Farm Forestry Development in Kenya: A Comparative Analysis of Household Economic Land Use Decisions in UasinGishu and Vihiga Counties

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Abstract
Tree growing on farms in Kenya is an important land use that has evolved over the last 100 years into multi-billion subsistence and commercial oriented enterprises. The smallholder farms in medium and high potential areas are facing serious shortage of quality farming land that has created severe competition among various competing land uses mostly agriculture and farm forestry. Therefore the economic competitiveness of farm forestry as a land use is assumed to be proportional to the size of household land allocated to its use. Understanding household decisions making in allocation of land to competing land uses has increasingly become an important subject to resource economists and policy makers. Therefore a study was undertaken in 2011/2012 to evaluate the socioeconomic decisions making in relations to farm forestry in two counties in high potential agricultural areas of western Kenya. The two counties were selected for the study differed settlement in history, agricultural land use, farm forestry development and demographic characteristics. Uasin Gishu represents the recently settled former European settler farms and Vihiga to represents the former African Reserves. The study was based on range of models such as spatial land use concepts, integrated land use decision making and land use efficiency criterion to underpin the household production function. 260 households were surveyed using systematic sampling methods with questionnaires being administered randomly to households in locations within selected divisions. The main data extracted from the standard questionnaire were household structure, ratio of land used for cropping, grazing and farm forestry, product output, prices, market information, marketing procedures and distribution of trees by species. Data was analysed by use of OLS regression models to generate key farm forestry decision making parameters. The results show that household land size had strong influence on farm forestry decisions irrespective of household's production strategy. Farm forestry incomes proved to be an importance driving force in decisions to plant trees thus supporting the importance of economic objectives on household land use decisions. A farm forestry income was stronger in areas where markets and marketing infrastructure were better developed. The density of planted trees increased with decreasing land size attested the strength of subsistence and commercial dimension of trees within an agricultural landscape. The study points out some policy lessons for development of farm forestry in developing countries like Kenya that include putting in place policies and regulations that attract, expand and sustain farm forestry product demand and infrastructure that improve marketing efficiency and thus better income to farmers from sale of trees.
Keywords: Farm forestry, Land use, Household decision making

1. Introduction

Tree growing on farms in Kenya is an important land use that has evolved through several stages that involved clearing of natural forest resources in the early stages of extensive farming through subsistence to current multi-billion commercial oriented enterprises (Cheboiwo, 2015). The reasons for the evolution changes include earlier laying claims to land and boundary marking to recent decline of public forest resources countrywide that has put farm forestry in pivotal position in provision of various forest products for local and national markets. The goods and services from farm forestry include Roundwood materials and non-timber goods and services such as biodiversity, fauna habitats, watershed protection, carbon fixation, shade, recreation scenery, windbreaks and soil and water conservation. Smallholder farms are facing chronic shortage of quality farming land to maintain desired levels of food production made worse by increasing poverty levels under high population and stagnation of off-farm income opportunities. These combination has created severe competition for household land base among various land uses mostly agriculture and farm forestry. The economic competitiveness of farm forestry as a land use is expected to be proportional to the size of household land allocated to its use. Therefore how to put value on timber products and non-timber services of farm forestry land use has increasingly become an important subject to resource economists and policy makers. To address the issue attempts have been made to development land use decision making framework for use in evaluating the land use options within an agricultural landscape (Parks et al, 1997, Muchiri, 2002). The study though emphasizes on the importance of economic based approaches in land use decisions cannot ignore the influence of non-timber goods and services in smallholder farms that may not be easily empirically integrated into the household decision making calculus. Therefore the paper used household decision making concepts and land use decision models to evaluate comparative farm forestry and agricultural land use interaction in two counties of Western Kenya.

1.1 Background Information on the study areas.

The selection of the two counties in Western Kenya for the study was based on their diversity in settlement history agricultural land use, farm forestry development and demographic characteristics. The Uasin Gishu represents the recently settled former European settler farms and Vihiga to represents the former African Reserves.

Uasin Gishu sit on an altitude of 2100-2700m above sea level with an area of 3,345km^2, population density of 187/km^2, rainfall of 642-1560mm/yr and public forests of 384km^2 of 64% are commercial plantations. The County is predominantly mixture of commercial and subsistence farming mostly maize, wheat pyrethrum and livestock. The County has strong forestry economy from both farm/private and public forests. The Eldoretis the industrial and education hub of the North Rift region mostly food processing and iron products moulding. Farm forestry is dominated by *A.mearnsii* woodlots for tannin and charcoal production, sawlogs from Cypres and Pines and lately Eucalyptus for transmission poles.

Vihiga is relatively smaller with land area of 563 km^2 that straddles an altitude of 1300-1800m asl and rainfall of 1800-2000mm/yr. The county is highly populated with 886 persons per km^2. The county is predominantly subsistence farming and off farming activities such retail business. Forestry has long history dating back to 1940s when Eucalyptus species was introduced enhance degraded environmental condition and provide scarce forest materials for domestic use (Humphrey, 1947). Current it is estimated that Eucalyptus and other trees occupy 30% of the land area with main use being construction poles and firewood for domestic and surplus for sale (Warner, 1997). The individual land holding can be as 0.05 hectares.

Therefore the socio-economic and land use differences between the two counties were shaped history and population related factors hence their farm forestry patterns are distinct and thus need dissimilar farm forestry development approaches and policy formulation.

1.2 Sampling Design

The study is based on farm and market data collected from some selected locations and market centres in the Usain Gishu and Vihiga counties in Western Kenya. Data collection was done with help of locally recruited enumerators in the selected locations and markets. The survey was divided into three levels: farm, wood based industries and market surveys. Farm surveys involved systematic selection of study locations depending on the importance of farm forestry as a land use to ensure that that sampling units are distributed uniformly over the entire geographical stretch of the counties thus avoiding over-representation as compared to random sampling (Ikiara, 1999). Farmers were randomly sampled within the locations. The survey teams consisted of enumerators and local foresters and agricultural officers that were assigned to the locations. Each team was to interview farmers randomly in the selected location thus giving each farmer equal chance of being sampled. The main data extracted from the standard questionnaire were household structure, ratio of land used for cropping, grazing and farm forestry, product output, prices, market information, harvesting procedures, marketing procedures, distribution of trees by species and area and future planting projection by species and area and other socio-economic data. Data on agricultural activities were also collected to include land under various crops, livestock numbers, farm outputs and sales. Main farm forestry products included in the survey were sawnwood, poles, fuelwood, posts and charcoal.

The farm surveys were conducted between June 2011 and June 2012. Those interviewed were mostly household head (husbands), wife, and son and in rare cases farm manager.

Table1: Distribution of Farmers by Counties and Divisions in the study area.

Divisions in UasinGishu	Farm survey	Divisions in Vihiga	Farm survey	Land quality	
Moiben/Soy	17	Luanda	30	0	
Ainabkoi	31	Emuhaya	34	19	
Kesses /Kapseret	29	Tiriki West	14	15	
Turbo	18	Vihiga/Tiriki West	34	19	Grand Total
Total	95	Total	112	53	260

1.3 Conceptual Framework

Forestry is one of the crucial components of global environment and human development whose role and importance has been changing over time but the ease at which it is overlooked is worrying (Tietenberg, 1992). Trees on farms are found in various spatial formations, woodlots, line, scattered single stems, and limited cases medium forest formations. The species mix on farms varies from few to dozens depending on several factors such as species preferences, structural experience, land size and land use intensity. The environment created by trees is a shelter to various insects, birds and animals. The animals that live in habitats created by farm forestry can have positive or negative impacts on agricultural land uses. To put into perspective a simple household production function that includes farm forestry attributes is developed and tested.

1.4 Model Specification

Use of spatial land use concept developed by Parks et al (1997) is hereby presented in a modified form as a production function consisting of two components:

$$f = f(T,E;q)$$
$$g = f(T,E;q) \qquad (1)$$

where f and g is timber and non-timber outputs per hectare of farm forestry, E is effort applied to a forest stand of age T on land quality q. The production convexity conditions stipulates that physical product of age and management effort are positive and decreasing in relevant ranges, $\delta f/\delta T > 0$, $\delta^2 f/\delta T^2 < 0$, $\delta f/\delta E > 0$, $\delta^2 f/\delta E^2 < 0$. Thus relationship between forest age, management effort and land quality may vary depending on value placed by the owner on timber and non-timber benefits.

For a specific land of quality q and distance d kilometres from an important market, household decision to adopt forestry land use and specific management intensity will be influenced by several factors. Assuming dynamic production model, the household faces the following economic land rent maximization problem (Parks et al, 1997):

$$J(T,E;q,d) = \mathrm{Max}\{\int_{0,T} g(t, E;q)e^{-rt}dt + (p_t-kd)f(T,E;q)\, e^{-rT} - wE)1 - e^{-rT}). \qquad (2)$$

Where p_t-kd is insitu prices for timber and w management effort in establishment, p_t is the timber prices net harvesting except transportation costs, k is unit transport cost per kilometres and d is the distance to the local market, r is continuous discount rate over rotation time T.

In a competitive land market, the value of forest use at the optimum rotation time and effort T^* and E^* must equal the discounted rental payments the farmer must pay for holding the land for rotation T^*, the payments may be opportunity cost when land is owned.

Farm forestry unlike public forests faces severe competition for scarce land and changing needs of the households. Thus land may not be available for farm forestry use in continuum and hence the need to use discrete discount rates. The unique imposition of farm forestry in an agricultural landscape calls for modification of farm level land use decision criteria to take into account certain inherent characteristics in specific farm profile. Farm forestry can fall into three categories in relation to agricultural production function, competitive, complimentary and supplementary. Studies have shown that *G. robusta* grown in a maize field reduce maize grain yield by 50% in Central Kenya despite farmers manipulation to reduce competitive edge through pollarding as compared to sole maize crop (Lott, 2000). Muchiri (2002) reports that except for 1st years *G. robusta* woodlot is financially superior than maize alone but farmer's food security has hindered farmers them to plant sole *G. robusta* on their farms. Further, dead leaves and twigs from farm forestry are reported to increase the amount of organic matter in soils (Raju, 1992) thus playing a complementary role to agricultural production. Other complimentary services from farm forestry include soil erosion control, shade and wind breaks. The incomes from sale of farm forestry products supplement on farm incomes with farming landscapes. Using cost-benefit analysis as described by Parks et al (1997) the following land use alternative options are feasible within an agricultural landscape in Western Kenya:

1. Optimal farm forestry management in which joint timber and non-timber services yields highest financial and non-financial benefits. Thus optimal revenue from farm forestry:

$R^*(q,d) = rJ(T^*,E^*,q,d)$ is possible when $T^*>0$, $E^*>0$, $\delta J/\delta T = 0$, $\delta J/\delta E = 0$ and hence,

$$g(T,E;q) + (p_t-kd)\, \delta f(T,E,q)/\delta T - r(p_t-kd)\, \delta f(t,E;q) = rJ = R^*(q,d) \qquad (3)$$

The land uses that fall into these categories according to past studies (Cheboiwo, 2014) include polewood production in Vihiga and transmission pole markets in UasinGishu

2. Maintain in agricultural use when agricultural outputs yields highest returns $R^*(q,d)$ to joint farm forestry management land use,

$T^*=0$, $E^*=0$, $\delta J/\delta T < 0$, $\delta J/\delta E < 0$ and hence

$$\delta J/\delta T < rJ(T,E;q,d) = R < R^*(q,d) = (p_a-kd)(x_a) \qquad (4)$$

Where $(p_a-kd)X_a$ is the agricultural benefits from land quality q, k is the transportation costs per kilometre is incurred, d distance from local market, p_a is the market prices for agricultural products and X_a is the agricultural outputs.

The land uses that fall in this category include competitive agricultural enterprises such as maize level II and Level III that yield the maximum periodic land use value R^* that exceeds the land rent under farm forestry and its associated non-financial values.

3. Complementarity between major agricultural land use and farm forestry land use where the combined land uses yield the optimal R^* than separate components under household's land use objectives. Thus optimal production function is:

$[rJ(T,E,q,) + (p_a\text{-}kd)X_a] = R^* (q,d) > rJ(T,E,q) = (p_a\text{-}kd)X_a$ (5)

Therefore household will earn more benefits from optimal joint agricultural and farm forestry land use combinations than separately.

The complementarities between agricultural and farm forestry land uses was not explicitly treated in the study because of lack of adequate data. It is assumed that based on economic efficiency consideration competition for land at the margin will favour the most efficient land use according to household objectives or criteria. However, studies cited above indicate that farm forestry enterprises are likely to fall into competitive and complimentary categories in Kenya. Since it was not possible to develop a model that can map land uses according to quality, distance to markets and favourable institutional factors the study assumed other alternative economic approaches to evaluate optimal land uses in the region.

Economic theory postulates that land use allocation is underpinned by its proportional contribution to the household's welfare in monetary terms. However, studies have shown that in some cases households do place high value on some environmental goods and services.

To establish the economic importance of current household land uses independent regressions models were therefore used to isolate key principle decision making factors on farms forest land use decisions. The assumption is that where economic variables don't explicitly explain the level of farm forestry activity, environmental goods and services may partially be playing a critical role in household land use decisions.

1.4 Integrated land use decision making

In integrated model approach is assumes that farm level decision making involves multiple factors, objectives, process and background factors that consciously or subconsciously influence household decisions.

The production function under integrated model approach can be presented as follows:

$$F = f(P, E, Z, V) \quad (6)$$

Where P is vector price of material output, E environmental values, Z is social objectives and V extrinsic factors. The equation states that farm forestry is a complex function of several attributes to include price of material outputs (income, material demand/supply), environmental values (amenity, landscape, privacy)social objectives (personality, status, security) and extrinsic factors(biophysical, policy). Using regression model approach spatial, economic and social variables are tested for their influences on farm forestry development in the region.

The household production function is assumed to be based on utility maximizing rationale and thus will increase its farm forestry holding and species selection to the extent of its income and consumption needs and other socio-cultural values. The following generalized econometric regression model can represent such production function:

$$Y_i = \alpha + \beta_i X_i + \mu \quad (7)$$

Where Y_i is the land area under farm forestry of ith households, X_i is the economic and socio-cultural values of household itch that influence adoption of farm forestry, β_I are the parameters to be estimated μ the stochastic disturbance term.

1.5 Land Use Efficiency Criterion

Classical economic theory based on efficiency criterion presumes that households allocate their land according to the returns to both factor and input resources. The land yielding highest net present value (NPV) or rent is expected to be allocated better quality and high proportion land base and vice versa on economic efficiency priori. The land owned by households is fixed and proportions allocated to each land use during the survey point time were also fixed. The expectation is that proportional land use allocation evolution across independent households is similarly influenced by land size and real net income from competing land uses.

1.6 Model Specifications.

Assuming that current land uses is a reflection of household supply response to past and prevailing demand for land based product outputs conditions in absence of external institutional intervention, inertia or irrationality. It also presumes that economic factors are more important and thus land use allocation is based on economic efficiency rationality. Seemingly unrelated regression model (SURE)(Alig et al, 1988) was chosen because of its advantage of using existing land uses as dependent variables and seeks how much of it is explained by prevailing economic variables. SURE uses series of system equations consisting of independent regressions for each major household land use with similar set of economic variables critical in land use allocation. The SURE regression model's systems of equations are as follows:

$$Fa/A = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e$$

$$Aga/A = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_8 X_8 + \beta_5 X_5 + \beta_6 X_6 + e$$

$$La/A = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_6 X_6 + e$$

Where Fa is the land under farm forestry, Aga is the land under crops, La is the land under grazing, X_1 is household per capita income, X_2 is the household density, X_3 is the farm forestry income X_4 is ratio of farm forestry to livestock income, X_5 is the ratio of farm forestry income to crop income, X_6 is the ratio of livestock income to crop income and e is the disturbance term.

The following factors are proposed independent variables for farm forestry land use, household per capita income (CAPUT), household density (HHDENSE) and farm forestry incomes (FFINC). These variables are proxies for net incomes expectations from competing land uses population density and prices of farm forestry products. Similar pattern is followed for other land uses.

To gauge the farm forestry competitive efficiency as compared to competing land uses two approaches, current land use intensity evaluation and economic land use efficiency approaches were used. The data were analysed using SPPS version 12 to generate regression outputs and graphs.

2.0 Results

2.1 Land use intensity Approach

Assuming the current land use intensity reflects household land use efficiency objectives or other household socio-economic values placed on array of alternative land uses. The expectation is that current household land use intensity is a reflection of rational household investments criteria based on socioeconomic denominators, which can be gauged in monetary values. Proportional land allocation of two key land uses, farm forestry and crop production in household land is used as a proxy for investment decisions within prevailing conditions.

Figures 1 and 2show that most households allocate small fractions of land to forestry use in comparison to the total household land in Uasin Gishu. Farm forestry in Uasin Gishu is skewed to the lower land use fractions as compared to agriculture. The results show that 80% of the households allocated to forestry uses between 0 and 0.1 of the total land as compared to 36% who allocated between 0.0 and 0.5 of their land holdings to cropping. For Uasin Gishu, the farm forestry proportion falls drastically to zero beyond 0.40. Since land use decisions are presumed as a supply response by households to meet some lagged or expected demand for specific products for own consumption needs and surplus for sale. The land allocation procedure in Uasin Gishu reflects agricultural emphasis because forestry product needs and its substitutes can still be obtained outside intensive land use activities or the proportion of land that can supply such products is still relatively low compared to the total household land due to low population density. Being a traditional surplus producer of agricultural products mostly maize and wheat households in UasinGishu set aside high proportion of its land base to commercial crop production and animal keeping activities. Grazing land is still an important land use as shown by excess land beyond farm forestry and crop production uses.

Farm forestry land use allocation by households in Vihiga is well spread across the fractions to total land use but with increasing trend until 0.2-0.4 fraction level when it gradually fall to beyond 0.75 mark before falling to zero. Farm forestry land use concentration in Vihiga is on the higher side, 0.0 to 0.15 of household land occupied by farm forestry is owned by 6.7% of households. The figure increases, between 0.15 and 0.50 is owned by 21.9% of the households and 0.5-75 range is of the total land is owned by 54.9% of the households. The results for Vihiga compares well with that of cropping thus showing that farm forestry has assumed a competitive land use category. In general, more land as a proportion of the total is under cultivation in Vihiga than Uasin Gishu, which is as a result of population density. The demand for combined on-farm products per unit land is greater in Vihiga than Uasin Gishu and hence efforts by households to pursue subsistence approach in which it attempts to produce all these products from its land for both household needs and surplus for sell.

In Vihiga, there is a general trend, as the household land size increases there is general tendency to for households increase area under both farm forestry and agriculture. This is a clear sign of land shortage for allocation to the two competing land uses. The trend in Uasin Gishu is such that as the household land increases, less land is allocated to farm forestry but that set aside for crop production increases.

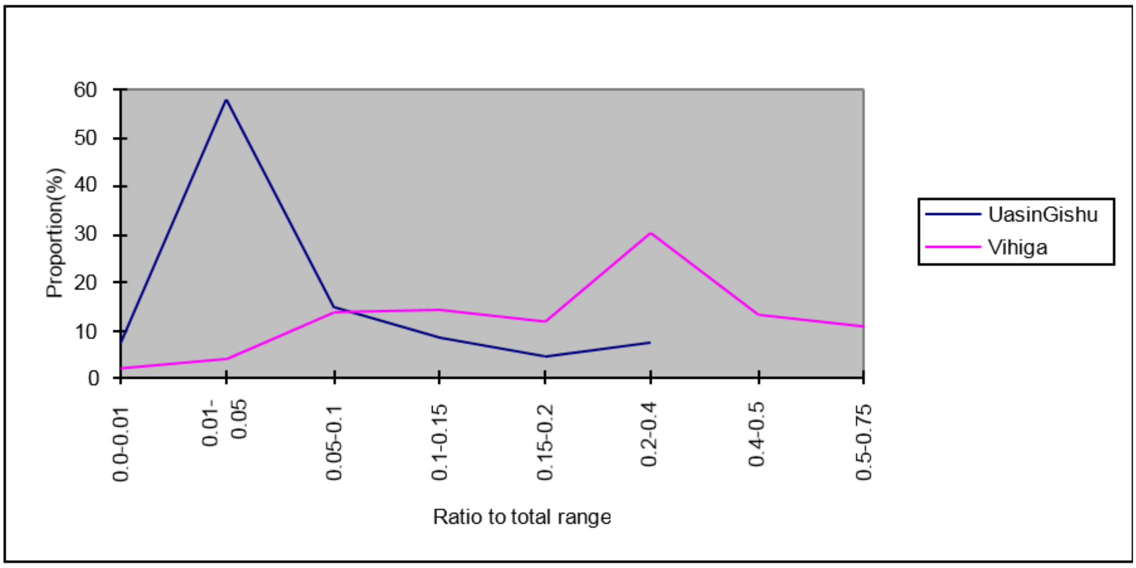

Figure 1: Ratio of farm forestry to total land in UasinGishu and Vihiga

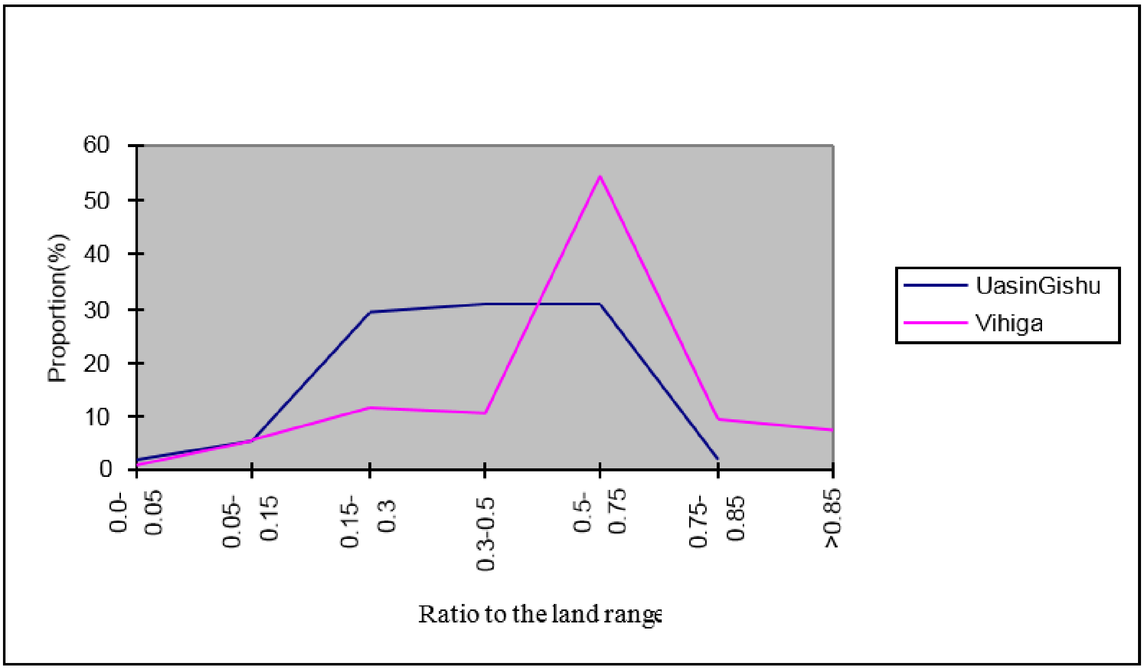

Figure 2: Ratio of cropland to total land use in UasinGishu and Vihiga

2.2 SURE Model Approach

The results for Uasin Gishu shown in Table1 reveal the importance of selected economic variables in explaining current household land uses. In Uasin Gishu where agricultural activities are more commercial, there should be a strong relationship between crop production and livestock keeping and the corresponding land uses. However, the outcome showed mixed relationship, relative income variables for crop production land use has correct signs but insignificant values whereas for livestock and farm forestry though insignificant were also positive contrary to the expectation. Farm forestry income has expected signs but only significantly related to cropland base indicating the importance of income generating farm forestry activities in the district. Since Uasin Gishu has a short settlement history it can be classified as a district in land use transition where transfer of land from other land uses to cropping. This is to increase crop output for household food requirements and surplus for sale with increased household members dependent on land. Household density positively influences crop production but at the expense of farm forestry and grazing land uses. The impact of per capita income on crop production is positive and significant. It increases household ability to use more inputs both land uses and as well to upgrade livestock quality. However, such decisions will be at the expense of farm forestry activities at the margin. Farm forestry incomes as expected had significant negative influence on cropland and livestock land uses.

Table 1: Farm Forestry SURE Regression Model for Uasin Gishu County

Independent variable	Dependent variable: Land use types(ha)		
	Crop	Grazing	Farm forestry
Intercept	-73.679 (-3.856)*** [a]	-67.529 (-2.648)**	1.410 (0.619)^{NS}
LNLIVINC/CROPINC	0.1005^{NS} (0.1095)^{NS}	0.828 ^{NS} (0.675)^{NS}	
LNFFINC/LIVINC		2.420 (1.746)*	0.151 (0.122)^{NS}
LNFFINC/CROPINC	0.291 (0.378)^{NS}		0.546 (0.787)^{NS}
LNCAPUT	10.556 (5.302)***	10.330 (3.887)^{NS}	-0.101^{NS} (-0.427)^{NS}
LNFFINC	-2.362 (-0.031)**	-2.282 (-1.585)^{NS}	0.122 (0.952)^{NS}
LNHHDENSE	2.634^{NS} (1.058)^{NS}	-2.027 (-0.609)^{NS}	-0.884 (-2.978)***
R^2 AdjR^2 F Durbin-Watson Aegen CI	0.326 0.352 10.765 2.205 CI =26.70	0.310 0.901 167.644 2.165 CI =22.52	0.291 0.711 45.820 2.225 CI =26.68

^{NS}: Not significantly different from zero at 0.1 level, * significantly different from zero at 1.0 level; ** 0.05 level and*** at 0.01 level, [a] Numbers in bracket below coefficients are t- statistics

Source: Own survey 2011/2012

Table 2 shows the outcome of regression outputs for Vihiga County, the results are more consistent in both correctly hypothesized signs and level of significance than those of UasinGishu. Livestock-crop relative income ratio were positive though insignificant need some explanation. Due to low crop outputs, surplus quantity for sale is limited and small-scale intensive zero-grazing activities have gained popularity and importance as a source of income in the county. Similar explanation is relevant for farm forestry-livestock income ratios that indicate positive relationship may be due to use of forestry areas for grazing or grass collection. Unlike UasinGishu, per capita income show negative and significant impacts on crop production and farm forestry indicating some scheming of surplus on-farm incomes to off-farm investments. This is supported by the fact that off-farm income generating activities are important source of incomes in Vihiga as compared to UasinGishu as shown under descriptive statistic in Chapter 4 and hence justification for such investment diversification. The impacts of farm forestry incomes have the correct sign and significant but the similarity to that of crop production is contrary to expectations. This may be due to the flow of surplus investments between the two important land uses. The critical importance of population density in Vihiga is reflected in its negative and highly significant impact across all land uses. The long history of settlement and high population density has evolved a more stable land use where transfer of land base between competing land uses is minimal under chronic land shortage. The land-man ratio in Vihiga is reaching critical plateau where settlements and other infrastructure is taking away land from existing commodity based land uses in the district.

In general, land allocation decisions among various land uses are poorly explained by the selected economic variables in UasinGishu as compared to Vihiga. Similarly, regional studies using relative economic variables in the United States rejected the hypothesis of significance of relative incomes in land use allocation using time series data (Alig et al, 1988). The problems associated with relative income ratios and land use decisions are compounded by several economic and non-economic factors that are not captured by relative economic variables selected. These include institutional interventions, cultural values, structural factors, and fluidity of grazing land use in relation to cropland and farm forestry. The appropriateness of using gross incomes in capturing land rent values and household income expectations and real incomes among other values are also critical. The fact that household's farm activities are heterogeneous in nature of land use management goals among various land uses and unique features of farm forestry in timing and regularity of incomes further complicates the analysis.

From the foregoing discussion current land uses and in particular farm forestry may not be fully explained by endogenous variables but external factors such as historical land use, trendal behaviour, cultural traits, structural developments, intervention programs and demand factors that cannot be easily measured and entered into regression models. Since relative economic variables and other proxy variables did not explain fully farm forestry land use decisions it can be assume that environmental goods and services such as amenity, privacy and social status that are not easy to capture are important in farm forestry land use decision in the region. Household descriptive statistics indicate that households placed high values on environmental goods and services. These environmental goods and services include climatic amelioration often described in such terms as bringing rain, cool environment and fertility improvement.

Table 2: SURE Farm Forestry Regression Model for Vihiga County

Independent variable	Dependent variable: Land use types(ha)		
Income ratio	Crop	Grazing	Farm forestry
Intercept	1.871 (3.819)***	1.581 (2.058)**	0.176 (0.256)^{NS}
LIVINC/CROPINC	0.0842 (0.151)^{NS}	0.491 (0.562)^{NS}	
FFINC/LIVINC		0.525^{NS} (0.558)^{NS}	-0.206 (-0.244)^{NS}
FFINC/CROPINC	-0.159 (-0.285)^{NS}		0.093 (0.119)^{NS}
FFINC	0.160 (2.334)**	-0.573 (-0.533)^{NS}	0.215 (2.237)**
CAPUT	-0.139 (-3.054)***	0.262 (0.367)^{NS}	-0.117 (-1.831)*
HHDENSE	-0.584 (-11.256)***	-0.412 (-5.059)***	-0.278 (-3.811)***
R^2 Adjust.R^2 F Durbin-Watson Eigen CI	0.649 0.629 32.420*** 1.854 11.483	0.2889 0.249 7.123*** 2.0723 11.774	0.247 0.204 5.735*** 2.108 11.480

^{NS}: Not significant different from zero, p<0.1 level * Significantly different from zero at P<0.01 level; ** p>0.05 leveland *** p<0.01 level. [a]Numbers in bracket below coefficients are t- statistics

Source: Own survey 2011/2012

3.0 Discussions of Results and Policy Implications

The study results though preliminary support the arguments that the there exists a strong link between land use decisions and economic indicators and that existing land uses partially reflect households economic interests. Thus structural changes that improve profitability of a specific land use and in absence inertia or impediments *ceteris paribus* more land will be allocated the most profitable enterprises. The final part of our investigation is to use market driven land use model to evaluate the potential economic and fiscal implications of forestry and agricultural land uses. Figure 9.1 depicts existing land use where agricultural land use such as maize level II and III is dominant and farm forestry enterprises (black wattle, pole production or sawlog) are emerging land uses.

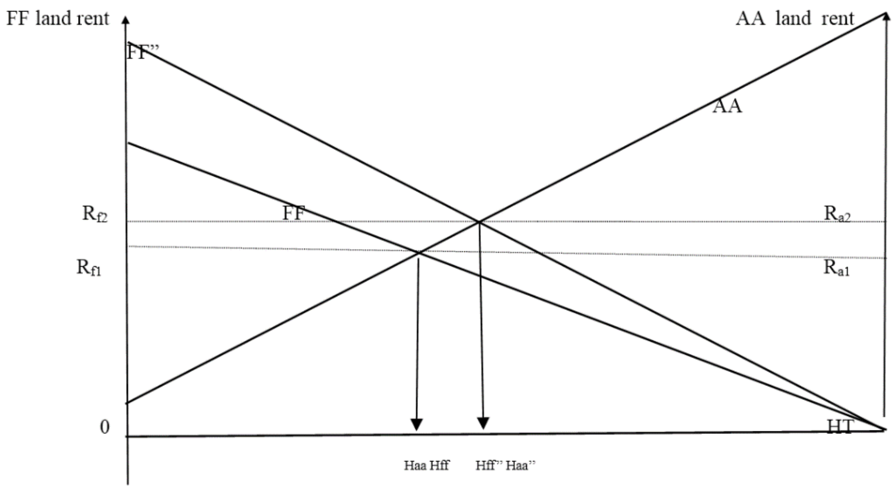

Figure 3: Economic driven shift in Farm Forestry land use.

Assuming the current aggregate household land allocated to farm forestry is depicted by $H_{ff}$and that allocated for agricultural use is H_{aa} whereas the total land holding is H_T; where $H_{ff} = H_T - H_{aa}$ and vice versa. It can further be assumed that households can switch land between the two land uses according to their profitability and hence rent value without any further costs and that the rental values of current land stock FF and AA represent forestry land use and agricultural land use respectively. The two values are defined relative to the horizontal axis depicted by 0 and H_T respectively.

At current valuation levels agricultural land exhausts it profit margins at higher level than forestry enterprises and hence aggregate land equilibrium price R_{f1} and R_{a1} has influenced existing land allocation levels at H_{aa} for agricultural use and H_{ff} for farm forestry use. When no change take place temporary land use equilibrium R_{f1} and R_{a1} may prevail on land use decisions, however, when structural changes take place such as fiscal policies, input and output prices, price information, market supply/demand and other economic factors the temporary equilibrium will be disturbed. When structural conditions that favour farm forestry are operationalized its puts upward pressure and the demand for forestland increases and so is its value. These favourable factors include increase of forestry product prices due to the expansion of wood based product markets, high population, high values placed on non-timbers goods and services and economic activities. The forestland rent values shifts upwards to FF" and more households are motivated to convert agricultural land to farm forestry use and hence shifting it from H_{ff} to H_{ff}" and agricultural land use shrinks from $H_{aa}$to H_{aa}" and land use competitive equilibrium in favour of farm forestry establishes at R_{f2} and R_{a2}. Fiscal and economic conditions such price support for maize, wheat, tea or coffee have the converse effects of reversing the aggregate land use landscape in the study region if the same assumptions of no impediments is assumed. The gestation periods for most farm forestry products are long and once the decision to plant trees has been taken limited options exist before the rotation age thus fixing land despite change in structural conditions in favour of competing land uses. In Vihiga 40 years old coppicing stumps may require enormous work to uproot them that may be costly to most households in the short run. These are some of the risks in which households may put into consideration in farm forestry decisions as compared to annual crops.

From the above illustration it is possible to postulate policy options for development of farm forestry in the region. Assuming that economic objectives predominates household land use decision making, several policy options are feasible. Experiences from both developed countries indicate that fiscal policies have been the frontline instruments for promotion of farm forestry in the EU and USA where farmers are subsidized to adopt tree planting through provision of establishment grants and other financial support (Crabtree, and Appleton, 1992). Such policies may not be applicable in Kenya where there is budgetary constraints and logistical limitations requirements for disbursements; supervision and evaluating millions of smallholder farms. Secondly, the subsidy approach has the handicap of not promoting efficient land use adoption because more often than not lead results in misallocation of public resources. However, skill improvement and market driven incentives are less costly and evolve in-built self-sustaining momentum in the long run. These include putting in place conditions that attract, expand and sustain farm forestry product demand and infrastructure that improve marketing efficiency and thus better income to farmers from sale of trees.

4.0 Conclusions

The integrated land use decision approach reveal that farm forestry investment decisions is influenced by several factors, most are largely as a result of demand and supply conditions. The important factors are directly related to economic and population activities in forms of household land size and incomes from on-farm activities. High population density increases the forest products subsistence needs of the households through intra and inter household demands. Most households may respond simultaneously by increasing land under tree crops and management intensity thus increasing the aggregated supply. The current economic conditions of falling household income opportunities has two effects that favour farm forestry expansion, increased subsistence needs become a critical factor in land use decisions due to shortage of income to purchase goods that they cannot produce on their own farms. Secondly, sale of surplus or stress related sales to cope with increased demand for cash to purchase off-farm goods and services.

Household land size revealed its strong influence land use decisions irrespective of household's production strategy whether it is skewed to subsistence or surplus for markets. Farm forestry incomes proved to be an importance driving force in decisions to plant trees thus supporting the importance of economic objectives on household land use decisions.

Farm forestry policies makers have to take into consideration some these key factors in order to enhance adoption of tree planting activities beyond subsistence level. According to the above results, though the density of planted trees increase with decreasing land size, however, surplus production for markets is subject to availability of sufficient land for the purpose. Where markets and marketing infrastructure exist forestry incomes become the main driving force in decision to plant and manage trees on farms as shown by black wattle in UasinGishu and commercial polewood in Vihiga.

5.0 References

Alig, R.J.; White,F.C.and Murray, B.C.(1988). Economic factors influencing land use changes in the South-Central United States Res. Paper, Ashville NC: USDepartment of Agriculture, Forest Service, Southeastern Forest Experiment Station.

Cheboiwo, J. K. (2015). A Review Farm Forestry Evolution for the last 100 years in Kenya: A look at some Key Phases and Driving Factors. A Paper Presented to 10th Forest Society of Kenya Policy Dialogue Conference Towards Achieving 10% Forest Cover: Is Agroforestry and Commercial Forestry the Answer?Held at Sai Rock Hotel, Mombasa 1-2 October, 2015.

Crabtree, J.R. and Appleton, Z.(1992). Economic Valuation of Forest Woodlot Scheme in Scottland.*J. Agric. Econ.43:3 355-368*

FAO (1989).Case Studies of Farm Forestry and Wasteland Development in Gujarat, India.FAO, and SIDA Forests, Trees and People,Bangok, Thailand.

Humphrey, N. (1947).The Liguru and Land: Sociological Aspects of some agricultural problems of North Kavirondo*,* Government Printers, Nairobi, Kenya.

Lott, J.E., Howard, S.B., Ong, C.K., and Black C.R. (2000). Long-term Productivity of *Grevillea robusta* based over storey Agroforestry Systems in Semi-Arid Kenya, *Forest Ecology and Management* 139: 187-201

Muchiri, N.M., Pukkala, T. And Milna, J. (2000). Optimizing the Management of Maize-Grevillea robusta on farms in Kenya, *Agroforestry Systems* 56: 13-15

Parks, J.P., Barbier, E.B. and Burgess, J.C. (1997). The Economics of forest Land use in Temperate and Tropical Areas, *Environmental and Resource Economics*, 11(3-4) 473-87.

Raju V.T. and von Oppen M.(1982). Marketing Efficiency for selected crops in semi-arid Tropical India, INCRISAT Patancheru, Andra Pradesh 502 324, India.

Tietenberg, T. (1994). Market-Based Mechanisms for Controlling Pollution: Lessons from the US, in Thomas Sterner (Eds), Economic Policies for Sustainable Development, Kluwer Academic Publishers.

Warner, C. (1997). Patterns of tree growing by farmers in East Africa pp 90:110, *Farms, Trees and Farmers*: *Responses to agricultural Intensification*, J.E. Michael Arnold and Peter A. Dewees (eds), Second Edition, London: Earthscan Publication Ltd.