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Original Article

Determinants of Commercial Tree Growing Among Smallholder Farmers in Nandi County, Kenya

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ABSTRACT

Commercial Forestry sector contributes more than $600 billion to the global economy each year. Farm forestry is expected to contribute immensely to meeting materials needs for this sector and also provide ecosystem services. To support the tree growing by farmers, it is essential to understand the factors that influence commercial tree growing. The findings of a study to assess the current state of on-farm tree planting and the key variables influencing adoption of commercial tree growing on farms are reported in this paper. Cross sectional data on commercial tree growing was collected from two hundred and eighteen (218) households. Using semi-structured questionnaires with closed and open-ended questions, these households were systematically and randomly sampled from a population of 3633 farming households practicing agroforestry. Descriptive statistics, logit and binary logistic regression models, and qualitative analysis were applied. The findings show that socioeconomic factors such as age, education level, and income have a strong influence on commercial tree planting among small holder farmers in Nandi County. Older farmers are more likely than younger farmers to participate in commercial forestry as farmers because their employment opportunities are limited. Farmers with a high level of education are also more likely to practice commercial forestry because they have access to information and training. Farmers with a high off-farm income are more likely to grow commercial trees as a long-term return investment than farmers who rely entirely on their farms. According to the study, the majority of farmers preferred commercially planting exotic tree species, with 70.2 % planting Cupressus lusitanica and 69.7 % planting Eucalyptus saligna. The study recommends that farmers should be educated on species site matching, according to the study, because they were found planting Eucalyptus species even in riparian areas. In conclusion, farmers of

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various ages can be encouraged to use commercial tree farming and good management practices to generate more income.

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INTRODUCTION

Over the last 50 years, the human population is expected to increase and is expected to reach 9.8 billion by 2030 (United Nations, 2017). Population growth has led to massive land use change that has impacted negatively on land productivity and diminished the flow of ecosystem services for human well-being (Cheboiwo et al., 2018). Globally, about 30% of the rural populations are dependent on tree resources available from 46% of all agricultural lands to meet most of their livelihood needs (FAO, 2010). This also acts as a safety net in periods of crisis or during seasonal food shortages (Langat et al., 2016). The commercial forestry sector contributes more than $600 billion to the global economy each year (World Bank Group, 2016) with 1.2 billion hectares of timber plantations globally (FAO, 2016). Farm forestry or agroforestry has the potential to diversify farmers' income opportunities and promote sustainability through the provision of ecosystem services.

Agroforestry, also known as farm forestry, is the incorporation of trees and shrubs into a farming system. Agroforestry is a system of sustainable land management that involves the integration of forestry and agriculture on the same land unit. Farm forestry is a broad definition that includes any trees on farm land that are managed to produce saleable products such as timber, oil, tannin, charcoal, or carbon credits, whereas agroforestry is a system of sustainable land management that involves the integration of forestry and agriculture on the same land unit. (Brown et al., 2018). Farm forestry refers to the cultivation of trees on farmlands for commercial purposes such as timber production or for a variety of non-commercial purposes (provision of ecosystem services e.g., groundwater control, prevention of soil erosion, prevention of polluting nutrients in the soil (Brown et al., 2018). Some of the

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positive outcomes of farm forestry are production of quality timber products, increase in farm incomes, employment and enhanced environmental benefits and community development. Given their multi-functionality, tree growing play a role in achieving several SDGs including SDG 1 on poverty reduction and SDG 7 on accessing sustainable energy for all (United Nations, 2015).

Farmers own the majority of forest resources in developed countries. For example, 42% of private forests in Germany are owned by farmers with less than 5 hectares of land, while smaller individuals and communities own 64% of forestland in Japan. Finland has the most developed private forests in the world, with small holders owning 60% of the forestland under the umbrella of a forest owners' association, whereas farm forestry accounts for 1.2% of the total area of land in South Africa (FAO, 1997).

The forest cover in Kenya is estimated to be 7.4 percent of total land area (Adger et al., 2003; MEWNR, 2013) which is insufficient in meeting the rapidly growing demand for wood and non-wood forest products (MEWNR, 2013). The wood deficit is estimated at 10.5 million cubic meters, and is likely to further increase the cost of fuel wood which has already hit Kenya’s households and industries. Population and economic growth is exerting more pressure on the forests resources and by the year 2030, the wood deficit is estimated to be at 66 million m^3. Commercial forestry has the potential to bridge the country's wood deficit while also improving food security (MEWNR, 2013). With limited public land, farmers are expected to grow trees through farm forestry. The country’s Forest Act, 2016 encourages private plantations to contribute to meeting the vision 2030 of 10% tree cover. The Act provides an inactive to encourage tree growing as it exempts part or all land rate charges and payments and other tax deductions to land owners practicing forest conservation activities. Kenya agroforestry with multiple design is adopted in small farms (De Giusti et al., 2019).

Farm forestry is a dynamic, ecologically based natural resource management system that integrates trees in agricultural landscapes to produce diversified and sustainable wood and non-wood forest products for farmers' well-being. It incorporates commercial tree growing in the farming systems and takes many forms including timber belts, plantations, and woodlots. Though, there is an increased awareness on the potential of farm forestry in meeting wood and non-wood forest products need in the country, there is inadequate information on determinants that drives farmers to engage in tree growing for commercial purposes. It has been found that output prices, tenure, information, credit, technology, government policies, and labor availability affect smallholder commercial tree cultivation (Godoy, 1992). Improved extension services and a market for existing planted timber resources are critical to facilitating the ongoing adoption and maintenance of small-scale plantation agroforestry systems (Versteeg et al., 2017).

Similarly, Dessie et al. (2019) discovered the determinants of the production and commercial values of Eucalyptus woodlot products in the Wogera District of Northern Ethiopia, indicating that providing capacity-building training to strengthen producer credit is critical

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to maintaining viable Eucalyptus Woodlot production. Determinants for commercial tree growing are local specific and essential to understand the factors that influence commercial tree growing by small scale farmers so as to design appropriate interventions.

MATERIALS AND METHODS

Study Area

The research was carried out in Nandi County, Nandi North Sub- County. It is situated about 500km west of Nairobi city at 0° 10' 0.00" N and 35° 08' 60.00" E (Figure 1). The County covers an area of 2,884.2 Km^2 of largely arable lands with a population of 885,711 and a density of 310 people per Km^2 (KNBS, 2019). The altitude of Nandi County ranges from 1,300m to 2,500m and is a source of major rivers. It experiences temperatures ranging from 15°C to 26°C and rainfall of between 1,200mm to 2,000mm per year. The County is notable for the scenic Nandi Hills and has rich agricultural area suitable for tea and tree growing (Nandi County, 2018). Forests, woodlots, wetlands, rivers, open grasslands with vegetation, the Nandi escarpment, valleys and hills, tea plantations, and the Kapsabet plateau are the major land types in Nandi (Nandi County, 2018). A larger proportion of the county's population makes a living from land-based activities (Nandi County, 2018). Large scale farming especially of tea farms, small and medium scale farmers own approximately between 2 and 50 acres, mostly used for subsistence and commercial agriculture and there is a growing land fragmentation of agricultural land due to urban expansion (Nandi County, 2018).

Figure 1: Location of the study area

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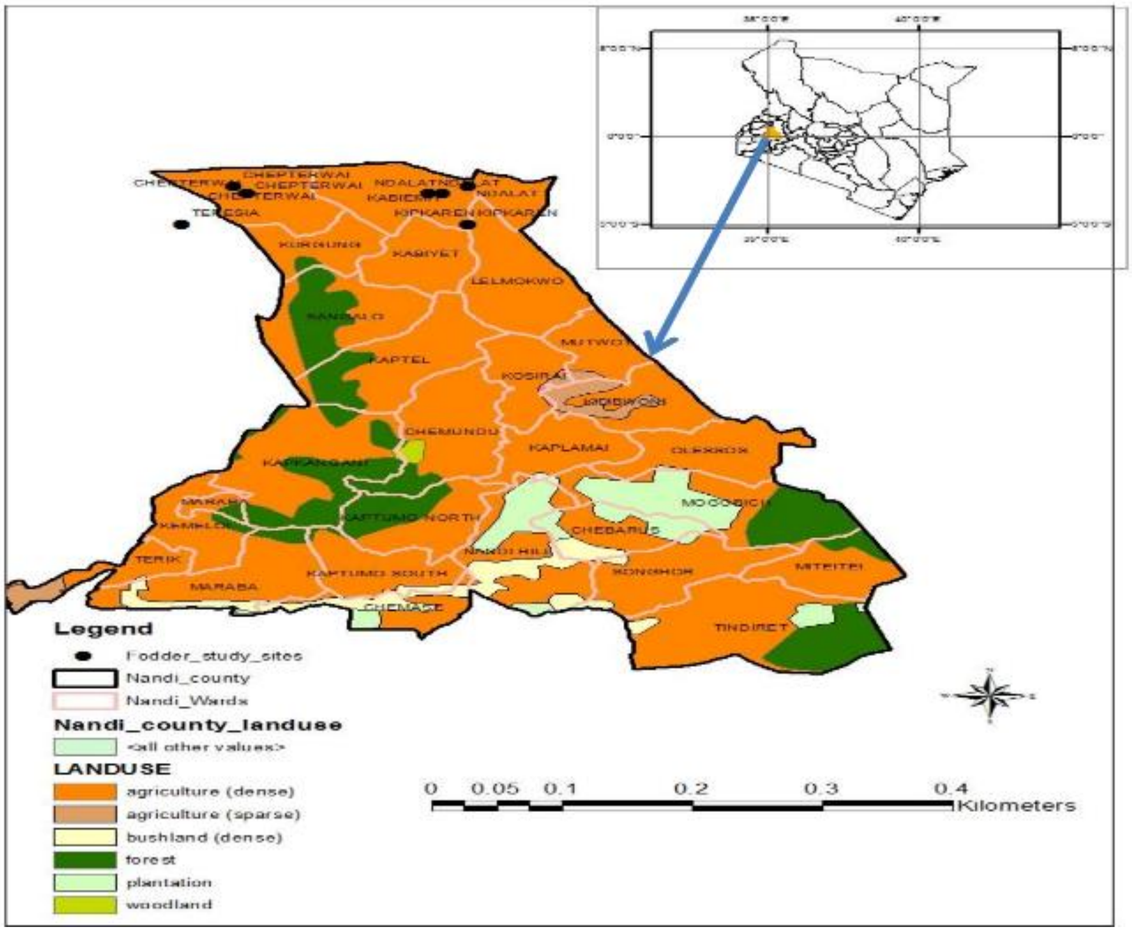

Sampling Design

Four locations with high prevalence of agroforestry were purposely selected and 218 households were systematically sampled from 3,633 farming households. The 218 sampled households were proportionately allocated to the four locations based on location's household population (*Table 1*). Social-demographic data, land use, trees grown on-farm, estimated number of trees planted, preferred niche and reason for planting were collected from the respondents using semi structured questionnaires (Kothari, 2004).

Table 1: Distribution of samples

Location	Households	Sampled
Kapsisywa	699	32
Kaptel	1459	60
Kebulonik	905	72
Sangalo	570	54
Total	3,633	218

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Description of The Variables

Each sampled household provided the following information: gender of household head (male/female), household size, age, household income, education level, size of household land, completed education years, distance to the edge of the forest, distance to the main road from the homestead, and total number of trees planted by the households (*Table 2*).

Table 2: Dependent and Explanatory variables, description of small holder farmers

Symbol	Variable	Variable description
Adoption	Adoption of commercial tree planting	1=farmers growing trees for commercial purposes 2=Non-commercial tree growers
Gender	The gender of the respondent	1=Male 2=Female
Age	Age of the respondent	The complete years of a farmers
Edu	Education Level of the farmers	1=Primary 2=Secondary 3=Tertiary/college 4=University 5=None
Eduyrs	Education years	The number of completed education years
Land	Land size of the Farmers	1=0-10 acres small scale farmers 2= >10 acres large scale farmers
HHSize	Household size	Number of the household members
Income	Total income of a household	The total income from all household activities in KES
Distance Home	Distance to the main road from the homestead	The distance in Kilometres (Km) from the homestead to the main road
Distance Forest	Distance to the edge of the forest	The total distance in Kilometres (Km) from the homestead to the forest edge

Modelling

Logistic regression model was chosen to predict the likelihood of a farmer planting trees for commercial purposes. A mathematical model of a set of explanatory variables is used in logistic regression to predict a logit transformation of the dependent variable (adoption of commercial forestry or non-commercial forestry). The model was used to fit the relationship between the determinants of commercial tree growing variables using the logit model below:

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$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_{4i} X_{4i} + \beta_{5i} X_{5i} + \cdots + \beta_{mi} X_{mi}$$

Where *pi* is the probability of adoption of commercial tree growing among the small holder farmers, where the farmers with income from tree farming were characterized as commercial tree growers while those without income are characterized as non-commercial tree growers. The logit given as odds,

$Odds = \frac{P_i}{1-P_i}$, and the logit given as: $Logit\ (P_i) = \left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_{4i} X_{4i} + \beta_{5i} X_{5i} + \cdots + \beta_{mi} X_{mi}$

The probability that an individual will adopt commercial tree growing on their farms is given by:

$$Chance\ of\ adopting\ commecial\ tree\ growing = \left(\frac{1}{1-e^{-Logit(P_i)}}\right)$$

Data Collection and Analysis

Data collected were verified for accuracy and consistency before analysis. All identified outliers in the data sets were excluded during data analysis after qualitative data was categorized, cleaned, coded, and subjected to a normality test (Histogram) (Chan., 2003) and SPSS (V21) software was used to summarize quantitative data.

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics Of Commercial Tree Growers

Table 3 below describes the determinants influencing commercial tree growing, outlining the mean socio-economic factors that affects commercial tree farming.

Standard deviation, test statistics, degrees of freedom and the p-values. The majority of the respondents were male (*N* = 140; 64.2%). The farmers had a mean age of 43.9±0.9 (*SD* = 14.2) years and an average education year of 9.9±0.2 (*SD* = 3.33). The respondents who had attained primary education were 48.6% (*n* = 106) and those with post primary education were 46.8% (*n* = 102) while those without any formal education were 4.6% (*n* = 10). The average land size per household was 3.9±0.2 (*SD* = 3.5) acres with the majority households owning less than 10 acres (*n* = 174, 80.7%). Majority of the respondents had an average annual incomes of KES 176,771.9±57.4 (*SD* = 209724.8).

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Table 3: Demography and Socio-Economic Conditions of commercial and non-commercial tree growers in North Nandi, Kenya

Variables		Non-Commercial farmers		Commercial farmers		Total		(χ^2)	df	P-value
		Mean	SD	Mean	SD	Mean	SD			
Age of respondent (Years)		43.2±1.8	14.7	44.1±1.1	14.8	43.9±0.9	14.2	7.87*	58	.026
Education (Years)		9.5±0.4	3.5	10.1±0.3	3.2	9.9±0.2	3.3	0.51**	2	.004
Number of trees planted (No)		133.3±30.3	240.4	263.2±30.5	368.7	223.9±23.5	339.92	5.39**	2	.001
Household size (No)		5.7±0.2	2.1	5.9±0.2	2.4	5.8±0.2	2.3	0.47	2	.918
HH Land size in acres (Ha)		1.37±0.12	1.13	1.70±0.12	1.58	1.58±0.08	1.42	55.83*	71	.906
Total Income (Ksh)		157,966.3±77.4	194,784.1	184,403.2±92.7	18362.1	176,771.9±57.4	209724.8	4.15*	2	.025
Distance to main road (Km)		4.9±0.5	25.1	2.8±0.3	3.7	3.4±0.9	13.9	0.18**	2	.006
Distance to nearest forest (Km)		1.5±0.2	1.3	1.7±0.1	1.3	1.7±0.1	1.3	0.73**	2	.008
Gender (%)	Male	61.8		65.9		64.2		0.03	1	.031
	Female	38.2		34.1		35.8				
Highest education level (%)	Primary	46.1		50.4		48.6		2.97*	3	.026
	Secondary	28.1		28.7		28.4				
	Colleges	16.9		14.0		15.1				
	University	3.4		3.1		3.2				
	None	5.6		3.9		4.6				
Land categories (%)	0-10acres	89.2		77.1		80.7		4.29**	1	.004
	> 10 acres	10.8		22.9		19.3				
Training on tree planting	Yes	15.4		11.8		12.8		0.089	1	.765
	No	84.6		88.2		87.2				

Number of observations $N = 218$, χ^2=Chi-square Test statistics, * = significant at 5%; **=significant at 1%

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Commercial and Commercial Tree Species Planted

The main tree species grown by the small-scale farmers for commercial purposes were *Cypress species* (*n* = 153, 70.2%), *Eucalyptus species* (*n* = 152, 69.7%), *Grevillea robusta* (*n* = 65, 29.8%) while for non-commercial purposes were *Psidium guajava* (*n* = 27, 12.4%) and *Croton megalocarpus* (*n* = 89, 40.8%) among others as presented in Table 4. The result indicted that farmers preferred to plant Cyprus and Eucalypts for production of timber and power transmission poles. The least preferred tree species was *Erybotrya japonica* and this is due to their low commercial gains. This finding is consistent with that of Sikuku (2014) who also found that majority of the farmers preferred planting commercial tree species with 60-75% (*Eucalyptus saligna*), 67-75% (*Cupressus lusitanica*) and 30-40% (*Grevillea robusta*). Furthermore, the majority of farmers prioritized planting exotic tree species over indigenous tree species. This is indicative of market availability and profitability of commercial tree species products and this acts as a good incentive for commercial forestry. The adoption of these exotic commercial tree species by majority of the farmers can be associated with the availability and low cost of purchasing their seedlings. Among the non-commercial tree species, *Croton megalocarpus* was the most preferred as it provides firewood of high calorific value for the farmers. *Calistemon* species and *Acacia* species were the least preferred non-commercial tree species as only 6.4% of the interviewed farmers had adopted these species as shown in Table 4. This low adoption of these species could be as a result of their low commercial and non-commercial uses.

Table 4: Trees species planted by farmers in North Nandi, Kenya

Species name	Common name	Reason	Number of households	Percent
Cypress species	Cypress	Commercial	153	70.2
Eucalyptus species	Blue gum	Commercial	152	69.7
Grevillea robusta	Grevillea	Commercial	65	29.8
Persea americana	Avocado	Commercial	84	38.5
Erybotrya japonica	*Loquat*	Commercial	9	4.1
Psidium guajava	Guava	Non- Commercial	27	12.4
Callistemon species	Bottlebrush	Non-commercial	14	6.4
Croton megalocarpus	*Croton*	Non-commercial	89	40.8
Acacia species	Acacia	Non-commercial	14	6.4
Casimiroa edulis	White sapote	Non-commercial	16	7.4

Source: Survey Data

Reason for Tree Growing er Preferred Niche

The majority of households grow trees for various purposes using various agroforestry technology practices, with the majority growing trees for commercial purposes using woodlots (99.1%), scattered trees on farm

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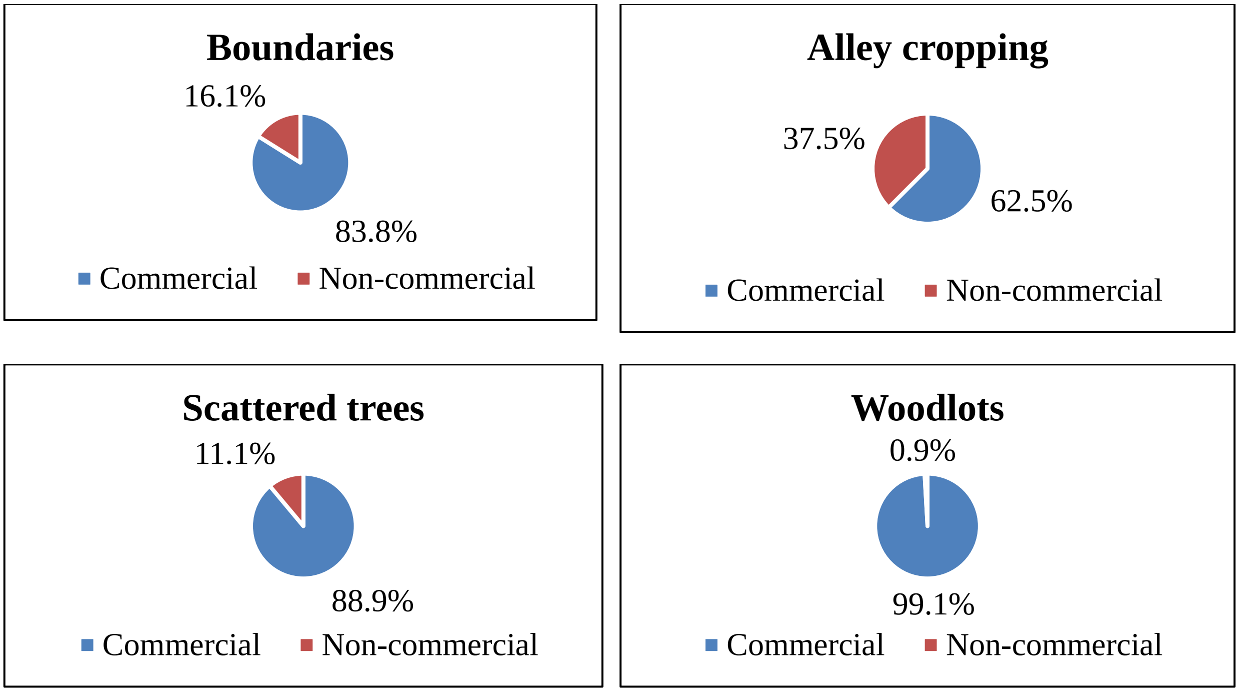
(88.9%), boundary plantings (83.8%), and alley cropping (62.5 %).

Figure 2: Planting niches and specific reasons



Preferred Niche for Commercial and Non-Commercial Purposes

The majority of small-scale farmers preferred to plant Cypress tree species along their farm's boundary (72.5 %), *Eucalyptus species* along the boundary (46.2%) and woodlots (43.9%), *Grevillea robusta* along the boundary planting (56.2%), *Avocado* for fruit production (51.9%),

Acacia species as scattered trees on farm (71.4%), *Croton megalocarpus* scattered (77.5%) within the farm and *Bottle brush* species along the boundary (50%) and also scattered (35.7%) as indicated in Table 5 below.

Determinants of Commercial Tree Growing among Small Holder Farmers

The logistic regression was used to predict the probability that a farmer either is a commercial tree grower or a non-commercial tree grower based on the independent variables that determines tree growing among small holder farmers within Nandi County, Kenya. *Table 6* outlines the various determinants of commercial tree growing by small scale farmers.

Table 5: Preferred three species per niche

Preferred niche for tree growing	Proportion of small scale farmers preferred niche for growing tree for commercial and non-commercial purposes (%, N)						
	Cypress spp.	Eucalyptus species	*Grevillea robusta*	*Persea americana*	*Acacia spp.*	*Croton megalocarpus*	*Callistemon spp.*
Boundaries	72.5(111)	46.2(80)	56.3(36)	14.8(12)	21.4(30)	21.3(19)	50.0(7)
Woodlot	20.9(32)	43.9(76)	4.7(3)	0.0(0)	7.1(1)	0.0(0)	0.0(0)
Scattered	5.9(9)	7.5(13)	21.9(14)	32.1(16)	71.4(10)	77.5(69)	35.7(5)
Alley cropping	0.7(1)	2.3(4)	14.1(9)	1.2(1)	0.0(0)	1.1(1)	14.3(2)

Source: Survey data

Table 6: Variables used in the Final determinant of commercial tree growing equation

Variables	β	S.E.	df	Sig.	Exp (β)	95% C.I. for EXP(β)	
						Lower	Upper
Number of trees planted	0.020	0.001	1	.027*	1.020	1.019	1.021
Household size	0.014	0.007	1	.854	1.014	1.007	1.021
Distance of homestead to the road	0.011	0.005	1	.442	1.011	1.006	1.016
Distance to forest edge	-0.202	0.036	1	.138	0.817	0.788	0.847
Age of the Household head	0.401	0.014	1	.019*	1.493	1.473	1.514
Income of the Household head	1.892	0.052	1	.021*	6.633	6.297	6.987
Gender of Respondent (Male)	-0.258	0.054	1	.467	0.773	0.732	0.815
Land Categories			2	.012*			
Land Category(0-5acres)	-0.612	0.046	1	.018*	0.542	0.517	0.568
Land Category (5-10acres)	0.303	0.015	1	.050	1.355	1.334	1.374
Education level			4	.014*			
Education (Primary)	0.486	0.086	1	.029*	1.626	1.462	1.772
Education (Secondary)	0.496	0.049	1	.016*	1.642	1.564	1.725
Education (Tertiary/ college)	0.634	0.132	1	.045*	1.895	1.660	2.162
Education (University)	1.150	0.506	1	.044*	3.158	1.904	5.238
Constant	1.346	1.725	1	.435	3.843		

*Dependent Variable: Adoption;** = significant at 5%; Logistic regression values: Number of observation = 218, Cox & Snell R Square=0.301, Nagelkerke's R Square=0.316, -2 Log likelihood=219.810*

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Age of Respondents

According to the results(**β**=0.401, $p=0.019<0.05$), age has an influence on adoption of commercial tree growing. The **β** coefficients for respondents' age are positive and significant, inferring that age is associated with increased probability of commercial tree planting adoption. The age of respondent $OR=exp^{(0.401)}=1.493$ (1.473, 1.514 CI at 95%), hence 1.49 times more likely to do commercial tree growing. This result is in conformity with other studies which have found that age has a positive influence on tree growing (Lwayo & Maritim, 2003; Dessie et al., 2019). According to studies (Khalwale et al., 2019; Amani et al., 2011), older farmers are more likely to partake in on-farm tree planting because their prospects to be hired or engrossed in other livelihood opportunities are more constrained than those of younger people who have more employment options. This finding can be supported by the argument that young people have many outlays demand as compared to the older people thus, the young people tend to grow high yielding and short rotation crops. On the other hand, older people practice commercial tree growing as a form of security for high future expenditure demands. Additionally, the positive correlation between age and tree growing can be concluded that the older farmers have more experience and skills on how best to make informed decisions for their farms and thus can practice a visible profitable commercial forestry on their farms. Contrary to these results, Jara-Rojas et al. (2020) found that age had negative and significantly affect decision on adoption and intensity of tree growing by farmers.

Level of Education

The results showed that education level ($p=0.014<0.05$) have a positive correlation with commercial tree growing adoption, indicating that an increase in education level is associated with higher probability of commercial tree growing adoption. Considering education level, the respondent with primary education level had $OR=exp^{(0.486)}=1.626$, secondary level $OR=exp^{(0.496)}=1.642$, Tertiary or college $OR=exp^{(0.634)}=1.895$, and University level $OR=exp^{(1.150)}=3.158$ times more likely to practice commercial tree planting. Farmers' level of formal education is the most significant explanatory variable of respondents' differential innovativeness, as expected. This is logical and consistent with adoption theory and previous literature, as educated farmers typically have greater access to information sources, can comprehend and benefit more from extension messages, and are generally more aware of environmental problems (Haggblade et al., 2005). Educated farmers can capitalize on opportunities because they are more motivated and adaptable. Additionally, they are able to adapt to changes and greatly benefits from trainings and work experience and are able to solve problems with great precision. Also, the educated farmers have a wider range for income opportunities and thus they are able to place more units of lands under trees in their farms (Haglund et al., 2011). Furthermore, the results of this study are also in agreement with findings by Meijer et al. (2015) who discovered that farmers with higher levels of technical knowledge, such as fertilizer application, pesticide use, and improved planting materials, are more likely to practice and benefit from agroforestry tree than farmers with no formal education. The literacy level of

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farmers also determines the adoption of improved technology and directly affects their capacity to absorb new ideas (Kinyili et al., 2020). In contrary, the study by Trinh and Ranola (2010) in Vietman indicated that education level is not important factor on farm tree growing by farmers. Despite the fact that upland farmers were more educated, both upland and minority farmers had the same level of tree adoption on their farms, according to the study. The minority groups tended to adopt more trees as they were strict rules governing the benefits of tree growing and they hugely depend on trees and forests as a source of their livelihoods.

Land Size

In his research, Kinyanjui (2005) noted that in Kenya, land is one of the most essential natural resources. The size of a farmer's land is thought to influence the type and quantity of trees that can be planted in a given unit of area. As the land size remains the same, a vast of the farmers still prefer to practice agriculture over tree growing for food production. These farmers reserve much of their lands for dairy farming and subsistence food crop farming. The results indicated that land size was statistically significant ($p=0.012<0.05$). The land category of 0 to 10 acres $OR=exp^{(-0.612)}=0.542$ showed a negative and significance decrease in commercial tree planting while land category between >10 acres $OR=exp^{(0.303)}=1.355$ was positive and significant. This indicates that the size of the land influences the adoption of commercial tree growing. The results demonstrated that smallholder farmers with small pieces of land had fewer commercial trees and fruit trees on their farms. These findings are consistent with the findings by Ashraf et al. (2015); Danquah (2015); Derbe et al. (2018) who found that land size has a positive influence on tree growing by farmers. This is however in conflict with the findings by Owooh (2013) who found out that farmers adopt agroforestry practices to mitigate challenges of land use in small farms. Despite having small land sizes, majority of the farmers are willing to practice farm forestry and this can be attributed to the realization of the importance of farm forestry in improving their livelihoods. Previous studies by Ogweno (2001) in Uasin-Gishu had indicated that farmers whom were receiving support services for tree growing tend to voluntarily grow more trees in their farms. In this study, only 14.7% of the farmers indicated that they had received training for both commercial and non-commercial tree growing.

Income

The off-farm income of the farmers was significant and has positive correlation with growing of commercial trees among farmers ($\boldsymbol{\beta}=1.892$, $p=0.021<0.05$). The income of respondents $OR=exp^{(1.892)}=6.633$ (6.297-6.987 CI at 95%), farmers with income are 6.6 times more likely to do commercial tree planting. It has been discovered that wealthier farmers are more likely to participate in commercial tree planting as they're more capable of taking uncertainties (Amacher et al., 1993). Furthermore, depending on the species and plantation objectives, trees require a long time to grow, making it a lengthy investment with minimal to no intermediate returns. Price fluctuations, job insecurity, and natural catastrophes all have relatively long-time horizons (Anglesen, 2007). This long gestation period, combined with high risks, doesn't really benefit poor farmers, who depend exclusively

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on their limited farm resources for day-to-day survival (Dewees & Saxena., 1997). However, the changing demand and supply conditions for major farm forestry products is likely to improve profitability and make commercial planting of trees more financially appealing (Cheboiwo et al., 2018). Similar views have been expressed in other research studies that have demonstrated the positive impacts of monetary earnings on farmers' commercial tree growing. On-farm earnings from crop cultivation is also significant in farmers' adoption of commercial forestry. Farmers would ultimately increase the management of a high-income generating crop as compared to other farm activities. As land sizes continue to decrease, trees and agricultural cropland continues to compete for the limited resources such as nutrients, water, and sunlight on the farms.

Commercial Tree Planting Model

The factors that determine planting trees on farms, were first subjected to bivariate analysis to determine the significant variables ($p<0.05$). The number of trees planted, farmer age, household income, land size, and farmer education level were identified to be significant and were thereafter modelled employing multiple logistic regression. The model coefficient of determination (R^2 value) was 0.301, which indicates that 30.1% variation fits the model for commercial tree growing on-farm among the small holder farmers. The estimated model was used to predict the likelihood of commercial tree planting adoption, as expressed below:

$$Logit(Pi) = \ln\left(\frac{P_i}{1-P_i}\right) = 1.346 + 0.02\ Trees\ planted + 0.401\ Age + 1.892\ HH\ income - 0.612\ Land\ Size\ (0 - 5acres) + 0.303\ land\ Size\ (5 - 10acres) + 0.486\ Education\ (Primary) + 0.496\ Education\ (Secondary) + 0.634\ Education\ (Tertiary\ or\ College) + 1.15\ Education\ (University) + Error$$

CONCLUSION

According to the study, socioeconomic factors such as age, education level, and income have a strong influence on commercial tree planting among small-holder farmers in Nandi County. These factors influence whether the farmer will practice commercial tree growing or for domestic use. The vast majority of farmers in the study area planted trees for commercial purposes as a result of the ready market in nearby Eldoret and Kisumu. Most of them were targeting electricity poles, supply of timber, poles and small diameter poles for the construction work within these towns. The government ban on harvesting of trees from public forests has had an effect on the supply of tree products and this resulted in increased demand of the tree products from farms and large-scale private farms. With the increase in the demand of the products, the farmers were able to get good returns for their efforts. However, it was observed that there is need to improve the farmer’s knowledge in species site matching as they were planting Eucalyptus species even in riparian areas. This will act as a motivation for farmers to plant more trees thus contributing in the increment of the county’s tree cover. This will ultimately increase the global tree cover thus reducing amount of carbon (iv) oxide in the atmosphere thus keeping the global temperature increment below 2ºC as per the recommendations of the Paris agreement.

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REFERENCES

Adger, W. N., Huq, S., Brown, K., Conway, D. & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in development studies*, *3*(3), 179-195.

Amacher, G. S., Hyde, W. F. & Joshee, B. R. (1993). Joint production and consumption in traditional households: fuelwood and crop residues in two districts in Nepal. *The Journal of Development Studies*, *30*(1), 206-225.

Amani, A., Mohamad, M. & Oraib, N. (2011). Factors affecting farmers decision to Continue farm activity in marginal areas of Jordan. *African journal of agricultural research*, *6*(12), 2755-2760.

United Nations and Department of Economic and Social Affairs, Population Division. (2017). *World population prospects: the 2017 revision, key findings and advance tables*. Working Paper No. ESA/P/WP/248 ed.

Angelsen, A. (2007). Forest cover change in space and Time: combining the von Thünen and forest *transition theories* (Vol. 4117). World Bank Publications.

Ashraf, J., Pandey, R., de Jong, W. & Nagar, B. (2015). Factors influencing farmers' decisions to plant trees on their farms in Uttar Pradesh, India. *Small-scale forestry*, *14*(3), 301-313.

Brown, S. E., Miller, D. C., Ordonez, P. J. & Baylis, K., 2018. Evidence for the impacts of agroforestry on agricultural productivity, ecosystem services, and human well-being in high-income countries: a systematic map protocol. *Environmental evidence*, *7*(1), 1-16.

Chan, Y.H. (2003). Biostatistics 102: quantitative Data- parametric & non-parametric tests. *Blood Press*, *140*(24.08), 79.

Cheboiwo, J. K., Mutta, D., Kiprop, J. & Gattama, S. (2018). Public private partnerships Opportunities for forestry sector development in Kenya: Synthesis of primary and secondary production actors, and trade. *Journal of Environment and Earth Science*, *8*(1), 47-69.

Danquah, J. A. (2015). Analysis of factors influencing farmers' voluntary participation in Reforestation programme in Ghana. *Forests, Trees and Livelihoods*, *24*(3), pp.176-189.

De Giusti, G., Kristjanson, P., & Rufino, M. C. (2019). Agroforestry as a climate change Mitigation practice in smallholder farming: evidence from Kenya. *Climatic Change*, *153*(3), 379-394.

Article DOI: https://doi.org/10.37284/eajfa.5.1.904

Derbe, T. (2018). Factors Influencing Smallholder Farmers Adoption of Eucalyptus Woodlot in Wogera District, North Gondar Zone, Amhara Regional State of Ethiopia.

Dessie, A. B., Abtew, A. A., & Koye, A. D. (2019). Determinants of the production and Commercial values of Eucalyptus woodlot products in Wogera District, Northern Ethiopia. *Environmental Systems Research*, *8*(1), 1-10.

Dewees, P. A. & Saxena, N. C. (1997). Wood product markets as incentives for farmer tree growing. Farms, Trees and Farmers, Tree Management in Farmer Strategies: Responses to, 10, pp.198-241.

FAO. (1997). Global Forest Resources Assessment 1997. Rome: FAO

FAO. (2010). Global Forest Resources Assessment 2010. Rome: FAO

FAO. (2016). Global Forest Resources Assessment 2016, Rome: FAO

Godoy, R. A. (1992). Determinants of smallholder Commercial tree cultivation. *World Development*, *20*(5), 713-725.

Haggblade, S., Hazell, P., & Reardon, T. (2005). The rural nonfarm economy: Pathway out of Poverty or pathway in the future of small.

Haglund, E., Ndjeunga, J., Snook, L., & Pasternak, D. (2011). Dry land tree management for Improved household livelihoods: farmer managed natural regeneration in Niger. *Journal of environmental management*, *92*(7), 1696-1705.

Jara-Rojas, R., Russy, S., Roco, L., Fleming-Muñoz, D., & Engler, A. (2020). Factors affecting the adoption of agroforestry practices: insights from silvopastoral systems of Colombia. *Forests*, *11*(6), 648.

Khalwale, T., Langat, D., Abuom, P., & Okoth, S. (2018). Factors influencing adoption of on-farm tree planting in Shinyalu Sub-County, Kakamega, Kenya.

Kinyanjui, M. J. (2005). Gender barrier to land Conservation in Kuresoi Location, Kericho District. *J, Hum, Ecol*, *8*, 41-50.

Kinyili, B. M., Ndunda, E., & Kitur, E. (2020). Influence Of Agroforestry on Rural Income and Livelihood of smallholder Farmers in the Semi-Arid Region of Sub-Saharan Africa. *Journal of tropical forestry and environment*, *10*(1).

KNBS. (2004). Kenya National Population Census 2019 Report. Nairobi, Kenya: KNBS.

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Langat, D. K., Maranga, E. K., Aboud, A. A., & Cheboiwo, J. K. (2016). Role of forest resources to local livelihoods: The case of East Mau forest ecosystem, Kenya. *International Journal of Forestry Research*, *2016*

Lwayo, M. K. & Maritim, H. K. (2003). Socio-Economic factors affecting farmers' decisions to adopt farm forestry: An

Article DOI: https://doi.org/10.37284/eajfa.5.1.904

application of Multivariate Logistic Analysis in Busia district, Kenya. In *XII world forestry congress, Quebec City, Canada*.

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., & Nieuwenhuis, M. (2015). The role of Knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. *International journal of agricultural sustainability*, *13*(1), 40-54.

Ministry of Environment, Water and Natural Resources (MEWNR). (2013). Analysis of demand and supply of wood products in Kenya.

Nandi County. (2018). County Integrated Development Plan 2018-2023. Nairobi: County Government of Nandi, GOK.

Oeba, V. O., Otor, S. C., Kung'u, J. B. & Muchiri, M. N. (2012). Modelling determinants of tree planting and retention on farm for improvement of forest cover in central Kenya. *International Scholarly Research Notices*.

Ogweno, D. O., Imo, M., Matano, A., & Orinda, B. (2001). Evaluation of the management and Sustainability of private tree nurseries in Kipkaren River catchment, Kenya. In *1st National Scientific Conference, Lake Victoria Environmental Management Project, Kisumu, Kenya*.

Owooh, B. K. (2013). *Assessment of the Adoption of Agroforestry Technologies by Limited-Resources Farmers in North Carolina* (Doctoral dissertation, North Carolina Agricultural and Technical State University).

Sikuku, F. O., Apudo, M. G., & Ototo, G. O. (2014). Factors influencing development of farm forestry in Lugari district, Kakamega county, western Kenya. *Journal of Agriculture and Veterinary Science*, *7*, 6-13.

Trinh, Q. T. & Ranola Jr, R. F. (2010). Decision Making by upland farmers on forest management in the northwest mountainous region of Vietnam. *Journal of ISSAAS (International Society for Southeast Asian Agricultural Sciences)*, *16*(1), 68-82.

United Nations. (2015). *United Nations Statistics Division Development Data and Outreach.* New York: UN.

United Nations and Department of Economic and Social Affairs, Population Division (2017). World population prospects: the 2017 revision, key findings and advance tables. *Working Paper No. ESA/P/WP/248 ed*.

Versteeg, S., Hansen, C. P., & Pouliot, M. (2017). Factors influencing smallholder commercial Tree planting in Isabel Province, the Solomon Islands. *Agroforestry Systems*, *91*(2), 375-392.

World Bank Group. (2016). *Forests and Terrestial Ecosystems (Landscapes).* Washington, D.C., United States: World Bank Group