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Full Length Research Paper

Household tree planting and its related constraints in meeting woodfuel production in Kiambu, Thika and Maragwa Districts of Central Kenya

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The objective of this study was to assess household tree planting for fuelwood production and investigate current constraints to tree establishment in Kiambu, Thika and Maragwa Districts of Central Kenya. The study was undertaken through household survey in Kiambu, Thika and Maragwa Districts of Central Kenya. The districts were purposively sampled on the basis of various factors which include diverse ecological conditions and population densities among others. Sampling of the households was done using multistage stratified random sampling technique where stratification was based on the weights in socio-economic and climatic activities as indicators. The results of the study showed that over 90% of the households in the three districts have planted trees in their farms and tree planting was found to be positively correlated to household farm size. Boundary tree planting was the most preferred as compared to woodlots which had the least preference. *Grevillea robusta* and *Eucalyptus* species were the most preferred tree species. Inadequate land was the leading major obstacles to tree planting in the three districts with 74, 60 and 57% of the household respondents followed by scarcity of seedlings with 16, 33 and 28% in Kiambu, Thika and Maragwa districts, respectively. The third most important constraint was tree establishment cost. The household land size ownership varied among the districts with a range of 1.9 to 3.6 acres. The small household land holdings indicate the need to integrate woodfuel production with farming systems as agricultural sector has a key role in supplementing wood production. The study was concluded by recommending development of decentralised woodfuel planning with site specific implementation strategies in the study area as there were varying tree planting parameters among the districts. Establishment of tree nurseries was also recommended for a sustainable seedling production.

Key words: Household land size, species preference, woodfuel planning, sustainability.

INTRODUCTION

In developing countries, woodfuel is the major source of cooking and heating where about 2 billion people rely solely on fuel wood for cooking (FAO, 2005). This figure demonstrates the critical importance of wood energy in meeting energy requirements in these countries. It is estimated that about 90% of Kenyan rural households use woodfuel either as firewood or charcoal (Ministry of Energy, 2002; Theuri, 2002; Kituyi, 2008). Wood energy provides 70% of Kenya's national energy needs and it is expected to continue as the country's main source of energy for the foreseeable future (Republic of Kenya, 2002a). Besides being the standard cooking fuel for the majority of Kenyan households, fuelwood is also an important energy source for small-scale rural industries like tea factories. A comprehensive biomass study undertaken in Kenya in 2000 revealed that the principal sources of fuel wood are the farm lands with a production of 84% of the total woodfuel requirement (NEMA, 2004).

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Table 1. Proportion of land sizes (acres) for Kiambu, Thika and Maragwa districts.

District	Land size (acres)											
	<1		1.1-2		2.1-3		3.1-4		> 4.1		% total (n)	
	%	n	%	n	%	n	%	n	%	n	%	n
Kiambu	46	92	22	43	8	15	6	12	18	36	100	198
Thika	41	63	20	30	13	20	7	11	18	28	100	152
Maragwa	44	86	24	48	19	38	5	9	8	16	100	197

Kenya has 3.467 million ha of forest cover which is equivalent to 5.9% of land area out of which 1.417 million ha comprises of indigenous closed canopy forests, mangroves and plantations (Kenya Forest Service Strategic Plan, 2009). Much of the closed canopy forest has been depleted due to internal and external influences. Continued losses of forests and associated resources have had far reaching negative effects on the country's economy and welfare of Kenyans. Some of the consequences include inadequate supply of woodfuel and timber which lead to overharvesting of trees leading to environmental degradation and loss of biodiversity among others (Nellie and Githiomi, 2009).

The Kenya Forest Service (KFS) strategic plan indicates that 10.385 million ha of land is covered with trees on farmlands with wood stocking of about 9.7 m^3/ha. The moratorium on tree harvesting from public forests in Kenya was imposed in 1999 and complete ban in 2002 which precipitated a shortage of sawn timber and wood products. This shortage lead to increase of timber prices which encouraged farm tree planting. The integration of trees in agriculture systems is a road map to follow to enhance sustainability (Schuren and Snelder, 2008). This integration has been made easier through research on farm forestry systems which are more diverse, efficient and easily adopted to the local condition (Adensinu and Chianu, 2002). The Government of Kenya has been involved in promoting tree planting at the farm level with the aim of increasing tree cover to 10% by the year 2030 (Republic of Kenya, 2007). There have been successful tree planting programs involving rural communities in Kenya led by government rural forest extension services and various non-governmental organizations (Githiomi et al., 2012). Lack of sustainable woodfuel production planning strategy has lead to scarcity and over-exploitation of natural resources and environmental degradation as supported by past studies by Akinga (1980) and Ministry of Energy (2002), which despite being two decades apart showed a widening gap between supply and demand in woodfuel.

The deficit in woodfuel was due to higher tree cutting rate than replenishment. The study aimed at determining the factors influencing tree planting for woodfuel production in Kiambu, Thika and Maragwa districts of central Kenya and suggest possible interventions strategies to ensure self sufficiency.

MATERIALS AND METHODS

The study was carried out in Kiambu, Thika and Maragwa districts of central Kenya. The districts were purposively sampled on the basis of various factors which include diverse ecological conditions and population densities, presence of agro based industries like tea factories among others. The selected districts have rainfall range of 800 to 1400, 500 to 2500 and 900 to 2700 mm for Kiambu, Thika and Maragwa districts, respectively (Republic of Kenya, 1997a, 1997b, 2002b). Sampling of the households was done using multistage stratified random sampling technique beginning with stratification sampling procedures as outlined by Lee-Ann and Martin (1997). Each of the three districts under study was stratified according to the weights in socio-economic and climatic activities as indicators. Using this procedure, at least 40% of the divisions with relatively homogeneous characteristics in each district were sampled to form a stratum. This ensured heterogeneity was well captured and represented. Similar procedure was followed for selection of administrative locations and sub-locations. Based on these sampling procedures, Kiambu, Thika and Maragwa districts were stratified into four, three and two strata, respectively. Each stratum in the district consisted of one or more divisions. A total of 200 households were sampled from each district.

Allocation of the sampling units in each sampled division was done proportionally to the total number of household obtained from 1999 census (Republic of Kenya, 2001). Data collection was done using structured and semi-structured household questionnaires. The information collected included proportions of land size per household, household land area under trees, tree planting practices, tree preferences and tree planting obstacles. The generated data was coded and entered in the computer using spread sheet of Ms-Excel. Statistical package for social sciences (SPSS) was used in analyzing the data.

RESULTS

The results showed that over 40% of the household respondents within the three districts had less than 1 acre of land (Table 1) and the proportion of land size ownership category varied significantly between the districts. (χ^2 = 21.489, d.f = 8, p = 0.006). The mean land size holdings for Kiambu, Thika and Maragwa were 3.6, 3.2 and 1.9 acres with s.e.d of 0.282, respectively, which was significantly different (p = 0.033). Further, multiple comparison of estimated land sizes among the three districts showed that there were significant differences (p<0.016) in land size between Maragwa and Kiambu as well as Maragwa and Thika (p<0.05), but no significant difference (p = 0.649) between Kiambu and Thika districts (Table 2). The significant differences in land size

Table 2. Pairwise comparisons of land sizes (acres) between Kiambu, Thika and Maragwa districts.

Comparison of district	Mean difference	s.e	p-value	95% confidence Interval for difference	
Kiambu versus Thika	0.345	0.759	0.649	-1.145	1.835
Kiambu versus Maragwa	1.719	0.709	0.016	.326	3.112
Maragwa versus Thika	-1.374	0.706	0.050	-2.760	0.012

Table 3. Mean land holdings of sampled division per district.

District of survey	Division of survey	Mean	Std. deviation	Range (acres)	N
Kiambu	Kiambaa	1.7	1.25	4.5	70
	Lari	2.7	2.72	13.8	64
	Ndeiya	2.3	3.50	14.5	16
	Limuru	7.8	18.82	84.9	48
Thika	Gatundu	2.4	2.31	14.0	68
	Kakuzi	5.1	6.32	40.0	48
	Thika Municipality	2.4	7.44	45.0	37
Maragwa	Makuyu	1.9	1.37	6.8	84
	Kigumo	1.9	1.67	9.8	113

Table 4. Proportion of household respondents who had planted trees on farm in Kiambu, Thika and Maragwa districts.

District	Proportion of households who planted trees on their farms					
	Planted		Not planted		Total	
	%	n	%	n	%	n
Kiambu	92	182	8	15	100	197
Thika	92	145	8	12	100	157
Maragwa	96	184	4	7	100	191

Table 5. Proportion of land planted with trees in Kiambu, Thika and Maragwa districts.

	Land size currently under trees													
	<0.5		0.5-1		1-2		2-3		3-5		>5		Total	
District	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Kiambu	65	121	22	42	7	14	3	6	0	0	2	4	100	187
Thika	84	121	13	19	2	3	1	1	0	0	0	0	100	144
Maragwa	85	167	12	24	2	20	1	1	1	1	0	0	100	196

noted in this study were clearly manifested within the divisions sampled where large variations were observed (Table 3). For example, Limuru division in Kiambu district had a large standard deviation implying that there was a high range of land sizes.

Proportion of household land under trees

The results showed that over 90% of the households sampled in the three districts had planted trees on their farms and there was no significant difference ($\chi^2 = 2.82$, d.f = 2, p = 0.242) in tree planting among Kiambu, Thika and Maragwa districts (Table 4). There were significant differences ($\chi^2 = 30.406$, d.f = 2, p<0.01) between the proportion of land under trees in the three districts. Majority of the households (over 65%) had less than a half an acre of land under trees cover (Table 5). There was a positive correlation (r = 0.55, p<0.01) between land size per household and area under trees (Table 6) across

Table 6. Association between household land size and proportion under trees across Kiambu, Thika and Maragwa districts.

Land size	Farm proportion in acres currently under trees													
	<0.5		0.5-1		1-2		2-3		3-5		>5		Total	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
<1	99	219	1	3	0	0	0	0	0	0	0	0	100	222
1-2	79	90	20	23	1	1	0	0	0	0	0	0	100	114
2.1-3	72	51	24	17	4	3	0	0	0	0	0	0	100	71
3.1-4	42	14	48	16	9	3	0	0	0	0	0	0	100	33
> 4.1	34	26	32	25	17	13	10	8	1	1	5	4	100	77

Table 7. Tree planting technologies adopted on farms in Kiambu, Thika and Maragwa districts.

District	The planting practices									
	Boundary/fence		Scattered trees in crop land		Home compound		Woodlot		Total	
	%	n	%	n	%	n	%	n	%	n
Kiambu	73	138	11	21	13	25	3	6	100	190
Thika	85	126	13	19	1	2	1	1	100	148
Maragwa	95	185	2	3	3	6	1	1	100	195

Table 8. Preferred tree species on farms in Kiambu, Thika and Maragwa districts.

District	Grevillea		Croton		Eucalyptus		Cypress		Pines		Others		Total	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
Kiambu	84	164	1	2	10	20	1	2	1	2	3	6	100	196
Thika	89	160	4	7	7	13	0	0	0	0	0	0	100	180
Maragwa	92	184	4	9	3	7	0	0	0	0	1	2	100	199

* Others: *Callistemon citrinus*, *Dovyalis caffra*, *Prunus, Olea* and *Terminalia brownie*.

all the three districts. Most of the households with less than 1 acre of land had planted less than 0.5 acres of their land with trees. There was also a significant Pearson correlation (r = 0.54, p< 0.01) between the land size and the number of trees planted.

Tree planting practices

The results revealed significant differences (χ^2 = 51.211, d.f = 6; p<0.01) among districts in tree planting practices adopted by farmers on their farms (Table 7). Boundary planting was the most preferred practice with 73, 85 and 95% of the household respondents in Kiambu, Thika and Maragwa district, respectively, while woodlots had the least preference.

Tree planting preferences

The results showed that exotic tree species were the most preferred for planting on the farms with *Grevillea robusta* being the most popular species followed by *Eucalyptus* spp. There was a significant difference (χ^2 = 47.906, d.f = 20, p<0.01) on tree preference among the districts (Table 8).

Tree planting obstacles

Household respondents identified various obstacles to tree planting as shown in Table 9, where inadequate land was the leading major obstacles, followed by scarcity of seedlings. These obstacles were found to be significantly different (χ^2 = 151.2, d.f = 54, p = 0.003) among the districts.

DISCUSSION

The reported mean land sizes between 1.9 to 3.6 acres in the three districts were higher than what was reported by a study in Kakamega district in western part of Kenya where average farm size was 1.44 acres (Van Gelder and Kekholf, 1984). The small land sizes in all the three districts indicate that tree planting has to be integrated to

Table 9. Obstacles to tree planting in Kiambu, Thika and Maragwa districts.

District	Obstacles encountered in woodlot establishment									
	Scarcity of seedlings		Inadequate land		High cost of establishment		Others*		Total	
	%	n	%	n	%	n	%	n	%	n
Kiambu	16	32	74	144	2	4	8	8	100	188
Thika	33	60	60	110	1	1	6	11	100	182
Maragwa	28	54	57	112	2	4	14	25	100	195

* Include poor weather, lack of interest, pest and diseases.

the household farming systems. The increase in frequency of small land sizes is likely to be intensified in future due to continued increase in population resulting to fragmentation of land holdings into smaller farm sizes (Kamau, 1998). The high variability in land sizes among the districts was due to large tea and coffee plantations that were found in Limuru, Kakuzi and Thika Municipality divisions within the districts. The high rate of household tree planting in the study area (90%) compares well with an earlier study done in Kakamega district in western Kenya, where 80% of the rural household had planted trees on 25% of their farms despite the small household land sizes in the district (van Gelder and Kerkhof, 1984). The high tree planting rate in the three districts indicates that there was high awareness on tree planting in all districts as it had been shown in an earlier study by Mercer in 2004 that tree growing awareness through extension services related positively to tree growing in the fields.

The study in the three districts revealed that trees on farms have assumed an important place as one of the many smallholder land use options. Similar observations had been reported in a study done earlier in the neighboring district of Muranga in 1995, where it was observed that despite the pressure of land, trees were grown in 5 to 10% of the agricultural land (Dewees, 1995). The high rate of tree planting among the rural smallholder farmers is likely to have been contributed by its low labor input and minimal annual operating cost which is coupled by greater risk resistance in case of rain deficiency. The significant difference between the proportions of land in the three districts justifies development of area specific wood energy plan with area specific implementation strategies under each of the district development committees (DDC). The high level of sensitization on tree planting gives a positive starting point to development of sustainable wood energy plan through increasing the farmlands area under trees. Taking into account that over 40% of the household had less than 1 acre of land, the tree planting of even less than a quarter acre by a household is a substantial contribution to wood production. The positive correlation between land size per household and area under trees implies that the larger the land size, the bigger the area under trees on households farms. This was further evidenced by significant Pearson correlation between the land size and the number of trees planted.

Similar observation was reported in Zimbabwe, Philippines and Ethiopia where land size of household was positively correlated with number of trees planted by individual household (Price and Campbell, 1998; Nick and Jungho, 2004; Zenebe et al., 2010). This positive relationship can be used in developing area specific wood energy plan where the proposed increase of the area under trees is taken proportionately to the household farm size. The reason for high boundary tree planting in the districts was due to the fact that land sizes were small. Traditionally, boundary tree planting was done to mark demarcation between sub-clan lands (Leakey, 1997). However, the practice has been adopted even when dividing different cropping systems in the same farmland as was observed in the study area. In all districts, *G. robusta* was the most preferred tree species due to its ability to intercrop in agroforestry systems. *Eucalyptus* species were the second preferred species due to their fast growth with coppicing ability and also being a good timber species. Similar observation was also reported in a study done in Kilosa District, Tanzania where another agroforestry species *Senna* spp were the most popular followed by Eucalyptus species (Aalbaek, 2000). An earlier study in Kakamega district in Western Kenya also found *Eucalyptus* tree species to be the most preferred species within that district due to similar characteristics (Van Gelder and Kerkhof, 1984). Eucalyptus has also been reported to have over 20% returns to investment by farmers in Northern Ethiopia which makes it economically viable to plant (Jagger and Pender, 2003).

Fast growth and utilization potential of species are important factors to be considered in future woodfuel development. The obstacles to tree planting were found to be significantly different among the districts where inadequate land size was more pronounced in Kiambu district, whereas scarcity of seedling was more evident at Thika than in Maragwa and Kiambu districts. Similar observation was reported in a study by Aalbaek (2000) who found that about 28% of surveyed farmers throughout Tanzania stated that land scarcity was one of the top constraints to tree planting. Given the importance of land as a household asset, the agricultural land use activities and poverty reduction strategies need to take into account the declining farm sizes. The other obstacles included poor weather, lack of tree planting interest and termite attack. These factors need to be considered while promoting establishment of trees at the farm level. The variation of the obstacles in tree planting and tree preferences among the districts justifies the development of area specific strategies for wood energy development in each district. This will avoid the generalized strategies that may not apply uniformly across all the regions.

The interventions suggested to increase farm tree planting should be compatible with the existing farming practices for easy adoption by farmers.

CONCLUSIONS AND RECOMMENDATION

The proportion of land under trees by the households was found to be correlated to their land size which is an important factor to consider in future development of wood energy plan. The household land size categories, tree preference and constraints were found to vary between the three districts which justify the decentralized micro-level wood energy planning with site specific implementation strategies. The main obstacle to household tree planting was inadequate land for planting, unavailability of seedling and the high cost of tree establishment. The most preferred tree species planted were *G. robusta* followed by *Eucalyptus* species which was based on their growth and utilization potential. The culture of tree planting was found to be eminent in the three districts where over 90% of the household had planted trees in their farms with boundary tree planting being the most prevalent as a result of small land sizes. The study recommended promotion of tree planting in the study area through assisting in establishment of tree nurseries for seedling production.

Integrations of tree planting to farming systems were also recommended as agricultural sector has a key role in supplementing wood production.

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