ROLE OF FOREST ECOSYSTEM RESOURCES IN ALLEVIATING HOUSEHOLD POVERTY IN EASTERN MAU, KENYA

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DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been submitted for any academic award in any institution, and shall not be reproduced in part or full, or any format without prior written permission from the author and the University of Eldoret.

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Declaration by the Supervisors

This thesis has been submitted with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my dear wife Winnie Chepkemboi Kottutt and my late mother Dorcas Kobilo Kottutt

ABSTRACT

The role played by forest ecosystem resources is critical to forest-fringe rural households who depend on it to sustain their livelihood outcomes like alleviating household poverty and reducing household income inequality. The importance of forest ecosystem resources has long been recognized but has seldom been quantified and analyzed. In this research study, we examine distributional and poverty effects of forest ecosystem resource extraction among households living in forest peripheries in Eastern Mau forest reserve. Primary data were collected from forest-fringe rural households living five 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 this study was to determine the role of forest ecosystem resources in alleviating poverty among rural households living in forest margins of Eastern Mau forest reserve. 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 index ($FGT_{(\alpha=0)}$) reduced from 0.299 to 0.252. This index drop indicates a reduction in measured household poverty by 15.7%. Also, forest ecosystem resources were shown to contribute about 12% to total household income. Equally, on-farm income activities as the mainstay household income sources contributed 53% to total household income. In conclusion, forest ecosystem resources have a significant role in alleviating household poverty. The study recommends to state-actors to formulate governance structures and policies that concomitantly enhance efficient conservation and management of forest ecosystem resources while embedding regular household primary income strategies. Also, state-actors should incorporate forest-based income in national income accounting by including it in the computation of national gross domestic product (GDP).

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LIST OF ABBREVIATIONS AND ACRONYMS

DD	-	Deforestation and degradation
DFID	-	Department for International Development
FAO	-	Food and Agriculture Organization
FGT	-	Foster-Greer-Thorbecke
GDP	-	Gross Domestic Product
KFS	-	Kenya Forest Service
KNBS	-	Kenya National Bureau of Statistics
KFA	-	Kenya Farmers Association
KWS	-	Kenya Wildlife Service
NEMA	-	National Environmental Management Authority
NGOs	-	Non-governmental Organizations
OECD	-	Organization for Economic Cooperation and Development
SPSS	-	Statistical Product and Service Solutions (IBM SPSS statistics) Version 21
TLU	-	Tropical Livestock Unit
UN	-	United Nations
UNEP	-	United Nations Environmental Programme
UNDP	-	United Nations Development Programme
VIF	-	Variance Inflation Factors
WCED	-	World Commission on Environment and Development
WARMA	-	Water Resources Management Authority
WB	-	World Bank
WRI	-	World Resource Institute

OPERATIONAL DEFINITION OF TERMS

Command and control is a state-actor traditional and non-participatory conservation approach that uses a top-down strategy and it is underpinned by legislative and regulatory frameworks.

Contextual variables are also known as intervening variables, for example, distance to the nearest all-weather roads, experiences that are caused by unexpected shocks, for example, climate-change-induced weather fluctuations. These are proxies for poor road networks and underdevelopment.

Forest-based income is income that forest-fringe rural household construct from foraging forest ecosystem resources

Forest ecosystem goods and products are food and non-food forest products that rural households extract and utilize for their livelihood improvements.

Forest protected areas are forest public areas under land-use and sustainable-use conservation restriction for the purpose of protection of biodiversity-ecosystem resources management.

Household is a unit of common food production where members live together and eat together.

Household asset-holdings variables are factors that influence the choice of rural household income dependency strategies, for example, the number of livestock, the size of land resources and the production equipment used in the farm.

Household income per capita is total household income earnings in a one year period divided by the number of all household members who live in the household in the year.

Household income dependency strategies are diversified income portfolios that rural households depend on to improve their livelihoods, for example, on-farm incomes, off-farm incomes, mixed-income sources, transfers incomes and forest-based income activities.

Household livelihood outcomes are rural household welfare improvements including alleviation of poverty and reduction of household income inequality.

Household poverty is experienced by households whose income shortfall makes them to be unable to meet their daily basic needs. The households face a situation where there more expenses that the income generated. Equally, households are poor when they are below a predetermined poverty line or household income earnings of below US$1.90 per day.

Non-state actors are NGOs, conservation organizations, research institutions, international actors and other forest ecosystem resource-stakeholders.

Sub-Saharan African Countries refers to all African countries, except countries in Northern Africa; the countries of North and South Sudan are included in sub-Saharan Africa. Whenever the term Africa is used in this thesis, it refers to sub-Saharan Africa.

Socio-economic variables are factors that influence the household choice of income dependency strategies, for example, percentage of land put under irrigation, amount of loans or credit that households can access for farm operations, income savings accumulated by households and membership of households in social groups

Socio-demographic variables are factors that influence the household choice of income dependency strategies, for example, household size, number of household members who are working, household-head specific variables like, age, ethnicity, the highest level of education and
gender.

State-actors are government agencies, institutions and departments that have the mandate to protect, conserve and manage forest ecosystem resources within Kenya's protected areas; these include KFS, KWS, NEMA, and WARMA among others.

Open-access resources are non-rivalry public goods that have no market-clearing prices. The goods are non-excludable, once offered none can be excluded. Public goods suffer from free-riders which cause resource undersupply and eventual degradation thus leading to the tragedy of the commons (Barbier, 2010).

Forest-Fringe Rural Households are households living in the margins of forest protected areas for the purposes of deriving economic benefits by extracting forest goods and products.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The economic mainstay of most forest-fringe poor rural households living in the tropical forests of the world and those in sub-Sahara Africa is derived from on-farm incomes or agricultural income activities. Over the decades, forest ecosystem conservation and rural development have converged. The increasing interest has been in the declining income derived from the tropical forests and the underperformance of the household regular income activities. Rural household regular income activities are derived from on-farm incomes or crop and livestock production. Others are off-farm incomes or wages and salary incomes, mixed-income sources or business activity incomes from non-wage and non-farm incomes. Also, transfers income is remittance income from kinfolk and friends. Forest ecosystem resources are extracted by rural households living in forest margins. They utilize the resources to construct forest-based income which is considered as non-regular household income (Gecho, Ayele, Lemma, & Alemu, 2014; Keenan et al., 2015; Tesfaye, Roos, Campbell, & Bohlin, 2011a). Rural households have utilized forest-based income as a safety net and insurance premium to cushion themselves against unexpected socio-economic shocks or risks caused by income shortfalls. Equally, the income has been used to increase total household income and to alleviate household poverty and to reduce income inequality (Brocklesby & Fisher, 2003; Chitiga-Mabugu, Mupela, Ngwenya, & Zikhali, 2016; Gibson, 2016).

Rural household poverty is a composite phenomenon with various versions of definitions. Studies by (Biyase & Zwane, 2018; Burger, Klasen, & Zoch, 2016; Ezzat & Ezzat, 2018;

B. Kumar, 2019; Ngema, Sibanda, & Musemwa, 2018; Wang, 2019) show household poverty as an income shortage that hampers household ability to meet household basic daily needs. The World Organization reports (World Bank, 2015, OECD, 2016; UNDP, 2015; UN, 2015; WRI, 2005; WECD, 1987) show that rural household poverty to be both multifaceted and a multidimensional phenomenon. It is shown as the result of deprivation of food and nutrition, housing or shelter, water and sanitation, healthcare and education. Also, the reports show these conditions are exacerbated by household income shortfalls and their inability to meet basic daily needs (Biyase & Zwane, 2018; Lin, Zhang, & Lv, 2019; Randall & Coast, 2015; Soltani, Angelsen, Eid, Naieni, & Shamekhi, 2012). Equally, household income shortfalls are manifested by poor household wellbeing (Ferreira et al., 2015; Jolliffe & Prydz, 2017; Maloma, 2016).

Rural households living in forest peripheries in the tropics have low-income from regular income activities which makes them depend on forest ecosystem resources to maintain a sustainable livelihood. The forest ecosystem resources are utilized mainly to increase total household income (Babulo et al., 2008a; William Cavendish, 1999a, 2000a). The income shortfalls are caused by climate-change-induced weather fluctuations. These cause erratic rainfall patterns which lead to disasters from floods and droughts. These are some of the main causes of food shortage, hunger and socio-economic insecurity in sub-Sahara Africa in general and Kenya in particular.

The floods and droughts cause unexpected income shocks and they occur in a cyclical sequence (Y. A. Boafo, Saito, Jasaw, Otsuki, & Takeuchi, 2016; Burtraw & Woerman, 2013; Farinola, Famuyide, Nosiru, & Ogunsola, 2014; Pramova, Locatelli, Djoudi, & Somorin, 2012). These climate-change-induced phenomena are the main causes of havoc

to crop and livestock production. Rural household suffer from income shortfalls because of underperformance of on-farm income activities which is the economic mainstay of the rural households (Illukpitiya & Gopalakrishnan, 2015; Kamanga, Vedeld, & Sjaastad, 2009a; Mutenje, Ortmann, & Ferrer, 2011; Tesfaye et al., 2011a; Vedeld, Angelsen, Bojö, Sjaastad, & Berg, 2007). The health and integrity of forest ecosystem resources are affected by persistent droughts which reduce the varieties, quality and quantities of forest products.

The deforestation and degradation caused by rural household poor landuse management practices are the cause of dwindling forest products. These phenomena inhibit forest ecosystem resources from providing its cushioning effects to rural households during times of income shortfalls. When there is underperformance by forest ecosystem resources, the poorest households in the lowest income quintiles suffer the most (Megbowon, 2018). Similarly, those in high-income quintiles depend more on high-income values of forest ecosystem resources (Walelign, Pouliot, Larsen, & Smith-Hall, 2017).

Regular household income activities and forest-based income have been declining in the past few decades in Kenya because of weak state-actor governance structures and policies. Regular household income activities contribute two-thirds to total household income. This means state-actors should focus on improving the performance of the agricultural sector while simultaneously conserving the forest ecosystem resources (Biyase & Zwane, 2018; Sujakhu et al., 2018).

Studies by (Das & Sarker, 2008; Illukpitiya & Yanagida, 2010; Walelign et al., 2017) show household regular on-farm income activities are augmented by forest-based income

in order to increase total household income. However, forest ecosystem resources are public goods that are decreased due to increased deforestation and degradation. These are concerns that lead to biodiversity losses of public goods. The foregone forest ecosystem resources, therefore, causes a substantial loss of the economic distributional effects (Kamanga et al., 2009a). Equally, biodiversity losses will cause the extinction of forest ecosystem resources flora and fauna in the foreseeable future (WRI, 2005).

Conversely, the primary household regular income activities from on-farm income contribute 65% to 70% to total household income (Eadie, 2017; Liu, Liu, & Zhou, 2017; Mtshali, 2018; Othman & Noor, 2017; Tittonell & Giller, 2013; Verkaart, 2018). However, rural households in the past several decades have been sliding down the poverty line because regular income and forest-based income have both been dwindling.

The off-farm income has also been declining because of weak macro-economic factors that have made institutions to shut down. Mixed-income sources from business enterprises have also been weakened because of structural adjustments in the rural economy. The transfer income has equally taken a dip because of a drop in remittances from those who are employed towards kinfolk or family members. This income reduces because of lay-offs and reducing the job market. The three regular income sources, the off-farm income, mixed-income sources and transfers income sources contribute (5% to 15%) to total household income (Brocklesby & Fisher, 2003; Gibson, 2016; Sujakhu et al., 2018). Even when there is a good performance from all these regular incomes, rural households still depend on forest ecosystem resources for supplementary income. Studies by (Babulo et al., 2008b; Dokken & Angelsen, 2015; Jamnadass et al., 2015; Kgathi,

Ngwenya, & Wilk, 2007; S. Shackleton, Delang, & Angelsen, 2011) show forest-based income contributes 12% to 28% to total household income.

Forest-fringe poor rural households depend on forest ecosystem resources for various economic functions but mainly for supplementary income to sustain the livelihoods (W Cavendish & Campbell, 2008; Thondhlana, Vedeld, & Shackleton, 2012; Illukpitiya & Yanagida, 2008; Hein, Van Koppen, De Groot, & Van Ierland, 2006; Ellis, 2000). Studies by (Das & Sarker, 2008; Illukpitiya & Yanagida, 2010; Walelign et al., 2017) show rural households living in the lowest income quintiles heavily depend on low value forest products and their counterparts in higher-income quintiles depend on high-value forest products.

Some of the underlying reasons for deforestation and degradation are also the same reasons for rural household poverty. This is because the underperformance of regular household income is linked to the underperformance of forest ecosystem resources. Some of the main causes of rural household poverty and forest ecosystem resource degradation have been highlighted in this study. First, forest ecosystem resources are public goods that are non-rivalry and non-excludable in consumption.

First, forest ecosystem resources once produced none can be excluded from consuming it. Again, this nature of public goods makes poor rural households to inefficiently allocate the forest resources in their consumption which causes resource undersupply and degradation. Equally, the inefficient allocation in consumption stems from the fact that forest-fringe poor rural households do not bear the total cost of production of these forest ecosystem resources.

Second, climate-change-induced effects, for example, droughts and floods together have been exacerbated by the increased rural household population. These two have conspired to drive up the demand for staple food and basic needs. In Eastern Mau, there is persistent a shortage of staple food which make households in Eastern Mau the most food insecure. With the ever-rising population, the demand for food has gone up while supply has gone down. The lack of state-actor driven agricultural extension services and technological innovations have been blamed for gaps in food production and poor supply of staple food for subsistence and sales. Studies by (Livingston, Schonberger, & Delaney, 2011; Rockström et al., 2017) show extensification of agricultural land can be mitigated by improved technological innovations that increase production yields. These are the most glaring causes of poverty and forest ecosystem resource degradation.

Thirdly, increased demand for food has led to agricultural extensification activities which make rural households to encroach and settle in designated forest reserve areas. The increased poverty and hunger due to undersupply of food which has motivated rural households to engage in poor land use management practices. Some of the practices include household conversion of biodiversity habitats, watersheds and wetlands into agricultural production areas. Studies by (Ebenezer & Abbyssinia, 2018; Ferreira et al., 2015; Ouedraogo & Ferrari, 2015) show the effects of diminished forest ecosystem resources affects forest-based income. The decline of freely produced forest ecosystem products, for example, mushrooms, vegetables, honey and berries have been affected by weather fluctuations.

Lastly, the integrity and health of forest ecosystem resources are compromised because of reduced quantities and qualities of forest products. This causes reduced forest-based

income distributional effects (Kamanga et al., 2009a; Mamo, Sjaastad, & Vedeld, 2007a; S. Shackleton et al., 2011; Vedeld et al., 2007). Conversely, diminished forest-based income because of dwindling forest ecosystem resources reduces its poverty alleviating effects (W Cavendish & Campbell, 2008a; Monica Fisher, 2004; Lopez-Feldman, Mora, & Taylor, 2007). In the past three decades, the forest-fringe poor rural households in the countries of sub-Sahara Africa, like Kenya, have slid down the poverty line. This has been attributed to underperformance of both regular household income and non-regular forest-based income.

In Kenya, the average rural household poverty rate is approximately 46%, this is despite the state-actor introduction of poverty reduction strategy frameworks (KNBS, 2010). The high level of poverty in rural household communities is attributed to weak state-actor policies as formulated by the relevant government ministries. The policies have failed to enhance the intensification of household on-farm income activities. These are activities that target the efficient conservation of forest ecosystem resources and maintenance of rural household livelihoods (Pretty, Toulmin, & Williams, 2011). In Kenya, the rural households in Eastern Mau are poor and food insecure. This is due to lack of technological innovations and agricultural extension services (Otsuka & Kijima, 2010). The rural households living in the forest margins of Eastern Mau forest reserve have an excellent climate for agricultural production. However, the wide range of montane forests and savannah woodlands have not been utilized to increase agricultural production (Chethan, Srinivasan, Kriti, & Sivaji, 2012; Klopp & Sang, 2011).

1.2 Statement of the Problem

In Eastern Mau, there has been deforestation and degradation of forest ecosystem resources mainly because the resources are public goods. The nature of public goods has made rural households to inefficiently allocate the forest resources in consumption since they don't bear the full cost of resource production. This is the main cause of forest resource undersupply and degradation. Equally, the dwindling forest ecosystem resources in recent decades have been caused by agricultural extensification and deforestation, a poor land use management practice. These two factors have compromised the health and integrity of forest ecosystem resources making its quantities and qualities to drastically reduce.

The reduction of forest ecosystem products is exacerbated by an increase in rural household population which increases the demand for more food and other basic needs increases. There have been diminished quantities and qualities of forest ecosystem resources in the recent past which have been attributed to the underperformance of both regular household income activities and forest-based income. Over the decades, there has been continued deforestation and degradation of forest ecosystem resources and increased household poverty. Equally, the state-actor governance structures and policies have not addressed this phenomenon. One of the ways of improving production performance is by introducing agricultural extension services, like for example, the introduction of technological innovations at the farm level. This will increase productivity since most poor landholders in Eastern Mau engage in peasant farming.

Some of the technological innovations include state-actor driven on-farm value chain support mechanisms. These mechanisms provide smallholder farmers with technology

transfer services and seasonal farm loans or line of credit to finance farm production activities. These farm services include the financing of land preparation, buy farming inputs like fertilizers, acaricides drugs used for controlling ticks and livestock veterinary drugs. The other inputs to be purchased are crop pesticides and herbicides. Another way of improving the value chain is engaging in contract farming and assurance for the loss of crops and livestock due to natural calamities.

Most poor smallholder-household-farmers are poor because of erratic commodity prices due to lack of steady demand and supply of farm produce. This affects the prices of crop and livestock products, for example, maize, milk, meat and hides. Most farmers engage in rain-fed production agriculture which creates a product glut caused by the farmers who sell the produce at the same time. The introduction of water abstraction, construction of water pans to be used for irrigation and production of horticultural high-value export crops. The staggered production of horticultural crops eliminates the problem of same time product oversupply. The other is the introduction of contractual and certified farming agreements for crop and livestock production. These technological innovations are state-actor driven activities that are envisaged to reduce underperformance.

1.3 Objectives of the Study

The overall objective of the study is to examine the role of forest ecosystem resources in alleviating rural household poverty among poor rural households living in forest-fringes of Eastern Mau, Kenya. In order to address this, the following specific objectives were formulated which included:

a) To explore performances of regular household income activities which constitute the primary economic mainstay of rural households living in the forest margins of Eastern Mau;

b) To determine factors that influence the rural household choice of income dependency strategies which is used to sustain household livelihoods in Eastern Mau;

c) To analyze impacts of forest-based income in alleviating rural household poverty;

d) To investigate roles of forest-based income in reducing rural household income inequality.

1.4 Research Hypotheses

The following are the research hypotheses that were tested:

a) That regular household income activities does not constitute the primary economic mainstay of forest-fringe rural households living in the forest margins of Eastern Mau;

b) That household socio-economic and demographic characteristics, asset holdings or endowment and contextual factors does not have an influence on rural household choice of income dependency strategies;

c) That forest-based income activities do not any effect in the alleviation of rural household poverty;

d) That forest-based income does not reduce rural household income inequality.

1.5 Significance of the Study

The results of this study will be useful in highlighting the role of forest ecosystem resources as a mechanism for alleviating poverty among rural households in Eastern Mau. Many studies in sub-Sahara Africa (Ferreira et al., 2015; Mamo et al., 2007a; Narain, Gupta, & Van't Veld, 2008; Vedeld, Angelsen, Sjaastad, & Kobugabe Berg, 2004) show the influence of forest ecosystem resources in alleviating household poverty and reducing income inequality. Forest-based income is derived from forest ecosystem resources. The study has shown that rural household poverty is reduced by forest-based income when it is considered with total household income.

This study will use Foster-Greer-Thorbecke (FGT) poverty indices to measure the effectiveness of forest-based income in reducing measured household poverty. Equally, the Gini coefficient indices will be used to show forest-based income reduces household

income inequality. These two measurement methods have not been used in Eastern Mau before. In the countries of sub-Sahara Africa, studies by (Angelsen et al., 2014a; Monica Fisher, 2004; Kamanga et al., 2009a; Mamo et al., 2007a) have measured household income inequality when forest-based income was considered with total household income. This current study shows that there has not been any such measurement done among rural households living in the fringes of Eastern Mau.

Conversely, the results from the Gini coefficient measurements will be used to show the effect of forest-based income in reducing household income inequality. A reduction in the Gini coefficients means a reduction in household income inequality. However, poverty alleviation and income inequality among rural households belonging to different income quintiles and income dependency strategies these means household categories are affected by forest-based income differently (William Cavendish, 2000a; Kamanga et al., 2009a; Thondhlana & Muchapondwa, 2014a). Studies by (Walelign, 2016a) shows rural households in on-farm and forest-based income dependency strategies exhibited the highest level for both poverty incidence and over-dependence on forest ecosystem resources (Walelign et al., 2017).

Also, the results from this current research study will show several reasons for a nexus between healthy forest ecosystem resources and sustainable rural household livelihood outcomes. First, in the context of Eastern Mau, the rural household dependence on forest ecosystem resources remains an under-researched area. Equally, there has not been any research conducted in the Eastern Mau area on rural household dependence on forest ecosystem resources across household income quintiles.

Secondly, this current study is significant because it explores the nexus between efficient conservation of forest ecosystem resources and sustainable household livelihood strategy choices. This study is the first to enhance our understanding of the relationship between efficient conservation of forest ecosystem resources and sustainable household livelihood outcomes among rural households living in forest peripheries of Eastern Mau.

Thirdly, the findings will be used to disqualify the various hypotheses of the study which were tested that regular household income activities does not constitute the primary economic mainstay of forest-fringe rural households living in the forest margins of Eastern Mau; that household socio-economic and demographic characteristics, asset holdings or endowment and contextual factors does not have an influence on rural household choice of income dependency strategies; that forest-based income activities do not any effect in the alleviation of rural household poverty; that forest-based income does not reduce rural household income inequality.

Fourthly, the findings will provide new knowledge and information to state-actor policymakers on the importance of forest-based income. The new knowledge is invaluable for the understanding of the reasons why forest-fringe poor rural households in Eastern Mau can't find a pathway out of poverty even though they employ forest resources dependence optimally.

Fifthly, the findings will fill the existing gaps in literature that have not highlighted the importance of embedding sustainable rural household livelihoods into efficient conservation and management of forest ecosystem resources. Sixth is that the findings will provide evidence on the importance of forest-based income as an important income source that needs to be incorporated into national income accounting and the computation

of national gross domestic product. This is because rural households use the income for various economic functions. For example, to increase total household income as a supplementary income. Also, to act as a safety net and insurance premium to cushions rural households against unexpected socio-economic shocks and risks resulting from climate-change-induced weather fluctuations. These cause erratic rainfall patterns that result in disastrous floods and droughts.

Seventh is that when all these factors of critical importance have been highlighted by this study, it will make forest-based income to be more appreciated by state-actors. In this way, the government will increase conservation budgetary subventions for forest ecosystem resources. Conversely, the state-actor will push for the inclusion of forest-based income in national income accounting and in the computation of national gross domestic product (GDP). This will have elevated forest-based income from non-regular to regular household income.

1.6 Scope of the Study

The scope of the study has provided the research bounds that have been dictated by parsimonious reasons. The primary data collection from the study area was done on a four-kilometer band radius touching the selected six-administrative sub-locations. The study site was covered by six administrative sub-locations purposively selected from Njoro and Molo sub-counties of Nakuru County. Studies by (Babulo et al., 2008a; Gecho et al., 2014; Tesfaye et al., 2011a) shows the relevance of an average distance to forest peripheries.

Equally, studies by (Kamanga et al., 2009a; Mutenje et al., 2011) reveals that the effects of forest income reduce drastically beyond the four-kilometer radius. The other reason is the opportunity costs of accessing the resources go up due to spatial costs. All the boundaries of the sub-locations touched the forest protected area. The terrain of Mau Hills Forest Complex is rugged and the roads are impassable in some sections. The four-kilometer distance is ideal for most poor rural households to travel to forage the forest products (Dewbre, Cervantes-Godoy, & Sorescu, 2011; Godoy et al., 1997; Illukpitiya & Gopalakrishnan, 2015). This study used a cross-sectional survey design in order to save on time and costs.

1.7 Limitation of the Study

This study faced some limitations included difficulties in the movement from one sub-location to another. The difficulty was caused by the rough terrain of the area. There are few passable roads linking major towns and across the sub-counties.

Equally, the study revealed that there was a lot more information needed to be collected. This is big data that was considered to be important and could have been useful in the generalization of findings to the greater Mau Hills Forest Complex. The kind study that was required for this kind of research is a longitudinal in-depth study that requires more research assistants, more time and resources to undertake.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter in section 2.2 reviews the theoretical and empirical literature on the role of forest ecosystem resources in alleviating household poverty. In section 2.3, a conceptual framework model is presented. The factors that influence household choice of income dependency strategies have been presented in section 2.4. In section 2.5, household diversified income dependency strategies are covered. Forest-based income as a household income dependency strategy is covered in section 2.6. In The role of forest-based income in alleviating poverty is presented in section 2.7. Lastly, in section 2.8, the effects of forest-based income in reducing household income inequality is covered.

2.2 Theoretical Framework

The theoretical framework of this study is anchored on rural household utility maximization. Rural households are rational beings who desire to maximize their satisfaction or happiness. The overarching objective of most rural households in Eastern Mau is poverty alleviation. The objective of households is to increase total household income per capita per year. In this respect, many rural households engage in diversified income-generating activities in an attempt to optimize their production activities and to increase their yields or net income. Satisfaction in consumption is measured by utiles or ability to achieve consumption self-satisfaction in the context of overcoming deprivation caused by income shortfalls. The theories and concepts that have been used in this study

have illuminated our understanding of rural household dependence on forest ecosystem resources for supplementary incomes.

The study theoretical framework and analytical models have been used in this study to highlight the research problem and to illuminate the research hypotheses. The theoretical models were used to disapprove the four hypotheses. The theories and models of the study were selected appropriately to support the analytical models. Equally, the analytical models have been shown to have strong explanatory power in analyzing the content and relevance of the predictor variables.

This study has ensured that the theoretical assumptions of the study provided the researcher with the tools to critically evaluate disparate issues, contexts and concepts. Also, the theoretical framework has provided the researcher the opportunity to tap into existing knowledge and to connect it to existing literature from past and present empirical studies. The influence of the independent variables or predictor variables on the dependent variables indicated the explanatory power of the model.

2.2.1 Multinomial Logistic Regression Model

The theory of the multinomial analytical logit model is based on household consumer behaviour theory (Walelign et al., 2017). The theory shows explanatory variables of the model influence the dependent variables and response variables. Equally, the household consumer behaviour theory is constrained by both household socio-economic variables and household asset holdings and contextual variables. The explanatory variables also explain the effect of the response variables. The response variables are two unordered outcomes that explain sustainable household livelihoods. These have explained in the

model as alleviation of household poverty and reduction of household income inequality. This is explained by a multinomial logit model which is a binary model used to show the explanatory power of the independent variables that influence household livelihood outcomes.

A binary model uses probabilities to measure the constraints that face rural households when making decisions to choose or not to choose a particular income dependency strategy. The household decisions are constrained by socio-economic, asset holdings and contextual factors. It is assumed in the model that rural households are rational beings who would like to pursue the most lucrative or most remunerating income dependency strategy. The model determines the factors that influence their decision given the probabilities of choosing any one of the income dependency strategies (Walelign, 2016a; Walelign et al., 2017). However, the rural household behaviour in the context of these variables attempts to maximize satisfaction (Nielsen et al., 2013).

The multinomial analytical model in this study, therefore, analyzes the parameters that influence the household choice of income dependency strategies in the context of scarce resources The analytical model, in theory, determines the parameters of explanatory variables like the coefficients of odd-ratios and marginal effects (Nielsen et al., 2013). In theory, the model is used to determine the vectors of these explanatory variables in theory according to Nielsen et al. (2013). Also, the coefficients of log-odds ratios explain the variables using the vector predictors of explanatory variables which reflect the indicative changes in log-odds-ratios. The multinomial analytical model, therefore, is used to measure the probability of a household choosing any other income dependency strategy when forest-based income is held constant. The overarching objective of the study is to

measure the impacts of forest-based income in alleviating rural household poverty and reducing income inequality. In order to do this, forest-based income is considered as the base income for purposes of comparison. This means a rural household decision to pursue an income dependency strategy is done in relation to a given unit change in forest-based income (Nielsen *et al*., 2013).

2.2.2 Elimination of Multicollinearity

Multicollinearity can affect any regression model or logit regression model with more than one predictor (Farrar & Glauber, 1967; Wichers, 1975). The problem occurs when two or more predictor variables overlap in what they measure which make their effects on the response variable to be indistinguishable and when logit model tries to estimate the unique effects of the predictor variable, it goes wonky (Daoud, 2017; ONDUSO, 2018; Wanambiro, 2019). In this study, the interest is in understanding the separate effects household socio-economic variables and household asset holding on the household choice of income dependency strategies. If there is a high correlation between the two predictors or explanatory variables, then it means there is an indication of multicollinearity.

A simple test for multicollinearity detection is using a bivariate correlation between two predictor variables. The rule of thumb is that, if the value is above 0.8 or below it, then it means there is a high chance of multicollinearity. The steps to eliminate multicollinearity is first, is how high that correlation has to be before determining the inflated variances. This is dependent on the sample size this is because it is possible that while no two variables are highly correlated, three or more put together may become multicollinear.

While checking for multicollinearity, it is important to check for multiple indicators and look for patterns among them. There are simple tests that are carried out to check for multicollinearity.

The first was to test for the presence of high standard errors in linear regression or logistic regression coefficients. These are caused by standard errors whose orders of magnitude are higher than their coefficients. Sometimes the overall model is significant but none of its coefficients are. This means the p-value for coefficient tests have a unique effect on the predictor when Y is zero. If all predictors overlap in what they measure, there is a little unique effect, even if the predictors when grouped together have an effect on Y. This study has ensured the model predictors were completely independent of each other. This, therefore, means the coefficients do not change when one is added or removed; but if they overlap, then the coefficients will drastically change.

This current study has been shown to have a high variance inflation factor (VIF) and low tolerance of its reciprocals. This means a high VIF gives a low tolerance factor which is indicative of no multicollinearity and the reverse is true. The VIF is, therefore, a direct measure of how much the variance of the coefficients or its standard errors is being inflated due to multicollinearity.

2.2.3 Household Consumer Behaviour

Rural household consumer behaviour is based on household livelihood outcomes according to the theory by (Leach, Mearns, & Scoones, 1999; Scoones, 1998, 2009) and (Babulo et al., 2008a; Walelign, 2016a) which show the presence of an endogenous interdependency among explanatory variables. This means rural household explanatory

variables influence the dependent variables and response variables. This implies rural household livelihood outcomes are determined by the household choice of income dependency strategies which in turn are influenced by household socio-economic variables, household asset holdings and contextual factors. The logistic regression model shows household income dependency strategies endogenously affect explanatory variables and household livelihood outcome variables. This analysis varies household income dependency strategies while holding forest-based income constant (for example, (Babulo et al., 2008a; Dasgupta, Deichmann, Meisner, & Wheeler, 2005, p. 20). In the logistic regression analysis, the standard errors and problems associated with endogeneity are eliminated in the analytical model by a predetermined selection of explanatory variables. The variables are selected before conducting a multicollinearity test to ensure that the explanatory variables are truly exogenous (Babulo et al., 2008a; Raes et al., 2016; Xu et al., 2015).

The household consumption allocative efficiency is, therefore, constrained by household consumer behaviour which aims at optimizing satisfaction. The household consumer behaviour theory according to (Walelign et al., 2017) is based on the demand side of the supply and demand model. The theory shows rural household consumption behaviour when allocating forest ecosystem resources is driven by income shortfalls from other regular income strategies. A utility function based on the household demand-side model compares forest ecosystem resources and substitute products. This is model is based on Cobb–Douglas utility function represented mathematically as:

$$U_D = f\left(X^{\beta} Y^{(1-\beta)}\right) \quad \text{.....Equation (2.1)}$$

Where U_D is utility demand for all goods and products that rural household demand and X are forest ecosystem products or public goods demanded by rural households, Y are forest-substitute products that are complement forest ecosystem products consumed in the absence of forest ecosystem resource products.

In order to get XY projection in the utility function for a given level of utility U_0, the forest-substitute products were taken as a function of the utility U_0. This was mathematically represented as:

$$Y = U_0^{\frac{1}{1-\beta}} X^{\frac{-\beta}{1-\beta}} \quad \text{.....Equation (2.2)}$$

Where $U_0^{\frac{1}{1-\beta}}$ is a constant along with the hyperbola projection or the indifference curve of a combination of forest ecosystem goods and products that is complementary or is a substitute for market goods (Henders & Ostwald, 2012; Poulos et al., 2012; Schmalensee, 1972).

2.3 Conceptual Framework Model of Sustainable Household Livelihoods

The conceptual framework of household sustainable income dependency strategies has been presented in Figure 2.1. This study has analyzed the effects of household socio-economic, household asset holdings or endowment and contextual factors, according to the conceptual framework model by (DFID (1999) and (Ellis, 2000b; Reardon & Vosti, 1995; Scoones, 1998). The independent variables are also known as the predictor

variables or independent variables. The independent or predictor variables include socioeconomic variables, household asset holdings or household endowments and contextual or exogenous variables. The forest-based income is considered as the base income which is held constant as the other household income strategies are varied. The dependent variables are the expected responses or household outcomes of the model. These are household income dependency strategies.

In a sustainable household livelihood conceptual framework model, the relationships between the predictor variables and the response variables are explained in detail. The predictor variables are socio-economic variables that were considered as continuous or dummy variables, for example, household size, age of household head, number of members who are working, the gender of household head, highest education level of household head and ethnicity of the household head. Household asset holdings or endowments include agricultural land size, percentage of land under irrigation, number of livestock herd, ownership of productive agricultural equipment, household savings, accessibility to loans and membership in social network groups.

Equally, the dependent variables are household income dependency strategies which have been clustered into five. The clustering of household income dependency strategies is done using a two-step cluster analysis. The steps use agglomeration of income sources to avoid the problem of dimensionality which manifests itself as a high correlation among variables. This problem was eliminated in the analytical model by using the indicators of independent variables. The indicators of independent variables were used because it significantly reduces the dimensionality in the variables. The multinomial logistic regression model used thirteen indicators of independent variables. These indicators were

for both socio-economic and asset holding variables. There were two indicators for contextual factors that were used as a proxy for household exposure to unexpected shocks caused by climate-change-induced income shortfalls. The distance traveled by rural households to reach to the nearest all-weather roads were used to measure the remoteness of rural households in the locality.

The dependent variable indicators, on the other hand, include household income dependency strategies. These were regular household sources that were considered as categorical variables derived from diversified income activities. The diversified income activities are also referred to as regular household income. For example, on-farm or agricultural income is derived from crop and livestock production. The other income sources include off-farm income sources derived from wages and salary employment incomes. Mixed-income sources are incomes derived from non-farm and non-wage income activities or income from business trading and entrepreneurship activities. Transfers income activities are incomes received from kinfolk or relatives and friends who send money back home. The money is usually sent from towns outside the locality or from the diaspora.

Rural households endeavour to maximize their satisfaction by pursuing the most remunerative income outcomes (Swinton, Escobar, & Reardon, 2003). However, the contextual variables come in the way of their decisions to endogenously constrain their optimal actions and decisions (Shankar, Smith, & Rangaswamy, 2003). The determinants that influence rural household choices also impede them from maximizing on any income combination of strategies (de Lima, 2017; Islam, 2019; Khan et al., 2019; Labaree, 2009). Equally, rural household asset holding variables are affected by the contextual variables.

This means a combination of external factors affect socio-economic variables and household asset holdings variables influence the decision of rural household choice of diversified income dependency strategies. This, by extension, influences the response variables which influence household livelihood outcomes. The household livelihood outcomes are the alleviation of poverty and the reduction of income inequality.

Forest-based income in the multinomial logistic regression analysis is held constant as other diversified income dependency strategies are varied to see the responses of the outcome. Studies from (Ellis & Freeman, 2004; M Fisher, 2009; Mamo et al., 2007a; Narain, Gupta, & van't Veld, 2008; Nielsen et al., 2013) show forest-based income has both poverty alleviating and income equalizing effects on poor rural households. Other studies by (Ellis, 2000b) show rural households attempt to maximize and diversify income dependency strategies. However, contextual factors are usually conditions that go beyond the direct control of rural households and they affect income performance (Angelsen et al., 2014a; Babulo et al., 2008a; Monica Fisher, 2004).

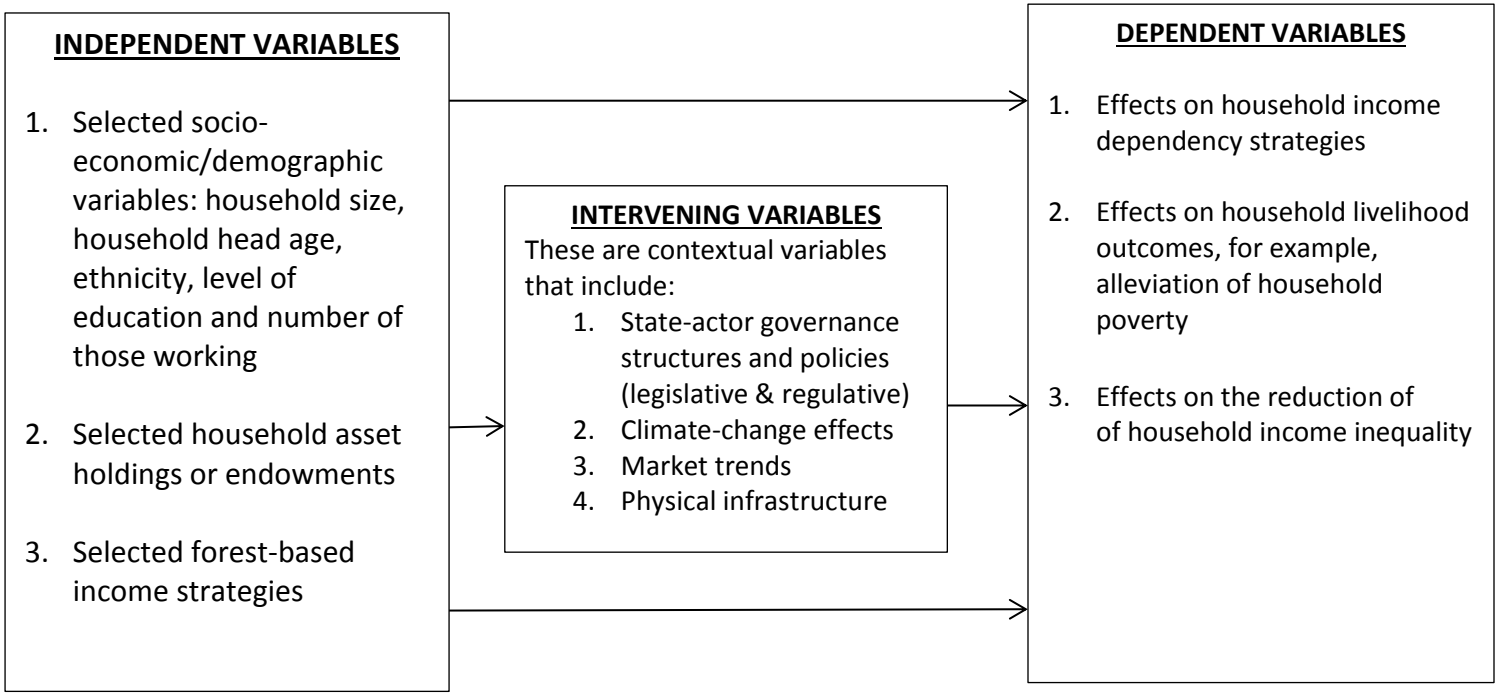

Figure 2.1: The Conceptual Framework of the Study

2.3.1 Linkage between Forest Ecosystem Resources and Household Poverty

The conceptual framework model has provided for the linkage between efficient conservation of forest ecosystem resources and household alleviation of poverty through sustainable livelihood strategies. Studies by (Angelsen et al., 2014a, p. 199; Reardon & Vosti, 1995) show the nexus between poor rural household extraction of resources for household livelihood sustainability and state-actor conservation of forest ecosystem resources. The current state-actor conservation interventions make poor rural households to be both agents and victims of degradation. A study by Reardon et al. (1995) asserts that forest ecosystem resources degradation is a household-poverty-phenomenon. It has been recommended that there should be an embedment of sustainable household livelihoods in the efficient conservation of forest ecosystem resources (Bucknall, Kraus, & Pillai, 2000).

In addition, Bucknall et al. (2000) reveal that degradation is not entirely a product of household poverty poor, but there are other causes with myriad factors and conditions. Conversely, the World Commission on Environment and Development (WCED, 1987) shows that poor rural households are forced by circumstances beyond their control to inefficiently allocate forest ecosystem resources in consumption. The report further points out that this household behaviour impoverished rural households and degraded forest ecosystem resources. This has, in turn, caused cyclical poverty leading to many more impoverished households who depend on already dwindling forest ecosystem resources. This scenario explains the reasons why most poor rural households are unable to find a pathway out of poverty. This is important to understand the web of poverty which has made rural household survival be more difficult and uncertain. This study

attempts to illuminate the factors that cause rural household poverty and what continued poverty means to forest resources degradation. These web of factors are underpinned by underperforming regular household income and forest ecosystem resources. These two have an effect on an already dwindling forest ecosystem resources and weak state-actor governance structures and policies (Soltani et al., 2012).

A study by (Vosti, Braz, Carpentier, d'Oliveira, & Witcover, 2003) shows household poverty is affected by household socio-economic characteristics, household asset holdings all conditioned by contextual factors. It is also shown that households can be abundant in one asset and poor in another which calls for equalization at total household income level. This means the other factor that affects household poverty is the household distribution of income. This is because rural household poverty is determined by the kind of household income-generating activities and land-use management practices households engage in.

2.3.1.1 Summary of Variables in the Logistic Regression Model

A summary of independent, dependent and outcome variables with their abbreviations has been presented in Table 2.1. The independent variables have been categorized into two, household socio-economic and contextual variables. The socio-economic variable indicators identified were mainly related to the household-head respondents being interviewed. The household-head indicators of socio-economic variables were: household head family members or size (HH_SIZE), age of household-head (HH_AGE), the gender of household-head (HH_GENDER), household ethnic group (ETHNICITY), number of

household members who are working (HH_WORKING) and highest education level of household-head (HH_EDU).

The indicators of the physical assets included: land size for each of the following, crops, livestock, homestead and fallow or with trees. This was indicated as land owned (HH_AGRI_LAND). The percentage of land under irrigation was captured as (IRRI_LAND). Other physical asset indicators include household size or number of livestock herd (HH_LIVES) and ownership of productive agricultural equipment or farm tools (HH_PROD_EQUIP). The financial capital variables were captured by two indicators of household income savings (HH_SAVINGS) and household accessibility to seasonal credit (HH_LOAN). Equally, household social capital variables were identified as membership in social groups or networks (HH_SOC_NETWORK).

Finally, the contextual variable indicators were measured by two proxies. These were measured by distance traveled to reach the nearest all-weather access roads (DIS_ACCESS_ROAD). The other was measured by households experiencing unexpected losses due to income shortfalls which cause shocks (UNEX_SHOCK). The dependent variables of the analytical model were identified as: on-farm income, off-farm income, mixed-income, transfers income and forest-based income. The summary of these independent and dependent variables have been presented in Table 2.1.

Table 2.1: Summary of Variables of Multinomial Logistic Regression Model

Dependent Variable	Variable Type	Variable Explanation
Household Income Dependency Strategies are assigned numbers one to five.	Categorical	The dependent variables take the value of one to five (1 to 5) according to household income dependency strategies. Income strategies have been numbered as: 1=on-farm income; 2=off-farm income; 3=mixed-incomes; 4=transfers incomes; 5=forest-based income, respectively.
Independent Variable	Variable Type	Variable Explanation
Household Socioeconomic Variables		
HH_AGE	Continuous	Age of the household head (years).
HH_SIZE	Continuous	The number of household members in a family (persons).
HH_WORKING	Continuous	Number of working household members (between ages 15 to 65 years)e
HH_GENDER	Dummy	Gender of the household head if male =1 and female =0)
HH_EDU	Dummy	The highest education level of household head (Secondary school and above =1 and otherwise = 0)
HH_ETHNICITY	Dummy	The ethnicity of the household head (Kalenjin =1 and otherwise = 0).
Household Asset Holdings Variables		
HH_AGRIC_LAND	Continuous	Total agricultural land owned by rural households (categorized) (ha).
IRRI_LAND	Continuous	Percentage of household land under irrigation (ha)
HH_LIVES	Continuous	The size of livestock herd (Tropical Livestock Units (TLU)
HH_PROD_EQUIP	Dummy	Ownership of productive farm tools and equipment (If they own tools = 1 and otherwise =0).
HH_SAVINGS	Dummy	A household with income savings (If they have savings = 1 and otherwise =0)
HH_LOAN	Dummy	Household accessibility to loan credits (Received loans in the period =1 otherwise = 0)
HH_SOC_NETWORK	Dummy	Household membership in social groups (Member of any group = 1 and otherwise = 0)
Contextual or Exogenous Variables		
DIS_ACCESS_ROAD	Continuous	Distance to the nearest all-weather road or passable access road
UNEX_SHOCK	Dummy	Experienced unexpected shocks from income losses (shocks and loss =1 and otherwise = 0)

Source: Survey Data 2013

2.3.1.2 Multinomial Logistic Regression Model

The summaries of independent variables which are given as socio-economic variables, household asset holdings and contextual variables have been presented in (Table 2.1). The multinomial logistic regression model assumes the explanatory or predictor variables to be continuous and normally distributed. The variables could also be treated as dummy variables in the model. The explanatory variables have been selected and identified based on theory and studies by (Narain, Gupta, & van't Veld, 2008; Nielsen et al., 2013). In the

analytical model, the dependent variables are assumed to be categorical and multinomial variables (Abdi & Williams, 2010; Abdullah, Stacey, Garnett, & Myers, 2016a; Parker, 2014).

In addition, the dependent variables are assumed to be agglomerative and hierarchical. This means the data on diversified household income earnings are first agglomerated into household income dependency strategies based on household income predominance (Abdi & Williams, 2010; Wold, Esbensen, & Geladi, 1987). The dependent variables, therefore, are an agglomeration of predominant household income earnings per capita per year. This household income earnings agglomeration is grouped as per hierarchical order of importance to rural households. The two-step cluster analysis allows agglomeration and hierarchical clustering of diversified household income dependency strategies was ensured to be mutually exclusive (Farinola et al., 2014; Walelign et al., 2017; Zainodin, Noraini, & Yap, 2011). Also, (Bacher, Wenzig, & Vogler, 2004; Budayan, Dikmen, & Birgonul, 2009) show the two-step cluster technique is a grouping of rural households as per their income earnings.

The grouping of rural households ensured that there was reduced dimensionality of data sets. Dimensionality is a problem related to the grouping of a household income earnings into income dependency strategies. The two-step cluster analysis, therefore, is significant in reducing dimensionality in household income data. The agglomeration of household income earnings data usually causes high correlation among variables. Studies by (Abdi & Williams, 2010; Parker, 2014; Vyas & Kumaranayake, 2006; Wunder, Angelsen, & Belcher, 2014a) show two-step cluster analysis reduces the dimensionality of data sets.

This problem is eliminated by using indicators of explanatory variables (Walelign et al., 2017).

2.3.1.3 Clustering Rural Household Income Sources Based on Relative Income

Rural households are clustered according to income earnings per capita per year. They are grouped and agglomerated into household income dependency strategies using a two-step cluster analysis (Bacher et al., 2004; Budayan et al., 2009). Cluster analysis agglomerates rural households according to diversified income dependency activities. Equally, a study by (Khai & Danh, 2012) shows cluster analysis groups household diversified income activities into normally distributed independent variables. Equally, the response variables are grouped into household livelihood outcomes (Soltani et al., 2012). A study by (Angelsen et al., 2014a; William Cavendish, 2000a; Hogarth, Belcher, Campbell, & Stacey, 2013; Rayamajhi, Smith-Hall, & Helles, 2012a) shows that rural households are clustered into income groups based on their dependence on forest-based income. Rural households are also classified into household income quintiles based on relative income or level of dependence on forest ecosystem resources.

The classification by (William Cavendish, 2000a) grouped households into five household income quintiles; lowest 20%, 20% to 40%, 60% to 80% and the top 20%. Other studies (for example, (Babulo et al., 2008a; Lopez-Feldman et al., 2007; Porro, Lopez-Feldman, & Vela-Alvarado, 2015) grouped rural household based on relative income level. Studies by Babulo et al. (2008) clustered rural households in the highlands of Tigray, Northern Ethiopia into four relative income clusters. The first cluster is households with less than 20% relative income; second is households with 20% to 40%

and the third cluster are households with 40% to 60% and those with relative income above 60% were the fourth cluster.

The first cluster was labeled as those with the least dependence on forest ecosystem resources while the fourth cluster was those with the highest dependence on forest ecosystem resources. There is no previous study in Eastern Mau that has focused on rural household dependence on forest ecosystem resources. This study, therefore, has used cluster analysis to group rural households into household income activities according to their dependence on forest ecosystem resources.

2.4 Factors that Determine Household Choice of Income Dependency Strategies

A study by (Nielsen et al., 2013) shows the multinomial logistic regression model uses a quantitative income activity approach to determine the factors that influence the choice of household income dependency strategies. The multinomial logit model uses the explanatory variables to show its influence on response variables with two unordered outcomes. In a comparative analysis by (Angelsen et al., 2014b; Wunder, Angelsen, & Belcher, 2014b) have shown the effect of forest-based income when it is held constant as other regular household income strategies are varied. The marginal analysis of forest-based income was used to measure the effect of forest-based income on total household income. As a component of diversified household income dependency strategies, forest-based income when it is held constant, and other regular income sources are manipulated, the effect of forest-based income is measured.

Studies by (for example, (Babulo et al., 2008a; Kleinschmidt et al., 2015) show that household explanatory variables provide endogenous interdependent variables for

household livelihood outcomes. Equally, household income dependency strategies endogenously affect household socio-economic, household asset holdings and contextual variables. The multinomial logit model is an ideal analytical model because it analyzes simultaneously the static role of rural household asset holdings (for example, (Babulo et al., 2008a; Saatchi et al., 2015; Walelign, 2016a). Equally, as per empirical results from (Nelsen et al., (2013) multinomial logit model is also able to detect the existence of multicollinearity problems which always associated with variable endogeneity. Multicollinearity may also be resolved by selecting and using predetermined independent variables that are truly exogenous and confirming the absence of multicollinearity by determining the variance inflation factors (VIF). This was used to confirm the absence of multicollinearity in the variables.

2.4.1 Household Socio-economic, Asset Holdings and Contextual Factors

The household socio-economic, asset holdings and contextual factors are the predictor variables that influence household income dependency strategies. Several studies by (Nielsen et al., 2013; Scoones, 1998; Soltani et al., 2012; Walelign, 2016a) show the rural household choice of income dependency strategies is determined by household socio-economic characteristics, asset-holdings and contextual factors. Rural household sustainable livelihood outcomes are influenced by these variables (Barrett, 2005; Scoones, 1998, DFID, 1999, WCED, 1987, UNDP, UNEP, WB, WRI, 2005). This current study attempts to show the relationship between explanatory variables or predictor variables and the outcome or response variables. The conceptual framework model presented in (Figure 2.1) shows how the response variables are influenced by the

predictor variables. Equally, the multinomial logistic regression model shows the influence of household socio-economic variables; household asset holdings and contextual factors have on the dependent variables.

2.4.1.1 Household Socioeconomic Variables

Forest-fringe rural households in Eastern Mau depend on diversified income dependency strategies to maintain their standards of living. Studies by (Narain, Gupta, & van't Veld, 2008; Nielsen et al., 2013; Reardon, Berdegué, Barrett, & Stamoulis, 2007; Scoones, 2009) show household socio-economic characteristics have an influence on the household choice of income dependency strategies. This current study has classified household income dependency strategies into regular household incomes and non-regular forest-based incomes. There are five types of household incomes that have been clustered based on their income-source-predominance. The socio-economic variables that influence the diversified income dependency strategies have been summarized in Table 2.1. The continuous variables are household size, number of households in the working bracket. The dummy variables are the highest level of education, gender and ethnicity. A study by (Babulo et al., 2009a; Ellis, 2000a; Ellis & Freeman, 2004; Monica Fisher, 2004) reveals these factors have a bearing on household income performance. The deficiencies in education level impacts on the ability to get employed and to earn high returns.

Equally, the higher the number of households in the working-age bracket, the higher the household chances of earning more income. This applies to household size and the ages of the household members. In addition, due to rampant household poverty, most households use own-labour for farm production and for foraging forest ecosystem

products (Angelsen & Kaimowitz, 1999; Babulo et al., 2008a; Monica Fisher, 2004).

Most of the household socio-economic variables are human resources factors related to household-head respondents (Narain, Gupta, & van't Veld, 2008). Narain et al. (2008) show the household-head age follows an inverted "U."

At a tender age, a household requires livelihood assistance from other household members. At a youthful age, the member is vibrant and productivity is high. Later in life after prime age, the productivity declines and old age sets in. This reduces the household-member physical strength and ability to engage in more rigorous on-farm activities or forest product scavenging. A study by (Godoy et al., 1997) shows there is a positive and significant relationship between consumption of forest ecosystem resources and the age of a household. Over the years, household dependents reduce in number as the young ones grow and move out in search of new opportunities or to start their own households (Godoy et al., 1997). A study by (Thondhlana, Vedeld, & Shackleton, 2012) shows the existence of a negative relationship between the age of household and consumption of forest ecosystem resources among the poor rural household communities living in the borders of the Kgalagadi Transfrontier Park, South Africa. These findings are in agreement with studies from (Adhikari, Di Falco, & Lovett, 2004) and (William Cavendish, 2000b) which reveal that rural households with older household heads tend to have low demands for forest ecosystem goods and products. This is because they have small household size at their advanced ages. Demand for resources declined because most rural households at an advanced age benefited from government social security support allowances and transfers incomes.

The studies by Babulo *et al*. (2008) in the Highlands of Tigray, Northern Ethiopia shows male household-heads in the rural community were less likely to engage in informal jobs. They were shown to engage in formal employment and the females were more inclined to perform forest products foraging. A study by (Baul, Rahman, Moniruzzaman, & Nandi, 2015) shows that most male household-heads were more likely to engage in crop cultivation than in extracting forest ecosystem products. Conversely, a study by (Adhikari et al., 2004; Kamal, Grodzinska-jurczak, & Kaszynska, 2015; Kamanga et al., 2009a) show male-headed households extracts more forest ecosystem products than female-headed households. A study by (Lambin & Meyfroidt, 2011; Parrotta, Yeo-Chang, & Camacho, 2016) shows women have insufficient knowledge in the extraction of forest ecosystem goods and products.

The highest education level of household-head was found to be a key household characteristic. This is because it contributed more to household's ability to improve income dependence strategy. A study by (Godoy et al., 1997; Mamo et al., 2007a; Narain, Gupta, & Van't Veld, 2008) shows the more educated a household head is the better-off they are in income earnings. The reason advanced for this is that more educated households have wider employment opportunities. Equally, more educated household heads can access more lucrative or high remunerative employment opportunities. Studies by (Illukpitiya & Gopalakrishnan, 2015; Mamo et al., 2007a; Tesfaye et al., 2011a) show educated households heads to have the capacity to access better-paying income earnings.

A study by (Mamo et al., 2007a; Vedeld et al., 2007) showed the size of households living in the forest margins of Dendi District, Ethiopia improved the ability to generate income earnings for the households. The quantitative income activity approach model by

(Nielsen et al., 2013) show the household size as a critical determinant for household income dependency strategy. Studies by (Angelsen et al., 2014b; Babulo et al., 2008a; W Cavendish & Campbell, 2008b) show bigger household sizes is advantageous for households to engage in a high-labour intensive income activities like on-farm activities and forest ecosystem foraging. Equally, studies by (Adhikari et al., 2004; Kamanga et al., 2009a; Mamo et al., 2007a) showed that the higher the number of adults in a household who are of high level of education places the household in a better position to earn more income from the most remunerative off-farm income activities.

2.4.1.2 Household Asset Holdings Variables

Rural household asset holdings have three continuous variables and four dummy variables. The household asset holdings are variables that have a bearing on the ability of rural households to choose income dependency strategies. The primary household income activity is derived from on-farm or agricultural income sources (Babulo et al., 2008a). Babulo et al. (2008) in his study in the highlands of Tigray, Northern Ethiopia show rural households income activities are influenced by the size of farmland and the kind of productive tools and equipment owned by households.

Farmland size is a critical factor since most rural households depend on crop and livestock production. The proximity to forestland pasture is also important to sustain livestock feeds. Specifically, the size of the livestock herd is dependent on availability of pasture and fodder hence proximity to the forest protected area. In crop cultivation activities, increased household livestock herd was related to increased crop residues that are used to feed the livestock. Increased cropland, proximity to forest peripheries and

large herds of livestock are expected to influence households to engage in on-farm income activities.

Similarly, a study by (Jansen, Pender, Damon, Wielemaker, & Schipper, 2006) used a quantitative livelihood approach to show that rural household communities in the hillsides of Honduras engaged in livestock production as a major household asset endowment because of the availability of forest pastures. Other studies by (Walelign, 2016a) show rural households in two villages of rural Mozambique depended more on forest pastures for livestock production since they owned limited farmlands. Most rural households engaged in crop production owned farm tools and equipment. For example, farm tilling tools, knapsack sprayers, oxen ploughs, bicycles for traveling to the farms and animal carts for transportation of inputs.

Babulo et al. (2008) show a great number of rural households depend more on crop production on hired or rented land or their own land. Results from these findings are in agreement with the findings from (Godoy et al., 1997; Heubach, Wittig, Nuppenau, & Hahn, 2011; Illukpitiya & Yanagida, 2010; Mamo et al., 2007a) which show the sizes of cropland and grazing land has a positive and statistically significant relationships with household dependency on forest ecosystem resources. These results show that farmland size has a positive and significant correlation with crop production income. Equally, farmland size directly influences household engagement in crop and livestock production. An increase in farmland size increases on-farm income and decreases household dependence on forest ecosystem resources (Heubach et al., 2011). The empirical findings have shown that household ownership of land resources increases their likelihood of engaging in on-farm income dependency strategies.

Household asset holdings as a variable give rural households the ability to access seasonal loans or credit facilities to finance farm operations. Studies by (Ellis, 2000a; Godoy et al., 1997) show rural households who are in formal employment are able to access loans. This is because loan facilities require some level of collateral which the poor rural farmers do not have. Seasonal farm activities include land preparation, purchase of cash inputs like fertilizers, seeds and cultivars. The others are pesticides, herbicides, acaricides, de-wormers and other veterinary services. The rural households in lower-income quintiles are mostly constrained by inaccessibility to loans since they have no other means of accessing financial working capital. Study results from (Kleinshmit et al., 2015; Walelign, 2016b) show that rural households in higher-income quintiles are engaged in off-farm income activities. Rural households in the off-farm income strategies access working capital to hire or purchase farm equipment and machinery (Ellis, 2000a; Ellis & Freeman, 2004). Studies by ((Babulo et al., 2008a; Illukpitiya & Yanagida, 2010) show off-farm income activities provide accessibility credit and finances for investment in initial cash outlays.

Equally, rural households in off-farm income activities have a high opportunity cost of extracting forest ecosystem resources (Illukpitiya & Yanagida, 2010).A study by (for example, (Kamanga et al., 2009a; Mamo et al., 2007a) shows that poor rural households living on forest-fringes of Chiradzulu District in Malawi and Dendi District in Ethiopia depend on forest ecosystem resources to supplement household income. A study by (Adhikari et al., 2004; Ellis, 2000a; Heubach et al., 2011) show forest-fringe rural households depend on income savings to finance crop and livestock production.

The social capital assets according to (Saatchi et al., 2015; Yamamoto & Takeuchi, 2012) and (Jansen et al., 2006) is measured by rural household membership in social networks groups which is used by rural households to access useful information. Studies by (Reardon et al., 2007) show that information and sufficient knowledge on emerging market trends, employment opportunities and agricultural extension services like adoption to new technological innovation on farming practices.

Agricultural extension services are critical for agricultural intensification that increase productivity and bridge yield gaps (Tesfaye, Roos, Campbell, & Bohlin, 2011b). In addition, studies by (Campbell & Luckert, 2002; Jagger, 2010) show household social network groups give households opportunities to access training programmes for value chain enhancement. Studies by (Angelsen et al., 2014b; Wunder et al., 2014a) show rural households participate in on-farm value chain if they have the technological know-how. Studies by (Agevi, 2014; Britt, 1998; Gautam & Andersen, 2016) show poor rural households depend on forest ecosystem resources as supplementary income which means all other income dependency activities have to be performing. Equally, studies from (Engel, Pagiola, & Wunder, 2008; Engel & Palmer, 2011) show that rural households are socially motivated to conserve forest ecosystem resources for their sustainability if they are members of forest associations.

The assignment of communal property rights to rural households is achievable through their membership in social groups (Adhikari et al., 2004; Katon, Knox, & Meinzen-Dick, 2001; Klopp & Sang, 2011). The rural household membership in social network groups establishes norms and rules for households to reduce forest ecosystem resource degradation. Studies by (for example, Dasgupta, Deichmann, Meisner, & Wheeler, 2003;

Joppa & Pfaff, 2010) show rural household membership in social networks reduce forest-based income dependency.

2.4.1.3 Intervening Variables

On contextual variable factors that influence household decision to choose income dependency strategies, a study by (Ellis, 2000a) show this as intervening variables. Research by (Jansen et al., 2006) shows physical infrastructure as one of the indicators of contextual variables. The distance that rural households travel to reach all-weather roads is used as a proxy for the physical structure and remoteness of the rural economy. This indicator also measures household accessibility to electric power connectivity, piped water supply and sanitation. A study by (Bezemer & Headey, 2008; Gathii & Hirokawa, 2011) shows road networks as an important physical infrastructure component because rural households use it for general transportation. It is also used to transport farm inputs and household individual movement.

The other indicator is household experiences of unexpected shocks due to income shortfalls. The climate-change-induced weather fluctuations cause fluctuations in market prices of farm produce and commodities (Pretty et al., 2011; Tiffen, 2003). The changes in market trends distort demand and supply of farm products which cause economic upheavals (Andama, Ferraro, Sims, Healy, & Holland, 2010; Berthe & Ferrari, 2012; Pattanayak, Wunder, & Ferraro, 2010). In a study by (for example, (Romijn et al., 2013), market fluctuations and poor physical infrastructure influence the performance of the rural economy. Equally, studies by (Atkinson & Bourguignon, 2001; Jumbe & Angelsen,

2006) show a thriving rural economic development is influenced by the good performance of household income activities and forest ecosystem resources.

Also, studies by (for example, (Bouda, Savadogo, Tiveau, & Ouedraogo, 2011) show state-actor policymakers have a role to play in rural economic development which is underpinned by the excellent performance of regular income activities and forest-based income. Studies by (Narain, Gupta, & Van't Veld, 2008) show rural economic development is driven by sound state-actor development policies that stimulate the performance of on-farm income activities and forest ecosystem resources. Narain et al. (2008) also shows shorter distances to reach accessible roads when transporting farm products reduces spatial costs and thus increases total household income.

A study by (McSweeney & Coomes, 2011) has documented long and winding up and down movement of households adversely affects the alleviation of poor rural households. A study by (Thondhlana, 2011; Walelign, 2016a) observed that rural households engage mainly in on-farm income activities and apart from climate-change-induced weather fluctuations, they are faced with other variables that reduce their productivity. They have pointed out that some of the household coping strategies against unexpected shocks are investing in mixed-income strategies which are mainly business-oriented. Studies by (Y. A. Boafo, Saito, Jasaw, et al., 2016; Y. Boafo, Saito, & Takeuchi, 2014) show forest-fringe poor rural households engage in no-farm and non-wage income dependency strategies to avoid calamities of on-farm income activities.

Conversely, studies by (Marschke, 2006) show that rural households that have not steered away from on-farm income activities tend to have high household poverty levels because of the underperformance of both forest ecosystem resources and on-farm income

activities. Studies by (Angelsen et al., 2014a; Marschke, 2006; Van den Berg, 2010) show the influence of contextual or intervening variables to influence household poverty. This is because rural households require working capital to relocate away from less lucrative to more remunerative income dependency strategies.

In the studies from William Cavendish, 2000; Babulo *et al*., 2008; Gopalakrishnan *et al*., 2005; Tesfaye *et al*., 2011) show rural household poverty and income inequality to be caused by household income sources. A combination of household socio-economic and asset holdings variables that are conditioned by contextual variables act as barriers household entry to more lucrative income dependency strategies. In order to dissuade poor rural households from over-extracting forest ecosystem resources, the regular household income needs to perform. A study by (Bullock, Aronson, Newton, Pywell, & Rey-Benayas, 2011) show entry barriers to rural household engagement in off-farm income and mixed income strategies can be eliminated by state-actor governance structures and policies. Rural household engagement in off-farm income and mixed-income strategies are influenced by household high level of education, accessibility to credit finance, ownership of productive equipment and state-actor investment in pro-poor income activities (Booysen, Van Der Berg, Burger, Von Maltitz, & Du Rand, 2008).

2.5 Household Diversified Income Dependency Strategies

Rural household income activities were classified as on-farm income, off-farm income, mixed-income, transfers income and forest-based income. Two-step cluster analysis was used to group these incomes into income dependency strategies. These income strategies were identified as dependent variables.

2.5.1 Household Index of Income Diversification

The household index of income diversification shows rural households living in the periphery of the Eastern Mau forest ecosystem are faced with choices of income sources. The household choice of pursuing diversified income dependency strategies is influenced by household socio-economic characteristics and household asset holdings. The household socio-economic characteristics include household size, age, gender, ethnicity, level of education and the number of households who are working. The household asset holdings include household livestock herd, size of household land for all purposes, household income savings and the number of farm tools and equipment (Byron & Arnold, 1999; Godoy et al., 1997; Pattanayak et al., 2010; Vedeld et al., 2004). These variables are associated with a household index of income diversification which is constructed by the inverse Simpson index of diversity (Hill, 1973) cited by (Joel, Wario, Mark, Grace, & Anderson, 2013). The Simpson index of diversity according to Hill (1973) is presented mathematically as:

$$\frac{1}{\sum_{i=1}^{N} P_i^2}$$ .....Equation (2.3)

Where P_i = proportion of household income generated by activity *i* as a contribution to total household income, N= the number of different household income sources.

Rural household total income sources are derived from five income clusters categorized into on-farm income S_1, off-farm income (S_2), mixed-income sources (S_3), transfers

income (S_4) and forest-based income (S_5). Rural household total income (RHT) is given by S_T. The computation of total household income is based on all income sources derived from all sources.

$$\frac{1}{\sum_{i=1}^{N} P_i^2} = \left(\frac{S_1}{S_T}\right)^2 + \left(\frac{S_2}{S_T}\right)^2 + \left(\frac{S_3}{S_T}\right)^2 + \left(\frac{S_4}{S_T}\right)^2 + \left(\frac{S_5}{S_T}\right)^2 \quad \text{..... Equation (2.4)}$$

The calculated mean index of diversification for rural households living in forest peripheries according to (Illukpitiya & Yanagida, 2008b) shows that the index of income diversification has a negative and significant effect on household income dependency on forest-based income. This means that the higher the diversification index, the less the rural households depend on forest ecosystem resources to supplement their regular household income. A positive relationship between the indexes of income diversification and total household income indicates an increase in total household income due to increasing income sources. This means income diversification should be part of a broader state-actor integrated policy on conservation of forest ecosystem resources. The results of this study found the average index of income diversification to be 2.58.

2.5.1.1 On-Farm Income Activities

Studies by (Oksanen & Mersmann, 2003) show that rural households in sub-Saharan Africa depend primarily depend on on-farm income which is derived from crop and livestock activities. Crop income is dependent on farmland size. On the other hand, livestock income is dependent on forest pasture since most rural households lack the financial capital to purchase animal feeds. Further, results from (Walelign, 2016a) show that rural households living in two villages of rural Mozambique depend on livestock for

their economic mainstay. These rural households depend mainly on forest pasture to feed their livestock. Results further show the wealth of the household communities hinges on the livestock herd they own. Unsurprisingly, a study by (Balint & Mashinya, 2006; Nielsen et al., 2013) shows that rural households have large herds of livestock which they use as near-cash security. They sell the livestock for immediate cash during times of financial stresses. A study by (Joel et al., 2013) shows that rural households in South Nandi forest peripheries sold livestock steers during hard economic times or when faced with financial stress during times of emergency cash needs. Livestock rearing, therefore, is an income-generating activity that is also a near-cash income activity.

Studies by (Heubach et al., 2011) show that rural households in Northern Benin depend on livestock rearing as a household income strategy that depends on forest pasture-based income. On-farm income strategies are derived from crop income and livestock income. Crop income is obtained by deducting all crop production costs from gross income earnings of crop production and does not include the labour cost of household members. Crop gross income includes the sum of all sales value, the value of crop by-products and crop residues. This also captures household subsistence-self-consumption crop products that are consumed at the household level. In addition, forestry products cultivated in the plots operated by the households but not from communal forests are also included in crop income. Crop production costs include land rentals, land preparation, farming inputs like for example, seeds, cultivars, fertilizers, pesticides, herbicides, hired labour, crop storage, distribution and marketing costs.

Equally, the determination of net livestock income is computed similarly as crop income. The initial cost of buying the animal is built onto the cost of livestock products consumed

at the domestic subsistence level. This could even be the cost of the livestock directly consumed and that of the value of livestock sales. Livestock products include the value of domestic consumption of products like, for example, poultry products (eggs, chicken and droppings). Animal products include milk, meat, hides and skins. Household consumption of these products includes domestic subsistence-self-consumption and animal purchases and other production costs. In support of these studies, a study by (Godoy et al., 1997) showed that rural household Amerindians living in Honduras were endowed with physical assets like livestock and productive agricultural equipment. It was found that rural households because of asset endowment were less dependent on forest ecosystem resources. The results of the study showed rural households that lacked physical assets depended more on forest-based income for improvements in standards of living. The findings from these two studies confirm that poor rural households with little asset-holds depend more on forest ecosystem resources.

2.5.1. 2 Off-Farm Income Activities

This is income earned from wage and salary employment by household members employed formally in the departments of forestry, education and public administration and that daily labourer job or monthly temporary/casual jobs of all kinds and types. These earnings are estimated by the sum of annual earnings and computed on a monthly basis. Other earnings include the value of in-kind payments from most time-consuming jobs.

2.5.1.3 Mixed-Income Activities

Mixed sources income includes non-farm and non-wage income activities that are captured by the number of income revenues that households earn from small trading businesses. These include the earnings from the sale of goods and the provision of services that are exchanged or consumed by rural households. In the rural household village markets, various products are traded, including, for example, medicinal plants and herbs, animal and plant by-products that are produced and consumed locally. The gross total household income excludes costs related to non-farm and/or non-wage business activities. Rental income is revenue from land rent and rental of premises for use by other households in the past 12 months. The income earnings include the sale of all types of household assets over the period. Other income sources include payments of pensions, lottery winnings, earning from share investments and loan interests from savings and loans.

2.5.1.4 Transfer Income Activities

This is income earnings remitted from the diaspora or outside the rural household locality. Remittances are income made by children and kinfolk, friends and relatives working overseas and in far towns but within the country. The transfer income also includes private money transfers, goods or products received from people from the rural household locality. Public money transfers include funds from various public institutions paid by insurance. It also includes retirement benefits funds and social security payments made to senior citizens in the past 12 months.

2.6 Forest-Based Income as Household Income Dependency Strategy

The household net income earnings per capita per year from various income activities were distributed into household clusters. Rural household net income earnings were categorized into clusters or household income dependency strategy groups using cluster analysis. Rural household income earnings data was organized by cluster analysis into clusters. Rural household income earnings typologies were grouped according to income share components that contribute to total household income. Rural household income distribution was further differentiated into five income dependency strategy groups. By means of descriptive tables, the means and ANOVA tests were applied for each specific indicator of interest. The testing of statistical significance and differences of means was done for income dependency strategy groups.

Forest-fringe poor rural households in Eastern Mau depend on diversified income portfolios to sustain their livelihood outcomes. Rural household outcomes include the alleviation of household monetary poverty and the mitigation of income inequality. Rural households in Eastern Mau utilize both regular and conventional household incomes and non-regular or forest-based income. Conventional household incomes are primarily on-farm income derived from crop and livestock activities. The other income is off-farm income from wages and salary employment. Mixed-income activities are derived from non-farm and non-wage income activities. For example, business and trading activities that include buying and selling of assets or hiring out of assets. The transfer income activities include income from remittances from outside the locality and the diaspora. Rural household regular income strategies and forest-based income are combined to form household income dependency strategies. These income strategies are income sources

that rural households use to form total household income. The higher this income is, the better the households are in alleviating poverty. The rural household overarching objective is to increase total household income to enable them to maintain the standards of living and to alleviate household poverty.

Forest-fringe poor rural households depend on forest ecosystem resources for their livelihood improvement. Rural households extract forest ecosystem products that include food and non-food goods and products which they utilize to sustain their livelihoods (Ambrose-Oji, 2003; Balooni & Inoue, 2007; Heubach et al., 2011; Mutenje et al., 2011; Quang & Anh, 2006). On the other hand, food products include raw water, fruits and berries, wild vegetables, honey, fish and mushrooms. The others are medicinal plants and herbs including mineral soils that supplement household diets (Narain, Gupta, & Van't Veld, 2008; Raes et al., 2016; Yemiru, Roos, Campbell, & Bohlin, 2010).

On non-food forest products that are consumed by rural households, these include energy fuel from firewood, structural and fibre materials, for example, construction poles, materials for furniture and utensils and fencing poles. The others include all forms of grasses like, for example, thatching grasses, pasture and fodder for livestock. Other extracted by rural households include products include clay soils for making bricks, quarry building stones, murram soils for roads, reeds used to make: wooden furniture, mats, baskets and utensils (Adalina, Nurrochmat, Darusman, & Sundawati, 2014; Angelsen & Wunder, 2003; S. Kumar & Choudhury, 2016; Paumgarten & Shackleton, 2011; Rayamajhi et al., 2012a). Further, there are salty clay soils and mineral-salt-licks used to supplement minerals for livestock (Ayuk, Fonta, & Kouame, 2013; Illukpitiya & Gopalakrishnan, 2015; Illukpitiya & Yanagida, 2010; Wunder et al., 2014b).

In addition, studies by (Kleinshmit et al., 2015; Larsen et al., 2015; Popoola, 2015) show rural households are motivated by household monetary poverty. Equally, research by (Sedano et al., 2016; Tegegne, Lindner, Fobissie, & Kanninen, 2016) reveals that forest-fringe poor rural households in most sub-Saharan countries depend on the forest-based income for improvement of their economic mainstay and to cover shortfalls not met by other income dependency strategies. Conversely, studies by (Babulo et al., 2008a) show that poor rural households who extract forest ecosystem resources have low levels of occupational skills, lack or have minimal working capital and the insignificant opportunity cost of labour. Studies by (Abdullah et al., 2016a; Y. A. Boafo, Saito, Kato, et al., 2016; Khai & Danh, 2012) shows that opportunity cost of labour is difficult to compute due to imperfect labour market hence rural household own labour costs are excluded in determining net crop income because of uncertainty on how to calculate the opportunity cost for household labour. These socio-economic factors make the gross value of forest-based income to be a good substitute for natural rent. An example of forest products widely consumed by rural households includes, for example, raw water resources. In this context, a study by (Walelign et al., 2017) shows that water resources as implicitly included in the production of crops and livestock and household own-consumption and own-labour costs.

In order to sustain household dependence on forest ecosystem resources, effective conservation of the resources needs to be strengthened. There is renewed global interest in sustainable forest ecosystem resources conservation according to (Angelsen et al., 2014a; Krogh, Markussen, & Bang, 2015; Mamo et al., 2007a; Vedeld et al., 2007). Effective forest ecosystem resources conservation breaks the household poverty-resource

degradation relationship which is a vicious circle. This vicious circle makes rural households be both agents and victims of degradation (Angelsen et al., 2014a; Reardon et al., 2007). In other studies by (Bucknall et al., 2000; Hosonuma et al., 2012; Narain, Gupta, & Van't Veld, 2008) show that not all degradation of forest ecosystem resources in developing countries is associated with poverty. As rural households tend to impoverish forest ecosystem resources, they degrade the resources further. This impoverishes the resources and rural households which then exacerbates household poverty and makes household livelihood outcomes a mirage under these conditions (Raes et al., 2016; Van Hecken, Bastiaensen, & Huybrechs, 2013).

Effective conservation of forest ecosystem resources, therefore, makes household dependence on forest ecosystem resources to sustain household livelihood outcomes (Dokken & Angelsen, 2015; Wunder et al., 2014a). Rural household economic activities are supported by household income dependency strategies as influenced by household asset holdings and contextual factors (Reardon & Vosti, 1995). This is so because rural households are abundant in some assets and poor in others. Household economic activities or income dependency strategies influence the types and levels of household poverty. Rural households are faced with multidimensional and/or monetary poverty (Abdullah et al., 2016a; Maloma, 2016; Megbowon, 2018). In addition, the level and type of household poverty influences household choice of income dependency strategies (Angelsen & Wunder, 2003; Lele, 1991; Scoones, 1998; Sunderlin et al., 2005), Studies by (Y. A. Boafo, Saito, Kato, et al., 2016; Kivelä et al., 2014) show that asset holdings and socioeconomic characteristics, when combined with contextual factors, affect household income dependency strategies. Other studies by (Boonperm, Haughton, &

Khandker, 2013; Bouda et al., 2011; Braat & de Groot, 2012) supports other literature that household asset holdings are explanatory variables conditioned by contextual factors.

2.6.1 Household Income Quintiles Dependence on Forest-Based Income

Forest-fringe poor rural households in Eastern Mau depend on forest ecosystem resources for various economic functions, especially for the provision of supplementary income. Studies by (Babulo et al., 2008a) shows forest-based income may be used to cluster rural household into income quintiles. Rural households depend primarily on on-farm income activities which provide over two thirds to total household income. There are other diversified income portfolios that rural households depend on to maintain their standards of living. Equally, studies by Babulo et al. (2008) show rural households may be clustered into four income quintiles based on amounts of income dependency strategies. The five identified income dependency strategies identified in Eastern Mau were: on-farm income, off-farm income, mixed-income sources, transfers income and forest-based income.

Forest-based income is considered a critical income to rural households because it acts as a supplementary income which increases total household income and thus reduces household poverty. Forest ecosystem resources according to (UNDP et al., 2005) are wild natural resources that are harvested from the wild environment. These resources are utilized by rural households to increase total household income across household income quintiles. Household income quintiles according to Babulo et al. (2008) are clustered according to household income earnings per capita per year. The quintiles range from lowest income quintiles which refer to the poorest and second poorest rural households.

The poorest households are those that earn a total per capita income per year of less than 20% of total household income.

The second poorest households earn less than 20% to 40% of total household income. Middle-income households are those midway and above the poverty line. They are households that earn 40% to 60% of total household income. The highest income quintiles according to this clustering are rural households regarded as the second richest households and the richest households. The second richest households earn 60% to 80% of total household income. Equally the richest households earn income above 80% of total household income.

Empirical studies by (Angelsen et al., 2014a) shown rural households were clustered into income quintiles and the lowest income quintiles were shown to depend more on forest ecosystem resources. Further, studies by Angelsen et al. (2014) reveal that, on average, the forest-based income contributes 28% toward total household income. Similarly, studies were done by (Thondhlana & Muchapondwa, 2014a; Vedeld et al., 2007) show rural households at high-income quintiles depend on forest ecosystem resources which contribute between 20% to 22% to total household income. Equally, studies by (William Cavendish, 2000b; Mamo et al., 2007a) show forest-based income to contribute 40% of total household income for the poorest and second poorest households in rural Zimbabwe. Empirical studies by (Yemiru et al., 2010) show the lowest income quintiles depend more on forest ecosystem resources which contribute 34% to 53% to total household income for rural households living in Bale Highlands of Southern Ethiopia. In the same region, empirical studies by (Tesfaye et al., 2011b) show the poorest and second richest households living in the forest margins of Dodola forest area of the Bale

Highlands, Southern Ethiopia, have forest ecosystem resources contributing 27% to total household income.

In support of these findings, studies from (Raes et al., 2016; Van Wilgen & Mcgeoch, 2015) show the poorest and second poorest rural households utilize about 18% to 30% forest ecosystem products to increase total household income. These studies have been supported by (Angelsen et al., 2014a; Larsen et al., 2015; Ribot, Lund, & Treue, 2010) which show both the poorest and the richest households consume forest ecosystem resources to varying degrees. Conversely, studies by (William Cavendish, 2000b; Monica Fisher, 2004; Kamanga et al., 2009a; Tesfaye et al., 2011b) suggest that higher relative income share is derived from forest ecosystem resources by lowest income quintiles. Meanwhile, the highest income quintiles were reported to derive the highest absolute income from forest ecosystem resources. Studies by (Aryal, Chaudhary, Pandit, & Sharma, 2009; William Cavendish, 2000b; Thondhlana & Muchapondwa, 2014a) reveal rural households in the lowest income quintiles depend heavily on forest ecosystem resources while rural households in highest income quintiles utilize greater quantities in absolute values. Rural households that lack household asset endowments were in the lowest income quintiles.

These are the poorest households who depended heavily on forest ecosystem resources. The lack of household asset endowments may be the cause of rural household high relative income across income quintiles (for example, (for example, (Barbier, 2010). Also, household dependency on forest ecosystem resources across income quintiles has been supported by (Kleinshmit et al., 2015) which revealed that the poorest rural households were found to pursue on-farm income strategies. Meanwhile, (Nielsen et al.,

2013) revealed that rural household reliance on forest ecosystem resources is the same regardless of household income dependency strategies and across household income quintiles. A study by (Quang & Anh, 2006) reported that in Nghe An province, Vietnam, low-income quintile households depended more on forest ecosystem resources than those in the high-income quintiles. In order to formulate effective poverty-related policies, information about household income dependency strategies across income quintiles is important.

2.6.2 Role of Forest-Based Income in Sustaining Household Livelihoods

Forest-fringe poor rural households in Eastern Mau depend on forest ecosystem resources for various economic benefits. The poorest rural households depend more on forest ecosystem resources in relative terms. The less rich rural households were revealed to depend more on the resources in absolute terms. Generally, rural households depend or forest ecosystem resources for household livelihood outcomes. This includes the alleviation of poverty and the reduction of income inequality. Specifically, rural households utilize forest ecosystem resources for three main purposes. First, the resources provide for subsistence-self-consumption (Campbell & Luckert, 2002). Secondly, the resource provides income equalizing effect for the reduction of income inequality (Ouedraogo & Ferrari, 2015; Pouliot & Elias, 2013; Walelign et al., 2017). Thirdly, rural households hawk forest ecosystem goods and products to defray their immediate cash needs (Carpenter et al., 2009; Joel et al., 2013; Kalaba, Quinn, & Dougill, 2013; Naughton-Treves, Alix-Garcia, & Chapman, 2011). Lastly, forest-fringe rural households use forest ecosystem resources as natural self-insurance and communal insurance. They use the resources to cushion themselves against natural disasters caused

by climate-change-induced disasters (Dercon, 2002; S. Shackleton et al., 2011; Ward & Shackleton, 2016, p. 201; Wunder et al., 2014a).

Empirical studies by Nielsen *et al*. (2013) show that the activity choice approach was used to show low-income rural households in developing countries have low diversified income portfolios. Further, it showed that poor rural households relied heavily on forest-based income, a component of diversified income strategy. This study provides a better understanding of poor rural household dependence on forest ecosystem resources in Eastern Mau. The study shows the income share contribution of forest-based income to rural household livelihood outcomes. This has been done by clustering rural households into five income activity variables.

According to studies by (Andres, Mir, van den Bergh, Ring, & Verburg, 2012; Calvet, Campbell, & Sodini, 2009) show off-farm income and forest-based income dependency strategies have the highest income equalization. On-farm income, on the other hand, has the lowest income equalization and lowest remunerative income. Forest-fringe poor rural households according to (Angelsen *et al*., 2014; Wunder *et al*., 2014; Kamanga *et al*., 2009; Thondhlana & Muchapondwa, 2014; Mamo *et al*., 2007) are shown to have a high relative income because of dependence on forest ecosystem resources. Also, poor rural households often inefficiently allocate forest ecosystem resources because of poverty. Prolonged consumption of forest resources has made rural households dependent on the resources and may not find a pathway out of poverty (Van Wilgen & Mcgeoch, 2015; Walelign et al., 2017).

In longitudinal studies by (McSweeney, 2005) results show rural households living in Tawahka Sumu Community, in Northeastern Honduras, provide compelling evidence that

forest ecosystem resources act as natural self-insurance and communal insurance against Hurricane Mitch. This is a climate-change-induced disaster that made rural households to have coping strategies to counter the disaster. However, the study also showed poor rural households to be vulnerable to extreme weather conditions. This disaster triggered rural households' latent adaptive capabilities that made them cope with disasters. This study also showed that the poorest households were highly vulnerable to Hurricane Mitch. Surprisingly, however, the poorest rural households in Tawahka Sumu Community were hardest hit by the disaster, but they managed to reposition themselves after the disaster.

Several studies by (Asfaw, Lemenih, Kassa, & Ewnetu, 2013; Ayuk et al., 2013; Heubach et al., 2011; Rayamajhi, Smith-Hall, & Helles, 2012b; Uberhuaga, Benavides, & Andersson, 2012; Van Oudenhoven, Petz, Alkemade, Hein, & de Groot, 2012; Yemiru et al., 2010) show forest ecosystem resources provide rural households with multiple economic benefits. The benefits include providing income equalization and improvement of rural household livelihood outcomes.

The income supports seasonal gap-filling, subsistence-self-consumption, and smoothing of consumption fluctuations during low-return cash activities. Rural households in Eastern Mau face unexpected income shocks resulting from failures in agricultural activities. This has been shown by research studies by (Y. A. Boafo, Saito, Kato, et al., 2016; Gecho et al., 2014; Yemiru et al., 2010) which revealed many developing economies forest-fringe rural households slide down the poverty line because of financial shortfalls and stresses. Conversely, studies from (Pagiola et al., 2007; Vedeld et al., 2007; Wunder, Engel, & Pagiola, 2008) show without forest-based income, a rural household may not reduce income inequality. This has been supported by studies by (Babulo et al.,

2008a; Lopez-Feldman et al., 2007; Porro et al., 2015) which show rural households depend on forest-based when all other incomes have failed. Also, a study among rural households living in the remote border region of Southern China by (Hogarth et al., 2013) shows forest ecosystem resources are used to improve household livelihood outcomes.

Studies by (Angelsen, 2010; S. Shackleton et al., 2011) reveal the existence of substantial variabilities in theories and methods of reporting the results of rural household income dependence on forest ecosystem resources. Equally, studies by (W Cavendish & Campbell, 2008b; Rayamajhi et al., 2012a, 2012b) show rural households depend on diversified income dependency strategies, and forest-based income is one of the income strategies. Research according to (Jodha, 1990; Pyhälä, Brown, & Adger, 2006) show measures of rural household dependence on forest ecosystem resources are measured in terms of employment from resource-based activities and earned income from direct harvesting of resources. According to studies by (Babulo et al., 2009b; Balana, 2007) rural household dependence on forest ecosystem resources for sustainable livelihood outcomes. This study is in line with studies by (Angelsen et al., 2014a; William Cavendish, 2000b; Monica Fisher, 2004; Mamo et al., 2007a; Vedeld et al., 2007) which show forest ecosystem resources alleviate poverty and reduce income inequality. Equally, a study by (Vedeld et al., 2004) defined forest-based income as income earned from wild or uncultivated natural resources or forest products extracted from forest resources. In the definition by a report of (UNDP et al., 2005), forest resource products are extracted from the natural environment for the benefits of forest-fringe households.

The poor rural households, however, normally do not gain directly from forest ecosystem resources hence their reluctance to conserve and protect the resources. This has been caused by state-actor failure to assign household stakeholders' legitimate rights to harvest the resource (Mamo et al., 2007a; Narain, Gupta, & Van't Veld, 2008; Vedeld et al., 2004). State-actors should formulate policies that embed forest resources in national income accounting which makes forest peripheral communities protect the forest as they benefit from it.

In studies by (Van Wilgen & Mcgeoch, 2015), there is compelling evidence that state-actors have insufficient knowledge and information on household direct economic benefits from forest ecosystem. This is evidenced by state-actor failure to incorporate forest-based income in national income accounting. Equally, state-actors have not appreciated forest ecosystem resource contribution to household livelihood outcomes. Consequently, forest-based income is not treated as conventional household income in national accounting by state-actors (William Cavendish, 2000b). This is because there is insufficient understanding of economic benefits to poor rural households from forest ecosystem resources. Consequently, poor rural households cannot find a pathway out of poverty despite extracting forest ecosystem resources (Ellis & Freeman, 2004; Fonta & Ayuk, 2013; Kabubo- Mariara, 2013; Olsson, Opondo, Tschakert, Agrawal, & Eriksen, 2014; RIGG, 2006). The minimal contribution of forest ecosystem resources to rural household livelihood outcomes has not been appreciated by state-actors in their policy frameworks (Blicharska & Grandin, 2015; Y. A. Boafo, Saito, Kato, et al., 2016; Bullock, Aronson, Newton, Pywell, & Rey-Benayas, 2011b; Heubach et al., 2011; Raes et al., 2016).

The shared knowledge in literature according to (William Cavendish, 2000b; Kamanga et al., 2009a; Tesfaye et al., 2011a; Thondhlana & Muchapondwa, 2014b) show forest-based income supports the alleviation of household poverty and reduction of income inequalities. Studies according to (Babulo et al., 2008a; W Cavendish & Campbell, 2008b) show forest ecosystem resources contribute 15% to 28% to total household income. Equally, Babulo et al. (2008) show forest ecosystem resources provide three principal functions. These include providing supplementary income and income safety nets. This critical function has been supported by (Angelsen et al., 2014a) which shows forest ecosystem resources to support household consumption at three levels.

First, forest ecosystem resources provide seasonal gap-filling when regular subsistence maintenance is low and during low-return cash activities. These functions prevent rural households from consumption risks during periods of financial shortfalls. All these functions aim at supporting the household livelihood outcomes which include alleviation of poverty and reduction of income inequality.

Second, according to studies by (Vedeld et al., 2004), the different functions played by forest ecosystem resources include, diversification of income dependency strategies. Equally, a study by (Vedeld (2007) show that forest ecosystem resources is expected to provide poor rural households with a pathway out of poverty or maintain the economic status. This means rural households that are below the poverty line do not become worse off or slide down the poverty line.

Lastly, forest ecosystem resources according to studies by (Borghesi, 2006; Das, 2010; Fonta & Ayuk, 2013) provides poverty alleviating effects and income equalizing effects. This has been supported by (Angelsen et al., 2014a; Monica Fisher, 2004; Kamanga et

al., 2009a; Mamo et al., 2007a) which show the forest ecosystem resources increase total household income. These studies have shown that forest ecosystem resources alleviate poverty and reduce income inequality. In general, forest ecosystem resources contribute positively and significantly to rural household livelihood outcomes and welfare. However, high dependence on forest ecosystem resources without state-actor intervention may potentially push the poorest and second poorest households to perpetual poverty (Pattanayak et al., 2010) cited in (Thondhlana & Muchapondwa, 2014a).

2.7 Role of Forest-Based Income in Alleviating Household Poverty

Globally, the estimated value of forest ecosystem resources is approximately US$ 145 trillion and in sub-Sahara Africa, forest ecosystem resources is estimated to be approximately $US 5.4 trillion (Babulo et al., 2008a; Costanza et al., 2014; Ouedraogo & Ferrari, 2015; Riera et al., 2012; Schaafsma et al., 2014; Tolessa, Senbeta, & Abebe, 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 increasing total household income and alleviating household poverty (Robinson, 2016; Ward & Shackleton, 2016).

Although rural households depend primarily on on-farm income activities, a study by (William Cavendish, 1999a) 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; Pretty et al., 2011) shows 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 in alleviating household poverty.

Also, a study by (Monica 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, Barrett, & Narjisse, 2002) which shows 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 are yet to succeed in introducing technological innovations to enhance on-farm income activities, for example, the use of value chain production mechanisms. These mechanisms according to studies (Brown & Brown, 2006; Greer & Thorbecke, 1986; Ricker-Gilbert, Jumbe, & Chamberlin, 2014; Worden, Western, & Waruingi, 2009) focuses on intensification of on-farm income activities aimed at bridging production yield gaps. In support of this,

studies by (Langat, Maranga, Aboud, & Cheboiwo, 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, Luckert, Banana, & Bahati, 2012) shows poor land use 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 by (Lambin & Meyfroidt, 2011; Popoola, 2015; Ingram, 2014; Arnold, 1998; Thondhlana & Muchapondwa, 2014; Van Hecken, Bastiaensen, & Huybrechs, 2013; 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.

2.7.1 Rural Household Poverty

Rural household poverty is a composite phenomenon that has been examined by several studies by (Biyase & Zwane, 2018; Burger et al., 2016; Ezzat & Ezzat, 2018; B. Kumar, 2019; Ngema et al., 2018; Wang, 2019) have shown the term poverty to have various versions of definitions. Equally, the reports of (World Bank, 2015a, OECD/FAO, 2016; UNDP, 2015; UN 2015) show there is no specific definition of poverty due to its

multifacetedness. These institutions have defined poverty as a diversity of deprivations a person or household experiences individually/separately or jointly. It is a phenomenon stifles the person's or households' abilities to function, live a life of purpose and fulfillment which where they are productive in society (Megbowon, 2018). Studies by (Brocklesby & Fisher, 2003; Chitiga-Mabugu et al., 2016; Gibson, 2016) show poverty as deprivations that are related to economic, social, political, cultural, physical or spiritual in nature.

Poverty causes a shortage of income and consumption thus affecting household general wellbeing. Household income shortfalls affect households economically, morally and socially, it even causes various other dynamic interactions. The level of household income or consumption makes households to be better off if they can meet their daily needs or worse off if they are in shortfall (Ferreira et al., 2015; Jolliffe & Prydz, 2017; Maloma, 2016). In2008 the World Development Report (World Bank, 2007) stated that on-farm income activities are the primary income sources for poor rural households. As a commitment to rural economic development, the world organizations adopted the Sustainable Development Goal (SDGs) 1 and 2 (UN, 2015). These two goals aimed at ending poverty and income inequality by the year 2030 (UN, 2015, World Bank, 2015b). Achieving these goals has been complex and difficult as there were rafts of demands that governments and their state-actors could not achieve.

The much needed policy formulations were not enacted by member states and so on-farm income value chains which contribute two-thirds of total household income has not been performing (Pretty, 2008; Pretty et al., 2011). In the past half-century, it has become hard to reduce rural household poverty and hunger in sub-Saharan Africa because there have

not been any overriding policy formulations (Verkaart, 2018). Studies by (Pretty et al., 2011) show on-farm income activities were used to improve rural livelihoods. In sub-Saharan Africa, like Kenya, Eastern Mau rural households depend primarily on rainfed crop production for subsistence-self-consumption and cash sales. It is because of reduced dependence on forest ecosystem resources and the reduced performance of forest ecosystem resources that sub-Saharan Africa remains the poorest and most food-insecure region in the world (OECD/FAO, 2016).

There are various low-income economies that impede the enhancement and improvement of household on-farm income performance in the rural economy. These are related to land use management practices, for example, the extensification of agricultural production through conversion of forestlands. These are caused by household population explosion that drives the need for more food and basic needs (Brown & Brown, 2006; Greer & Thorbecke, 1986; Ricker-Gilbert et al., 2014; Worden et al., 2009). The development of on-farm income activities is considered critical for sustained household livelihood outcomes that include alleviation of poverty and mitigation of income inequality (Langat et al., 2016).

When household on-farm income activities underperform, there are crop production yield gaps that poor rural households attempt to bridge by extracting more of forest ecosystem resources. Forest ecosystem resources, therefore, act as safety nets and insurance premium against unexpected shocks from income shortfalls. Several studies by (Babulo et al., 2008a; William Cavendish, 1999a, 2000a; Mamo et al., 2007b, 2007b) shows rural households are faced with income fluctuations because they rely on red-fed crop production which is vulnerable to climate change-induced weather patterns. Rural

households, therefore, extract forest resources to cushion themselves from income shortfalls and other risks.

It is estimated globally that forest ecosystem resources contribute approximately US$ 145 trillion to the world income (Costanza et al., 2014; Joel et al., 2013; Ward & Shackleton, 2016)Turner, Morse-Jones, & Fisher, 2010). The value of forest ecosystem resources in sub-Saharan Africa is estimated to be approximately $US 5.4 trillion (Schaafsma *et al*., 2014; (Joel et al., 2013). Studies by (Mamo et al., 2007b; Turner, Morse- Jones, & Fisher, 2010b; Ward & Shackleton, 2016) show that over 1.3 billion people in the world depend on various form of forest ecosystem resources for household livelihood outcomes which are mainly increasing total household income, alleviating household poverty and mitigating income inequality.

In sub-Sahara Africa, most forest-fringe poor rural households depend on forest ecosystem resources to alleviate poverty and to reduce income inequality (Ward & Shackleton, 2016); Shackleton & Shackleton, 2006). They use the forest ecosystem to construct forest-based income that has an equalizing effect on poverty and income inequality (Babulo et al., 2009; (Kabubo-Mariara & Gachoki, 2008); (Robinson, 2016); William Cavendish, 2000). Equally, most sub-Saharan African countries derive multiple economic benefits from harvesting forest ecosystem resources (Mamo et al., 2007b; Timko, Waeber, & Kozak, 2010). They depend on forest ecosystem resources for various purposes, for example, for seasonal gap-filling, household subsistence-self-consumption and for smoothing consumption fluctuations during periods of low-return cash activities (S. Shackleton et al., 2011; Sunderland et al., 2014; Wunder et al., 2014b). Also, rural households use forest ecosystem resources as safety nets and insurance premiums. Forest

fringe poor rural households often experience unexpected losses and shocks due to climate-change-induced disasters. Forest ecosystem resources are, therefore, utilized during these periods to cushion against exposure to risk from economic hardships (Burtraw & Woerman, 2013; Claessens et al., 2012; Pramova et al., 2012).

Equally, forest ecosystem resources are used to generate forest-based income which is used to increase total household income (Y. A. Boafo, Saito, Jasaw, et al., 2016; Farinola et al., 2014; Illukpitiya & Gopalakrishnan, 2015; Mamo et al., 2007b). With increased total household income, rural households improve household livelihood outcomes. This includes alleviating household poverty and mitigation of income inequality. Studies by (Lambin & Meyfroidt, 2011; Popoola, 2015; Ingram, 2014; Arnold, 1998; Thondhlana & Muchapondwa, 2014; Van Hecken, Bastiaensen, & Huybrechs, 2013; Van Hecken et al., 2013) shows forest-fringe poor rural households depend on forest ecosystem resources to increase total household income and to provide a pathway out of poverty and income inequality.

Rural household poverty has been defined by (Farinola et al., 2014; Sola & Zimbabwe, 2001) as a status where household total income earnings are less than what households require to meet their daily defined needs. Equally, according to (J. E. Foster & Shorrocks, 1988, p. 199) rural households are deemed to be poor when the combined total household income from all household members is less than the household subsistence income level. Rural household poverty status is measured using a variety of methods that include Foster-Greer-Thorbecke (FGT) poverty variant indices. These variant indices of poverty measurement are household headcount, poverty gap and squared poverty gap or poverty severity (J. E. Foster & Shorrocks, 1988; J. Foster et al., 1984). According to Foster et al.

(1984), the three methods of measuring are by Foster-Greer-Thorbecke (FGT) indices. Forest-based income marginal analysis measurement shows the impact of forest-based income on household poverty. The impact of forest-based income on the alleviation of household poverty is determined by computing FGT poverty indices when forest-based income is considered with total household income according to (Babulo et al., 2008a). The FGT poverty index measures the poverty headcount index ($FGT_{\alpha=0}$), poverty gap ($FGT_{\alpha=1}$) and poverty severity ($FGT_{\alpha=2}$) according to (Thorbecke, 2004).

In support of this, (William Cavendish, 2000a) reveals that forest-based income, when considered with total household income, decreases household measured poverty by approximately 45% and reduces household measured income inequality by approximately 30%. Similarly, a study by (Thondhlana & Muchapondwa, 2014b) shows forest-based income when considered with total household income reduces household measured poverty by 13% and the poverty gap by 7%. A similar comparison by Babulo *et al*. (2008) shows the marginal effect of forest-based income in reducing household poverty. The three steps were followed by first subtracting the forest-based income from total household income, secondly, is by calculating the poverty indices for total household income with and without consideration of forest-based income. Lastly, FGT poverty indices are compared when forest-based income is considered and when it is not considered with total household income. This forest-based income marginal effect was considered by Babulo et al.(2008) as the best model of estimating the impact of the forest-based income on rural household poverty.

A study by (Akanbi, 2015) shows rural households depend on forest ecosystem resources for livelihood outcomes by forest-based income increasing total household income.

Studies by (Leibbrandt et al., 2010; Maloma, 2016; Ouedraogo & Ferrari, 2015; S. Shackleton et al., 2011) shows structural and institutional factors, for example, gross domestic product (GDP) and human capital have been used to determine household income poverty. These two factors are proxies of household employment incomes which is used to measure the highest level of education because these two are statistically significant determinants of poverty. Studies by (W Cavendish & Campbell, 2008b; Fonta & Ayuk, 2013; Yemiru et al., 2010) show household poverty has a direct relationship with the factors that influence household income dependency strategies.

This hypothesis has been supported by (Maloma, 2016) which quantified the social cost of air pollution in a predominantly Black Township of Bophelong located in a low-income settlement area of South-West Emfuleni Municipality, Gauteng Province, South Africa. In addition, this finding shows there is a positive and significant relationship between household poverty status and socio-economic characteristics or household asset holdings.

In a study by (W Cavendish & Campbell, 2008b) among rural households living in rural Zimbabwe used total household income per capita per year as a convenient method of measuring household poverty. A study by (Demombynes & Hoang Vu, 2015) shows rural households in Vietnam used total household income and predetermined household poverty line to measure rural household poverty. In comparison to these two methods, the study by (Khai & Danh, 2012) shows household poverty measurement using household income method is common for household poverty measurement. Another study by (Lopez-Feldman et al., 2007) shows forest-based income is the most appropriate income

for alleviating rural household poverty among the Lacandona Rainforest Community in rural Mexico.

2.7.2 Rural Household Income per Capita

Household income earnings per capita per year is used to measure household prosperity or poverty level (Alkire et al., 2015; J. Foster et al., 1984; Thorbecke, 2004). This measurement index is total household income earnings divided by the adult number of rural household members in one year. Household per capita income per year measures household standards of living in a specified area. The income measure commonly uses international currency such as the US$ measured on a daily basis and extrapolated to calculable the nominal gross domestic product (GDP) as per report (World Bank, 2014). Gross domestic product is a useful statistic for comparison of wealth level in a country by comparing rural and urban poverty and development status.

Another measure of household income per capita is using the Human Development Index (HDI) of a country. Rural household income per capita measures the mean monetary income that rural households receive in a period of the past 12 months. This index is computed by dividing total household income earnings by the number of adult men, women and child children who are above eighteen years buy live together in one household in a geographical area. Critics of this method (Meshack, Adhikari, Doggart, & Lovett, 2006; Ruiz-Pérez et al., 2004; Sunderland et al., 2014) claim that measuring household poverty using household income per capita has several weaknesses like for example, measuring rural household monetary and not multidimensional poverty. They also claim that capturing household income per capita over a time period is not adjusted

for inflation. All figures should be adjusted for inflation, otherwise, they will overstate the effects of economic growth or poverty rates of a rural household. In addition, non-monetary activities in a rural household are not captured and accounted for by this index. For example, activities like barter trade or provision of services by household members in a locality without monetary exchange. Finally, household per capita income measurement according to (Boonperm et al., 2013; Larsen et al., 2015; Quang & Anh, 2006) is criticized because it does not include income investment in physical infrastructure development, for example, housing, roads network, health centres, education faculties, electricity connectivity, water and sanitation.

When making international comparisons of household living standards between countries, the differences are adjusted using purchasing power parity (PPP) of a given year. This PPP index has been lauded for being more accurate in reflecting what rural households actually are able to buy with their money. This figure is a mean value and does not reflect in any way the income distribution of a household. If a country's income distribution is skewed, a small wealthy class can increase income per capita substantially while the majority of the population has no income. In this respect, the median income is more useful when measuring prosperity than income per capita, as it is less influenced by outliers. The identified outliers in the data are always removed in order to have the data conform to the normal distribution (Ghasemi & Zahediasl, 2012).

2.7.3 Rural Household Poverty Line

The household poverty line was determined using household income quintiles. A predetermined household poverty line is obtained from household income quintiles. Rural

households with daily income earnings of less than US$ 1.90 were considered as poor (World Bank, 2017). In Kenyan standards, US$1.90 translates to KES 190 per day or KES 4,940 per month (at the exchange rate of 1US$=100KES). This computation is based on 26 working days in a month which excludes four Sundays or days of rest. Studies by (Lopez-Feldman et al., 2007; Porro et al., 2015; Pouliot & Elias, 2013) show that rural household poverty levels are often overstated because forest-based income is not considered as a conventional household income. This is supported by (Babulo et al., 2008a) which revealed that most developing countries omit forest-based income in the computation of nominal gross domestic product (GDP.

A comparative analysis of poverty indices across household income dependency strategies uses the decomposition of poverty indices (Babulo et al., 2008a; J. Foster et al., 1984; Greer & Thorbecke, 1986; Thorbecke, 2004). Income decomposition provides for the marginal effects or changes in the poverty level of each household income quintile cluster in relation to their total household income earnings (Babulo et al., 2009b). Conversely, a study by (Demombynes & Hoang Vu, 2015) shows that household poverty lines are predetermined using household income earnings per capita per year and/or household total consumption per capita per year since the two indicators measure household welfare. According to Demombynes et al. (2015), rural households living below the poverty line in rural Vietnam were more than those in the urban areas. This comparison shows that the national poverty index rate is usually an average. A World Bank report (World Bank, 2012) reported that Kenya's population estimated to be living on less than US$ 1.90 per day (equivalent to KES 190 per day) was high. Similarly, based on the Kenya national population and housing census of 2009, revealed the average

rural household poverty rate as 46% (KNBS, 2010). The computation of this poverty rate was based on rural household income earnings per capita in the year 2009.

Most countries in sub-Saharan Africa rely primarily on agricultural farming activities or on-farm income activities and forest ecosystem resources for their livelihoods. However, rural poverty computation tends to be overstated because forest-based income is not considered as a regular income. This means that forest-based income is not included in the computation of nominal gross domestic product or national income accounting. Studies by (Babulo et al., 2008a; William Cavendish, 2000b; Thondhlana & Muchapondwa, 2014b) show that most developing countries do not include income from forest resources in national income accounting.

2.7.4 Household Poverty Indices and Decomposition of Household Income Sources

Rural household poverty decomposition indices according to ((J. Foster et al., 1984; Kgathi et al., 2007; Reardon et al., 2007) is done in two methods. Results of the decomposition show that decomposition is done by household sub-groups and by FGT poverty coefficients. Decomposition focuses on changes in household income before and after severe shocks. The study by (You, Wang, & Roope, 2014) shows that rural households in China measured poverty in relation to a predetermined household poverty line. Other studies by (Demombynes & Hoang Vu, 2015) show that rural household poverty in Vietnam is measured using poverty indices. Results from (Yemiru et al., 2010) show that in the Bale Highlands of Southern Ethiopia, rural households alleviate monetary poverty using forest ecosystem resources. Studies by (Walelign et al., 2017) show that in two rural households living in forest fringes in Mozambique, rural household

depends on forest ecosystem resources to improve household livelihood outcomes, for example, alleviating household poverty and reducing income inequalities.

Furthermore, studies Walelign *et al*. (2017) show that forest-fringe poor rural households utilize forest ecosystem resources to improve total household income and household livelihood outcomes. Equally, studies from (Thondhlana & Muchapondwa, 2014a) show that rural households living in the Kalahari drylands of South Africa utilize forest ecosystem resources for household livelihood outcomes which are measured by poverty indices of total household income with and without forest-based income. Comparative results of this study show household poverty indices across different household livelihood dependency strategies. Results poverty decomposition indices show that household headcount index, poverty gap and poverty severity were reduced considerably when forest-based income was included in total household income. Other comparative studies from (William Cavendish, 2000b; Thondhlana, 2011) show that poverty headcount index was used to investigate the depth of poverty among forest-fringe poor rural households living in rural Zimbabwe and those living in San and Mier bordering Kgalagadi Transfrontier Park in Southern Kalahari, South Africa. Results found that rural household poverty depth increased when forest-based income was not included in the decomposition of total household income.

Results from Cavendish (2000) revealed that forest-based income when included in total household income decreased household measured poverty by a significant 50% in measured poverty and decreased by 30% in measured income inequality. Similarly, research results from (Thondhlana et al., 2012) revealed that the inclusion of forest-based income in total household income reduced poverty incidence by 13% and poverty gap by

7% for forest-fringe rural households living in San and Mier bordering Kgalagadi Transfrontier Park in Southern Kalahari, South Africa.

Studies by (Babulo et al., 2008a) reported that forest-fringe poor rural households living in the highlands of Tigray, Northern Ethiopia, depend on forest ecosystem resources for the improvement of their income dependency strategies and for household livelihood outcomes. The results of the study indicate that poverty indices were computed with and without the inclusion of forest-based income in total household income. Results by (C. M. Shackleton & Shackleton, 2006) revealed that rural household wealth status in the Kat River Valley, South Africa depended on forest-based income to improve household income dependency strategies and total household income. In conclusion, forest-fringe poor rural households in most developing countries depend on household income dependency strategies in order to spread their consumption risks.

2.8 Effects of Forest-based Income in Reducing Household Income Inequality

Research by (for example, (Bellù & Liberati, 2005a; W Cavendish & Campbell, 2008b) shows that Lorenz curves and Gini coefficients are two common methods used to assess household income inequality. Results from (Angelsen et al., 2014d; Yemiru et al., 2010) show that the impact of forest-based income on household income inequality may be analyzed in terms of the income inequality effect. Rural household total income with and without forest-based income is used to analyze household inequality status across different household income dependency strategies and income quintiles.

2.8.1 Aggregate Gini Coefficient on Household Income Inequality

The study by (Yemiru et al., 2010) shows that forest-fringe poor rural household utilizes forest-based income which reduced Gini coefficients reduced by 15%thus reducing household income inequality. The study interviewed 350 rural households living in Bale highlands of Southern Ethiopia. This indicates that household income inequality reduced by the same amount. The effect of forest-based income in reducing household income inequality is evaluated using the Lorenz curve procedure (Bellù & Liberati, 2005a; Moyes, 1987). The procedure starts with the sorting of forest-fringe rural household income earnings into income share distribution which determines the percentage of income earnings as per each rural household. The total income earnings percentage of each household is the cumulative income that corresponds to the rural household cumulative population, this is used to identify the equal distribution line or equality line in a Lorenz curve (Lambert & Aronson, 1993). Income inequality assessment using Lorenz curve analysis assumes that all rural households have the same level of income (Farris, Bendle, Pfeifer, & Reibstein, 2010; Stark, Taylor, & Yitzhaki, 1986). According to (Moreno-Sanchez, Maldonado, Wunder, & Borda-Almanza, 2012), the Lorenz curve is plotted using a cumulative percentage of household income on the x-axis and the cumulative percentage of the household population on the y-axis.

Similarly, the Gini coefficient decomposition as proposed by (Yao, 1999) is analyzed based on the rural household sub-group population. Similarly, studies by (Druckman & Jackson, 2008; Leibbrandt et al., 2010; Lopez-Feldman et al., 2007) show that income inequality assessment using the Gini coefficient is based on analysis of household total income inequality with and without forest-based income across household income

dependency strategies. However, the Gini coefficient inequality analysis may be extended slightly using the income decomposition method (Lerman & Yitzhaki, 1985). This method estimates the marginal effect of forest-based income on total household income inequality in two ways. First, the comparison of Gini coefficients with and without forest-based income is first done by deducting forest-based income from total household income. Secondly, Gini coefficients for total household income with and without forest-based income are computed. Finally, a comparison of the Gini coefficients with and without forest-based income provides an estimation of the impact of forest-based on household income inequality (Druckman & Jackson, 2008; Leibbrandt et al., 2010; Lerman & Yitzhaki, 1989; Yitzhaki & Lerman, 1991).

Studies by (William Cavendish, 1999; Narain, Gupta, & Van't Veld, 2008) classified forest-fringe poor rural households into five equal bands income quintiles of 20% in each group. In addition, Narain *et al*. (2008) show that key informants were sampled from rural households based on socio-economic characteristics. Results of the study show that total household income with and without the contribution of forest-based income across the income quintile group. In addition, other studies by (William Cavendish, 2000b) used income intervals to assess household income quintiles based on cumulative distribution function (CDF) of income random variables. Findings from (Rayamajhi, Smith-Hall, & Helles, 2012) show that cluster analysis is used to cluster rural households into household income quintiles. Studies by (Rayamajhi et al. (2012) show rural households living in the central Himalayas depend on forest ecosystem resources for household livelihood outcomes. Findings from (Thondhlana & Muchapondwa, 2014) show that rural indigenous households living in San and Mier around the neighbourhood of Kgalagadi

Transfrontier Park in South Africa depend on the forest-based income to reduce household income inequality among rural households. Further, findings point to the heterogeneous resource accessibility by indigenous forest-fringe poor households of San and Mier neighbourhoods. Results from Thondhlana et al. (2014) further show that forest-based income contributes on average 20% for the less poor households in absolute income as a contribution to total household, whereas it contributes 31% relative income for the poorest households.

Studies by (Bandyopadhyay &, Tembo, 2010; W Cavendish & Campbell, 2008b; Pretty et al., 2011) show that forest-fringe poor rural households in Zimbabwe depend on the forest-based income for improvement of household livelihood outcomes. Despite the considerable economic significance of forest ecosystem resources in most sub-Saharan Africa countries, there is still insufficient information and inadequate data. Results from (Das, 2010; K Deininger & Minten, 2002; Ebert, 1995; Torras & Boyce, 1998) show that forest ecosystem resources contribute to forest-fringe rural household well-being in society. Studies by (Rabbi, Bauer, & Idalinya, 2010) show that forest ecosystem resources reduced income inequality of fest-fringe poor rural households in rural Pakistan. Empirical analysis from (Rabbi et al., 2010) shows that a dataset of 180 observations and interviews was used to collect data from three regions in Northwestern Pakistan. The results of the study reveal that 59% of rural households reduced income inequality by consuming forest ecosystem resources. Equally, studies by (Bray et al., 2008; Bredemeier, Rüter, von Haaren, Reich, & Schaarschmidt, 2015) show that the Gini coefficient index and Lorenz curve analysis are used to assess rural household income inequality.

2.8.2 Gini Coefficient Index Decomposition on Total Household Income Inequality

Gini coefficient index according to studies by (Bellù & Liberati, 2005a; W Cavendish & Campbell, 2008b; Hogarth et al., 2013; Yemiru et al., 2010) has been used to assess the effect of forest-based income in reducing household income inequality. Gini coefficient analysis is used to assess the impact of forest-based income by analyzing inequality effect on total household income with and without forest-based income. Results from these studies show that the inequality effect analyzes household income inequality across household income dependency strategies.

The study by (Farris et al., 2010; Rabbi et al., 2010) shows that a decrease in the Gini coefficient index also decreases household income inequality when forest-based income is added with total household income. In order to assess the reduction in income inequality, Gini decomposition analysis is performed on total household income without forest-based income. Secondly, decomposition analysis is then performed with forest-based income added to total household income. Gini coefficient indices from these two analyses are then compared to show a decrease in the Gini coefficient. Moreover, studies by (Borghesi, 2006; Das, 2010; Guedes et al., 2012) show that rural household Gini decomposition analysis when Forest-based income is added reduced Gini coefficients and household income inequality. Other studies by Farris (2010) and Rabbi *et al*. (2010) show forest-based income has positive externalities that include improving household livelihood outcomes. Conversely, a study by (Guedes et al., 2012; Mcelwee, 2008) shows that a prolonged dependence on forest ecosystem resources by forest-fringe poor rural

may potentially push the poorest rural households into perpetual poverty. Equally, results from (Belcher, Achdiawan, & Dewi, 2015; C. V. Nguyen, Van den Berg, & Lensink, 2011; T. T. Nguyen, Do, Bühler, Hartje, & Grote, 2015) have argued that significant numbers of poorest rural households have substantial portions of their total household income derived from forest-based income.

Although Gini coefficients have been used to measure rural household income inequality, this method has been criticized by (Babulo et al., 2009b) who has argued that the analysis does not easily decompose total household income across household income dependency strategies. Other literature has argued (Abou-Ali, El-Azony, El-Laithy, Haughton, & Khandker, 2009; Druckman & Jackson, 2008; Farris et al., 2010; Lambert & Aronson, 1993; Lerman & Yitzhaki, 1984) that decomposition analysis makes it hard to show the sources of household income inequality. Despite this shortcoming, just like in the analysis of poverty indices, decomposition of Gini coefficients is recommended because Gini coefficients are decomposable. Studies by (Babulo *et al*., 2009) show Gini coefficient decomposition allows for examination of a particular income component that contributes to the total Gini coefficient. Equally, other studies (Pyatt, Chen, & Fei, 1980; Shorrocks, 1983) have supported Gini coefficients as decomposable by household income sources and by household income dependency strategies. Several studies by (Lerman & Yitzhaki, 1984, 1985, 1989; Yao, 1999; Yitzhaki & Lerman, 1991) show that Gini decomposition by income source is widely used because it provides the marginal effect of forest-based income on the overall income inequality. Gini coefficient index decomposition on income sources, therefore, is an income inequality measure that has

been used widely to measure the contribution of household income dependency strategies.

Results from (Monica Fisher, 2004) assessed rural household income inequality in Southern Malawi and showed that forest-based income had an equalizing effect by reducing household income inequality. In addition, the study results show that forest ecosystem resources support rural household livelihood outcomes. In a study by Babulo *et al*. (2009) forest ecosystem resources have been shown to reduce rural household inequality among rural households in Tigray, Northern Ethiopia. Study findings show forest-based income reduced household income inequality by reducing Gini coefficients from 0.46 to 0.27. In addition, a study by (Mamo et al., 2007a) shows that forest-fringe poor rural households in Dendi District, Ethiopia show that relative income reduced household income inequality by reducing the Gini coefficient from (0.41 to 0.28). Another study by (Heubach et al., 2011) shows rural households in Northern Benin used the forest-based income to reduce the Gini coefficients from (0.51 to 0.28). Results from ((Borghesi, 2006)show that forest-fringe rural households utilize forest ecosystem resources to sustain their standards of living and to reduce drastically household income inequality. Additionally, a study by (Joel et al., 2013) shows that poor rural households living on the margins of the South Nandi forest, Kenya used non-timber forest products (NTFPs) to reduce household income inequality. Study results from (for example, (Kamanga et al., 2009a) show the poorest rural households living along the peripheral forest protected areas in Chiradzulu District in Malawi depended on forest ecosystem resources to reduce inequality by reducing Gini coefficient index from (0.45 to 0.41).

2.8.3 Lorenz Curves on Household Income Inequality

Sampled rural households in the study area were clustered into household income quintiles from the poorest, second poorest, medium, second richest and richest rural households. Household groupings were done based on rural household income earnings per capita per year. Clustering was done according to (Babulo et al., 2008a) which grouped households into income quintile scales based on household income earnings per capita per year. In the results from Babulo et al. (2008), the poorest rural households were shown to own less than 20% of total household income. The second poorest households own 20% to 40%, and medium households own 40% to 60%, while the second richest own 60% to 80% and the richest households own over 80% of total household income. This clustering places rural households as per their share contribution to total household income and it compares them from the poorest to richest (Abdullah et al., 2016a; Maloma, 2016). In general, the poorest income quintile accounts for 6 to 10% of all total household income and the richest household income quintile account for 35 to 50% of total household income (Leibbrandt, Bhorat, & Woolard, 1999; Leibbrandt et al., 2000, 2010).

Lorenz curve determination of rural household income inequality is done according to (Bellù & Liberati, 2005a; Moyes, 1987). First, is to identify and sort out rural household income dependency strategies. Secondly, is to determine household income percentage that corresponds to household sub-population that generated income. This then effectively identifies the equidistribution line where each household has the same level of income (Farris et al., 2010; Lambert & Aronson, 1993; Stark et al., 1986). Lorenz curve is plotted as an accumulative percentage of household income on the x-axis and

accumulative percentage of the household population on the y-axis (Moreno-Sanchez et al., 2012). Similarly, decomposition of the Gini coefficient index by population sub-group has been proposed by (Yao, 1999).

Gini coefficient inequality analysis according to (Lerman & Yitzhaki, 1985) has been extended to estimate the marginal effects of forest-based income on total household income inequality. In order to compare Gini coefficients with and without forest-based income forest-based income, forest-based income is first deducted from total household income. Secondly, Gini coefficients for total household income are computed with and without forest-based income. Finally, a comparison of the Gini coefficients with and without forest-based income provides an estimation of the impact of forest-based on household income inequality (Lerman, 1985; Leibbrandt *et al*., 2000; Druckman *et al*., 2008). Rural household income quintiles are determined using a Gini coefficient model derived from (Yao, 1999). The measurement model by Yao (1999) classifies rural households into a finite number of household income quintiles based on income per capita per year. A graphical representation of the Lorenz curve shows income distribution and the variation in total income inequality. The graphical representation of the curves, therefore, shows total household income with and without forest-based income added to total household income. Lorenz curve shows a straight diagonal line that represents perfect equality and the curve beneath it that shows the reality of income distribution. The difference between the straight line and the curved line measures the amount of household income inequality. The closer the curve to the straight line or equidistribution line, the less the income inequality and the further away it is, the higher is the income inequality.

Rural household poverty indices were analyzed across household income quintiles (Babulo et al., 2009a) shows the decomposition of poverty indices across household income quintiles (J. Foster et al., 1984). This study has been adapted the decomposition model that grouped rural households into k distinct groups of (i=1, 2, 3…….k). The decomposition model was adapted from (Babulo et al., 2009a). The model is mathematically represented as:

$$Ua = \sum_{r=1}^{t^{(1)}} \frac{1}{n} \left[\frac{R - Z_j^{(1)}}{R} \right]^a + \sum_{r=1}^{t^{(2)}} \frac{1}{n} \left[\frac{R - Z_t^{(2)}}{R} \right]^a + \cdots + \sum_{r=1}^{t^{(k)}} \frac{1}{n} \left[\frac{R - Z_t^{(k)}}{R} \right]^a$$

.....Equation (2.5)

Where $t^{(k)}$ is the number of rural households who are below the poverty line in household income quintile group k, n_k is the number of rural houses in income quintile group k, $Z_r^{(k)}$ is the income of the j^{th} rural household in income quintile group k with income below the poverty line. This model provides the effects of change in household income quintiles. The results of total household poverty have been presented as:

The quantity $\sum_{r=1}^{t^{(k)}} \frac{1}{n} \left[\frac{R - Z_t^{(k)}}{R} \right]^a$ which denotes the poverty index of the total contribution of household income quintile k in relation to the overall household poverty index.

The percentage contribution of poverty index to household income quintile r is presented mathematically as:

$$100 \sum_{r=1}^{t^{(k)}} \frac{1}{n} \left[\frac{R - Z_r^{(k)}}{R} \right]^a / U_a$$

.....Equation (2.6)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The introduction is in 3.1 and 3.2 is the measurement variables and 3.3 is the details of the study area. Research design and sampling procedures are in 3.4 and 3.5 is the data types and methods of data collection. In 3.6 is the validation of survey instruments and lastly in 3.7 are ethical issues of the study. Equally, this study has attempted to disapprove of the four research hypotheses that were to tested.

3.2 Measurement of Variables that Determine Household Livelihood Outcomes

The factors that determine rural household income dependency strategies have neither been understood nor researched. Rural households depend on diversified income dependency strategies for sustainable household livelihoods. A multinomial logistic regression model has been used to determine the factors that influence the choice of household income dependency strategies. The model uses a quantitative income activity approach to assess the predictor variables which include household socio-economic, asset holdings and contextual variables. These predictor variables influence the response variables or outcome or dependent variables that have been identified in this current study. Rural households are rational beings who attempt to maximize their outcomes given the existing constraints and contextual variables. The dependent variables are regular household diversified income dependency strategies and forest-based income strategies (Reardon & Vosti, 1995; Walelign et al., 2017). Studies by (Hogarth et al., 2013; Jagger, 2010; Van den Berg, 2010) shows forest-based income to have an impact

on the alleviation of household poverty and alleviation of income inequality. Equally, studies by (Abdullah et al., 2016a; Berhanu, Colman, & Fayissa, 2007; Guedes et al., 2012) show forest ecosystem resources to be threatened by deforestation and degradation activities due to poor household land use management practices.

3.2.1 Measurement of Factors that Influence Household Choice of Income Strategies

This study used a multinomial logistic regression model to analyze a set of predictor or explanatory or independent variables that affect the dependent or outcome or response variables. The explanatory power of the logistic regression model will show the factors that determine the response outcomes (Walelign et al., 2017). The measurement model uses a probability approach to analyze the odd-ratios or probabilities that a rural household will choose a particular income dependency strategy given the prevailing conditions. (Walelign et al., 2017) in his findings shows that predictor variables including contextual factors constitute some of the entry barriers to more lucrative income dependency strategies when forest-based income is held constant, given all other factors. The analytical model as adapted from (Walelign, 2016a; Walelign et al., 2017) has been presented mathematically as:

$$\text{Prob}\left(X_i = q \mid r_i\right) = \frac{e^{\beta^1 q^r qi}}{1+\sum_{p=1}^{r} e^{\beta^1 p^x qi}} \quad \text{.....Equation (3.3)}$$

Where $q = 0,1,2,\ldots,q; i = 1,2,3,\ldots,n \; and \; \beta_0 = 0$, where β_{qi}^{1} are vectors of coefficients r_i which are associated vectors of predictor variables. The multinomial logit model is used in this study to show the effects of predictor variables on log-odds ratios. This is represented mathematically as:

$$\ln\left[\frac{s_{iq}}{s_{ip}}\right] = r_i^{'}\beta_j \; if \; p = 0 \qquad \text{.....Equation (3.4)}$$

Where β_j indicates the change in log-ratio between the probability of the choice of income dependency strategy j and the probability of the choice of income dependency strategy k (forest-based income) which is the base group, given each unit change of x_i according to (Nielsen *et al*., 2013).

However, the odd-ratios are given by $\frac{s_{iq}}{s_{ip}}$ does not depend on the other household income dependency choices.

However, the analytical model by (Leach et al., 1999; Scoones, 1998, 2009) shows household income dependency strategy choices are determined by three predictors, socio-economic, asset-holdings and contextual variables. Equally, studies by (Babulo et al., 2008a, p. 20; Walelign, 2016a) show the existence of endogenous interdependence among rural household asset holdings variables and livelihood outcomes (poverty alleviation and reduction of income inequality). This implies that rural household livelihood outcomes are generated by chosen household income dependency strategies which could in turn endogenously affect rural household asset holdings (Babulo et al.,

2008a; Dasgupta et al., 2003). Rural household diversified income dependency strategies were analyzed as determinants with a focus on forest-based income as a base. The errors of endogeneity were eliminated by using indicators of variable according to (Babulo et al., 2009a; Raes et al., 2016; Xu et al., 2015). In this study, predetermined predictor variables were selected to ensure that they were truly exogenous before conducting a multicollinearity test.

3.2.2 Measurement of Household Poverty using FGT Poverty Indices

The degree of poverty amongst poor rural household is measured by means of three variants, the poverty headcount, poverty gap and poverty severity indices using Foster-Greer-Thorbecke (FGT) metric according to (J. Foster et al., 1984). This method of household monetary poverty measurement has been criticized by (Alkire et al., 2015) for not taking into account the extent of multidimensional household poverty. This study has calculated rural household monetary poverty using the Foster et al., (1984) model. This has been represented mathematically in a generic model as:

$$FGT_a(y;z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^a \quad \text{.....Equation (3.5)}$$

Where z is the household poverty line ($z<0$), y_i is the per capita income of the i^{th} poor household. The total household income is applicable if $y<z$, $q_{=}y;z$ is the number of households with income below the poverty line, n is the total number of households, α is a value that can take (0, 1 and 2). When $\alpha = 0$, then FGT_0 is the headcount index, and when $\alpha=1$, then FGT_α is the poverty gap index and when $\alpha = 2$, then FGT_2 is the squared poverty gap or poverty severity index (Foster et al., 1984).

The commonly used household poverty index measurement is the headcount index. The poverty gap index and the squared poverty gap index are not commonly used. Headcount poverty index (FGT_0) where $\alpha = 0$ is used to measure household poverty incidence or the proportion of rural households that have income below the poverty line. This index does not change even if the households below the poverty line become poorer or richer as long as they remain below the poverty line (Lopez-Feldman, 2007). Headcount poverty index (R_0) as adapted from (Lopez-Feldman et al., 2007) is mathematically represented as:

$$FGT_O(y;z) = \frac{1}{n}\sum_{i=1}^{q} 1 = \frac{n_q}{n} \quad \text{.....Equation (3.6)}$$

Where n_q is the number of rural households with total household income below the household poverty line. On the hand, the household poverty gap index (FGT_1) where $\alpha = 1$ is a measure poverty gap or depth of poverty to which rural household has fallen below the poverty line.

The poverty gap index is represented mathematically as:

$$FGT_1(y;z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z - y_i}{z}\right) \quad \text{.....Equation (3.7)}$$

The poverty gap index measures the amount in monetary values that are needed to push rural households to move up the poverty line. This poverty gap index, however, does measure or reflect the differences in inequality among forest-fringe poor rural households

(Abou-Ali et al., 2009). This index shows that rural households at lower income quintiles in welfare terms or the poorest and second poorest households hence require greater income to move up the poverty line hence the greater is the index (Demombynes & Hoang Vu, 2015; Lopez-Feldman et al., 2007).

Squared poverty gap index (FGT_2) where $\alpha = 2$ according to the research by (Boonperm et al., 2013) measures household poverty severity. The squared poverty gap is calculated as averages of the squares of poverty gaps relative to the poverty line. This measure although it is important is rarely used because it is difficult to interpret its results (Abou-Ali et al., 2009). Squared poverty gap index has been presented mathematically as:

$$FGT_2(y;z) = \frac{1}{n}\sum_{i9=1}^{a}\left(\frac{z-y_i}{z}\right)^2 \quad \text{.....Equation (3.8)}$$

3.2.3 Measurement of Household Income Inequality using Gini Coefficient Indices

Aggregate Gini coefficient (G) decomposition is calculated for total household income inequality derived from *k* exclusive household income dependency strategies. Household income dependency strategies are on-farm income, off-farm income, mixed-income, transfers income and forest-based income. Rural households use these income dependency strategies for the reduction of household income inequality. A Gini decomposition approach adapted from (Lerman & Yitzhaki, 1985) shows that rural household population (n) consists of N rural households (n=1,2,3,4,...N). The total household income is the sum of household income components from *k* different income dependency strategies. The aggregate Gini (G) coefficient for total household income

inequality with k exclusive income components has been decomposed in a mathematical representation as follows:

$$G = \sum_{k=1}^{k} S_k D_k R_k$$

.....Equation (3.9)

Where S_k is the share of income strategy *k* of total household income ($S_k = I_k / \sum I_k$), D_k denotes disaggregated Gini coefficient for income strategy *k*, and R_k is the measure of Gini correlation between income source *k* and the cumulative distribution of total household income and income source *k* is I_k.

The decomposition of the Gini (G) coefficient by income source presents the effect of changes in forest-based income on overall income inequality in comparison with other income sources. The study assumes that a change in each household income sources *k* equals $I_k$where I is close to 1. The marginal effect of a particular income source *k* is presented mathematically as:

$$\varepsilon_k = \frac{I_k}{G}\frac{\partial G}{\partial I_k} = \frac{S_k G_k R_k}{G} - S_k$$

.....Equation (3.10)

This study adapted the formula from (Lerman & Yitzhaki, 1984, 1985, 1989). The marginal effect is a percentage change in income from source *k* (I_k) divided by aggregate Gini (G) coefficient. The marginal effect represents the Gini elasticity or income elasticity of G that is given asε_k. The above equation shows the percentage change in aggregate Gini (G) coefficient when income sources *k* increases by 1%.

The approach examines how changes in particular household income dependency strategies contribute to total household income. The income components also have some effects on household overall income inequality. The net effect of household income components including forest-based income was finally measured as a contributor to the aggregate Gini coefficient. This study has also calculated the marginal effects of each household income strategies. The income from *k* different strategies contributes to the reduction of household overall income inequality.

3.2.4 Measurement of Income Inequality using Lorenz Curves

The sampled rural households in the study area were clustered into household income quintiles. The grouping was done using rural household income earnings per capita per year. On this basis, rural households were clustered into income quintiles. The clusters were: poorest 20%, second poorest 20% to 40%, medium-income households at 40% to 60%, second richest at 60% to 80% and richest at 80% and above. This clustering places rural households as per their total household income earnings from the poorest to richest (Abdullah et al., 2016a; Maloma, 2016). In general, the poorest income quintile accounts for 6 to 10% of all total household income and the richest household income quintile account for 35 to 50% of total household income (Leibbrandt et al., 1999, 2000, 2010). Gini coefficient index is another method of measuring household income inequality (Lerman & Yitzhaki, 1984, 1985, 1989). Other studies (Lambert & Aronson, 1993) derived the Gini coefficient indices from the Lorenz curve. Other studies by (Bellù & Liberati, 2005a; W Cavendish & Campbell, 2008b; Hogarth et al., 2013; Moyes, 1987) show the Lorenz curve as one of the methods of measuring rural household income

inequality. Lorenz curve is drawn with the x-axis measuring the rural household cumulative proportion of income share contribution. On the y-axis is the rural household cumulative population share that contributes to the income share. In this study, the rural household cumulative population share and household cumulative income share were computed. The computation of a household cumulative income share was done for a given share of household income quintiles. This was then divided by the total household income T. The Lorenz curve was determined according to the model adapted from (Bellù & Liberati, 2005a) and is presented mathematically as:

$$Q\left(\frac{r}{w}\right) = \frac{\sum_{i=1}^{r} y_1}{T} \quad \text{.....Equation (3.11)}$$

Where: Q= Lorenz curve rages from:

r = 1….n is the total number of households in a given proportion of household income quintiles who are at a defined income level;

i = 1….r is the position of each rural household in the income distribution given by the proportion of the household population;

w = is the total number of rural household in income distribution;

y_t = is the income of the i^{th} rural household in the income distribution;

$\sum_{i=1}^{r} = y_i$ Is the cumulative income up to k^{th} household; and

$\sum_{i=1}^{r} = y_i$ ranges between 0, for r = 0, and T, for r = n;

Therefore, $Q\left(\frac{r}{w}\right) = \frac{\sum_{i=1}^{r} y_i}{T}$ (range is between 0 and 1).

3.3 Description of Study Area

Kenya's current forest cover is estimated at approximately 6.99% of the total landmass (KNBS, 2010). This coverage is considered to be below the constitutional requirement of 10% (KNBS, 2010). Forest ecosystem resources in Kenya have high species richness and endemism. It comprises small and mega terrestrial biodiversity (Mango, Melesse, McClain, Gann, & Setegn, 2011; Mati, Mutie, Gadain, Home, & Mtalo, 2008). The twenty-one forest reserves are contiguous forest ecosystem resources rich in diverse flora and fauna. Several studies by (Brown & Brown, 2006; Kabubo-Mariara & Gachoki, 2008; Kristjanson, Radeny, Baltenweck, Ogutu, & Notenbaert, 2005; Langat et al., 2016) show forest-fringe poor rural households living in forest-peripheral areas of Eastern Mau reserve sustain household livelihoods by cropping forest products.

The area is situated about 190 km North-West of Nairobi at 35°58'00" E and 00°32'00" S. The area lies on an altitude range of 1100m at the lowlands to 2800m at the highlands. The highest levels of Eastern Mau are the mountain summit that is 5800m above the mean sea level. The study area has been shown (Figure 3.1). Eastern Mau forest reserve is a tropical montane rainforest with a plentiful supply of forest ecosystem goods and products. Forest-fringe poor rural households extract these products to supplement their livelihoods and to improve their standards of living (Barber, Cochrane, Souza, & Laurance, 2014; Ellis, 2000b; Ellis & Freeman, 2004). Eastern Mau forest reserve used to measure 65921 ha equivalent to 2372 Km^2. This forest ecosystem is a watershed and upper water catchment Mau Hills Forest complex, one of Kenya's water towers. The forest ecosystem sustains seven major rivers, four lakes, one national park and two game

reserves. Also, river basins flow from the Mau hills forest complex. The river basins are Rift Valley, Lake Victoria, Athi River, Tana River and Ewaso Ngiro North river basins in Appendix XIX. Eastern Mau is the upper watershed or river catchment area for Rift Valley and Lake Victoria river basins in Appendix IV.

Eastern Mau forest ecosystem is now a fraction of its former size before it was degazetted, excised and allocated to farmers for agricultural extensification activities from 1980 to 2000. Government policy at the time led to the loss of forest ecosystem that has been exacerbated by climate change-induced weather fluctuations that have caused erratic rainfall patterns. The forest excision and allocation of protected forest reserve areas paved the way for the conversion of the forestland to agricultural lands. Eastern Mau is one of the most viable forest ecosystems according to the Kenya Forest Service (KFS) (GoK, 2005). Mau Hills Forest Complex has 22 protected forest reserves including the Maasai Mau which was under the Narok County government until recently. All the 21 forest reserves are under the conservation and management of the Kenya Forest Services. Eastern Mau forest ecosystem is one of the 21 forest reserves in Appendix XVII.

Molo sub-county area measures 478.79 Km^2 with a population of 140,584. Equally, the Njoro sub-county area measures 713.13 Km^2 with a population of 208, 359. This study employed purposive sampling and multi-stage sampling techniques to sample forest-fringe rural households living five kilometers away along six sub-locations. The three sub-locations in the Njoro sub-county are Sigotik, Nessuit and Misepei. The sampled administrative sub-locations in the Molo sub-county were Ndoshua, Kitito and Kiptunga. Purposive sampling was used to select the six sub-locations that are adjacent to the contiguous forest ecosystem that provided a variety of forest ecosystem resources for

rural households. In the Molo sub-county, three administrative sub-locations were sampled from a possible 12 sub-locations and three sub-locations were sampled from the Njoro sub-county from a possible 24 sub-locations. A band of five kilometers radius from the periphery of forest protected reserve area covering the six sub-locations was delineated for sampling.

Eastern Mau Forest reserve is a habitat for endemic fauna and flora that includes monkeys, baboons, forest hogs, waterbucks, gazelles, antelopes, hyena and wild foxes. The others include honey badgers, tree hyrax and African genet. Among these are endangered mammals the yellow-backed duiker (*Cephalophus sylvicultor*), and the African golden cat (*Felis aurata*). It is predicted by studies (Baldyga, Miller, Driese, & Gichaba, 2008; Gichero, Nabwile Makokha, Chen, Gachimbi, & Wamuongo, 2012; Mango et al., 2011; Were, Dick, & Singh, 2013). Degradation of the forest ecosystem resources in Eastern Mau, therefore, potentially threatens with extinction some of the flagship fauna that is supported by the Mara River whose source is Eastern Mau. The fauna includes lions, leopards, cheetahs, buffalos and elephants. There are enormous gene bank and flora biodiversity that is in the Eastern Mau forest reserves. The increased species and genetic material at the ecosystem level are greater in Eastern Mau because of its proximity to the equator. The warm equatorial climate is conducive for the primary productivity of the diverse flora (Mutune, Hansen, Wahome, & Mungai, 2017; Thygesen, Løber, Skensved, & Hansen, 2016). Equally, the forest ecosystem resources sustain economically forest-fringe rural household communities in Molo and Njoro sub-counties.

Eastern Mau forest ecosystem has rolling hills and plains (Okwi et al., 2007; Olang & Kundu, 2011). Studies by (Kinyanjui, 2011; Klopp & Sang, 2011) show that the Mau

Forest Hills area is composed of quaternary and tertiary volcanic deposits. Studies by (Langat et al., 2016) show that topsoils in Eastern Mau compose a variety of loam soils and clay loam soils to silty clay loam soils. Most of the soils in the Eastern Mau area have pH values of (5.6 to 6.4) (Were et al., 2013). The results of their study also show the soils of Eastern Mau to be moderately acidic in the lowland areas. Studies by (Baldyga et al., 2008) show that soil types are mainly luvisol, vertisol, planosol, cambisol and solonetz which were formed from Holocene sedimentary deposits (Baldyga et al., 2008). According to (Sombroek, Braun, & van der Pouw, 1982), soil prevalence in Eastern Mau is characterized by soils that occur in saline and sodic phases. Studies from (Kimutai & Watanabe, 2016; Mango et al., 2011; Mati et al., 2008) show that in the highland agro-ecological zones, soil content is high in silt and clay and is dominated by ferrasols, nitisols, cambisols and aerosols. The peripheral settlement areas adjoining most parts of Molo and Njoro sub-counties were found to be gentle slopes with deep fertile-volcanic soils. These areas were found to be suitable for agricultural products that include on-farm income activities, for example, crop and livestock production. Rural households living in the precincts of the Eastern Mau forest ecosystem engage in diverse income dependency strategies for livelihood outcomes.

The climate of Eastern Mau is characterized by a trimodal precipitation pattern. The long rains are intense and fall in April to June and short rains fall in August. The less intense rains fall from November to December. The area has a total annual precipitation of 1200mm with a mean monthly rainfall of 30mm to 120mm. Eastern Mau area has a mean annual temperature ranging from 12°C to 16°C with the greatest diurnal variation being in the dry season. Molo and Njoro sub-counties are located in highland parts of Nakuru

County with poor physical infrastructure. The road network of this area is not developed which increases spatial costs for poor rural households when transporting agricultural commodities to reach all-weather roads en-route to the markets. The electricity and piped water are also not widely spread in the area. The state-actor structural and institutional governance policies have not embedded rural household livelihood.

The population of the greater Molo District which was covered by the greater Eastern Mau Forest reserve had a population of 542,103 (KNBS, 2010) (see Appendix XVII). Eastern Mau in general terms is a low-income rural economy with high unemployment rates. The area also has high poverty rates and high-income inequalities. The Kenyan average poverty rate stands at 46% but according to the national economic survey, the World Bank shows that rural poverty reverberates in the rural economy (World Bank, 2014). However, the estimates of rural poverty being 50% to 60% on average may be overstated (KNBS, 2010). This is because forest-based income is not factored in the computation of national gross domestic product (GDP). This has been thought to be the major reason state-actors do not appreciate forest ecosystem resources which supplement household livelihood outcomes (Babulo et al., 2008a, 2009a). This has been thought to be the reason for state-actor low budgetary investment in conservation subventions. This has equally disenfranchised rural households from legitimately depending on forest ecosystem resources for their livelihood outcomes.

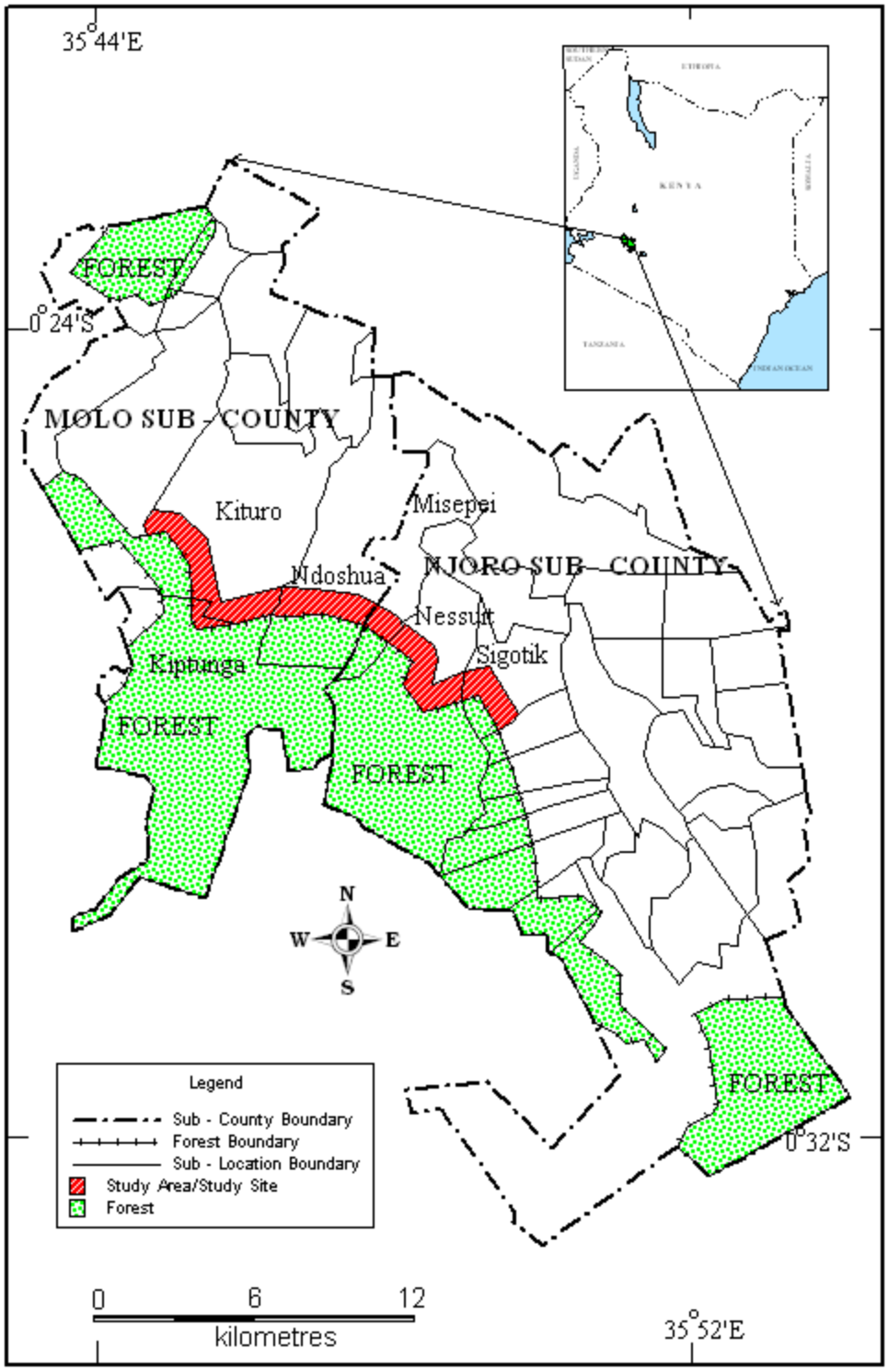

Figure 3.1: Map of Eastern Mau Forest Reserve Showing Study Site

The results of this study will be used to illuminate the importance of forest ecosystem resources in supporting household livelihood outcomes of forest-fringe poor rural households. Consequently, it will highlight how forest ecosystem resources impact positively household income dependency strategies and total household income.

3.4 Research Design and Sampling Procedures

3.4.1 Cross-Sectional Research Design

A cross-sectional study was conducted with the same set of variables over a certain period of time. The study was conducted in a single instance, unlike longitudinal studies, where variables could change over the period of extensive research. The cross-sectional study gave the flexibility of evaluating multiple variables together as a constant. This was done with only one variable being the focus of the cross-sectional study. This study encapsulated the households as a group at a snapshot point in time. This method was chosen because it captured what was happening in real-time, at the moment.

The bivariate data were analyzed at two levels; first, categorical data were collected and analyzed into percentages and frequencies using chi-square tests. Equally, continuous data was collected and analyzed into means and standard deviations using analysis of variance (ANOVA). Secondly, collected data was further analyzed using a multinomial logit model, descriptive statistics and tables. This is where qualitative data was tabulated and descriptive statistics used. The multinomial logit model is a binary method was used to process, analysis and interpret the results. The model was used to analyze the factors that influence the rural household choice of income dependency strategies. Rural household monetary poverty was measured using the Foster-Greer-Thorbecke (FGT) model indices. Equally, Gini coefficients and Lorenz curves were used to measure

household income inequality. The methods of data collections and statistical analyses were used to ensure independent variables explained the dependent variables. The measurement of these variables was done based on ton theoretical foundations and past empirical studies. Equally, a correlational analysis was employed to process the data so as to be able to understand and interpret the results. From the representative sample, data were collected were managed and processed using Statistical Product and Service Solutions (IBM SPSS Statistics) version 21.

3.4.2 Survey Instruments

The first instrument was a semi-structured household questionnaire survey instrument which was used to capture information from respondents. The instrument captured data from a dataset that included explanatory variables and their indicator variables. The second was a semi-structured interview guide that was administered face-to-face on the respondents. Other instruments included focus group discussions (FGD) that were used to discuss issues that needed a wider involvement of respondent groups, for example for clarification. Also, the forum was used to clarify information from the collected data. Those in the focus group discussion included eminent household community members who were not respondents. Key informant interviews were also used to provide qualitative information on those who were more knowledgeable about the community.

3.4. 3 Sampling Procedures

The onset of sampling commenced with the determination of a sampling frame or universe. This was followed by determining the representative sample size. The study

employed a multi-stage sampling procedure to collect the data from the sampled area. The onset of the sampling procedure commenced with the determination of a sample frame or the universe and representative sample size and multi-stage sampling.

3.4.3.1 Determination of Representative Sample Size

The representative sample size for the study was determined using a multi-stage cluster sampling formula adapted from (Bassioni, Price, & Hassan, 2003; Grandval & Vergnaud, 2006; Mouakhar & Tellier, 2013). The formula is mathematically represented as:

$$n_c = \frac{p^2 q.r}{s^2} \quad \text{.....Equation (3.15)}$$

Where:

n_c = is a representative sample size of rural households.

p = is the confidence level (95%) that is (z=1.96).

q = is the proportion of the sampled rural households from the target population (or sample frame of 1, 800)

r = is (1-q) the proportion of total population other than that of rural households

s = is the desired precision (0.05 level).

Rural households were clustered into income quintiles based on per capita income earnings per year. The formula is based on parsimonious consideration which includes scarcity of funds and time. A household questionnaire survey instrument was administered to 450 rural household respondents. A semi-structured questionnaire instrument was administered to rural households using an interview schedule. A representative sample of 450 rural household units was calculated and randomly sampled

from the sample frame. A study by (Mamo et al., 2007a) defined a household unit as a common food production unit where members of a household live together and eat together.

3.4.3.2 Multi-Stage Random Sampling Design

Multi-stage sampling procedures commenced with the determination of a representative sample size (n=450) which was determined using a multi-stage cluster sampling formula adapted from (Bassioni, Price, & Hassan, 2003; Grandval & Vergnaud, 2006; Mouakhar & Tellier, 2013). Once the sample size is determined, the first stage of sampling was delineating households that live within a four-kilometer radius from the forest protected area. The households must those who have been resident in the area for the past 12 months. Equally, the households were those living in the purposively selected six administrative sub-locations of Molo and Njoro sub-Counties. The second stage of the procedure is to select five villages in the six sub-locations using a stratified random sampling technique. This technique s ensures that the distribution of survey villages that lie within the four-kilometer radius from the forest-band taking into consideration geographical factors, population densities and on-farm income activities. Also, the stratification technique considers other household variations across the six sub-locations in the study (N=30 villages). The location of each village was checked to ensure sufficient geographic distribution in the four-kilometer forest band. This was based on a list of rural households that was compiled containing rural households residing in each of the villages within the six sub-locations. The village register was done by key informants and village leaders with guidance from the research assistants. On the basis of this, sixty

households were randomly selected from five villages per sub-location or thirty villages. The third stage was to enumerate households living in all the 30 identified villages. A total of 1,800 rural households formed the sample frame which was a combined household in both Molo and Njoro Counties. These households were counted in all the five villages which straddled the six administrative sub-locations. They were registered and enumerated from a designated commencement point on the frame. 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 5^{th} household was assigned a random number #1 then interviewed. The next four households were counted and the 10^{th} 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.

3.5 Types of Data and Methods of Data Collection

There are two broad types of data that were collected for purposes of this study, primary data and secondary data. The primary data included household socio-economic characteristics, diversified conventional household income activities and forest-based

income sources. Secondary data included data collected from state-actor institutions and agencies.

3.5.1 Primary Data

The primary data was collected directly from respondents using a semi-structured household questionnaire survey instrument and face-to-face direct interviews using the interview guide. The reconnaissance survey of the study area was carried out from June 2011 to December 2011. The survey was done so as to understand the geographical topography of the study (see Appendix II). The pre-testing of the questionnaire survey instrument was done from August 2011 to December 2011. Pre-testing was done in a non-sample area which is different from the six sub-locations. The pre-testing of the questionnaire was done by interviewing twelve selected key informants two from each of the six sub-locations. Pertinent information from the pre-testing of the questionnaire was used to calibrate the instrument accordingly.

A representative sample size of 450 households was determined using a multi-stage cluster sampling formula (Bassioni et al., 2003; Grandval & Vergnaud, 2006). This sample size represented 20% of the household community. The respondents in the sample were interviewed using a multi-stage sampling technique. The technique was used to determine the sample frame and a sampling fraction and the sample frame was 2,250 households. The sampling commenced with a reconnaissance survey which was done from June 2012 to July 2012. The questionnaires were pre-tested in August to December 2012. The collection of data was done beginning in January 2012 and ended in June 2013. The study area is the peripheries of the Eastern Mau forest ecosystem. The sample

was collected from six sub-locations located in Molo and Njoro sub-counties of Nakuru County. The study focused on this forest reserve area because it is a contiguous forest reserve that is rich in forest resources. The agricultural land surrounding the forest reserve is also enjoying good microclimate as a result of the forest ecosystem. This climate is ideal for crop cultivation and livestock production. These are the two economic mainstays of forest-fringe rural households in the Eastern Mau area. The independent or explanatory variables of the study are household asset endowments. These are factors that influence or constrain rural households in livelihood improvements. The dependent variables are household income dependency strategies that influence household livelihood outcomes. The outcomes are the objectives of this study which is the alleviation of household poverty and reduction of income inequalities.

A semi-structured questionnaire instrument and interview schedule was used to solicit information on primary data from respondents. The commencement of the primary data collection commenced in January 2012 and it ended in June 2013. Four trained research assistants were engaged to administer the survey instruments. Research assistants administered semi-structured questionnaires and conducted face-to-face interviews following the interview guide. The primary data were collected from households. They provided socio-economic and demographic characteristics which are mainly household asset holdings or endowments. The other data was on household conventional income earnings. Lastly was data on forest-based income earnings that were derived from extracting forest products.

3.5.1.1 Data on Household Socio-Economic and Demographic Characteristics

The primary data on rural household socio-economic and demographic characteristics were data on household asset holdings or endowments. This first data was elicited from rural households using semi-structured questionnaire survey instruments. A semi-structured interview was also conducted using interview guides. Data were collected from rural household-heads who provided household data on, size, age, sex, number of members who are working, highest education level, ethnicity and gender. The questionnaire survey instrument provided data and information that was considered sensitive and personal. Some of the information that touched family, finances and marital status was captured using an electronic recording device and was transcribed later. The transcribed data was recorded in the data log sheet and stored in case it was necessary to retrieve it later. All socio-economic data that was collected and generated was verified by key informants and sometimes counterchecked in focused group discussions. These two groups of respondents were used to authenticate and corroborate information data that needed to be clearer from the respondents and interviewees. Studies by (Mbewe, 2016; Zakour & Bienefeld, 2014; Lyatuu, 2015) revealed that data on household asset holdings and contextual variables also influenced the household choice of income dependency strategies.

3.5.1.2 Data on Household Asset Holdings

Rural household asset holdings have three continuous variables and four dummy variables. The household asset holdings are variables that have a bearing on the ability of rural households to choose income dependency strategies. The primary household income

activity is derived from on-farm or agricultural income sources. The data collected was on the size of agricultural land owned or operated by rural households. The other is the percentage of agricultural land under irrigation which has a bearing on the reduction of rain-fed agriculture and stability against the effects of erratic rainfalls. The number of livestock herds is also important and household proximity to forestland pasture. It is also important to sustain their livestock. Specifically, the size of the livestock herd is dependent on available pasture and fodder. These are some of the factors that influence the performance of on-farm income activities. The information on different types of crops and the value of the crops in the past year was captured. Household ownership of farm tilling tools, knapsack sprayers, oxen ploughs was captured. The households' accessibility to seasonal loans or credit facilities required for financing farm operations was captured. Farm working capital was captured under the financial services received by households. The rural households who live above the poverty line were shown to have income savings that they can use as collateral to qualify for seasonal loans or to purchase inputs directly. The important information that households provided was on household membership in any social network groups.

3.5.1.3 Data on Contextual Factors

The contextual data variable was collected based on the physical infrastructure in the Eastern Mau area. The distances that rural households traveled from one place to another before they could reach all-weather roads were computed and measured. This was taken to be a proxy for the physical infrastructure and remoteness of the rural economy. This indicator measured household accessibility to electric power connectivity, piped water

supply and sanitation. The distances to most places were captured. The other is the household experiences they face from unexpected shocks resulting from income shortfalls. The households were asked whether they had come out of shock or they still were in shock from the past year.

3.5.2 Data on Regular Household Income Dependency Strategies

Rural households depend on regular household income activities to sustain their standards of living. The regular household income activities data was collected using the questionnaire survey instrument and the semi-structured interview schedules. There are four regular household income earnings that households derive income from. Rural households engage in on-farm income activities for example crop and livestock production. The other is off-farm incomes that are earned from all kinds of labour jobs, wage employment and salary employment. Mixed-income earnings are derived from non-wage and non-farm income activities that are related to trading in goods and services. Finally, the transfers-income is income earned from remittances from kinfolk from outside the locality and those in the diaspora.

A semi-structured questionnaire survey instrument was used to elicit the income data from household respondents. The quantities and prices were measured using market-based approaches. This is because these income activities have market-clearing prices and rural households were able to remember the quantities they harvested in the past 12 months. Rural household income earnings data was measured as income per capita per year. Crop and livestock production as on-farm income activities were measured. Off-farm income activities were household income derived from wages and salary

employment. Mixed-income activities were derived from non-wage and non-farm income activities. Transfers-income activities were income activities derived from public and private fund transfers and remittances from kinfolk and friends.

A rural household questionnaire survey instrument was used to elicit income data from crop income activities. The income was estimated to total household income earnings from each crop that was cultivated in the past twelve months. The crop income included crop values that were used for subsistence-self-consumption and for cash sales. The unit of output was calculated per month or as crop seasonality depending on the type of crop. All computations were done for the past 12 months or one calendar year. The data on crop prices were counter-checked by the prices of the particular crops in the local village market at the time. Care was taken to avoid overstating or understating of the crop incomes. Similarly, the same care was taken to ensure there were no exaggerations or undervaluation by some respondents. The gross crop incomes were computed by including total crop sales and income from income sales from its by-products. The value for household subsistence-self-consumption was also included in crop gross income. The net crop income was obtained by deducting the costs of production. The crop production costs include costs of inputs like for example, seeds, cultivars, fertilizers, pesticides, land rentals, hired labour, storage, transportation and marketing. The dominant crops generally in Eastern Mau were maize and beans. The others were horticultural crops like for example; french beans, peas, potatoes, tomatoes, carrots, kales and cabbages. The prices of these crops varied from one village to another, but the market prices in the last one year were used especially as provided by those reaching adjacent urban towns like Elburgon, Molo, Njoro and Total Junction, Mau Summit and Nakuru. The prices of all

crops in Eastern Mau were affected by seasonal weather fluctuations and other external macroeconomic factors. This means prices varied from year to year and that most horticultural crops also depended on prices as determined by market demands for the crops.

Livestock income activities were computed based on livestock unit sales in a 12 month period. The livestock gross income was determined based on the number of livestock sold and the livestock by-products consumed by households. The cost associated with livestock was livestock initial unit price plus input costs. The livestock input costs include, for example, de-wormers and treatments and vaccines. The other management costs include acaricides for controlling ticks, artificial insemination and security. Most rural households in Eastern Mau keep dairy cows, heifers and steers. The others include sheep, goats, poultry, pigs and donkeys. Just like crops, the selling prices livestock were determined by external macroeconomic factors. The input costs include the cost of pasture and fodder paid to the District Forest Office. The net livestock income was computed after deducting all associated costs. These include values for by-products like milk, eggs or whatever was consumed in the past 12 months by the family. This may include slaughtered livestock for subsistence consumption. Just like crops, the livestock unit selling prices was taken to be what was fetching in the local village market at the time.

Off-farm activities were captured as wage and salary employment income that working members of rural households earned in the past 12 months. Wages income was considered as income from manual or labourer kind of odd jobs that many were engaged in. These incomes include earnings from farm casual or daily work-labourers doing

various odd jobs. For example, households working in urban centres as shop attendees and others as craftsmanship. Most household workers were farm labourers or motorbike transporter (*boda-boda).* Salary employment is related to monthly regular pay as a primary school teacher, provincial administration staff, forest-warden and nursery caretaker. The salaried jobs were those earning income that had pensions. For example, those working as wardens, teachers and any other government institutions that also earned regular pay. The net wage and salary income was a sensitive item on the questionnaire and so care was taken to ask for it indirectly and privately. These employment incomes were estimated based on the kind of job and the level of the person in the job place. The gross incomes included the sum of all annual earnings in wages, salary and benefits that household members received in-kind payments in the past 12 months period.

Mixed-income activities included income sources from trading with farm produce, farm inputs and forest products. These are business income activities that are non-wage and non-farm related. The rural household was elicited to provide information on these activities in the past 12 months. Other income that was captured included those that earn interest income from bank savings. The income from pension fund payments and other retiree pension investments. In Eastern Mau, many rural households engage in small business trading which includes sales of all kinds of goods or provision of services. The net mixed-income was obtained after deducting the cost of goods sold and related expenses of doing business. In this category of income is household business in land and house rentals. The income captured rental income from hired out land, real estate and production assets in the past 12 months.

Transfers-income activities were considered as income earned by rural households in the locality of Eastern Mau. It included income from private money transfers from persons outside the locality. It also included money remittances by kinfolk, relatives and friends working in far towns within the country and even in other diaspora towns abroad. There were money transfers from public institutions. For example government social security assistance for elderly citizens that were remitted periodically through the local chiefs. All this money attracted little transaction costs and was computed over the past 12 months period. Rural household conventional income data was estimated based on certain assumptions. The income was computed based on actual crop or livestock quantities produced and sold. This information was provided in semi-structured questionnaire instruments. Where actual unit prices of produce were missing or prices or respondent forgot or did not know, the prices of the village markets were used according to studies by (Walelign *et al*., 2017; Larsen *et al*., 2015; Angelsen *et al*., 2014).

3.5.3 Data on Forest-Based Income Dependency Strategies

Forest-based income sources are derived from extracting forest ecosystem goods and products. Forest ecosystem resources are non-market goods or public goods which is difficult to value. These forest goods and products do not have market-clearing prices. The assessment of the value of these products was done using direct forest product pricing or direct substitute pricing methods according to (Kiplagat, Mburu, & Mugendi, 2010). These two approaches were utilized to capture the values of forest ecosystem products. Also, this estimation of forest products data captured household subsistence-self-consumption and what they sell for immediate cash.

Forest ecosystem goods and products are public goods that do not have market-clearing prices. The prices of the goods and products are estimated based on local village market prices or prices of substitute products. Respondents were elicited to provide information on the kind of products they extract from the forest and what they pay for it. Forest-based income was estimated for products that were harvested and consumed in the previous 12 months period of household active involvement. A semi-structured questionnaire survey instrument was used to capture actual quantities and average prices for it. The prices of forest products like medicinal plants, wild honey, wild berries, vegetables and mushrooms were not readily available. 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 cases, the products were estimated using the consumption of other households within the same area. The prices of forest products were provided by the local village market. Other ways of obtaining the prices of forest products were by using shadow prices or opportunity costs for the forest products that did not have market-clearing prices. In addition, gross forest-based income was applied where information on prices was not already available. 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. Consequently, the computation of the 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 the Kakamega forest. In this study, forest products that used direct pricing included firewood, pastures and medicinal plants. This is because these products were consumed in sizable quantities and were easy for respondents to remember. The forest products that were consumed by rural households directly were computed together with forest pasture. These included forest fodder and thatching grasses and building materials. Other products that were consumed directly were computed together with medicinal plants. These included wild honey, vegetables, mushrooms, fruits and berries. The valuation of these forest products was pre-conditioned by the need to have deterministic monetary prices in the local market. The quantity and prices of products consumed by each household were estimated. However, most of these forest products did not have readily available market-clearing prices. The prices of the market substitutes from adjacent village markets were used.

Rural households were found to consume substitutes for forest products. Price substitutes of marketed commodities were used to estimate the prices of forest products. This was used because forest products had market substitutes in the local village market. These forest products that were categorized with medicinal plants included wild vegetables, wild mushrooms, wild honey, wild fruits and berries. These forest products were

measured using weight in kilograms or according to portions. The prices of substitute products found in nearby local village markets were used for forest products that did not have prices. Most forest products in this category were available during particular seasons. This study computed the prices of forest products that were collected in the previous 12 months period. Some of these forest products were harvested and sold as merchandise in the village market. The study used the buying price of the merchants to compute the forest-gate prices. This price was used for products that were consumed by rural households and the prices were not known presently.

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 amenable to rural households. These included women back-loads or head-loads, donkey-loads, bicycle-loads or motor-bike-loads. Others use donkey-cart-loads or pick-up loads. The prizes of these firewood loads were in Kenya shillings. They were sold in village markets but rural households also fetched their own from the nearby forests. Also, rural households paid for firewood levies on a monthly basis just like livestock grazing permits. The permits were paid for in the local or nearby District Forest Offices. Rural household firewood consumption was computed for the previous 12 months when it was consumed. However, firewood was consumed daily by fetched on a daily, bi-weekly or weekly basis. This is because firewood was also fetched and sold to consumers in the nearby urban centres for immediate cash income.

Additionally, medicinal plants were used by most rural households for the treatment of livestock. These medicinal plants are utilized as the need arises or at a particular time of the year or season. They are used widely to treat poultry and cows. Whenever

respondents were in doubt of the price for these products, approximation was done based on market substitutes. For example, market drugs for treating common poultry coccidiosis and livestock east coast fever were estimated based on market substitute prices. The cost of conventional drugs and their substitutes for the treatment of livestock diseases was confirmed by veterinary staff and the local agro vet shops. Medicinal plants and herbs were used to treat household members since time immemorial. The herbalist charges were estimated per household member and the number of times they became sick in a year.

The other products that were extracted by rural households and were consumed seasonally included, for example, fruits, berries, green vegetables, mushrooms, termites and honey. The quantities of these products were measured by the number of trips made by the extractor and/or the quantities of products they carried per trip per season. These forest products had market price substitutes in the conventional local village markets. Household cost of labour and opportunity cost was factored in the cost of products. For example, women fetching firewood also collected vegetables, while livestock herders also gathered firewood, extracted fruits, berries and mushrooms. Rural household-heads responded that women fetched firewood and collect vegetables and fruits. The male herders were often tasked with grazing livestock in the forests and also collecting honey, mushrooms, fruits and berries. For most of the men and young adult boys, this multi-tasking posed a challenge of information-recall. Most of the men could barely remember the periods but remembered for sure the quantities they extracted during what period. This necessitated research assistants to counter-check with other respondents in other

sub-locations. This was necessary to confirm the forest products that were frequently extracted and in what quantities so as to make an educated guess.

The Kenya Forest Services provided levies and fees they charge for each livestock that grazes in the forest per month. This captured the cost of forest pasture and fodder. Rural households were charged per the number of cattle. The policy of Kenya Forest Services does not allow sheep, goats, donkeys and pigs to be grazed in the forest. This means that the bigger the size of cattle like heifers and steers is equated to the quantities of forest pasture consumed. The bigger the herd, the more the quantities of pasture consumed and so the higher the fees. As for thatching grasses, rural households were charged on estimated quantities they have collected measured in lot sizes. Again, this depended on the type of grasses that were consumed or harvested for thatching.

3.5.4 Secondary Data

Secondary data was collected from state-actor agencies that are charged with the conservation and management of natural resources. These agencies include, for example, Kenya Forest Services (KFS), Kenya Wildlife Services (KWS), the National Environmental and Management Authority (NEMA) and Water Resources Management Authority (WARMA). These agencies were used to authenticate and corroborate information that was not clear from the primary data collection.

Secondary data was used to corroborate, verify and authenticate the information from primary data. In spite of this, the mining of secondary data from documents in various ministries and state corporations was not easy to access and retrieve. Some of the government ministries and state agencies were interviewed to authenticate the primary

data that was doubtful. Equally, employees in government conservation ministries were interviewed for them to corroborate primary data. These included the Ministries of Planning and Devolution, Foreign Affairs and International Trade, Transport and Infrastructure, Tourism and Wildlife, Environment and Natural Resources, Water and Irrigation, Agriculture, Livestock and Fisheries, Industrialization and Enterprise Development. The state corporations include Kenya Forest Services (KFS), Kenya Wildlife Services (KWS), Water Resources Management Authority (WARMA) and Kenya National Bureau of Statistics (KNBS). Other non-state actor institutions include UNEP, UNDP, DFID and World Bank. The non-state corporations include NGOs, academic institutions and conservation institutions. Most of these institutions did not have the kind of information and data that was needed. The collected data were processed and managed using Statistical Product and Service Solutions (IBM SPSS Statistics) version 21.

3.5.5 Data Processing

The information data obtained from the questionnaires and interview guides were coded and exploration is done early to clean up the data. The coding process ensured that the right procedure was followed. An exploratory analysis was used to reveal the structure and patterns of the data so as to eliminate the gross errors in the data. Early cleaning of data was done to eliminate the possibilities of incorrect conclusions. In addition, cleaning ensured the scope and distribution of explanatory variables were factored in relation to other endogenous variables. The cleaning of data was done to reduce errors before actual data analysis was done. Data were processed and managed using Statistical Product and

Service Solutions (IBM SPSS Statistics) version 21. In order to understand more about the issues that underlie the investigations, descriptive tools were used to analyze the data. Descriptive analyses of variables were done and descriptive statistical tables were used. During the processing of data, means, frequencies and standard deviations were computed. This analysis provided a better understanding of the variables in the datasets. The study used bivariate and multivariate statistical analysis tools were used to understand better the explanatory variables. Bivariate data analysis was measured by one-way analysis of variance (ANOVA). According to studies (Klaus Deininger & Squire, 1996; Quirk, 2012), the tests analyze whether there are differences in absolute incomes and relative incomes from forest-based incomes. Analysis of variance (ANOVA) was also used to analyze whether there are any differences in household characteristics. These include household ethnicity, gender, sex, size, number of household members in the working bracket, level of education and household income earnings. Equally, chi-square ($\chi 2$) tests measured whether there were any significant differences in the means of individual and household characteristics. Equally, chi-square ($\chi 2$) and F-test were used extensively in the study. These two were used to measure whether there were any statistical mean differences between various explanatory variables. In addition, chi-square tests ($\chi 2$) were applied to test the association between categorical variables and the distribution of income between household income quintiles. Correlation analyses were used to determine the relationships between the various income dependency strategies in relation to total household income. All the above tests were carried out to know whether the variables were statistically equal. The explanatory variables included socio-economic and demographic variables, household asset holdings or endowments. These were the

endogenous variables of household income dependency strategies. The other exogenous variables were the intervening variables or contextual variables.

In multinomial logistic regression analysis was used in the study to determine the factors that influence the choice of rural household income dependency strategies. The multinomial logit model is a binary logit model that is used to test the association and correlation among explanatory variables. The explanatory variables are also referred to as predictor variables. The variables predict the outcome of the dependent variables as response variables for household livelihood outcomes. Household asset holdings are mainly socio-economic and demographic characteristics. Other multivariate statistical analyses include R^2 values which were determined to explain the impact of the explanatory variables on the estimation of the dependent variables.

Focused group discussions were conducted to understand issues that could not be answered directly by the questionnaire or interview schedule. Some of the discussions included the measurement of poverty and inequality. The other is the understanding of the extent to which rural households depend on forest ecosystem resources. The discussions also covered the choosing of villages in the six sub-locations that were within the four-kilometer radius from the forest periphery.

3.6 Validation of Survey Instruments

The research study questionnaires were used as rating scales and the interview schedules and guides were used to provide self-checklist. These are the household questionnaire survey instruments. The study ensured that there was good instrument usability. This is

the ease with which the instruments could be administered, interpreted by the participant, and scored/interpreted by the researcher or research assistants.

3.6.1 Reliability and Validity of Instruments

The reliability and validity of the procedures and the research process depended on the attributes of scoring while administering the questionnaires. This study ensured the scores were both reliable and valid for it to allow multivariate analysis to be done. The relationship between the two is that score reliability is a necessary but insufficient condition for validity. Reliable scores may also be valid but unreliable scores cannot be valid.

3.6.1 Scale Reliability

The study ensured there was the reliability of the scores from the interviews and questionnaires. Reliability measurement ensured the scores were free from random measurement errors. There were different types of random errors that were eliminated when evaluating the different aspects of score reliability. The main types of reliability are internal consistency reliability, test-retest reliability, alternate forms reliability and inter-rater reliability. The focus of this study was to ensure there was internal consistency reliability. With regard to this study, Cronbach's coefficient alpha (α) was used to evaluate the internal consistency of data scores. This is a statistic that measures internal consistency reliability. The internal consistency measures the degree to which responses are consistent across the items within a single measure. If internal consistency reliability is low, the content of items may be so heterogeneous that the total score is not the best possible unit of analysis for the measure (Denzin, 2017; Fusch, Fusch, & Ness, 2018).

Cronbach Alpha is a coefficient that measures the internal coherence of a scale that has been constructed from a group of items. However, this is not without limitations. Some of its limitations include the need for uni-dimensionality of the concept, the degree of correlation between the items and the number of items on a measurement scale (Lincoln & Guba, 1990; Teddlie & Tashakkori, 2009). Although there is no absolute standard on how high coefficients should be, some proposed guidelines on score reliability have been offered (Fusch, Fusch, & Ness, 2018). Accordingly, the general reliability coefficients close to 0.90 may be considered excellent and the values around 0.80 as very good whereas the values around 0.70 are adequate. Since the researcher may either evaluate the reliability of scores in his or her own samples or rely on prescribed sources, this study adopted the former since the concepts were relatively new and the context largely unexplored in regard to measurement of the constructs in the questionnaire scales.

3.6.2 Validation of Data

The validation of data collection tools focused on the soundness of the inferences based on the scores. This was done to ensure the scores from the measurement scales measured what they are supposed to measure, but also not measure what they are not supposed to measure (Teddlie & Tashakkori, 2009). The two most important forms of validity are internal and external validity. One of the measures of internal validity is based on construct validity. Construct validity concerns itself with whether the scores measure the hypothetical construct the researcher believes they should. Hypothetical constructs are not directly observable and these can be measured only directly through observed scores.

There is no single descriptive test of construct validity nor is it typically established in a single study.

Content validity is a facet of construct validity and concerns whether the test items are representative of the domain they are supposed to measure. Content or face validity was important for variables developed for this study. For this purpose expert opinion was the basis for establishing whether item content was representative of the concept under study. A Professor in the school of postgraduate studies in the School of Business and Economics was provided with a draft questionnaire to establish the completeness of items for each construct. Their comments were enjoined in the subsequent revision of the instrument. Criterion-related validity is another facet of construct validity. It concerns whether a measure relates to an external standard (criterion) against which the measure can be evaluated. These relations are usually assessed with correlations called validity coefficients. Concurrent validity is used when scores on the predictor and criterion are collected at the same time. Predictive validity is used when the criterion is measured later and postdictive validity is used when the criterion is measured before the predictor (Bettman, Capon, & Lutz, 1975; Csikszentmihalyi & Larson, 2014).

3.7 Ethical Issues of the Study

This social science inquiry hence it considered ethical issues in the procedure of data collection, analysis and interpretation of results. In undertaking these procedures, the rights of participating respondents were respected. Specifically, prior to data collection, an introductory letter was prepared for the purpose of seeking informed consent from respondents to participate in the study. Details revealing the purpose of the study and guarantee of anonymity and confidentiality were included in the letter. All research

assistants were required to show the letter to all potential respondents when soliciting participation in the research. As indicated in the introductory letter, the right of anonymity and confidentiality was guaranteed in this study. Research assistants were required to assure respondents that the study was only for academic purposes and not for circulation to other parties. Equally, the assurance includes making sure that there was respondent anonymity which guaranteed the respondent's right to privacy. The data and results were kept confidentially within the scope of the study. Confidentiality allowed the respondents to the individual freedom to determine the time, extent and circumstances under which the private information would be shared with or withheld from others. This ensured that the wishes of respondents and ideas were observed in order to ensure their privacy.

CHAPTER FOUR

RESULTS, PRESENTATION, ANALYSES AND INTERPRETATION

4.1 Introduction

This chapter reports the presentation of results, analyses and interpretation. There are four sections in this chapter. In section 4.2, household characteristics have been examined, in section 4.3, the distribution of forest ecosystem resources and their impact on rural household livelihood strategies is presented. In section 4.4, the factors that determine household choices of income dependency strategies have been covered. In section 4.5, the impacts of forest-based income in alleviating rural household monetary poverty are covered. Finally, section 4.6 covers the reduction of household income inequality using forest-based income.

4.2 Results of Study Area Characteristics

Eastern Mau forest ecosystem protected area was previously a big forest reserve covering the Molo District. Most of the forest protected area has been degazetted, excised and allocated for agricultural activities. This conversion has reduced the Eastern Mau forest protected area to a few sub-counties. The study area is part of Eastern Mau and a section for this study falls within Molo and Njoro sub-counties in Nakuru County. The study area has three agro-ecological zones, lowland, midland and highland zones. The results of the area household characteristics are presented in Table 4.1. Results show the study area is divided into sub-location units that cover the forest protected area. Results show the six sub-locations that includes the forest protected area. These sub-locations have proximity to contiguous forest ecosystems with plentiful forest goods and products for extraction.

Conversely, sub-locations were also mapped based on climate suitability for rain-fed agricultural production. The mapping considered landforms, soil types, land uses and vegetation cover types. These were taken into consideration for specific agricultural potentials. These agro-ecological specific potentials for crop and livestock production include, for example, altitude levels, temperature regimes and soil types. Results show that the area had good seasonal rainfall amounts and distribution during the growing season. The analysis household population was done across household livelihood quintiles. Results show the population of rural households living in delineated areas of the six sub-locations. The sampled households were those living within a four-kilometer distance from the forest periphery as shown in the delineated study area Figure 3.1.

Results show the six sub-locations bordering the forest reserve areas with indigenous contiguous forest. Rural households living in these areas were identified to depend on forest ecosystem resources to supplement total household income. Results in Table 4.5 show the distribution of the surveyed rural households within the six sub-locations of Kituro, Kiptunga, and Ndoshua in Molo sub-county. In the Njoro sub-county are Misepei, Nessuit and Sigotik. In addition, results show how rural households from different income groups are aggregated into urban and rural communes where they find service provision. Results show the study area characteristics to exhibit statistical differences across household income quintiles at the 1% level of significance. ANOVA tests were applied and the results show that there are significant differences across all the five household income quintiles at 1% level of significance.

Further, results in Table 4.1 show the distribution of households was strongly associated with household income quintiles. The majority of surveyed rural households were located

in lowland and midland agro-ecological zones of Ndoshua 26.77%, Kitaro 20.34% and Sigotik 18.04%. The population of rural households was small in highland agro-ecological zones of Misepei 9.43% and Kiptunga 9.20%. The distribution of surveyed rural households in different sub-locations was different across household income quintiles. The majority of surveyed rural households in the poorest and second poorest income quintiles live in Ndoshua 34.5% and 32.75%, respectively). The richest households were found to live in Nessuit 23.78%. The middle-income quintiles were found to live in Ndoshua 27.97%, Sigotik 24.41% and Kituro 21.22%. Meanwhile, a high percentage of the second richest were located in Kitiro 23.96%, Ndoshua 21.73% and Nessuit 15.13%. The richest households were located in Kitiro 27.18%, Nessuit 23.78% and Ndoshua 13.08%. These results mean that of the surveyed rural households, rural households were out in villages across the six sub-locations. However, richer households (second richest and richest households) were more likely to be located in areas close to urban areas where their business activities and away from mountainous or hilly areas. Results show that these areas were suitable for tea production, wheat farming and horticultural crop production. The results of the study are in agreement with the findings from (Langat et al., 2016) which showed that forest-fringe poor rural households in Eastern Mau depend on agricultural activities and extraction of forest ecosystem resources to supplements their household livelihood outcomes.

As presented in Appendix X, rural households were shown to be spread across the sub-locations in the study area. The highest number of rural households was spread in Nessuit location 7,272 and Kitiro sub-location 4,741. This was followed by rural households in

Sigotik sub-location (4,230), Ndoshua sub-location 3,707, Mariashoni location 2,630 and lastly by Misepei sub-location at (1.986).

Table 4.1 Study Area 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	$\chi^2(16)=731.42$***
Total	100	100	100	100	100	100	
Rural and Urban Areas							
Rural	89.59	88.06	80.04	72.43	76.12	75.65	$\chi^2(4)=77.04$***
Urban	10.41	11.94	19.96	27.57	23.88	24.35	
Total	100	100	100	100	100	100	

Source: Survey Data 2013

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

4.3 Results of Rural Household Income Dependency Strategies

The results of the study presented in Table 4.2 show rural household net income distribution across household income dependency strategies. The average total household net income earnings from eight income sources, namely, crops, livestock, wages and/or salary, rents and /or asset incomes, non-farm and non-wage incomes, transfers incomes, forest resources incomes and other miscellaneous incomes. These incomes were clustered into five income clusters. These are, namely, On-farm income is derived from crop and livestock production and was grouped and labeled as cluster 1. Equally, off-farm income

is derived from wages and salary was grouped and labeled as cluster 2. Mixed-income is derived from asset selling, rental income and non-farm/non-wage incomes grouped and labeled as cluster 3. The transfers income is derived from remittances from outside the rural household and is grouped and labeled as cluster 4. Finally, forest-based income is derived from foraging forest products and goods were grouped and labeled as cluster 5. This clustering of diversified rural household income dependency strategies was done according to empirical studies by Babulo et al. (2008).

Results are shown in Tables 4.2 and 4.3 show that total household net income in absolute and in relative terms. The total household income per capita per year is presented Tables 4.2 and 4.3 is KES 16.86 million. Further, results show the average household net income per capita per year is (KES 37, 464 thousand) (16,858,840/450). This yearly income shows rural households on average are below KES 59,280 per year which is equivalent to US$ 1.90 per day (World Bank, 2012; KNBS, 2010). The computation is based on the assumption that rural households work for 26 days in a month earning KES 190 per day which is (190x26x12). This income may be slightly low because the study has not included households with negative net incomes and those with irregular and doubtful income. Also, this income was reported in (KNBS, 2010) as real income adjusted for inflation.

In the context of the Eastern Mau forest reserve area, the applicable household poverty line for rural areas is KES 59,280 income per capita per year. Results from the Kenya National Population and Housing Census of 2009 (KNBS, 2010) are in agreement with the report (World Bank, 2012). Further, results as earlier presented in Table 4.2 show that 46.09% of the surveyed rural households earned a net income per capita of KES 35,000-

55,000 by the end of June 2013. This means that rural households who earned up to KES 55,000 were 48.60% of the sampled households. Equally, it shows that 48.60% of rural households were clearly below the pre-determined of KES, 59,820. In addition, rural households who earn a net income of clearly above the poverty line were 21.86% (16.64+5.22). The households in the borderline or middle ground were 29.54%, these are rural households that could be used to tip over to either side of the poverty divide.

Conversely, results from Tables 4.2 and 4.3 show net income spread per capita per year of rural households in off-farm income dependency strategy is KES 20.92 million in the period ending June 2013. Equally, rural households' net income earnings per capita in mixed-income income dependency strategies were KES 20.29 million. Results also show that mixed mixed-income dependency strategy earned close to KES 20.12 million. Rural households in transfers income and forest-based income dependency strategies earn KES 12.03 million and KES 9.72 million, respectively. On average, the highest net income was derived from crop income activities which had a net income per capita of KES 6.8 million. Rural household income earnings from wages and/or salary employment and from livestock production were KES 3.99 million and KES 3.44 million, respectively. The total net income per capita from forest-based income sources was computed as KES 1.96 million. Results show the contribution of forest-based income to total household income as a relative income of 12.0% (1,955,110/16,858,840).

Table 4. 2: Diversified Household Income Dependency 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.

Rural households extract food-based and non-food based forest ecosystem resources from Eastern Mau. Rural household dependence on forest-based income is measured as relative income. Results are in line with the findings from (Babulo et al., 2008a; Monica Fisher, 2004; Kamanga et al., 2009a; Mamo et al., 2007a; Tesfaye et al., 2011a; Vedeld et al., 2007) which show that rural household livelihood outcomes are supported by forest-based income. Forest fringe rural households construct income portfolio from forest ecosystem resources. These results are in agreement with (Ellis, 2000b) which showed that rural households consume forest ecosystem resources to improve their standards of living.

Table 4. 3: Diversified Household Income Dependency 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.

4. 4 Household Socio-economic and Demographic Characteristics

The results of household socio-economic and demographic characteristics have been presented in Table 4.4. Equally, it shows the household-head specific characteristics which include age, gender, ethnicity and highest level education attained. The general household head socio-economic characteristics include household size, number of household members who are working and the size of household members.

4.4.1 Household-Head Characteristics

Results presented in Table 4.4 show that household-head statistical variables were significantly different at the 1% level. This means that rural household-head characteristics display statistical differences across household income quintiles. In addition, results show that variables have statistically significant differences in the means between at least one pair of income quintile groups. In addition, the distribution of rural

household income across income quintiles, poorest, second poorest, middle income, second richest and richest households, are strongly associated with the variables of household-head characteristics.

Results show that the average age of household-heads is 49.69 years which is approximately 50 years-old. The age of household-heads has been categorized into five age brackets of (18 to 98) years. Most household-head respondents were shown to be in the age bracket of (31-65) accounting for 27.99% of surveyed households.

Table 4.4: Household-Head Specific Characteristics

	Household Income Quintile Level						
Household-Head Characteristics	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistics
Age							
18-30	8.58	8.74	7.49	5.12	4.58	6.9	
31-40	30.29	23.72	21.36	17.17	19.14	22.34	
41-50	28.22	25.52	28.16	29.64	27.74	27.85	$\chi^2(16) = 100.76$***
51-65	18.95	25.66	26.35	34.07	13.59	27.99	F=8.75***
66-98	13.97	16.37	16.64	13.99	13.59	14.91	
Total	100	100	100	100	100	100	
Mean age of household head	47.14	49.36[a]	50.09[a]	51.05[a]	50.79[a]	49.69	
Gender (%)							
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistical Test
Female	13.55	18.45	20.11	18.42	21.36	18.38	
Male	86.45	81.55	79.89	81.58	78.64	81.62	$\chi^2(4) = 6.93$***
Total	100	100	100	100	100	100	
Ethnicity (%)							
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistics
Non-Kalenjin	74.41	47.3	30.65	14.96	8.74	35.23	
Kalenjin	25.59	52.7	69.35	85.04	91.26	64.77	$\chi^2(4) = 890.87$***
Total	100	100	100	100	100	100	
Highest Education Level (%)							
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistics
Cannot read and write	42.13	18.43	8.11	4.25	2.19	14.68	
Completed Primary School	25.77	28.35	25.07	18.59	15.74	22.58	
Completed Secondary School	28.40	43.94	49.26	51.68	47.67	44.35	$\chi^2(12) = 785.33$***
Post-Secondary Training	3.70	9.29	17.55	25.48	34.40	18.38	
Total	100	100	100	100	100	100	

Source: Survey data 2013
n=450 households. *, ** and *** indicates the significance levels at 10%, 5%, and 1%, respectively.
Means sharing the same letter (s) in the group label are not significantly different from one another at the 5% level.

The percentage of richer households (second richest and richest) was shown to increases as the age of household-head increased.

In addition, the lowest income quintile groups were the poorest and second poorest households were in the age bracket of 31 to 40. These rural households represented 30.29% and 23.72%, respectively of the surveyed households. Further, the majority of the high-income quintile groups, the second richest and richest household-heads were in the age bracket of (51-65) years. The second richest and richest households were 34.07% and 13.59%, respectively of the surveyed households. These results mean that rural households with older household-heads were more likely to be in the higher income quintiles.

In terms of household-head gender, the majority of the surveyed rural household-heads in Eastern Mau were found to be male 81.62%. This is not surprising since society in rural Kenya is mostly paternalistic. Again, males are usually the main income earners in most rural economies in Kenya (KNBS, 2010). These results, therefore, presents a strong voice to state-actor policymakers. State-actors need to formulate policies that focus on pro-poor programmes to uplift females in society. Other interesting findings are about the association between gender and poverty. It has been shown that when women take control of resources, rural households are more likely to be less poor. This pattern has been supported by the reduced poorest rural households headed by females 13.55% as compared to the poorest headed by males 86.45%. Equally, the richest female-headed households were represented by 21.36). In addition, female-headed households constituted a minor percentage of the surveyed rural household-heads (18.38%). Equally,

in Appendix 1, female headed-households constitute 23.5% and 17.0%, respectively of the poorest and second poorest households. On the other hand, male-headed households constituted 76.5% and 83.0 %, respectively of the poorest and second poorest household groups. These findings are consistent with the results of the (World Bank, 2012) report. The report highlighted that females in most rural economies of developing countries are unlikely to live in poorer households when gender is analyzed on its own. Gaps in the economic situation between women and men in Eastern Mau still remain when there is an interaction of gender with other individuals and group characteristics (KNBS, 2010).

In terms of ethnicity, the largest ethnic groups living in the peripheries of Eastern Mau were the Kalenjin ethnic group 64.77%. This is compared with other minority ethnic groups (35.23%). This result is unsurprising because household income quintiles comparison showed Kalenjin 91.26% to be the in the richest category of the surveyed households. The poorest households were the minority households at 74.41% and the Kalenjin in the poorest category was (25.59%). This means that a higher percentage of Kalenjin households are in the richer income quintiles as compared to minority households. Findings suggest that Kalenjin households are significantly more likely to pursue more remunerative income dependency strategies.

In terms of the household-head highest general level of education categorized as those who completed Primary School, Secondary School. Beyond this level were those who completed Post-Secondary School or attained training in professional courses. The majority of the surveyed rural household-respondents were shown to have attained at least a Secondary School level 44.35%. On the other hand, those who dropped out of Primary School at an early stage before they could read and write were 14.68%. There

are distinct differences in literacy levels across household income quintiles. Results show that the richest household-heads were clearly more educated. It is only a small 2.19% of them reported they could not read and write. This is compared to the poorest household-heads at 42.13% who could not read or write. With respect to professional training or post-secondary training, there is a relatively high percentage in the second richest and richest households 25.48% and 34.40%, respectively who have attained professional training. This is compared to the poorest and second poorest households at (3.7% and 9.29%, respectively.

4.4.2 General Household Characteristics

Rural household characteristics have been presented in Table 4.5. Results show that all household variables are statistically significant at the 1% level. Results show that rural household characteristics displayed statistical differences across household income quintile groups. In addition, statistically significant differences in the means between at least one pair of income groups were shown.

The average household size is 4.48% which is approximately five members. It is also shown that a higher prevalence of households had household members of 1-4 members representing 54.74% of the surveyed households. Rural households with members in the bracket of 5-7 represented 39.63% of the surveyed households. Equally, households with 8 and above members represented a combined 5.63% of the surveyed households. In comparing poverty across income quintiles in Eastern Mau, the majority are in the lowest income quintiles. These are the poorest and second poorest households with members in the bracket of 5-7. Rural households in this bracket represent 54.77% of the sampled

poorest households. Equally, the richest rural households were in the bracket of 1-4 members representing 72.26% of the surveyed richest households. The variables influenced by household size across income quintile groups are significant at the 1% level. This means that richer households are more likely to have fewer household members compared to their poorer counterparts. This is in line with economic theory that shows that in the rural economy, the poverty rates are lower on average. This finding is in line with the results of (Ebenezer & Abbyssinia, 2018; Maloma, 2016) which showed that rural household poverty is overstated. This is because state-actors do not consider forest-based income as a conventional household income. This, therefore, shows that households with1-4 members tend to be richer. The poorest households had 5-7 members representing 54.77% of the surveyed poorest households. The reasons for this behaviour are attributed to various reasons. For example, in rural areas, rural households tend to live communally or have more than one generation living in one household. The other is that most poor rural households engage in agricultural activities (crop and livestock production). These activities are labour-intensive that utilize household own labour force. Equally, the absence of a birth control policy is less effective in most rural areas of Eastern Mau. This is because fewer rural households are not exposed to family planning information.

Results of rural household members in the income-earning age were high for households with 1-2 members representing 44.55% of surveyed households. earners. Rural households with household members 3-4 represented 38.78% of surveyed households. The rural households with 1-4 members represented a combined 83.33% of the surveyed households. In addition, results show that rural households with more than 5 households

who are in the income-earning category represented 14.18% of the sampled households. On average, the number of income earners for rural households in Eastern Mau is 2.97% of the sampled rural households. Equally, the proportion of the poorest rural households with more than 4 income earners was much higher at 25.84% of sampled poorest households versus the richest households at 6.51% of the richest households. This implies that a high number of income earners do not guarantee a higher overall household income. The variation of characteristics across income quintile groups is significant at the 1% level.

In as far as the number of children in a household is concerned, the households with 1-2 children are 51.86%. The average number of children in a household was 1.45 or approximately two. This is significantly different across household income quintiles at the 1% level. Results also show that the majority poorest rural households with 3-4 children account for 35.11% of the sampled poorest households. In contrast, the majority of the richest households have 3-4 children representing 5.09% of the sampled richest households. In addition, the proportion of rural households with more than four children is much higher in the poorest households than in the other household income quintiles. This means that households with more children are more likely to be under financial pressure.

Land results are presented Table 4.5 is an important household asset in the choice of holding income dependency strategy. Rural households in Eastern Mau may have the right to land or to operate or to hire for agricultural activities. Households can either be renting it out or renting it to other rural households to operate. Results show that a substantial percentage of rural households 98.84% have the property rights to own or

operate land. Results show the difference in this household agricultural landholding to be significant at the 5% level and the variance is not distinct. In addition, rural households that do not own the land but rent it from others and utilize it for agricultural activities is 21.08% of the surveyed rural households. In addition, there are richer households 35.95% who don't own land but rent it for agricultural activities. This is compared to the poorest households who rent land but don't own it 9.68%. This result indicates that the richest households are more likely to have adequate land for their production demands. Equally, rural households that own land and don't do anything to it are 13.05% of all sampled households. The highest owners of land who leave their land fallow are the richest households 24.69%) compared to the poorest households 9.68%.

On the household net income earned at the end of June 2013, rural households across household income quintiles are displayed in Table 4.2. The difference in household net household income is statistically significant at the 1% level. Rural household income earnings were clustered according to their levels of poverty. Poor rural households are defined as those who earn less than US$ 1.90 per day (World Bank, 2012). This is equivalent to KES 190.0 per day (exchange rate of KES 100=1US$. It is assumed that rural households work for 26 days in a month, which translates to KES 4,940 per month and KES 59,280 per year. Results show that households earning KES 35-55 thousand per year represent 46.39% of the surveyed households. The households that earn slightly above the poverty line KES 56-85 thousand per year are represented by 29.45%) of the surveyed households. Rural households who earn above KES 85 thousand) are 21.65%) of the sampled households. It is shown in Table 4.2 that the poorest households earn less than KES 34 thousand and are represented by 2.51% of the surveyed households.

Rural households in Eastern Mau depend on diversified income dependency strategies, for example, on-farm income, off-farm income, mixed-income, transfers income and forest-based income. These income dependency strategies support household livelihood outcomes. These outcomes are household alleviation of poverty and reduction of income inequality. The choice of household income dependency strategies influences household livelihood outcomes. Conversely, the factors that influence the choice of household income dependency strategies are explanatory variables, for example, household asset holdings and contextual factors. The explanatory variables influence the dependent variables and livelihood outcome variables. The explanatory variables are human resources, land resources, household physical assets, financial capital and social capital.

Results in Table 4.5 show the net income distribution of household income earnings generated from various income sources across household income quintiles. Household income is generated from different sources. This study has classified income-generating sources into six income category categories. These are crop and livestock income activities or agricultural income activities). These two are clustered as on-farm income activities. Incomes derived from wages and salary employment were clustered as off-farm income activities. On the other hand, incomes from rental income, sales of assets and interest income earned from savings and share investments were clustered as mixed-income sources. The transfers income was categorized as derived from remittances from outside the locality. Forest-based income is derived from the extraction of forest products and the utilization of the products for subsistence-self-consumption. The household net income distribution was computed for the financial year from July 2012 to the end of June 2013.

The results of the study show that 33.34% of the surveyed rural households derived their income earnings from crop production. The rural households who had the highest income dependence from crop production activities were in the second poorest, middle-income and second richest income quintiles. The percentage of net income dependency was at 37.13%, 34.22% and 49.01%, respectively. In addition, the second richest rural households were found to depend more on livestock earnings 33.52% second to crop income activities 49.01%. Generally, in Eastern Mau, the percentage of rural households who earned income from livestock was 20.31% of the sampled households. The proportion of rural households in Eastern Mau who depended on wages and salary income was 19.16% of the surveyed households.

The rural households who depended mainly on forest-based income in relative terms were the poorest households who earned 18.27% of net income. This is in line with theory and findings from (Babulo et al., 2008a; William Cavendish, 2000b) which showed that the poorest rural household depends more on relative terms on forest-based income and richest household rely more on absolute values. In this poorest household income quintile, the highest net income was earned from crop activities 28.02. The rural households who depended on forest-based income in Eastern Mau were 11.61% of the sampled households. The rural households who depended on transfers income were 6.15% of the total sample. Most rural households in the second poorest and middle-income quintiles were reported to have almost the same net income earnings 8.05% and 7.02%, respectively. In comparison, the other income quintiles were minimal.

However, the importance of household income sources changes according to household income dependency strategies. For example, the two lowest income groups depend on

crop activities which are the most predominant income source. However, wages and salaries are classified as off-farm income and households in this category are high-income quintiles comprising the second poorest, middle-income and transfers income groups 25.55%, 21.35% and 22.36%, respectively. The relatively high percentage of total net income from wages implies the household increased reliance on wage and salary employment outside the household locality. These results show that there is a wider variation in income distribution for poorer households. This is reflected by poorer households heavily depending on certain income sources compared to the rich. For example, the poorer households tend to rely more heavily on forest-based income in relative terms and the richest households depend on absolute terms.

Table 4.5: General Household Socio-Economic Characteristics across Income Quintiles

Household Characteristics	Household Income Quintile Levels						
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistical Test
Household size							
1-4	30.01	47.99	62.27	61.22	72.26	54.74	
5-7	54.77	46.60	34.40	35.87	26.49	39.63	$\chi^2(12) = 392.49$***
8-10	13.14	4.85	2.77	2.91	1.25	4.99	F= 117.05
11 and over	2.07	0.55	0.55	0.00	0.00	0.64	
Total	100	100	100	100	100	100	
Mean	5.62	4.64	4.22[a]	4.18[a]	3.77	4.48	
Number of Income earners in a Household							
None	1.54	2.23	2.92	2.37	3.39	2.49	$\chi^2(12) = 172.80$***
1-2	32.72	39.8	49.72	44.55	56.01	44.55	F= 49.64***
3-4	39.89	42.04	36.77	41.06	34.09	38.78	
5 and above	25.84	15.92	10.58	1201	6.51	14.18	
Total	100	100	100	100	100	100	
Mean of income earners	3.53	3.06[a]	2.77[b]	2.87[ab]	2.54	2.97	
Number of Children per Household							
None	11.80	22.35	29.81	38.13	47.52	29.90	$\chi^2(12) = 682.67$***
1-2	42.92	55.03	60.31	53.77	47.10	51.86	F= 200.51***
3-4	35.11	20.67	9.19	7.96	5.09	15.61	
5 and above	10.11	1.96	0.70	0.14	0.28	2.63	
Total	100.00	100.00	100.00	100.00	100.00	100.00	
Mean number of children	2.47	1.65	0.85	0.85	0.85	1.45	
Land owned and Operated by Household (%)							
yes	99.86	99.03	98.61	98.61	98.06	98.84	$\chi^2(4) = 11.25$**
No	0.14	0.97	1.39	1.39	1.94	1.16	
Total	100	100	100	100	100	100	
Land not owned but Operated by Household (%)							
yes	9.68	15.95	17.75	26.07	35.95	21.08	$\chi^2(4) = 21.88$***
no	90.32	84.05	82.25	73.93	64.05	78.92	
Total	100	100	100	100	100	100	
Land Owned but not used by the Household (%)							
yes	3.87	8.18	12.9	15.65	24.69	13.05	$\chi^2(4) = 159.05$***
no	96.13	91.82	87.1	84.35	75.31	86.95	
Total	100	100	100	100	100	100	
Household Net Income by end of June 2013 (KES 000) (This is not income per capita)							
Less than 34	8.05	4.47	0.00	000	0.00	2.51	$\chi^2(16) = 3,226.66$ ***
35 - 55	90.01	78.33	44.94	13.71	3.47	46.09	F= 200.51***
56 - 85	1.94	17.06	51.32	57.62	19.83	29.55	
86-100	0.00	0.14	3.74	28.28	51.04	16.64	
101 and above	0.00	0.00	0.00	0.42	25.66	5.22	
Total	100	100	100	100	100	100	
Net Income Distribution as a percentage of Total Household Net Income							
Crop	28.02	37.13	34.22	49.01	18.32	33.34	
Livestock	12.41	21.12	25.46	33.52	9.44	20.31	
Wages/Salary	7.22	9.31	10.35	43.36	25.56	19.16	
Forest income	18.27	4.64	6.64	11.22	17.28	11.61	
Transfers	5.32	8.05	7.02	3.85	6.51	5.80	
Mixed-Income	4.13	8.32	9.56	11.78	12.01	8.80	
Other sources	0.51	0.72	0.69	1.40	1.58	0.98	
Total	100	100	100	100	100	100	

Source: Survey Data 2013

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

Specifically, 28.023% of the poorest rural household income comes from crop activities. The second richest households have been reported to have almost twice the amount of income 49.01% from crop activities. This is a noticeable finding that is in agreement with theory and results from (Hossain et al., 2014; Laborte et al., 2009) that showed that wealthiest households tend to invest more in mixed-income activities and less in agricultural activities.

These results are in line with economic theory that states that those who take high risks are likely to get high returns. This has been supported by studies from (William Cavendish, 2000b; Kamanga et al., 2009a; Thondhlana & Muchapondwa, 2014a) which show the poorest rural households do not engage in mixed-income activities which require high capital outlay. Most of them engage in on-farm income activities and extract forest ecosystem resources. In addition, the authors have revealed that rural households in the low-income quintiles (poorest and second poorest) depend heavily on relative terms on forest ecosystem resources while the highest income quintiles (richest and second richest) greater quantities of forest ecosystem resources in absolute terms.

4.4. 3 Household On-Farm Income Characteristics

Results of on-farm income dependency strategies are income activities derived from crop and livestock production. The characteristics of crop and livestock activities have been analyzed across rural household income quintiles. Results presented in Table 4.3 for crop characteristics and in Table 4.4 for livestock characteristics show there are distinct patterns where applicable, according to ANOVA tests which show these characteristics to influence household income dependency at the 1% level.

4.4.3.1 Crop Production Income Characteristics

The results of this section present a descriptive analysis of rural households who engage in crop production activities. It also shows the number of forest-fringe rural households in Eastern Mau primarily depends on crop income activities. Rural households engaging in crop production earn income from farming activities either on their own land or plots or from hired plots. Results in Table 4.3 show the characteristics of crop activities involve the purchase of farm inputs, types of crops, crop inputs and commercialization of crops. Results of crop production show (85.31%) of the sampled households engage in crop activities. This means the crop is the mainstay economic activity of forest-fringe poor rural households in Eastern Mau. This is illustrated by the importance of several crops that are grown by rural households in Eastern Mau. This means crop production is a primary income for all households. The high household involvement in crop production activities indicates crop activities as a critical source of income. Results also show that there is a low commercialization of crop activities. This shows that there is low-value addition to crops because of low technology and that households prefer direct sales of crop production and its by-products. These findings are in line with results from (Belcher & Schreckenberg, 2007) which showed that crop produce handling and processing are not done adequately to the level of commercialization. Results show that the differences in crop activities across income quintiles are statistically significant at the 1% level. This means that the variables have an influence on the rural household income quintiles at all levels.

Results presented in Table 4.3 show that the low-income quintiles (poorest and second poorest households) engage more frequently in maize crop production 94.31% and

91.26%, respectively. In comparison to the high-income quintiles (richest rural households), in the year 2013, most of them 70.18% engaged in general crop production. The richest household planted 61.54% of maize crops in the same period. The income differential of household likelihood is in engagement in crop production across household income quintile is significant at the 1% level. This indicates that the distribution of income quintiles is strongly associated with rural household engagement in crop production activities. These results are in agreement with the findings of (Sedano et al., 2016; Tegegne et al., 2016) which shows crop production is the mainstay economic activity of rural households, it contributes 50% to 60% of total household income. Equally, the dependence on crop production was supported by studies from (Mullan, 2014) which showed crop production alleviates poverty among poor rural households. With respect to the crop production farming structure by rural households, maize is still the predominant crop in Eastern Mau as indicated by 82.39% of the surveyed households. It shows that over 50% of all the sampled household plant maize. The common crops that are planted in Eastern Mau include beans 38.79%, carrots 24.78%, Irish potatoes 19.59%, tomatoes 19.15%, tree tomatoes 15.67%, peas 14.77% and avocados 4.08%.

Results also show the structure of crop production among rural households varies by household economic status. Most of the annual crops which require little investment in terms of inputs, land preparation, herbicides and pesticides are more likely to be cultivated by low-income quintiles. The horticultural crops that require expensive certified seeds and cultivars are also planted by the wealthier rural households. Equally, tree crops like fruits and perennials are also planted by richest households. In addition, domesticated forest trees that are farmed, for example, cypress, pines and bamboo are

planted in this category. Meanwhile, the richest households are more likely to cultivate horticultural crops like for example, french beans are 31.76%, carrots are 21.3%, tomatoes 34.54% and tree tomatoes 28.40%. The fruit trees planted by the rich households include avocados 31.38%, oranges 20.20%, medicinal trees 35.59%, and other commercial trees 31.97%.

The possible explanations for this pattern are that most perennial crops are tree crops that require long-term investment commitment. Also, engagement in this kind of perennial crops requires accessibility to credit facilities to finance the required higher investment capital. The richer households, therefore, are able to engage in these crops because they have accumulated savings which makes them accessible to credit loans.

Table 4.6: Crop Production Characteristics across Income Quintiles

Engagement in Crop Production (%) n = 450							
	Household Income Quintiles						
Household Characteristic	Poorest	2nd Poorest	Middle Income	2nd Richest	Richest	Total	Statistical Test
Engagement in Crop Production (%)							
Yes	94.33	91.26	87.79	82.96	70.18	85.31	
No	5.67	8.74	12.21	17.04	29.82	14.69	$\chi^2(4) = 205.74$***
Total	100	100	100	100	100	100	
Types of Crops Produced (%)							
Maize	94.31	88.18	82.97	78.30	61.54	82.39	
Beans	69.55	46.52	32.18	22.20	15.19	38.79	
Bananas	11.76	10.61	8.47	9.17	6.38	9.28	
Sweet potatoes	1.02	1.52	1.10	1.34	0.99	1.20	
Irish Potatoes	31.92	26.52	20.03	8.68	6.31	19.59	
Tomatoes	9.66	8.03	17.73	25.84	34.54	19.15	
Cabbages/Kales	15.08	8.33	5.05	3.34	3.35	7.36	
Carrots	32.65	24.85	23.82	19.70	21.30	24.78	
Cassava	3.51	5.91	5.21	4.84	4.54	4.80	
French beans	16.54	21.82	26.18	26.21	31.76	24.04	
Tree tomatoes	4.54	13.03	15.46	20.70	28.40	15.67	
Avocados	2.05	1.52	13.63	21.84	31.38	14.08	
Oranges	1.29	3.32	3.43	15.17	20.20	8.68	
Peas	11.61	15.61	14.73	16.84	15.52	14.77	
Sugar cane	0.15	1.97	0.47	1.00	1.58	1.01	
Pepper	0.15	1.06	2.21	3.51	8.28	2.76	
Medicinal trees	4.98	8.12	13.26	25.50	35.59	15.59	
Other trees	5.86	8.58	9.68	21.84	31.97	15.58	
Forest products	2.05	1.97	2.21	3.51	3.35	2.56	
Commercialization of Crops (%)							
(Value addition and direct sales)	14.81	22.55	34.61[a]	50.75[b]	56.65[b]	35.87	F=21.16***
Crop Inputs required (% of Households who say yes to using farm inputs for crops)							
Seeds (certified)	67.95	71.28	75.13	83.58	88.61	77.31	
Cultivars (certified)	27.22	21.05	13.33	2.93	7.26	14.35	
Inorganics Fertilizers	48.07	57.52	56.09	71.38	83.23	63.26	
Organic fertilizers(self-produced)	59.85	45.86	38.76	24.80	15.94	37.03	
Organic fertilizers (bought)	7.46	17.29	21.86	46.67	55.23	29.70	
Pesticides/herbicide	22.87	28.38	31.47	48.94	64.02	39.14	
Outside hired labour	17.16	23.90	27.26	49.43	68.43	37.22	
Other types of inputs	12.43	16.76	38.53	45.76	14.87	25.67	

Survey Data 2013.
n=450 household heads. *, **, and *** indicates the significant levels at 10%, 5% and 1%, respectively. Superscript letters denote the significant difference between groups.

The planting of these horticultural crops is done in the wetland areas where there is plenty of water for irrigation. Most poor rural households depend on rain-fed agriculture and the rich use irrigation which requires higher initial capital outlay. Horticultural farming also requires exposure as to certified commodity markets, certification of crops and the use of expensive inputs, for example, certified maize seed, herbicides, pesticides, inorganic and organic fertilizers.

Crop farming and commercialization are measured by the share of trade in farm products which requires orientation in the kind of products they engage in as per timed seasons. Increased commercialization reflects increased market orientation where rural households are more dependent on markets to buying certified inputs, contractual markets for produce, trained hired labour which is expensive for poor rural households. The commercialized produce in the whole sample is 35.87% of the products produced are sold in Eastern Mau. The rest of the products are used for rural household self-consumption. The correlations of commercialization and household income are differences in the average share of sold products by income quintiles that are statistically significant at the 1% level. In particular, higher market involvement falls in richer household income groups. The two highest income quintiles had the highest level of commercialization, the second richest households had 50.75% and the richest households had 56.65%. This is followed by the middle and second poorest income households at 34.61% and 2.55%, respectively. The poorest households are the least involved in commercialization at 14.81%. This could be explained by the financial limitations of poor households. This constraint restricts many poor households from being able to produce sufficient products to sell or to add value to the produce. Small-scale production implies fewer goods

available to sell and more for their own consumption requirements. In addition, poor households are more likely to reside in remote areas which create significant challenges because of increased spatial costs due to long distances traveled to reach the village markets. The other costs are related to certification and packaging which poor rural households lack certified seeds and fertilizers to start with. In addition to selling crop produce and its bye-products, households also commercialize activity processes. This is related to the purchase of farm inputs and the hiring of farm labour from outside the family household. Purchasing of farm inputs is done competitively in order to enable households to increase their scale of production because self-produced farm inputs are not sufficient.

Results presented in Table 4.3, results show that rural households purchase various farm inputs for production activities. The most frequently used farm inputs for crop production include certified seeds, saplings and cultivars, inorganic and organic fertilizers. It was revealed that most farming households were poor and that they utilize their self-produced cultivars and/or saplings. They also used their compost manure and livestock droppings instead of inorganic fertilizers. In maize crop planting, they used inorganic fertilizers mainly inorganic fertilizers. Other farm inputs that households purchased included farm chemicals, for example, pesticides, herbicides and foliar fertilizers used for top dressings.

In general, results show the commonly used inputs are certified maize seeds 77.31% and inorganic fertilizers 63.26% like Di-ammonium Phosphates (DAP). Results show rural households use 39.14% of both pesticides and herbicides. They use 37.03% of self-produced organic fertilizers and 27.90% or purchased organic or manure fertilizers. Some rural households are able to hire 37.22% of outside labour to supplement their own

labour. In contrast, and in line with economic theory (Bryceson, 1999; Thieme, 2006), households in high-income quintiles have the ability to hire labour 68.43% outside their own labour. This figure is higher in comparison with the labour low-income quintiles can hire 17.16%. This pattern is partly because rural households have financial constraints and that they are peasant-small-holder farmers. The pattern of chemical fertilizer use, pesticides, herbicides, bought organic fertilizers are not as clear as other types of inputs. This pattern is attributed to the highest percentages of households using these inputs. Those who fall in the middle are 38.53%, whereas the second richest income quintiles 45.76% are slightly higher. However, a higher frequency of richer households, in general, uses all these kinds of inputs.

4.4.3.2 Livestock Income Characteristics across Income Quintiles

The characteristics of livestock production are summarized in Table 4.7. The information includes rural household involvement in livestock and commercialization status. In terms of livestock production, 77.51% of the surveyed households indicated they undertake livestock production. Results show that the difference in household likelihood to engage in livestock production across household income quintiles is statistically significant at the 1% level. In particular, it is shown that the lowest income quintiles (poorest and second poorest) participate in livestock production 67.14% and 77.67%, respectively as compared to the richer households (second richest and richest) at 88.31% and 69.51). This reflects the same trend in crop production Table 4.6 which confirms that poorer rural households depend more on the crop (94.33% and 91.26% respectively) as compared to richer households 82.96% and 70.18%, respectively.

Results revealed in Table 4.7 the prevalence of households engaging in livestock by the kind of livestock they keep. Results show household engagement in general livestock income activities is by itself statistically significant according to the ANOVA test which shows it is significant at the 1% level. Equally, the engagement in cattle income activities was shown to be significant at the 5% level. Similarly, households who engage in cattle rearing 40.84% are less than those who don't keep cattle 59.16%. Therefore, cattle rearing is more predominant in richer households 43.71% and 57.70%, respectively, than with poorer households 27.46% and 39.48% respectively. The reason for this is that richer households tend to have access to extra feeds in addition to forest pasture and fodder (Chantarat, Mude, Barrett, & Carter, 2013; Thornton et al., 2007). The rearing of cattle was also considered as high income-return activity and is relatively low labour-intensive. Equally, rearing of cattle is considered a moderately less risky activity and has a low level of uncertainty in terms of returns on investment (Castro et al., 2015; Duru, Theau, & Martin, 2015; Joel et al., 2013).

Rural households normally raise different types of livestock, such as dairy cows, donkeys for transportation, steers, sheep, goats, poultry, pigs, fish and honey bees. As shown in Table 4.7, the most common livestock are dairy cows raised for milk 73.15% and poultry 99.34%. Most rural households keep steers 32.48% for sell during times of need as they provide near-cash storage. Poultry is kept by almost all households because they require little space and they feed on crop residues and by-products. In addition, poultry and pigs have shorter life expectancies than other types of livestock. Rural households, therefore, get returns quickly from investment. In terms of wealth status, poultry, pigs, fish and honey bees are found to vary across household income quintiles. In general, except for

poultry, rural households in higher-income quintiles exhibit the lowest rate for raising most types of livestock except for dairy cows, steers, fish and honey bees ((Baiyegunhi & Oppong, 2016; Quang & Anh, 2006).

Livestock production is a proxy for commercialization and that, overall, 44.00 % of the livestock products produced are used for commercial purposes. The difference in the average share of livestock trade by household income quintiles is significant at the 5% level. The richer households have higher 50.67% and 63.46%, respectively, levels of commercialization compared to 26.44% and 37.7% respectively of their poorer counterparts. More specifically, a difference is only displayed between the poorest household and the four (second poorest, middle-income, second richest and richest) households. Results show there is no statistical difference in the average share of trade products among these four groups. This indicates that livestock product commercialization is associated with rural household welfare. These findings are in agreement with findings by (Dewi, Belcher, & Puntodewo, 2005; Farinola et al., 2014) which indicated that richer households tend to engage more in livestock product commercialization.

Table 4.7: Livestock Income Characteristics across Income Quintiles

Household Characteristics	Household Income Quintile Levels						
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistical test
Involvement in Livestock Activities (%) (n=450)							
Yes	67.14	77.67	84.91	88.31	69.51	77.51	$\chi^2(4) = 297.47$***
No	32.86	22.33	15.09	11.69	30.49	22.48	
total	100	100	100	100	100	100	
Involvement in Cattle Income Activities (%) (%) (n=450)							
Yes	27.46	39.48	35.83	43.71	57.70	40.84	
No	72.54	60.52	64.17	56.29	42.30	59.16	$\chi^2(4) = 31.70$**
Total	100	100	100	100	100	100	
Types of Livestock Herd							
Cattle							
Dairy Cows	74.39	78.98	73.28	71.68	56.14	73.15	
Steers	24.55	20.79	31.46	39.81	45.77	32.48	
Sheep	32.50	33.33	8.89	7.14	3.45	21.09	
Goats	26.18	21.15	16.33	7.50	12.90	15.42	
Other Types of Livestock							
Poultry	98.56	99.58	99.49	99.73	99.68	99.34	
Donkeys	88.46	90.24	70.45	68.14	74.32	66.43	
Pigs	28.62	27.17	25.79	22.63	20.18	26.03	
Fish	2.54	9.38	6.07	17.78	19.53	13.70	
Honey bees	1.23	2.45	8.54	11.26	12.98	5.29	
Commercialization of Livestock (n=450)							
Share of trade	26.44a	37.70ab	39.78ab	50.67ab	63.46ab	44.00b	F=2.47**

Source: Survey Data 2013

n=450 households. *, **, and *** indicates the significance level at 10%, 5%, and 1%, respectively.

Means sharing the same letter (s) in the group label are not significantly different from one another at the 5% level. For livestock production and livestock product commercialization, only households engaging in commercialization are included (n=125).

4.4 Household Dependence on Forest-Based Income Activities

Results from Tables 4.8 and 4.9 show rural household dependence on various forest-based income activities. The Chi-square tests show that there are strong significant differences in rural household participation in the extraction of forest ecosystem products at the 1% level of significance. Similarly, results show there is a distinction between rural households engaging in non-food forest ecosystem products and food-based forest ecosystem products. Overall, 80.88% of all sampled rural households depend on forest ecosystem resources for their livelihood improvements. Results further show that the

highest number of dependence is in the poorest income quintiles at 94.17%. Results show the richest rural households within 80.88% are 62.22%. Further, 69.94% of the sampled rural households engage in the consumption of food-based forest ecosystem goods and products and 67.02% of them are in the poorest income quintile and 58.03% rural households were found to be in were in the richest income quintiles. By comparison, the extraction of non-food forest ecosystem resources is less concentrated in the wealthier rural households who tend to exploit less at 62.22% while the poorer households extract more at 94.17%. Chi-square tests show that there are strong significant differences in rural household participation in the extraction and utilization of forest ecosystem goods and products at the 1% level.

Table 4.8: Forest-Based Income Contribution to total Household Income

Income Category	Household Income Dependency Strategy Clusters					Total	Statistical Test
	On-farm income dependency	Off-farm income dependency	Mixed-income dependency	Transfer income dependency	Forest-based income dependency		
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]

Source: Survey Data 2013
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

Another finding is that some common food-based forest products and non-food products are extracted by rural households to varying degrees. An example is that 88.76% of the sampled rural households depend on firewood as non-food forest ecosystem products. Firewood is a prominent rural household fuel energy fuel used in most of the cooking. All

forms of wood products include charcoal, construction poles and materials used for making furniture and utensils.

Table 4.9: Household Dependency on Forest-Based Income across Income Quintiles

Household Characteristics	Household Income Quintile Levels						
	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total	Statistical Test
Engagement in general forest ecosystem goods and products (%)							
Yes	96.54	94.22	84.38	77.42	76.23	85.76	χ2(4)=860.09***
No	3.46	5.78	15.62	22.58	23.77	14.84	
Total	100	100	100	100	100	100	
Engagement in non-food Forest Ecosystem Resources (%)							
Yes	94.17	92.68	81.56	73.74	62.22	80.88	χ^2(4)=20.96***
No	5.83	7.32	8.44	6.26	7.78	7.13	
Total	100	100	100	100	100	100	
Engagement in food-based Forest Ecosystem Resources (%)							
Yes	67.02	64.17	64.06	61.41	58.03	69.94	χ^2(4)=20.32***
No	32.98	35.83	35.94	38.59	41.97	31.06	
Total	100	100	100	100	100	100	
Types of non-food Forest Ecosystem Resources							
Firewood	96.54	94.22	89.38	83.42	79.23	88.76	
Fodder/pasture	66.87	75.94	65.79	64.15	56.23	66.78	
Med. Plants	62.36	70.95	74.29	34.26	42.12	56.80	
Others	46.16	53.12	46.17	28.15	37.56	42.23	
Other forest ecosystem goods and products							
Fruits	18.33	14.20	12.76	8.48	6.43	12.04	
Berries	14.29	10.34	11.12	9.12	5.93	10.16	
Bush meat	18.57	11.14	8.33	5.76	3.33	9.43	
Fish	4.29	8.86	15.87	18.39	24.07	14.30	
Honey	12.26	10.13	11.92	12.71	11.23	11.65	
Vegetables	14.44	13.46	11.84	12.23	11.32	12.66	
Mineral soils	12.50	11.06	10.65	9.75	5.38	9.87	
Mushrooms	8.75	9.54	12.19	14.23	13.25	11.59	

Source: Survey Data 2013

n = 450 households. *, ** and *** indicate the significance levels at 10%, 5% and 1%, respectively.

The other is livestock pasture and fodder which is depended on by 66.78% rural households. In addition, 43.23% of rural households depend on other forest products, for example, building stones, quarry stones, clay soils for making bricks, thatching grasses and papyrus materials for making mats and baskets. The results of this study are in agreement with the findings from (Newman, Tarp, & Van Den Broeck, 2015) which shows poorest and second poor households in most sub-Sahara Africa depend on forest

ecosystem resources to increase total household income and to alleviate household poverty and to reduce income inequality.

Results on ethnic dependence on forest ecosystem resources show Dorobo ethnic minority community as forest-dwellers for centuries. The community has learned to co-exist with the forest ecosystem by extracting medicinal plants, as hunters and gatherers surviving on forest products like bush meat and wild honey. They use the forest as cultural sites and so its protection and conservation of forest ecosystem resources are guided by norms and taboos. Rural households in Eastern Mau extract various food-based forest ecosystem products like berries 10.16%, mushrooms 11.59%, honey 11.65%, fruits 12.04%, berries 10.16%, wild vegetables 12.66%, mineral soils 9.87% and fish 14.30. Results show that there is no distinct pattern by rural households in their extraction of forest ecosystem resources. They extract both food-based and non-food forest ecosystem resources. Results of this study are in agreement with the findings from (Schaafsma et al., 2014) and (Asfaw et al., 2013) which show most poor rural households living in the fringes of protected forests in developing countries depend on various forest products for household livelihood outcomes or alleviation of poverty and reduction of income inequality.

4.4.4 Forest-Based Income Contribution across Household Income Quintiles

Results of cluster analysis of rural households across rural household income dependency strategies have been presented in Table 4.10.

Table 4.10: Forest-Based Income Contribution 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

Source: Survey Data 2013

4.5 Factors that Determine Household Choice of Income Dependency Strategies

Households are affected by factors that determine their choice of income dependency strategies. These include socio-economic and demographic characteristics, household asset holdings and contextual variables. These independent variables were analyzed using multinomial logit model.

4.5.1 Multinomial Logit Model

The results of a multinomial logistic regression analytical model have been presented in Table 4.16. Results show that forest-fringe rural households depend on household income dependency strategies. Results have shown the factors that influence the choice of household income dependency strategies. The income strategies are defined as dependent variables that influence household livelihood outcomes. The five dependent variables are on-farm, off-farm, mixed-income, transfers income and forest-based income. The dependent variables determine household livelihood outcomes. These are poverty

alleviation and reduction of income inequality. Conversely, the explanatory variables that influence the dependent variables are household asset holdings and contextual factors. The five explanatory variables are household asset-holdings or endowments. These are human resources, land resources, physical resources, financial capital and social capital. Equally, contextual factors are state-actor physical infrastructure and external market-driven forces. In order to analyze the influence of household asset holdings on the choice of household income dependency strategies, a multinomial logit model that was adapted from (Walelign et al., 2017) was used. The results of these analyses have been presented in the subsequent sections.

The multinomial logit model was used to examine the explanatory variables as endogenous interdependent variables. Accordingly, household income dependency strategies are endogenous response variables that are affected by household asset holdings. In the model, results show that rural household livelihood outcomes are achievable with the optimal choice of household income dependency strategies. A multinomial logit model according to empirical results from (Nielsen et al., 2013) is ideal to analyze and determine the choice of rural household income dependency strategies with a focus on forest-based income. This model analyzes simultaneously the static nature of rural household asset holdings.

4.5.2 Household Socioeconomic and Demographic Variables

Results presented in Table 4.11 show the mean values of the indicators from ANOVA tests of human resource factors across rural household income dependency strategies to be statistically significant at the 1% level of significance**.** These results highlight the

effects of human resource variables and indicators on household income dependency strategies. Results indicate the mean values of human resource indicators that influence the choice of rural household income dependency strategies. The human resources variable has seven indicators; household size, number of household members who are in the working-age, household level of education. The other household heads the highest level of education. There are those that completed primary school, secondary school and post-secondary school. The other indicators are household-head include ethnicity and gender.

Results in Table 4.11 show on average the surveyed households comprised 4.48 members with 2.92 members being of working age. Households that pursue the on-farm income dependency strategy had the highest household members 5.15 and those in the working-age 3.29. Those in the mixed-income dependency strategy exhibited the lowest values members in the working group 1.93). The high numbers of household members and working members are in on-farm and forest-based income dependency strategy; these two activities are labour-intensive. Equally, in Eastern Mau, those in mixed-income, off-farm income and transfer income have the lowest household members who are of working age. The large household size and numbers of working age are two indicators that show rural households engage in labour-intensive activities.

The education level of household heads was shown across income dependency strategies. Most household heads had completed primary or secondary levels of education. The average of those who completed the primary school level attained 2.66 or three years in school. Those who attained the secondary level attained 1.37 or two years. A household head typically has been shown to have completed primary school in all five categories.

Results show that the household-heads who completed post-secondary education depended least on forest-based income dependency strategy 1.11. The percentages of household-heads that cannot read and write in this category were high. The household-heads in post-secondary education who engage in off-farm and mixed-income dependency strategy had the highest education level of 1.59 and 1.44, respectively). Results presented in Appendix V show rural households that attained post-secondary professional courses. There are those who did not take up further training 80.22% of the sampled households. The higher the training the fewer the households, for example, those in longer professional training, professional courses and college or university degrees were 1.70%, 3.54% and 2.79%, respectively.

The average age of household head is 49.68 years which is still in the working-age range. The household head in the forest-based income dependency strategy had the lowest average age 45.92 years. However, those in off-farm income dependency had the highest average age of 61.23 years. The average age of a household head in a forest-based income dependency strategy is not statistically different from that of the head who is in off-farm income dependency strategies but are statistically different from the other three groups. This pattern reflects that households with poor labour endowments, such as low household size, numbers of working-age members, and high age of household heads, are more likely to depend on income from other family members or support from public funds.

Male heads were still predominant in Eastern Mau 82% male and 18% female in all strategy categories. In comparing gender across income dependency strategies, female household-heads were more likely to be in the mixed-income 33% female and 67% male

and transfers income 25% female and 75% are male. Results exhibit the fact that women were more disadvantaged than men in all economic activities in Eastern Mau.

The ethnicity of rural household heads was seen as an important characteristic. Among the communities living in Eastern Mau, 65.0 % of the surveyed household heads were from the dominant Kalenjin ethnic group. The results of the study show that few ethnic minority household members were not involved in the income dependency strategies. Most of the minority ethnic groups were involved in transfers income dependency strategies as compared to the majority 66% and 34%, respectively. As presented in Table 4.11, the minority ethnic groups (non-Kalenjin) were more likely to depend on forest-based income dependency strategies. This means that the minority ethnic group has limited access to all four income dependency strategies. Consequently, on rural household ethnicity, those who engage in on-farm income dependency strategies were the dominant group at 94.0%. On off-farm income, the majority ethnic group were (82%), mixed-income they were 79.0% and forest-based income was 77.0%. Some of the reasons for this are that minority ethnic groups have low household asset endowments. For example, they have limited land holdings, low levels of education. This explains why they are often locked out of most job opportunities. In summary, ethnicity significantly influences the household's ability to engage in different income-generating activities at the 1% level of significance.

4.5.3 Household Asset Holdings Variables

Results in this section have shown the factors and variations of indicators of the five household asset holdings that influence household income dependence strategies. These

are human resources, land resources, physical assets, financial capital, social capital and contextual factors. The results of the study have shown the effects of explanatory variables or household asset holdings that affect endogenous or dependent variables. Analysis of variance (ANOVA) has been applied to provide detailed insights into the differences in household asset endowments and the effects it has on household income dependency strategies.

Table 4.11: Mean Value of Household Socio-economic Indicator Variables

Household Variable Indicators	Household Income Dependency Strategy Group						
	On-farm income Dependency	Off-farm income dependency	Mixed-income dependency	Transfers income dependency	Forest-based income dependency	Total Sample	Statistical Test
Household Size	5.15[b]	3.29[ab]	4.41[a]	4.09	4.05	4.48	F=113.15***
Numbers of Working	3.19[a]	2.69[ab]	1.93[b]	2.97	3.12[a]	2.92	F=89.96***
Attained Primary Level	2.87[a]	3.09	2.80[a]	2.78[a]	2.24	2.66	F=102.90***
Attained Secondary Level	1.38	1.59[a]	1.44[a]	1.38[a]	1.11	1.37	F=46.81***
Age of Household Head	46.50[b]	61.23[ab]	54.51	48.34	45.92[a]	49.68	F=145.99***
Gender of Head (1=male 0=female)	0.80[bc]	0.90[cd]	0.67[ab]	0.75[a]	0.84[d]	0.82	F=36.94***
Ethnicity of Head (1= Kalenjin 0=Others)	0.94[a]	0.82[a]	0.79[a]	0.34[a]	0.77	0.65	F=268.66***

Source: Survey Data 2013

*, **, and*** indicate significance levels at 10%, 5%, and 1%, respectively. Superscript letters denote the significant difference between groups. Mean values sharing the same letter(s) at the group level are not significantly different from one another at the 5% level.

4.5.4 Land Resource Variables

Results presented in Table 4.12 indicate the mean values of land resource indicators that influence the choice of rural household income dependency strategies. There are eight indicators that have been shown to influence household dependent variables. These include the household size of homestead land, farming land size, cropland area, livestock

area, horticultural area, percentage of irrigated land and the percentage of household landlessness. Results presented in Table 4.12 show the mean values of the indicators land resource across rural household income dependency strategies and that according to ANOVA tests, the indicators were statistically significant at the 1% level**.** These results, therefore, highlight the effects of the land resource factors on household income dependency strategies.

The land resource indicators show the farming activities to include crop and livestock production. The activities are in line with theory and studies by (Ellis, 2000b) which showed that land resources support rural household income dependency strategies and livelihood outcomes. Results show that regardless of the household income dependency strategy, the land resource remains a major input of production. The land resource is the main input associated with agricultural production (crop and livestock production). The land is considered a natural capital and has been examined to know ownership, size and land use types across all income dependency strategies.

The one-way ANOVA tests show that there are significant differences in the indicators at the 1% level. Generally, this implies that there is an association between the choice of household livelihood strategy and the quantity and quality of the land. However, this association is not clear in terms of the types of land. Also, this shows the percentage of landless households who neither own nor operate any kind of land in Eastern Mau. Rural households owning land engage in crop activities as a primary income-earning activity. This finding is in agreement with the results from (Ouedraogo & Ferrari, 2015) and (De Merode et al., 2004) which show agricultural land size affects land use activities of rural households.

Further, results show in Table 4.12 that there is landlessness in five income dependency strategies. On average 55% of the surveyed households were considered landless households. Landlessness among the surveyed households was found to be highest in the forest-based income and transfer income dependency strategies 72% and 68%, respectively. Landlessness was, however, found to be lowest among rural households engaging in off-farm income and on-farm income dependency strategies 38% and 41%, respectively. Results indicate also that landlessness is generally related to household income-poverty in Eastern Mau. Results from this study are in agreement with the findings from (Baker & Miller, 2013) and (Megbowon, 2018) which showed that most countries in sub-Saharan Africa were vulnerable to multidimensional poverty because of landlessness. This finding has been reinforced by the findings from (Thondhlana & Muchapondwa, 2014a) and (Lamsal, Pant, Kumar, & Atreya, 2015) that showed landlessness and economic shocks to be responsible for rural household monetary poverty. This pattern equally shows rural households in Eastern Mau who engage in off-farm income dependency strategy own 38.0% land. This category is the lowest landowners in the study area. Equally, on average, the rural households in Eastern Mau own 1.02 ha for crop activities and 0.91 ha for livestock. The average livestock land size is small because most rural households depend on forest pasture to feed their livestock. Consequently, land resources are definitely indispensable assets for forest-fringe poor rural households in Eastern Mau. This pattern is in line with theory and research findings from (Ellis, 2000b; Rabbinge, Babin, & Pulleman, 2010; Xu et al., 2015) which have shown rural household poverty and vulnerability is linked to landlessness. This finding reinforces the conclusion by (Pretty et al., 2011; Scherr & McNeely, 2008) that showed

landlessness in most sub-Saharan African countries to be the cause of monetary poverty and economic shocks. The results of this study have also revealed that, on average, each household operates a household farm area of 1.47 ha and the homestead area of 0.28 ha. The presentation of results in Table 4.12 further shows that farm size is highest for households engaging in off-farm income and on-farm income dependency strategies 3.38 ha and 2.33 ha, respectively. These findings are in line with results from (Khai & Danh, 2012) that showed that cropland is an important household asset for alleviating rural poverty. On the percentage of irrigated land, results show that most rural households in Eastern Mau are dependent on rain-fed production activities. This has been shown by the low percentage of irrigation at (5.0%) in the entire Eastern Mau. Rain-fed production is, therefore, seen as a limitation in agricultural productivity. In comparison, the percentage of irrigated land is a proxy for stable land quality and productivity. The irrigation activities in Eastern Mau being confined to river water abstraction. This is, unsurprisingly, the lowest percentage of irrigated plots. However, rural households in the forest-based income dependency strategy only irrigate 1.0% of their land. This may be partly explained by the financial limitations that restrict households in this group from investing in irrigation (Lamsal et al., 2015).

Table 4.12: Mean Value of Land Resource Indicators

Land Resource Variable Indicators	Household Income Dependency Strategies						
	On-Farm Income Dependency	Off-Farm Income Dependency	Mixed-Income Dependency	Transfers Income Dependency	Forest-Based Income Dependency	Mean	Statistical Test
Homestead (ha)	0.10	0.03	0.70	0.21	0.36	0.28	F=1.02***
Farm Size (ha)	2.33	3.38	1.46	1.24	1.10	1.47	F=1.64***
Cropland area (ha)	0.59^{a}	0.61^{ab}	1.05^{b}	0.79^{b}	1.56	1.02	F=39.59***
Livestock area (ha)	0.52^{a}	0.45^{a}	1.16^{bc}	0.68^{ab}	1.41^{c}	0.91	F=37.27***
Horticultural (ha)	0.55^{a}	1.46^{a}	1.12^{bc}	0.74^{ab}	0.49^{c}	0.87	$F=43.00^{ns}$
Irrigated lands (%)	0.02^{a}	0.03^{a}	0.09^{a}	0.07^{a}	0.01	0.05	$F=49.97^{ns}$
Fish ponds/bees (ha)	0.02	0.08	0.06	0.01	0.01	0.15	$F=1.80^{ns}$
Landlessness (%)	0.41^{a}	0.38^{b}	0.54^{ab}	0.68^{ab}	0.72	0.55	F=39.47***

Source: Survey Data 2013

Rural households who own and operate agricultural land are included in farm size calculation. Equally, rural households who are not landless but have hired land for farming operations are also included in the land analysis.

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

4.5.5 Household Asset Variables

Results presented in Table 4.13 indicate the mean values of physical assets indicators that influence the choice of rural household income dependency strategies. The two main indicators that were identified to influence physical factors are livestock herds and ownership of productive agricultural equipment. Results presented in Table 4.13 show the mean values of indicators from ANOVA tests that physical assets have on the choice of rural household income dependency strategies at the 1% level. Results, therefore, highlight the effects land resource factors have on the choice of household income dependency strategies. This indicates that the sizes of livestock herd are strongly associated with the household income dependency strategy engagement. Results presented in Table 4.8 shows that each household owns an average livestock herd size of 2.67 TLU. In comparing the different household income dependency strategy groups, households in forest-based income dependency were reported to have the highest size of

livestock herd (3.24 TLU. Comparing the four income dependency strategies, the average size of the livestock herd is statistically the same.

As indicated in the previous results presented in Table 4.8, the surveyed rural households in Eastern Mau that engage in livestock activities were 77.51%. From Table 4.13, it was further shown that rural households that engage in cattle rearing were 40.84%. Results also showed rural households reared dairy cows 73.15%, steers 32.48%, sheep 21.09% and goats 15.42%. All the rural households in Eastern Mau were found to engage in poultry 99.34%, pigs 26.03%, fish 13.70% and honey bees 5.29%. Results from Table 4.8 show, on average, rural households' off-farm income and mixed-income dependency strategies followed forest-based income in livestock ownership. Those pursuing off-farm incomes had livestock herds 2.98 TLU and mixed-income strategy had 2.86 TLU. To estimate the size of household livestock herd, tropical livestock units (TLU) conversion factors were applied.

Rural household ownership of agricultural equipment was also seen to be significant at the 1% level. Rural household ownership of equipment included farm tools and machinery like for example, hammer mills or grinding machines, pesticide knapsack sprayers, tractor-driven mouldboards, ox-driven ploughs, bicycles, motor bicycles, hand and animal driven carts. The equipment ownership indicator allows assessment of equipment ownership its contribution to household income dependency strategy. Results show that a small percentage 12% of the surveyed rural households own at least one type of agricultural equipment. The highest prevalence of agricultural equipment was shown to be in a mixed-income dependency strategy 30.0% and off-farm income dependency

strategy 22.0%. The lowest prevalence of equipment is in the forest-based income dependency strategy 1.0%.

The results of this study have shown that ownership of livestock and agricultural equipment improves the likelihood of rural household dependency on on-farm income dependency strategies. The poor rural households who don't have either of these resources were shown to depend on human-labour-intensive production. This finding has been reinforced by the findings from (Khai & Danh, 2012) and (Xu et al., 2015) which showed that rural households with low livestock and equipment tended to engage in labour-intensive activities. Equally, this is in line with the theory that agricultural productivity is enhanced by ownership of livestock and equipment. Those households without these asset endowments tended to have high monetary poverty and income inequality. Again, these results are in agreement with the findings of (Ferraro & Hanauer, 2011) which showed that rural households with low levels of agricultural equipment and livestock were in the poorest income quintile. In conclusion, results revealed that the low prevalence of agricultural equipment was a major constraint to rural household alleviation of poverty and reduction of income inequality.

4.5.6 Financial Capital Variables

Results presented in Table 4.13 the mean values of financial capital indicators that influence the choice of rural household income dependency strategies. The financial capital factors were measured by two indicators. One indicator accounts for financial credit or loans in monetary value that is accessed by rural households in the financial July 2012 to June 2013. The other indicator captures the amounts of household savings

accumulated within the financial year beginning July 2012 and ending June 2013. Results presented in Table 4.8 show the mean values of indicators from ANOVA tests showed the financial capital variables have an influence on the choice of rural household income dependency strategies at the 1% level. Further, results highlight the effects financial capital factors have on the choice of household income dependency strategies. This implied that loans and savings were linked to the choice of rural household income dependency strategies.

In Table 4.13 the average value of loans that were available across household income dependency strategy categories in the financial year was KES 20.64 million. In particular, rural households in the off-farm income dependency strategy received the highest value of loans KES 81.8 million. This is attributed to the off-farm income strategy being in formal employment where they can access job guaranteed loans. Unlike the rural households who borrow loans based on their group collateral from microcredit institutions. The other three rural household income clusters had low yearly loans. The on-farm income strategy KES 11.78 million, the transfers income strategy had KES 12.65 million and the forest-based income dependency strategy had KES 12.65 million. These results are in agreement with theory and the findings from (Abdullah, Stacey, Garnett, & Myers, 2016b)which showed that rural poor households in developing countries are unable to venture into business enterprises. This is because they cannot access loans for initial capital outlays and start-ups. Rural households depend mainly on traditional crop production. They cannot venture into horticultural sub-sectors where horticultural high-value export crops require much capital. Again, these crops require training and extension services support, the crops are high risk yet highly remunerative. This finding

is in agreement with the findings from (Kgathi et al., 2007)which showed that rural households that managed to access loan facilities had accumulated savings. Also, these households had better risk-coping strategies. This includes being able to withstand unexpected shocks and financial losses caused by climate-change-induced fluctuations.

The loans and savings go hand in hand and are used by rural households to guarantee seasonal farm loans. In most rural households of Eastern Mau, farm assets like, chattels, livestock, farm equipment and group collateral were used to guarantee loan financing for the purchase of seasonal farm inputs. The inputs include fertilizers and certified maize seed and for land preparation in the season. In addition, rural households in mixed-income strategies use loans to expand their retail businesses. Specifically, income savings and loan facilities are vital for rural households to expand their working capital. This is a strategy to achieve household livelihood outcomes especially alleviating household poverty and reducing income inequality. These findings are in agreement with the results of (Xu et al., 2015) which shows that most poor rural households in developing countries are unable to access loans from commercial banks or financial institutions. In Eastern Mau, many rural household heads fail to access financial support which they use to access during the days when cooperative societies were vibrant. This is the reason why agricultural extension services have to be re-financed a fresh by the state-actors. The rural households in Eastern Mau depend on relatives, friends or moneylenders (*Shylocks*) for working capital.

4.5.7 Social Capital Variables

The results presented in Table 4.13 show the mean values of social capital. The study has used only one indicator to measure this variable. Rural household membership in social networks indicator was used to measure the influence of social capital on the choice of rural household income dependency strategies. Results presented in Table 4.13 show the mean values of one the indicators tested using ANOVA tests showed the social capital variable has an influence on the choice of rural household income dependency strategies at the 1% level. This implied that rural household membership in a social network is linked to the choice of rural household income dependency strategies.

The rural households mean values of membership in social network indicators have been presented Table 4.13 and Appendix V. The indicator was examined as rural household membership in social group networks. Rural household membership in social networks was identified as membership in three social network groups. These are community forest associations, membership in the Kenya Farmers Association (KFA) and membership in any other social associations which were open to men, women and youth. Further, the youth were shown to belong to mainly self-help groups such as membership in community forest associations were at 50.38%. The membership in the Kenya Farmers Association was at 55.09% and in community self-help groups was at 37.18%. In Eastern Mau, the Kenya Farmers Association before it was run down was a vehicle that was used to champion the interest of farmers. Most of the farmers in Eastern Mau were members of this association. Most of the rural household members now belong to community forest associations. The one-way ANOVA tests that were applied showed that the variance by household income dependency strategies was statistically significant at

the 1% level. This significance means there is a strong association between rural household memberships in social groups that influence the choice of household income dependency strategies.

The results of this study show that rural household membership in social groups has some benefits. For example, it enhances information dissemination which may enhance household job opportunities. This is in line with theory and findings by (Markussen & Røed, 2015) and (Brockington, 2007). Results from these studies show rural household participation in social networks provides a bargaining power and a platform for rural households to protect and to champion their interests. Similarly, rural household membership in social groups makes them be reached in a structured manner. They can access training and loan facilities when they are informal groups. This is in agreement with the findings from (Newman et al., 2015) which showed rural household was able to alleviate monetary poverty using social benefits from their organized groups.

Table 4.13 Mean Value of Assets Holdings Indicators

Indicator Variables	Household Income Dependency Strategy Group						
	On-Farm Income Dependency	Off-Farm Income Dependency	Mixed-Income Dependency	Transfers Income dependency	Forest-Based Income Dependency	Mean	Statistical Test
Household Assets							
Livestock herds (tropical livestock units (TLU)	2.11[a]	2.98[a]	2.86[a]	2.13[a]	3.24	2.67	F=22.28***
Ownership of productive equipment (1=yes, 0= No)	0.02[b]	0.22[b]	0.30[ab]	0.07[ab]	0.01	0.12	F=6.94***
Financial Capital							
Credit loan value (KES million)	6.78[a]	17.49	17.65[a]	5.63[a]	5.65[a]	10.64	F=28.47***
Total Savings (KES million)	7.88[a]	19.09	11.23	7.03[a]	4.02[a]	9.85	F=75.35***
Social Networks							
Membership in a social network (1=yes,0=no)	0.67[b]	0.65[ab]	0.56[ab]	0.38[b]	0.31[a]	0.51	F=5.95***

Source: Survey Data 2013

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

4.5.8 Contextual Variables

The results presented in Table 4.14 show the mean values of contextual factors. The ANOVA tests were applied to two indicators and it showed that they have an influence on the choice of rural household income dependency strategies at the 1% level. This implied that contextual factors were linked to the choice of rural household income dependency strategies. In addition, results presented in Table 4.14 show that contextual factors are explanatory variables that influence rural household income dependency strategies. Equally, results show there are two indicators of contextual variable factors. These indicators are significantly associated with the rural household choice of income dependency strategies at the 1% level. The indicators were identified as climate-change-induced losses from unexpected catastrophes measured by shocks. In addition, contextual factors include state-actor physical infrastructure development measured by distance traveled by rural households to reach the nearest all-weather roads. Results in Table 4.14) show contextual variables are significantly associated with household income dependency strategy at the 1% level. Results show that rural households face unexpected shocks due to fluctuations from weather patterns and erratic rainfall.

The results presented in Table 4.14 show three indicators of rural household shock experience during the period. Also, results show rural households face various shocks that were categorized into natural shocks, biological shocks and socio-economic shocks. Results show that rural households that experience some kind of shocks had recovered completely, partly or are still suffering after a severe shock experience. Results show rural households in Eastern Mau suffer shocks across income dependency strategies. Further, results show that there is 71.0% of the surveyed rural households reported

experiencing losses from at least one or all the types of shocks. The frequencies of these shocks were attributed to climate-change-induced disasters. Due to increased weather fluctuations are in recent years, these findings are in line with the results from (Burtraw & Woerman, 2013) which showed frequent shocks caused by weather changes have increased socio-economic losses to rural households. It is further shown that households suffering from natural shocks were 21.07% of the surveyed households.

Table 4.14: Mean Value of Contextual Factor Indicators

	Household Income Dependency Strategy Group						
Contextual Factors	On-farm income dependency	Off-farm income dependency	Mixed-income dependency	Transfers income Dependency	Forest-Based Income Dependency	Mean	Statistical Test
Shocks from unexpected losses (1=Yes,0=No)	0.81[a]	0.65[a]	0.68[ab]	0.79[b]	0.62	0.71	F=39.30***
Distance to the nearest all weather access road (km)	1.93[a]	1.16[a]	1.38[b]	2.40[a]	2.54	1.88	F=71.11***

Source: Survey Data 2013
*, **and *** indicate the significance levels at 10%, 5% and 1%, respectively.
Superscript letters denote the significant difference between groups. Means values sharing the same letter(s) in the group label are not significantly different from one another at the 5% level.

Those who suffered biological shocks were 32.96% and socio-economic shocks were 27.25% of the surveyed households. These results are in agreement with the findings of (Newman et al., 2015) and (Kgathi et al., 2007) which showed that rural households suffered from unexpected shocks from all the shocks.

4.6 Effects of Explanatory Variables on Household Choice of Income Strategies

The results that were presented as mean values of indicators were analyzed in the previous Tables 4.6 to Table 4.14. Results have depicted rural households to be constrained by socio-economic characteristics. These results show that total household income is far less than what rural households require to cover their daily basic needs. This traps rural households in a cycle of poverty thus making them engage mainly in subsistence-self consumption with little income left for immediate cash sales. The indicator values of explanatory variables (household asset holdings) were analyzed and determined. The summaries of the analysis were presented in a multinomial logit model. This model showed the factors of explanatory variables that determine dependent variables (household income dependency strategies).

The results presented in Table 4.11 shows there is influence by the human resource variable on the household choice of income dependency strategies. The human resource indicators include household size, highest educational level, age of household, number of household members in the working age, gender and ethnicity of the household. In this study, household size is a continuous variable that is calculated by the number of members in a household. Results show a household with many members is more likely to engage in labour-intensive activities. Further, the highest education level variable was given a dummy variable. It took the value of 1 if the household head has completed primary school and above and 0 otherwise. Household heads with higher educational levels were considered to have higher chances of accessing more remunerative income activities. This variable represents rural household labour endowment. It includes households being able to access well-paying jobs that earn higher incomes. They are also

more likely to engage in activities that are non-farm and/or non-wage businesses that yield higher returns. The number of household members who are of working age is another continuous variable.

Results also showed the age of a household head variable is a measure of the expectation that older household heads are less likely to engage in formal employment. Older households are unlikely to extract labour-intensive forest ecosystem resources or crop production. Gender of household showed that male household heads are predominant in Eastern Mau which is a patriarchal society. In addition, results shoe females are normally considered as more disadvantaged household members than males. This is because females were not able to engage in as many income dependency activities across household income quintiles. This result, therefore, shows the gender of the household head is important in the model. This is because it tests whether a male-headed household is more likely to be involved in more remunerative income dependency strategies. Ethnicity variable is also a factor in Eastern Mau because minority ethnic groups are characterized by low asset endowments and live mostly in remote areas of the sub-counties. In this regard, household ethnicity is taken into consideration in the model as a dummy variable. This variable takes the value of 1 if a household head belongs to the majority Kalenjin ethnic group and 0 otherwise. The size of farming land owned by a household and the percentage of irrigated agricultural land act as proxies for the quantity and quality of the land. This is an important component of rural household natural assets that influences household income dependency strategies. This means that a high household asset endowment on physical assets is expected to improve rural household income dependency strategies. Equally, this may also dissuade rural households from

engaging in the extraction of forest ecosystem resources. Similarly, household possession farming equipment and machinery are expected to increase agricultural productivity. Household high-income activities are expected to increase income dependency strategies and to reduce positively rural household dependence on forest ecosystem resources.

Rural household savings and loans are two important indicators of the financial capital variable. These two have an influence on rural household choice of income dependency strategies. The results of this study show the financial capital variable as an important factor in improving income dependency strategies. Further, results show that rural households with loan credits and savings also are able to engage in capital intensive activities. These indicators of the variable show that rural households engage in activities that require high initial capital outlay if they have financial capital. In this regard, therefore, loans and savings are included as dummy variables in the model. A loan takes the value of 1 if a household has had a loan in the preceding year ending June 2013 and 0 otherwise. Similarly, saving equals 1 if the household has savings at the time of the interview, and 0 otherwise. Loans and savings are expected to reflect positively on the impact of the rural household choice of more remunerative income dependency activities. This result has been supported by research findings from (Babulo et al., 2008a; Walelign, 2016a) which showed that rural households with access to loan credit have savings and are better placed to expand into highly remunerative income activities.

Results of rural household social capital variables were measured by household membership in various social networks. Membership in formal and informal organizations was seen to enhance rural household accessibility to public benefits and information sharing. Results show that rural households with strong social network

connections may access more remunerative income activities. This means that rural household membership in social networks reduces household dependency on forest ecosystem resources. It also means that rural households informal social networks tend to shift to higher return income activities. This increases the chances of rural household engagement in more remunerative income dependency strategies. The results of this study have been supported by results from (Markussen & Røed, 2015; Newman et al., 2015) which showed that rural households may access better jobs and loans if they are members of a formal social group.

Results on rural household experience on contextual factor variables are measured by shock indicators. Rural households experience shock from unexpected losses caused by climate-change-induced disasters. The households which had experienced shocks in the year ending June 2013 were assigned the value of 1. Equally, rural households who had not experienced any unexpected shocks were assigned a value of 0. This finding is in line with the results from (Van den Berg, 2010) which showed shock experience to induce rural households to be more defensive. This means rural households become risk-averse by reallocating their resources from one activity into another. Another variable of contextual factors is physical infrastructure. This was measured by an indicator of distance traveled by rural households to reach the all-weather roads. Infrastructure development is a state-actor policy intervention. These findings of Ellis (2000) are supported by (Babulo et al., 2008a) and (Vedeld et al., 2007) is because of the following reasons: Firstly, road network reduces spatial costs of input and output transactions. Secondly, a good road network assists in the transportation of household members to travel easily from one to another. Also, this enables households to improve their

opportunities and access to different income-earning opportunities. Thirdly, some markets would not exist without the assistance of roads. Finally, roads are essential for information transmission between rural centres and remote areas. This is in agreement with the results from which showed that road accessibility encourages households to engage in more profitable activities. Results from (Ellis, 2000b) show that road infrastructure development is a crucial factor in the choice of household income dependency strategy.

Table 4.15: Summary Statistics of Explanatory Variables

Variable	Total Sample		On-Farm Income Dependency		Off-Farm Income Dependency		Mixed-Income Dependency		Transfers Income Dependency		Forest-based Income Dependency	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
HH_SIZE	4.48	1.86	5.15	1.54	3.29	1.60	4.41	1.91	4.09	1.89	4.05	1.90
EDU_HEAD	2.92	0.19	2.87	0.42	3.09	0.45	2.80	0.40	2.78	0.41	2.24	0.29
HH_AGE	49.69	14.30	46.50	13.27	61.23	11.79	54.51	15.02	48.34	15.34	45.92	12.33
HH_WORKING_AGE	2.92	1.45	3.19	1.29	2.69	1.29	1.93	1.57	2.97	1.55	3.12	1.39
HH_GENDER	0.82	0.39	0.80	0.40	0.90	0.37	0.67	0.44	0.75	0.47	0.84	0.30
HH_ETHNICITY	0.65	0.11	0.94	0.12	0.82	0.13	0.79	0.11	0.34	0.05	0.77	0.17
HH_AGRIC_LAND	1.02	0.02	0.59	0.08	0.61	0.13	1.05	0.85	0.79	0.09	1.56	0.12
IRRI_LAND	0.05	0.01	0.02	0.11	0.03	0.37	0.09	0.19	0.07	0.47	0.49	0.18
HH_LIVES	2.67	2.28	2.11	1.30	2.98	1.35	2.86	1.36	2.13	1.08	3.24	3.35
PRODUC_EQUIP	0.12	0.49	0.02	0.47	0.22	0.41	0.30	0.46	0.07	0.45	0.01	0.49
HH_SAVINGS	29.85	3.38	17.88	4.38	54.09	6.37	144.5	6.34	17.03	2.43	21.02	1.37
HH_LOANS	20.64	9.49	11.78	3.49	81.83	11.50	36.65	8.48	11.63	7.47	12.65	9.49
SOC_NETWORK	0.51	0.36	0.67	1.33	0.65	0.36	0.56	0.35	0.38	0.32	0.31	0.39
UNEX_SHOCK	0.71	0.50	0.81	0.49	0.65	0.68	0.68	0.50	0.79	0.50	0.62	0.48
DIS_ACCES_ROAD	1.88	1.11	1.93	4.05	1.16	2.61	1.38	3.44	2.40	2.78	2.54	8.62

Source: Survey data 2013

4.6.1 Multinomial Logistic Regression Model

There were thirteen out of the fifteen measured indicator variables in the model that were shown to have an influence on the household choice of household income dependency strategies. The results of the effects of indicator variables have been presented. With the

focus on identifying the determinants for the household choice of income dependency strategies and investigating the constraints facing rural households who depend on forest ecosystem resources instead of more remunerative income strategies. Forest-based income is the base outcome in the model. The coefficients, log-odd ratios or odds-ratios and marginal effects in the model reveal the influence of the explanatory variables on rural household choice of income strategies relative to forest-based income strategy as a base. Results presented in Table 4.16 presents the significant influence of household socio-economic variables of household head on size, highest education level, age, number of household members who are of working age, ethnicity, land size owned, livestock herd owned, ownership of tools and equipment, savings, loan accessibility, membership in social groups, shocks and distance to all-weather roads. The gender and percentage of irrigation were shown to have no effect on the dependent variables.

The results of the multinomial logit model have been analyzed and presented in Table 4.16. Results of the model reveal that thirteen out of the fifteen identified predictor variables have a positive and significant effect on the household choice of income dependency strategies. The analysis was carried out for the four income clusters, for example, on-farm income, off-farm income, mixed-income and transfers income. In the model analysis, forest-based income was taken as a base income. This means the analysis was carried out and forest-based income as held constant. The effect of the predictor variables was measured in the model which analyzed the probabilities of households choosing any of the four income dependency strategies.

The analytical model showed the predictor variable estimated coefficients, odd-ratios and marginal effects. Conversely, the potentiality for multicollinearity which is a problem

associated with the model was accounted for by eliminating it using the variance inflation factor (VIF) and its inverse. The results of VIF in the model showed no evidence of multicollinearity since the mean (VIF = 1.38). This result is in agreement with the theory that the VIF values that are greater than the value 1 do not have the problem of multicollinearity. Results of VIF as presented in (Appendix VIII) do not show evidence of multicollinearity. Equally, the likelihood ratio (LR) based on Chi-square tests shows that the model is significant at the 1% level of significance (LR Chi^2 (60) = 1680.04, Prob > Chi^2 = 0.0000). This indicates that at least one of the predictor variables has a significant influence on the dependent variable.

The results of the study show the constraints that are faced by forest-fringe poor rural households when choosing an income dependency strategy. Results, therefore, have been demonstrated by estimated coefficients, odd-ratios and marginal effects in Table 4.16. These results have shown that household socio-economic variables, asset holdings and contextual factors have an influence on the household choice of income dependency strategies when forest-based income is held constant. Equally, statistics of these analyses have revealed that all three predictor variables have a significant influence which is negative or positive) on the rural household choice of diversified income dependency strategies relative to forest-based income which is the base income in the model.

4.6.2 Effect of Socioeconomic Variables

Results of the multinomial logit model presented in Table 4.16 show household size (HH-_SIZE) has a significant and negative influence on the likelihood of a household to choose an off-farm income, mixed-income and transfers income strategy choices. This implies

that rural households with more family members are more likely to adopt on-farm income and forest-based income strategy choices. The odd ratios of 0.897, 0.886, 0.817 are for off-farm income, mixed-income and transfers income strategy choices, respectively. These ratios indicate that given an additional member in the household size, the relative probabilities or relative odds of being in the three income strategies are from 1.11 to 1.12 (1/0.897 to 1/0.817) times lower when other variables in the model are held constant. The marginal effects of the household size effect on the household choice are minimal for off-farm income, mixed-income and transfer income are (-0.015, -0.013 and -0.016, respectively). Marginal effects are calculated at the mean values and have little meaning for discrete values (Welsh & Poe, 1998). The marginal effects of these results indicate that an additional member of a household reduces the likelihood of the household being in the off-farm income, mixed-income and transfers income by 1.5%, 1.3% and 1.6%, respectively when all other variables in the model are held constant. This finding is expected in theory and results from Babulo et al. (2008) which shows the more members a household has, the more likely they will pursue labour-intensive income strategies, for example, on-farm income and forest-based income strategies.

The highest level of education of household head (EDU_HEAD) was shown to have a positive and significant influence on the likelihood of households' decision to choose three income dependency strategy choices. The odds ratios reveal the odds for household heads to engage in off-farm income, mixed-income and transfer income strategy choices as 1.704, 2.622 and 2.104, respectively times higher than for households who have a low level of education or below secondary education level. This means household heads who attained secondary school level or higher are more likely to participate in the three

household income strategies, off-farm income, mixed-income and transfers income. This is because a high school level of education earns households better skills and knowledge. This gives households a better capacity to get employed in well-being jobs and/or engage in more remunerative income activities, for example, engaging in business activities that are non-farm and non-wage businesses. In addition, the household heads that are more educated tend to have broader social connections. They are easily able to get employed in both private and public institutions.

The age of household head (HH_AGE) was shown to significantly and negatively influence the households' likelihood to pursue off-farm income strategy. Equally, this variable exhibits a positive effect on the likelihood to pursue mixed-income and transfer income dependency strategy choices. This implies that older household heads are more likely to be in mixed-income and transfers income dependency strategies. Equally, they are less likely to pursue on-farm income or off-farm income dependency strategies relative to their younger household heads. However, The marginal effects of this explanatory variable on a rural household choice of income dependency strategies are minimal. This means an increase by one year of the age of a household head decreases the likelihood of a household choosing off-farm income dependency strategy by 1.1% and increases the likelihood of a household being in a mixed-income and transfer livelihood strategy by 2.1 % and 2.3 %, respectively. The reasons advanced for this behaviour include older households having more accumulated capital. The older they may be, the more conservative or risk-averse they become in investing in business enterprises. This is so notwithstanding the lucrative and yet riskier income strategies. A rural household with high capital accumulation allows them to engage in mixed-income strategies, for

example, the business of buying and selling of assets and/or renting assets. Equally, as household heads grow old, they decline in their ultimate physical fitness and strength. It is during this period that their children have grown up and moved away in search of new opportunities or to set up their own households. Also, older households are unlikely to participate in labour-intensive activities, for example, in on-farm income and extraction of forest ecosystem resources. These findings are in line with the theory (Babulo et al., 2008a; Godoy et al., 1997) which shows that households exhibit an inverted "U" in their physical fitness and ability to engage in manual activities.

Results on the household head on the number of household members who have attained a working age (HH_WORKING AGE) show the variable has mixed effects on household choice of income dependency strategies. It has a significant and positive influence on the household choice of income dependency strategy at the 1% level of significance. This means it has a positive influence on the probability of households choosing off-farm income and mixed-income dependency strategies. Also, it shows that it has a negative influence on the likelihood of a household choosing transfers income dependency strategy. This means households with more labour are more likely to belong to off-farm and mixed-income dependency and less likely to engage in transfers income dependency strategy relative to forest-based income dependency strategy. Conversely, if a household has one additional worker, the likelihood for them to engage in off-farm income and mixed-income dependency strategy choices increases by 8.8% and 1.6%, respectively). Equally, the likelihood for the household to pursue transfers income dependency strategy declines by (4.5%). Results reveal that that household with more labour are more likely to be in off-farm income and mixed-income dependency strategies relative to the forest-

based income dependency strategies. These results are in agreement with theory and findings by (Adhikari et al., 2004; B. Kumar, 2019) which shows that more workers in a household allow others to go into wage and salary employment and mixed business that are less labour-intensive. Rural households in Eastern Mau have fragmented the farmlands a phenomenon that has made on-farm income activities to be for subsistence self-consumption. In the circumstances, the smallholder household farming activities are small-scale with low-return on investment. Due to this kind of activity, a marginal increase in forest-based income is relatively small even when the number of workers engaging in the activities increases. Equally, due to the shrinking economy, most wage income activities on on-farm or off-farm seasons are paying minimum wages. The additional workforce, therefore, will seek higher return employment opportunities from outside the locality. This leaves the older and the youth to work for little pay in the farms and businesses around Eastern Mau.

Results of household head ethnicity variable (HH_ETHNICITY) show the variable has a significant and positive influence on the household choice of income dependency strategy at the 1% level of significance. This result suggests that households from the Kalenjin ethnic group are less likely to engage in the extraction of forest ecosystem resources or forest-based income as compared to other minority ethnic groups. The possible reasons for this influence are that the majority of ethnic groups have more advantaged over the minority groups. For example, most of them own land and can access land from hiring it from others. Most of the members of the ethnic groups are highly educated with a few having a minimum primary level of education. Also, these households have asset accumulation and better social networks. These socio-economic characteristics make

these households to be engaged in more remunerative income activities. The odds ratios of this variable are high, especially for mixed-income dependency strategies. This result reveals the relative probability of a household choosing mixed-income dependency strategy is for the Kalenjin ethnic group is 13.78 times higher than for the minority ethnic groups. Similarly, the odd-ratios or the odds that a Kalenjin household head will engage in on-farm income, off-income and transfer income dependency strategies are 2.68, 2.14, and 2.79, respectively times higher than minority ethnic groups.

4.6.3 Effect of Land Resources Indicators

The land size owned by a household and the percentage of irrigated farmland is included in the model. This variable is used to examine the influence of land resource capital on the choice of household income dependency strategy. The size of land owned by households as an indicator shows the variable has a significant influence at the 1% level. Results presented in (Table 4.16) show that when holding all other variables constant, an additional hectare of agricultural land to a household reduces the likelihood of the household being in the off-farm income dependency strategy as indicated by the marginal effects which decrease by (18.5%). The household likelihood of pursuing a mixed-income dependency strategy is indicated by marginal effects decrease by 10.9%.

The percentage of irrigated land in the model was shown to have no significance in household income dependency strategy decisions. The results presented in Table 4.16 shows there is a negative influence on the household farmland size owned by households and more the likelihood of a household choosing off-farm income and mixed-income. In other words, rural households with larger land sizes tend to pursue forest-based income

and on-farm income dependency strategies rather than pursuing off-farm income and/or mixed-income dependency strategies. These results are in line with theory and findings by (Babulo et al., 2008a; Jansen et al., 2006; Xu et al., 2015) which shows the size of agricultural land as a key factor in on-farm income production, more so on crop production. Equally, results reveal the larger the agricultural land sizes a household owns, the higher their capacity to increase their production yields and the higher the chance of increasing total household income. Subsequently, increases total household income improves household livelihood outcomes, for example, alleviation of poverty and reduction of income inequality. Also, the improved performance of regular household income, for example, on-farm income, dissuades rural households from over-exploiting forest ecosystem resources. In addition, the more agricultural land a household owns the more labour they require to work on the land. This means the family members are would be less likely to migrate to other towns outside their locality in search of jobs. Thus, rural household dependence on on-farm income or agricultural activities is far greater.

Finally, forest-fringe rural households in Eastern Mau are still characterized by low levels of education and low financial capital endowments. These two factors have created entry barriers for rural households wishing to pursue more lucrative or remunerative income strategies. For example, trying to adopt or engage in off-farm income or mixed-income dependency strategies. The results presented in Table 4.16 show the marginal effects of this indicator variable on household income dependency strategy choice.

4.6.4 Effect of Physical Capital Indicators

The influence of physical capital assets is measured by two indicator variables; namely, ownership of agricultural tools and machines and the size of livestock herds. Results show that ownership of tools, machinery and equipment significantly and negatively influences the household likelihood of choosing all the four income dependency strategies relative to forest-based income dependency strategy. Equally, the odd-ratios displayed in Table 4.16 imply that the odds that households who own agricultural production equipment (tools, machinery and equipment) in on-farm, income, off-farm income, mixed-income and transfers income strategies are (3.14 (1/0.318); 1.85 (1/0.541); 2.2 (1/0.453) and 2.1 (1/0.478), respectively) times lower than the households without the productive equipment. The households who own agricultural productive equipment have been shown to increases their scale of agricultural production hence achieving economies of scale. This means households owning productive equipment are less likely to engage in forest-based income dependency strategies.

Similarly, ownership of land and livestock herds increases on-farm/agricultural productivity. This subsequently increases total household income which in turn alleviates household poverty. When household poverty is alleviated, rural households are dissuaded from over-reliance on forest ecosystem resources. Equally, households with accumulated assets, for example, land, livestock, productive tools and machines increase their yields from on-farm or agricultural income production activities. A large herd of livestock, for example, allows households to earn more income from livestock and livestock products. This, in general, allows households the capacity to increase total household income, thus reducing its poverty alleviating capacity. This result is in agreement with the theory by

(Gecho et al., 2014) which shows increased performance in on-farm income through the use of productive equipment and larger livestock herd increases rural household capacity to alleviate poverty and reduce income inequality. The improved performance of regular household income or on-farm income through livestock production is revealed by marginal effects. These effects imply that the odds that households who own production equipment and are in on-farm income, off-farm income, mixed-income and transfers income dependency strategies are (4.5%, 0.8%, 0.5% and 0.3%, respectively) times lower than those without production equipment. These results reveal the likelihood of a household owning production equipment increases their scale of on-farm/agricultural production which, in turn, enhances the household's total income. Conversely, ownership of land and livestock increases on-farm income productivity thus encouraging households to depend less on forest ecosystem resources.

4.6.5 Effect of Financial Capital Indicators

The influence of financial capital on the household livelihood strategy choice is confirmed by two indicator variables, loans and savings. These two variables have a significant influence on household decision to pursue mixed-income and transfer income dependency strategies. Results show household income savings have a negative influence on the likelihood of a household decision to pursue a transfer income dependency strategy. This result indicates that rural households with income savings are less likely to engage in a transfer income dependency strategy. The odds-ratio of 0.865 indicates that the relative probability of a household having income savings pursuing transfer income dependency strategy is 1.16 (1/0.865) times lower than those who have no income

savings. The explanation to this is that rural households engaging in forest ecosystem resources or in forest-based income dependency strategy need financial capital to buy the required farm inputs for on-farm income/agricultural activities and finances to support the extraction of forest ecosystem resources. This is considered to provide rural households with the motivation to save and accumulate their capital assets. The findings are contrary to results by (Walelign et al., 2017) that show rural households with more income savings were less likely to engage in on-farm income activities and extraction of forest ecosystem resources.

Meanwhile, a household with accessibility to credit finances in the form of seasonal loans is shown to have a positive effect on the households' decision to pursue a mixed-income dependency strategy and transfers income dependency strategies. This result means that households with loans were more likely to pursue two household income dependency strategies. Again, this confirms that household accessibility to financial credit in the form of loans, allows them to pursue more remunerative or lucrative income-generating activities. This is because these activities require more financial capital outlay, especially small business start-ups which require business incubations. The effect of this indicator variable is in line with theory and studies by (Soltani et al., 2012; Walelign, 2016a) which shows rural households with access to financial credit are more likely to pursue more lucrative or more remunerative income dependency strategies. These two income dependency strategies are income-generating activities are not labour-intensive and don't require land and/or land-inputs. These two income strategies have substituted labour and land requirement with business enterprises dealing with rentals, asset selling and buying.

These income-generating activities are not affected by land scarcity, shortage of inputs or rainfall fluctuations.

4.6.6 Effects of Social Capital Indicators

The influence of social capital indicator variables on the household livelihood strategy choice is confirmed by rural household membership in the social group network. This indicator variable is shown to have a positive and significant effect on the choice of households to pursue off-farm income and transfers income dependency strategies relative to the forest-based income dependency strategy. The odd-ratios presented in Table 4.16 shows the odds that the rural household with memberships in social groups being involved in off-farm income and transfers income dependency strategies are 1.542 and 1.628 times higher when compared to those who are not members in any social groups, respectively. These results show the probability of rural households being members of social groups was more likely to have broader connections. This means households would, in turn, access more job opportunities. Equally, they would be able to get assistance from relatives, friends and kinfolk when in the need of assistance.

4.6.7 Effects of Contextual Indicators

The influence of contextual indicator variables on the household livelihood strategy choice is revealed by the household experience of unexpected losses from income shortfall-shocks and the distance households travel to reach the nearest all-weather road. These two indicator variables are included in the model to examine the effect of contextual factors on household income dependency strategy choices. The shock variable indicator was shown to have a positive and significant effect at the 1% level on

household likelihood to pursue transfers income dependency strategy. These results mean that rural households who experience unexpected losses from shocks were more likely to be in the transfer dependency strategy when compared to those who have never faced any unexpected loss from shocks. The possible reason for the causes of these shocks is attributed to income shortfalls due to climate-change-induced weather fluctuations that affect rainfall patterns and cause crop failures and food shortages or yield gaps which affect household income and consumption. Rural households who face losses from shocks tend to become more conservative or risk-averse in their investments. The households are forced by circumstances to re-allocate their resources and investments to more defensive income dependency strategies. This finding is in line with theory and findings by (Van den Berg, 2010) which shows that rural households in Nicaragua experience disasters from hurricanes which makes households pursue more defensive income strategies for their survival and improvement of their livelihoods.

Equally, the distance indicator variable was shown to have a positive and significant effect at the 1% level on household likelihood to pursue all the household income dependency strategies. Both indicator variables were shown to have a significant influence on the likelihood of a household to pursue transfers and all other income dependency strategy for both shock and distance variables, respectively. Distance to the nearest all-weather road has been used as a proxy for remoteness by many environmental economists. A study by (Stifel & Christiaensen, 2007) shows remoteness of a locality affects household transaction costs and the degree of household accessibility to markets which, in turn, influences the households' decision to choose an income dependency strategy. The results equally show the longer distance to the nearest all-weather road, the

less likely the household will engage in all four income dependency relative to the forest-based income dependency strategy. However, the marginal effect of the distance indicator variable on the choice of household income dependency strategy is quite small. For example, the addition of one kilometre to the distance to be traveled to the nearest all-weather road reduces the likelihood of a household being in all the four income dependency strategies. The marginal effect on-farm income, mixed-income and transfers income reduces by 0.3%. When the distances to various destination points in the rural economy were to be reduced, rural households would easily travel to seek employment, buy goods like farm inputs, reach markets of farm produce easily and thus reduce spatial transaction costs. Road accessibility makes households to access more opportunities and to participate in more lucrative income-generating activities. The finding is consistent with theory and studies by (Babulo et al., 2008a; Xu et al., 2015) which shows rural household dependence on agricultural activities among rural households in remote areas in China. Equally, rural households in far-flung rural areas were more likely to engage in on-farm or agricultural income production activities. The study on household livelihood strategies and dependence on agriculture in China, Xu et al. (2015) found that households living in more remote areas are more likely to depend on agricultural activities. Babulo et al. (2008) also reported similar findings where a longer distance to all-weather roads induced households to be in the forest-dominant strategy group compared to their less forest-dependent counterparts.

On contextual factors, the results of the model presented in Table 4.16 show the variable are measured by two indicators. These are experienced from unexpected losses from shocks and long distances traveled by rural households before they reach the nearest all-

weather roads. These indicators have been used in the model to examine the effects it has on rural household choice of income dependency strategies. Results of the model show both indicators of contextual factors have a significant influence on the rural household choice of income dependency strategies at the 1% level. In particular, the shock indicator variable has a positive effect only on rural household transfers-income dependency. This means rural households who experience unexpected losses from shocks are more likely to be in the transfers-income dependency strategy compared to those who have not experienced any losses from shock in the last one year ending June 2013. The possible reason for this is that shocks cause household shortages in income and consumption. These results show that rural households who experience losses from shocks tend to be risk-averse in their allocation of resources. Also, as the households become conservative in their investment, they re-allocate their resources to more defensive income dependency strategies. The results of this model are in line with the theory and findings by (Van den Berg, 2010) which shows rural households in Nicaragua experienced hurricanes and natural disasters. This shock causes income losses and consumption to rural households. Rural households then became defensive by pursuing income dependency coping strategies to mitigate disasters. This is because households experienced shocks from disasters that destroyed productive assets. The defensive mechanism employed by rural households allowed them to use latent survival mechanisms.

Rural household distance to the nearest all-weather road has been used in the model as a proxy for rural household remoteness. Study findings by (Stifel & Christiaensen, 2007) support the theory that rural household remoteness is caused by households being in far-flung areas of forest reserves. These areas have no access roads and households use

footpaths. Rural household remoteness increases household spatial transaction costs and reduces household accessibility to urban centres where they buy supplies or markets for farm produce. This, in turn, influences rural household choice of income dependency strategies. Results of the multinomial logit model show longer distances to the nearest all-weather roads decreased the probability that a rural household engages in the four income dependency strategies relative to forest-based income dependency strategy.

Table 4.16: Results of the Multinomial Logistic Regression Model

	Cluster 1 On-farm Income Dependency			Cluster 2 Off-Farm Income Dependency			Cluster 3 Mixed-income dependency			Cluster 4 Transfers Income Dependency		
Variables	Coeff.	Odd-ratios	ME	Coeff.	Odd-ratios	ME.	Coeff.	Odd ratios	ME.	Coeff.	Odd ratios	ME.
HH_SIZE	0.147	0.893	0.186	-0.113	0.897***	-0.015	-0.121	0.886***	-0.132	-0.202	0.817***	-0.164
		(0.0662)			(0.0360)			(0.0641)			(0.00442)	
EDU_HEAD	0.533	1.019*		0.482	1.704***		0.484	2.622***	0.015	0.432	1.914**	0.024
		(0.330)			(0.246)			(0.0641)			(0.00442)	
HH_AGE	0.011	0.989	-0.002	-0.011	1.989*	-0.001	0.021	1.622***	0.002	0.023	1.104***	0.006
		(0.00640)			(0.00432)			(0.389)			(0.388)	
WORKING_HHM	0.230	1.258	0.096	0.390	1.477***	0.088	0.079	1.132***	0.016	-0.153	0.654***	-0.045
		(0.0890)			(0.0970)			(0.0984)			(0.0585)	
HH_GENDER	0.230	1.258		-0.175	0.840		0.096	1.100	-0.003	-0.188	0.829	-0.041
		(0.0989)			(0.130)			(0.0982)			(0.583)	
HH_ETHNICITY	2.752	2.683***	0.128	1.112	2.141***		1.341	13.786***		1.034	2.789***	
		(4.263)			(0.388)			(0.186)			(0.159)	
AGRI_LAND	-0.584	0.507	-0.175	-0.676	0.559***	-0.185	-0.255	0.908***	-0.109	1.062	0.892	0.005
		(0.0558)			(0.0317)			(0.827)			(0.494)	
IRRI_LAND	0.000	1.000	0.000	0.001	1.001	0.000	-0.020	0.980	0.018	-0.063	0.939	0.030
		(0.00230)			(0.00157)			(0.0468)			(0.0441)	
HH_LIVESK	-0.026	0.670***	-0.045	-0.261	0.543***	-0.008	-0.022	0.165***	-0.005	-0.013	0.761***	-0.003
		(0.0278)			(0.0460)			(0.00264)			(0.0354)	
AGR_PROD_EQP	-1.146	0.318***		-0.588	0.541***		-0.205	0.453***		-0.129	0.478***	
		(0.0546)			(0.0597)			(0.0551)			(0.0354)	
HH_LOAN	-0.308	1.361		0.112	0.894		-0.801	0.449***		0.677	0.508***	
		(0.211)			(0.0946)			(0.0858)			(0.0721)	
HH_SAVING	0.228	1.256		0.114	1.121		-0.278	0.758		-0.321	0.865***	
		(0.266)			(0.158)			(0.143)			(0.191)	
SOC_NETWORK	0.326	1.385		0.502	1.542***		0.462	1.588		0.345	1.628***	
		(0.316)			(0.248)			(0.447)			(0.122)	
UNEX_SHOCK	-0.056	0.945		-0.120	0.887		0.369	1.446		0.485	1.624***	
		(0.152)			(0.0968)			(0.397)			(0.341)	
DIS_ACC_ROAD	-0.021	0.931***	-0.003	-0.027	0.973**	-0.000	-0.047	0.865***	-0.002	-0.065	0.973***	-0.004
		(0.00958)			(0.0279)			(0.0246)			(0.0179)	
Constant	-0.454	0.650*		-3.599	0.0450***		-0.326	0.0234***		-2.143	0.0432***	
		(0.149)			(0.0243)			(0.0126)			(0.0213)	

Source: Survey Data 2013

Observations = 450; Log Likelihood = -3,314.81; LR $Chi^2(6)$ = 1,580.08; Prob > Chi^2 =0.0000
*p<0.1, **p<0.05, *** p<0.01

However, the marginal effect of this indicator variable is quite small. For example, an addition of one kilometer to the distance to be traveled to reach the all-weather road reduces the likelihood of households to be on off-farm income dependency strategy by 0.3%. This means if the distance was shorted to all-weather roads increases households'

accessibility to labour and commodity markets. It also reduces transaction costs, for example, it reduces transportation costs for people, inputs and farm produce. Results of the model, therefore, shows rural households have more opportunities to engage in more remunerative income-generating activities when the distance is reduced.

4.7 Impacts of Forest-Based Income in Alleviating Poverty

Results presented in Table 4.13 show rural household income earnings and distribution across household income quintiles. Results of one-way ANOVA tests show rural household net income earnings per capita per year across household income quintiles impacts household poverty alleviation at the 1% level. The results of the study show the distribution of household net incomes and the contribution of forest-based income towards total household income. Rural household net income earnings per capita per year have been computed for the period beginning July 2012 to June 2013. Results of net income earnings were summarized across rural household income quintiles.

4.7.1 FGT Poverty Indices Decomposition across Household Income Strategies

The FGT poverty indices decomposition on each of the household income sources f across household income strategies shows comparative FGT poverty indices on household income dependency strategies. The income dependency strategies include on-farm income, off-farm income, mixed-income, transfers income and forest-based income. The three FGT poverty variant indices show the effect of forest-based income across household income components. The analysis of these results provided the upper and lower bounds on the magnitudes of forest-based income when considered with total household income. The results presented in Table 4.18 shows measured FGT poverty

indices for each household income dependency strategy. The FGT poverty measurement gives the relevant insights into household poverty headcount, poverty gap and poverty severity. Household poverty headcount measures the extent of poverty, poverty gap measures the number of households who are poor below the poverty line and the income amounts required to bring them to reach the poverty line. Lastly, the poverty severity measures of the severity of poverty. The analysis of results of FGT poverty indices decomposition of household income strategies shows there are disparities in household income alleviation effects. The results in Table 4.18 show the FGT poverty indices decomposition on household income dependency strategies. Results show that household income dependency strategies with the highest reduction of household poverty have the highest FGT poverty indices. In Table 4.18, forest-based income and on-farm income dependency strategies have the highest Gini coefficient indices 0.331 and 0.284, respectively.

Further, the results in Table 4.18 present the FGT poverty indices decomposition of each household income dependency strategy. The household income dependency strategies was shown to have the highest poverty alleviation effects $FGT_{(\alpha=0)} = 0.331$, on-farm income $FGT_{(\alpha=0)} = 0.284$ and transfers income ($FGT_{(\alpha=0)} = 0.214$.

The relative importance of forest-based income on alleviation of household poverty is measured by $FGT_{(\alpha)}$ poverty indices decomposition as presented in Table 4.18. The $FGT_{(\alpha)}$ poverty indices decomposition of income was used to analyze the effects of forest-based income on total household income. The analysis of $FGT_{(\alpha)}$ poverty indices shows the contribution of each household income sources towards the alleviation of aggregate household income inequality. Conversely, $FGT_{(\alpha)}$ poverty indices were used to

show the reduction in aggregate household income poverty is attributed to the performance of each household income source. Equally, the FGT poverty indices of decomposition show the household poverty alleviation effects of forest-based income on each household income source.

Equally, results of $FGT_{(\alpha=0)}$ poverty indices decomposition show total household income with and without forest-based income being considered. The results show when forest-based income is considered with total household income, the FGT poverty indices reduces the household headcount index ($FGT_{(\alpha=0)}$) from 0.299 to 0.252. This means the number of households below the poverty line has reduced from 29.9% to 25.2% which is a reduction of measured household poverty by approximately 15.7%.

In addition, the household poverty gap index ($FGT_{(\alpha=1)}$) reduced from 0.262 to 0.257 and the household poverty severity index ($FGT_{(\alpha=2)}$) reduced from 0.071 to 0.066. These poverty indices show forest-based income has a poverty alleviating effect for household poverty gap and poverty severity by 1.9% and 7%, respectively.

Table 4.17: FGT Poverty Indices Decomposition of Household Income Sources

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	0.252	0.257	0.066

Source: Survey Data 2013

4.7.2 FGT Poverty Indices and Marginal Effects of Forest-Based Income

The results presented in Table 4.19 show the marginal effects of forest-based income FGT poverty indices. The FGT poverty indices have shown the results of total household income with and without the inclusion of forest-based income. In either of the two scenarios, the FGT poverty indices analysis shows the Gini coefficient index drop from 0.497 to 0.421 for the household poverty headcount index ($FGT_{(\alpha=0)}$). This indicates the rural households classified as living below the poverty line reduces from 49.7% to 42.1%. Equally, the FGT poverty index shows forest-based income has reduced measured household poverty by approximately 15.86%. Equally, the other FGT poverty indices show the Gini coefficient indices drop from 0.435 to 0.418 for the poverty gap. This is a reduction in the poverty gap by 3.9% (0.017/0.435). Equally, the household poverty severity showed a Gini coefficient drop from 0.398 to 0.334. This shows a household poverty severity reduction by 16% (0.064/0.398). These results indicate that forest-based income has poverty alleviating effects on measured household poverty. This disapproves of the hypothesis that tested that forest-based income has no effects on household poverty. These results are in agreement with the findings from (Sahn & Stifel, 2003) which show rural household poverty headcount index for most sub-Sahara countries is between 0.54 to 0.56.

In terms of the depth of poverty or headcount index, results are in agreement with the findings from (Maloma, 2016; Megbowon, 2018) which show household poverty headcount index is reduced when forest ecosystem resources are considered in household income accounting. However, studies by (Fonta & Ayuk, 2013; Lopez-Feldman et al.,

2007, p. 20; Porro et al., 2015) have criticized these poverty measures for not giving the actual number of poor rural households who benefit below the poverty line.

Table 4.18: Effects of Forest-Based Income on FGT Poverty Indices

	FGT Index Without Forest-Based Income		FGT Index 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

Source: Survey Data 2013

4.8 Equalizing Effects of Forest-Based Income on Household Income Inequality

Results of the Gini coefficient analysis of the marginal effect of forest-based income on household income inequality have been presented Tables 4.20. The measurement of household income inequality using the Gini coefficient analysis shows the effect of forest-based income when considered with total household income in order to measure its income equalizing effects that reduce household income inequality. Equally, the results from this study show the Gini coefficient decomposition of household income sources. The results show the decomposition of household income sources with and without the consideration of forest-based income in total household income. The results show the aggregate Gini coefficient decomposition analysis of the contribution of individual household income components in the reduction of total household income inequality. Also, results show when forest-based income is considered together with each individual household income component shows a drop in the Gini coefficient which is equivalent to a reduction in household income inequality.

The results of this study in Table 4.20 shows forest-based income contributes to the mean difference of the Gini coefficient when the income is added to each of the five household income dependency strategies. The Gini coefficient decomposition of household income source or household income dependency strategies shows the forest-based income equalizing effects on household income inequality.

The results presented in Table 4.20 shows the Gini coefficient index of decomposition on each of the household income sources. The results show the equalizing effects of forest-based income when it added when it is not added to total household income. Further, the results show forest ecosystem resources have the highest income equalizing effect as measured by the Gini coefficient index drop from 0.581 to 0.479. This shows that forest-based income has the highest income equalizing effect when compared to other regular income dependency strategies. The difference in the Gini coefficient shows the forest-based income to reduce household income inequality by approximately 17.56% (0.102/0.581). The analysis has also shown the second-highest effect of income inequality is by transfers income dependency which had a Gini coefficient drop from 0.508 to 0.457. This indicates the reduction of household income inequality by approximately 10.03% (-0.51/0.508). The overall household income inequality reduction was shown by the Gini coefficient indices drop from 0.578 to 0.472 when forest-based income was added to total household income. The combined equalizing effect of forest-based income on total household inequality is a reduction of aggregate income inequality by approximately 18.34% (0.106/0.578).

The results of this study show forest-based income en added to each of the household income sources has income equalizing effects on Gini coefficient indices of decomposed

household income sources. Equally, forest-based income when added to total household income or combined household income dependency strategies reduces aggregate income inequality.

Table 4.19: Gini Coefficients and Forest-Based Income Equalizing Effects

Income Dependency Strategy	Gini coefficient Without Forest-Based Income	Gini coefficient With Forest-Based Income	Mean Difference	Percentage drop attributed to Forest-Based Income (%)
On-farm income dependency	0.471	0.427	-0.044	9.34
Off-farm income dependency	0.678	0.624	-0.054	7.96
Mixed-income dependency	0.654	0.630	-0.024	3.67
Transfers income dependency	0.508	0.457	-0.051	10.03
Forest-based income dependency	0.581	0.479	-0.102	17.56
Total	0.578	0.472	-0.106	18.34

Source: Survey Data 2013

The findings from this study is in agreement with the studies by (Monica Fisher, 2004; Heubach et al., 2011; Kamanga et al., 2009a; Mamo et al., 2007a; Vedeld et al., 2007) which shows the Gini coefficient decomposition of household income sources have been shown to reduce household income inequality. This means, when forest-based income is considered with total household income, the Gini coefficient of individual household income sources, reduces individual Gini coefficient which when put together reduces the aggregate household income inequality.

4.8.1 Gini Decomposition by Household Income Dependency Strategies

The household on-farm income activities are shown in Table 4.21 to have a high Gini coefficient $G_k = 1.02$ and a high Gini correlation $R_k = 0.418$. Equally, the on-farm income dependency strategy accounts for 61% for $S_k=0.61$ of total household income. Also, on-farm income activities are associated positively with household income inequality since a 10% increase (column 6) in on-farm income activity increases the Gini coefficient by

0.92%. Equally, other household income dependency strategies like off-income, mixed-income, transfer income and forest-based income when increased by 10%, the Gini coefficients reduce (column 6) by minimal percentage points of 0.22%, 0.23%, 0.11% and 0.20%, respectively. These impacts have been shown to be statistically different from zero. These results, therefore, show off-farm income is the most unequally distributed G_k = 0.542 as compared to other income dependency strategies. However, the Gini correlation between off-farm income and total household income is (R_k = 0.241 which indicates that off-farm income favours poor rural households at the bottom of income distribution or the poorest income quintiles. Other things being equal, a 10% increase in off-farm income is associated with a 0.22% decrease in the Gini coefficient which is a reduction in total household income inequality. This means that off-farm income, when compared with other income activities, has a high income equalizing impact on rural household income inequality. In addition, results have shown forest-based income to be unequally distributed G_k = 0.803. This means the Gini correlation between forest-based income total household income is low R_k = 0.106. This indicates that forest-based income favours rural households living in the lowest income quintiles who are the poorest and the second poorest. If all other incomes are held constant, a 10% increase in forest-based income is associated (0.26%) decrease in the Gini coefficient of total household income. This means forest-based income has the highest income equalizing impact on rural household income inequality.

This result means forest-based income in Eastern Mau has the highest income equalizing effect on household total income inequality. This forest-based income effect presents a policy recommendation to state-actor policymakers. It is recommended that the

conservation of forest ecosystem resources should be embedded in sustainable household livelihood outcomes. The livelihood outcomes are factoring in the alleviation of household poverty and reduction of income inequality. Equally, it means state-actors should ensure governance structures and policies entrench forest-based income as a conventional household income. This means the income should be included in the computation of nominal gross domestic product (GDP). Also, pro-poor rural development programmes should be included in the management of forest ecosystem resources. This ensures that rural households are involved in conservation decision making processes. This provides legitimate consumption of forest ecosystem resources which provides rural households with a pathway out of poverty. These results are in line with findings from (William Cavendish, 2000b) and (Babulo et al., 2009a) which show that unless rural households are given legitimate rights to consumption, they will remain potentially dependent on forest ecosystem resources and will not find a pathway out of poverty.

Table 4.20: Gini Coefficient Decomposition by Household Income Strategies

Income Source	Household total income per capita (KES)	Share contribution to total income per capita (S_k)	Gini coefficient for each income activity (G_k)	Gini Correlation with total income per capita (R_k)	Share of total income inequality	% Change in Gini from 10% change in income source
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
On-farm Income	10,243.07	0.610	1.021	0.418	0.357	0.92
Off-farm Income	3,992.56	0.238	0.542	0.241	0.421	-0.22
Mixed Income	477.02	0.028	0.711	0.016	0.135	-0.13
Transfers Income	133.49	0.008	0.564	0.029	0.013	-0.11
Forest-Based Income	1955.11	0.116	0.803	0.106	0.003	-0.26
Total Income	16,801.25					

4.8.2 Lorenz Curve Analysis and Reduction of Household Income Inequality

The results of this study have been presented in Figures 4.1 and 4.2 by Lorenz curve analysis. Lorenz curve is a visual illustration of the impact of forest-based income on household income inequality. The crosswise line that runs 45^0 is the equidistributional line that represents perfect inequality. These results are in agreement with the findings by (Bellù & Liberati, 2005b) and (Monica Fisher, 2004) which showed an equidistribution line as perfect inequality. This means that there are no better-off households on this line. Results from rural household income earnings from all income dependency strategies were used to develop the Lorenz curve. The results presented in Figure 4.1 show the Lorenz curve when forest-based income is added to household income dependency strategies and when it is not added. The curve that is near the equidistributional line is the one with forest-based income added. Equally, the line that is further away from the line of equity doesn't have forest-based income added to it. These results mean that forest-based income reduces household income inequality.

In comparison, the Lorenz curves for different income dependency strategies have been presented in Figure 4.2. These Lorenz curves confirm the findings from the Gini coefficient analysis in section 4.62. This showed off-farm income and forest-based income dependency strategies have the Lorenz curves closest to the line of equity, respectively. The on-farm and transfers income dependency strategies had the furthest Lorenz curves away from the equalization line or line of equity. Results, therefore, show that income inequality is highest in the mixed-income dependency strategy and lowest in the off-farm income dependency strategy.

Lorenz curves were developed using total household income earnings. The graphs were plotted with and without forest-based income being included in total household income. In Figure 4.1 the plotted Lorenz curve is shown when forest-based income is included in total household income. The Lorenz curve is seen to shift towards the equidistributional (equality) line. Conversely, when forest-based income is excluded, the Lorenz curve shifts further away from the equality line. This shift of the curves shows that forest-based income reduces household income inequality.

Conversely, the Lorenz curves were plotted for each of the income dependency strategy sources. In comparison, the Lorenz curves for different income dependency strategies have been presented in Figure 4.2. These Lorenz curves confirm the findings from the Gini coefficient analysis in section 4.62 and Table 4.20 and 4.21 which shows off-farm income and forest-based income dependency strategies to be closest to the equidistributional line. The furthest away the curve is, the less equalizing effect it has on income inequality. In Figure 4.2, it is shown that on-farm and transfers income dependency strategies are the furthest away from the equalization line.

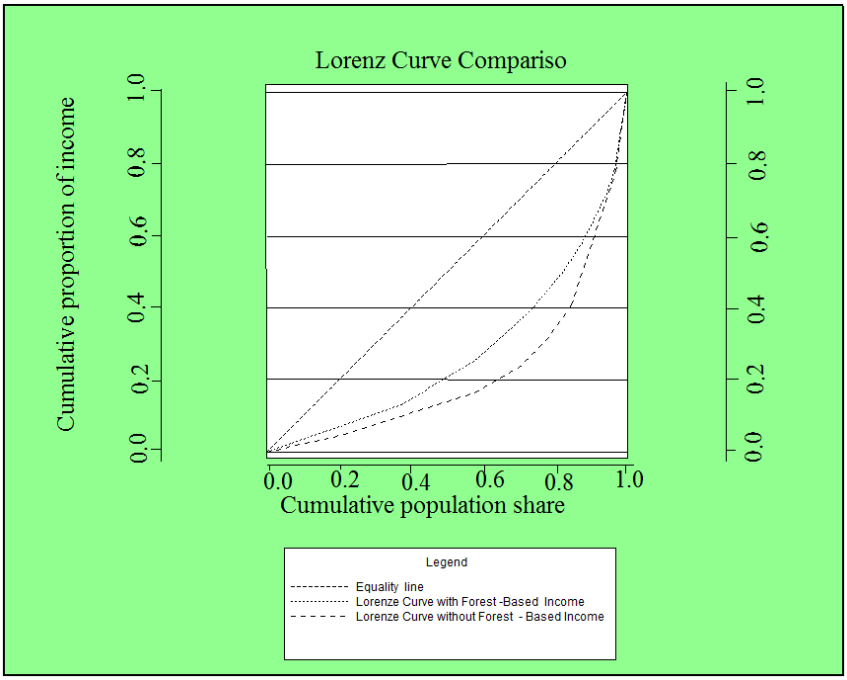

Figure 4.1: Lorenz Curve Comparison with and without Forest-Based Income

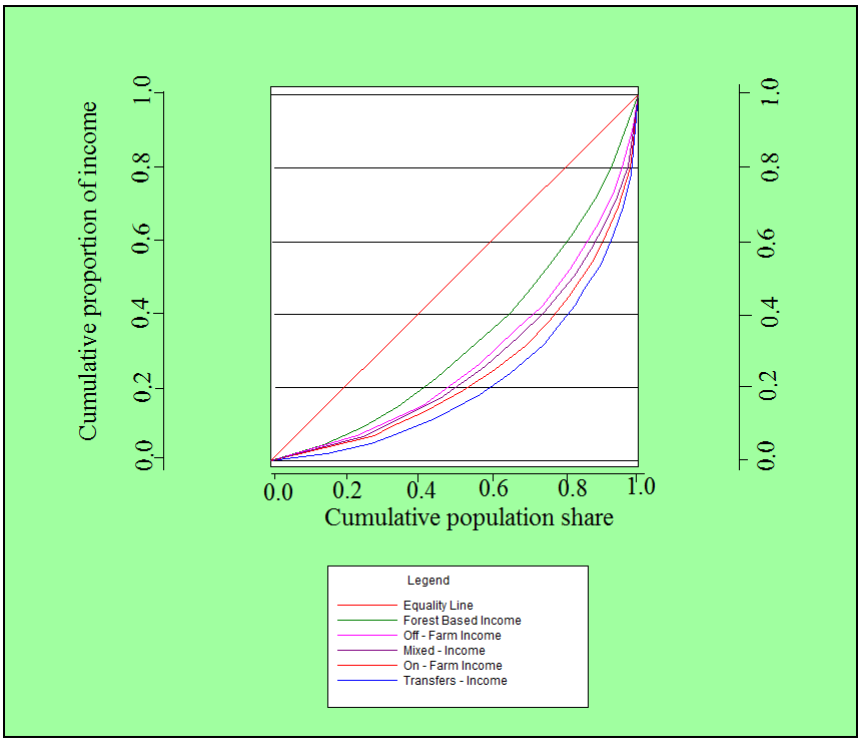

Figure 4.2: Lorenz curve comparison of five income dependency strategies

Results of the Lorenz curve in Figure 4.2 show the curve drawn for the five income dependency strategies in relation to the equidistribution line. The Lorenz curves confirm the results of the Gini coefficient analysis in section 4.62. In addition, Lorenz curves have revealed that income dependency strategies have varying marginal effects on total household income inequality. Lorenz curves closest to the equality lines have greater inequality reduction as compared to those furthest from the line. Results show the Lorenz curves of forest-based income and off-farm income have the highest reduction of household income inequality. This means nearness to the line of equality is associated with a higher equalizing effect. The equalizing effect is lowest for on-farm and transfers income dependency strategies.

CHAPTER FIVE

DISCUSSIONS

5.1 Introduction

This chapter introduces discussions in section 5.1 and in section 5.2 logical inferences are covered which attempts to give meaning to the results of the study. In section 5.3 the outstanding findings of the study have discussed. Special emphasis has been placed on the possible application of the study by state-actor policymakers. This is with respect to improving the performance of regular household income strategies. These strategies are underpinned by household on-farm income activities. These are the main economic mainstay of rural households living in the forest margins of Eastern Mau. Discussions have also examined the factors that determine the rural household choice of income dependency strategies that sustain household livelihoods in Eastern Mau. The analytical models have also analyzed the impacts of forest-based income in alleviating rural household poverty and mitigating household income inequality.

The results of the study have disapproved the hypotheses that were posed by the study. The findings have confirmed that the household socio-economic characteristics, asset holdings variables and contextual variables have an influence on household choices of regular diversified income dependency strategies. Equally, the findings that forest-based income has poverty alleviating effects and income equalizing effects on rural household poverty and income inequalities. This disapproves of the second and third hypotheses of the study which tested that forest-based income has no effects on the alleviation of rural household poverty and reduction of household income inequalities. Finally, the findings

have revealed that forest-based income has income distribution effects among forest-fringe poor rural households in Eastern Mau.

5.2 Discussions and Logical Inferences from the Study

The results of this study have led to logical inferences related to household economic activities in the context of Eastern Mau. This section has coved the effects of the three selected predictor variables on household income dependency strategies. It has also highlighted the effects of forest-based income in the alleviation of measured household poverty. Lastly, it has shown the income equalizing effects of the extraction of forest ecosystem resources in the reduction of each of the household income sources and the aggregate household income.

5.2.1 Effects of Predictor Variables on Household Income Dependency Strategies

The results of the multinomial logit model have been analyzed and presented in Table 4.16. Results of the model reveal that thirteen out of the fifteen identified predictor variables have a positive and significant effect on the household choice of income dependency strategies. The analysis was carried out for the four income clusters, for example, on-farm income, off-farm income, mixed-income and transfers income. In the model analysis, forest-based income was taken as a base income. This means the analysis was carried out and forest-based income as held constant. The effect of the predictor variables was measured in the model which analyzed the probabilities of households choosing any of the four income dependency strategies.

The analytical model showed the predictor variable estimated coefficients, odd-ratios and marginal effects. Conversely, the potentiality for multicollinearity which is a problem

associated with the model was accounted for by eliminating it using the variance inflation factor (VIF) and its inverse. Results of VIF in the model showed no evidence of multicollinearity since the mean (VIF = 1.38). This result is in agreement with the theory that the VIF values that are greater than the value 1 do not have the problem of multicollinearity. Results of VIF as presented in (Appendix VIII) do not show evidence of multicollinearity. Equally, the likelihood ratio (LR) based on Chi-square tests shows that the model is significant at the 1% level of significance (LR Chi^2 (60) = 1680.04, Prob > Chi^2 = 0.0000). This indicates that at least one of the predictor variables has a significant influence on the dependent variable.

The results of the study show the constraints that are faced by forest-fringe poor rural households when choosing an income dependency strategy. Results, therefore, have been demonstrated by estimated coefficients, odd-ratios and marginal effects in Table 4.16. These results have shown that household socio-economic variables, asset holdings and contextual factors have an influence on the household choice of income dependency strategies when forest-based income is held constant. Equally, statistics of these analyses have revealed that all three predictor variables have a significant influence which is negative or positive) on the rural household choice of diversified income dependency strategies relative to forest-based income which is the base income in the model. These results, therefore, have disapproved of the first hypothesis which tested that the three selected predictor variables (socio-economic, asset holdings and contextual variables) had no influence on the rural household choice of income dependency strategies.

5.2.3 Forest-Based Income Poverty Alleviating Effects

The results presented in Table 4.19 show the marginal effects of forest-based income FGT poverty indices. The FGT poverty indices have shown the results of total household income with and without the inclusion of forest-based income. In either of the two scenarios, the FGT poverty indices analysis shows the Gini coefficient index drop from 0.497 to 0.421 for the household poverty headcount index ($FGT_{(\alpha=0)}$). This indicates the rural households classified as living below the poverty line reduces from 49.7% to 42.1%. Equally, the FGT poverty index shows forest-based income has reduced measured household poverty by approximately 15.86%. Equally, the other FGT poverty indices show the Gini coefficient indices drop from 0.435 to 0.418 for the poverty gap. This is a reduction in the poverty gap by 3.9% (0.017/0.435). Equally, the household poverty severity showed a Gini coefficient drop from 0.398 to 0.334. This shows a household poverty severity reduction by 16% (0.064/0.398). These results indicate that forest-based income has poverty alleviating effects on measured household poverty. This disapproves of the hypothesis that tested that forest-based income has no effects on household poverty.

These results are in agreement with the findings from (Sahn & Stifel, 2003) which show rural household poverty headcount index for most sub-Sahara countries is between 0.54 to 0.56. In terms of the depth of poverty or headcount index, results are in agreement with the findings from (Maloma, 2016; Megbowon, 2018) which show household poverty headcount index is reduced when forest ecosystem resources are considered in household income accounting. However, studies by (Fonta & Ayuk, 2013; Lopez-Feldman et al., 2007, p. 20; Porro et al., 2015) have criticized these poverty measures for

not giving the actual number of poor rural households who benefit below the poverty line.

5.2.4 Forest-Based Income Equalizing Effects

The results presented in Table 4.20 shows the Gini coefficient index of decomposition on each of the household income sources. The results show the equalizing effects of forest-based income when it added when it is not added to total household income. Further, the results show forest ecosystem resources have the highest income equalizing effect as measured by the Gini coefficient index drop from 0.581 to 0.479. This shows that forest-based income has the highest income equalizing effect when compared to other regular income dependency strategies. The difference in the Gini coefficient shows the forest-based income to reduce household income inequality by approximately 17.56% (0.102/0.581). The analysis has also shown the second-highest effect of income inequality is by transfers income dependency which had a Gini coefficient drop from 0.508 to 0.457. This indicates the reduction of household income inequality by approximately 10.03% (-0.51/0.508). The overall household income inequality reduction was shown by the Gini coefficient indices drop from 0.578 to 0.472 when forest-based income was added to total household income. The combined equalizing effect of forest-based income on total household inequality is a reduction of aggregate income inequality by approximately 18.34% (0.106/0.578). These results disapprove of the hypothesis that was tested by the study that forest-based income as no income equalizing effect on the reduction of total household income. These results are in agreement with the findings by Babulo et al. (2008) and Fisher at al. (2004) that forest based-income when added to each

of the household income sources and when added to total household income reduces income inequality.

5.3 Study Applications for State-actor Policymakers

The results of this study are useful for state-actor policymakers in many ways. First, the results would provide sufficient knowledge on the need to enhance and support the performance of regular household on-farm production activities. The improvement of the performance of crop and livestock production will cushion the smallholder-household-peasant farmers from the vulnerabilities of climate-change-induced weather fluctuations. Equally, state-actor policy formulation will stem the current agricultural extensification which is a household poor land use management practice since it causes deforestation and degradation of forest ecosystem resources. In the place of current poor land use management practices, the state-actors should introduce agricultural intensification. This increases agricultural productivity by supporting agricultural extension services, for example, introducing agricultural value-chain production and marketing services.

The poor performance of regular household incomes causes a spiral effect in the rural economy. This is because the extensification of agriculture causes deforestation and degradation of forest ecosystem resources. These two forest resources phenomena are manifested by household poor land use management practices. This, in turn, compromises the health and integrity of forest ecosystem resources. This poverty cycle is thought to be the primary causes of dwindling quantities and qualities of forest products. Overall, these actions erode the poverty alleviating effects and income equalizing effects of the forest ecosystem resources.

Second, the policymakers should ensure that there is efficient conservation of forest ecosystem resources. This conservation should embed sustainable household livelihoods to efficient conservation of forest ecosystem resources. The improved conservation efficiency should stem from the persistent household inefficient allocation in the consumption of forest ecosystem resources. In addition, the new approach should make the consumers of forest resources bear the full cost of production of these resources. Also, the policymakers should ensure the forest ecosystem resources are included in the national income accounting and in the computation of national gross domestic product (GDP).

Thirdly, the state actors should provide coping strategies to cushion poor rural households against the vulnerabilities brought about by household exposure to climate-change-induced weather vagaries. The main thrust of the policy formulation is sufficient information that has bridge the existing knowledge gaps in the literature. The state-actor governance structures should ensure formulated policies address the rampant rural household phenomena. These include household monetary poverty due to increased daily expenses and dwindling income sources. These are caused by multidimensional poverty deprivations, for example, increased hunger and poor nutrition, poor shelters, lack of potable water and sanitation. All these shortcomings have been caused by poor rural economic development across the board.

. All these factors around the degradation of forest ecosystem resources are the factors that cause household poverty and income inequality. When the forest ecosystem can no longer be able to act as a safety net and insurance premium that cushions poor rural households from the risks and uncertainties resulting from income shortfalls.

These are critical issues that state-actors should handle and address diligently but the most important thing to do is to invest in agricultural extension services. These include intensification of agriculture and on-farm value chain strategies. This is important for it will improve the performance of on-farm income activities which account for over two-thirds of total household income.

The study applications to government policy and management of forest ecosystem resources have been highlighted. The implication of this study is to inform state-actor policy formulations to enhance the performance of forest ecosystem resources and on-farm regular income activities. Enhancing the two-income strategies is important for the alleviation of household poverty, reduction of income inequality and efficient conservation of forest ecosystem resources. The analysis of results shows state-actors must formulate policies that enhance the performance of forest ecosystem resources and on-farm income dependency strategies. This is because the poorest rural households in Eastern Mau exhibited the highest dependence on forest-based income dependency strategy. These households had the highest level of both poverty incidence and income inequality. This means state-actors must invest in both on-farm income dependency strategies and forest-based income to counter this.

As a result of this current study, the nexus of forest ecosystem resource conservation and sustainable household livelihoods influence the household choice of income dependence strategies. State-actors will invest in this win-win strategy because this study has highlighted our understanding of the extent of forest-based income on household livelihood improvement. The new knowledge and information from this study is not only critical for state-actor policymakers to formulate other policies and evaluate which

strategic policies to pursue, but it is also invaluable for understanding why most forest-fringe poor rural households in sub-Sahara Countries, like Kenya, could not find a pathway out of poverty even though they employ optimally the forest resources. State-actor policymakers will fill the existing gap in the literature on rural household dependency on forest-based income which they utilize to achieve household livelihood outcomes, mainly alleviation of poverty and income inequality.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this section, the conclusions of the research study have been presented in section 6.2. Equally, recommendations of the study are presented in section 6.3 and in section 6.4; the areas for further research have been presented.

6. 2 Study 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 shown to be 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 total household income is considered with and without forest-based income. Further, results show total household income when considered with forest-based income reduces household headcount index ($FGT_{(\alpha=0)}$) from 0.299 to 0.252. This means that the number of household 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%. Household headcount poverty index measures the incidence of poverty among the rural households.

Thirdly, the results of the study show 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 ($FGT_{(\alpha=2)}$) was used to measure forest-based income when it is considered with total household income. The FGT poverty severity was shown to drop from 0.071 to 0.066. This means the number of rural households facing severe poverty reduces from 7.1% to 6.6%. This translates to a household poverty severity reduction by 7.0%.

Finally, these findings are supported by theory and studies by (Barbier, 2010) which show 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 according to (Wunder, 2001) means that rural households who inefficiently allocate forest resources in consumption thus leading to forest resource undersupply and degradation.

6.2 Study Recommendations

The findings of this study will 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 incomes constitute the primary household income source by contributing 53% to total household income.

b) Secondly, state-actor governance structures and policies should embed sustainable rural household livelihoods sustainability 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 results have shown forest-based income to play a critical role of sustaining rural household livelihood outcomes by contributing 12% to total household income.

6.4 Further Research

Future research in this area should focus on longitudinal research in order to understand more about rural household sustainability on forest ecosystem resources. Equally, future research requires adequate funding and ample time in order to do an in-depth research study covering a bigger rural population.

In order to get the dynamics of rural sustainable household livelihood resources strategy, detailed information on the relationship between utilization of forest-based income across different household income quintiles and across household diversified income dependency strategy groups is required. This needs time and more coverage of the study area.

Future study should focus on at least 15 forest reserves out of the 21 forest reserves under KFS and one under the trust lands of Narok County Government. Such as study in future should illuminate our understanding on the factors that determine rural household dependence on forest-based income and the needed intervention mechanisms that will ensure efficient conservation and management of forest ecosystem resources in the entire Mau Hills Forest Complex ecosystem. This kind of study requires the use of panel data from relevant ministries. These ministries to be involved would include that or, Devolution, Economic Planning and Rural Development, Education and Health. The other ministries include line ministries of Environment and Natural resources, Wild life and Mining. Results from such a wide research area should be generalized to the greater Mau Hills Forest Complex.

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APPENDICES

Appendix I: Household Questionnaire Survey Instruments

Name of Village…… Name of Sub-location……Classification……
Sub-County.....
Question No. ……

1. Household-Head Characteristics
   a) What is your age bracket? Please indicate appropriately the age range as shown.
      (i) 18-30, (ii) 31-40 (iii) 51-65 (iv) 66-98
   b) What is your gender? Please indicate appropriately.
      (i (Male) (ii) (Female)
   c) What is your ethnic group? Please indicate appropriately.
      (i) (Kalenjin) (ii) Non-Kalenjin
   d) What is the highest education level attained? Please indicate appropriately.
      (i) Not attended any schooling) (ii) (Completed Primary School) (iii) Completed Secondary School) (iv) (Did Post-Secondary Courses)
   e) What is your highest professional Training? Please indicate appropriately.
      (i) (Vocational training) (ii) (Certificate Course) (iii) (Diploma Course) (iv) (completed College or University)

2. General Household Characteristics
   a) How many household members live with you? Please indicate appropriately as shown.
      (i) (1-4) (5-7) (ii) (8-10) (iii) (11 and above)
   b) How many children (below the age of 18 years) live with you in the household? Please indicate appropriately as shown.
   c) How many income earners are in the household? Please indicate appropriately as shown.
   d) (1-2) (ii) (3-4) (iii) (5-8)
   e) Do you have land you own and operate? If (yes) (no) Please indicate land size for:
      (i) Homestead (ii) Crops (iii) Livestock (iv) others
   f) Do you have land you operate but you don't own? (Yes) (No). If yes, please indicate land size for the following reasons.
      (i) Land owned and operating (ii) Land owned by not operating (leasing it out) (iii) Land hired from others because what I have is insufficient
   g) Do you own land and that you have left fallow? If yes indicate what purpose is it used for currently.
      (i) Fallow (ii) Grazing (iii) (iv) hired out
   h) What was your household net income by the end of June 2013? To be computed privately as per understanding with respondent. The amount is calculated per capita (KES, 000). To be computed separately and privately. The range is given as a range between:
      Less than 34 (ii) 35-55 (iii) 56-85 (iv) 86-100 (v) 101 and above

i) What was your net income distribution from various income sources (list supplied) for you to indicate by the end of June 2013 per capita (KES 000)? To be computed separately and privately. List income earnings against each activity as guided by a research assistant.

3. Household Income Earnings from Crop Cultivation

a) Did you engage in crop cultivation in the year ending June 2013? If yes, please indicate the crops cultivated from the list and indicate the amounts earned per capita for each in (KES 000).

b) Did you undertake any horticultural crop production? If yes, please list the different types of horticultural crops you cultivated during the period and the earnings per capita per for each in (KES 000).

c) Did you engage in the commercialization of your crop produce like value addition, for example, packaging or processing? Please the amounts per capita earned from this in (KES 000).

d) Did you use any crop inputs during the year for planting? If yes, please mark on the list provided and the quantities used in the year ended June 2013. The amount you used for this will be computed for you in (KES 000).

4. Livestock Income Earning Activities

a) Did you rear livestock during the just-ended year of June 2013? If yes indicate by marking on the list of livestock provided.

b) Did you rear cattle during the year ended June 2013? If yes indicate by marking on the list of cattle provided.

c) What type of other livestock did you keep in the period? If yes indicate by marking on the list of other livestock provided.

d) Did you get to engage in the commercialization of livestock during the period? If yes indicate by marking the livestock commercialization activities provided.

5. Rural household Geographic Characteristics

a) Which of the two administrative sub-counties do you come from?
(i) (Molo) (ii) (Njoro)

b) Do you live in urban townships or in rural areas away from urban centres?
(i) (Urban) (ii) (Rural)

c) Which of the six sub-locations do you come from? Please indicate on the list of six provided.

6. Household Income Earnings Distribution

a) What were your total net income earnings per capita in the year ended June 2013? Please indicate the amount in KES (000). Please use the list of income dependency strategies provided.

b) What type of forest ecosystem resources did you extract for your subsistence self-consumption and for sell? Please indicate in (KES 000) the amounts against the list of forest products provided for your guidance.

c) How many times do you harvest the forest products: (a) every day (b) weekly (c) monthly (d) seasonally (e) yearly. Please indicate the frequency of harvest against the list of forest products provided.
d) What is the most common product that you harvest from the forest on a daily basis or weekly basis? Pick the forest products from the list of food and non-food forest products.

7. Household Land Holdings in hectares (ha) or in %
   a) What is the land area under the homestead?
   b) What is the household farm size?
   c) What size of the land is under crop cultivation?
   d) What size of the land is under horticultural crops?
   e) What size of the land is under irrigation (%)?
   f) Do you have the land area under beekeeping or fish ponds?
   g) Do you own land or you are landless? (Yes) (No)

8. Household Physical Assets, Financial and Social Capital
   a) What is the size of your livestock herd? Please list all the livestock and give the numbers
   b) Do you own any agricultural productive equipment? (Yes) (No)
   c) Do you access any credit facility for farm inputs and land preparation? If yes indicate the amounts in (KES 000).
   d) Do you have any savings from all total income earnings? If yes, indicate the amount of savings in (KES 000).
   e) Do you belong to any social networks? If yes indicate whether you are a member of more than one social grouping.

9. Contextual factors affecting rural household income dependency strategies.
   a) Have you been affected by climate-change-induced disasters like floods and drought? What was the financial shock you experienced? Choose from the list provided for ease of reporting. Other types of shocks may be listed in addition to the one provided in the year ended June 2013.
   b) How did you recover from the shocks? Please the ways in which the respondent recovered from shocks.
   c) If you have not recovered from shocks, indicate what needs to be done for you to fully recover.
   d) How far (in kilometers) do you travel to reach all-weather roads? What are your ideas on the impassable roads in the rural economy? Please list.

10. What is the monetary value (in KES) of the total value of forest products that you consumed in the past year ended June 2013?

11. Please list the forest ecosystem goods and products and the amounts consumed in quantities or amounts in KES.

Appendix II: Gender of Household-Head

Gender	Poorest	2nd Poorest	Middle	2nd Richest	Richest	Total
Female	19	18	18	14	12	81
	(23.5)	(17.0)	(19.1)	(18.4)	(12.9)	(18.0)
Male	62	88	76	62	81	369
	(76.5)	(83.0)	(80.9)	(81.6)	(87.1)	(82.0)
Total	81	106	94	76	93	450
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Survey Data 2013

Appendix III: Distribution of Rural Household Income Earnings

Cluster	Household income dependency strategy group	Household Numbers	Percentage
1	On-farm income dependency	290	64.40
2	Off-farm income dependency	46	10.20
3	Mixed-income dependency	35	7.79
4	Transfers income dependency	25	5.55
5	Forest-based income dependency	54	12.06
	Total	450	100

Source: Survey Data 2013

Appendix IV: Household General Education Level

General Education	On-Farm Dependency	Off-Farm Dependency	Mixed-Income Dependency	Transfers Dependency	Forest-Based Income Dependency	Total Sample
Cannot read and write	2.56	6.31	9.69	10.32	29.95	14.68
Primary	1.51	22.82	20.92	22.62	24.96	22.58
Secondary	48.06	53.28	48.98	46.23	3.61	44.35
Post-Secondary	22.82	29.16	20.41	20.83	9.0	18.38
Total	100	100	100	100	100	100

Source: Survey Data 2013

Appendix V: Highest Household Professional Training

Highest Education Level Attained	Wage Dependency	Non-farm Non-wage Dependency	Mixed-income Dependency	Transfers/remittances Dependency	Forest-Based Dependency	Total Sample
No diploma	67.94	74.38	79.33	83.87	92.75	80.22
Short Term Vocational Training	19.97	15.43	11.54	5.73	5.21	11.76
Long Term Vocational Training	2.03	3.86	2.88	1.79	0.49	1.70
Professional Course	4.87	4.13	3.85	5.56	1.06	3.54
College/University	5.19	2.20	2.40	3.05	0.49	2.79
Total	100	100	100	100	100	100

Source: Survey Data 2013

Appendix VI: Rural Household Social Networks

Household Capital	Household Income Dependency Strategy Groups						
	On-Farm Income Dependency	Off-farm Income Dependency	Mixed-Income Dependency	Transfers Dependency	Forest-Based Income Dependency	Total	Statistical test
Community Forest Association (CFA)							
No	46.74	33.27	35.59	62.23	52.30	46.01	$\chi^2(4)=$
Yes	53.26	66.73	64.41	37.76	47.70	53.98	23.68***
Total	100	100	100	100	100	100	
Kenya Farmers Association (KFA)							
No	39.48	35.77	46.20	59.70	66.90	49.61	$\chi^2(4)=$
Yes	60.52	64.23	53.80	40.30	33.10	50.39	193.58***
Total	100	100	100	100	100	100	
Community Self-Help Groups (CSHG)							
No	76.24	76.60	65.36	46.26	82.40	62.82	$\chi^2(4)=$
Yes	23.76	23.40	34.64	53.74	17.60	37.18	236.47***
Total	100	100	100	100	100	100	

Source; Survey Data 2013

Appendix VII: Shock Experiences and Extent of Recovery from Shocks

Shock Experience	Household Diversified Income Dependency Strategy Group						
	On-Farm Income Dependency	Off-Farm Income Dependency	Mixed-Income Dependency	Transfers income Dependency	Forest-Based Dependency	Total Sample	Statistical test
Types of Shocks							
Natural shocks	23.77	22.64	14.92	21.24	31.05	22.72	χ^2=(64) =333.28***
Biological shocks	52.76	49.68	47.68	56.99	42.25	49.87	
Socio-economic shocks	23.47	27.68	37.40	21.77	26.70	27.41	
Total	100	100	100	100	100	100	
The extent of Recovery from Shock							
Completely	4.06	46.81	34.31	36.19	31.13	35.56	
Partly recovered	42.41	30.85	47.45	46.21	4.56	43.96	
Still suffering badly	16.99	22.34	18.25	1.76	23.27	20.49	χ^2 =(8) =41.47***
Total	100	100	100	100	100	100	

Source: Survey Data 2013

Appendix VIII: Assessing Multicollinearity using Variance Inflation Factors (VIF)

Variables	VIF	1/VIF
HH_SIZE	2.15	0.466108
HH_WORK_AGE	1.96	0.511188
HH_ETHNICITY	1.63	0.612306
IRR-LAND	1.31	0.761583
DIS_ACCESS_ROAD	1.16	0.860544
UNEX_SHOCK	1.16	0.861839
HH_AGE	1.14	0.874013
HH-GENDER	1.14	0.878737
PROD_AGRI_EQUIP	1.14	0.879696
HH-EDU_LEVEL	1.08	0.923188
AGRI_LAND_OWNED	1.07	0.931858
HH_LOAN	1.07	0.933879
HH-LIVES_HERD	1.07	0.934041
SOCIO_NETWORK	1.04	0.966059
HH_SAVING	1.02	0.976153
Mean VIF	1.28	

Source: Survey Data 2013

Appendix IX: Percentage of Rural Households Owning Land

Ownership of Land	On-farm income Dependency	Off-farm income Dependency	Mixed-income Dependency	Transfers income Dependency	Forest-Based Income Dependency	Total Sample
Yes	74.07	79.09	72.87	76.83	48.84	64.02
No	25.93	20.91	27.13	23.17	51.96	35.98
Total	100	100	100	100	100	100

Source: Survey Data 2013

Appendix X: Population Statistics in the Sampled Sub-Locations

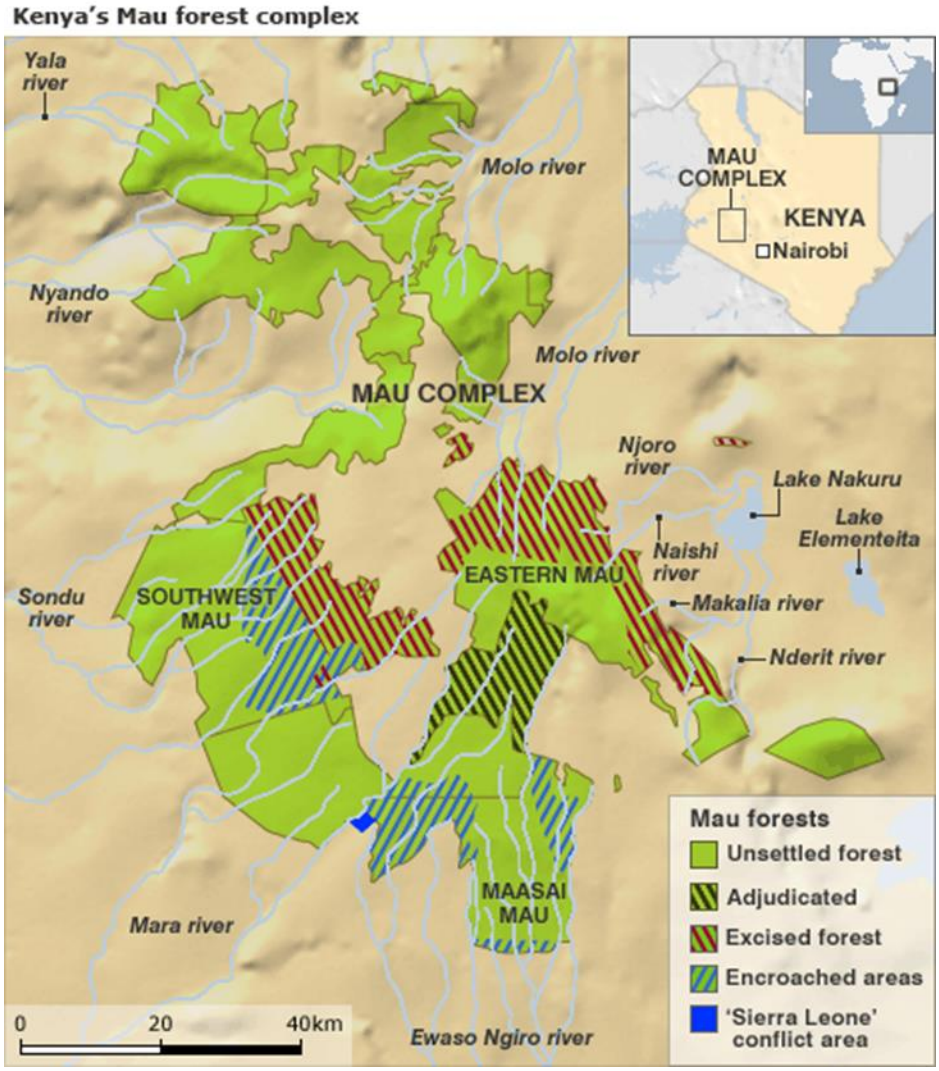
Molo Sub-County						
Sub-Locations	Male	Female	Total	Households	Land Area (Km^2)	Population Density
Kiptunga	2,147	1,859	4,006	904	149.33	27
Kitiro	2,496	2,245	4,741	959	44.56	106
Ndoswa	1,976	1,731	3,707	767	51.76	72
Njoro Sub-County						
Sub-Locations	Male	Female	Total	Households	Land Area (Km^2)	Population Density
Misepei	1,019	967	1,986	394	17.72	112
Nessuit	3,687	3,585	7,272	1,469	43.59	167
Sigotik	2,223	2,007	4,230	881	13.86	305

Source: Kenya Population Census of 1999 (KNBS, 2010)

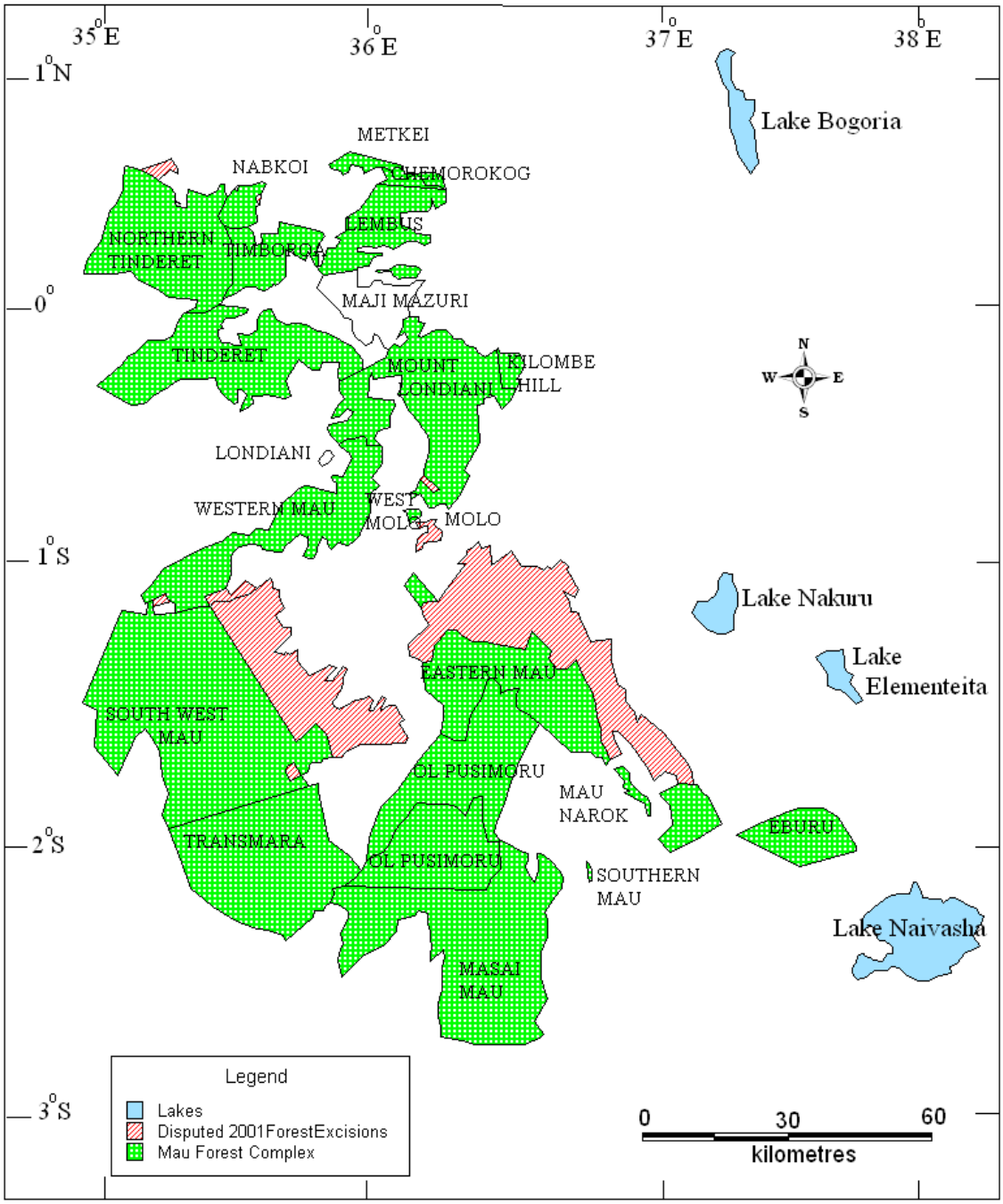
Appendix XI: Summary of Population Statistics of Molo and Njoro Sub-Counties

Location/Sub-Location	Male	Female	Total	Households	Area Km^2	Pop Density
MOLO SUB-COUNTY						
Molo Location	17,026	17,960	34,986	9,309	30.5	1,147
Molo Town	15,702	16,613	32,315	8,664	22.72	1,423
Matumaini	1,324	1,347	2,671	645	7.79	343
Sachangwan Location	4,104	4,008	8,112	1,851	27.68	293
Sachangwan	1,458	1,400	2,858	636	10.17	281
Kabianga	2,646	2,608	5,254	1,215	17.51	300
Turi Location	12,577	12,871	25,448	6,013	77.8	327
Kiambiriria	3,982	4,169	8,151	1,850	24.88	328
Turi	8,595	8,702	17,297	4,163	52.93	327
Elburgon Location	21,928	21,510	43,438	10,980	97.1	447
Elburgon	16,581	16,073	32,654	8,548	53.54	610
Mutamaiyu	1,272	1,328	2,600	606	15.02	173
Arimi	4,075	4,109	8,184	1,826	28.53	287
Mariashoni Location	6,619	5,835	12,454	2,630	245.64	51
Kiptunga	2,147	1,859	4,006	904	149.33	27
Kitiro	2,496	2,245	4,741	959	44.56	106
Ndoswa	1,976	1,731	3,707	767	51.76	72
NJORO SUB-COUNTY						
Nessuit Location	6,929	6,559	13,488	2,744	75.17	179
Misepei	1,019	967	1,986	394	17.72	112
Nessuit	3,687	3,585	7,272	1,469	43.59	167
Sigotik	2,223	2,007	4,230	881	13.86	305
Njoro Location	25,150	25,600	50,750	13,048	109.6	463
Mukungugu	5,559	5,521	11,080	2,899	19.57	566
Njoro	19,591	20,079	39,670	10,149	90.03	441
Bagaria Location	3,877	4,236	8,113	1,901	40.54	200
Bagaria	2,670	2,926	5,596	1,319	23.23	241
Kapyemit	723	786	1,509	355	8.66	174
Milimani	484	524	1,008	227	8.65	117
Gichobo Location	2,980	3,159	6,139	1,418	23.41	262
Gichobo	1,374	1,435	2,809	661	10.99	255
Sinendet	1,606	1,724	3,330	757	12.41	268
Lare Location	4,767	5,018	9,785	2,255	35.48	276
Lare	3,152	3,407	6,559	1,567	26.03	252
Ndulele	1,615	1,611	3,226	688	9.45	341
Naishi Location	2,875	2,909	5,784	1,258	39.71	146
Naishi	1,887	1,959	3,846	801	26.35	146
Pwani	988	950	1,938	457	13.36	145
Kapkembu Location	2,995	2,930	5,925	1,177	23.72	250
Chebitet	1,525	1,541	3,066	632	12.2	251
Kapkembu	1,470	1,389	2,859	545	11.52	248
Teret Location	3,791	3,636	7,427	1,417	71.77	103
Lelechenet	2,003	1,872	3,875	738	26.53	146
Teret	1,788	1,764	3,552	679	45.24	79
Tuiyotich Location	3,579	3,520	7,099	1,501	22.97	309
Loitepes	2,352	2,369	4,721	972	17.6	268
Siriat	1,227	1,151	2,378	529	5.37	443
Mauche Location	2,332	2,305	4,637	899	40.81	114
Mauche	1,424	1,394	2,818	563	10.63	265
Tachasis	908	911	1,819	336	30.18	60
Mau Narok Location	17,534	17,895	35,429	8,726	159.29	222
Kianjoya	2,232	2,398	4,630	1,088	17.88	259
Siapei	15,302	15,497	30,799	7,638	141.41	218
Kiptulel	4,529	4,427	8,956	1,753	25.21	355
Lusiru	1,858	2,096	3,954	909	12.78	310

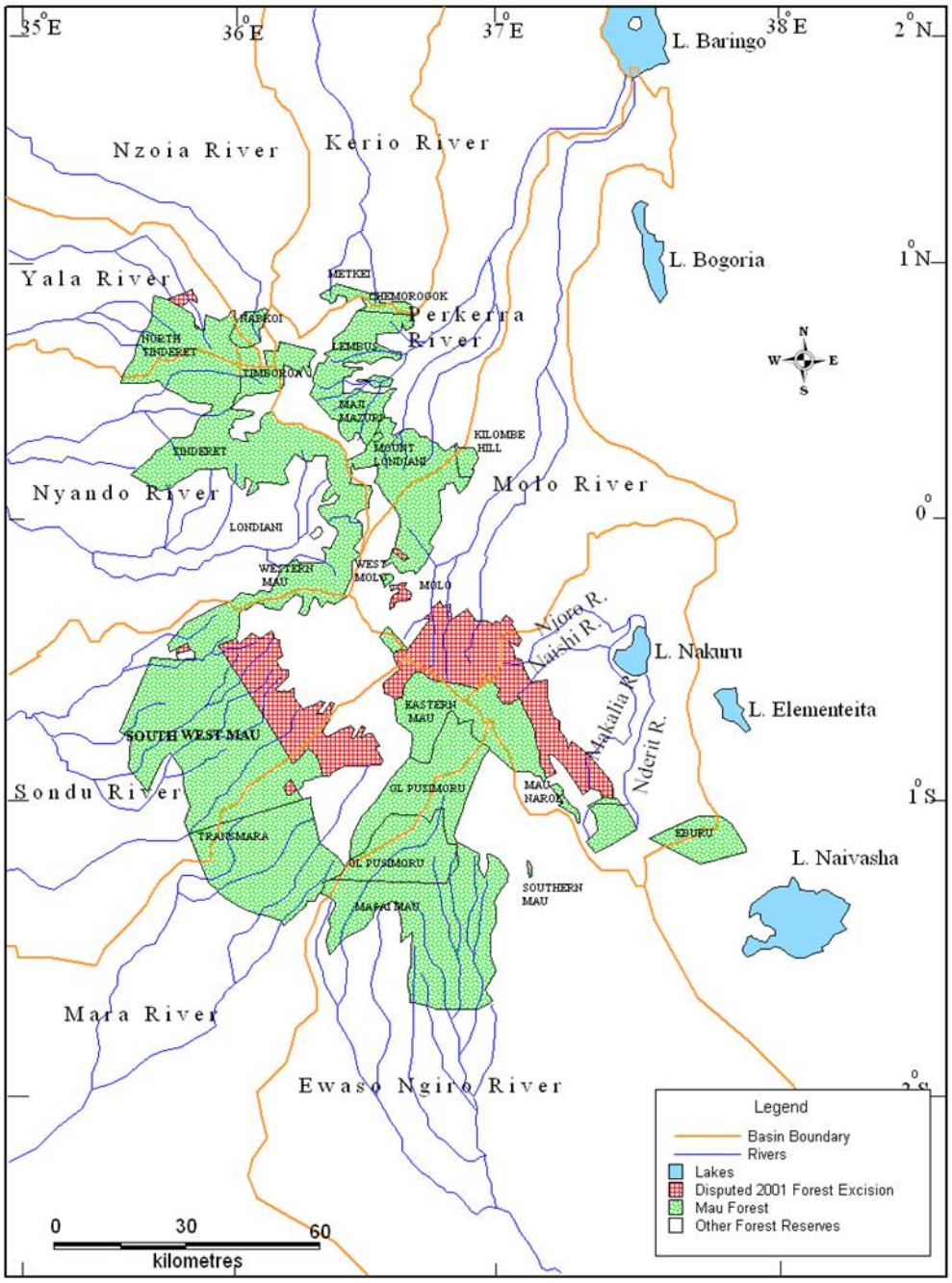
Source: Kenya Population Census of 1999 (KNBS, 2010)



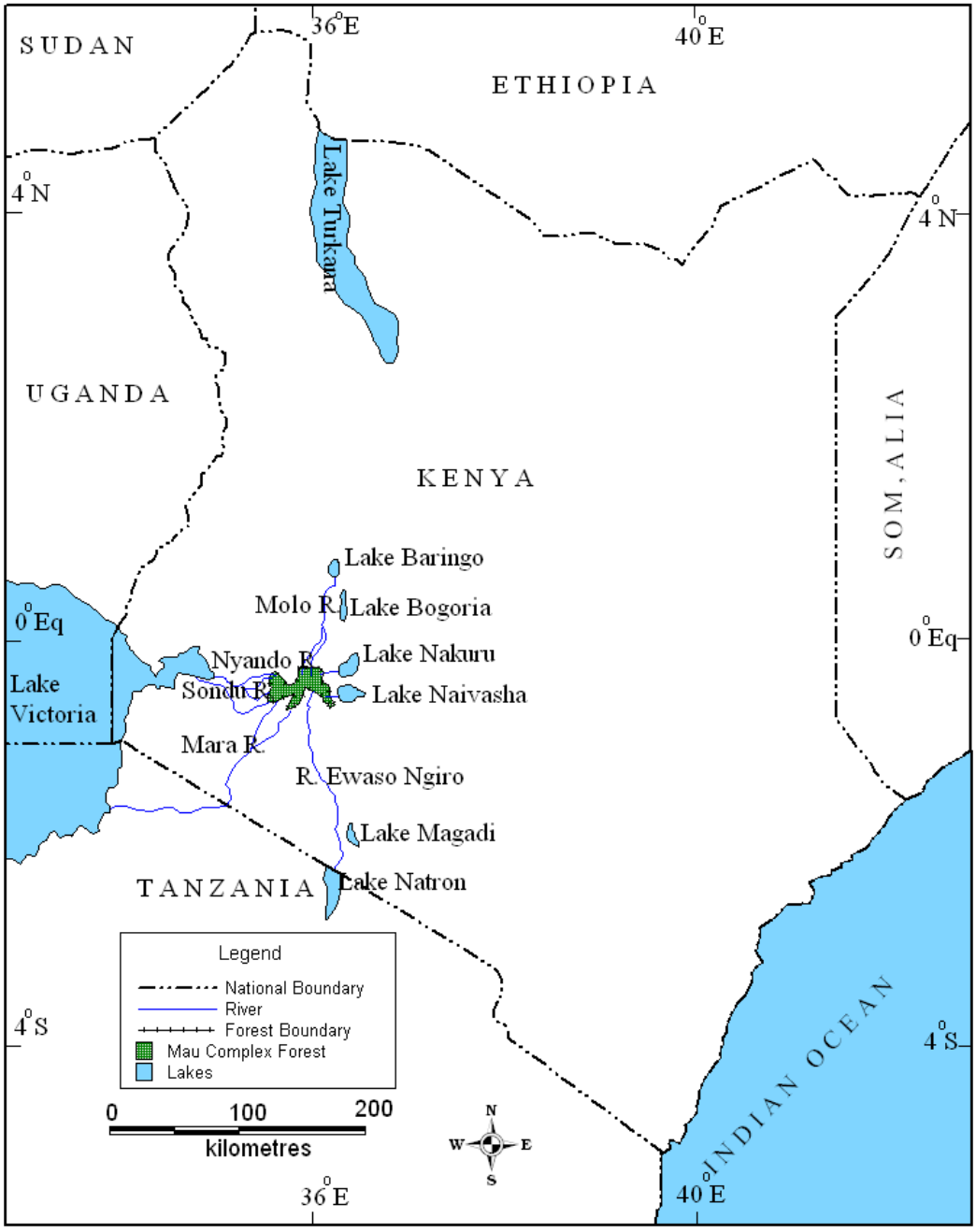
Appendix XII: Map of Mau Hills Forest Complex Showing Status of Forest Cover



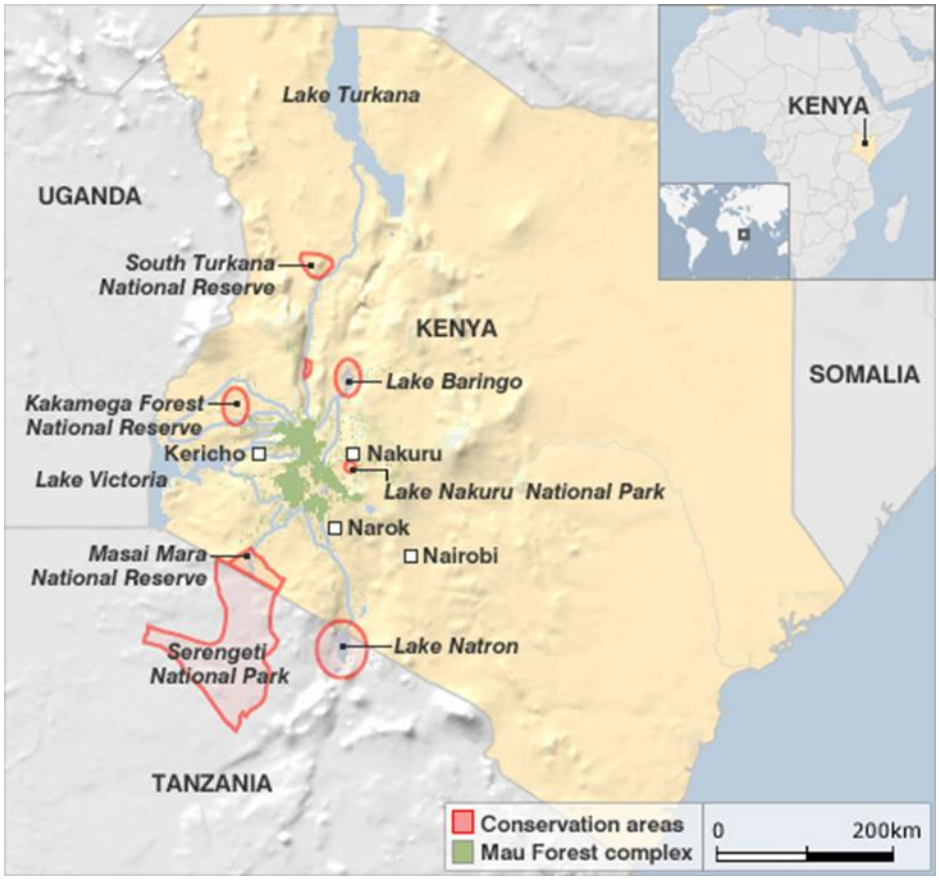
Appendix XIII: Map of Mau Hills Forest Complex Showing Location of Eastern Mau



Appendix XIV: Map of Mau Hills Forest Complex Showing River Sources



Appendix XV: Map of Mau Hills Forest Complex showing Lakes and Rivers



Appendix XVI: Map of Kenya Showing National Parks and Game Reserves

MOI UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR
RESEARCH AND EXTENSION

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Eldoret - 30100
Kenya

Ref No. **MU/DVC/REP/27B....** **Date: 15th August, 2010**

TO WHOM IT MAY CONCERN

RE: AUTHORITY TO UNDERTAKE RESEACH – SAM KOGGO KIPKEMBOI S. KOTTUTT

Mr. Sam Koggo Kipkemboi S. Kottutt is a student at Moi University, School of Environmental Studies. He is currently undertaking a Doctor of Philosophy (Ph.D.) in Environmental Economics. He has applied for authority to carry out her research in Eastern Mau Forest Reserve in the greater Molo, District, Kenya.

The purpose of this letter is to request you to accord him all the support as he conducts his research on the topic: *"How Socio-economic Incentive Mechanisms Influences Biodiversity Conservation in Kenya"*. By a copy of this letter, authority is hereby granted for him to conduct the said research.

After the completion of the research, a complete report in both hard and soft copy shall be submitted to the office of Deputy Vice-Chancellor, Research & Extension.

Any assistance accorded to him will be highly appreciated.

Yours faithfully,

PROF. B. E. L. WISHITEMI
DEPUTY VICE-CHANCELLOR
RESEARCH & EXTENSION

SKKkm

Cc: Mr. Sam Koggo Kipkemboi S. Kottutt

Appendix XVII: Letter of Approval to Collect Primary Data in Molo and Njoro

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P.O. Box 3900
Eldoret - 30100
Kenya

MU/DVC/REP/27B **10th March, 2011**

TO WHOM IT MAY CONCERN

RE: PERMISSION TO CARRY OUT RESEARCH – KOGGO SAMMY KIPKEMBOI S. KOTTUTT

The above subject matter refers.

Mr. S.K.K.Kottutt is an employee of Moi University. He is currently pursuing a Ph.D. as a student at University of Eldoret. His research will lead to a Doctor of Philosophy degree from the Department of Environmental Economics, School of Environmental Studies.

Mr. Kottutt has applied for authority to conduct research in several institutions in Kenya. He will administer questionnaires to respondents from: Kenya Wildlife Service (KWS), Kenya Forest Service (KFS), National Water Resources Management Authority (WARMA), National Environmental Management Authority (NEMA), Brookbond Liebig, Oserian Flowers, National Irrigation Board (NIB), and Sondu–Miriu (KENGEN) among others.

The purpose of this letter is to request you to accord him all the necessary support as he conducts his research on the topic: *"The Influence of Stakeholder Incentive Mechanisms on Ecosystem Conservation in the Mau Forest Complex, Kenya"*. By copy of this letter, authority is hereby granted to him to conduct the said research.

After the completion of the research, a complete report in both hard and soft copy shall be submitted by him to the office of Deputy Vice-Chancellor, Academics, Research & *Extension.*

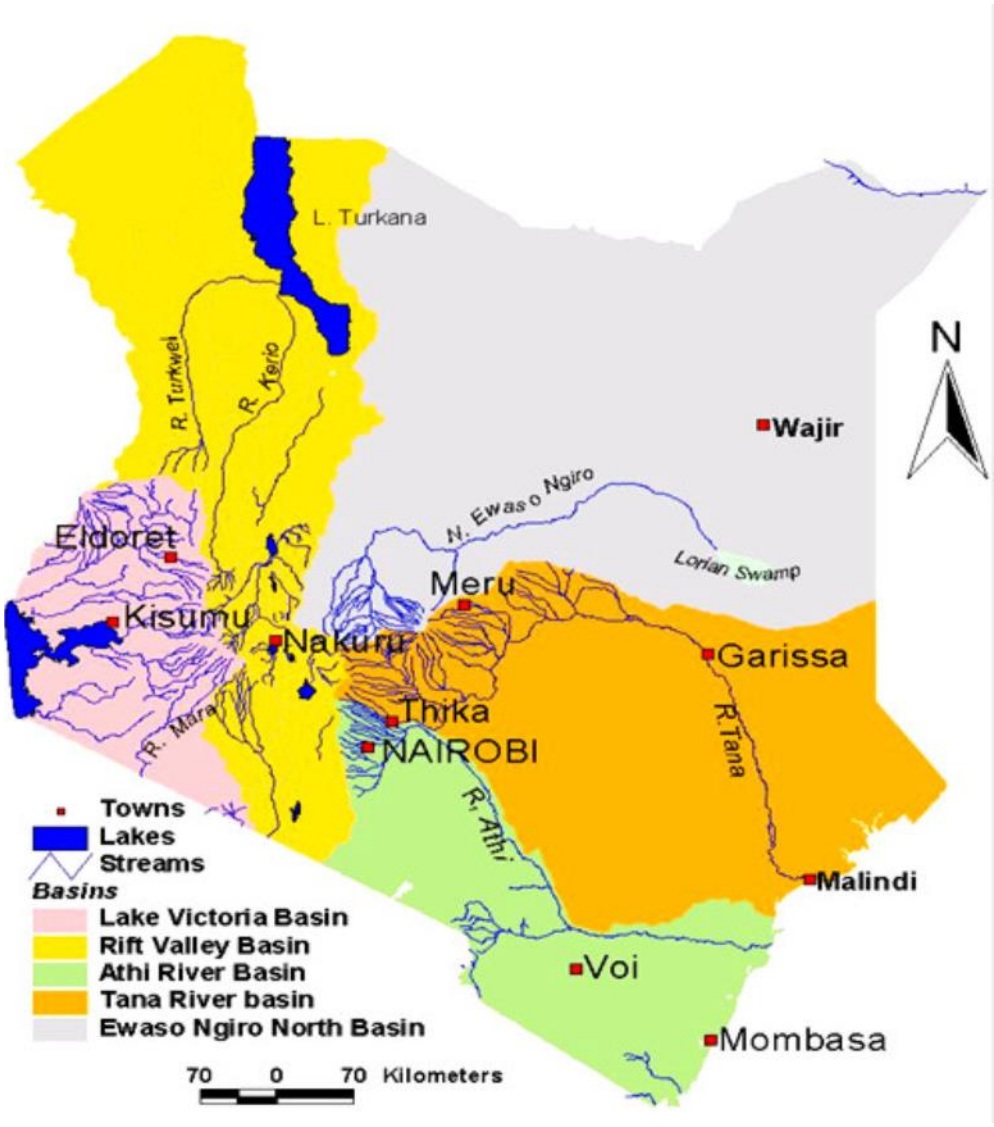
Any assistance accorded to him will be highly appreciated.

Thanking you in advance.

Yours faithfully,

PROF. B. E. L. WISHITEMI
DEPUTY VICE-CHANCELLOR,
ACADEMICS, RESEARCH &EXTENSION

Appendix XVIII: Letter of Approval to Collect Secondary Data



Appendix XVII: Map of Kenya Showing Five River Basins

Appendix XVIII: Similarity Index/Anti-Plagiarism Report

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