		0.564 (1.571)*			
ln MAN		-0.556E-01 (-0.328)			
ln FERT		-0.166 (-0.3901)			
ln TERACE		0.182 (0.981)			
N	125	125	125	125	125

* Significant at p<0.10, ** Significant at p<0.05, *** Significant at p<0.01. Figures in parentheses are the t-statistics for the probability that respective coefficients are zero, Source: Field survey, 2000

Table 5: 3SLS estimates of terrace investment for beans crop

Variable	Equation 1	2	3	4	5
dependent variable	(TERACE)	(CROPAC)	(LAB)	(MAN)	(FERT)
(CONSTANT)	15.875 (1.801)**	5.442 (3.453)***	-0.443 (-0.146)	10.199 (1.128)	4.194 (-1.310)
ln ACET	-3.0049 (-3.891)***		-0.904E-01 (-0.303)	0.385 (0.405)	0.217 (.711)
ln FAMCA	-0.608 (-1.212)		-0.376 (-1.897)**	-0.249 (0.403)	-0.212 (-1.039)
ln SHH	-0.1293 (-0.1599)		-0.575 (-1.733)**		
ln DISTH	-0.460 (-2.875)***		0.644E-02 (.959E-01)	-0.256 (-1.198)	0.577E-01 (0.862)
ln SLOPE	1.992 (1.797)**				
ln TENURE	-0.472 (-0.421)		-0.611 (-1.431)	-0.767 (-0.564)	-0.376 (-0.790)
ln EDUC	0.333 (0.6197)				0.774 (2.255)**
ln FAROR	-1.386 (-1.851)**		0.857 (2.678)***	0.286E-01 (.295E-01)	0.164 (.538)
ln INC	0.230 (0.6134)		0.612 (3.835)***	-0.999E-01 (-.213)	-0.101 (-.692)
ln AGE	-1.536 (-0.938)		-0.714 (-1.184)	-1.220 (-0.661)	1.511 (2.330)**
ln WEALTH	1.644 (2.641)***				0.951E-01 (.369)
SELFHG	-0.575 (-0.855)				
ERODE	1.659 (2.528)***		-0.858 (-0.321)	0.178E-01 (.208E-01)	-0.105 (-.396)
LOC	0.315 (0.3878)	0.41285 (0.5734)	-0.186 (-0.623)	1.421 (1.517)*	-0.853 (-2.716)***
ln SEARCO	-0.562E-01 (-0.1998)		0.209E-01 (0.188)	-0.353E-01 (-0.102)	-0.152E-01 (-0.1363)
ln LAB		0.409E-01 (0.114)			
ln MAN		-0.101 (-0.497)			
ln FERT		0.188 (0.4191)			
ln TERACE		-0.533E-01 (-0.3995)			
N	47	47	47	47	47

* Significant at p<0.10, ** Significant at p<0.05, *** Significant at p<0.01, Figures in parentheses are the t-statistics for the probability that respective coefficients are zero, Source: Field survey, 2000

As for age, we posit that old people may have high discount rates and are not physically strong. While for young heads of households, they are physically strong and have low discount rates. This might explain the apparently negative coefficient for age for both maize and bean crops; though not significant. However, it shows that its direction of influence is through labour and fertiliser use respectively. It is thought that this could be as a result of imperfect markets. The older one is the more probable that there is an accumulation of wealth or farming experience[40]. The implication is that such farmers are obliged to apply more fertiliser on their farms.

With education, it is plausible that the more highly educated one is, the higher the chances of getting an off-farm job and hence the higher the opportunity costs of staying in the farm. Moreover, terracing does not necessarily require skilled labour. Nevertheless, education has been known to increase allocative efficiency[41,42]. We note that education has a significant influence indirectly through fertiliser use.

Wealth is positive and significant for both crops. Our considered inference is that wealth is conspicuous and that there is prestige for having well laid down terraces. Thus, wealth is likely to influence soil conservation through prestige or attitude rather than income. The other possible explanation could be financial constraint as a result of imperfect credit markets[34]. Besides, social structures and power distribution bias technologies and the flow of technical information in favour of the wealthy, thus shaping adoption outcomes[43] .

The erosion status of the fields positively influences terracing intensity for both crops. The direction of effect is through the recognition of the threat of soil erosion (i.e. perception). The degree of farm orientation is negative and significant. Pender and Kerr[34] argue that a negative coefficient of the share of income earned from farming (which suggests that off-farm income has a positive effect on terracing) is due to financial constraints. The degree of farm orientation is also influenced a great deal by the state and conditions of rural roads.

Road infrastructure is thus an important factor in explaining the level of investment. Road transport improvements can ease the transport burden on the rural and urban poor. For example, new or rehabilitated feeder roads will allow motor vehicles to operate to the village level, transporting farm inputs from the villages to market centres. Improving paths or tracks can reduce the transport burden where non-motorized modes such as foot, bicycles or carts are involved. Improvement or construction of bridges or water crossings can shorten journeys. Thus the poor the road infrastructure faced, the lower the expected returns and thus low investment in soil conservation.

CONCLUSIONS AND POLICY IMPLICATIONS

The results of this study show that poor and inadequate rural roads impose significant constraints towards soil conservation investments by smallholder farmers in the study region and, elsewhere in Kenya and in other parts of Africa where similar conditions prevail. Poor or inadequate transport facilities to the product and input markets affect farmers in form of high transportation costs[4]. Farmers faced with high farm-to-market access time invest less in soil conservation measures. It is thus necessary to make some investments to improve the conditions of access roads. An obvious policy implication is that governments should invest in improved rural infrastructure. This move will increase returns to crop production with a consequent increase in soil conservation investments.

However, with sluggish growth of the economy and shrinking revenue, few governments can afford the high costs of major rural infrastructural investments. Furthermore, pragmatic governments confronted with the need to cut public expenditures are forced to turn to the private sector for assistance in financing transport infrastructure. But, private sector participation may not possible with rural access roads[44].

The policy challenge under the existing conditions is to adopt a wide range of innovations that reduce transaction costs of accessing product and factor markets. Some of these measures include formation of farmers' associations[45]; trader associations[46] and organizations that link farm input supply with information dissemination[47]. Active support and participation should be encouraged in all these measures.

With support from government institutions and non-government organizations, rural communities can be mobilized to grade or upgrade and maintain rural access roads, given the high returns from improved market access in the rural areas of developing countries[8,48]. Moreover, involving communities themselves in planning local transport interventions is likely to increase the effectiveness of the services by allowing an accurate identification of bottlenecks and ensuring regular maintenance[44].

Improvement in roads and paths, especially in rural areas, have the potential to improve the position of the poor[3], although they have to be provided as part of a package of measures that include credit, extension services and investments in areas such as irrigation and water. These improvements can raise incomes of the poor through diverse mechanisms. Agricultural output, especially where bulky, low-value crops are involved, would benefit from the reduction in the time spent on water and firewood collection, particularly by women. Trucks can be hired to move bulk produce and fertilizer can be moved to villages and stored close to where it is needed. Improved tracks and foot paths facilitate the movement of hired farm labour to the fields. In isolated rural areas where there is great difficult in marketing produce, crops can be moved in smaller quantities by non-motorized transport if roads or paths are in good condition. Improving roads will result in better access to social services, including health clinics and increase non-agricultural, income-generating activities and travel from peri-urban to urban locations to work in services and construction in the informal sector. In addition, 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.

There is also need to encourage the entry of development projects and Non Governmental

Organizations (NGOs). A number of NGOs such as Plan International sometimes facilitate the upgrading of rural roads. Moreover, a forum of NGOs may be formed that may assist in sourcing funds for upgrading of these roads. Besides, private companies undertaking agricultural or mining activities often upgrade surrounding roads. For instance, the Dominion group of companies in Siaya is upgrading the surrounding roads at its own costs. Such efforts should be encouraged.

We also note that about Ksh 5 million has been allocated the National Roads Board for roads in each constituency. This amount of money should wholly be used in upgrading rural roads with the support of the local communities in the provision of labour services.

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