Journal of Agricultural Economics, Extension and Rural Development: ISSN-2360-798X, Vol. 3(10): pp 326-337, October, 2015.

Full length Research

Forest use and dependence by forest adjacent households on East Mau forest ecosystem, Kenya

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Accepted 5th October, 2015

Forests play a key role in the livelihoods of local people in most developing countries. Local communities depend on forests for various products such as fuel wood, construction materials, medicine, and food. Forests in Kenya are threatened by unsustainable uses and conversion to alternative land uses. In spite of the consequences of forest fragmentation, biodiversity erosion and reliance of local communities on forests for ecosystem goods and services there is little quantitative information on forest use and dependence to guide sustainable use. A study was therefore, undertaken in East Mau forest ecosystem to determine (i) forest uses and (ii) the economic dependency of the local communities on forests. Data on socioeconomic, demographic and forest use were collected using semi-structured and structured questionnaire with 367 households and market surveys in adjacent urban centres. The data collected were analyzed using SPPS program. Findings showed that forest income is significant to households contributing up to 33% of household income. Fuel wood (firewood and charcoal) contributed up to 50%, food, 27%, construction material, 18% and grass products (fodder and thatching material) 5% of forest income. These translate to (US$) 509.0, 274.9, 186.2 and 53.4 per household per year respectively. The data authenticated that poor households are more dependent on forest resources. These results provide valuable information on the kind and magnitude of ecosystem values that could be relevant in decision-making concerning biodiversity conservation and management of East Mau Forest ecosystem for enhanced ecosystem goods and services for supporting livelihoods.

Keywords: Forest use, forest product, Absolute forest income, Relative forest income, forest dependence

INTRODUCTION

Forests play an important role in the livelihoods of local people in most developing countries. Local communities depend on forest resources for various products such as fuel wood, construction materials, medicine, and food. An estimated 1.6billion people depend to varying degrees on forests for their livelihoods and about 60million forest dwellers are almost fully dependent on forests. Furthermore, 350million people who live adjacent to dense forests depend on them for subsistence and income (World, 2004). It is estimated that 20-25% of rural peoples' income is obtained from environmental resources in developing countries (Vedeld et al., 2007) and provide food reserve for use in periods of crisis or during seasonal food shortages (Emerton, 1996; Shackelton and Shackleton, 2004; Shackelton and Shackleton, 2006). The ecological and economic significance of forest ecosystems in Kenya is widely acknowledged. Despite the increasing degradation of forest ecosystems, there is dearth of quantitative information on forest use and dependence to guide sustainable use within the context of local livelihoods. This study was, therefore, undertaken to determine forest use, level of dependence among forest adjacent households in East Mau forest ecosystem in Kenya (Figure 1).

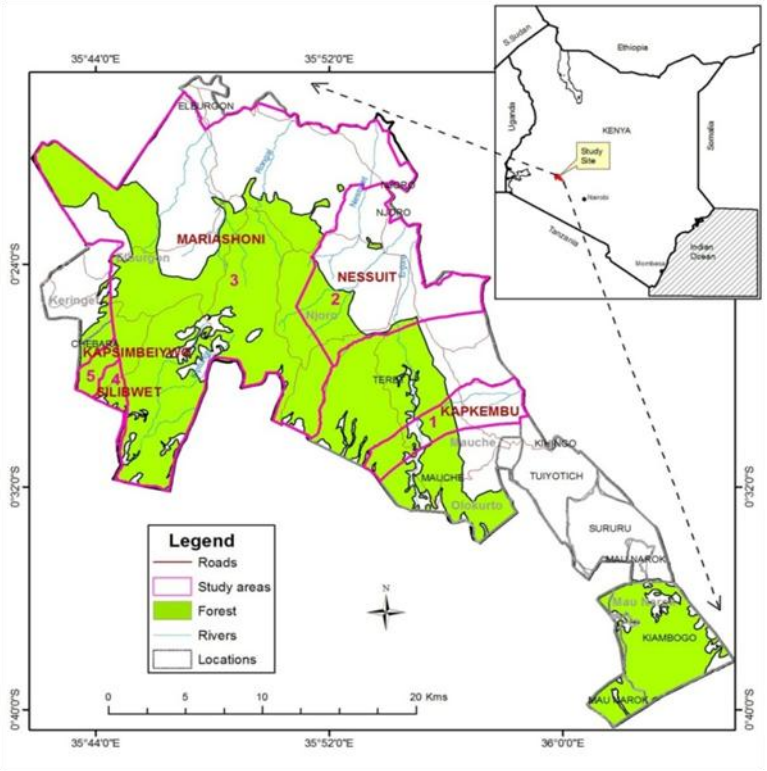

Figure 1: Map of the study area in East Mau forest in Kenya.

MATERIALS METHODS

Materials and Methods

The study site is located about 50 Km south of Nakuru Town at 35° 58' 00" E and 00° 32' 00" S, with an altitude range of 1200 and 2600 m (Fig. 1). It has an area of approximately 280 km^2 and has the highest number of indigenous forest dwellers dominantly belonging to the the Ogiek community. East Mau forest forms an important watershed within the Mau Forest Complex, feeding major rivers and streams that make up the hydrological systems of Lake Victoria and inland Lakes of Nakuru, Baringo and Natron. The forest is a home to endangered mammals like the yellow-backed duiker *(Cephalophus sylvicultor)* and the African golden cat (*Felis aurata*) and other important fauna such as: Giant Forest Hog, Gazelle, Buffalo, Leopard, Hyena, Antelope, Monkey and small animals like the giant African Genet, Tree Hyrax, and Honey badger (Sang, 2001). This makes the forest ecosystem an important resource base for the local communities, national and international community. The total forest area was originally about 66,000 ha but more than one half of it was excised for human settlement in 2001(UNEP et al., 2006). The remaining 30,699 ha consists of high forest, grassland and planted forest mainly of Cypress and Pines (KFS, 2012). The area comprises of the escarpments, hills, rolling land and plains with slopes ranging from 2% in the plains to more than 30% in the foothills. Geological studies have shown that the area is mainly composed of quaternary and tertiary volcanic deposits (Sombroek et al., 1980). In the lowlands , the top soils are of mainly clay loam (CL) to loam (L) in texture and the subsoil texture ranges from silty clay loam (SCL) to clay loam (CL) and clay (C), with pH values ranging from 5.6 to 6.4, making them slightly to moderately acidic in nature (China, 1993). In the lowland, Luvisol, Vertisol, Planosol, Cambisol and Solonetz soils from the Holocene sedimentary deposits are primarily prevalent and occur in saline and sodic phases. In the upland areas however, the soils have a high content of silt and clay predominantly Ferrasols, Nitisols, Cambisols and Acricsols (China, 1993). The adjoining settlements have gentle slopes with deep-fertile-volcanic soils which are suitable for maize, wheat, potatoes, horticultural crops and livestock keeping (Jaetzold and Schmidt, 1982). The climate is characterized by a trimodal precipitation pattern with the long and intense rains from April to June; short rains in August; and shorter, less intense rains from November to December with mean monthly rainfall between 30 mm to 120 mm and total annual precipitation of 1200 mm (Kundu, 2007; Okelo, 2008). The mean annual temperatures are in the range of 12 - 16°C, with greatest diurnal variation during the dry season (Kundu, 2007).

Data collection

Socio-demographic and market survey instruments using semi structured personal interview were used in collection of quantitative data. In most cases, the head of the household was interviewed and in his absence, the wife or the eldest son was interviewed. Household data was collected from respondents from the month of January to May 2013 and September to December 2013. All households within and adjacent to East Mau forest totaling 43,257 households from 17 administrative units (locations) (KNBS, 2010) constituted the research population. Five administrative units were selected in consultation with local administrative officials using two main criteria: age of settlement and ethnic composition of residents. The following administrative locations were selected: Mariashoni representing an old settlement predominantly occupied by Ogiek indigenous community, Kapkembu – representing a recent settlement with a homogenous community of the Kipsigis, Nessuit – representing a recent settlement with a heterogeneous population of indigenous and immigrant ethnic groups and Kapsimbeiywo and Silibwet-representing a relatively old settlement with a homogenous community of the Kipsigis community. Study villages in all the five locations were randomly selected from the list of villages provided by local administrative officials and village elders. Respondents from each village were randomly selected from detailed households' lists on the basis of random numbers. In polygamous unions, households were listed according to the wife's name and each considered a separate household.

The sample size for each study village and location was determined using the most recent national census data (KNBS, 2010) and applying the method by Mugenda and Mugenda (1999). In total 367 households were selected for the study. The socio-demographic survey examined the livelihoods, resources endowment, land size, education level, household size, years of residence, ethnicity, income sources and magnitude, livestock size and distance from the forest. The forest use data included; consumption patterns of forest products (including their sources, average quantity per month, and household monthly consumption), collection and type of forest products, and other associated information. The information obtained from respondents was triangulated using key informants and focus group discussions. The market survey captured the prices of various forest products traded in local markets and prices used to value the household forest-product consumption and determined monetary contribution of the forest products to the total household income.

DATA ANALYSIS

The collected field data were compiled and analyzed using the statistical package SPSS 13.0 and Microsoft Office Excel 2007. In all income calculations, cost of own labour was not taken into account because of substantial existing variations in labour prices depending on tasks and the possibility of multiple work at the same time can lead to under or over estimations of own labour costs (Campbell and Luckert, 2002). All total incomes reported are the sum of cash and subsistence annual household incomes and were computed as shown below:

Household annual income =∑(Forest Income +Agriculture Income +Return to Wealth + Wage Income)

$$Y_{tinc} = \sum_{i=1}^{n} [s_i] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .1$$

Where:

Y_{tinc}= Total household income, S_i= Income source *I,*

Forest income =∑ (Fuel wood annual income +wild fruits income+ poles income + Thatching grass income and forest grazing(The value of forest grazing was estimated based on substitute approach using hay equivalent (Appendix 1 etc.)

$$Y_f = \sum_{i=1}^{n} [C_i P_i - (K_i)] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 2$$

Where:

Y_f= Total forest income, F_i= Quantity of product collected *I*, P_i = Market price of forest product *I*, K_i= Production costs of forest product *i*

Crop income; this was summation of value of yield from various crops grown by a household less all costs of production. Total crop income was calculated as:

$$Y_c = \sum_{i=1}^{n} [C_i P_i - (K_i)] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 3$$

Where:

Y_c= Total crop income, C_i= Yield of crop *I*, P_i = Market price of crop *I*, K_i= Production costs of crop *i*

Livestock income = Σ (Cattle sale income + Goats income + Sheep income + Donkeys income + Chicken income) +income from livestock products i.e.

$$Y_l = \sum_{i=1}^{n} [N_i P_i - (K_i)] + \sum_{i=1}^{n} [Q_i P_i - (Ki) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 4$$

Where:

Y_l= Total livestock income, N_i = Number of livestock in category I, Q_i =is quantity of product from livestock I, P_i = Market price of livestock *I*, K_i = Cash costs of keeping livestock *i*, like pay for herder, costs of medicines, feeds.

Value of household physical assets = Σ (Radio residual value + TV residual value + Bicycle residual value + Tractor residual value + Donkey cart residual value + Car residual value + Cell phone residual value + Fridge residual value +furniture residual value) i.e.

$$Y_{Va} = \sum_{i=1}^{n} [A_i] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 5$$

Where:

Y_{Va} = Total household value of physical assets A_i= Current value of asset *I,*

Income from off-farm income /employment; this was the total value of earnings through hiring out of labour on other households' lands for agricultural or any other economic activity.

Statistical tests

Socioeconomic data presents a challenge in a heterogeneous community where extreme income values from individual households are expected. The data was subjected to normality tests (Box-plot, histogram). All the identified outliers in the data set were removed from the dataset to conform to normal distribution. It was then that parametric tests (ANOVA) were applied (Chan, 2003). In several statistical tests, P≤0.05 level of significance was used. Several tests were conducted on socioeconomic characteristics, χ^2 test for association of locations and sources of forest products, wealth, education level and ethnicity. Comparison of means and ONE-WAY ANOVA were used to test the difference on forest incomes, relative forest incomes on locations, ethnicity and wealth class and separation of means was done using Tukey B.

Measuring forest dependence by households

Total Net forest income (TFI) is summation of both cash and subsistence returns from forest environmental products less transaction costs. Relative forest income (RFI) was calculated as a share of forest income to total household income accounts derived from consumption or sale of forest environmental resources. This was derived as:

$$RFI = \frac{TFI}{TI} \quad \text{.....6}$$

Where: *TI* is the total household income and *TFI* is total forest environmental income.

To test the level of forest dependence of income groups, sampled households were categorized into 3 income groups based on their level of total households income in Kenya Shillings (Very poor: 0-156,000) (Moderately poor: 156001-270,000) and (less poor: > 271,000). The categories were based on local conditions and do not reflect the general poverty levels in the study area and Kenya.

RESULTS AND DISCUSSION

Socioeconomic and demographic characteristics of households

The gender distribution of household heads showed that 62.6% (n= 243) were males while 37.4% (n=145) were females. The mean age of household head was significantly different (P<0.001) for female (53.35±1.9) and male-headed households (47.56±1.2). The majority of the respondents in the Kapsimbeiywo and Silibwet location are immigrants (100%) while in Nessuit there was an equal presence of indigenous (Ogiek-50%) and non-indigenous people (50%). In Mariashoni and Nessuit, the majority of households were of Ogiek tribe (65%) and Nessuit (50%). In Kapkembu, the area is inhabited mostly by non-indigenous group of Kipsigis (92.5%) and a small proportion of Ogiek at 7.5% (Table 1). The majority of households were not born in the current place of residence (64.8%) and only about one third (35.2%) were born in current place of residence.

Results on the highest educational level attained by heads of households revealed that, 73.4% have at least primary level education, while 20% have attained secondary level education and only 6.9% have completed post-secondary education with the lowest 2.4 % and 4.9% in Nessuit and Mariashoni respectively (Table 1).

Livelihood activities of households

Most of the households (90.5%) interviewed are farmers (n=344) relying mostly on rain-fed agriculture and livestock keeping. Crop farming and livestock keeping are the primary occupations of the local people while business, formal employment and sale of forest products and other activities are secondary activities. The total household income ($F_{(4,372)} = 5.10$; $p \leq 0.001$) was significantly different across location and between indigenous and non-indigenous groups ($F_{(1,372)} = 7.82$; $p \leq 0.05$). The total household income in 3 locations of Kapsimbeiywo, Nessuit and Kapkembu was significantly different (Table 1). Agricultural income was significantly different across locations ($F_{(4,382)} = 2.55$; $p \leq 0.05$). The Tukey B test separation of means showed that households in Kapsimbeiywo were significantly different from the households in other locations. However, agricultural household income in Silibwet, Kapkembu, Nessuit and Mariashoni was not significantly different. In addition, income from sale of forest products was not significantly different across location ($F_{(4,\ 72)} = 1.23$; $p \geq 0.05$) and between indigenous and non-indigenous groups ($F_{(1,\ 75)} = 1.62$; $p \geq 0.05$).

Table 1: Socioeconomic and demographic characteristics of sampled households (N=367)

Variable		Location					
		Kapsimbeywo	Silibwet	Kapkembu	Nessuit	Mariashoni	Sig(LSD)
Gender(HH) %	Male	73.3	85.4	67.2	72.0	60.5	NS
	Female	27.7	14.6	32.8	28.0	37.4	NS
Age of HH(yrs)		44.8	48.5	40.3	42.3	40.5	0.05*
HH size							
Number		9.0	10.0	10	9.0	7.0	0.472NS
Adult equivalent		4.9	6.0	5.7	5.1	3.3	NS
Land size and use							
Land size(Ha)		2.5	2.1	2.1	1.7	1.9	0.472NS
Natural forest		0.4	0.4	0.4	0.3	0.4	0.00***
Planted forest		0.4	0.3	0.3	0.3	0.4	0.406NS
Food crops		0.8	0.7	0.7	0.8	0.8	0.204NS
Cash crop		0.5	0.4	0.4	0.3	0.6	0.017*
Pasture land		0.6	0.3	0.3	0.6	0.8	0.00***
Wastelands		0.4	0.3	0.3	0.3	0.4	0.129NS
Resident years		24.8	23.0	13.6	14.8	16.2	N.S
Food months		3.6	4.7	4.4	4.3	4.0	NS
Ethnicity (%)							
Indigenous		0.0	0.0	7.5	50	65	
Non-indigenous		100	100	92.5	50	35	
Education level (%)							
Primary		66.7	60.4	62.7	87.9	89.3	0.05*
Secondary		33.3	27.1	22.4	9.7	5.8	N.S
Post-secondary		0.0	12.5	14.9	2.4	4.9	N.S
Household cash incomes							
Total		170075.85±19237.75(26)^{a}	259363.80±21404.55(44)^{bc}	203385.34±9506.64(67)^{ab}	212286.69±10677.74(123)^{ab}	247952.86±9448.39(117)^{bc}	0.01*
Agriculture		48965.52±7841.79(29)^{a}	56545.45±7899.30(44)^{ab}	65530.30±5140.098(66)^{ab}	73305.08±4626.89(118)^{ab}	58817.39±4161.96(115)^{ab}	0.05*
Livestock		60644.82±7599.54(29)^{ab}	86521.67±8955.22(48)^{c}	62231.34±4571.41(67)^{ab}	37007.90±3642.59(124)^{a}	51899.66±4710.23(118)^{ab}	0.01*
Forest product		18666.67±15666.67(3)^{a}	7937.50±2161.15(16)^{a}	5100.00±1805.55(5)^{a}	25982.14±8182.06(28)^{a}	19720.00±3335.93(25)^{a}	NS
Off farm		127789.65±15021.36(29)^{a}	141563.11±12708.57(45)^{a}	130873.13±6702.83(67)^{a}	119698.18±7509.90(121)^{a}	114714.56±6988.97(114)^{a}	NS

Means followed with the same letter are not significantly different: NS= not significant; LSD= Least significant difference

Table 2: Reported sources of products by households (N=367)

Products	Sources of products (% of households)			
	Public forest	Own farm	Neighbours	Market
Firewood	72.9	21.6	3.4	2.1
Timber	57.0	16.6	6.2	19.2
Charcoal	67.3	8.2	7.6	16.9
Honey	51.6	13.9	9.7	24.9
Medicine	49.9	18.7	5.0	26.4
Poles	35.7	21.7	14.0	28.6
Thatch Grass	30.6	35.0	6.2	28.2
Fruits	34.0	22.3	9.8	34.0
Animal Fodder	66.8	31.3	1.8	0.3
Agricultural Tools	42.8	18.9	1.3	37.0
Forest soils	45.1	21.8	7.3	25.7
Building Stones	41.2	20.0	9.2	29.2
Mushrooms	49.3	14.4	8.1	28.1
Fibres	54.8	19.3	10.6	15.3
Meat	47.1	3.7	2.3	26.8

Livestock ownership among households

Livestock keeping is an important economic activity undertaken by households. The average number of cattle, sheep, goats, donkeys, hens was 5.0, 4.0, 2.0, 1.0 and 7.0 respectively and the mean TLU per household is 4.65 units. Separation of means by Tukey B test indicated that livestock holdings for the very poor households (Mean=3.85, SD=2.78) was significantly different from that of moderately poor households (Mean=5.23, SD=2.41) and less poor households (Mean=4.76, SD=2.54). Total livestock units per household across locations were significantly different ($F_{(4,372)}$ =11.86; p<0.05). Separation of means by Tukey-B test showed that TLU for households in Nessuit (Mean =3.49, SD=2.81) and Kapsimbeiywo (Mean=6.33, SD=2.60) were significantly different. However, households in 3 locations of Sililbwet (Mean=4.99 SD=1.84, Kapkembu (Mean=5.02. SD=1.71) and Marioshion (Mean=5.10, SD=2.46) were not significantly different in livestock units. Additionally, livestock holding (TLU) for indigenous and non indigenous groups were not significantly different ($F_{(1,384)}$ =0.410, P> 0.05).

Land ownership among households

Total land size, land under cash crops and pasture were significantly different however; land under forests (planted and natural), food crops and wastelands were not significantly different (Table 1). Most households in the study area allocate their land use to crops. Between 52% to 74% of the land holding is allocated to agricultural crops and less than 21% (14.2%- 21%) is allocated to forest resources (planted or natural regeneration) (Table 1). The ownership of land differs across locations with highest number of households indicating alternative ownership of land being highest in Kapsimbeiywo (73.3%) and least in Nessuit (4.0%). There was a strong association between alternative land ownership and location (χ^2 =118.65, d.f=4, P<0.001).

Forest use and dependence

All interviewed households reported to obtain and use different products from the forest ecosystem to meet various household needs. Diverse products were collected for home consumption and for sale (Table 2). Generally most of the products were obtained from East Mau forest. Most households reported obtaining their firewood and charcoal from public forest compared to the other sources-(72.9% and 67.3% respectively) and this trend was similarly observed for all products (Table 2). Households obtained food products such as indigenous fruits (34.0%), mushrooms (49.3%), game meat (47.1%) and honey (51.6%) and a small number of households obtained them from other sources (own farms, neighbours and markets). Overall, 45.5% households obtained various foods from the East Mau forest ecosystem. About fifty percent of the households obtained medicinal herbs from East Mau forest. In the study area, 57.0%, 35.7% and 54.8% of households reported to obtain construction materials (timber, poles and fibers respectively) from the public forest (Table 2).

Quantities and value of forest products

The extent of use and monetary value of various products is depicted in Table 3. Most households in the study area collected firewood (90.3%); herbal medicine (83.3%), poles (34.8%), honey (27.4%) and the least collected building stones (5.7 %Table 3). Wood fuel

Table 3: Quantities and value of forest products collected by households ($HH^{-1}Yr^{-1}$)

Product	Unit	Quantities	Value (KES)	% Households
Firewood	Kg	4070.45±167.67	25447.47±1104.60	90.3
Herbal Medicine	Kg	48.78±2.69	7677.09±1781.22	83.3
Poles	Number	343.22±17.62	32959.22±1855.49	34.8
Honey	Kg	102.39±16.95	69424.33±5301.33	27.3
Agricultural tools	Number	104.73±17.50	1053.82±174.60	27.1
Meat	Kg	125.24±12.84	12919.20±1502.18	24.9
Fruits	Kg	256.68±23.44	9573.34±552.13	22.4
Timber	Running feet	171.38±18.46	18292.06±1963.06	20.9
Murram	Tons	120.22±38.21	102.18±32.48	20.8
Fibre	Kg	251.77±38.98	4227.20±383.12	19.9
Mushroom	Kg	257.92±45.98	3021.28±467.80	19.3
Charcoal	Kg	4505.55±1103.20	144156.77±22375.53	9.9
Thatch grass	Kg	179.08±27.80	4530.72±7142.99	7.8
Building stones	Running feet	34.50±4.20	1000.00±656.05	5.7

(Values are arranged as means, followed by SEM (Standard Error of Means)

Table 4: Main products providing forest income (percent of income category)

Product	Location					
	Kapsimbeiywo	Silibwet	Kapkembu	Nessuit	Mariashoni	Mean
Fuel	**17.20**	**59.80**	**50.30**	**51.40**	**66.90**	**49.10**
Firewood	10.80	3.90	5.10	4.40	4.10	5.70
Charcoal	6.40	55.90	45.10	47.00	62.90	43.40
Food	**26.60**	**28.30**	**28.70**	**29.00**	**19.70**	**26.50**
Fruits	1.00	3.10	2.80	1.90	1.90	2.10
Honey	9.40	15.50	13.40	13.90	10.00	12.40
Mushroom	14.10	7.60	10.00	8.40	5.50	9.10
Meat	2.00	2.00	2.60	4.80	2.30	2.70
Structural and fibre	**46.00**	**7.10**	**14.40**	**11.80**	**7.40**	**17.40**
Timber	6.40	2.70	5.40	4.00	2.10	4.10
Poles	39.40	4.30	8.50	7.60	5.00	13.00
Agricultural tools	0.20	0.10	0.60	0.30	0.20	0.30
Grass	**7.60**	**3.80**	**4.60**	**5.10**	**4.60**	**5.10**
Thatch grass	1.10	1.10	0.80	2.00	2.80	1.60
Fodder	6.50	2.70	3.70	3.10	1.80	3.60
Herbal Medicine	2.60	0.90	2.00	2.60	1.20	1.90
Others	0.00	0.10	0.00	0.00	0.20	0.10
Total	100.00	100.00	100.00	100.00	100.00	100.00
% of total household income	28.80	30.70	32.90	36.50	33.40	32.50
Absolute value(KES)	47662.00	63427.00	65218.00	66580.00	71642.00	62906.00
Absolute value (US$)	530.00	705.00	725.00	740.00	796.00	699.00

(firewood and charcoal) was the dominant source of forest income with a mean of 49.1% of forest income per household and this was followed by food products (26.5%) and structural and fibre products (17.4%). Firewood was the most frequently collected product by households and each household collected an average of 122 back-loads (4100 kg) of firewood per year worth about KES 25,000 (US$ 280) accounting for 5.7% of forest income (Table 4). Another popular product collected by households was medicine (83.3%) with an average of about 50kg per year. However, in terms of monetary value per household charcoal, honey and poles scored the highest. The values of these products were KES 144 156, 69 424 and 32 959 respectively (Table 3). Though charcoal was not the most collected product (9.9%); its contribution to household forest income was 43.4%. Other individual valuable products in terms of accrued income were poles and honey each contributing to 13.0% and 12.4% respectively. The total forest income ranged from 28.8 % to 36.5% with overall

Table 5: Absolute forest income, relative forest income (%) by study location, wealth status and ethnicity

Variable		Absolute forest income	Relative forest income (%)
Location	Kapsimbeiywo	47662.10±6236.81[a]	28.85±3.70[a]
	Silibwet	63427.11±6470.64[a]	30.71±3.34[a]
	Kapkembu	65217.56±4801.03[a]	32.89±2.18[a]
	Nessuit	66579.73±3762.37[a]	36.46±1.84[a]
	Mariashoni	71641.51±4711.57[a]	33.42±2.40[a]
Overall mean		65836.28±2232.06	33.73±1.10
		$F_{(4,309)}$=1.76 ;P >0.05	($F_{(4,294)}$ = 1.18 P >0.05
Wealth status	Very poor	46275.90±2822.40[a]	41.40±2.13[a]
	Moderate poor	67277.30±3932.40[b]	35.60±2.03[b]
	Less poor	81463.80±3797.70[c]	26.30±1.30[c]
		$F_{(2,309)}$ = 23.87; P< 0.01	$F_{(2,296)}$ = 18.35; P< 0.01
Ethnicity	Indigenous	63536.12±3961.22[a]	31.93±1.75 [a]
	Non-indigenous	62658.47±2196.54[a]	33.15±1.25 [a]
		($F_{(1, 241)}$ = 0.74; P> 0.05)	($F_{(1, 245)}$ = 0.307; P> 0.05)

*same letters indicate no significant difference

mean of 32.5% (Table 4).The proportion of households whose animals depended on grazing resources in the public forest ranged from 57.1% (Kapsimbeiywo) and the highest of 77.9% in Mariashoni. Overall, 66.8% of the households reported using the forest as a source of fodder for their livestock. The monetary value of this use ranged from KES 11983 to 17974 per household /yr.

Forest dependence by household in East Mau

The households in East Mau are dependent on East Mau forest for various products and services. The net forest income and relative forest income is summarized in Table 5. The forest dependence was calculated as the ratio of total forest environmental income to the total household income and expressed as a percentage.

Comparison of absolute forest income and relative forest income

The level of dependence is greater than 25% in all study locations –ranging from 28.8% to 36.5% with overall mean of 33.7% (Table 5). The absolute forest income and relative forest income were not significantly different between households in the five study locations.

Comparison between income and ethnic groups

The differences in absolute and relative forest income among income classes and between ethnic groups regarding forest dependency were analyzed using one-way ANOVA. Absolute forest income and % forest income across income groups (P<0.01) were significantly different, meaning there is substantial difference in absolute forest income (Very poor = 46275.90±2822.40, moderate poor household = 67277.30±3932.40 and less poor household = 81463.80±3797.70) and relative forest income (%) (Very poor = 41.40±2.13, moderate poor household = 35.60±2.03 and less poor household =26.30±1.30). The very poor households benefit less in absolute terms from the forest resources than the moderate poor and the less poor (Table 5) (Very poor < Moderate poor < Less poor). However, in relative terms (%forest income) the very poor derive more than the two categories (Very poor > Moderate poor > Less poor) (Table 5 and Figure 2). Additionally absolute forest income ($F_{(1, 241)}$ = 0.74; P > 0.05) and relative forest income ($F_{(1, 245)}$ = 0.307; P> 0.05) were significantly different between the ethnic groups.

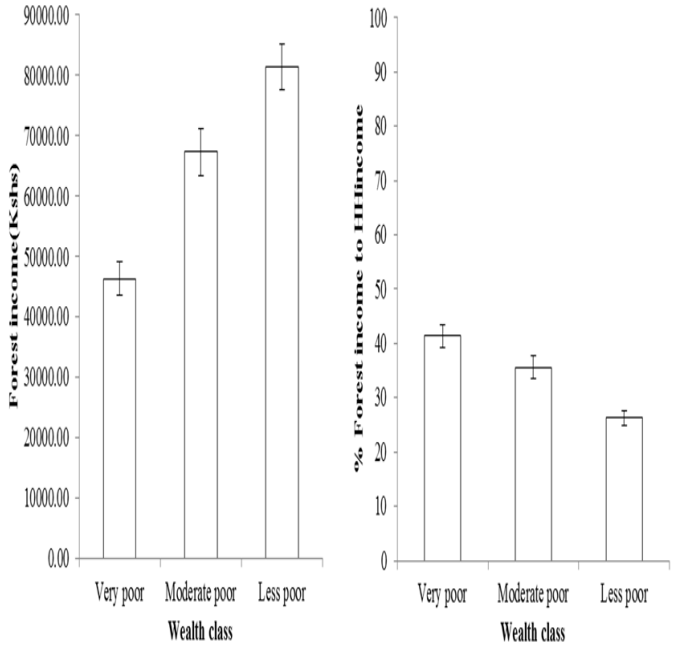

Figure 2 Absolute and relative forest income (%) among wealth groups in East Mau

DISCUSSIONS

Socio-economic and demographic characteristics

The average family size in the study areas of (8.8±3.2) is higher than national average of 5.3 persons per households (KNBS, 2010). However, households in Mariashoni showed lower family size. Male headed households are dominant in the study locations and this is consistent with customs of the local people where males are expected to be the heads of households and only females assume this role upon bereavement. It was established that there was significant variation in asset endowment (land, physical assets, and livestock). Because crop farming and livestock are main livelihood activities in the study area ownership and access to land is one of the key determinants of livelihood options of the local people. On average, households in Nessuit and Mariashoni have less land compared to households in other locations.

Most of the study areas, (Mariashoni, Nessuit and Kapkembu) were once part of East Mau forest. However, it was excised in 1990's and early 2000 for human settlement (UNEP et al., 2006). Each household in the settlement scheme was allocated 2.5ha. The results showed that households in Nessuit and Mariashoni currently have smaller land size than originally allocated. This is most likely due to land transactions which may have occurred in the two locations. This finding was corroborated during focus group discussions which indicated that the area has attracted new settlers due to high productivity of the land for food and cash crops. Influx of immigrants into the new settlement areas has been witnessed in the last decade. This is evident from the growing heterogeneity in ethnic composition as affirmed by household data which revealed that most of the household heads (64.8%) were not born in the current place of residence (Table1). Households in Kapsimbeiywo have the highest access to land and this is reflected in the fact that about 78% of households have alternative access to land. This phenomenon of emigration from other areas in search of land and livelihood opportunities conforms to what has been established in other African societies where migration is influenced by demographic trends and the search for livelihood opportunities (Heubach, 2011). Furthermore, male-headed households are better off than female-headed households in terms of land ownership, livestock and physical assets. There was no significant association between gender and income class (χ^2=5.49, df = 2, P>0.05; P_{value}=0.064). The implication of this finding is that gender is not an important factor in explaining the wealth status in the study area. This could be attributed to the fact that most female headed households may have inherited assets of their husbands – a practice common among the local community. Households in the study area have adapted a diverse portfolio of livelihood activities such as farming, livestock keeping, forest product, small trade and remittance. The most common livelihood activity is farming and livestock keeping. The local indigenous communities such as the Ogiek have largely depended on livestock and forest resources. This is however, changing due to the growing influence of immigrants from other counties. There is evidence of increasing diversification of income opportunities by the indigenous community. This is consistent with what has been observed by other studies on rural communities where livelihood diversification in livelihood strategies is predominant (Ellis, 2000; Belcher et al., 2005; Mamo et al., 2007; Kamanga et al., 2009) because single livelihood strategy is insufficient for the needs of most rural households (Sunderlin et al., 2005).

There was a strong association between educational attainment and ethnicity (χ^2=3.49, df = 2, P>0.05; P_{value}=0.034)). The household heads of non-indigenous groups had higher post -secondary qualifications compared to areas (Mariashoni and Nessuit) dominated by Ogiek community which we observed had fewer schools. Livestock size (TLU) in the study area showed significant results pointing to the fact that the ownership of large herds is associated with access to alternative land. The households which had alternative land also showed large livestock size and lowest forest grazing incidence. Forest grazing is dependent on seasonal availability of fodder on the farms and forest grazing is an alternative resource .The implication is that alternative land ownership accounts for the additional livestock units owned.

The results from this study support the premise that local people depend primarily on forest resources for subsistence needs and at times for sale. The highest contribution to household forest income is fuel wood (50%) and food products (27%). The high value from fuel wood use category could be explained by the significantly high level of firewood collection by majority of households (90.3%) and the relatively high value of charcoal. The study has revealed that forest income contributes between 25% and 36.5% of household income in the study area. This could be explained by low level investment in tree growing and less retention of natural forests on individual farms and ease of access to public resources (Table 1). These findings are consistent with the results from studies in two forest blocks of Mau forest complex (Western Mau, Tindiret) (Langat et al., 2005; Langat and Cheboiwo, 2010) and in Uganda which found that local people are increasingly dependent on forest resources for subsistence and cash income (Barirega et al., 2012). The findings on forest reliance confirm what others have concluded in other parts of Africa for example, Cavendish (1999) found out that 35% of rural household income is derived from environmental products in Zimbabwe. Fisher (2004) showed that 30% of household income in rural Malawi is contributed by forest income. Mamo et al., (2007) in Ethiopia highlands found out that 39% of the household income is contributed by forest income and nearly equaled

combined livestock and agricultural incomes. Another study by Kalaba et al., (2013) in Miombo woodlands of Zambia showed that forest income contributed 43.9% to the average household income. In a compressive comparative analysis of environmental income, Angelsen et al., (2014) found that environmental income accounted for 28% of household income in 24 developing countries. Therefore it can be argued that the findings of this study are in agreement with similar findings elsewhere and corroborate the importance of forest resources to households. In terms of who benefits more from forest resources, the moderately poor and higher income households derive higher absolute forest income than the very poor households. This is probably because the high income (less poor) households are engaged in high value products such as timber, poles which require more resources such as (equipment) which may not be accessed by very poor households and the poor in most cases are engaged in less lucrative and often labour intensive forest extractive activities (Arnold and Townsend, 1998). This fact is supported by the finding that poor households had the lowest aggregate physical value of assets. Limited access to financial and social capital has been advanced by various authors (Angelsen and Wunder, 2003; Dewi et al., 2005) to explain the inability of the very poor households to benefit substantially from environmental resources. In some cases, difference in political power has been suggested to explain why resource use is skewed in favour of the rich (CBD, 2010). However in relative forest income, lower income households showed higher level of forest dependency. These findings on the higher dependency on forest resources by the very poor income groups are consistent with findings of Cavendish (2000), Neumann and Hirsch (2000); Babulo, (2007); Mamo et al., (2007), Mariara and Gichuki, (2008); Kamanga et al., (2009); Babulo, et al., (2009); Illukpitiya and Yanagida (2010), Heubach (2011) and Angelsen et al., (2014).

CONCLUSION AND RECOMMENDATIONS

The study has revealed the important role of forest resources in household income. It was found out that the contribution of forest income was higher for poor households. However, in absolute terms, the better off households are advantaged. Very poor households showed high dependence on the forest resources despite the illegal access to these resources. On average 33% of annual household income is generated by consumption and sale of forest products. With the increasing population in East Mau and surrounding areas, the demand on forest resources are likely to rise and this will exert pressure on the state of forest resources in East Mau. However, reflecting on the findings of this study, it would not be prudent to exclude the access of forest resources to the local community because; it may worsen their welfare and may lead to increased poverty.

One way of managing the situation would be to allow low level extractive activities such as firewood collection and enforcing licensing procedures to allow for low extraction level, essentially for subsistence use and discourage commercial extraction. Another way to ease the pressure on East Mau is to promote intensification of tree growing on farms through support for agro forestry or farm forestry interventions. The current policy on 10% cover on farms is an important entry point for this kind of intervention. Another strategy is to lower the opportunity cost of engaging in forest resources by creating robust income opportunities independent of forest product extraction or improving the technical efficiency of agricultural and production systems in order to minimize illegal forest exploitation. These measures may improve rural livelihoods and conserve forest resources and biodiversity.

ACKNOWLEDGEMENTS

The authors express their gratitude to East Mau community for their willingness to share with us their information on forest use. Special appreciation to field data crew: Judy Chepwogen, Paul Ngetich, Jona Ngetich, Maureen Chebet and Clarkson Ruto and local administrative officials in the study areas. We are grateful to the Director Kenya Forestry Research Institute for financially supporting this study.

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APPENDICES

Appendix 1: Estimation of the value forest grazing

According to the household data livestock data the mean livestock numbers 4.9 livestock units and 67% of households graze their animals inside the forest and forest fodder/browse make up to 40% of the fodder requirements. From literature, the dry fodder requirement for livestock is taken to be about 2−3% of the body weight per day (Ganesan, 1993) and a livestock unit (250Kg) requires a minimum quantity of fodder for maintenance of between 5.0-7.5 kg per day.

Step 1: Calculate the number of households who graze their animals = (43.527*67)/100=29.163

Step 2: Calculate the total number of livestock units grazing inside the forest =29163*4.9=142898

Step 3: Calculate the Total Dry matter requirements for the total livestock units for the whole year from the forest

1 TLU requires between 5.0 and 7.5Kg per day; therefore 365 days =142.898*(5.0 -7.5)*365

The total dry matter requirements per year is between 260.788.850 and 391.183.275kg

40% of the total fodder requirements are obtained from the forest and therefore forest contribute between 104.315.540 and 156.473.310 kg.

Step 4: Convert the estimate quantities of dry matter into Hay equivalent

1 bale of hay weighs 30kgs; the number of equivalent hay is between 3.477.185 and 5.215.777 bales.

Step5: Calculate the monetary value of hay using the current market price. The current market price of 1 bale is Kshs 150.

The total value of forest grazing is Kshs 521.577.750 and 782.366.550/yr

The value /HH/Yr is between 11.983 and 17.974