ESJ Natural/Life/Medical Sciences

Determinants of Tree Growing and Cover Retention in Arid and Semi-Arid Areas of East Africa: The Case of Machakos County, Kenya

Heeran M. Mutuku
Harun M. Kiruki
Department of Environmental Science and Land Resources Management,
School of Agriculture, Environment, Water and Natural Resources,
South Eastern Kenya University, Kitui, Kenya

Doi:10.19044/esj.2023.v19n18p212

Submitted: 13 October 2022
Accepted: 23 June 2023
Published: 30 June 2023

Cite As:
Mutuku H.M. & Kiruki H.M. (2023). *Determinants of Tree Growing and Cover Retention in Arid and Semi-Arid Areas of East Africa: The Case of Machakos County, Kenya*. European Scientific Journal, ESJ, 19 (18), 212. https://doi.org/10.19044/esj.2023.v19n18p212

Abstract

Rapid human population growth, increased demand for land, over-exploitation and the degradation of local natural resources have led to serious socio-economic and environmental challenges in Machakos County, Kenya, East Africa. This has led to a drastic reduction in tree cover in arid and semi-arid areas over the years. To reverse this trend, it is important to understand the socio-economic factors that determine household tree growth and cover retention in Machakos County. Based on a structured questionnaire targeting 412 respondents (233 men and 179 women) as well as 2 focus group discussions and 14 key informants, we assessed the determinants of tree growing and cover retention among small scale farmer households using a logistic regression model. The study found that socioeconomic variables that significantly influenced tree growing and cover retention in Machakos County in Kenya included gender (p= 0.011), household size (p=0.030), Farm size (p= 0.005), and title deed ownership (p=0.023). The respondents used tree products to enhance their socio-economic resilience. In total, 58 different types of tree species were planted or retained on the farms. The major tree species included Eucalyptus saligna, Grevillea robusta, Mangifera indica, Persea americana, Croton megalocarpus, and Terminalia brownie. Based on

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

our findings we recommend more involvement of women and youth in tree-growing activities in the Matungulu Sub-county.

Keywords: Degradation, natural resources, livelihoods, tree cover, climate change

1. Introduction

Trees play a critical role from both an environmental and socio-economic perspective. Sufficient trees on farms can enhance socio-economic and environmental resilience and mitigate climate change (Insaidoo *et al*., 2014). Trees on a farm and their goods and services are barely captured in conventional national accounting systems in many countries (Zomer *et al*., 2016). Although tree cover has been declining generally in the world, it has been necessary for human survival since the creation of humankind (Zomer *et al*., 2016). According to Wunder *et al*. (2014), the majority of rural communities across the developing world still derive their livelihoods from trees. These wood and non-wood benefits from trees, mainly from public forests, accrue to vulnerable community members. Adopting and establishing trees at the farm level would reduce pressure on public forests and reduce the rates of deforestation (Siraj *et al*., 2018).

A global study found subsistence crop farming and tree growing, indeed, are complementary economic activities for rural communities (Angelsen *et al*., 2014). In Sri Lanka, income from trees has been used to strengthen household income and subsistence (Ekanayake *et al*., 2018). A study in rural Pakistan found gender, household size, age, and literacy level of the household head to be strong determinants of tree growth. In addition, the households with trees were found to have higher incomes, lower poverty levels, and consume more tree-based products (Ali & Rahut, 2018). In rural Sub-Saharan Africa, the youth form the greater majority of the population, and their tree-growing activities are not well documented, although communities generally have diversified livelihood sources to enhance their chances of survival in lean times (Macneil *et al*., 2017).

Tree cover increases soil minerals and organic matter, improves soil moisture, and increases farm production significantly (Shiferaw *et al*., 2017). Most importantly, trees promote resilience to climate change and future uncertainties facing vulnerable communities in developing countries. (Quandt *et al*., 2018). The tree acts as a safety net for vulnerable communities and their livestock during times of famine and drought. Research in Kenya by Quandt *et al*. (2018) show that trees help to diversify rural livelihood sources besides improving the overall socio-economic status of the farmers. The immense potential for trees to provide both socio-economic and environmental benefits

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

simultaneously makes them an important vehicle for sustainable development in rural areas (De Leeuw *et al*., 2014).

To better understand what motivates communities to plant trees and retain tree cover on their farms, context-specific information that differentiates between the diverse characteristics of community groups is necessary. We have chosen Matungulu Sub-county, Machakos County in the drylands of South Eastern Kenya to evaluate the socio-economic and cultural factors that influence tree growth and cover retention practices. The area was chosen for this study due to its scanty tree cover, low farm yields, degraded ecosystems, frequent droughts, and high levels of poverty. These negative attributes are being compounded by the effects of climate change. To plant or maintain tree cover on the farm or not is a deliberate decision made by the farmer according to various circumstances. The quantity and quality of on-farm tree growing is influenced by climatic factors as well as socio-economic factors.

Within this context, the objective of the study was to understand what drives rural tree growth and cover retention. Specifically, we are looking at the socio-economic factors that determine the likelihood of tree growth and cover retention in the Matungulu Sub-county to have a nuanced view of what drives tree growth and cover retention. We hypothesize that mobile phones, gender, age, location, marital status, household size, education, occupation, farm size, title deed ownership, years of tree growing and household income are all factors that influence tree growth and cover retention.

2. Methods

2.1 The Study Area

The study was carried out in Matungulu Sub-county, Machakos County, a semi-arid region of south-eastern Kenya. The Sub-county covers an area of about 610.351 Km^2 and lies between latitudes 1.076^0 and 1.358^0S and longitudes 37.083 and 37.387^0E (Figure 1). Within the Sub-county two locations, namely; Komarock and Sengani, which are far apart and of different sizes, topography, soil types, population sizes, ethnic compositions, and vegetation types were chosen as study sites.

The area receives a mean annual rainfall is 950mm, with some areas receiving more rainfall than others due to relief (Machakos County Government, 2015). The mean annual temperature is about 22^0 C, with a maximum of 28^0 and a minimum of 12^0 C. The geology of the area consists of quartz-rich granitoid gneisses which resulted in the formation of well-drained, reddish brown, stony, and rocky sandy clay loam soils. The natural vegetation consists of dispersed mixed indigenous species such as *Terminalia brownie, Acacia nilotica, Acacia drepanalobium, Acacia xanthophloea, Acacia brevispica, Acacia elatior, Acacia melifera, Rhus natalensis, Lannea schweinfurthii, Premna chrysoclada, Dovyalis abyssinica, Dombeya kirkii,*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Combretum collinum, *Carrissa spinarum* and *Zanthoxylum chalybeum* (MENR, 2006). The main economic activity in the area is farming both large and small scale. Commonly grown crops include maize, beans, coffee, pigeon peas, and horticultural crops.

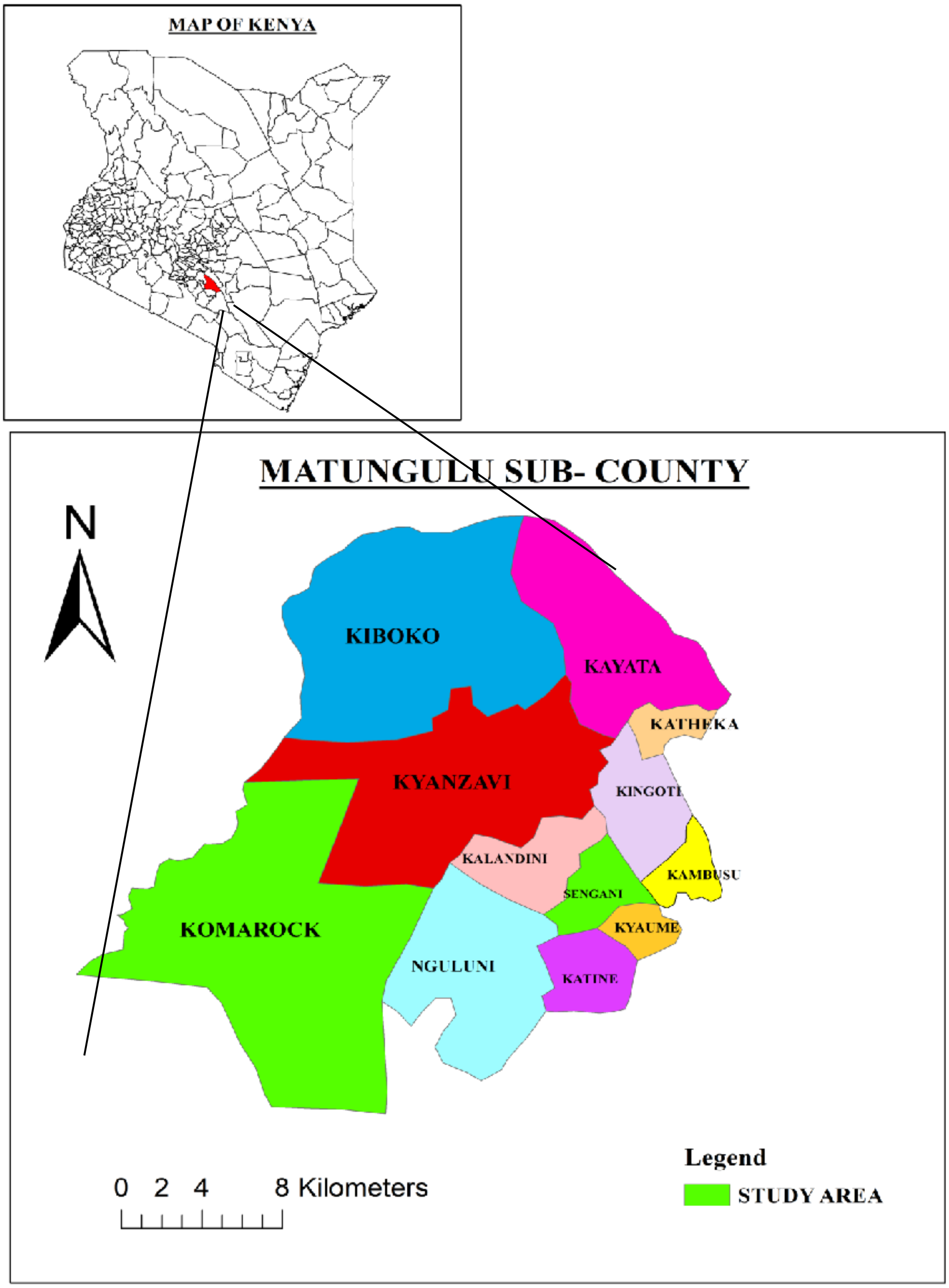

Figure 1. A map of the study area
Source: Survey of Kenya (2018)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2.2 Sampling and interview setup

Non-probability sampling, particularly purposive sampling, was used in the selection of the two administrative locations and key informants for the interview. Sample size determination was done following the method of Kothari (2004). In total 412 households were sampled from 4341 households residing in the two locations with 136 and 276 households being sampled from Koma and Sengani locations respectively. Both nonprobability and probability sampling techniques were used to allocate the households determined. Within each of the selected locations, systematic sampling was done to identify respondents per location for the interview. This was based on records of households kept at the local Chiefs' offices. The respondents were household heads who owned land and practiced some form of farming. An interpreter was used where necessary to ease the problem of the language barrier and minimize errors in data collection. At the household level interview, socio-economic data such as age, gender, and land ownership details were recorded. In addition, information on tree growing such as species preference, location, and the motivation for tree growing was also recorded. In addition, 14 key informants including the Ward Forestry Officers and their frontline extension staff in Koma and Sengani locations, the Ward and Locational Agricultural Extension Officers, Chiefs and Assistant Chiefs, women leaders, area elected representatives, heads of schools, representatives of NGOs and church organizations, as well as other community leaders were also interviewed.

Two focus group discussions (FDGs) of ten people each were carried out in each location to triangulate the information collected during the household interviews. The FGDs were useful in bridging research and practice, and in providing an insight into different opinions among different parties involved in the tree-growing practice. Secondary data was obtained from the Internet, office reports, development plans, research theses, pamphlets, and other materials found in public offices, libraries, and documentation centers. The study adopted a mixed methods research design (Mburu, 2013).

2.3 Data Analysis and Presentation

The use of both qualitative and quantitative methods ensured that the overall strength of the study is greater than using either method (Guetterman *et al*., 2015). Descriptive analysis of data was used to determine the frequency distribution and summaries of various sample characteristics. Quantitative methods were used to test for relationships between variables in the results. A logistic regression model was used to estimate the probability of tree growing by farmers using socio-economic predictors (Shrestha *et al*., 2018). The socioeconomic predictors included ownership of mobile phones, gender, age,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

location, marital status, household size, education, occupation, farm size, title deed ownership, years of tree growing, and household income. These predictors were chosen based on previous studies on tree growing and cover retention in rural areas of Sub-Saharan Africa. Tree growing cover retention was the dependent variable while all the other parameters were explanatory variables to the logistic model. The Hosmer & Lemeshow test of the goodness of fit was used to test the goodness fit of the model while *Nagelkerke's* R^2 was used to estimate for models' categorical response variables (Hadi, 2018). The Wald test was used to test the statistical significance of each of the independent variables. The data were analyzed using the Statistical Package for the Social Sciences (SPSS) computer software. Table 1 below shows the predictors and type of data collected.'

Table 1. Measurement scale and type of data used in the regression model

Parameters	**Variable type**	**Description**	**Measurement**
Mobile phone ownership (X_1)	Dummy	Farmer owns a mobile phone	0=Does not own phone, 1= Owns phone
Gender (X_2)	Dummy	Gender of head	0=Female, 1=Male
Age (X_3)	Categorical	Age in years of head	
Location (X_4)	Dummy	Location of farmer	-0=Sengani, 1=Koma
Marital status (X_5)	Categorical	Marital status of head	1=Married, 2= Single, 3= Widowed, 4= Divorced,5= Separated
Household size (X_6)	Numeric	Number of members in a house hold	
Education (X_8)	Categorical	Highest education of the head	1=None, 2= Primary, 3=Secondary, 4= College, 5=University
Occupation (X_9)	Categorical	Occupation of household head	1=Farm manager, 2= Farmer 3= Civil servant, 4=Business, 5= Other
Farm size (X_{10})	Numeric	Farm size (Acres)	
Title deed ownership (X_{11})	Dummy	Farmer owns title	0=No title, 1= Has title
TLU (X_{12})	Numeric	Farm livestock units	Calculated. See explanation
Tree cover (natural + planted)	Numeric	Farm trees ≥ 2m	Number
Years of tree growing (X_{13})	Numeric	Duration of tree growing (years)	
Total household income (X_{14})	Numeric	Sum of household income (Kshs)	

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3. Results and Discussion

3.1 Socio-Economic Characteristics of the Households

3.1.1 Age distribution of the respondents in the study area

About 57.3% of the respondents were within the productive age bracket of 25-54 years, followed by those over 65 years (22.8%) as shown in Table 2 below.

Table 2. Age distribution of respondent farmers in Machakos County

Age group	Frequency (F)	Percentage (%)
18-24	3	0.7
25-34	47	11.4
35-44	95	23.1
45-54	94	22.8
55-64	79	19.2
Over 65	94	22.8
Total	412	100.0

According to Focus Group Discussions (FGDs), many young people from the region prefer to go to big towns such as Nairobi, Athi River, Thika, Machakos or Nakuru immediately after secondary school to search for paid work. The involvement of people aged 64 years and above in farming within the study area could therefore be attributed to youth "missing in action", the compelling rural poverty, and being retired from formal employment. The study findings agree with other studies across Sub-Saharan Africa and the rest of the world, which have shown an "aging farmer population" (Guo *et al*., 2015).

3.1.2 Gender of the respondents

The majority (57%) of the respondents were male, while 43% were female. The study findings are similar to those of Wambua *et al*. (2018), which found that although 70% of households in Kenya are headed by women, this figure was only 8% in Machakos County.

3.1.3 Household sizes in the study area

The majority (69.2%) of the respondent households comprised 3 or fewer members while a minority (2.4%) of households had 7 or more members. That the study found mainly small families could suggest that there may be an acute shortage of household labour in Machakos County. Such households would have to hire additional labour for the establishment and management of on-farm trees, depending on their income levels.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3.1.4 Education level of respondents in the study area

The majority (57.3%) of the respondents had attained at least secondary education, while about one-tenth of the respondents had no formal education. Famines, teenage pregnancies, and early marriages were among the key drivers of low levels of education in the study area.

3.1.5 Occupation of the respondents

The majority (60.7%) of the respondents were farmers by occupation, who spent most of their time on the farms although they frequently referred to themselves as 'unemployed'. Some (2.7%) of the households had employed farm managers to manage their farms, although these assistants alleged the inability to make major decisions like growing trees by themselves.

3.1.6 Mobile phone ownership of respondent farmers

About 81% of the respondents owned mobile phones, leaving only 19% without the communication gadgets in Machakos County. Besides a mobile phone being a socio-economic status indicator in the village, it can also be a useful source of learning, information, and communication, and capable of influencing tree cover levels and management in the rural areas. Wyche *et al*. (2018) found 54% of respondents in Kenya's rural semi-arid areas had access to a mobile phone – through either ownership or sharing with neighbors, which is way below the rate in Machakos County. Masuki *et al.* (2010) found that the use of mobile phones improved communication and passage of information among farmers themselves and their extension agents, thereby effectively impacting the adoption of farm-improvement technologies.

3.1.7 Farm sizes in the study area

A large majority (83.5%) of the respondents in the study area had 3 acres of farmland or less, making them essentially smallholder farmers. Singh (2018) found that farm size, as a resource factor and a means of production, has a significant influence on the adoption of tree cover by farmers in rural India. Permadi *et al*. (2018) found that faster rates of adoption of tree cover are associated with smallholder farmers having larger land holdings.

3.1.8 Land ownership in the study area

Husbands and sons (86.1%) owned most of the land in Machakos County. This means that land ownership and most likely the decision-making that goes with it was patriarchal in Machakos County. A large majority (93%) of the farmers in Machakos County had land title deeds, signifying absolute legal ownership of their properties. Land ownership with title deeds made the farmers more confident to undertake long-term investment plans, such as

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

growing trees, without the fear of losing the property to other people at a later date.

3.1.9 Years of tree growing by the respondents

The majority (76%) of the respondent farmers had tree-growing experience spanning five years and more. According to Focus Group Discussions, the respondents had learned over the years, from fellow farmers, basic tree growing skills and associated aspects such as common names of tree species and their uses. The learners then honed their skills over time, to the extent that they could prescribe and select tree species to match the local site potential. Meijer *et al*. (2015) found that intrinsic factors (such as knowledge, self-motivation, and income) are as critical in the adoption of new innovative technologies by farmers as extrinsic factors. Deressa *et al.* (2009) also found the tree-growing experience to be one of the determinants of tree cover adoption by farmers in the Nile Basin of Ethiopia.

3.1.10 Income levels of respondents in the study area

The mean annual income for a respondent in Machakos County was 88,443.00 Ksh, compared to a national figure of 289,800.00 Ksh in 2017 (KNBS, 2018). This translates to 7,370.00 Ksh per month per household. The highest income came from livestock and livestock product sales (21.4%). This was followed by income from small and medium businesses (19.9%), tree covers product sales (17%), and monthly wages (17%), followed by farm cereals (8.7%), respectively. Incomes from many of these sources fluctuated with seasons and were not predictable. According to focus group discussions, good harvests (of cereals whether for sale or subsistence) are rare and far apart due to the erratic nature of rainfall in the study area. The main tree products sold included round wood (such as sawlogs, poles, and posts), fruits (such as mangoes and avocados), wood fuel (firewood and charcoal), and animal fodder. Small-scale timber merchants would buy logs from farmers and later convert them to sawn timber for sale in the local retail markets at a higher profit.

3.1.11 Tree growing behavior of farmers in Machakos County

The majority (97%) of the respondents acknowledged that they had planted some trees on their farms. There was a reasonable level of tree growing of both indigenous and exotic species by farmers in Machakos County although the long-term rate of wood utilization appeared to have out-paced new growings. In total, the study recorded 58 tree species grown by farmers, with major ones including *Eucalyptus saligna*, *Grevillea robusta*, *Mangifera indica*, *Persea americana*, *Croton megalocarpus*, and *Terminalia brownie*. *Eucalyptus saligna* and *Grevillea robusta* recorded the highest relative

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

densities (33.9% and 23.1%), respectively while *Mangifera indica*, *Persea americana*, *Croton megalocarpus*, and *Terminalia brownie* have relative densities exceeding 1.0%. *Eucalyptus saligna*, *Grevillea robusta*, *Mangifera indica,* and *Persea americana*, are majorly grown for timber and fruit production. Farmers also indicated that these tree species were easier to manage besides their household income benefits. *Eucalyptus saligna was* also preferred because it grew fast, coppiced when cut, and had a readily available market for timber, poles, posts, and wood fuel. On the other hand, *Grevillea robusta* had multiple products such as timber, wood fuel, and shelterbelt formation for coffee-based farming systems in the Sub-county.

During Focus Group Discussions, it came out that more farmers had planted or maintained more tree cover in Sengani Location than in Koma Location - a discrepancy they attributed to unfavorable black cotton soils. Sengani's Location has largely arable red loamy soils. Another reason given for reduced tree cover in Koma Location was that there were too many roaming animals in the location, both domestic and wild, which were destructive to newly planted tree seedlings.

3.2 Effects of Socio-Economic Factors on Tree growing and Cover retention in the Study Area

A logistic regression model was used to estimate factors that influenced tree growing and cover retention in Machakos County (Table 3).

Table 3. Logistic regression model of factors affecting tree growing and cover retention in Machakos County

Parameters	B	S.E.	Wald	df	Sig.	Exp (B)
Mobile phone ownership	-0.362	.469	.595	1	.440	.696
Gender	-0.936	.370	6.401	1	.011	.392
Age	0.017	.014	1.444	1	.229	1.017
Location	0.315	.451	.488	1	.485	1.370
Marital status	0.273	.256	1.137	1	.286	1.313
Household size	0.282	.130	3.735	1	.030	1.326
Education	0.133	.216	.383	1	.536	1.143
Occupation	0.230	.242	.904	1	.342	1.258
Farm size	-0.429	.151	8.042	1	.005	.651
Title deed ownership	1.169	.513	5.186	1	.023	3.220
TLU	-0.049	.048	1.017	1	.313	.952
Years of tree growing	-0.016	.165	.009	1	.924	.984
Total household income	0.000	.000	1.093	1	.296	1.000
Constant	-3.514	1.767	3.954	1	.047	.030
Percentage correct cases	76.1					
Nagelkerke R^2	51.0					
Hosmer and Lemeshow test	Chi-square =11.8, df = 8, sig = 0.159					

**Notes*: B = Regression coefficient, S.E = standard error, Wald = wald Chi square, df = degrees of freedom, Sig = probability, Exp (B) = odds ratio.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The logistic regression model was statistically significant, explaining 51% (Nagelkerke R^2) of the variance in tree-growing behavior and correctly classified 76% of cases (Table 3). Parameters that affected tree cover included gender, household size, farm size, and title deed ownership.

There was a non-significant relationship (p = 0.229) between the age of respondents and tree cover in the study area (Table 3). This finding contradicts Gyau *et al*. (2014) and Ali & Rahut (2018) who found a positive significant relationship between the age of respondents and adopters of tree cover, with younger generations being more likely to plant and maintain tree cover. Results could differ due to the influence of a strong training and advocacy policy and age group priorities in a given area (Kaakkurivaara & Stampfer, 2018).

Gender had a negative but significant influence (p = 0.011) on tree cover (Table 3). Male-headed households were 0.392 times more likely to plant exotic tree species than female-headed households while increasing the household size by one member increased the odds of growing exotic trees by 1.326 times. This could be explained by the glaring household labour, gender, and land tenure imbalances in Machakos County where there are more male-headed households and males owned more land than the females. Gender, as a fundamental aspect of social organization determines the distribution of land titles in developing countries (Kiptot & Franzel, 2011).

Nkamleu and Manyong (2005) found that male farmers were likely to plant exotic trees suggesting that male-managed farms were more likely to engage in tree-growing activities. Women's involvement in tree growing in the rural villages will continue to be low as they are passed over during selection for sensitization and training - unless there is a change in policy by the relevant institutions and technical service authorities (Kristjanson *et al*., 2017). Marital status had no significant influence on tree cover in Machakos County. However, when the study sites were split between the model, it was found that marital status significantly influences tree cover in Sengani Location (p = 0.038) but not in Koma Location (p=0.856). Thus, the marital status of respondents was significantly linked with location and was more significant in Sengani Location. Sengani Location, which is mainly ancestral land, had higher proportions of married (82.2%), widowed (9.1%), and divorced (2.2%) respondents than Koma Location (married 79.7%; widowed 6.8%; and divorced 0.8%), which was occupied by relatively more modern settlers who were heterogeneous and less culturally inclined. A similar study by Verkaart *et al.* (2017) in Kitui and Embu Counties in Eastern Kenya showed that married respondents were more likely to intensify and diversify agriculture as a pathway from poverty than respondents of other marital statuses.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The study found that there was a significant relationship (p = 0.030) between household size and tree cover in the study area (Table 3). Bigger families were more likely to establish tree cover than smaller ones - because big households are driven by bigger household livelihood needs and they have the required labour to do so. Household labour was found to be an important factor in the rehabilitation of wastelands and enhancement of food security using a combination of tree cover establishment, soil, and water conservation activities ((Nkamleu & Manyong, 2005; Etongo *et al*., 2018).

Education did not significantly influence (p = 0.536) tree cover in Machakos County (Table 3). This is most likely due to a lack of training, extension, and sensitization opportunities in tree cover in Machakos County. Education level in the adoption of technologies is effective when coupled with the relevant technical training and extension services (Ekanayake *et al*., 2018). While investigating the effects of climate change on dry-land agriculture and the adaptation strategies by small-scale farmers in the neighboring Yatta Sub-county, Mburu (2013) observed that education was a significant factor in climate change adaptation as it enabled farmers to diversify their sources of livelihood.

Mobile telephony did not have a significant influence on tree growing and cover retention in the study area (Table 3). That there were no known promotional mobile phone-based policies, advocacy, or software packages in tree cover technologies for farmers in Machakos County explains the insignificance of mobile phone ownership in relation to tree cover. Meijer *et al*. (2015) found that technology and knowledge play a key role in the uptake of agricultural and agroforestry technologies among smallholder farmers in Sub-Saharan Africa.

The study found a significant relationship (p = 0.005) between farm size and tree growing and cover retention in Machakos County (Table 3). Farmers with a larger farm size by 1 acre were 0.651 times more likely to plant trees than farmers with a lesser land area. Farm size is also an indicator of household economic resources and farmers with larger parcels of land are more likely to possess other resources required for tree growing, even under situations of multiple competing land uses. Simotwo *et al*. (2018) found that farm size is significantly linked to the adaptive capacities of farmers in Transmara County, Kenya. Trinh *et al.* (2018), indeed, found farm size to be the most important factor affecting farmers' decision on adaptation to climate change.

There was a significant relationship (p=0.023) between title deed ownership and tree cover (Table 3). Households who had title deeds were more likely to adopt tree cover in their farms than those without. Households with title deeds were 3.2 times more likely to plant exotic tree species than farmers without land titles. Our findings agree with Lawin and Tamini (2018) who

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

found that land tenure significantly influences farmers' decision to adopt new long-term agricultural innovations. Nkamleu and Manyong (2005) identified land ownership as a key driver for tree cover development in Sub-Saharan Africa because the latter is a long-term capital investment. Our findings contradict those by Muriu-Nganga *et al*. (2017) who found a negative relationship between land tenure and adoption.

Conclusion and recommendations

Socio-economic variables that significantly influenced tree cover included gender (p= 0.011), household size (p=0.030), title deed ownership (p=0.023), and Farm size (p= 0.005). Gender and Farm size had negative significant influences on tree cover. Male-headed households were more likely to plant trees than female-headed households. Age, marital status, education level, occupation, mobile phone ownership, years of tree-growing experience, and household income did not have a significant influence on tree management in Machakos County. Based on these results we conclude that some socio-economic factors do significantly affect tree growing and cover retention in Machakos County.

We recommend more involvement of women and youth in tree-growing activities in Matungulu Sub-county. Women are held back from tree-growing activities by cultural factors while the youth migrate to towns. We also recommend on leveraging of mobile phone technology to reach out to more farmers with the message of tree growing and cover retention on their farms.

References:

1. Ali, A. & Rahut, D. B. (2018). Forest-based livelihoods, income, and poverty: Empirical evidence from the Himalayan region of rural Pakistan. *Journal of Rural Studies*, 57, 44-54.
2. Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., Börner, J., Smith-Hall, C. & Wunder, S. (2014). Environmental Income and Rural Livelihoods: A Global-Comparative Analysis. *World Development*, *64*, (1), S12-S28.
3. De Leeuw, J., Njenga, M., Wagner, B. & Iiyama, M. (Eds.) (2014). Treesilience: An assessment of the resilience provided by trees in the drylands of Eastern Africa. World Agroforestry Centre, Nairobi, Kenya.
4. Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T. & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global environmental change*, *19*(2), 248-255.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

5. Ekanayake, E. M. B. P., Feng, M., Murindahabi, T., Nissanka, A. H. S. & Patrick, G. S. (2018). Contribution of Indian Gooseberry (*Phyllanthus emblica*) to Household Economy in Sri Lanka: A Case Study from Udadumbara Divisional Secretariat. *Small scale forestry, 17*, (2), 277 – 292.
6. Etongo, D., Epule, T. E., Djenontin, I. N. S. & Kanninen, M. (2018). Land managementin rural Burkina Faso: the role of socio-cultural and institutional factors. Natural Resources Forum, Blackwell Publishing Ltd, Oxford, UK.
7. Guetterman, T. C., Fetters, M. D. & Creswell, J. W. (2015). Integrating quantitative and qualitative results in health science mixed methods research through joint displays. *The Annals of Family Medicine*, *13*(6), 554-561.
8. Guo, G., Wen, Q. & Zhu, J. (2015). The impact of aging agricultural labor population on farmland output: from the perspective of farmer preferences. *Mathematical Problems in Engineering*, 1, 1-7
9. Gyau, A., Franzel, S., Chiatoh, M., Nimino, G. & Owusu, K. (2014). Collective action to improve market access for smallholder producers of agroforestry products: key lessons learned with insights from Cameroon's experience. *Current Opinion in Environmental Sustainability*, *6*, 68-72.
10. Hadi, A. L. A., Wahab, N. A. A., Noh, N. A. M., Razali, N. M., Yusop, N. M., Khairudin, Z. & Othman, R. (2018, June). Determinants of depression among tertiary level students: A logistic regression approach. In *AIP Conference Proceedings* (*1974*(1), 050007. AIP Publishing.
11. Insaidoo, T. F. G., Derkyl, M. & Acheampong, E. (2014). Farm level tree planting in Ghana: Potential for reducing vulnerability and mitigating climate change. JENRM.*1*, 19-28.
12. Kaakkurivaara, N. & Stampfer, K. (2018). Assessment for Improvement: Harvesting Operations in Small-Scale Forest on Thai Steep Terrain. *Small scale forestry*, *17*(2), 277 – 292.
13. KNBS (2018) Kenya National Bureau of Statistics. Kenya Integrated Household Budget Survey (2017/2018), Government Printer, Nairobi, Kenya.
14. Kiptot, E. & Franzel, S. (2011). *Gender and Agroforestry in Africa: Are Women Participating.* Occasional Paper, World Agroforestry Center, Nairobi, Kenya.
15. Kothari, C.R. (*2004*). Research Methodology Methods and Techniques. 2nd Edition, New Age International Publishers, New Delhi.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

16. Kristjanson, P., Bryan, E., Bernier, Q., Twyman, J., Meinzen-Dick, R., Kieran, C. & Doss, C. (2017). Addressing gender in agricultural research for development in the face of a changing climate: where are we and where should we be going? *International Journal of Agricultural Sustainability, 15*(5), 482-500.
17. Lawin, K. G. & Tamini, L. D. (2018). Land Tenure Differences and Adoption of Agri-Environmental Practices: Evidence from Benin. *The Journal of Development Studies*, pp. 1-14.
18. Machakos County Government. (2015). Machakos County Integrated Development Plan. Machakos, Kenya.
19. Macneil, C., Brown, H. C. P. & Sonwa, D. J. (2017). Investigations of the Livelihood Strategies of Young Men and Women in Forested Landscapes of Eastern Cameroon. *International Forestry Review 19*(4): 437- 448.
20. Masuki, K. F. G., Kamugisha, R., Mowo, J. G., Tanui, J., Tukahirwa, J., Mogoi, J. & Adera, E. O. (2010). Role of mobile phones in improving communication and information delivery for agricultural development: Lessons from South Western Uganda. *Workshop proceedings*, Makerere University, Kampala, Uganda, pp. 22-23.
21. Mburu, B. K. (2013). Effects of climate variability and change on dry-land agriculture and the adaptation strategies by small-scale farmers in Yatta District, Kenya. PhD thesis, Kenyatta University, Nairobi, Kenya.
22. 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. Pages?
23. MENR (2006). Ministry of Environment & Natural Resources. Forest Department annual Report for Kangundo District. Unpublished Report.
24. Muriu-Ng’ang’a, F. W. (2017). Utilisation of selected rainwater harvesting and saving technologies for improved crop production in Tharaka South Sub-county, Kenya. Ph.D Thesis, Kenyatta University, Nairobi, Kenya.
25. Nkamleu, G. B. & Manyong, V. M. (2005). Factors affecting the adoption of agroforestry practices by farmers in Cameroon. *Small-scale forest economics, management and policy*, *4*(2), 135-148.
26. Permadi, D. B., Burton, M., Pandit, R., Race, D., Ma, C., Mendham, D. & Hardiyanto, E. B. (2018). Socio-economic factors affecting the rate

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

of adoption of acacia plantations by smallholders in Indonesia. *Land use policy*, *76*, 215-223.
27. Quandt, A., Neufeldt, H. & McCabe, J. T. (2018). Building livelihood resilience: what role does agroforestry play? *Climate and Development*. Volume, and pages? doi.org/10.1080/17565529.2018.1447903.
28. Shiferaw, S. T., Frédéric, B., Hae, K. & Giller, K. (2017). Climate-smart agroforestry: *Faidherbia albida* trees buffer wheat against climatic extremes in the Central Rift Valley of Ethiopia. *Agricultural and Forest Meteorology*. 248, 339-347.
29. Shrestha, S., Shrestha, U. B. & Bawa, K. (2018). Socio-economic factors and
30. management regimes as drivers of tree cover change in Nepal. *Peer J*, *6*, e4855.
31. Simotwo, H. K., Stella, M., Mikalitsa, S. M. & Wambua, B. N. (2018). Climate change adaptive capacity and smallholder farming in Trans-Mara East Sub-county, Kenya. *Geoenvironmental Disasters* *5*:5.
32. Siraj, M., Zhang, K., Xiao, W., Bilal, A., Gemechu, S., Geda, K., Yonas, T. & Xiaodan, L. (2018). Does Participatory Forest Management Save the Remnant Forest in Ethiopia? In Proceedings of the National Academy of Sciences, India Section B: Biological Sciences *88* (1), 1–14.
33. Singh, C. (2018). Adoption of Agroforestry Practices: Chi 2 Function Approach in Determining Influence of Individual and Social Factors on Farmers' Decision to Adopt or not to Adopt Agroforestry. *Indian Forester, 144* (7), 646-652.
34. Survey of Kenya, (2018). Map of Machakos County and its position in Kenya. County Survey Office, Machakos, Government of Kenya.
35. Trinh, T. Q., Rañola, R. F., Camacho, L. D. & Simelton, E. (2018). Determinants of farmers’ adaptation to climate change in agricultural production in the central region of Vietnam. *Land use policy*, *70*, 224-231.
36. Verkaart, S., Orr, A., Harris, D. & Claessens, L. (2017). Intensify or diversify? Agriculture as a pathway from poverty in eastern Kenya, *Socioeconomics Discussion Paper Series*, Series Paper Number 40 http://oar.icrisat.org/id/eprint/9937.
37. Wambua, S., Birachi, E., Gichangi, A., Kavoi, J., Njuki, J., Mutua, M. & Karanja, D. (2018). Influence of productive resources on bean production in male-and female-headed households in selected bean corridors of Kenya. *Agriculture & Food Security*, *7*(1), 85.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

38. Wunder, S., Angelsen, A. & Belcher, B. (2014). Forests, Livelihoods, and Conservation: Broadening the Empirical Base. World Development, *64*(1), S1-S11. https://doi.org/10.1016/j.worlddev.2014.03.007.
39. Wyche, S., Simiyu, N. & Othieno, M. E. (2017). Understanding women's mobile phone use in rural Kenya: An affordance-based approach. Mobile Media & Communication. https://doi.org/10.1177/2050157918776684.
40. Zomer, R. J., Neufeldt, H., Xu, J. C., Ahrends, A., Bossio, D., Trabucco, A., van Noordwijk, M. & Wang, M. (2016). Global tree cover and biomass carbon on agricultural land: The contribution of agroforestry to global and national carbon budgets**.** http://www.worldagroforestry.otg/ publications/.