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Integrating Tree Cultivation in Farming Systems in Fragile Landscapes in Kenya: Some Empirical Evidence from Meru and Machakos Districts

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Abstract

The integration of tree cultivation into farming systems has been thought of as an integral part in sustainable rural development in marginal areas in developing countries. If successfully carried out, tree cultivation ensures that the resultant farming systems are economical and sustainable by ensuring an ecologically sound approach to land management. Where erosion is a problem, tree cultivation may reduce the rate of erosion by providing adequate soil cover.

Even though there have been efforts in Kenya through government ministries and NGOs to promote the integration of tree cultivation into farming systems, very little exists in terms of empirical evidence on the socioeconomic factors that determine the adoption of tree cultivation. This paper attempts an evaluation of the effects of some important farm, family and institutional variables on the adoption of tree cultivation. The analysis is based on a farm-household data from a survey in two districts in Kenya.

The results indicate that extension efforts of the government, tenure arrangements, the management abilities of the farmers and the size of the farms held are the most important determinants of tree cultivation. For sustainable development in these areas, special attention will have to paid to these factors.

Introduction

The rapid increase in population in recent years has brought with it severe land related problems. The high population growth has led to a high demand for land. New plots have been opened up for cultivation and increasingly, marginal areas have been encroached upon. This has led to deterioration of the soils either because the soils have not been given sufficient time to recover nutrients or through soil erosion. In certain areas, this has meant shortages of wood fuel, fodder and even food (Kimwe,1993). All these have had, without a doubt, serious environmental implications.

There have been attempts in Kenya by the government in collaboration with donor and non-governmental organizations to arrest deforestation and rural poverty through tree cultivation. This has mainly involved efforts to integrate tree cultivation into the existing farming systems. This offers an attractive option for two reasons. First, if successfully carried out, the practice ensures that the resultant farming systems are economical and sustainable by ensuring an ecological sound approach to land resource management. Secondly, in areas

where soil erosion is a problem, tree cultivation reduces the erosion rates by providing adequate soil cover and improved water percolation through improvement in soil texture. The Kenya Woodfuel and Agroforestry Programme under the Ministry of Energy has sought since 1984 to propagate Agroforestry practices[53] especially among small holder farmers. Other notable attempts particularly in Machakos include those by the Kenya Forest Research Institute (KEFRI) in its on-going Dry Land Agro-forestry Research Project. Despite all these efforts, very little exists in terms of empirical evidence on the socioeconomic factors that determine family decisions to adopt tree cultivation[54]. Scarcity of cross-sectional household data, among other things, have prevented detailed analysis of household decisions and hence our understanding of the determinants of tree cultivation remains limited.

The major objective of this paper is to evaluate the effects of some important farm, family and institutional variables that determine tree cultivation practices among small scale farmers in Kenya. Variables investigated in this study include the size of the farm, labor availability, tenure system, farmers' knowledge and extension among others. The analysis is based on a recent household survey in Machakos and Meru districts of Kenya involving a total of 225 farmers; 127 in Machakos and 98 in Meru. The present analysis is based on villages mainly in the fragile, erosion prone areas of the districts in which there has been an active campaign to promote tree cultivation as a measure to combat soil erosion. These usually hilly areas are, because of the altitude, also the most fertile and therefore have high population densities in the two districts (Development plan, Meru and Machakos, 1994-1996). It is to be noted that about 50% of machakos districts and parts of Meru districts receive rainfall well below 750mm per year and are therefore classified as marginal areas.

The importance of this analysis can be seen in several ways. First, it fills an empirical gap in the existing literature by providing evidence on some socioeconomic and institutional determinants of tree cultivation on fragile landscapes in Kenya. Secondly, it is widely recognized that the great bulk of investments in conservation of the resource base (e.g. terraces, bunds, gully, wind breaks) will need to be done with the farm household in the absence of government or donor commitment (Godoy, 1992). Farm households are thus the key target of policy and the driving force of success or failure to achieve both growth and resource conservation (Readon and Vosti, 1991).

From a farming system research and development perspective, the household is considered an important sub-system upon which the development of the entire farming system is predicated. In fact, farming systems may be considered as the totality of production and consumption activities of the farm household, including the choice of crop, livestock and off-farm enterprises, as well as the food consumed by the household (CIMMYT staff, 1984). In making these choices, including the choice of whether to plant trees or not, households are typically influenced by a number of internal and external factors. The farming system perspective is thus important in analyses of small farmers in developing countries. This is because several characteristics of their environment lead to a complex farming system and add to the importance of interaction in farmer decision making. According to Doppler (1993)

[53] This, according to KWAP constitutes the harmonious integration of trees, crops and even animals within the same farm.

[54] To our knowledge, the only comprehensive study in Kenya that has sought to examine tree cultivation practices and why farmers undertake them is that by Dewees (1993). This study, however was undertaken in only one high potential district in Kenya, (Murang'a district). There is certainty need for more studies in other areas with different ecological and economic potentials.

the household is seen as the core of a system in which people make decisions based on their perception of the physical, economic and cultural conditions. Thus, an understanding of some of these factors and how they impact on the household decisions are crucial to the understanding of farming systems as a whole.

Figure 1 below shows in a simplified form the interactions between the farm system, for which the household is an integral part and its biophysical and socioeconomic environment. The interaction between the farm system and its biophysical environment occurs through the use of resources (water, soils etc.) as inputs in production and through degrading natural resources (especially soils) in the process of production. The farm system, on the other hand interacts with the socioeconomic environment through both the input and the output markets, including labour. With such linkages, it is expected that the decision making process within the farm household is influenced by the socio-economic factors as well as the biophysical characteristics. Also important, is the cultural environment in which the farm household finds itself.

The empirical analysis in this paper focuses on the interaction of the household mainly with its socioeconomic environment. The paper seeks to examine the nature and effect of certain socioeconomic and institutional variables on household decisions, and particularly the decision to integrate tree cultivation into existing farming systems.

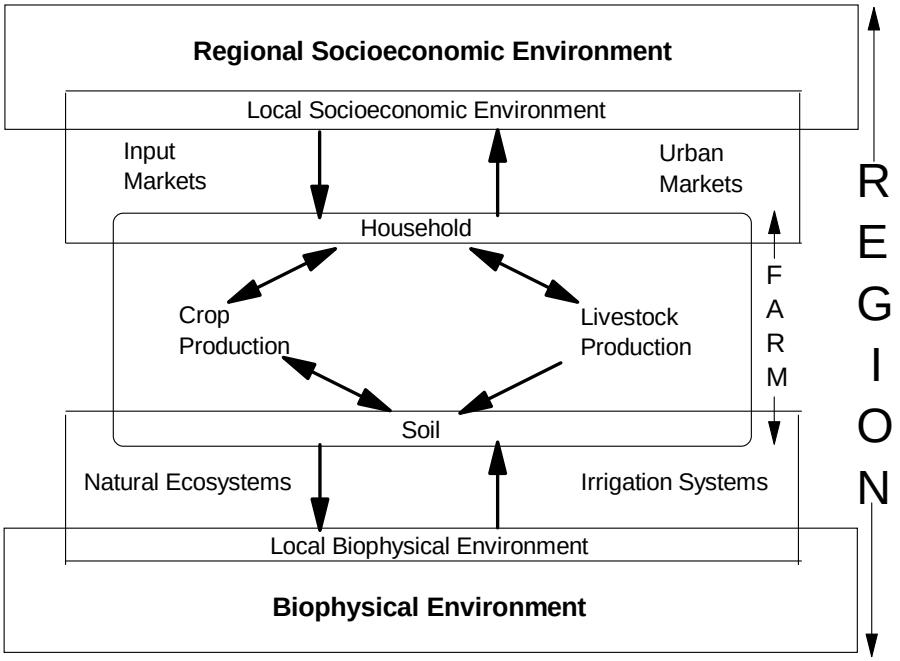

Figure 1. System interaction framework

Source: Norman and Douglas, 1994.

The rest of this paper is arranged as follows: The next section presents a short description of the land use systems in the study areas. Emphasis is put on tree cultivation, its types, and stated reasons for its adoption. Section three of the paper deals with the methodology adopted in the study and the hypotheses while the results of the analysis are presented and discussed in section four. Conclusions and the relevant policy implication are drawn in section five.

Land Use Systems in the Study Areas

Meru and Machakos districts fall under the Eastern Province of Kenya, a province dominated mainly by smallholder farmers. The average land holding in the two study areas is below 10 acres. The land use is dominated by mixed farming systems in which every farmer keeps at least one cow. The lead cash crop in the two areas is coffee (and tea in Meru). The major food crops are maize, a variety of beans, yams (and cassava in Machakos).

Besides coffee trees, all the farmers in the two study areas deliberately plant a few selected trees at various spots of their farms. Others go even further to set up small gardens containing a mixture of trees, shrubs, herbs, food crops and vegetables in order to maximize land utilization (agrosilviculture). A few others in Meru and Machakos will even set aside whole pieces of land for particular types of trees. One can still find in these areas other types of agroforestry practices. According to the district development plan, 19994-1996, about 60% of the rural communities in Machakos have consciously or unconsciously practiced this form of land management involving tree cultivation. The major type of trees include fruit trees, bananas, indigenous trees (specific to the area), and some exotic ones. Table 1 below presents some information on the types of trees grown on cultivated land by our sample farmers during the period 1994/95.

Table 1. Trees grown by sample households on cultivated farm land in Meru and Machakos Districts, 1994/95

Type of tree	Meru (n=98) No. of households	Machakos (n=127) No. of households
Coffee trees only	51	78
Fruit trees only	6	12
Indigenous trees only	1	4
Bananas Only	4	8
Both Fruit and Indigenous trees	12	26
Bananas Mixed	62	76
Exotic trees	0	2

Source: Own survey, 1994/95

Trees in the region are grown for a number of motives depending, on the type of tree itself and, the climate and the topographical conditions. Our survey reveals that small scale farmers grow trees ;(1) to reduce the impact of wind and/ or run-offs; (2) to provide food, mainly fruits and fodder; (3) to provide shed and shelter (fencing); (4) for commercial purposes e.g. tea and coffee or to sell poles and timber; (5) for fuel wood.

The Variables and Hypotheses

Godoy (1992) provides a vivid discussion of some determinants of smallholder tree cultivation for commercial purposes. Although his review leaves out the other motives of tree cultivation, one finds a lot of parallels or similarities in the determinants. This paper thus draws substantially from this discussion. An important factor that determines the decision of small scale farmers to cultivate trees is farm size. With the already high population densities in most developing countries, land shortage for cultivation is a serious problem. To meet the increased food requirements to feed the increasing numbers, more and more land has been brought under cultivation and less for other purposes including tree cultivation. Under these circumstances, it is reasonable to assume that the amount of land operated by the household is an important variable that determines whether farmers adopt tree cultivation and to what extent. Related to this is the inherent competition for land between trees and crops. Farmers usually weigh the potential gains from trees with the possible losses from shade, water/nutrition competition and a possible infection from pests harbored in the trees (Warner, 1995).

A number of family specific variables can also play an important role in determining tree cultivation practices. These include the size of the household. The direct implication of large household sizes in land use patterns is usually the allocation of more land for food production. This also means that less land will be available for other uses like tree cultivation. In most third world countries, it is this growth in household sizes that has led to the encroachment of marginal areas and even forests. It is therefore reasonable to expect a negative relationship between the household size and the intensity of tree cultivation. However, where land is not a major constraint, larger household sizes may provide the necessary labor in tree cultivation processes like seedling, weeding, pruning, etc. In many rural settings, households are experiencing labor shortages and a growing dependency on off-farm income as more men seek work outside the homestead.

The management ability of the farmer can also be an important determinant in tree cultivation. Trees will require some form of management at one time or the other if they are to meet the objectives for which they were planted. Even though most farmers (albeit erroneously) look at trees as hardy plants which are able to thrive under poor sites conditions and under minimal management, experiences in Kenya and indeed in other countries have shown that processes like protection (at the early stages), weeding, pruning, thinning and coppicing are all necessary (Kimwe, 1994). Farmers' knowledge and capability is, in this regard important. The education level of the farmer is in this analysis used as a proxy for the farmers knowledge and capability. It is thus hypothesized that the more knowledgeable and capable a farmers is, the greater is the intensity of tree cultivation. Age may also play a role in determining whether tree cultivation is adopted on not. Younger farmers are usually hypothesized to be more inclined to adopt new innovations than older ones. There are, however, observations at the same time that older farmers because of their experience and 'wisdom' are superior to younger farmers in adopting modern practices (Panin, 1980).

In addition to farmers' knowledge, extension services by the government or other agencies can also play an important role in the determination of the intensity of tree cultivation. Besides providing the technical know-how on the right species of tree for different areas, extension workers also show farmers how to raise their own seeds which they later plant on their own farms. Extension services are even more important where tree cultivation is to be

used as part of soil conservation structures. In such cases, decisions on planting configurations, spacing, planting sites are crucial. Access to extension services by farmers is therefore hypothesized to be an important determinant of the intensity of tree cultivation.

There is increasing evidence in developing countries of the relationship between land tenure and conservation of land resource. The inclination to conserve and maintain land is greater where farmers enjoy security over land and are assured of reaping the benefits from it (Beets, 1990). On the contrary, "farmers eschew planting and maintaining trees if the society denies them a stake in the future benefits of the tree"(Godoy, 1992, pp.718). In certain parts of our study area, clear cut private ownership of land is the exception rather than the rule. The predominant tenure system, the traditional communal system, where the right to use the land is vested on the clan or in the family, has led to low land utilization and management in Meru (Development plan, 1994-98). It is the hypotheses in this analysis that the most favorable position for land resource management through tree cultivation is where land is privately owned and where individuals own clear and unambiguous land titles.

The pattern and the degree to which farmers grow trees will obviously depend on the agro-ecological characteristics of a given area. The type of soils, the pattern and amount of rainfall and the terrain are all important factors in this regard. Generally, areas with high rainfall are more favorable for tree cultivation as opposed to marginal areas where the survival of seedlings are lower. However, the role of trees are likely to be more important in marginal areas characterized by low production, high risks, where natures regenerative process is low and farming is best confined to extensive land use based on the natural vegetation (Werner, 1995).

The Model

The following simple relationship is used to estimate the determinants of the intensity with which tree cultivation takes place on the marginal landscape in Kenya.

TIN = F (FARMSZ, HHSZE, AGEHHD, EDUHHH, EXT, LT, LOCATION)

Where TIN is the intensity of tree cultivation measured by the ratio of the total number of trees and the farm area, FARMSZ is the actual area under cultivation; HHSZE is the number of persons in a household; AGEHHD is the age of the household head; EDUHHH is the number of years of schooling of the household head; EXT is a dummy variable for access to extension (EXT = 1 if farmer received extension services and EXT = 0 if otherwise); LT is a land ownership dummy (LT = 1 if farm is privately owned and LT = 0 if otherwise); and LOCATION is a location dummy (LOCATION = 1 if the farm is located in an erosion prone area and LOCATION = 0, if otherwise).

Since there is no apriori theoretical basis for choosing any specific functional form of the model, different forms of the model were tried to find out which yielded higher explanatory powers. Our experimentation showed that the linear form of the model was better and was thus adopted. The Ordinary Least Squares method of estimation (OLS) was used in the estimation of the model.

Results

To test the influence of the independent variables in the two study regions, the simple econometric model was estimated for the two regions separately and for the entire sample. The results of the parameter estimation are presented in Table 2 below.

The overall goodness of fit (measured by the coefficient of determination adjusted for the degrees of freedom) for the entire sample and for Machakos is fairly high and explains about 70 percent of the variations in the intensity of tree cultivation. The F-ratios including those of Meru were all significant at the 1 percent level of significance.

Inspection of the individual independent variables in Table 2 reveal that extension (EXT), farmers knowledge proxied by the level of education (UDUHHH) and the pattern of land ownership (LT) are important factors that determine the density of tree cultivation. The variables not only take the expected positive signs but are also significant in all the three runs. Farm size, (FARMSZ), a variable widely expected to be important, is significant for the entire sample case and in Meru. Though carrying the correct positive sign, the variable is not significant in Machakos. The little influence of this variable in Machakos compared to Meru could be explained by relative larger land holding in the former district.

The coefficient for the age of the household head (AGEHHH) and the dummy variable for the location (LOCATION) even though carrying the right signs, are not statistically different from zero at the specified confidence levels. This indicates that age and location have no significant influence on the intensity of tree cultivation. The size of the household (HHSZE) carries, contrary to expectation, a negative sign except in the entire sample case. The variable is however not significant at all in any of the three runs of the model indicating that it may not be an important factor determining the intensity of tree cultivation in the study areas.

Table 2. Ordinary Least-Squares Estimates of the Determinants of the Intensity of Tree Cultivation in Machakos and Meru Districts, 1994/95

Variable	Machakos	Meru	Entire Sample
	(n=98)	(n=127)	(n=225)
FARMSZ	3,0	-21,5	7,1**
	(1.48)	(2.50)	(2.66)
HHSZE	6,4	17,4	7,8**
	(1.52)	(1.64)	(1.79)
EXT	219,8***	416,2***	95,0**
	(4.64)	(7.27)	(2.42)
EDUHHH	10,9**	2,7	9,7*
	(2.07)	(0.34)	(2.01)
AGEHHH	2,1	7,1**	1,9
	(1.48)	(2.62)	(1.42)
LT	53,6	79,2	89,5*
	(1.08)	(0.87)	(1.97)
LOCATION	-9,2	-99,1*	176,1***
	(0.19)	(1.69)	(4.45)
Intercept	-82,6	-312,2*	-71,1
	(0.75)	(1.94)	(0.70)
R2 (adjusted)	0,69	0,45	0,72
F-ratio	4,6***	10,7***	5,4***

Figures in parenthesis are the absolute t-ratios
*** = significant at 1% level of significance
** = significant at 5% level of significance
* = significant at 10% level of significance
Source: Own survey, 1994/95

Conclusions and Policy Implications

The adoption of tree cultivation into farming system in marginal and erosion susceptible areas in Kenya is crucial for the economic and environmental sustainability of these regions. This will not only help to reduce soil erosion and improve soil quality, but also provide opportunities for improving farm income. Knowledge of factors, both socioeconomic and institutional that influence tree cultivation practices are thus crucial.

The analysis in this paper has demonstrated that the primary determinants of the intensity of tree cultivation in some of the fragile landscapes in Kenya are the extension efforts of the

government, the land ownership pattern, farmers management ability and farm size. The successful adoption of tree cultivation in farming systems depends on the dissemination of information about tree planting. This may be through the governments extension services or through other agencies. In Kenya, NGOs play an important role in promoting tree cultivation practices and their efforts have tended to be more successful than those of the government mainly because of their flexible approaches which encompass participatory approaches to tree cultivation.

The results of this analysis also provide some evidence, though preliminary, of a positive and significant relationship between land ownership and the intensity with which trees are grown. This indirectly confirms the hypotheses that farmers will only plant trees if they are certain as to whether they will continue to have the right of access to their holdings. Such access is typically associated with freehold or private property regimes. There is however a need for detailed analysis of the exact nature of the relationship between land tenure and tree cultivation in the region.

The intensity of tree cultivation will also depend on the managerial abilities of the farmer. This ability not only determines the survival rate of seedlings but also the sustainability of the system.

For policy formulation, it is important to note that sustainable agricultural development, which is imperative in these areas considering the rapid growing population and the subsequent shrinkage of arable land in the area, will require that special attention be focused on the provision of quality agro-forestry extension services. At the same time, strong awareness campaigns on soil conservation and the importance of tree cultivation in the process will be important. In the long run, public policy on land management will also require support of basic educational services. There will also be a need at the same time to continue with the already stated efforts of the government of land demarcation and registration to bring more and more land under private ownership.

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