LAND TENURE AND FARM LEVEL SOIL CONSERVATION IN SEMI-ARID AREAS, KENYA

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Paper prepared for the forthcoming International Association of Common Property Resources, Common Property Resources and Globalization, Victoria Falls, Zimbabwe, June 2002

Sub-theme 4: *Land /Water and Resource Tenure and the Commons in an Era of Globalisation*
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Abstract

Studies in the past have shown that traditional tenure regimes are not a hindrance to farm investments in Sub-Saharan Africa. However, with the rapid Globalisation proxed by migrations, tenure security is increasingly becoming important. Investments in soil conservation measures can only be undertaken when sufficient returns are expected or guaranteed. This is possible with secure tenure especially with soil conservation that has a long gestation period. A study conducted in Machakos and Kitui shows that land titling is indeed crucial to soil conservation investments.

1.0: INTRODUCTION AND THE RESEARCH PROBLEM

Agriculture has been and is still an important sector of the Kenyan economy. Currently the sector contributes about 26% of the GDP. Agriculture is also a major income earner. The sector accounts for 80% of national employment, 60% of total export earnings and 45% of Government revenue. In the rural areas, where much of the Kenyan population resides, about 80% of the people derive their livelihood from agriculture. The majority of the farmers are small holders. Their production accounts for about 70% of total output and 50% of gross marketed output (GOK, 1997-2001). Agriculture is thus still the engine of growth and is the one to provide impetus if any meaningful development is to be achieved.

However, about 82% of the agricultural land in Kenya are marginal. These areas are faced with frequent food shortages, are ecologically vulnerable and receive irregular and low amounts of rainfall. They also face very serious problems of

environmental degradation such as soil erosion and soil mining. Soil degradation is increasingly being regarded as a major, perhaps the most threatening environmental problem in less developed countries (LDCs). The main negative consequences of soil degradation are on-farm decline of crop production, and off-farm damages caused by the siltation of reservoirs (reducing the capacity to store water and the availability of water for irrigation, and the production costs of irrigation schemes) and riverbeds (increasing the frequency of flooding and the costs of flood prevention), and the destruction of the ecological environment (reducing the environmental absorption capacity and increasing the frequency of natural calamities such as droughts). As the population increases in these areas due to immigration and births, the situation is bound to get worse. Consequently, food availability and accessibility of large population groups may be severely reduced in the near future (World Bank, 1992).

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.

Evidence of this sustainability has been observed in some areas in the country. In the 1950's, the semi-arid Machakos district in Kenya was a disaster area, evidenced by soil erosion, low crop productivity, and poverty. However, as Tiffen *et. al.*, 1994 points out, population has increased threefold and so has per capita output increased with a similar magnitude. Soil erosion has also been arrested significantly. Machakos district now, boasts some of the best-terraced land in Kenya. There are other districts in Kenya with similar conditions as to that of Machakos in the earlier periods, yet they have not undergone the transition that Machakos has. Some of these districts include Taita-taveta, Baringo, Kitui, Mbeere, lower parts of Keiyo district and Tharaka. This raises the question as to how Machakos made it while the other Districts have not. Can the "Machakos miracle" be induced on a large scale in other similar areas?

As a first step, it is indeed crucial to understand the factors that induced investment in land quality improvement in Machakos district. Investments into soil conservation may be undertaken when sufficient returns are expected in comparison

with the situation when no such investments are made. In addition and more importantly, it is when farmers are assured that they will reap the benefits for a considerable period of time. This is possible with secure land tenure.

Despite the on-going market reforms in Kenya and indeed other developing countries with an aim of increasing agricultural incomes, their effect seems at best to be mixed. Insecure tenure rights on land and the imperfect functioning of the land market tend to reduce incentives for small farmers. If land tenure is less than secure, a farmer faces lower expected returns from soil conservation investment because of the probability of being evicted before realising all the benefits. Institutional reforms are therefore increasingly receiving attention as complimentary policy devices for improvement of farming systems. Even though extensive studies undertaken in Africa indicate that indigenous tenure system create no major disincentives to investments in land (see Bruce J.W. and Migot-Adhola S.E., 1994:eds), land tenure reform is particularly crucial due to the changing socio-economic environment and the increased challenges that might result.

Land tenure is the system of rights and institutions that govern access to and use of land and other resources. The rights are derived from statutory and customary law, as well as from institutions of marriage, of power and control, and of inheritance. Whether customary or statutory, tenure regimes are rarely static, and the evolution of customary tenure as well as the impact of directed land reform constitute two major strands of land tenure research. Land reform in Africa - more properly labelled land tenure reform - typically refers to evolutionary or legal changes in the form of land tenure - nudging customary tenure systems in the direction of private property regimes - rather than in the distribution of land itself. Such changes are intended primarily to serve efficiency goals, by enhancing tenure security and thereby (at least theoretically) by improving both conservation and productivity. Land tenure potentially affects sustainable land use by improving production incentives and increased investments into soil and water conservation. Thus changes in access to agricultural holdings and the ability to exclude others from enjoying the benefits accruing from land result in changes in resource use. This in turn affects labour and capital demand, productivity and therefore income and sustainability.

The possible negative effect of indigenous land right systems on the efficiency of input use and on the incentives for land improvement in Africa is generating increased interest among researchers and policy makers. Concern has been

heightened by the low use of modern inputs and by widening degradation of croplands on which negligible investments to improve land quality are being made (Matlon, 1994).

This study therefore focused on the influence of land tenure on investments into soil conservation on agricultural holdings of individuals and households. Some of the questions addressed were:

Is having a tittle deed to land significantly different from that of traditional tenure arrangements? Is there a significant difference when it comes to investments into soil and water conservation? What is the linkage between land tenure and resource use?

The latter aspect is considered important especially within the framework of the ongoing policy debate on suitable incentives for improving sustainable land use systems and practices. The "property rights" school of institutional economics has long viewed security of tenure as necessary to internalise costs and benefits and to capture the future income streams resulting from investments. Private ownership is viewed as the most efficient way to accomplish this (Bromley, 1989; Coase, 1960; Demsetz, 1967; Platreau, 1992). Private property is an arrangement, which becomes optimal in conditions of resource scarcity[1]. Land tenure security acts mainly through an increase in demand for medium- to long-term land improvements. Increased security makes it possible for the farmer to capture returns. In addition, it is expected to reduce the incidence of disputes, thus releasing resources that would otherwise have been used for litigation. Demand for short-term inputs is likely to increase also. Tenure security may also influence the choice and the amount of resources the farmer would commit to soil conservation investments.

2. Methodology

Modelling adoption and investment levels

Past empirical studies have used different methodologies including linear regression models to estimate the determinants of technology adoption and productivity. Adoption was mainly expressed in terms of the percentage area cultivated by farm households to the new technology over total cultivated area. Non-adopters were often excluded from the study sample, thus resulting in sample selection bias and attendant biases in the estimated coefficients (Heckman, 1979;

Feder and Umali, 1993). Yet, inclusion of non-adopters also yielded biased and inconsistent estimates since clustering of observations, due to the prevalence of zero-values of the dependent variable, violated the ordinary least squares (OLS) assumptions of a continuous dependent variable. Estimation of OLS with a dichotomous dependent variable was also inappropriate because resulting parameters would be inefficient due to the heteroscedastic structure of the error term.

When there are few observations or just one observation on each decision maker, the maximum likelihood function is used to examine the factors that affect the probability of making a choice in a given possibility set. In general, information on dependent variables from population is sometimes limited in its range. This would be true if observations on the dependent variable, corresponding to known values of independent variables, are not observable or are missing. Using OLS yield asymptotically biased estimates. Estimating a model that omits the limit observations would create a bias and ignoring them would be discarding relevant information, yet including these observations as though they were ordinary observations also creates a bias. This limitation is overcome by using a censored sample Tobit model. In its simple form a censored Tobit model can be expressed as:

$$y_i^* = x_i(\beta) + u_i \qquad u_i \sim NID(0, \sigma^2) \tag{1}$$
$$y_i = y_i^* \qquad \text{if } y_i^* > 0 : \; y_i = 0 \;\; \text{otherwise}$$

where y_i^* is a latent variable which is observed only when it is positive, x_i is a vector of independent variables, β is a set of parameters to be estimated and u_i represents the error terms that are normally and independently distributed. The likelihood function for the above model is given by:

$$\sum_{y_i=0} \log\left(\Phi\left(-\frac{1}{\sigma} x_i(\beta)\right)\right) + \sum_{y_i>0} \log\left(\frac{1}{\sigma}\phi\left(\frac{1}{\sigma}(y_i - x_i(\beta))\right)\right) \tag{2}$$

The impact of tenure on terracing intensity may or may not be direct. Alternatively, some factors may simultaneously affect both tenure and the intensity of terracing. In

[1] As a result, population density was taken into account during sampling

which case we are dealing with simultaneous equations model in that two or more endogenous variables are determined jointly within the model, as a function of exogenous variables, pre-determined variables and error terms. 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 techniques are indirect least squares (ILS), two stage least squares (2SLS), limited-information maximum likelihood (LIML), three-stage least squares (3SLS), and full-information maximum likelihood (FIML). ILS, 2SLS, and LIML are essentially single-equation methods in which attention is focused on one equation at a time without using all the information contained in the detailed specification of the rest of the model. In principle, information on the complete structure, if correct, will yield estimators with greater asymptotic efficiency than that attainable by limited-information methods. FIML is computationally more expensive as it involves the solution of non-linear equations, leaving 3SLS as the best estimation technique (Porkomy, 1987).

Model specification

Two models were estimated in this study. A Tobit was used to estimate the determinants of the length of terraces on farmers' fields. A three-Stage-Least Square full-system method in which all parameters that appear in the model are jointly estimated, was used to determine the effect of tenure security on aggregate crop productivity. A system of five equations was estimated simultaneously.

The models are specified as follows:

Tobit Equation

$$TERACE = f(SLOPE, TENURE, LOC, DISTH, LCROPAC, SEARCO, EDUC, WEALTH, SEX, FAROR, SELFHG, SHH, FARMA, INC, AGE, ERODE) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Three-Stage-Least squares system equations:

$$
\begin{aligned}
&1.\ TERACE = f(SLOPE, TENURE, LOC, DISTH, LCROPAC, SEARCO, EDUC, WEALTH, SEX \\
&FAROR, SELFHG, SHH, FARMCA, INC, AGE, ACESCOS, ERODE) \\
&2.\ CROPAC = f(LAB, MAN, FERT, TERACE, LOC) \\
&3.\ LAB = f(SLOPE, TENURE, LOC, DISTH, LCROPAC, SEARCO, EDUC, WEALTH, SEX, \\
&FAROR, SELFHG, SHH, FARMCA, INC, AGE, ACESCOS, ERODE) \\
&4.\ MAN = f(SLOPE, TENURE, LOC, DISTH, LCROPAC, SEARCO, EDUC, WEALTH, SEX, \\
&FAROR, SELFHG, FARMCA, INC, AGE, ACESCOS, ERODE) \\
&5.\ FERT = f(SLOPE, TENURE, LOC, DISTH, LCROPAC, SEARCO, EDUC, WEALTH, SEX, \\
&FAROR, SELFHG, SHH, FARMCA, INC, AGE, ACESCOS, ERODE)
\end{aligned}
\tag{4}
$$

The description and measurements units of the variables that are used in the various models presented above is as follows: *TERACE*[2] is the length of terrace in metres per acre, *ACESCOS* is the transport costs to the District main market in Ksh, *SEARCO* are search costs in Ksh for finding a buyer, *SHH* is household size, *EDUC* and *AGE* are characteristics of principle household member, *SELFHG* is whether a household participates in self-help group activities or not and takes a value of 1 or 0, *DISTH* is distance, in metres, from the crop fields to the homestead, *SLOPE*, *TENURE* are characteristics of the fields, *ERODE* is whether the fields are eroded or not, *WEALTH* is wealth of the household proxed by number of rooms of the main house in the homestead, *FAROR* is the degree of farm-orientation, *FARMA* is farm size per capita, *INC* is household income in Ksh , *LOC* is a dummy indicating whether household is in Machakos or Kitui district, L*CROPAC* is the lagged aggregate crop output of the farm in Ksh per acre, *LAB* is the labour use, in man-days per acre, *MAN* is manure use in Kgs per acre and *FERT* is the fertiliser use in Kgs per acre.

3.0: DATA

The data used in this study comes from a survey of rural households in Machakos and Kitui districts in the 1999/2000 cropping season. Four sub-locations were chosen in each district on the basis of population density and distance to Nairobi. Two sublocations with high population density but far and near Nairobi were selected in each district. Likewise, two sublocations with low population density

[2] Terracing is the predominant soil conservation measure in Machakos and Kitui districts. See Zaal (1999)

but far and near Nairobi were also selected. A village was then selected from each of the sub-locations randomly. The villages selected in Machakos district were Kisaki, Musoka, Ngalalia, and Ngumo; while in Kitui district were Mwanyani, Kitungati, Utwiini and Kyondoni. The survey involved 105 households in each district with about 25 households in each village selected randomly too.

The study areas were in agro-ecological zone 4(see Jaetzold and Schmidt, 1983). 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 18^0C 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 24^0C. 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.

4.0: RESULTS AND DISCUSSIONS

In this section, both descriptive and econometric results are presented and discussed.

Table 1 below shows the tenure regimes for the fields of sampled farmers' vis-à-vis whether they were terraced or not.

The table shows that the first three land tenure types are the most predominant (38.1%, 44.3% and 15.2%). If we combine the first two (for that is essentially the same group with differences being in time), the percentage of plots terraced in the combined regime is 64.1%. This shows clearly the importance of obtaining title deeds (titling) on investment in sustainable land use. As Tiffen et al (1996) argue, secure land tenure is important to farmers willingness to invest in land improvement, most particularly in long term measures such as soil and water conservation.

Table 1: Land tenure and whether fields terraced or not in Machakos and Kitui districts, 2000

Tenure regime	Terraced	not terraced	Total
Private title deed	118 (28.1%)	42 (10%)	160(38.1%)
Still obtaining title deed	151(36%)	35 (8.3%)	186(44.3%)
Traditional private rights	43 (10.2%)	21 (5%)	64(15.2%)
Communal rights	5 (1.2%)	0 (0%)	5(1.2%)
Squatter	0 (0%)	1 (0.2%)	1(0.2%)
Rented in	0 (0%)	3 (0.7%)	3(0.7%)
Rented out	0 (0%)	1 (0.2%)	1(0.2%)
	317 (75.5%)	103(24.4%)	420(100%)

Source: Field Survey, 2000

The last three tenure regimes though of less significance, attest that we cannot expect investment in incremental land capital with risky land tenure types. Here, one is not sure of reaping the benefits of investment in terraces yet they accrue over time. With rented in land, the owner may get back his land, in most cases after one season or two. This does not make it worthwhile for the person who has rented to make long term investments like terraces. With rented out plots, there also might be no incentive to invest due to imperfect land markets, which fail to reflect the value of terracing. Discussions with farmers revealed that rent for both terraced and unterraced land is the same. This implies that if the land market functions perfectly so that land values fully reflect the value of investments, owners of leased land would have incentive to make investments.

The table above seems to be surprising in two aspects: the first aspect is the higher percentage of plots whose title deeds are being processed that have been terraced (36%) compared to the ones that have title deeds already (28.1%). Possibly this is just a coincidence. It can also be said that in reality this represents one regime with the difference being in the level of continuum. Perhaps and more importantly, tenure security and having a title deed are not necessarily the same. High levels of tenure security (i.e. robustness, sufficient duration and assurance) might be possible under still obtaining a title deed and also under traditional private rights as well as already having a title deed. The second aspect is that all the plots under communal ownership have been terraced. The latter may be possible if some project may have introduced the food for work program on communal land to show the importance or

benefits of terracing. It is also possible that group effort was expended and it would be reasonable to do it on communal land in which all would have some access in one way or the other. A different explanation for this scenario is also possible. The relationship between land tenure and investments has two sides. On one side, secure land tenure improves investments on land. While on the other side, realisation of investments in land such as terraces and trees is an established procedure for improving defacto ownership rights. In this situation, insecurity in land tenure may even be an incentive for investments (Otsuka et al, 1997). Matlon (1994) also argues along the same line but with respect to manuring, that it is a method of enhancing security of land use rights in marginal security situations.

Comparing the means of length of terraces with land tenure type, a startling scenario is also observed (table 2). The table does not reveal significant differences between already having a title deed or still in the process. As already argued earlier, the two essentially belongs to the same class and it is only matter of time. This implies that perhaps it is the feeling of security, which may be the most important. However, the mean of length of terrace for traditional rights is lower which is surprising. This suggests perhaps that it is still reasonable to have individual titles as they offer some level of security. One can prove ownership in a court of law and also acquire credit with it.

Table 2: Land tenure and mean length of terraces in Machakos and Kitui districts in 2000

Tenure situation	Mean	N	STD
Private title deed	113.83	78	202.42
Still obtaining title deed	116.77	90	146.00
Traditional private rights	87.80	38	126.30
Communal rights	94.50	2	49.00
Rented out	0.00	1	

Source: Field Survey, 1998

Table 3 shows how land tenure regime influences some long-term investments on the farm like tree planting. The table conforms to theoretical expectations in that it is private title deed that shows the highest percentage (8.4%), followed by still obtaining title deed (7.6%), traditional private rights (2.7%) and communal rights (0%). The surprising scenario is that the differences with the first two regimes: private title and still obtaining title deed are minor. However, for traditional rights, the

proportion is very low. As Hanna & Munasinghe, (1999) argue, sustainable resource management is not dependent on a particular property regime but rather on well-specified and generally accepted rules that are congruent with the ecological and social context.

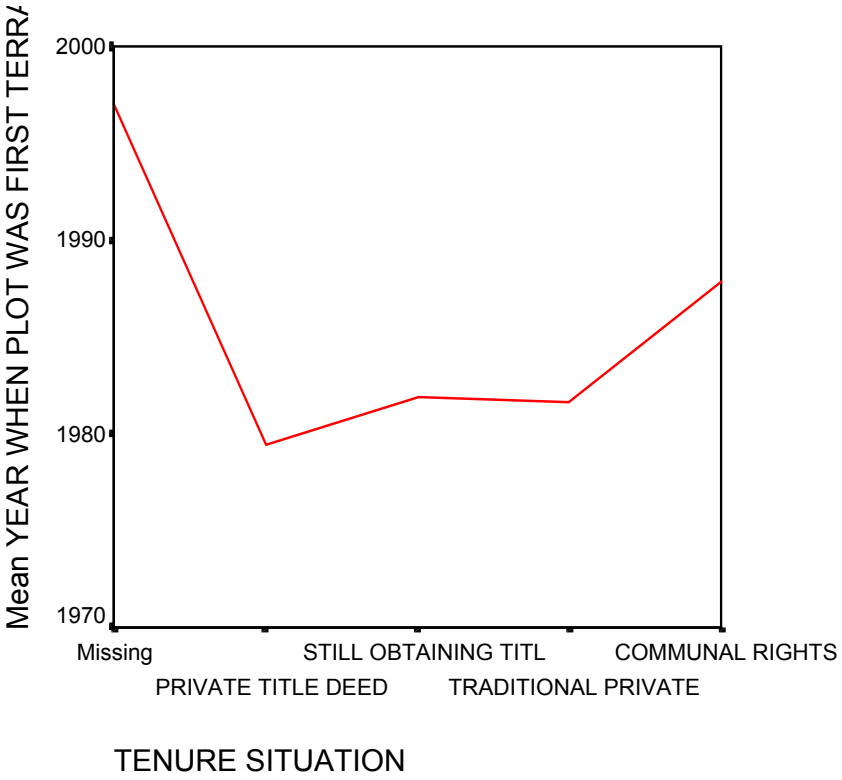
Table 3: Land tenure and whether trees are planted on field or not, in Machakos and Kitui districts in 2000

Tenure regime	Trees planted	Trees not planted	Total
Private title deed	31 (8.4%)	117(31.6%)	148(40%)
Still obtaining title deed	28 (7.6%)	131(35.4%)	159(43%)
Traditional private rights	10 (2.7%)	52 (14%)	62 (16.7%)
Communal rights	0 (0%)	1 (0.3%)	1 (0.3%)
	69(18.7%)	301(81.3%)	370(100%)

Source: Field Survey 2000

When the timing of investments is considered, the results are startling. Assuming that a farmer has four plots with the different regimes as shown above, and with scarce resources for terracing, would always start with the one with private title deed, followed by still obtaining title deeds /traditional private rights, and then communal rights (see figure 1). The mean start up years as shown by the graph are about 1980 and 1983.

Figure 1: Mean year when terracing begun with land tenure regimes in Machakos and Kitui districts

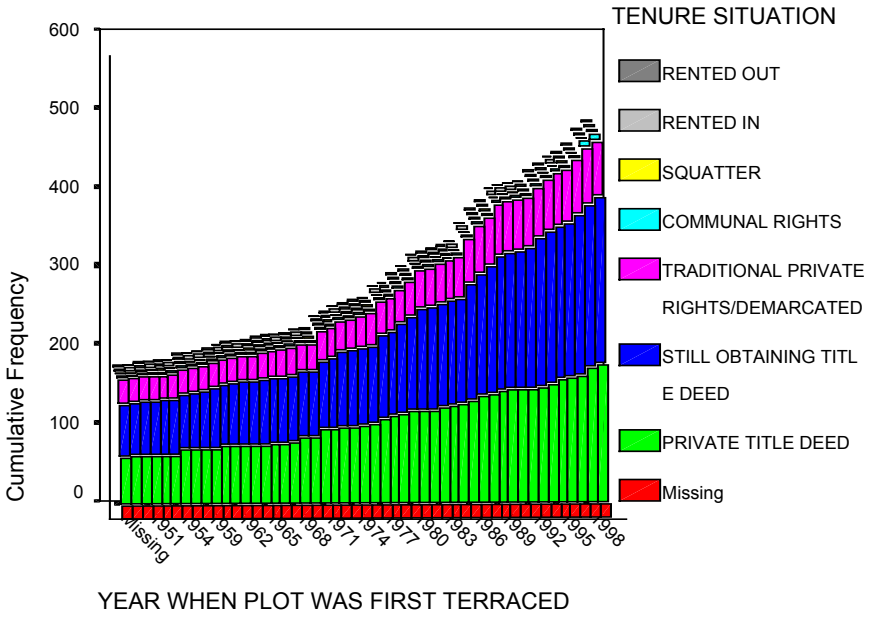


This is very reasonable. Again the surprise here is the mean start up year with the two regimes - still obtaining title deeds and traditional private rights. Careful observation shows that the two types of regimes have the same mean start up year.

The graph in figure 2 below shows the tenure regimes and the years when plots were first terraced. It is clear that the most important regimes in the study areas are: private title deed, still obtaining title deed and traditional private rights. The graph also indicates significant increases after 1968, 1974 and 1983. The pattern for private title deed is a little bit gradual upwards though some break in trend can be discerned. While for the other two, they are gradual till 1968, steeper afterwards and then much steeper after 1983. Major events must have caused such breaks. As for 1983, it was majorly the influence of development projects, i.e. Kitui Integrated Development Project (KIDP) and Machakos Integrated Development Project (MIDP). It is worthy to note too that the special rural development program was in operation in 1974 and may have influenced terracing on farmers' field. It has been recorded that 1965, 1974, and 1983 were drought years. In 1968, large food imports were made and significant cattle movements were observed. As for 1974 and 1983, government food aid, drought-resistant crops, and stock improvement schemes were undertaken. The

Kambas had accepted the food for work program during famine years, and communal work on their own land. This is likely to have led to the massive increase in the number of plots terraced after a major famine. Thus droughts have provided major terracing drives but with strong linkage to tenure regimes. In addition, the Permanent Presidential commission of Soil Conservation and Afforestation was very active in 1983. The President himself frequented the semi-arid areas and led the people in constructing cut-off drains, and other soil conservation structures. It became a rallying call and this might also explain the jump.

Figure 2: First year of terracing of plots and land tenure regime in Machakos and Kitui districts



This finding is also supported by Tiffen et al (1994) who argue that the conversion of grazing land to arable use; and investment in terracing proceeded more rapidly after 1961 than before.

We now move to econometric results. The Tobit regression results for terrace construction are presented in table 4 below. We find that tenure, farm size per capita, education and location are significant. The implication is that security of tenure increases the incentive for terrace construction because farmers are able to realize or recoup the benefits of terracing that flow or occur over time. Pagiola (1996) finds in Kitui and Machakos that it takes about 48 years for a farmer to beak-even once soil conservation structures are constructed. With such a time horizon, it would be prudent for farmers to participate in terrace construction if they are assured of

ownership of the land for at least 48 years. In addition, due to the bequest motives of many African farmers, secure tenure ensures that such goals are realized.

This finding is also supported by Gerrits (2000). In a study in Kitui District, Gerrits finds that farmers who are squatters have very low terracing density, compared to those farmers under traditional tenure arrangements and those that have title deeds. The positive impact of tenure on terracing is not due to selectivity bias. A correlation between terrace investment at the plot level with fertility rating of plots by farmers was found to be insignificant. This rules out the possibility that it is the fertility of the plot rather than the tenure status that is important.

The locational variable tends to underscore that terrace investments in Machakos are much higher than those of farmers in Kitui. This enhances the uniqueness of Machakos in the whole investment phenomena.

Table 4: Tobit regression results of terrace construction (metres per acre) at the household level in Machakos and Kitui districts, Kenya

	Coefficient	t-statistic	Marginal effects
SLOPE	3.080	.090	2.279
TENURE	50.657 (2.240)**	2.240**	37.482
LOC	-154.416 (-2.96)***	-2.96***	-114.256
DISTH	.368E-03 (.110)	.110	.273E-03
LCROPAC	.679E-04 (.039)	.039	.502E-04
SEACOS	-.132E-01 (-.331)	-.331	-.978E-02
EDUC	-44.511	-1.80*	-32.935
WEALTH	14.229	.901	10.528
SEX	122.234	1.508	90.444
FAROR	.303	.352	.224
SELFHG	11.531	.236	8.532
SHH	4.997	.553	3.698
FARMCA	-65.735	-1.852*	-48.639
INC	.811E-03	2.064**	.600E-03
AGE	-.775	-.401	-.573
ACESCOS	-.568	-.955	-.421
ERODE	-52.142	-1.122	-38.581
SIGMA (σ)	283.442	16.45***	
N		168	
Log L		-126.034	

* significant at P<0.10, ** significant at P<0.05, *** significant at P<0.01
The t-statistics are the probabilities that respective coefficients are zero
Source: Estimates from field survey, 2000

Farm size per capita is found to be negative and significant, implying that as land becomes scarce, farmers invest in soil conservation. Two reasons contribute to this. First, to meet their livelihoods, farmers have to increase land productivity, which is possible through soil conservation investments along with other inputs such as manure and fertiliser. Secondly, putting land under fallow to allow regeneration in cases of land scarcity is not even a possibility.

As with education, heads of households with lower levels of education tend to have a high probability of deciding to terrace and also higher terracing intensity due to

their low opportunity costs. Better-educated heads of households could easily land well paying off-farm jobs.

Table 5 below shows the results of the Three Stage Least Squares. We find that tenure has a positive though not significant direct effect on terraces. We suppose that the direct effect is perhaps weak, hence the lack of significance. As shown by the Tobit results, we note that the overall effect (direct and indirect) is substantial. Our results show that it is the indirect effect which is perhaps more stronger. This comes through fertiliser use, which in turn has a positive and significant effect on aggregate crop yields. This in turn positively and significantly influences terrace construction through the positive feed back effects. The results also show that there is a higher terrace construction in Machakos compared to Kitui districts.

Table 5: Three Stage Least Squares regression results for Machakos and Kitui Districts, Kenya

N=148	1	2	3	4	5
	(terraces)	(manure)	(fertiliser)	(labour)	(crop yields)
ln *SLOPE*	-.134	.266	.156	-.134	
	(.418)	(.724)	(.948)	(-1.436)*	
ln *TENURE*	.221	-.913	1.587	-.412	
	(.178)	(-.640)	(2.479)***	(-1.077)	
LOC	-.854	-.274	-.803	-.664E-01	.341
	(-2.159)**	(-.592)	(-3.862)***	(-.469)	(.959)
ln *DISTH*	-.118	-.373E-02	.418E-01	-.252	
	(-1.625)*	(-.450E-01)	(1.126)	(-1.163)	
l*n LCROPAC*	.225	-.280	.356E-01	.566E-01	
	(1.598)*	(-1.717)**	(.486)	(1.223)	
ln *SEARCO*	-.651E-02	-.338	.544E-01	.235E-01	
	(.504E-01)	(-2.291)**	(.822)	(.612)	
ln *EDUC*	-.338	-1.094	.831	-.342	
	(-.707)	(-1.970)**	(3.332)***	(-2.093)**	
ln *WEALTH*	.714	.222	-.276E-01	.151	
	(1.983)**	(.541)	(-.150)	(1.425)*	
SEX	-.467	.801	-.299	-.295	
	(-.765)	(1.153)	(-.961)	(-.166)	
ln *FAROR*	-.323E-01	.872	.103	.474	
	(-.118)	(2.766)***	(.729)	(5.266)***	
SELFHG	.149	.187	-.278E-01	-.140E-01	
	(.427)	(.475)	(-.157)	(-.145)	
ln *SHH*	.184	.173	-.468	-.503	
	(.393)	(.322)	(-1.935)**	(-3.404)***	
ln *FARMCA*	-.139	-.537E-01	.416E-01	-.748	

	(-.545)	(-.179)	(.309)	(-8.113)***	
ln *INC*	.111	.944	.232	.411	
	(.546)	(4.015)***	(2.194)**	(6.267)***	
ln *AGE*	-.508E-01	-1.248	.804	-.184	
	(-.671E-01)	(-1.443)*	(2.071)**	(-.808)	
ln *ACESCOS*	-.958	-1.116	.382E-01	.276E-01	
	(-1.885)**	(-1.925)**	(.147)	(.184)	
ERODE	-.255	-.674	-.270	.103	
	(-.746)	(-1.735)**	(-1.547)*	(1.034)	
ln *TERACE*					-.146
					(-.754)
ln *LAB*					1.208
					(5.253)***
ln *FERT*					.421
					(1.471)*
ln *MAN*					.189
					(1.857)**
(CONSTANT)	6.793	4.562	-8.656	-.704	3.887
	(1.277)	(.743)	(-3.139)***	(-.406)	(4.045)***

* significant at P<0.10, ** significant at P<0.05, *** significant at P<0.01
The t-statistics are the probabilities that respective coefficients are zero
Source: Estimates from field survey, 2000

It is likely that the proximity to Nairobi, which is a major market, may explain the apparent high terracing intensity in Machakos compared to Kitui. Others may have to do with historical reasons (Tiffen et al, 1994). Other significant variables are distance from the homestead to the crop fields, lagged crop output and wealth. Distance to the crop fields has negative effect on terracing intensity. Effective costs of terracing and other inputs applied on distant fields are high. Farmers respond by reducing application, hence lower terracing intensity. Lagged aggregate crop yields has a positive feed back effect on terracing intensity. Access to markets appears to play an important role in soil conservation both directly and indirectly.

A caveat is necessary at this point. As Place et al (1994) argue, improvements in agricultural performance may not simply improve as security of tenure increases. They argue that farmers' investment demand may be constrained by other factors such as unfamiliar technological options, investments may be unprofitable, or returns may be risky. Moreover, the input supply system may be poor resulting in higher input prices. This suggests that although secure tenure is necessary, other complementary structures must also be in place if at all sustainable land use is to be achieved. This is also collaborated by Carter et al, 1991.

Conclusions

The above results have shown the importance of secure land tenure towards investments into sustainable land use. This illustrates the need for polices aimed at titling of land hand in hand with other relevant complementary policies if sustainable land use is to be achieved.

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