The Influence of Land Quality on Allocation of Land for Farm Forest in Kenya: The Case of Vihiga County

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Abstract
Kenya has long history of promoting tree growing on farms for various purposes ranging from laying claim to property and boundary marking in 1940s to response to socioeconomic drivers such commercial interests through vibrant market for tree products. The Rural Afforestation and Extension Services Division (RAES) started in 1971 was aimed at accelerating tree growing on farms through training of farmers, establishment of tree nurseries countrywide and deployment of extension staff to offer technical services to rural farmers. Farms within agricultural landscapes are not uniform but differ in various forms such as slope, drainage, soil texture, fertility, water holding capacity, stone/rock outcrops and other attributes that impose land quality variation hence influencing their potential uses. The study was therefore undertaken to evaluate the influence of land quality on farm forest land use allocation through use of land quality concept developed by von Thunnen in 1826. The study was done in one of the highly populated counties in western Kenya, the Vihiga County where farm forests occupies 30% of household land. Samples of 112 households were surveyed in 4 sub-counties. The study mapped quality aspects within households land profile into four categories gentle, steep, steep and rocky and flood plain and swampy and intensity of trees in respective category. OLS regression analysis was used to determine the influence of land quality on farm forest land allocations. The results indicate that farm forest allocations was not significantly influenced by poor land quality aspects across the study household lands. This is because the land sizes were very small and farm forests were adopted across the household land profile irrespective of quality aspects. However, households indicated that poor quality lands were preferable for farm forest largely for they were not favourable for crop production. The study observes that farm forests were highly influenced by high population density and small land sizes that has masked the importance land quality in land use allocation decisions.
Keywords: farm forest, land quality, land use allocation

1.0 Introduction
Farm forest is defined as the practice of growing trees on privately owned agricultural land, for household use and surplus for sale (F A O, 1989). Management of trees on farms in Kenya has evolved through several stages in the 100 years in terms of planting patterns, species mix, density, utilization and commercialization that has been shaped by local biophysical, institutional and socioeconomic conditions (Arnold, 1997). These stages evolved from common resource extraction to planting in compound, boundary and windbreaks, inter-cropping and lately intensive mono-cropping in form of woodlots for commercial purposes. These factors have also shaped some regional tree growing intensity and species dominance. These trees are grown for various purposes such as fencing, timber, posts, fodder, food, poles, fuelwood and bark. The household agricultural land in most cases is less than uniform but exhibit several key land quality characteristics such as slope, drainage, soil texture, fertility, stone/rock outcrops and other attributes. These attributes impose land quality variation across farm profile and hence its potential uses. From their experiences farmers allocate different land uses to different land quality sites to mitigate constraints it imposes on production possibilities. Therefore existing land allocation patterns on farms can be evaluated by use of land quality concept first developed by von Thunnen in 1826. The concept id premised on the principle of decreasing land use capacity and rental returns with decreasing land quality and increased distance to markets. The principal land use capacity component is location that is due to its fixed nature exhibit specific land quality and accessibility. Therefore land use optimization objective of households is limited by the fixed area, location, size and land quality by purchase price or cultural norms. According to the land use capacity concept, rational households are expected to give high priority to high value land uses in high quality land sites and lower value land uses are crowded to lower quality land uses. The principle of best use is assumed to prevail across most landscapes unless presence of institutional programs, barriers, contrary goals or individual inertia. For the current study assumed absence of these factors and proposes that farm forest and agriculture land uses are based on allocative preferences of households, which is shaped by quality land and prevailing socio-economic environment.

1.1 Study Area
Vihiga County is located in the western Kenya and is a relatively small with land area of 563 km^2 with population density of 1,051 persons per km^2 which is one of the highest in the country. It falls within an altitude

of 1300-1800m above sea level and receives rainfall of 1800-2000mm per year. The county land use is predominantly subsistence farming and off-farming activities such as employment and retail business. Tree growing has a long history dating back to 1940s when Eucalyptus species was introduced to reverse deforestation that was rampant and provide scarce forest materials for domestic use (Humphrey, 1947). Tree are estimated to occupy 30% of the land area with Eucalyptus being dominant with main uses being construction poles, timber and firewood for domestic and surplus for sale (Warner, 1997). The individual land holding can be as 0.05 hectares.

1.2 Conceptual Framework

The concept of land rent assumes that a farmer who own heterogeneous land quality through experience will allocate land to various land uses according to its returns to household resources and objectives. Therefore modified economic rent theory can be used to test the relationship between land quality and farm forest in the country and specifically Vihiga County.

In absence of regulatory and other external factors while it is explicitly recognized that land quality is heterogeneous, farm level land use profiles can be used to model equilibrium land uses between farm forest and agricultural land uses. The study assumes that land fertility decreases with land quality from optimal crop farming to sub-optimal land uses such as grazing and farm forest. To postulate the outcomes an inverse index of land fertility defined by $\phi \geq o$, which indicates that land quality decreases with ϕ (Lopez, 1997). Therefore by defining the density function of land quality by $z(\phi)$, total land used for agriculture by ith household is

$$A^i(Z) = \int_{Zo}^{Z} Z(\phi)d\phi = F^i(Z) \qquad 1$$

where Z is the minimum fertility of the land used for crop farming and F(Z) is the cumulative distribution function. The function states that due to fertility or other attributes which decrease quality of land use for crop farming goes from the maximum ϕ = Zo to minimum that is profitable for crop farming use, Z. The cumulative function can be suppressed to $F^i(.)$ given that Zo is exogenously determined. The infertility of the land in Vihiga is related to soil characteristics, such as slope, swamps and rockiness in its simplest form

$$\phi = e^{\Omega\psi}$$

Where ψ is the measure of the steepness or other soil infertility measure and $\Omega \geq 0$ is a parameter. Equation 1 can be expressed in integral terms of s as follows

$$\int_{zo}^{z} Z[e^{\Omega\psi}]\, \Omega e^{\Omega\psi}\, ds = F(\psi_Z) \qquad 2$$

Where the lower limit of integration is obtained by assuming a zero slope (e^0 =1) and ψ_Z is the maximum slope of any soil type used in crop farming. Assuming that slope is the only important land characteristic that affect land productivity them $F(\psi_s)$ is an index of the quantity of land in production efficiency units, crop production is thus a function of $F(\psi_s)$ and hence crop revenue function (or rent = R) is also a function of $F(\psi_s)$. Therefore it is assumed that households use the most fertile land for crop production and the residual land is allocated to sub-optimal land use uses such as farm forest if it is inferior land use. The same procedure is followed for any other infertility characteristic. This establishes the essence of land quality variation and its impacts on land productivity and hence land use profitability. The households faces various land use possibilities within a given portion of land depending on the expected land rent values across the farm profiles.

A new general production equation 3 is introduced reflect household options:

$$q_i = f(P,R,A, F_Z) \qquad 3$$

Where q_i, is existing land uses production functions in the study area that is a function of vector prices P, input prices R, land quality parameter F_Z and household size A. Assuming that farm forest is a sub-optimal land use to maize production, the production function stipulates that greater proportion of unsuitable land for agricultural uses will positively influence farm forest adoption under severe land scarcity conditions in Vihiga.

The farmers land use rationality in presence of heterogeneous land quality is tested using a regression model with farm forest as dependent variable and land quality variation as independent variables to reveal the presence and strength of such relationship. The influence of land quality on household production function can be stylized as follows:

$$F_{Zi} = f_1(S_{Z3}, S_{Z2}, S_{Z1}\, F_{Z0}) \qquad 4$$

Where F_{Zi} is the heterogeneous quality(fertility) land of surveyed household, F_{Z3} is the gentle sloping land, F_{Z2} is the steep sloping land, F_{ZZ}, is the rock/boulder occupied land and F_{Z0} is the flood plain or swampy areas. The land quality for agricultural purposes falls from q F_{Z3} through to F_{ZZ}. The existing land allocation patterns was tested using regression analysis to evaluated the significance of land quality on decision to allocate land to farm forest uses.

1.3 Models Specification

Due to difficulty in estimation of economic returns for heterogeneous land use quality profile due to lack of data on land productivity across these land quality profiles makes the use of proxies as best option. The proxies chosen were related to slope characteristics which influenced land productivity and hence revenue. The following regression model for farm forest production function was adopted:

$$Y_i = \beta_0 + \beta_i X_{ij} + u, \quad i= 1,2,3....n; j= 1,2,3,4 \qquad 5$$

where Y_i is the land under farm forest of household ith, X_i is the household ith land of quality jth, u is the disturbance term, β_0, β_I ....$b_k$parameters to be estimated. In more simple form

FFLSZ = f(GENSLOPE, SSSLOPE, SSRBOUL, FLOPLAIN) 6

Where, land under farm forest (FFLSZ), gentle sloping land(GENSLOPE), steep sloping land(SSLOPE), steep sloping land occupied by rocks and boulders(SSROUL) and flood plain and swampy areas(FLOPLAIN).

Depending on the competitiveness of farm forest land use, the hypothesis is that under less competitive scenario farm forest will be positively influenced by poor quality land categories (swamps, flood plan, rocky/boulder and steep), however, under competitive scenario and situations where all household land is suitable to agricultural uses, small size lands will positively influence farm forest development due to supply/demand forces. However, our interest is more on the general influence of poor quality lands on farm forest allocation within an household agricultural land profile.

1.4 Sampling method

Vihiga County is reported to have 30% of its land base occupied by farm forest despite land scarcity for agricultural purposes and shortage of food. This contrasting phenomenon has not been explicitly explained by empirical studies. Due to the highly heterogeneous nature of land in the area, it was observed that trees are concentrated in steep slopes, rocky terrain, and flood plains. Maize and other agricultural crops and settlements were located in gentle slopes with red soils that were good for agricultural production. A sample survey of 112 households was undertaken to map out land use allocation across their agricultural land profile land owned by households and how it changed with varying land quality in 2015 (Table 1). Farm maps were drawn for sample units distributed in the selected sub-counties depending on land quality variation and farm forest land use. Sampling was done in selected location within the sub-counties documenting the tree growing intensity per land sub-categories namely gentle slope, steep slope and steep with rocky terrain and flood plains/swamps. The sub-counties surveyed were were Vihiga, Tiriki West, Emuhaya, Sabatia and Tiriki West.

The purpose of the mapping was to present land use allocation across farm profile and tests it in accordance to the land use capacity concept and theory. This was aimed at partly seeking to confirm if it true that high proportion of land allocated to farm forest by households was due to prevalence of poor quality land in Vihiga County.

Table1: Distribution of Farmers by Divisions in Vihiga County.

Sub-county	Households sampled
Luanda	30
Emuhaya	34
Tiriki West	14
Vihiga/Tiriki West	34
Total	112

1.5 Data Analysis

The data was subjected to OLS regression analysis of SPPS version 12.

2.0 Results

Table 1 presents the unrestricted OLS regression outputs which show that in general, farm forest is practiced in all land qualities across household farm profiles in Vihiga County. The results show that farm forest is statistically influenced by all the land quality proposed GENSLOPE ($t_{5,49}$<0.05), SSSLOPE ($t_{5,49}$<0.05), SSRBOUL ($t_{5,49}$<0.01) and FLOPLAIN ($t_{5,49}$<0.05). Though, the ρ values for the poor quality lands are slightly smaller as compared to better quality lands hence confirming their relative preference of the former for planting trees. The study results may have been comprised by factors that may have minimized the choices of household within the farm landscape such as the small sizes of the landholdings and emerging importance multiple land use to meet various household materials needs that masks the influence of land quality aspects. Since tree planting on household land irrespective of land quality aspects is already significant the poor land quality aspects may not be significantly different from other land qualities. Since the sample households had varying land quality aspects dominance of good land planted with trees may have strengthened the influence of better quality land on farm forest allocation that otherwise.

However, discussions with households indicate they prefer to allocate poor quality land mostly steep slopes and swamps to farm forest for several reasons. Steep slopes have overtime undergone erosional processes exposing boulder/rocky sites that have thin soil profiles and low nutrients hence not favourable for crop production. The waterlogged swamps are expensive to drain and therefore submerge crops for prolonged periods thus destroying them but planting Eucalyptus helps in draining such sites thus improving its quality for cropping purposes. Further, the frequent floods that occur during the rainy season result in strong water storms that flatten agricultural crops. However, some parts of swamps are cropped during the dry seasons but likelihood floods due to unpredictable weather has made farmers to plant Eucalyptus that have the ability so resist the flood torrents and water logging.

The findings do not reject the hypothesis that land quality statistically influence farm forest land use allocation because of the difficulty in isolating the critical importance of poor quality land in farm forest development as compared to high quality land as assumed. However, field observations support the positive influence of poor quality land on farm forest location and expansion within the farm profile. The findings concur with other studies that have shown that population density positively influence tree planting intensity due to increased economic importance of farm forest (Tiffen et al, 1995).

Table 1: Unrestricted OLS Multiple Regression Results: VihigaDistrict : Dependent variable land under trees.

Variable	Unst B	SE	Std Beta	t	Sig.
Constant	-0.0069	0.026		-0.269	0.789^{NS}
GENSLOPE	0.125	0.024	0.540	5.225	0.000***
FLOPLAIN	0.386	0.090	0.404	4.284	0.000***
SSRBOUL	0.126	0.04	0.307	3.538	0.001***
SSSLOPE	0.180	0.046	0.348	3.884	0.000***

R = 0.788, Adjusted R^2 = 0.590, F= 20.084 Significance 0.000 CI = 5.62, n = 112 df = 105

^{NS} Not significant at10% significance level; * significant at 10%; ** significant at 5% level and *** significant at 1% level.

Conclusions

The study confirms that in Vihiga County farm forest development is influenced by high population density, small farm sizes and multiple land uses to meet various household materials that cut across all land quality aspects. However, households preferred to allocate poor quality lands to farm forest largely because they are not suitable for agricultural production. The poor quality sites preferred for farm forest include steep slopes, rock/boulder, flood plain and swamps. Therefore combination of high population density and small land sizes may have masked the assumed positive influence of land quality on farm forest. The findings indicate that the factors that influence farm forest adoption at farm level in developing countries like Kenya are linked in complex ways that need to be adequately understood to inform farm forest sector policy decisions.

Farm forest policies makers have to take into consideration some land quality aspects of farm profiles that farmers may tend to be set aside for tree growing. The lower quality land may tend to be allocated for farm forest depending on the value placed on it as compared to competing agricultural enterprises hence the larger size of such land available translate to greater areas under trees.

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