AFRICA ENVIRONMENTAL REVIEW Journal
ISSN: 1727-8341

AER Journal Volume 3, Issue 2, pp. 1-19, 2019

RESEARCH ARTICLE
Available Online at *http://www.aer-journal.info*

Forest Ecosystem Resources for Alleviating Household Poverty in Eastern Mau, Kenya

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Abstract

Forest ecosystem resources are critical to forest-fringe rural households who depend on it to sustain their livelihood outcome like alleviating household poverty. The importance of forest ecosystem resources has long been recognized but has seldom been quantified and analyzed. In this paper, we examine distributional and poverty effects of forest ecosystem resource extraction among households living along forest peripheries in Eastern Mau forest reserve. Primary data was collected from forest-fringe rural households living four kilometers from the forest margin. This study site was purposively selected to be within six-administrative locations that straddle Molo and Njoro sub-counties. Semi-structured questionnaire survey instruments and interviews were used to generate the data. The main objective of the study was to determine the effect of forest-based income in poverty alleviation on forest-fringe rural households. The marginal impact of forest-based income on total household income was computed to analyze the effect of forest-based income on household poverty. Similarly, Foster-Greer-Thorbecke (FGT $_{(\alpha)}$) poverty indices were used to decompose diverse household income components. The model was used to determine the impact of each household income component on (FGT $_{(\alpha)}$) poverty indices. The (FGT $_{(\alpha)}$) poverty indices revealed the marginal impact of forest-based income on household headcount poverty (FGT $_{(\alpha=0)}$) which reduced from 0.497 to 0.421, indicating a reduction in measured household poverty by 15.86%. Also, forest ecosystem resources contribute approximately 12% to total household income. The paper concludes that forest ecosystem resources have a significant role in alleviating household poverty. As such, it recommends to state-actors to formulate governance structures and policies that concomitantly enhance efficient conservation and management of forest ecosystem resources while embedding sustainable household livelihood outcomes.

Keywords: Forests, Ecosystem, Poverty, Livelihoods, Sustainability, Mau, Kenya

INTRODUCTION

The economic mainstay of most forest-fringe poor rural households in sub-Sahara Africa is derived from on-farm income or agricultural income activities. These activities are derived from crop and livestock production. Other household regular income activities include off-farm incomes, mixed-income sources and transfers incomes. Forest ecosystem resources are extracted by households and utilized to construct forest-based income, a

non-regular household income (Gecho *et al*., 2014; Keenan *et al*., 2015; Tesfaye *et al*., 2011). Forest-based income is most critical because rural households use it to increase total household income and thus alleviate rural household poverty (Brocklesby & Fisher, 2003; Chitiga-Mabugu *et al*., 2016; Gibson, 2016).

Rural household poverty is a composite phenomenon with various versions of definitions. Scholars such as Biyase and Zwane (2018), Burger *et al*. (2016), Ezzat & Ezzat (2018), Kumar (2019), Ngema *et al*. (2018) and Wang (2019) have observed poverty effects on rural households to be hampering their ability to meet basic needs. Studies by Biyase and Zwane (2018) show that rural household poverty is multifaceted and multidimensional and is caused by conditions of deprivation. For example, household inadequate food and nutrition, poor housing or shelter, inadequate water and sanitation, poor healthcare and lack of universal education. These conditions are exacerbated by a household income shortfall which is a failure to cover basic household daily needs (Biyase & Zwane, 2018; Lin, Zhang & Lv, 2019; Randall & Coast, 2015; Soltani *et al*., 2012). Equally, rural household poverty manifests itself as income shortfall that affects the general wellbeing of households (Ferreira *et al*., 2015; Jolliffe & Prydz, 2017; Maloma, 2016). A report from World Bank, (2004) shows poor rural households depend majorly on household on-farm income activities to maintain their standards of living but forest ecosystem resources are still critical in supplementing total household income.

Globally, the estimated value of forest ecosystem resources is estimated to contribute approximately US$ 145 trillion to rural household total income. In sub-Sahara Africa, forest ecosystem resources is estimated to contribute approximately $US 5.4 trillion to total household income (Babulo *et al*., 2008; Costanza *et al*., 2014; Ouedraogo & Ferrari, 2015; Riera *et al*., 2012; Schaafsma *et al*., 2014; Tolessa *et al*., 2017). Over 1.3 billion rural households in low-income economies of the world, therefore, depend on forest ecosystem resources for sustaining their household livelihood outcomes and reducing household poverty (Babulo *et al*., 2009; Kabubo-Mariara & Gachoki, 2008). The overarching objective of forest-fringe poor rural households the world over is to increase total household income thus alleviating household poverty (Robinson, 2016; Ward & Shackleton, 2016).

The forest-fringe poor rural households living in the margins of low-income tropics depend on forest ecosystem resources for various economic functions. The main function is to increase total household income (Babulo *et al*., 2008; William Cavendish, 1999, 2000). There are other economic functions of forest ecosystem resources as noted by Illukpitiya and Gopalakrishnan (2015), Kamanga *et al*. (2009), Mutenje *et al*. (2011), Tesfaye *et al*. (2011) and Vedeld *et al*. (2007). These functions include the resources being used as a safety net, insurance premium and a cushion to rural households against unexpected shocks resulting from climate-change-induced weather fluctuations. These studies have shown forest-based income to be critical in household livelihood sustainability. The forest-based income in most developing countries, like Kenya, is not considered in the computation of national income accounting and national Gross Domestic Product (GDP). The climate change-induced weather fluctuations have caused calamities of floods and droughts which cause unexpected losses and shocks due to resultant income shortfalls. As a way of mitigating against these shocks, households utilize forest ecosystem resources to construct forest-based income to ease income shortages (Boafo *et al*., 2016; Burtraw & Woerman, 2013; Farinola *et al*., 2014; Pramova *et al*., 2012). Forest ecosystem resources, therefore, play a

critical role in augmenting regular household on-farm income activities.

Most poor rural households living in forest margins in sub-Sahara Africa primarily depend on on-farm income activities to maintain their standards of living and to sustain their livelihood outcomes (Megbowon, 2018). Equally, rural households in low-income quintiles depend more on large quantities of forest ecosystem resources with low income values. Similarly, those in high-income quintiles depend more on low quantities of forest ecosystem resources but with high income values. The household on-farm income activities are, therefore, considered as the primary regular household income activities derived from crop and livestock production and these two household on-farm income activities contribute two-thirds to total household income (Biyase & Zwane, 2018; Sujakhu *et al*., 2018). Equally, the other regular income activities are off-farm incomes, mixed income sources and transfers income (Das & Sarker, 2008; Illukpitiya & Yanagida, 2010; Walelign *et al*., 2017). The studies cited above have illuminated our understanding on the underlying causes of deforestation and degradation that threaten the health and integrity of forest ecosystem resources. Studies (Bouda *et al*., 2011; Ouedraogo & Ferrari, 2015; Ward & Shackleton, 2016) show that forest ecosystem resources are public goods that are non-rivalry and non-excludable in consumption. This means the forest ecosystem resources are free-ridden by households in consumption. This is because once the resource products are produced, none can be excluded from consuming it. This nature of public goods is thought to be the cause of household inefficient allocation of forest resources which has led to resource undersupply and degradation. Also, studies (Hermans-Neumann *et al*., 2016; Hojas-Gascon *et al*., 2015; Soares-Filho *et al*., 2006) show forest ecosystem deforestation and degradation is caused by household poor land use management practices. The practices have led to degradation of watersheds, loss of biodiversity habitats and pollution of wetlands. Equally, the practices have led to the encroachment and settlement in the forestlands. This has led foregone forest resources and loss of forest-based income leading to substantial loss of economic distributional effects (Kamanga *et al*., 2009). It is estimated that the loss of these forest ecosystem resources may lead to the extinction of the gene resources in the foreseeable future (WRI, 2005). The household motivation of forest encroachment and settlement is agricultural extensification pushed by household population explosion. The increase in population has pushed up the demand for more food and other basic needs. In addition, the forest resource quantities and qualities have, over the decades, been dwindling hence the encroachment has not been able to increase resource products for household use. Studies by Ebenezer and Abbyssinia (2018), Ferreira *et al*. (2015) and Ouedraogo and Ferrari (2015) show the effects of diminished forest ecosystem resources have reduced the availability and access to free forest ecosystem resources.

Over the decades, forest-fringe poor rural household in the countries of sub-Sahara Africa, like Kenya, have slid down the poverty line because of non-performance of both regular income sources and non-regular forest ecosystem resources. In Kenya, the average rural household poverty rate was approximated at 46% and it has been estimated to have increased in the last decade. This is the current situation despite the state-actor introduction of poverty reduction strategy frameworks (KNBS, 2010). A study by Barbier (2010) shows that rural households who are deeply in poverty tend to over-extract the forest products in an attempt to find a pathway out of poverty. This is supported by Wunder (2001) who shows that rural households inefficiently allocate the forest resources in consumption as they attempt to increase their total household incomes.

Research (Kamanga *et al*., 2009; Mamo *et al*., 2007; Shackleton *et al*., 2011; Vedeld *et al*., 2007) shows there has been inefficient conservation of forest ecosystem resources in low-income economies caused by a drop in the available quantities of forest ecosystem resources. Consequently, the forest resources drop has led to poor distributional effects of forest-based income. A drop in the values of forest-based income decreases total household income which reduces poverty alleviating effects (Cavendish & Campbell, 2008; Fisher, 2004; Lopez-Feldman *et al*., 2007). Although rural households depend primarily on on-farm income activities, a study by Cavendish (1999) shows forest ecosystem resources are critical in the alleviation of household poverty. Cavendish (1999) reveals the computation of household poverty is often overstated by 98% because state-actors do not consider forest-based income in national income accounting. Equally, a study (Reddy & Chakravarty, 1999) reveals that when forest-based income is simultaneously set at zero and on-farm income is increased by 10%, rural household poverty increases by 28%. This analysis is evidence that on-farm income activities alone are not sufficient to neutralize household poverty. It can be inferred from this analysis that an increase in on-farm income without forest-based income cannot alleviate household poverty. Conversely, studies by Pretty (2008) and Pretty *et al*. (2011) show that improved performance of on-farm income activities, does not alleviate household poverty alone without considering forest-based income. This result proves that forest-based income as constructed from forest ecosystem resources plays a critical role in alleviating household poverty. Also, a study by Fisher (2004) shows rural households living in Southern Malawi reduced household poverty by 12% by consuming on-farm income and forest ecosystem resources. Equally, a study by Jodha (1990) shows rural households living in the dry regions of India depended on forest-based income and on-farm income to reduce household poverty by 7%. This result has been supported by research findings from Lybbert *et al*. (2002) who observe that rural households in Morocco use argan oil products and other income sources to alleviate household poverty.

In most countries of sub-Sahara Africa, like Kenya, state-actors have not introduced technological innovations to enhance on-farm income activities. For example the use of value-chain production mechanisms (Brown & Brown, 2006; Greer & Thorbecke, 1986; Ricker-Gilbert *et al*., 2014; Worden *et al*., 2009) which focuses on intensification of on-farm income activities aimed at bridging production-yield-gaps. In support of this, studies by Langat *et al*. (2016) show rural households living on the margins of the Eastern Mau forest ecosystem utilized forest ecosystem resources to smooth shortfalls in on-farm income activities. This shows that forest ecosystem resources acted as compensating mechanisms for rural households against the losses from underperforming household on-farm income activities. Conversely, studies by Jagger *et al*. (2012) show poor land uses in Western Uganda are the causes of on-farm income underperformances, for example, household population explosion, household land conflicts and forest clearing for household settlement. It shows that these land-use activities affect the performance of both forest ecosystem resources and on-farm income activities. According to studies (Lambin & Meyfroidt, 2011; Popoola, 2015; Ingram, 2014; Arnold, 1998; Thondhlana & Muchapondwa, 2014; Van Hecken *et al*., 2013), many forest-fringe rural households have become poorer over the decades because of underperformance of forest ecosystem resources and on-farm income activities. Lastly, the continued underperformance of household regular income activities has caused households to over-extract forest resources in an attempt to smoothen the income shortfalls.

The general objective of this study was to assess the impacts of forest-based income in alleviating rural household poverty and the specific objectives have been analyzed. The first objective is to evaluate the economic importance of regular household on-farm income activities which are derived from crop and livestock product and to determine its income contribution to total household income. The second objective is to determine the economic functions that rural households derive from foraging forest ecosystem resources how much forest-based income contributes to total household income. The third objective is to use the Foster-Greer-Thorbecke (FGT) poverty indices to analyze the poverty alleviating effects of forest-based income when it is considered with and without total household income.

STUDY AREA AND METHODOLOGY

Study Site

Sampling in the study area commenced with a reconnaissance survey which was done in June 2012 to July 2012. The questionnaires were pre-tested in August to December 2012. The collection of data commenced in January 2012 and ended in June 2013. The representative sample size was determined using a multi-stage cluster sampling formula (Bassioni *et al.*, 2003; Grandval & Vergnaud, 2006). A representative sample of 450 households was obtained from a sample frame of 1,800 households in the study area. The representative sample represented 25% of the sample frame. The 450 respondents were interviewed using a multi-stage sampling technique. The study site comprised six administrative sub-locations of Molo and Njoro sub-counties of Nakuru County (Figure 1). The population concentration in the sub-locations has been summarized in Table 1. The highest population in the study site was located in Ndoshua (26.77%) and Kitiro (20.34%). The inhabitants in the study area were rural at 75.65%.

This site is situated along Eastern Mau forest reserve. It is one of the remaining 21 contiguous forests of the greater Mau Hills Forest Complex. Kenya's current forest cover is estimated at approximately 6.99% of the total landmass and is expected to be expanded to 10% which is the constitutional minimum level (KNBS, 2010). Eastern Mau forest ecosystem has high species-richness and endemism that comprises small and mega terrestrial biodiversity. Forest-fringe poor rural households living along forest-peripheral areas of Eastern Mau utilize forest ecosystem resources to sustain their livelihood outcomes. The study area was purposefully selected because Mau Hills Forest Complex, as one of Kenya's largest water towers, is rich in forest resources. It is situated about 190 km North-West of Nairobi and lies on 35°58'00"E and 00°32'00"S. The area is on an altitude range of 1100 m above mean sea level at the lowlands and rises to 2800 m at the highlands. The highest level of Eastern Mau is the mountain summit that is at 5800 m above the mean sea level. The site was chosen because of its demographic stability in the past 12 months. Equally, the area lies in the peripheries of rich forest resources. Forest-fringe rural households living along Eastern Mau forest reserve mainly engage in smallholder on-farm and other income activities to maintain their standards of living. The farming activities in these areas have high yields because of good microclimatic conditions.

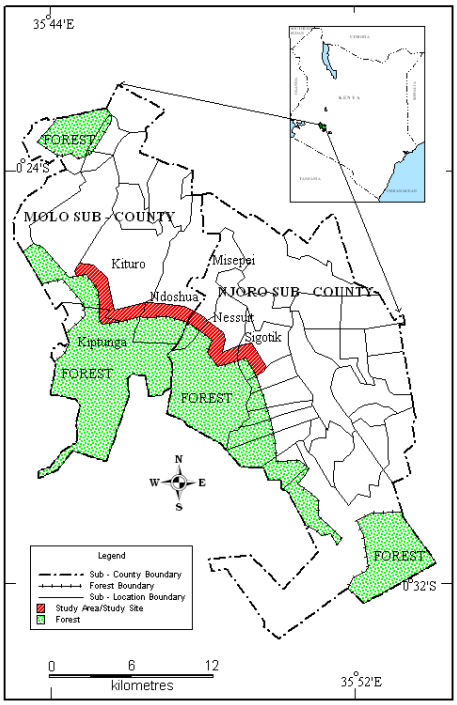

Figure 1: Map of Kenya and Eastern Mau Forest Reserve.

Sampling Procedures

A representative sample size (n=450) was determined using a multi-stage cluster sampling formula adapted from Bassioni *et al*. (2003), Grandval and Vergnaud (2006) and Mouakhar and Tellier (2013). The first stage was to delineate households living within a four-kilometer radius from the forest protected area. These were households living in the six sub-locations purposively selected as study sites. The second stage was to select, using stratified random sampling method, five villages in the six sub-locations. The method was used to as it took into consideration the distribution of survey villages along with the four-kilometer forest band. The stratification method also put into consideration the variations across the six sub-locations in the study (N=30 villages) (Figure 1). The location of each village was checked to ensure sufficient geographic distribution along with the forest band. A list of rural households residing in each village of the six sub-locations was compiled. The village register was done by key informants and village leaders. Sixty households were randomly selected from the thirty villages. The third stage was to enumerate households living in all the 30 identified villages. A total of 1,800 (sample frame) households were enumerated in the six villages. The fourth stage was to determine a sampling fraction to guide in systematic random sampling. A sampling fraction was computed by dividing the representative sample by the sample frame which gave (0.25 or 1/4) as the fraction (450/1,800). In a multi-stage random sampling procedure, all rural households in the sample area get a fair and equal chance of being sampled. A systematic random sampling procedure was performed. The counting was commenced from a predetermined commencement point on the sample frame. This started with systematic counting of four households from the commencement point. The 5th household was assigned a random number #1 then interviewed. The next four households were

counted and 10th household was assigned a random number #2 then interviewed. The process continued until all the 1,800 households were counted. The last household to be counted and interviewed was assigned a random number #450.

Estimating Regular Household Income Dependency Strategies

Semi-structured questionnaire survey instrument was used to collect data from respondents. The household income earnings per capita per year were computed for each household and clustered into data diversified household income dependency strategies. The incomes were captured in absolute and relative terms as in tables 2 and 3. The data on the quantities for each household income activity and the prices of the products consumed and sold for immediate was captured. The household income earnings were estimated using market-based approaches and so the market-clearing prices for each product were used. Rural households were asked to remember the quantities and prices of products they harvested and those they consumed in the past 12 months. The income earnings were measured as income per capita per year. Rural households engaging in regular or conventional income was measured as aggregate net income from diversified household income portfolios. The diversified income portfolios include on-farm or agricultural income which was derived from crop and livestock production. Off-farm income was from wage and salary employment income. Mixed-income was derived from non-farm and non-wage income, asset selling, rental income of premises or land hired out. Transfers income activities included all income received as remittances from kinfolk and friends in the diaspora or away from the locality. Household on-farm/agricultural and all these other incomes were aggregated as net income earnings per capita per year (Tables 2 and 3). All these incomes were treated as regular or conventional household income portfolios. The incomes were estimated as a separate income component.

Estimating Income Values from Crop Production

Crop production income was accounted as the gross value of crop production minus purchased inputs and any costs of handling in the past 12 month's period of assessment. Crop production included commercial crop production and that which was consumed by the household. The computation of gross crop incomes included total crop sales and income from the sale of its by-products. Crop production costs were computed and netted off from the gross income. Cost of crop inputs, where applicable to a household could include, for example, certified seeds, cultivars, organic and inorganic fertilizers, pesticides, herbicides, land rentals, hired labour, storage, transportation, and marketing. Most household inputs were seeds and organic manure or for some inorganic fertilizers. Most of the poorest households consumed their produce as subsistence-self consumption. The foods consumed were staple foods like maize, beans, potatoes, and vegetables. The questionnaire captured the value of crops given out to other households or as gifts to other third parties. In each of the estimation of crop values, households were asked to provide the gross value of commercial production. They provided the quantities of the produce and the prices for which they were paid. These prices were paid for commercial were used to compute the value of the produce they had consumed at the household level as presented in Tables 2 and 3.

Estimating Income Values from Livestock Production

Livestock production income activities were computed based on livestock unit sales in the past 12 month's period of assessment. Livestock production income was estimated as the change in the value of standing herds. This income included income from sales and gifts of animal and animal products to other households. It included value for subsistence self-consumption of own-produced animal and animal products. The computation deducted livestock purchases

or associated input costs. For example, animal feeds and animal security if any, pasture and fodder, veterinary drugs, treatment costs, and vaccines. The other costs include acaricides or tick control management which includes the cost of de-worming drugs and Artificial Insemination (AI) services. Livestock gross incomes were determined based on the number of livestock sold including by-products sold or consumed by households. The cost associated with livestock was computed as livestock initial unit price plus input costs as presented in Table 2 and Table 3.

Estimating Income Values from Other Income Sources

The estimation of off-farm income which is income derived from wages and salary employment was aggregated across all household members employed and the job income from each. Off-farm income activities were captured as wage income from menial jobs or for a daily labourer or hourly wages or piece rate. The wage income was captured for each worker for all jobs done in the past 12 months. Salary employment income was also captured across rural households and jobs in the past 12 months as presented in Tables 2 and 3.

Mixed-income activities were estimated for those households engaging in trading of all kinds. There are shopkeepers and middlemen and women trading in farm produce, farm inputs and forest products. They also trade in all forms of asset selling, rental hiring, land hiring all these re mainly business activities that are non-wage and non-farm. These businesses were aggregated as income-generating activities across all household members (Tables 2 and 3). Transfers-income was estimated as remittance income from outside the locality. This was treated as income from diaspora being remitted by friends, kinfolk and other forms. These incomes were aggregated across all remitters.

Other income sources included for example household own-labor and own equipment used in specific production activities. However, because of this, it was not possible to impute values of household inputs on these. The estimation of some of the incomes treated as miscellaneous necessitated some to be made. Some of the assumptions were that there was no zero or negative values allowed some specific household income activities. Equally, the household poverty line that was predetermined for this study was that those earning below US$ 1.90 earnings per day were considered poor. The exchange of Kenya Shilling to the dollar at the time was 1US$=100 KES. The minimum monthly pay a household could earn working for 26 days is KES 4,940 per capita per month. This translates to KES 59,280 per capita per year. This assumption means that this amount is the minimum yearly amount a household should earn per capita per year. The households earning is less than the required amounts needed to purchase the basic household basket of food in Eastern Mau. This estimation of incomes from household activities and sources is in line with theory and studies by Walelign *et al*. (2017), Larsen *et al*. (2015) and Angelsen *et al*. (2014) which showed that household income diversified income activities presents households with a better chance of staying above the poverty line, *ceteris paribus.*

Estimating Income Values from Forest-Based Income Strategies

Forest-based income was estimated for products that were harvested and consumed in the previous 12 months period of household active involvement (Table 4). Firewood and other goods produced for home consumption were valued by asking households what price they would have had to pay to purchase these goods in the local village market. However, the assessment of forest resources value has been using direct forest product pricing or direct substitute pricing methods (Kiplagat *et al*., 2010). These two approaches are used to capture the values of forest ecosystem products. Also, the estimation captures products consumed internally by households as

subsistence-self-consumption and for immediate cash sales. Most forest resources were estimated based on local village market prices or prices of substitute products. A semi-structured questionnaire survey instrument was used to capture actual quantities harvested and consumed and average prices for it. Households were elicited to provide information on the kind of products they extract from the forest and what they pay for it.

The prices of forest products like medicinal plants, wild honey, wild berries, vegetables, and mushrooms were provided by the local village market and summarized in Table 4. Equally, forest ecosystem resources percentage contribution to total household income across household income quintiles has been presented in Table 5. In some instances, rural households could not remember the quantities or the number of times they consumed the products in the previous year. In such instances, the products were estimated using prices of substitute products. In some instances, were there no market-clearing prices, the forest products were estimated using shadow prices or opportunity costs. The opportunity cost of labour was considered to be insignificant because extractions of forest products require the low or medium skill level of household own labour. This makes gross forest-based income a good substitution for natural rent. The price of raw water was difficult to measure since it is considered a free good. In this regard, water was assumed to have minimal impact on rural household total income. Equally, rural households consume water indirectly. Also, this good is implicitly included in other products like crops and livestock. The net forest-based income, therefore, includes household own-labour costs. This is because household extraction of forest products is done in an imperfect labour market and consequently the computation of opportunity cost of labour in this study was not captured.

Conversely, the monetary equivalents of forest products that were consumed directly by rural households were found to have an equivalent monetary value. A study by Kiplagat *et al.* (2010) used both direct pricing and substitute approach to value forest ecosystem products in Kakamega forest. Kiplagat *et al*. (2010) used direct pricing to estimate the income value of products consumed directly, for example, firewood, medicinal plants, pastures, and fodder. In Eastern Mau, these products were consumed in sizable quantities and it was easy for respondents to remember it. Other forest products that were consumed directly included thatching grasses and construction or building materials. Other products that were consumed directly but in small quantities were computed together with medicinal plants. These included wild honey, vegetables, mushrooms, fruits and berries (Table 4). The valuation of these forest products was pre-conditioned by the need to have deterministic monetary prices in the local market. The quantities of most of these small products were measured using portions or sizes, for example, mushrooms, vegetables, wild honey, berries, and fruits. The prices of substitute products of most of these products were found in nearby local village markets. Firewood was an important domestic energy fuel that was consumed by all rural households in Eastern Mau. Equally, firewood fuel energy was measured using quantity-load-sizes that were agreeable to rural households. The sizes included woman back-loads or head-loads, donkey-loads, bicycle-loads and/or motor-bike-loads (*boda-bodas*) and pick-up loads. In study areas near the District Forest Offices, the payment for pasture and firewood was done as and when it is collected or a monthly charge was levied as a permit fee. Some households were engaged in buying firewood from the Forest Offices and selling it to the nearby urban village markets. The estimation of forest products is in line with studies by Kamanga *et al*. (2009), Schaafsma *et al*. (2014) and Vedeld *et al*. (2007).

Measuring Household Poverty

The degree of poverty amongst poor rural household is measured by three Foster-Greer-Thorbecke (FGT) variants (Foster & Shorrocks, 1988; Foster *et al*., 1984). The poverty variants are household headcount poverty, poverty gap and poverty severity (Foster *et al*., 1984). The model of measurement by Foster *et al*. (1984) has been criticized by Alkire *et al*. (2015) because it does not take into account the extent of multidimensional household poverty. These poverty dimensions are household deprivation of food and nutrition, general security and safety, lack of water and poor sanitation, lack of housing and homelessness (Walelign *et al*., 2017; Ward & Shackleton, 2016; Megbowon, 2018). The measurement of multidimensional poverty, therefore, is outside the scope of this study since it focuses on household monetary or income poverty using Foster-Greer-Thorbecke (FGT). The FGT poverty measurement model adapted from (Foster *et al*., 1984) poverty analysis has been used in this study. The mathematical presentation has been presented as:

$$FGT_{\propto}(y;z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^{\propto} \quad (1)$$

Where z is the household poverty line *(z>0)*, y_i is the per capita income of the i^{th} poor household. Total household income is applicable if $y_i<z$; $q=y;z$ are the number of households with income below the poverty line, *n* are the total number of households sampled, $\propto$ takes the value of (0, 1 and 2). When $\propto = 0$, then $R\alpha$, it measures the headcount index, and when $\propto=1$, then $R\propto$ measures the poverty gap index and when $\alpha = 2$, then R_2 measures the squared poverty gap or poverty severity index (Foster & Shorrocks, 1988).

The headcount index measures the depth of household poverty, while it is intuitive is easy to interpret. However, this index has some drawbacks. For example, it treats poverty as discrete rather than a continuous characteristic. Equally, household poverty headcount measure does not change household poverty status whether the income of poor households increase or decrease so long as the household is unable to move above the poverty line. Similarly, the household poverty headcount measure does not increase even if households below the poverty line face a negative shock that decreases their income, no matter how severe the shock might be.

In order to provide a more complete picture of how poverty changes under different scenarios, the household poverty gap, and household poverty sensitivity (poverty gap-squared) measures are commonly used in addition to the poverty headcount measure. The poverty gap measurement corresponds to the $FGT_{(\alpha=1)}$ index which is a poverty measurement that reflects how far below the poverty line the household is. It also shows the required income on average a poor household requires to move up to the poverty line. This is, therefore, a measurement of the depth of or incidence of household poverty. Equally, if the income of a poor household increases but not sufficient enough to nudge the household above the poverty line, total household poverty severity as measured by $FGT_{(\alpha = 2)}$ index will decrease even though the poverty headcount measure does not change.

RESULTS AND DISCUSSION

Results of Study Site Characteristics

The household income quintile levels of the study sites have been presented in Table 1. The results indicate that the administrative sub-location with the highest population is Ndoshua with 26.77% followed by Kituro with 20.34% and Nessuit with 16.22%. The rest of the three sub-locations were almost equal in population contribution to total household population of the study site.

Table 1: Study Site Characteristics

Sub-Locations	Household Income Quintile Levels						
Population (%)	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistical Test
Ndoshua	34.5	32.75	27.97	21.73	13.08	26.77	
Nessuit	14.89	10.74	16.56	15.13	23.78	16.22	
Sigotik	21.48	15.08	24.41	16.04	13.59	18.04	
Kituro	19.68	9.66	21.22	23.96	27.18	20.34	
Misepei	12.56	10.11	9.32	8.14	7.02	9.43	
Kiptunga	1.91	5.69	9.57	13.43	15.40	9.20	$\chi^2(16)=7$
Total	100	100	100	100	100	100	31.42***
Rural and Urban Areas							
Rural	89.59	88.06	80.04	72.43	76.12	75.65	
Urban	10.41	11.94	19.96	27.57	23.88	24.35	$\chi^2(4)=77.$ 04***
Total	100	100	100	100	100	100	

n=450 households. *, ** and*** indicates the significance levels at 10%, 5% and 1%, respectively. Urbanized locations indicate central areas of commune like for example, village markets, schools, hospitals, community offices where there is population concentration

Results of the Distribution of Household Income Dependency Strategies

Results of household income dependency strategies have been computed in relative and absolute values and presented in Table 2 and Table 3. The income sources were grouped into five household income clusters. These clusters are on-farm income, off-farm income, mixed-income, transfers income and forest-based income. Results of income distribution show on-farm income sources to contribute (53.7%) to total household income.

Table 2: Diversified Household Income Strategies (Absolute Values)

Income Sources	Household Income Strategies						
	On-Farm Income Dependency	Off-farm, Income Dependency	Mixed-income Dependency	Transfers Income Dependency	Forest-Based Income Dependency	Total Sample	Statistical test
Crop Incomes	12,987.35	9,980.70^{ab}	8,915.53	7,095.10^{b}	4,046.07^{a}	6,804.96	F=554.30***
Livestock Incomes	3,610.20^{a}	4,535.46^{a}	4,828.32	2,062.69^{a}	2,153.89	3,438.11	F=126.40***
Wages/Salary	1,714.73^{ab}	4,539.20	3,408.04^{b}	1, 904.88^{ab}	395.95^{a}	3,992.56	F=276.20***
Rent /Asset Incomes	44.86^{a}	132.81^{a}	1,274.12	122.06^{a}	7.39^{a}	345.78	F=26.58***
Non-farm/Non-Wage	125.16^{a}	158.42^{a}	213.11	83.87^{a}	75.60^{a}	131.24	F=117.07***
Transfers Sources	97.46^{a}	126.31^{a}	135.96	252.60	55.16^{a}	133.49	F=378.67***
Forest Incomes	2,494.10^{a}	1,455.40^{a}	1,421.65^{a}	1,461.20^{a}	2,943.20	1,955.11	F=36.21***
Other Sources	45.60^{a}	54.67^{a}	88.98	56.25^{a}	42.46^{a}	57.60	F=27.69***
Total Net Income	20,119.46^{b}	20,982.97	20,285.71	12,038.65^{b}	9,719.72	16,858.84	`

N=450, *, **, and *** indicate the significance levels at 10%, 5% and 1%, respectively. Superscript letters denote the significant difference between groups. Means sharing the same letters(s) in the group label are not significantly different from one another at the 5% level.

Means sharing the same letter (s) in the group label are not significantly different from one another at the 5% level.

Table 3 –Diversified Household Income Strategies (Relative Values)

Income Share	On-Farm Income Dependency	Off-farm, Income Dependency	Mixed-income Dependency	Transfers Income Dependency	Forest-Based Income Dependency	Total Sample
Crop income	69.89	36.18	21.41	20.16	19.06	33.34
Livestock income	17.23	14.25	18.36	17.69	34.42	20.39
Wages/salary income	29.84	46.72	38.54	28.53	37.38	19.36
Asset selling income	2.05	3.09	8.27	2.13	1.16	3.34
Rental/hiring income	1.19	2.16	2.84	3.68	1.06	2.05
Non-farm/non-wage	2.51	2.61	7.36	3.04	3.33	3.77
Transfers income	4.59	3.71	4.33	13.85	2.52	5.80
Forest resources income	9.87	8.51	7.79	8.69	23.14	12. 0
Other incomes	0.63	0.09	0.23	0.41	0.68	0.35
Total						100

N=450, *, **, and *** indicate the significance levels at 10%, 5% and 1%, respectively. Superscript letters denote the significant difference between groups. Means sharing the same letters(s) in the group label are not significantly different from one another at the 5% level.

Distribution of Forest-Based Income Activities

The relative importance of forest-based income is the 12% contribution to total household income. Results in Table 5 show firewood contributes the highest value 64.4% of the forest-based income. This is followed by pastures 24.3% and medicinal plants 8.10%. In Table 6 results show households in the lowest income quintile as being the poorest and second poorest. These households have the highest dependence on forest resources 13.2%. Equally, households in high-income quintile are the second richest and the richest households with less dependence on forest resources 9.54%. Equally, poorest and second poorest household have low asset holdings which impede them from engaging in remunerative regular income activities.

Households in the second richest and richest income quintiles engage in off-farm income being derived from wages and salary employment which contributes 22.36% and 21.78%, respectively. In as much as forest ecosystem resources play a critical and important role, other income activities are primarily important.

Table 4: Distribution of Forest-Based Income Activities

Forest Income Category	Household Income Dependency Strategy Clusters						
	On-farm income dependency	Off-farm income dependency	Mixed-income dependency	Transfer income dependency	Forest-based income dependency	Total	Statistical Test
Absolute Income per capita in 2012 (KES 000)							
Firewood	1,469.85[a]	1,283.53[a]	1,103.07	1,103.66[a]	928.87[a]	1,259.87	F=126.40***
Pastures	81.59[a]	113.43[a]	105.88[a]	59.52[a]	83.97[a]	475.87	F=36.21***
Med. Plants	31.92[a]	6.36[a]	4.65[a]	8.54[a]	9.14[a]	158.36	F=27.93***
Others	10.92[a]	16.52[ab]	21.01[ab]	7.07[ab]	5.47[ab]	60.99	F=3.84***
Total Income	1,694.28[a]	1,419.84[a]	1,234.61	1,178.79	1,027.45[a]	1, 955.11	F=142.35***
Relative Income (%)							
Firewood	75.18[a]	61.65	56.42[a]	56.45[a]	72.50	64.44	F=2094.28***
Pastures	16.80[b]	38.94	32.79[ab]	11.66[a]	21.51[a]	24.34	F=149.73***
Med. Plants	4.65[b]	11.34	10.48[ab]	5.52[ab]	4.51[a]	8.10	F=136.84***
Others	1.07[b]	3.94	1.07	19.16	3.61	3.12	F=1.17[ns]

N=265, *, **and *** indicate the significance levels at 10%, 5% and 1%, respectively. Superscript letters denote the significant difference between groups. Mean values sharing the same letter(s) in the group label are not significantly different.

Table 5: Forest-Based Income across Household Income Quintiles (%)

Poorest		2nd Poorest		Middle	
On-farm income	61.36	On-farm income	55.64	On-farm income	55.35
Off-farm income	15.02	Off-farm income	25.66	Off-farm income	21.35
Forest-based income	13.24	Forest-based income	12.09	Forest-based income	12.29
Mixed-income	2.21	Mixed-income	10.41	Mixed-income	6.99
Transfers income	7.32	Transfers income	7.05	Transfers income	4.02
Total	100	Total	100	Total	100
2nd Richest		Richest		Total	
On-farm income	54.32	On-farm income	45.43	On-farm income	54.42
Off-farm income	22.36	Off-farm income	21.78	Off-farm income	21.23
Forest-based income	10.89	Forest-based income	9.54	Forest-based income	11.61
Mixed-income	8.58	Mixed-income	19.38	Mixed income	9.51
Transfers income	3.85	Transfers income	6.87	Transfer income sources	5.82
Total	100	Total	100	Total	100

Poverty Alleviating Effects of Forest-based Income

Results of (FGT $_{(\alpha)}$) show poverty indices with and without forest-based income being considered in total household income. The poverty headcount index (FGT $_{(\alpha=0)}$) when forest-based income is considered in total household income reduced from 0.497 and 0.421. This means the rural households classified to be living below the poverty line reduced from 49.7% to 22.1%. Equally, it means forest-based income reduced household poverty by approximately 15.86%. To understand the relative importance of forest-based income in alleviating household poverty, it is important to analyze the decomposition of FGT poverty indices. The decomposition shows aggregate household income sources without considering forest-based income. In this scenario, the poverty headcount (FGT $_{(\alpha=0)}$) is 0.242, poverty gap (FGT $_{(\alpha=1)}$) is 0.262 and poverty severity (FGT $_{(\alpha=2)}$) is 0.071. However, when forest-based income is considered in total household income, the poverty indices drop meaning forest-based income has reduced household measured poverty. For example, poverty headcount (FGT $_{(\alpha=0)}$) drops from 0.242 to 0.225, poverty gap (FGT $_{(\alpha=1)}$) drops from 0.262 to 0.257 and poverty severity (FGT $_{(\alpha=2)}$) drops from 0.071 to 0.066. The analysis of (FGT $_{(\alpha)}$) poverty indices, therefore, shows forest-based income reduced measured household poverty. Equally, it means forest ecosystem resources have poverty alleviating effects on measured household poverty.

Table 7: Measuring Household Poverty by Decomposing FGT Poverty Indices

Income Dependency Strategy	Total Household Income Per Capita	($FGT_{(\alpha=0)}$) Poverty Headcount	($FGT_{(\alpha=1)}$) Poverty Gap	($FGT_{(\alpha=2)}$) Poverty Severity
On-farm income dependency	10,243.07	0.284	0.273	0.074
Off-farm income dependency	3,992.56	0.122	0.164	0.027
Mixed-income dependency	477.02	0.175	0.185	0.034
Transfers income dependency	133.49	0.214	0.296	0.088
Forest-based income dependency	1,955.11	0.331	0.368	0.135
Total	16,858.84	0.225	0.257	0.066

Table 8: Measuring Household Poverty With and Without Forest-Based Income

	Gini Coefficient Without Forest-Based Income		Gini Coefficient With Forest-Based Income		
Poverty Index	Mean	SD	Mean	SD	Mean difference
($FGT_{(\alpha=0)}$)	0.497	0.321	0.421	0.479	-0.076
($FGT_{(\alpha=1)}$)	0.435	0.112	0.418	0.345	-0.017
($FGT_{(\alpha=2)}$)	0.398	0.146	0.334	0.372	-0.026

CONCLUSIONS

The results of this study have resulted in the following conclusions: First, study results indicate that regular household on-farm income activities constitute household primarily income sources. The household on-farm income activities are derived from crop production activities 33.34% and livestock production activities 20.39%. These two household income activities contribute over 53% to total household income.

Secondly, results of the study indicate that forest-based income is a non-regular income which contributes to various household economic activities and 12% to total household income. This forest-based income acts as safety net, insurance premium and a cushion to rural households against unexpected shocks resulting from climate-change-induced weather fluctuations. The forest-based income is critical in the livelihood sustainability of rural households despite not being considered in the computation of national income accounting and national gross domestic product (GDP).

Thirdly, results of FGT poverty indices of decomposition reveal that forest-based income has poverty alleviating effects on household monetary or income poverty. The results of the study show FGT poverty indices when the total household income is considered with and without forest-based income. Further, it shows that total household income when considered with forest-based income reduces the household headcount index ($FGT_{(\alpha=0)}$) from 0.299 to 0.252. This means that the number of households who live below the poverty line reduces from 29.9% to 25.2%. Equally, the results indicatives that forest-based income has reduced measured household poverty by approximately 15.7%. This is because the household headcount poverty index measures the incidence of poverty among the rural households.

Thirdly, the results of the study show the household poverty gap index ($FGT_{(\alpha=1)}$) when forest-based income is considered with total household income, the FGT poverty gap indices reduces from 0.262 to 0.257. This means that the percentage of rural households requiring a specific income amount to move above the poverty line reduces from 26.2% to 25.7%. This translates to a reduction of household poverty gap index by 1.9%. Also, the household poverty severity index ($FGT_{(\alpha=2)}$) is measured when forest-based income is considered with total household income. The FGT poverty severity indices drop from

0.071 to 0.066. This means the number of households facing severe poverty reduces from 7.1% to 6.6% and it translates to a household poverty severity reduction by 7.0%.

Finally, these findings are supported by theory and studies by Barbier (2010) which showed that rural households who are deeply in poverty tend to over-extract their products in an attempt to find a pathway out of poverty. This, according to Wunder (2001), means that rural households who inefficiently allocate the forest resources in consumption are the ones who cause resource undersupply and degradation.

RECOMMENDATIONS

The findings of this study provide sufficient knowledge and information for state-actor governance structures and policies.

a) Firstly, state-actor policymakers should invest in programme activities that will increase the income performance of household on-farm income activities. The household on-farm income is the primary income source for rural households as it contributes over 53% to total household income.

b) Secondly, state-actor governance structures and policies should embed sustainable rural household livelihoods improvement into efficient conservation and management of forest ecosystem resources. This twin-strategy will ensure there is sustainable production of sufficient qualities and quantities of forest ecosystem products to support various economic functions of forest-fringe rural households.

c) Thirdly, state-actors should include forest-based income in national income accounting by incorporating the income in national gross domestic products (GDP). This is because forest-based income plays a critical role of sustaining rural household livelihood outcomes and contributing 12% to total household income.

ACKNOWLEDGMENT

This research was funded through a grant to the first author by Moi University, Division of Academics, Research and Extension (AR & E). The 457 households living in the six-administrative locations of Molo and Njoro Sub-Counties who participated in this study commencing January 2012 to June 2013 and the community at large are acknowledged for willingness to share information on the challenging and controversial topic of Mau Hills Forest Complex and Eastern Mau Forest Reserve. Many of the households hosted the first author in their homes for more than a year and a half. The staff of Moi University Office of Research, technical staff and research assistants were supportive and very resourceful.

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