Research Article

Modelling Determinants of Tree Planting and Retention on Farm for Improvement of Forest Cover in Central Kenya

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Farm forestry has proved to be an important enterprise for small- and large-scale farmers worldwide. It has the potential of improving forest/tree cover across the globe. In Kenya, the forest cover is less than 2%. The country envisions achieving 10% forest cover over the next decade through promotion of farm forestry. However, the decision to plant trees on farmers' land could be difficult. The study aimed to analyze the determinants of tree retention on farm for improvement of forest cover. Stratified and simple random sampling techniques were used in selecting 209 farmers. The results showed that sites, land size, age, education level, monthly income, tree management, extension services, availability of markets, harvesting regulation, and aesthetic and environmental motivation were significant determinants of tree retention. In particular, the chances of farmers who had gained technical skills in tree management were about 2.2 times higher to retain trees as compared to those who had not acquired such skills. Similarly, chances of farmers motivated to plant trees for environmental conservation were about 3.5 times higher to retain trees as compared to the group of farmers planting trees as a source of livelihood. These determinants would be instrumental in strengthening the current policies and reforms in forestry and agricultural sectors to enable Kenya to achieve 10% of forest cover.

1. Introduction

Farm forestry in the context of evergreen agriculture is emerging as an affordable and accessible science-based solution to caring better for the land and increasing small-scale food production [1]. It combines trees and food crops with principles of conservation farming. It has proved to be an important enterprise for small and large-scale farmers in low, medium and high potential areas worldwide [2]. In particular, it offers multiple benefits to farmers. This includes sources of green fertilizer, livestock fodder, timber, and fuel wood. Farm forestry has also other environmental benefits such as greater resilience to climate change and carbon storage, shelter, erosion control, watershed protection, and increased biodiversity [1].

The success of farm forestry may be assessed in terms of effects of various determinants such as advanced use of farm labour, positive environmental changes, increased financial returns among others [3]. When attempting to judge whether farm forestry is successful, it is important to note that the people involved may change their objectives over the years. For instance, markets may alter and force changes to the products required implying that as the farm business changes, economic calculations of the farm forestry enterprise will need to be adjusted. Successful farm forestry is therefore perhaps best seen as an incremental improvement and likelihood of long-term profitability and sustainability. Other studies by [4–7] reported that farmer's age, farm size, land value, erosion rate, tenure system, expected net returns/resource endowment, site description/biophysical factors, and market incentives as factors that influenced tree growing. In particular, secure land tenure significantly influenced tree planting practices as renters were less likely to adopt medium- or long-term conservation practices. Farmers who invested in timber stand improvement could improve the value of a stand and subsequent income from harvesting. This implied that forestland owners who derived significant income from their trees and viewed their

forests as sources of income to be tapped periodically for income would engage in practices that would maintain or enhance income generating opportunities. Conversely, forestland owners who did not view their trees as a source of substantial income would have less incentive to invest in forestland. In the same vein, land-owners who claimed to be interested in aesthetics or enjoying woods generally had higher volumes per hectare than those who owned woods as part of their farm.

The developing countries in sub-Saharan Africa have continued to experience forest destruction as a result of uncontrolled timber harvesting, conversion of forests to farm and pasture lands, increased needs of human population, migration, education, energy prices, road construction, fire outbreaks, and other related mortality factors [8–10]. For example, farm households that occupied land illegally or insecure land title deeds were more likely to clear forests for agricultural expansion. In particular, Kenya is among developing countries in sub-Saharan Africa that shares problems of deforestation with other eastern Africa nations due to conversion of forests to other land use especially agriculture and settlement to meet the needs of ever increasing human population. The country is currently considered a low forest cover. The remaining natural forests have been degraded and can no longer provide sustainable supply of water, raw materials and other services. Clearing of woodlands in dry areas for charcoal production has led to environmental degradation. Further, trees on farmlands and industrial plantations have been overcut resulting in widening gap between the supply and demand for forest products [11].

As a result, the Government of Kenya has developed various strategies to counter the decrease of forest cover in the country. The first one was ban of tree harvesting in the state forests in 1999. Since then, the country has been sourcing domestic and industrial wood from farms, supplemented with timber imported from neighbouring countries. This strategy has seen the country over depending on farms for forest products which, has led to depletion of farmland wood stock [11]. The country therefore, requires to urgently intensifying tree planting on farms to restock tree cut as well as increase the forest cover. The Sessional Paper No. 1 of 2007 on Forest Policy and Forests Act 2005 emphasizes the development of farm forestry as a way of increasing low forest cover, diversifying subsistence products and income, while contributing to soil and water conservation [11, 12]. It also points out the need to support farmers with sound management, utilization principles, incentives, information, better germ plasm and marketing strategies. Similarly, the Agriculture (CAP 318) on Farm Forestry Rules 2009 stipulates a 10 per cent forest cover on farms. The other strategies are described in various government blue prints such as Vision 2030 where the Ministry of Youth Affairs and Sports (MOYAS) developed an ambitious programme of trees for job. This was meant to encourage the youth in tree planting and nurturing for pay with a main aim of creating employment and conserving the environment.

Since inception of these strategies in Kenya, limited studies have been carried out to assess factors associated with tree planting and retention by farmers in order to realize the expected output of improving tree/forest cover. The decision by farmers to plant trees may be difficult due to many land use needs especially agriculture in enhancing food security of about 40 million Kenyans. Subsequently, land size for farm forestry has continued to shrink as a result of high land fragmentation and settlement, unsupportive land tenure arrangements whereby women, married sons and other landless have limited access to land for either tree planting or management of naturally growing woodlands [12–14]. Also there are gaps on adequate knowledge and understanding of the tree enterprise, which has been predominantly linked to supply driven research, markets, ineffective extension services and lack of user friendly packaging of the relevant information on the available technologies [12]. These are likely to pose serious challenges on Kenya's ambitious tree planting programme on farmlands for attaining 10% forest cover. It is on this background that we designed this study in order to evaluate various determinants such as demographic characteristics of farmers, land ownership, tree management and economic benefits of tree growing that would be crucial in developing approaches of improving forest cover. Therefore, the main objective of this study was to identify and analyze the determinants of tree retention on farm for improvement of forest cover in Central Kenya. The findings are expected to help the government of Kenya in mainstreaming strategies for forestry and agriculture policies in improving forest cover.

2. Materials and Methods

2.1. Study Area. Kenya is divided into 47 Counties [15]. Central Kenya has five Counties, namely, Nyandarua, Nyeri, Kirinyaga, Murang'a and Kiambu. In this region of Central Kenya, there is evidence of high land fragmentation and continuous farming causing a lot of pressure on natural and plantation forests as well as partial woodlands for settlement. Human encroachment and destruction of existing forests in Aberdares and Mt. Kenya ecosystems are on continuously rising. Therefore, this area was a selected for a case study to identify determinants of tree retention for improvement of forest cover in Central Kenya. The study sites were situated in Lari and Kikuyu districts in Kiambu County as well as Nyeri South and Nyeri North districts in Nyeri County.

2.1.1. Nyeri South and Nyeri North Districts of Nyeri County. Nyeri North comprises the most western part of the moist windward side of Mt. Kenya, the drier western leeward side of the extinct volcano and the borders of the semi-arid Laikipia Plateau. Nyeri South comprises the moist windward eastern slope of the Aberdare Range (Figure 1). The average annual rainfall ranges from 2200 mm on the most easterly exposed edge of the Aberdare range to 700 mm on the Laikipia Plateau. The altitude ranges from 2100 to 2400 m. a.s.l. It is the most expansive and vast area in Central highlands of Kenya covering 3,284 km^2. It's high densely populated area. In all divisions (Kieni West, Kieni East, Mathira, Mukurweini, Tetu, and Othaya) except Kieni West and Kieni
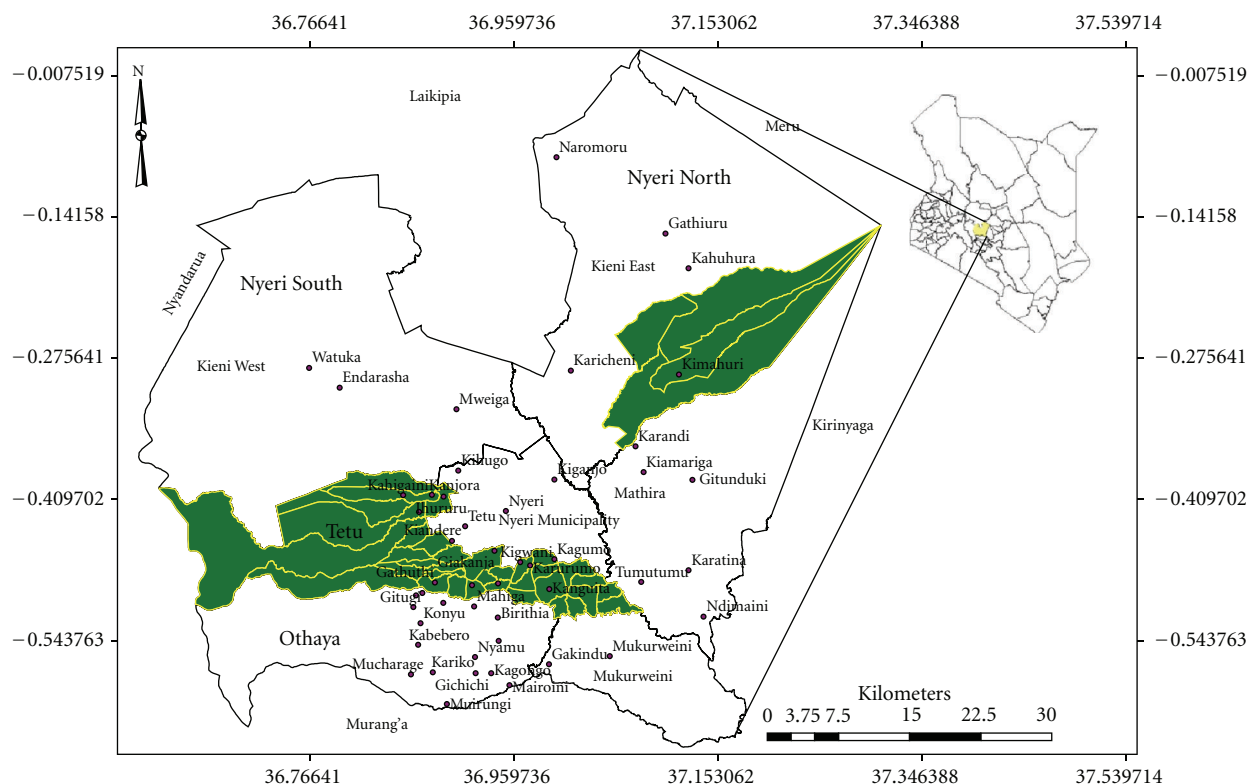
FIGURE 1: Map showing Nyeri South and Nyeri North districts in Nyeri County.

East, which are generally semi-arid, available agricultural land is less than 0.88 ha per household [16].

2.1.2. Lari and Kikuyu Districts of Kiambu County. Kiambu's agroecological zone (AEZ) extends in a typical pattern along the eastern slopes of the Aberdare Range. It is the most densely populated area with 640 persons per km² in 2009 compared to 562 persons per km² in 1999 and 280 persons per km² in 1979. It occupied 1323.9 km² as compared to 2448 km² in 1979 implying a great decrease of agricultural land size holding per person. Also due to its combination of good soils, climate and proximity to Nairobi, the country's main market, makes Kiambu the most economic farming region in the country [16].

Lari district lies on the upper highland AEZ one (UH 1). It is classified as sheep and dairy zone with permanent cropping possibilities, dividable in a long cropping season followed by medium one. It ranges from 2415 to 2591 m a.s.l and receives 1150 to 1276 mm mean annual rainfall. Kikuyu district lies on the lower highland AEZ two (LH 2) Figure 2. It is grouped as wheat/maize-pyrethrum zone with a medium to short and a weak short cropping season. It lies on 2067 m a.s.l receiving 1000 mm mean annual rainfall. It extends to the drier area of Karai and Kikuyu escarpments [16].

2.2. Sampling of Farm Households and Data Collection. A sampling frame was designed in all study areas where a list of farmers who planted over one hundred trees or at least a quarter an acre under woodlot or plantations was drawn.

Farmers were then stratified according to land sizes, tree planting densities, and species diversity varying from intense boundary planting, woodlots to plantation. To quantify the area under trees for cases of boundary planting conversions were done to assume uniform area under trees. This was equated as either a woodlot or a plantation of 0.5 ha. In each stratum, a list of farmers was drawn and each individual farmer was assigned random number. The random numbers were then ranked and targeted numbers of farmers were selected using the simple random sampling. Questionnaires were then allocated proportionately in each of the stratified category resulting to selection 209 respondents. A total of 48, 79, 48, and 34 questionnaires were allocated to Nyeri South, Nyeri North, Lari and Kikuyu districts, respectively. The data collected were mainly on household and farm characteristics. Data collectors were trained before carrying out the survey. Pre-testing was done to ensure consistency, reliability, and validity of the instrument.

2.3. Data Analysis and Model Applications. The selections of determinants used in this study were based from government of Kenya blue prints and authors conceptualization from cited literature. These were broadly classified as: demographic characteristics, land ownership and land use, tree planting on farm and use, problems of tree planting, tree management, social function of farm forestry, and economic benefits of trees on farm. In each of these classes, specific variables were assessed in relation to tree planting and retention. It was hypothesized that the likelihood of the
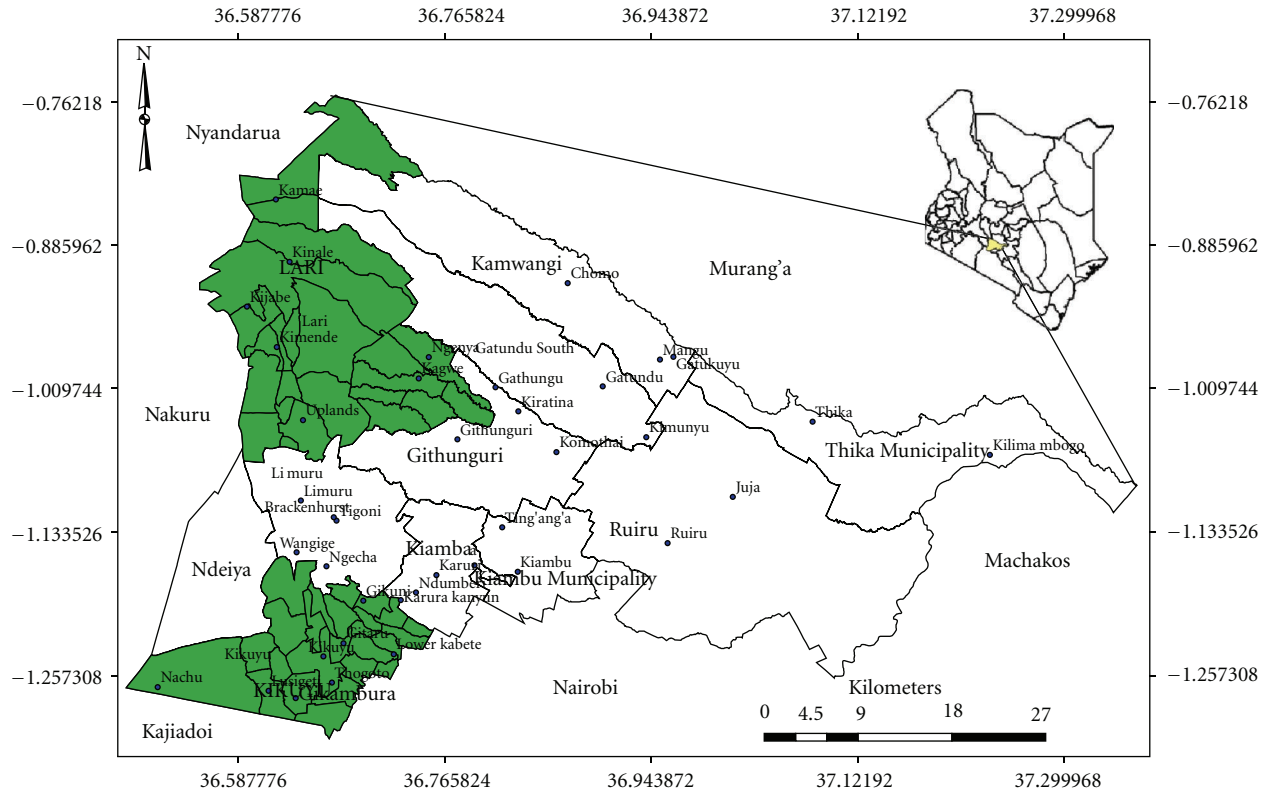
Figure 2: Map showing Lari and Kikuyu districts in Kiambu County.

farmer willing to retain trees on farm would be influenced by a number of determinants in each of the seven broad categories. Tree retention was assessed on the basis of farmers' frequency of tree planting in at least 10 years where a sample of data of tree planting was taken from 2004 to 2010 based on the respondent's recall. The other attributes considered for tree retention included; availability of different tree sizes on farms, species diversity of different growth rates, available plans of land use management, and willingness to invest in tree farming. In this case a group of farmers were considered to most likely or likely to retain trees on their farms if it was found that they were planting trees yearly on their farms, there were different trees on their farm of difference sizes (small diameters <10 cm, medium diameter 10–20 cm, and large ones >20 cm) some ready for harvesting but farmer not willing to cut because of some reasons. The other measure of retention especially for large scale planting was indirect benefits of tree planting such as carbon credits. In this regard group farmers had anticipated of accessing carbon market with the understanding that they were not likely to harvest their trees after some period of time where they would be compensated with payment of carbon credits. This was observed in farmers' field where some had started shifting to planting of indigenous trees which have slow growth rate and likely to be in a long period of time on their farms. The other characteristics of tree retention were based on the fuelwood demand and regulation mechanisms by Kenya Forestry Service (KFS) where farmers ensured that any given time, they had trees on their farms to meet

the increasing needs of various household demands. This was evidenced from the pattern of planting. It is in this respect that retention was measured as a latent variable but categorized into three or two levels farmers who were most likely, less likely and not likely; likely and not likely to plant and retain trees on farm as the dependent variable. This classification lead to the use of multinomial and binary logistic regression models, respectively. A criterion based on land size, age of the farmers, species diversity on farm, last period/frequency of tree planting, land use management priorities, hindrances of tree planting, and tree harvesting regimes was used to group farmers as "not likely", "likely", and "most likely" to retain trees on farm. Table 1 provides the description of the determinants hypothesized to influence the likelihood of tree planting and retention.

2.3.1. Descriptive Statistics. Chi-square statistical test and percentage frequencies were used to explore the association between the likelihood of tree retention and selected determinants. In order to control multi-collinearity among determinants, correlation analysis was performed in order to identify correlated variables before fitting the models.

2.3.2. Multinomial and Binary Logistic Regression Analysis. In order to examine the probability and extent at which the farmers were willing to retain trees on farm, multinomial and binary logistic regression models were used. In particular, when the dependent variable was in three categories,

TABLE 1: Definitions and description of modelling variables.

Variables	Description	Dummy description
Dependent variable:		
Farmer's tree retention on farm	Farmer classified as most likely, less likely and not likely to retain trees on farm or likely and not likely to retain trees on farm	0 = not likely; 1 = less likely; 3 = most likely or 0 = not likely, and 1 = likely.
Explanatory variables:		
Occupation (X_1)	Main occupation of the household head classified as either formal employment or non-formal employment	1 = Formal; 2 = non-formal; 0 = otherwise
Age (X_2)	Age of the household head	
Education (X_3)	Education level of the household head	1 = Formal learning; 0 = otherwise
Marital status (X_4)	Marital status of the head of household	1 = Married; 0 = Single
Number household (X_5)	Number of members of the household	
Income (X_6)	Income of the household head	
Land (X_7)	Land ownership of the household head	1 = Household that owns land; 0 = otherwise
Land size (X_8)	Land size owned by household members	
Landuse (X_9)	Area of land under trees	1 = Area under trees; 0 = otherwise
Tree use (X_{10})	Purpose of trees planted on farm	1 = Fuelwood; 2 = Aesthetic
Technical skills (X_{11})	Provision of technical skills on tree management	1 = Received technical skills; 0 = otherwise
Labour (X_{12})	Labour involvement on tree management	1 = intensive; 0 = Not intensive
Extension services (X_{13})	Accessing regular extension services	1 = Accessed extension services; 0 = otherwise
Regulation (X_{14})	Regulation by KFS on tree harvesting	1 = Supports KFS regulation; 0 = otherwise
Forest association (X_{15})	Existence and participation on forest organization	1 = Existence of forest association; 0 = otherwise
Marketability (X_{16})	Knowledge and access to markets and policies	1 = Ready market; 0 = otherwise
Economic motivation (X_{17})	Economic returns from tree growing	1 = High returns; 0 = otherwise

"not likely", "likely", and "most likely," multinomial logistic regression model of the form below was used:

$$\ln\left[\frac{p_j}{1 - p_j}\right] = P(\text{FRT})$$
$$= \frac{1}{1 + \exp\{-(\beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n)\}}, \quad (1)$$

where $j = 3$ (1 = not likely, 2 = less likely, and 3 = most likely), $P(\text{FRT})$ = the probability of the farmer willing to retain trees on farm, $0 \leq \text{FRT} \leq 1$ β_0 = intercept, $\beta_1 + \cdots + \beta_n$ = set of 17 ($n = 17$) regression coefficients of the determinants as provided in Table 1, $X_1 + \cdots + X_n$ = set of 17 ($n = 17$) determinants as provided in Table 1 and exp = base of the natural logarithm.

When $j = 2$, (1 = not likely and 2 = likely) the multinomial logistic model was an estimate of binary logistic regression model.

Both multinomial and binary logistic regression models assumed that there exists an index/a desire or intent by the farmer to retain trees on farm which was a linear function of the vector of predictors expressed as

$$I_t = X_t \beta, \quad (2)$$

where $I_t = (1 \times 1)$ latent determinant that is unobservable or index of intent/desire to retain trees by farmer t; $X_t = (1 \times k)$ vector of observations on 17 determinants for farmer t; and $\beta = (k \times 1)$ vector of coefficients.

If this index exceeds the individual threshold, retention of trees occurs.

Similarly, extend of planting trees was also a function of the determinants, through the index. The greater desire to plant trees on farm, the greater the extent of retaining:

$$y_t = 0 \quad \text{if } I_t < I_t^* = I_t - I_t^* \quad \text{if } I_t > I_t^*, \quad (3)$$

where $y_t = (1 \times 1)$ dependent variable representing extent of planting trees on farm by farmer t; $I_t^* = (1 \times 1)$ critical threshold or limiting factor for famer t.

Essentially, each farmer may have a different value. For instance, if extension services are a significant determinant (predictor variable), then more of the extension services may be required to push one farmer over threshold than that required to induce another farmer's retaining ability. Since individual threshold differ, at any given index value, there will be both a concentration of zeros (for non-retaining) and a distribution of positive extents of retaining (for those who would retain). Therefore the probability of planting and retaining trees, given a particular index value was given by

$$
\text{Prob}\left\{y > \frac{0}{I}\right\} = \text{Prob}\left\{I^* < \frac{1}{I}\right\} = F\left(\frac{1}{I}\right),
$$
$$
\text{Prob}\left\{y = \frac{0}{I}\right\} = \text{Prob}\left\{I^* > \frac{1}{I}\right\} = 1 - F\left(\frac{I}{\delta}\right),
\tag{4}
$$

where $F(I/\delta)$ is the value of the standard normal cumulative distribution at I/δ.

Expected extend of the planting and retaining, given a particular index value was given by

$$
E\left(\frac{y_t}{I_t}\right) = IF\left(\frac{I_t}{\delta}\right) + \delta F\left(\frac{I_t}{\delta}\right),
\tag{5}
$$

where $F(I_t/\delta)$ is the value of the standard normal density distribution at I_t/δ.

Estimation of β and δ was accomplished through maximum likelihood, since the functional form is non-linear. The data was captured and checked in MS Excel 2007 and analyzed using Statistical Package for Social Scientists (SPSS V17). Statistically significant differences were declared at five percent level, unless stated otherwise.

3. Results

3.1. Descriptive Statistics on Tree Retention Determinants

3.1.1. Study Sites and Household Determinants of Tree Retention. The results showed study sites were significantly associated ($P < 0.05$) with the likelihood of the farmer willing to retain trees on farm (Table 2). Nyeri North district followed by Lari district had high significant proportion of farmers who were most likely to retain trees on farm as compared to those from Kikuyu and Nyeri South districts. Consequently, the study revealed significant associations ($P < 0.05$) between gender of the household head and farmers' decision to retain trees on farm. Male-headed households were most likely to retain trees on farm as compared to female-headed households.

Similarly, there were significant association ($P < 0.05$) between main occupation and farmers' willingness to retain trees. Farmers in formal full time employment had high proportion of tree retention as compared to full time farmers. Education was also a significant factor associated ($P < 0.05$) with farmers' decision to retain trees on farm. Of those attained post secondary and primary education had high

proportion as compared to those who had no academic qualification. This was in contrast with marital status, which was not significantly associated ($P > 0.05$) with farmers decision to plant and retain trees on farm (Table 2).

Consequently, of the sampled farmers, 59, 31, and 10 per cent owned their land through inheritance from their parents, purchase, and given by the community/government, respectively. However, no significant associations were found between type of land ownership and farmers' decision to retain trees (Table 2). Land size significantly influenced ($P < 0.05$) farmers' likelihood of tree retention. Farmers with average land size of 4.7 ha were most likely to retain trees as compared to those with 1.6 ha who were less likely. Farmers with an average land size of 1 ha were not likely to retain more trees on their farm. The study also revealed that exotic tree species were most preferred as compared to indigenous ones. In particular, eucalypts, *Cupressus lusitanica* and *Grevillea robusta*, were the most planted exotic species whereas the indigenous were dominated by *Olea africana* followed by *Prunus africana* and *Croton megalocarpus*. Subsequently, farmers who were motivated in tree planting for environmental conservation and improving sources of livelihood were mostly likely to plant and retain trees on farm.

3.1.2. Tree Management and Marketability Determinants. The study revealed 84 per cent of farmers interviewed lacked any technical skills in tree management as compared to 16 per cent who had acquired such skills. The specific skills were nursery establishment, thinning, pollarding, short rotation coppice, fertilizer application, tree harvesting, forest economics, and management of tree competition with agricultural crops among others. The acquisition of the technical skills was significantly associated ($P < 0.05$) with farmers' decision to retain trees on farm. Sixty six per cent of farmers with the technical skills were most likely to retain trees on farm as compared to those who had not obtained the same skills (Table 3). Similarly, the results showed that 94 per cent of the farmers did not receive forest extension services as compared to 6 per cent who received such services. The latter were most likely to retain trees on farm.

Farmers who sought authority from Kenya Forestry Service (KFS) to harvest their trees were significantly associated ($P < 0.05$) with the likelihood of tree retention on farm. In addition, farmers who found such regulations necessary on tree farming were most likely to plant and retain trees on their farms. The results also showed that 74 percent of the farmers viewed labour involved on tree management less intense. This significantly influenced their decision to plant and retain trees on farm for various uses (Table 3). Comparatively, no significant association was found between existence of village forest association and level of likelihood of farmers planting and retaining trees. Similarly, there was no significant association found between marketing problems and farmer's likelihood of tree planting and retention on farm (Table 3).

3.2. Correlation Analysis among Determinants for Tree Retention. The results also showed a positive significant correlation ($P < 0.05$) between major occupation and monthly

TABLE 2: Study sites, household, and land ownership determinants associated with likelihood of farmers' tree retention in Central Kenya.

| Determinants | Categories | J = 3 | | | | J = 2 | | |
		Not likely %	Less likely %z	Most likely %	Total (n)	Not likely %	Likely %	Total (n)
Site	Kiambu-Lari	19	35	46	48	46	54	48
	Kiambu-Kikuyu	38	21	41	34	59	41	34
	Nyeri-South	32	27	40	47	60	40	47
	Nyeri North	15	23	62	79	38	62	79
Gender	Male	19	28	53	161	47	53	161
	Female	39	21	40	199	61	40	38
Main occupation	Full time farmer	25	28	47	174	53	47	174
	Formal job	15	19	68	14	33	68	27
	None	30	35	35	23	65	35	23
Education level	Primary	22	24	54	79	46	54	79
	Secondary	22	32	46	69	54	46	69
	Post secondary	18	11	71	28	29	71	28
Marital status	Married	22	26	52	187	48	52	187
	Not married	40	20	40	15	61	40	15
Land ownership	Inherited	21	30	49	120	51	49	120
	Bought	28	17	55	60	45	55	60
	Donated	30	20	50	20	50	50	20

TABLE 3: Tree management and marketability determinants of influencing farmer's tree retention on farm in Central Kenya.

| Determinants | Categories | j = 3 | | | | j = 2 | | |
		Not likely %	Less likely %	Most likely %	Total (n)	Not likely %	Likely %	Total (n)
Technical skills	Yes	14	21	66	29	34	66	29
	No	26	28	46	163	54	46	163
Use of skills	Yes	14	7	79	28	21	79	28
	No	26	19	55	31	45	55	31
Labour and cost	Yes	9	28	63	43	37	63	43
	No	30	24	46	127	54	46	127
Extension services	Yes	0	22	79	9	22	78	9
	No	25	27	48	183	52	48	183
Harvesting permission	Yes	18	26	57	97	43	57	97
	No	32	27	41	71	59	41	71
Harvesting regulation	Yes	16	29	55	76	45	55	76
	No	35	20	45	75	55	45	75
Village forest associations	Yes	16	35	49	57	51	49	57
	No	27	22	51	112	49	51	112
Membership	Yes	23	31	46	35	54	46	35
	No	25	26	49	148	51	49	148
Ready market	Yes	21	25	54	109	46	54	109
	No	36	21	42	33	58	42	33
Marketing problems	Yes	10	29	61	31	39	61	31
	No	28	25	47	117	53	47	117

income as well as education level. There was a positive significant correlation ($P < 0.05$) between gender of the household head and major occupation. On the other hand, there was negative significant correlation ($P < 0.05$) between marital status and size of household as well as age of the household respondent (Table 4).

Consequently, there was a positive significant correlation ($P < 0.05$) between technical skills farmers gained in tree management and use of such skills in influencing them in tree growing and harvesting. The skills were equally highly correlated ($P < 0.05$) with harvesting regulation, which farmers found to be necessary and useful in motivating

TABLE 4: Correlations among various demographic variables of tree retention.

Demographic variables	Gender of household head	Marital status	Major occupation	Household size	Monthly income	Age (yrs)	Education
Gender of household head	1.000	0.247	−0.125	−0.038	−0.048	0.063	−0.098
		$P = 0.001$	$P = 0.064$	$P = 0.324$	$P = 0.281$	$P = 0.224$	$P = 0.118$
Marital status		1.000	−0.032	−0.165	−0.041	−0.227	0.070
			$P = 0.351$	$P = 0.022$	$P = 0.310$	$P = 0.003$	$P = 0.197$
Major occupation			1.000	−0.108	0.240	−0.029	0.374
				$P = 0.094$	$P = 0.002$	$P = 0.361$	$P = 0.000$
Number of members household				1.000	0.035	0.063	−0.169
					$P = 0.335$	$P = 0.449$	$P = 0.019$
Monthly income					1.000	0.011	0.179
						$P = 0.449$	$P = 0.014$
Age in years						1.000	−0.452
							$P = 0.000$
Education							1.000

*Probability value (P value).

TABLE 5: Correlation matrix among the farm determinants of tree retention.

	Technical skills	Use of skills	Labour cost	Extension services	Harvesting permission	Harvesting regulation and tree farming
Technical skills	1.000	0.819	−0.024	0.275	0.152	0.483
		$P = 0.00$	$P = 0.434$	$P = 0.025$	$P = 0.144$	$P = 0.000$
Use of skills		1.00	0.013	0.204	0.145	0.372
			$P = 0.463$	$P = 0.075$	$P = 0.155$	$P = 0.004$
Labour and cost			1.000	−0.081	−0.063	−0.188
				$P = 0.286$	$P = 0.331$	$P = 0.093$
Extension services				1.000	0.130	0.231
					$P = 0.182$	$P = 0.051$
Harvesting permission					1.000	0.244
						$P = 0.042$
Harvesting regulation and tree farming						1.000

*Probability value (P value).

their decision for tree farming. Similarly, the technical skills obtained on tree farming by farmers were significantly correlated ($P < 0.05$) with extension services received on tree management. This was consistent with the use of skills gained in tree farming. Seeking permission from Kenya Forestry Service to harvest trees was significantly correlated ($P < 0.05$) with level of acceptance on such regulations. This was found to be necessary and useful in motivating the farmers to participate in tree farming (Table 5). The extension services were also positively and significantly correlated ($P = 0.015$) with motivation to plant trees for environmental conservation and source of livelihood.

There was also a significant positive correlation ($\rho = 0.570$; $P = 0.000$) between existence of village forest village association and membership of the farmers. Similarly, there was significant correlation ($\rho = 0.491$; $P = 0.002$) between village forest membership and ready market of

forest products. In addition, there was a significant positive correlation ($\rho = 0.175$, $P = 0.001$) between land size and monthly income as well as land size and age ($\rho = 0.18$, $P = 0.013$). In addition, there was a significant correlation ($\rho = 0.213$, $P = 0.000$) between land size and the number of trees planted on farm. There was also positive significant correlation ($\rho = 0.217$, $P = 0.008$) between acquisition of technical skills and marketability of tree produce.

3.3. Determinants of Tree Retention Using Multinomial and Binary Logistic Regression Models.
Both binary and multinomial logistic regression following stepwise method of fitting variables showed gender, age, major occupation, education level, monthly income, land size, extension services, site, motivational reasons of tree planting, labour, acquisition of technical skills, cost involved in tree management, harvesting

TABLE 6: Likelihood ratio tests and model classification of tree retention determinants using binary and multinomial logistic regression.

Determinants	−2log likelihood		d.f		P value		% Model classification	
	*Logt	*Mult	Logistic	Multinomial	Logistic	Multinomial	Logistic	Multinomial
Site	281	45.1	3	6	0.05	0.04	59	50
Gender HH*	273	24.8	1	2	0.12	0.03	55	51
Occupation	275	20.6	1	2	0.06	0.16	55	50
Age	262	238	1	126	0.93	0.06	52	67
Education	267	40.0	3	6	0.04	0.14	58	52
Marital status	279	18.7	1	2	0.38	0.32	53	51
NMH*	275	85	1	2	0.47	0.47	53	52
Income	220	168	1	80	0.00	0.00	60	53
Land tenure	276	43.9	2	10	0.76	0.15	52	51
Land size	231	130	1	6	0.00	0.00	68	68
Tree use	240	27.3	2	4	0.35	0.53	55	48
Motivation	225	27.5	1	2	0.20	0.01	56	52
Technical skills	262	21.1	1	2	0.05	0.13	56	49
Skill effect	71.8	16.6	1	2	0.05	0.14	66	66
Labour and cost	232	25.8	1	2	0.05	0.01	57	50
Extension services	263	18.8	1	2	0.07	0.06	53	50
Harvest permission	229	23.9	1	2	0.04	0.05	58	50
Harvesting regulation	208	25	1	2	0.22	0.02	55	50
Forest associations	234	22.1	1	2	0.83	0.11	51	50
Membership	253	18.1	1	2	0.70	0.79	51	49
Ready market	195	19.8	1	2	0.24	0.22	55	51
Marketing problems	203	21.7	1	2	0.16	0.07	55	50

*Logt: Logistic regression values; *Mult: multinomial logistic regression values; HH*: household head; NMH*: number of members in the household.

permission from KFS and existence of forest associations as significant determinants influenced the likelihood of the farmer willing to plant and retain trees on farm (Table 6).

Farmers with higher monthly income and large land size had high chance of planting and retaining trees on farm. Specifically, increase of income had a unit increase in tree planting and retention. Similarly, unit increase of land resulted to about 1.4 times chances higher of farmers' decision to plant and retains trees. The computed predicted probabilities on monthly income and land size of the farmers showed that as monthly income increased and land size, there was corresponding increase of probability of the farmers planting and retaining trees on farm with 100% model prediction (Figures 3 and 4).

The odds of farmers from Nyeri North district likely to retain trees on farm as compared to those from Nyeri South, Kikuyu, and Lari were 60, 60, and 50 per cent higher, respectively (Table 7). Similarly, farmers from Nyeri North district had significantly high logits of most likely to retain trees on farm as compared to Kikuyu and Nyeri South farmers.

However, there were no significant differences ($P > 0.05$) on the logits of the farmers who were not likely to retain trees on farm from Nyeri North as compared to those from Nyeri South and Lari districts (Table 7).

Farmers on full time formal employment had 50 per cent higher logits of tree planting and retention as compared to full time farmers. In addition, farmers with postsecondary
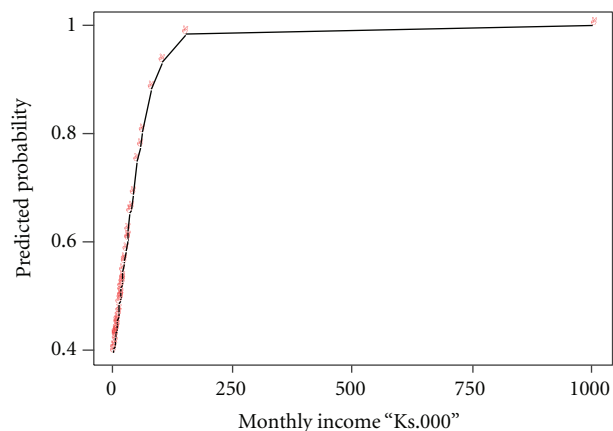

FIGURE 3: Monthly income (Kenya Shilling) and predicted probability of the farmers tree planting and retention on farm in Central Kenya.

education had about 80, 50, and 70 per cent chances higher of planting and retaining trees on farm as compared to those with formal primary and secondary education, respectively. Furthermore, the logits of the male-headed households most likely and less likely to retain trees on farm were about 2.9 and 2.8 times significantly higher as compared to female-headed households not likely to plant and retain trees (Table 8).

TABLE 7: Binary logistic regression model on fitting determinants of farmer's tree retention on farm in Central Kenya.

| Determinants	Categories	Reference category	β	S.e (β).	Odds ratio	P value
	Kiambu-Lari	Nyeri North	−0.66	0.37	0.5	0.076
Site	Kiambu-Kikuyu		−0.85	0.42	0.4	0.043
	Nyeri South		−0.88	0.38	0.4	0.020
Gender	Male	Female	0.56	0.37	1.8	0.125
Household members	—	—	0.04	0.05	1.8	0.477
Monthly income	—	—	0.00	0.00	1	0.004
Land size	—	—	0.36	0.07	1.4	0.000
Marital status	Single	Married	0.48	0.55	1.6	0.380
Major occupation	Formal job	Full time farmer	−0.81	0.44	0.5	0.064
	None	Post secondary	−1.55	0.61	0.2	0.011
Education	Primary		−0.74	0.48	0.5	0.120
	Secondary		−1.06	0.48	0.3	0.028
Age	—	—	0.001	0.01	1.0	0.927
Tree use	Fuel wood	Aesthetic	−0.55	0.47	0.6	0.243
	Timber		−0.16	0.49	0.8	0.533
Tree Motivation	Conserve environment	Source of livelihood	0.420	0.330	1.5	0.203
Technical skills	Obtained technical skills	Did not obtain skills	0.802	0.421	2.2	0.057
Effect of skills	Skills were useful	Skills not useful	1.105	0.585	3.0	0.059
Labour and cost	Intensive	Not intensive	0.697	0.362	2.0	0.054
Extension services	Received extension services	Did not receive extension services	1.329	0.815	3.8	0.103
Harvesting permission	Sought harvesting permission	Did not seek permission	0.640	0.317	1.9	0.043
Harvesting regulation	Harvesting regulation important	Harvesting regulation not important	0.399	0.327	1.5	0.223
Forest associations	Existence of forest associations	No existence of forest association	−0.071	0.325	0.9	0.828
Membership	Member of forest association	Not a member	−0.145	0.377	0.9	0.701
Ready market	Ready market access	No ready market access	0.471	0.401	1.6	0.241
Marketing problems	Existence of marketing problems	No marketing problems	0.579	0.413	1.8	0.160
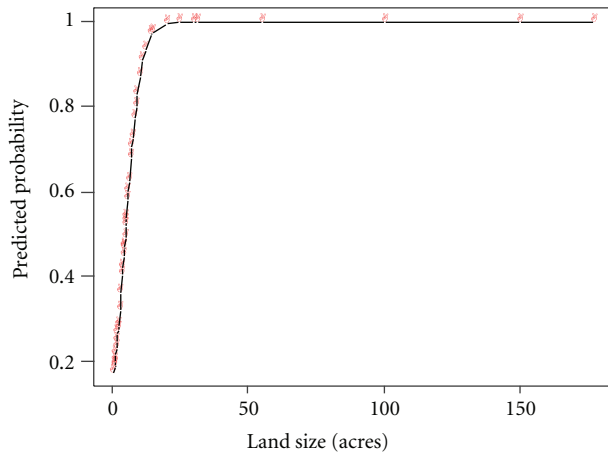
FIGURE 4: Land size and predicted probability of the farmers' tree planting and retention on farm in Central Kenya.

Farmers with technical skills had about 2.2 times chances higher of planting and retaining trees than those who had not acquired similar skills. Moreover, farmers who did not view labour involved in tree management as intense and costly had about two times chances higher of tree planting and retention as compared to who viewed tree farming as labour intense and costly. The chances of farmers who sought permission from KFS to harvest their trees were about 2.6 times higher to plant and retain trees (Table 8). Farmers motivated to plant trees for environmental conservation as compared to those for source of livelihood were about 3.5 times most likely to retain trees on farm as compared to those who were not likely. Similarly, farmers not experienced any marketing problems of tree produce had about 3.8 times chances higher of most likely to plant and retain trees on farm as compared to unlikely ones (Table 8). Overall, logistic regression model provided better prediction of uncorrelated determinants of tree planting and retention as compared to multinomial logistic regression model. The binary logic regression model correctly predicted 82% and 81% not likely and likely to plant and retains trees, respectively. This resulted to 81% of the overall prediction of determinants influencing tree planting and retention (Table 8).

4. Discussion

The significant effect of site in influencing farmers' decision to plant and retain trees on farm underscored the importance

TABLE 8: Multinomial logistic regression model on fitting determinants of farmer's tree retention on farm in Central Kenya.

Explanatory variable	Most likely/not likely				Less likely/not likely			
	β	S.e (β).	P value	Odds ratio	β	S.e (β).	P value	Odds ratio
Intercept	1.41	0.32	—	—	0.41	0.37	—	—
Site								
Lari	−0.51	0.51	0.315	0.6	0.23	0.56	0.678	1.3
Kikuyu	−1.33	0.50	0.008	0.3	−1.03	0.60	0.087	0.4
Nyeri South	−1.17	0.47	0.013	0.3	−0.55	0.53	0.302	0.6
Gender	1.05	0.42	0.013	2.9	1.03	0.50	0.038	2.8
Intercept	0.00	0.37			−0.63	0.44		
Education								
None	−1.25	0.72	0.082	0.3	0.64	0.90	0.472	1.9
Primary	−0.46	0.58	0.426	0.6	0.62	0.80	0.439	1.9
Secondary	−0.63	0.59	0.287	0.5	0.89	0.80	0.266	2.4
Intercept	1.39	0.50			−0.511	0.73		
Motivation	1.24	0.44	0.005	3.5	1.40	0.49	0.005	4.0
Intercept	0.37	0.31						
Labour and cost	1.49	0.58	0.010	4.4	1.30	0.63	0.038	3.7
Intercept	0.42	0.21			−0.20	0.24		
Harvesting permission	0.94	0.39	0.017	2.6	0.58	0.44	0.191	1.8
Intercept	0.23	0.28			−0.19	0.31		
Harvesting regulation	0.98	0.42	0.019	2.7	1.16	0.48	0.017	3.2
Intercept	0.27	0.26			−0.55	0.32		
Marketing problem	1.33	0.66	0.043	3.8	1.23	0.71	0.085	3.4
Intercept	0.51	0.22			−0.13	0.26		
Forest association	0.49	0.445	0.267	1.6	0.98	0.48	0.043	2.7
Intercept	0.64	0.27			−0.18	0.27		

of taking into account the uniqueness of each geographical location. This is because sites vary in climatic conditions and other characteristics that are likely to have a great influence in tree planting and retention. In this study the four selected sites were very distinct in amount of rainfall, soils, population density, and proximity to other geographical features/major towns among others. For instance, Nyeri North district had large land sizes, which may explain high level of tree planting and retention as compared to other three districts. This corroborates with other studies that have shown land is a significant factor influencing community's decision to plant trees on large scale. One percent increase in land under outright ownership, there was a 7.6 per cent in the probability that farmers will establish forest plantations. Farmers with small-scale land holdings opted for agricultural rather than forest plantations, as they needed immediate cash flow hence shorter rotations of crops cultivated [17, 18]. The proximity of Nyeri North district to the slopes of Mt. Kenya and surrounding of forest plantations may have as well induced farmers into the culture of tree planting. This might be a result of strict regulation imposed by the Government of the Republic of Kenya in accessing forest products from government owned and managed forests. The inhabitants therefore around this region were more likely to shift in establishing their own woodlots/plantations or tree boundary planting in meeting their household wood energy and other forest products needs. Also, with imposed

ban on tree harvesting from government forest plantations, availability of forest products such as timber, transmission poles, construction posts, and many others were likely to be limited in supply. The prices of such products were virtually on increase due to high demand. This may have triggered farmers with large land sizes to venture into tree farming with an aim of capitalizing existing market. During the data collection around this region, it was evident that farmers with large land sizes had widely invested in tree planting.

The low levels of likelihood of farmers to plant and retain trees at Nyeri South and Kikuyu districts may be attributed to small land holdings due to high population. The nature of their farming activities were dairy, tea growing and subsistence crops. This may have delineated them from active participation in tree farming as most of the land was needed for pasture and food crops. This was in contrast with Nyeri North district where the concept of planting alone was not adequate to advance forest cover but the interest to keep trees on farm will significantly contribute to forest cover. For instance, the discussions held with farmers during data collection in this region pointed out that majority of them viewed tree growing as a long-term investment with no immediate cash to offset household needs, hence lowly prioritized. Therefore, chances of finding more trees on farm of varied sizes were small reflecting less retention. In cases where farmers had trees on their farms, the site was less productive and sometimes with deep gradient which was

not suitable for agricultural farming. This demonstrated that such group of farmers least valued trees in their fertile lands as compared to food crops hence a motivation of continuous tree planting and retention so long as the site of the land remained unproductive. This was further evidenced by farmers in the drier area of Kikuyu district engaged more in tree planting due to less land productivity and less rainfall for agricultural crops. In this case there was high likelihood that such farmers would continue planting and keeping trees on their farm to meet various household needs unless better alternatives of land uses for drier areas were availed. This corroborates with findings of other studies where farmer-owned woodlands were reported to generally occur along rivers and streams which were too hilly or rocky for row crops [6]. Landowners who had higher percentage of land in crops were considerably less likely to express interest in agroforestry suggesting that row crops and trees were incompatible [5]. Overall, location factors have been found among key determinants influencing variationsonthe likelihood of managing natural resources including trees on farm and engagement in forest management [19].

The significant contribution of male headed household in the likelihood of tree planting and retention as compared to female headed households may be explained by cultural setting of the community members of the study sites. Women might have limited access to landownership, participation in community groups as a result of household duties among others resulting to less interest in tree farming. Similar differentials were reported by [20–22]. Social cultural norms and traditions define and shape behaviour of men and women, which present obstacles to participation in resource management effort. Men are considered to be responsible for village development and governance, reducing women to their personal and household attributes, which continue to constrain them. However women's participation in community forest management has been enhanced by roles of various institutions, which changed the assumption that men were more actively involved in forest management than women [22].

The major occupation of farmers particularly, those in formal employment were leveraged in tree planting and retention. These groups of farmers in formal employment were not necessarily depending on their land for their livelihoods hence may give environmental, aesthetic and recreational factors more weight than financial ones when making land use decisions. This resulted to high likelihood of tree planting and retention corroborating well with the findings of [5]. Similarly, studies have shown that those who had off time employment opportunities, access to credit and total household income may be associated with reduced tree felling on farm leading to high probability of tree retention. Consequently, farmers who derive significant income from their trees and viewed their forests as source to be tapped periodically for income would engage in practices that would maintain or enhance income regenerating opportunities [6, 23].

Education plays a significant role in understanding the need to conserve the environment through various practices. During the learning period individuals acquire relevant knowledge, skills, and values appropriate for sustainable farm forestry. This was evident on this study where farmers with secondary school and post secondary education qualifications were most likely to plant and retain trees. Knowledge in agroforestry has been found to significantly correlate with level of education where college graduates tended to be more interested in agroforestry than their counterparts with less academic qualifications. Every additional year of education decreased the probability that the household exploited forest/tree products and less conversion of woodlands to arable land [5, 9, 10, 19, 24]. The acquisition of technical skills improved techniques of the farmers on silvicultural tree management and created awareness on the role of trees on farm and for environmental conservation. The positive correlation between technical skills and extensions services implied that majority of the farmers had not obtained knowledge on tree management. Access to and use of extension services has a positive impact on silvicultural investment by farmers who had established plantations. Forest owners who had attended forestry extension activities were 2.6 times more likely to have decided to thin their stands than those that had not [17, 25, 26].

Middle aged and young farmers were planting trees on their farm with an aim of generating income and household needs like supply of fuelwood, timber, construction poles, and boundary marking of their lands from neighbours. This tended to influence the probability of likelihood of tree planting and retention. For instance, with population increase, there will be always demand for wood products indicating ready market that is likely to stimulate tree planting and retention for future direct and indirect needs. This concurs with a study carried on farmer participatory evaluation of agroforestry trees in eastern Zambia which showed that fuelwood and construction materials were most important and second most important by-products among the group of farmers likely to have influenced tree growing [27]. Nevertheless, some studies have shown that young households contemplated on forest farming as an income activity whereas older people possesses superior knowledge about various forest resources, more likely to participate in forestry programs and may utilize more medicinal plants and wild foods resulting to high retention of trees on farm [4, 16, 22, 24].

The significant contribution of village forest association on the likelihood of tree planting and retention implied that the roles undertaken by these groups such as: supply of seeds, seedling production, tree planting, thinning, pruning, bee keeping, environmental conservation, and marketing had a positive effect on farm forestry. Studies have shown that becoming a member of a farmers' group increased knowledge and farmers' participation in forestry activities [17, 18, 24]. This has been revitalized in Kenya through the new Forests Act No. 7 of 2005, which has formally recognized establishment of Community Forests Associations (CFAs) in all forests Conservancies. These groups have a national mandate in comanagement of forest resources with the government at grassroots level. Some of the activities they undertake include, community forests policing, tree planting, sustainable use of forest resources, trainings in

nursery establishment, and marketing of forest products among others. Deriving such forest benefits will not only strengthen the associations but also change attitude on tree farming. This would cumulatively improve the forest/tree cover in the country through planting and conservation.

The reinforcement of forest regulation on tree harvesting by Government of Republic of Kenya through KFS significantly influenced the farmers to retain trees on farm and participate in tree growing. This was in contrast with what has been reported in the past where seeking permission to harvest trees, which the farmers had planted, would discourage them from continuous tree planting [28]. However, in this study farmers viewed such measures as important because harvesting trees without permission would not only affect the environment but also encourage theft in farmers' field and government forests. This was further evidenced by [29] who examined Ukrainian forest regulatory policy on forest groups and permit classifications that permit or prohibit final felling and found out that such instruments were directed towards maintaining the environment and social functions of specified forests.

5. Policy Implication and Conclusion

The household, farm attributes, tree management and marketability characteristics were instrumental determinants that influenced the farmer's decision on tree planting and retention. The findings of this study therefore would be crucial in assisting the government of Kenya to effectively address forestry and agriculture sector policy reforms geared towards improving forest cover to 10% in the next decade. One objective of such policy reforms would perhaps be enhancing capacity to monitor the land use management systems across the country. This would lead to identification and mapping of specific sites that would be useful in tree planting such as top hills, degraded areas not suitable for agricultural crops and fallow lands among others. Consequently, the forest policy would provide direction on evaluation of farm forestry needs in each of the specific locations of the country in strengthening the culture of tree planting. This is likely to direct the allocation of resources while greening the country. The role played by gender, age, and major occupation in tree planting and retention would guide activities of promoting specific forestry programmes in Kenya. For instance, it is important to match the type of tree to the needs of men and women and farmers of different ages.

The need for extension services requires more investment in human capital and facilities. This would dictate for allocation of more funds to recruit and equip the personnel with appropriate facilities to enable them undertake their extension services well. The revision of Sessional Paper No. 1 on Forest Policy which is currently underway and new farm forestry guidelines in the Agricultural Act (Cap 318) would need to take into account of these needs if 10 per cent forest cover in Kenya would become a reality. For example, it has been currently diagnosed that Kenya has a shortfall of over 3000 agricultural and forestry extension officers. This would significantly hinder evergreen agricultural services to the general public. The significant contribution of household income in tree planting and retention would as well shift the government policies on employment opportunities in order to reduce pressure on land and enhance tree planting. Equally, enhancing the level of literacy in the country would strengthen efforts of environmental conservation measures. Overall, the significant determinants found in this study influencing tree planting and retention would significantly help the country to develop appropriate technical working papers that will spearhead the success of farm forestry with an aim of improving forest cover in Kenya.

In conclusion, the approaches used in undertaking this study especially the application of binary and multinomial logistic regression model explicitly revealed the key determinants influenced farmers' decision to plant and retain trees on farm. Ideally tree planting alone is not sufficient to indicate that tree cover will be improved but an assessment of retention forms a critical point that needs to be assessed because in farm forestry farmers have out right ownership of land and management. They are likely to shift to different land uses other than tree growing. Accounting the contribution of various determinants to tree growing would lead to set of realistic objectives and strategies that would enable the country realize the dream of increasing tree/forest cover to 10 per cent.

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