RURAL LIVELIHOOD CHOICES IMPACT ON ENVIRONMENTAL DEGRADATION IN KIENI EAST AND KIENI WEST SUB - COUNTIES, KENYA

FRED KHISA WAMALWA

DOCTOR OF PHILOSOPHY

(Development Studies)

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

2019

Rural Livelihood Choices Impact on Environmental Degradation in Kieni East and Kieni West Sub - counties, Kenya

Fred Khisa Wamalwa

A Thesis Submitted in Partial Fulfillment for the Degree of Doctor of Philosophy in Development Studies in the Jomo Kenyatta University of Agriculture and Technology

2019

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

Signature:……..Date:……..

Fred Khisa Wamalwa

This thesis has been submitted for examination with our approval as University Supervisors.

Signature:……..Date:……..

Dr. Florence Ondieki – Mwaura, PhD

JKUAT, Kenya.

Signature:……..Date:……..

Dr. Fredrick Ouma Ayuke, PhD

University of Nairobi, Kenya.

DEDICATION

To Almighty God, my father James Wamalwa and my wife, Linet Khisa for their encouragement and support during the entire duration of this work. Also to the treasured memory of my mother Cecelia, daughter Sheila, and my children; Ivy, Faith, and Mercy to whom this work will serve as an inspiration.

ACKNOWLEDGEMENT

Many people have contributed to the completion of this work. Since the journey has been long, it is difficult to list all of them on this page. This thesis could not have been completed without the interest and support from my supervisory team. I am deeply indebted to my first supervisor, Dr. Florence Ondieki-Mwaura, for her guidance and encouragement throughout my studies. I am grateful to her for the freedom and independence she gave me in my research. I am equally indebted to my second supervisor and co-mentor, Dr. Frederick Ouma Ayuke, who put in many hours to ensure the completion of this thesis. Both Dr. Ondieki and Dr. Ayuke worked flexibly, allowing for meetings as was necessary and possible at their offices. They liberally shared their personal library with me and held many fruitful discussions, including telephone conversations in Nairobi and in the field in Nyeri. These gave me invaluable guidance for my field data collection. I also wish to thank the other members of the graduate committee, Professors Lawrence Njoroge and Maurice M. Sakwa. Your contributions, comments and insight were of great value to me. My thanks go to the Dean, Prof. Hellen Kinoti Mberia and the Principal, Prof. Elegwa Mukulu of COHERD. Many thanks too to Prof. Sakwa who chairs the Department of Development Studies for providing administrative support for the completion of this thesis. I also thank seminar participants at JKUAT for their comments on aspects of this work at different times.

I am very grateful to all the rural households in Kieni East and Kieni West who willingly and humbly spared their time and energy to provide the required information. Many thanks to all my Research Assistants who endured the hard work of walking to all sampled households and assisted me in the house-to-house questionnaire survey. The survey would have been impossible without the assistance of these devoted enumerators.

I am grateful to NACOSTI for granting the requisite permit to conduct this research. I am indebted too to the Nyeri County Commissioner's office for welcoming me to conduct research in the County. I am very thankful to the officers in Kieni East and Kieni West sub-county offices. The Deputy County Commissioners, Messrs T. Mburugu

and J. Chacha were helpful by introducing me to relevant government officers as key informant interviewees, permitting me to carry out the research in their areas, and accessing the sub-county office records. In this regard I am grateful to Assistant County Commissioners Mr. Simon Kimani and Ms. Lydia Kithinji, and Ms. Fatuma Sirai and Samuel Katiuki of Kieni East and West subcounties, respectively, and the respective field officers. I thank the offices of the location administration led by the Area Chiefs Paul (Naromoru location), Daniel (Kamburaini), John (Gathima), Simon (Kabaru) and Lazaras (Lusoi) in Kieni East; and John (Labura location), Richard (Endarasha), Francis (Mweiga), Lawrence (Gatarakwa), Francis (Mweiga), John (Labura) and Richard (Endarasha) in Kieni West, for their assistance in identifying qualified local Research Assistants and making practical arrangements for my field work. Others were Assistant Chiefs in charge of sampled sub-locations Kariuki (Gathiuru), Gladys (Ndiriti), Micheal (Kamburaini), Dominic (Gathiuru), Beatrice (Kirima), Lazaras (Thungari), Joseph (Labura), Francis (Gakanga), Peter (Bondeni), Julia (Kamatongu) and Lydia (Embaringo), who were instrumental during the household sampling process for the survey.

Finally, my utmost thanks go to my family. I thank my parents for their resolve to send me to school in the 1970's. I hope I have lived their dream, and so to you Mum (deceased) and Dad – Cecelia and James – a big thank you. I would particularly too like to thank my wife, Linet who, during my long absence in the field and/or writing, shouldered all the family responsibilities alone, and my children Ivy, Sheila (deceased), Faith and Mercy, without whose patience and love, pursuing my studies would have been impossible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

ADB	African Development Bank
ASALs	Arid and Semi-Arid Lands
COHRED	College of Human Resources Development
DFID	Department for International Development
EU	European Union
FAO	Food and Agriculture Organization
FGDs	Focused Group Discussions
GIS	Geographical Information Systems
GoK	Government of Kenya
HDI	Human Development Index
HH	Household Head
IDI	International Development Institute
IFAD	International Fund for Agricultural Development
IIED	International Institute for Environment and Development
ILO	International Labour Organization
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KFS	Kenya Forest Service
KIPPRA	Kenya Institute of Public Policy and Research Analysis
KNBS	Kenya National Bureau of Statistics
MDGs	Millennium Development Goals
MoA&LD	Ministry of Agriculture & Livestock Development
MoE&F	Ministry of Environment and Forests
NACOSTI	National Commission on Science, Technology and Innovation
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NR	Natural Resources
NRM	Natural Resources Management
ODI	Oversees Development Institute

PPP	Public Private Partnership
PSRST	Proportionate Stratified Random Sampling Technique
RoK	Republic of Kenya
SDG	Sustainable Development Goal
se	Standard error
US$	United States Dollars
SHG	Self-Help Group
SL	Sustainable Livelihoods
SLA	Sustainable Livelihood Approach
TLU	Tropical Livestock Unit
T&V	Training and Visit
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNDP	United Nations Development Programme
UK	United Kingdom
VIF	Variance Inflation Factor

DEFINITION OF KEY TERMS

Cropping activities These are activities households carry out on their farms and in the forests for a living. According to Winters et al. (2006), households expand cropping activities in order to meet market demand and food security. For purposes of this research these included growing crops for subsistence and commercial purposes.

Deforestation Deforestation is the removal of a forest or stand of trees from land which is then converted to a non-forest use. This can involve conversion of forest land to farms, ranches or urban use (Bradford, 2015). As was demonstrated in this study, it occurs for several reasons: trees can be cut down to be used for building or sold as fuel (sometimes in the form of charcoal or timber), while cleared land can be used as pasture for livestock and plantation. The removal of trees without sufficient reforestation may thus result in biodiversity loss.

Environmental degradation Environmental degradation is the deterioration of the natural environment through human activities and natural disasters, leading to the exhaustion of the natural resources like land, air, water, soil, and so forth. According to Chertow (2001), it is caused by the combination of an increasing human population and economic growth, and the application of resource depleting and polluting technology. In this study, household livelihood activities as part of human activities were investigated in terms of their impact on deforestation, water scarcity and soil erosion in the area.

Extension services According to Anderson & Feder (2003), extension services comprise the entire set of organisations that support and facilitate people to solve problems and to obtain information, skills and technologies to improve their livelihoods. In this study, the moderating role of extension services between household assets and livelihood choices to improve living standards and environmental conservation was investigated.

Forest activities These are activities households carry out in the forests for a living through, for example, earning an income (Velded et al., 2007). For purposes of this research, these included farming, grazing and logging, among other activities carried out in the forests.

Household Household in the context of livelihood studies is defined in different ways by scholars. It generally consists of one or more people who live in the same dwelling and also share meals or living accommodation, and may consist of a single family or some other grouping of people **(**Havilland, 2003). In this study, a household was the centre of data collection and analysis.

Livelihood A livelihood comprises of assets, the activities and access to these that together determine the living gained by the individual or households (FAO, 2003; Ellis, 2000). The choice of a livelihood activity that a household pursues is dependent on the socio-economic characteristics of the household including the assets which its members have at their disposal (Jianchu et al., 2005).

Livelihood activity A livelihood activity is a specific use of a combination of various assets (Barrett et al., 2001). Based on access to a particular set of assets for a given period, the household may choose which activities it will employ and the intensity of involvement in that activity. For purposes of this research, livelihood activities were actions taken by the household to earn a living. They involved the use of a single asset or a set of assets. Agricultural production, for example, may use natural capital in the form of land and water, human capital, physical capital such as road infrastructure, financial capital for the purchase of inputs and social capital in the form of labour assistance by community members. Alternatively, non-farm wage employment may only use human capital. The intensity of an activity depends on the degree to which assets are used as was demonstrated in this study.

Livelihood asset Livelihood assets refer to the resource base of people (FAO & ILO, 2009). They are stocks that can be utilised directly or indirectly to generate the means of survival of the household or to sustain its material well-being at different levels above survival. In this study, these consisted the following:

i) *Human capital* – the labour available to the household: its education, skills and health.
ii) *Physical capital* – includes rural infrastructure such as roads, piped water and electricity.
iii) *Financial capital* – the stock of money or income to which the household has access or savings.
iv) *Natural capital* – for example land, water and biological resources.

v) *Social capital* – community and wider social claims on which the households can draw by virtue of their belonging to social groups.

Livestock activities Include activities households engage in to earn a living through livestock keeping. For example, Steinfeld et al. (2006a) and FAO (2009) reported that the main motivation of households to keep livestock was increasing household income and changing food preferences, respectively. For purposes of this research, livestock activities include keeping cattle, poultry, donkeys, sheep and goats, among others.

Soil erosion Soil erosion is the displacement of the upper layer of soil and is one form of soil degradation (Appolo et al., 2018). It is caused by the dynamic activity of erosive agents like water, air/wind, plants, animals and humans. In accordance with these agents, erosion may be divided into water erosion, wind erosion and anthropogenic erosion. This study was interested in human activities that cause erosion including overgrazing, over cultivation, forest clearing and mechanized farming, among others.

Water scarcity Water scarcity occurs when demand for freshwater exceeds supply in a specified domain, that is, an excess of water demand over available supply (FAO, 2012). Water scarcity is both a relative and dynamic concept, and can occur at any level of supply or demand, but it is also a social construct: its causes are all related to human interference with the water cycle. It varies over time as a result of natural hydrological variability, but varies even more so as a

function of prevailing economic policy, planning and management approaches. Scarcity can be expected to intensify with most forms of economic development. However, if correctly identified, many of its causes can be predicted, avoided or mitigated, as founded in this study.

Off-farm activities These are activities carried out off household farms to earn a living through income for the survival of the household. Households engage in non-farm activities because of the inability of agriculture alone to continue sustaining livelihoods (Bacho, 2004). For purposes of this research, these included employment (formal or informal), forest-based activities and small business ventures, among others.

ABSTRACT

Poverty continues to pose livelihood challenges hence environmental problems among rural populations in semi and arid communities. One of the most understated impacts of livelihood activities on human wellbeing is their implication on environmental degradation. Most studies regarding poverty and the environment overlook implications of rural livelihood choices in marginal areas on the environment, and how organizations and institutions intervene to save or augment the problem. The purpose of this study was to investigate the socio-economic profile of respondents, how livelihood activities are chosen based on household assets and their impact on environmental degradation in Kieni East and Kieni West sub-counties of Nyeri County. Also examined in this study was the moderating effect of rural extension services on livelihood choices in the study area. The study adopted a cross-sectional research design. The main source of quantitative data was household survey while qualitative data was collected mainly using semi-structured interviews, participant observations and desk reviews. Proportionate stratified random sampling technique was used to establish a 400-household sample size in 10 sub-locations. Data was analyzed using descriptive and econometric modelling techniques. Socio-economic data was analyzed using statistical descriptive techniques. An independent T-Test was carried out to test statistical significance at $p<0.05$. Data with quantifiable factors was subjected to log-linear and hierarchical multiple regression analyses. Qualitative data was analyzed using grounded theory, discourse and narrative analyses. Results show that the proportion of female-headed households and single-headed households was 23% and 36%, respectively. Illiteracy level for household heads was 11% with an average age of 55 years, who had lived in their present land holding for an average of 28 years. The average family size was four members with an adult labour force (19–59 years) of 57%. Study results further showed that the main household livelihood choices included cropping activities [CA] (77% of respondents), off-farm activities [OA] (61%), forest activities [FA] (49%), and livestock activities [LA] (40%). Findings indicate that all household livelihood activities are influenced by household assets. However, the type and extent of influence on the choices was distinct for the different household assets. Out of the five household assets, only education and household income had significant influence on all the four livelihood choices. Education had the strongest influence on forest activities [$\lambda = 0.470$] and household income on livestock activities [$\lambda = 0.200$] at $p<0.05$. Findings further indicated that livelihood activities in the study area contribute to environmental degradation, manifested in three common phenomena, that is, water scarcity, deforestation and soil erosion. Pooled results showed that all livelihood activities cause overall environmental degradation, that is, FA [$B = 0.386$], CA [$B = 0.205$], LA [$B = 0.224$], and OA [$B = 0.122$] at $p<0.05$ significance. The interaction of extension services and household livelihood assets (Z*X), results showed had insignificant [$b = .074$, $SEb = .048$, $\beta = .071$, $p>.001$] influence on household livelihood choices. The study concluded with some recommendations for policy and further research considerations.

CHAPTER ONE

INTRODUCTION

In this chapter, information is provided on the context of the study. It commences with a section of the background to the study. Other sections of the chapter include statement of the problem, objectives, study hypotheses and significance of the study, while the scope and limitations of the study are the last sections of the chapter, respectively.

1.1 Background to the Study

Both poverty alleviation and environmental degradation are serious global issues with a mutual relationship. They are, however, generally treated independently (Nunan et al., 2002). The relationship between poverty and environment has been the subject of extensive debate because poor people are often impoverished by a declining resource base and in turn often forced by their circumstances to degrade the environment further. Therefore, relationship between poverty and the environment is complex and varies according to the local socio-economic conditions. In this background section, highlights on specific aspects of this relationship are described. It is shows how poverty may relate to the various dimensions of environment; the relationship between poverty and livelihood strategies; and the association of livelihoods with the environment. The final part of this background section deals with the linkage between livelihood strategies and rural extension services; and the Kenyan situation.

1.1.1 Poverty and Environment Linkages

Universally, poverty is associated with the rural populations because they are largely deprived of both basic and economic livelihood opportunities. Contemporary apprehensions about the level of poverty in rural areas have led to significant research interests. In 2002, three out of four poor people in developing countries lived in rural areas, with the majority of them relying on agriculture for their livelihoods (World Bank, 2007). FAO (2003) Report on Forest and Poverty Alleviation shows that agriculture

remains the main source of income for around 2.5 billion people in the developing world. In an effort to improve living standards of populations in developing countries, the goal of promoting rural development over the last decades has been closely associated with the continuous evolution of development models. These models have been applied as strategies for poverty reduction with noteworthy examples like community development, small farm development, integrated rural development, market liberalization, participatory development and human development. Others are sustainable livelihoods, poverty reduction strategies, food security programmes, sustainable agriculture and rural development, and since the year 2000, the Millennium Development Goals (MDGs) (Avila et al., 2005), and from 2015, Sustainable Development Goals (SDGs) (UN, 2015).

Generally, poverty remains a significant issue despite the rapid rate of development. A report on poverty (Shepherd et al., 2014) indicates that there are millions of people worldwide who are still living in chronic poverty in spite of progress made in the achievement of MDGs. According to IFAD (2011), the population of the developing world is still more rural than urban based with about 3.1 billion people still living in rural areas. Moreover, the UNDP Multidimensional Poverty Index shows that almost 1.5 billion people in 91 developing countries are living in poverty with overlapping deprivations in health, education and living standards, noting that although poverty is declining (Shepherd et. al., 2014), almost 800 million people are at risk of falling back into poverty if setbacks occur.

According to Babbier (2010, 2013), poverty remains the main obstacle to promoting environmental conservation. The author additionally reports that some of the environmental problems faced in both developed and developing countries are deforestation, land degradation, water shortage and contamination, air pollution and the loss of biodiversity. This revelation is consistent with other studies indicating that the rural poor in developing countries are heavily dependent on local natural resources for sustenance (Shiva & Varma, 2002; Escobal & Aldana, 2003; Narrain, Gupta & Veld, 2005). This is coherent with findings that the poor heavily depend on open access

resources like forests, pastures and water thus leading to their overexploitation (Jodia, 2000). Over the last decades, interest in sustainable development (Babbier, 2003) has been out of these concerns. Although current economic development may be leading to rapid accumulation of wealth, it is at the expense of excessive depletion and degradation of natural resources. In the past, though, human development and environmental issues have generally been articulated as separate issues (Nunan et al., 2002). In their study on poverty and environmental links, Comim et al. (2009) reported that although many studies have focused on poverty as an impediment for economic development, the debates on poverty reduction often only concentrate on the concept of poverty and its measurement.

Rural poverty has thus been acknowledged as the main outcome of degraded soils, vegetation, forests, water and natural locations. The significance of poverty–environment association for the livelihood and natural resource susceptibility for the poor is evident as indicated in past studies (for instance, Gupta & Veld, 2005). According to DFID (2001), environmental factors are responsible for almost at least 25% of the entire disease burden of poor countries; leading to problems for the poor like unsafe water, inadequate sanitation and waste disposal, and air pollution. Besides, rapid deforestation and biodiversity losses deprive people of valuable forest resources, such as fuelwood, food and medicine (Bauman, 2002). Also, soil degradation is a major threat to the livelihoods of the poor who are more likely to live in degraded or fragile areas. Projections of rural population growth, agricultural expansion and intensification, and poverty in the next few decades suggest a potentially serious conflict between poverty and natural resource sustainability in rural areas (Comim et al., 2009). Therefore, with the renewed international commitment to poverty reduction there is continuous significant interest in practical innovations in the way poverty–environment linkages are considered in mainstream development policy (Bauman, 2002).

1.1.2 Poverty and Livelihood Strategies

The World Development Report on Agriculture for Development (World Bank, 2007) indicates that poverty reduction in Sub-Saharan Africa could be achieved through livelihood diversification in rural areas. Consequently, rural households have four possible options to choose livelihoods for their wellbeing. They practice crop farming, animal husbandry, and also engage in small businesses. The last option is access to common forest resources when the need to survive arises. As an active social process, livelihood diversification involves the maintenance and continuous adaptation of diverse portfolio of activities over time in order to secure survival and improve living standards (Ellis, 2000b).

Studies made on livelihoods adoption in Africa identify a number of household attributes that influence rural households' decision regarding livelihood choices and impact on the environment. They include agro-ecological characteristics, family landholding size, household demand for forest products, availability of existing timber resources, farming practices, cultural influences, changes in rural economy, access to market, and external interventions like policies and extension services (Bannister & Nair, 2003; Salam et al., 2000; Viswanath, et al., 2000). The body of literature on households' livelihood decisions highlights the complexity of factors involved in the behavioural function of households. The intricacy however, arises from the diversity of circumstances under which rural households operate. It is generally recognized in literature that a number of factors elucidate the differences in household livelihood choices in rural areas. However, the specific socio-economic and institutional variables affecting the decisions, differ across countries, regions, villages and farms. Moreover, the direction and significance of influence of a given variable is not often consistent across studies.

Livelihood activities are thus the sources of household means of survival. A study on rural livelihood diversity in developing countries (Ellis, 2000) reported that livelihood activities are also dependent on assets access and determine the living gained by the

rural households. Like in most contemporary developing countries, the fundamental characteristic of rural households in Kenya is the ability to adapt, through the rural livelihoods diversification, in order to survive. Rural livelihoods diversification is thus a socio-economic process in which factors of both threat and opportunity cause the rural household to adapt intricate and diverse livelihood strategies in order to survive (Ellis, 2000). Although participation in multiple activities by rural households is not new, there was relative neglect of diverse dimensions of rural livelihoods other than access to farming until the mid-80s. This failure to understand households' preferences has mystified the success of the poverty reduction efforts aimed at improving rural livelihoods (Achalu, 2004) since very little was known about the constraints farm households face that limit their potential to develop livelihoods. The dominant strategy then for improving rural welfare has thus been small farm output growth. Therefore, the extent of diversification away from agriculture is an indicator of the degree to which farming operations only cannot provide a secure and improved livelihood.

Past studies (Bauman, 2002) have also drawn attention to the enormous diversity of livelihood strategies at all levels, that is, within geographic regions, across sectors, within households and over time. Therefore, amidst high levels of material uncertainty and risk, rural populations have become more occupationally flexible, spatially mobile and increasingly dependent on non-agricultural income generating activities (Bauman, 2002). This is attributed to the fact that though farming is still an important activity in the present day, it is increasingly unable to provide a sufficient means of survival in rural areas. The declining productivity of natural resources has thus been isolated as a key factor pushing people out of agriculture and into non-farm based activities. Often the very poor and the relatively rich who for different reasons are most prone to diversify their livelihood strategies.

However, livelihood diversification has consequences for the rural communities, and therefore the overall process of structural transformation impacts on the use of resources and the environment in general (Loison, 2015). Since the environment is a critical input for rural households, environmental degradation in turn implies a shrinking input base

for the poor households that increase severity of poverty. From this discourse, it has been argued that poor people are concentrated in less favourable or fragile land (Barbier, 2008, 2010), in line with evidence that poverty has positive correlation with fragility of lands (Dasgupta et al., 2005); and that the role of environmental resources in the share of aggregate income of the poor is strong (Vedeld et al., 2007; Kamanga, et al., 2009; Hogarth, et al., 2012). Although poor environmental condition is a determinant of poverty (Shyamsundar, 2002), environmental degradation such as deforestation, land degradation and limited water supply worsens the condition of the poor. Yet, policy-makers as well as the national and international research and extension systems have neglected these areas over time (Kuyvenhoven et al., 2004), thus aggravating some of the problems.

1.1.3 Livelihoods and the Environment

Access to natural resources has been a constant theme in debates on poverty alleviation strategies. The important role that natural resources play in the livelihood strategies of the rural poor has been confirmed in a number of participatory poverty assessments that set out to consider the issue from the perspective of the poor themselves (Bauman, 2002). People in rural areas place emphasis on access and control over natural resources particularly in relation to food security and agricultural production (DFID, 2001). Therefore, deprived households in developing countries are greatly reliant on the natural environment for their livelihoods.

An economic survey in Kenya (Republic of Kenya, 2008) showed that up to six million people are dependent on natural resource exploitation in the arid and semi-arid lands (ASALs). This suggests that ASAL areas are nationally important in terms of supporting rural livelihoods in Kenya. Nonetheless, in the 21st century, the impact of environmental unpredictability has significantly affected the livelihoods of the poor in developing countries. For decades now, promotion of rural livelihoods by rural development agents in developing countries has focused mostly on basic universal approaches of adopting sustainable livelihoods (Ayele, 2008). Consequently, a lot has been learnt about poverty

reduction and environmental conservation in the last decade (2008–2018), in terms of the relationship between poverty and environmental degradation. Regardless of advances in the development and promotion of sustainable development, rural households' motivation to take up new sustainable livelihoods, particularly among the traditional farm households has remained minimal. This has led to the realization that livelihood adoption is not only a technical problem but also a socio-economic problem, which in recent times, has directed attention to the influence of socio-economic and behavioural factors in rural households' livelihood choices. This shift in focus is evident from the ever increasing literature on factors affecting adoption of livelihoods in recent times.

a) Livelihoods and Water Resources Access

In developing countries, rivers provide a direct source of water for domestic use with minimal or no treatment at all. For water-scarce countries like Kenya (WRI, 2007), this means that water catchment areas should be managed properly so as to retain their capacity to supply good quality water all year round. However, studies show that the harnessing of environmental resources in order to satisfy the increasing demands of the world's ever growing population is undermining the sustainability of the earth's ecosystem which is critical to human survival (Kremen, 2007). It is argued that in the absence of any alternative means of survival, the poor are forced to use the services of nature such as water, food, fodder and other health requirements. This situation is highly prevalent in Sub-Saharan Africa where about 70 per cent of the population live in rural areas and are mainly dependent on the natural environment and rain fed agriculture (Toulmin, 2009) that have contributed to the water scarcity challenges in developing countries.

b) Livelihoods and Forest Resources Access

According to Davidar et al. (2010), tropical forests continue to be transformed at startling proportions although conservation efforts might have slowed down the speed of

deforestation (FAO, 2010). As a strategy, rural folk in their quest to diversity farming livelihood depend on forest resources and this continues to result in biodiversity depletion. Hersperger et al. (2010) and Hosonuma et al. (2012) further argue that the direct cause of forest conversion is to create space for commercial or subsistence agriculture. Therefore, forest as a resource becomes important as an additional natural resource to define household survival. Moreover, a study on economics of nature (van Kooten & Bulte, 2000) showed that deforestation results in the conversion of forest to an alternative permanent non-forested land use such as agriculture, grazing or urban development. Studies have identified five elements to this logic (Sunderline et al., 2004). Firstly, people and the forests they live in or nearby are in some cases "islands" of comparative stability that are relatively untouched by rapidly changing socio-economic systems; secondly, some forest dwellers are indigenous people whose dependence on forests are deeply rooted in history and long predate modern social change; and thirdly others are rural in-migrants who colonize the "forest frontier" as a source of new agricultural lands and other economic opportunities, though often they are not the poorest of the poor. The fourth rationality is where forests have long been a refuge for relatively powerless and poor rural people fleeing war and conflict; while the fifth logic is where open-access to entry character of many forests is a "pro-poor" characteristic that provides people a means of survival and a magnet of economic opportunity for the rural folks with limited options (Sunderline et al., 2004).

c) Livelihoods and Soil Degradation

Rural households in their quest to exploit their natural resources lead to its degradation if remedial measures are not mainstreamed during the exploitation process. According to Sharda et al. (2013), it is estimated that 80 per cent of the current degradation on agricultural land in the world is caused by soil erosion due to water. Erosion by water is a primary agent of soil degradation at the global scale, affecting about 1094 million hectares, or roughly 56 per cent of the land experiencing human induced degradation (Nasri et al., 2009). A GIS-based sedimentation assessment (Lim et al., 2005) demonstrates that crop productivity reduces by about 20 million ha/year due to soil

erosion and degradation. In Iran, for instance, soil erosion rates in agricultural lands vary between 7.6–32 ton/ha/yr and 4.3–22 ton/ha/yr in rangelands (Samani et al., 2009). Also, according to Van-Camp et al. (2004), soil erosion is severe in Romania (6.7 million ha), Bulgaria (4.8 million ha), Poland (4.7 million ha) and Hungary (3.8 million ha). A study on the effects on changes of land use in Ethiopia shows that the rate of soil erosion ranges from 16–300 tons/ha/year (Itanna et al., 2011). With a very slow rate of soil formation, any soil loss of more than 1 ton/ha/year can be considered as irreversible within a time span of 50–100 years (Van-Camp et al., 2004). It is estimated that cultivated and degraded land generates 10–20 times more runoff than do forests; thus, expanding cultivation can drive soil degradation unless the land is well managed (Moges et al., 2009). Moreover, Kodiwo et al. (2013) in their study on agricultural land use show that 23 and 8 per cent of the total land area in Kenya is severely and very severely degraded, respectively.

1.1.4 Livelihood Diversification and Rural Extension Services

Livelihood diversification in the rural areas of poor countries has received significant research attention since the 1990s following the introduction of sustainable livelihood frameworks (Muhammad et al., 2014). A number of issues also received recognition during the late nineties when various studies on diversity of rural livelihood strategies (Smith et al., 2001), and its relationship with agricultural productivity (Ellis, 2000) were undertaken. Rural development therefore has been an important policy goal for many developing countries, where structural reform measures and poverty reduction have been taken to address this. For this reason, the control of negative impact of livelihood diversification on the environment has been effected through the integration of subsistence orientated smallholder farming into the market economy. This continues to receive considerable attention among rural development policymakers and researchers around the world (Barrett, 2008). As a result, millions of rural people have been able to come out of poverty through better farm incomes, environment conservation, employment in agriculture, and rural non-farm enterprises, hence contributed to better livelihoods (World Bank, 2008).

Consequently, the role of rural extension services has proved to be important in addressing this transformative agenda. According to Amevenku et al. (2019), households with access to agricultural extension services have a higher tendency to diversify from their farming activities than those with very little access to extension services. A common argument is that in order to produce marketable surpluses and sustain food security, smallholder households need not only access to agricultural technologies, but also private assets (for example land and equipment) and public goods (Barrett, 2008). Among public goods, there is evidence that agricultural extension services have had a significant impact on farm productivity. For example, Dercon et al. (2009) studied the impact of agricultural extension and roads on poverty in Ethiopia. The results suggested that the impact of access to agricultural extension by rural households on poverty reduction was greater than the impact of access to infrastructure. Besides, investment in agricultural extension ensures increased returns in both developing and developed countries (Evenson, 2001).

Extension services have therefore come in to serve as opportunities to support the rural populations to improve their living standards by addressing the challenges of rural livelihoods. However, it is widely acknowledged that appraisal of extension impact on rural livelihoods is challenging in terms of dealing with attribution issues and linking cause and effect quantitatively (Anderson & Feder, 2007). Although the use of Sustainable Livelihood Approach (Allison & Ellis, 2001; Niehof, 2004; Morse et al., 2009) to investigate the impact of extension services on rural livelihoods may fill in the gap of this challenge, it is not common practice in many developing countries including Kenya. Likewise, while there is a large literature dealing with issues related to agricultural extension in developing countries, rigorous impact evaluations of this kind are less common (Waddington et al., 2010).

1.1.5 The Kenyan Situation

According to Mwang'ombe et al. (2011), only 16 per cent of Kenya's land is classified as medium to high potential while the rest is arid and semi-arid lands (ASALs). Of the

country's total area, forests and woodland occupy about 6.5 per cent while national reserves and game parks together account for 10 per cent. About 80 per cent of the Kenyan population live in rural areas and derive their livelihood mainly from agriculture. Therefore, Kenyan rural households have extended farming activities to ASAL areas of Nyeri County but land degradation through grazing, continuous farming and drought conditions have lowered farm yields (Business Daily, 2014; Jaetzold et al., 2010). As a result, ASAL households in Kenya are generally poor with insufficient productivity, and so food requirements are generally not fully met (RoK, 2007).

Kieni East and West sub-counties in Nyeri County both lie on the leeward sides of Mt. Kenya and the Aberdare Ranges, respectively (Jaetzold et al., 2010). In these areas, like other Kenya ASAL areas, the most pressing problems for rural development are related to environmental degradation (IFAD, 2007) and food insecurity (Business Daily, 2014; Wambugu, 2014). Since the mid-1990s, donor supported interventions in Kieni have been a common phenomenon to promote biodiversity conservation, among other development interventions (GoK, 2012). Earlier in the 1970's and 1980's, state and non-state development extension programmes were launched in the area as recognition of the importance of soil and water conservation outside of forestlands (Jaetzold et al., 2010; Ngugi et al., 2014).

In the past few years, programmes have been rolled out to promote sustainable livelihoods for the Kieni populations through community development programmes in agriculture, livestock and environment conservation (GoK, 2007). Therefore, the battle against poverty remains an important priority on Kenya's development agenda as articulated in Vision 2030 (GoK, 2007). The Vision aims to make Kenya a "middle" income country providing high quality life for Kenyans by the year 2030. However, the majority of the poor and food insecure groups continue to be concentrated in rural areas, where their livelihoods (Lufumpa, 2005) depend on subsistence agriculture, making poor households encroach on fragile land that leads to degradation of natural resources. As a newly industrializing country, Kenya therefore faces the challenge of improving her economic performance and the lives of her citizens without undermining the

environment upon which her national earnings and individual people's livelihoods depend (GoK, 2007).

1.2 Statement of the Problem

The increasing rate of environmental degradation in Kenya, including Nyeri County, has been a matter of national concern. Depletion of the forest, soil erosion, drying rivers and land degradation has become a common feature of the environment in which the poor eke out their living (IFAD, 2007). This physical deterioration of the environment has left thousands of the population wondering how to live harmoniously with nature and efficient handling of their livelihoods. As a result, households have been facing a wide range of problems arising out of the degradation of the environment.

Kieni East and West sub-counties in Nyeri County continue to experience rapid environmental degradation resulting from household livelihood activities (IFAD, 2007; Business Daily, 2014). The sub-counties are predominantly ASAL and most of the people are poor. Environmental degradation and destruction of the region's water catchments have had a compounding effect on local production (Karienye et al., 2012; Kenya News Agency, 2014; Business Daily, 2014). These environmental threats have affected agricultural production and water catchment areas negatively. For instance the drought of 2013 resulted in a 15% decrease in crop areas in *Kiamathaga* and *Munyu* locations, and an equal reduction in maize yields (Orre et al., 2013). According to Karienye et al. (2012), water scarcity in Kieni will continue to manifest following a reduction in rainfall amounts after every 3–4 years mainly as a result of human activity. Therefore over 60 per cent of the Kieni populace continue to be food insecure owing to season failures that is further compounded by drops in livestock yields, income and loss in casual engagements.

Agriculture, among other activities, is the main livelihood of the people in these sub-counties. Poverty coupled with poor farming methods has led to the clearing of tracts of land for cultivation of food crops. Most of these lands have been exposed to water

scarcity, deforestation and erosion. This is because low productivity from agriculture has forced the poor to adopt livelihood strategies unfavourable to the environment like felling of trees for charcoal and fuelwood, and bush burning for farming to earn a living. Besides, most of the rivers in the area have dried up due to human activities and pressure from cattle overgrazing and consumption. The areas are thus managed at low levels of productivity, affecting 20–50% of the land and at least 170,000 people each year. Therefore environmental degradation remains and presents the greatest threat to the survival of Kieni populations (IFAD, 2007), in spite of rural extension services offered in the area.

Consequently, human activities that contribute to water scarcity, forest biodiversity loss and land degradation are among the common environmental challenges in the Kieni area (IFAD, 2001, 2007), and these have led to pressing problems in the area such as food insecurity (Wambugu, 2014). However, not much evidence exists on research carried out in the area about the effect of livelihood assets on livelihood choices, their subsequent impact on environmental degradation, and the role of rural extension to avert the situation. This study sought to fill the gap so that strategies to improve livelihoods and environmental conservation mechanisms in Kieni succeed.

1.3 General Objective

The general objective of the study was to establish the rural livelihood choices impact on environmental degradation in Kieni East and Kieni West sub-counties of Nyeri County, Kenya.

1.3.1 Specific Objectives

a) To characterise households in Kieni East and Kieni West sub-counties based on socio-economic factors.
b) To determine the effect of household assets on livelihood choices in Kieni East and Kieni West sub-counties.

c) To determine the impact of livelihood activities on water scarcity, and soil erosion) in Kieni East and Kieni West sub-counties.

d) To assess the moderating effect of rural extension services between household assets and livelihood activities in Kieni East and Kieni West sub-counties.

1.4 Hypotheses

H_{02} Livelihood assets do not affect household livelihood choices.

H_{03} Household livelihood activities do not have significant impact on water scarcity, deforestation and soil erosion.

H_{04} Rural extension services do not moderate the relationship between household assets and livelihood activities.

1.5 Significance of the Study

Up to six million people in Kenya are said to depend on natural resource exploitation in the arid and semi-arid lands (ASALs) (Mwang'ombe et al., 2011). This suggests that ASAL areas are nationally important in terms of supporting rural livelihoods in Kenya. This study is important as it focused on the environmental degradation outcomes, where livelihood choices was taken as a multi-dimensional concept that encompasses not just the farm based activities such as cropping and livestock activities, but also the non-farm dimensions that covered forest and off-farm decision-making at household level. Therefore, the findings of this study will enhance the understanding of the relationship between household livelihood choices and environmental degradation. This will in turn guide evidence-based policy formulation.

Given that livelihood interventions by the government of Kenya is meant to improve the socio-economic position of households and achieve sustainable livelihood outcomes, research on environmental degradation outcomes is essential to contribute to knowledge that is useful in the continuous improvement of livelihood and environmental conservation programme plans, programme delivery and other institutional activities. Findings of this research therefore provides timely feedback to policymakers, NGOs and development partners working either independently or closely with government institutions in programmes aimed at achieving overall development of the Kenyan populace.

Empirical findings of this study also adds to the existing body of knowledge and forms a basis for further research. Therefore analysis of the impact of livelihood activities on environmental degradation has implications for several academic disciplines including agriculture, economics, political science and sociology. This is especially significant to the field of development studies, whose inter-disciplinary and multi-disciplinary underpinning strives for holistic view of development challenges and their possible solutions.

1.6 Scope of the Study

This study focused on households in Kieni East and Kieni West sub-counties in Nyeri County who use local assets to earn livelihoods. It included households resident in the two sub-counties who engage in forest, cropping, livestock and off-farm activities depending on their access to assets in form of education, income, road infrastructure, land and membership in self-help groups.

1.7 Limitations of the Study

One of the limitations of this study was the challenge in obtaining accurate records in some of the sub-locations in relation to households that had accessed services from County offices and could be reached at the time of the survey. It was evident that there were households who had changed residence to other locations, making their traceability a challenge. The study therefore relied mainly on records prepared by the Area Sub-Chiefs at the sub-location level to determine the active households in the area.

Due to the geographical dispersion in terms of location of households, it was difficult to reach some households that were initially listed during the preliminary survey. Constant migration and change of residence had also affected composition of some of the sub-locations over time, with some households migrating to other sub-locations. By obtaining telephone contacts from the local area administrators (Area Assistant Chiefs),

it was possible to locate some of the households and arrange for interviews at times of their convenience at their homesteads.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The first section of this chapter covers some of the theoretical aspects that have shaped the rural livelihood approach perspectives in sustainable development. It explores among these perspectives for useful insights on the study objective, identifies the gaps that exist in these approaches, and on this basis, elaborates some of the key concepts that feature in the rest of the document. The second section deals with empirical evidence from past studies on the socio-economic characteristics of the rural poor, relationships between household assets and livelihood choices, and livelihood choices and environmental degradation outcomes, including the moderating effect of rural extension services on livelihood choices. The third section of the chapter provides a critique of empirical evidence and delineates a new area of study by relating the present study with the previous ones. The final part of this chapter clarifies the conceptual framework used in the study, and elaborates the variables of the study including a description of a household as a unit of analysis.

2.2 Theoretical Review

According to Zikmund et al. (2012), a theory is a logical explanation of some events that includes predictions of how things relate to one another. Therefore, a theory comprises of a set of interrelated concepts, definitions and propositions that explain or predict events or situations by specifying relations among variables. This study used the theory of Sustainable Livelihood Approach to conceptualise the problem under study and explanation of findings.

2.2.1 Theory behind the Sustainable Livelihood Approach

The Sustainable Livelihood Approach (SLA) recognises that assets are at the centre of livelihood choices. Assets are seen in terms of "capitals" which are viewed as accessible or inaccessible to people mainly on the basis of structural factors. The SLA framework is often shown diagrammatically as indicated in Figure 2.1 (Ahmed et al., 2011; DFID, 2000). According to Carney (2003), a summary of SLA and propositions for setting it into practice can be found in the "guidance notes" produced by DFID. At the centre of the framework is the evaluation of the different capitals (FAO & ILO, 2009) that are believed to buttress livelihoods at the level of the individual, household, village or community. These capitals are classified as human, social, physical, natural and financial (Toner et al., 2004). They are measured in terms of their vulnerability to shocks and the institutional context within which they occur. Once this is apprehended or fathomed, interventions can then be mainstreamed to enhance livelihoods and their sustainability through enhancing the capital available or by decreasing vulnerability. The analysis process is thus about understanding the prevailing situation and developing suggestions for improvement based upon that understanding (see Figure 2.1). Therefore, SLA is meant to avoid a situation where intervention is unguided giving little positive impact or is at worst detrimental.

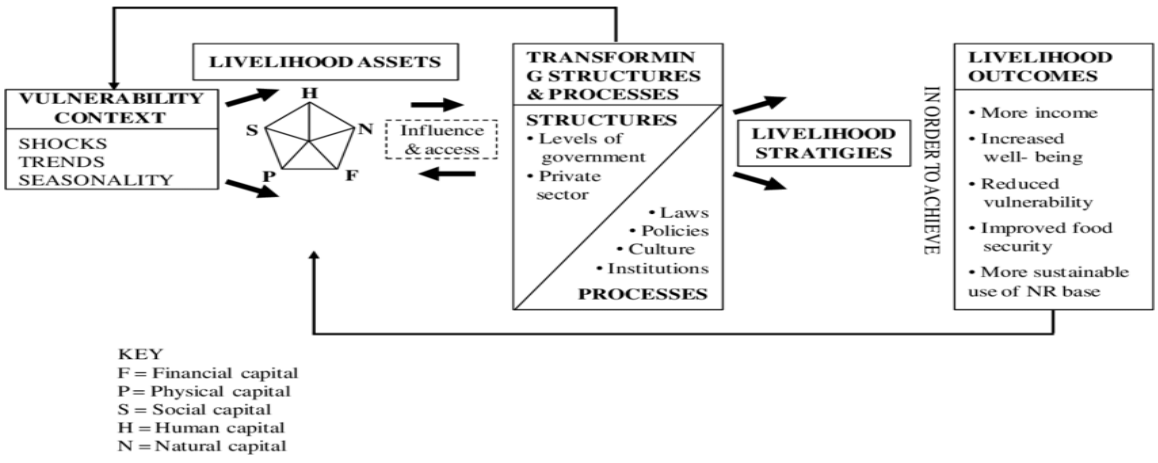

Figure 2.1: Sustainable Livelihood Framework (DFID, 2000**)**

The SLA framework (Figure 2.1) therefore consists of five major components that are related through sequential relationships and feedback (DFID, 2000). The first is the vulnerability context, which describes the external uncontrollable factors that influence people's assets and livelihood opportunities (DFID, 2000). Broadly, these factors are classified as: shocks (for example environmental and conflict-related); trends (for example resources and technology); and seasonality (for example price fluctuations and employment opportunities). The second component of the framework is livelihood assets, outlined in terms of five categories (DFID, 2000; FAO & ILO, 2009) necessary for the pursuit of positive livelihood outcomes. These include:

i) *Human capital* that includes the amount and quality of knowledge and labour available in a household;
ii) *Natural capital* that entails the quality and quantity of natural resources, ranging from fisheries to air quality;
iii) *Financial capital* that includes savings and regular inflows of money;
iv) *Physical capital* that entails the infrastructure, tools and equipment used for increasing productivity; and
v) *Social capital* that includes social resources like networks for cooperation, mutual trust and support.

The third component comprises of transforming structures and processes. Here, "structures" refer to the organizations that create and enforce legislation, provide the necessary requirements for acquiring and capitalizing upon assets (for example private suppliers of materials for building shelters), manage natural resources, and provide other services crucial for gaining access to assets, exchanging them, and benefiting from their use. Meanwhile, "processes" determine the interactions between the structures and individuals. Examples of processes include policies, legislation, power relations, norms, market stability and general rule of law. The fourth component of the SLA framework shows livelihood strategies, which concern the individual's available and implemented options for pursuing livelihood goals. The greater the diversity of livelihood strategies, the higher the household's resilience to the shocks, trends and seasonality conditions

within the vulnerability context. The last SLA framework component includes livelihood outcomes that refer to the outputs of livelihood strategies (DFID, 2000). Achievements may include higher income, greater well-being (for example self-esteem, physical security and political empowerment), reduced vulnerability, greater food security, and/or improved environmental sustainability.

It should be noted that SLA as set out in Figure 2.1 does not specify particular methods and techniques that have to be applied to assess the capitals, institutions, vulnerability and livelihoods, and their outcomes. In practice, the analysis by SLA could exploit different choice of methods including standard techniques based upon observation, focus groups and interviewing.

2.2.2 Sustainable Livelihood Approaches

Studies on sustainable livelihoods (Shankland, 2000; Carney, 2003) indicate that these kinds of approaches were developed by DFID in the 1990s. In the past, livelihood studies have come to the forefront in reaction to the limited success of poverty studies and other types of studies in informing policy and practice in poverty alleviation (de Haan & Zoomers, 2003; Kaag et al., 2004). As such, poverty studies have been seen as too engrossed on the limitations and powerlessness of poor people, to the extent of being defensive. Nooteboom (2003) found that livelihood approaches have enhanced poverty studies by starting its analysis with the creative choices of people in making a living. The approach changes from a focus on poor people's inability to work to analysing how they manage to survive and so underscore the strengths of the poor rather than their weaknesses.

Many livelihood studies that have followed DFID's conceptualisation are based on identifying and analysing four main social domains. Swift & Hamilton (2001) identify these to include assets (depicted as a pentagon) on which livelihood is based; the contextual setting that frames access to and utilisation of the assets; the emergent livelihood strategies; and the particular livelihood outcomes of this process. The rural

household maximizes benefits by participating in multiple means of survival in terms of a diverse portfolio of assets and activities that produce the livelihood outcomes. Livelihood assets are thus the key possessions in the household's diverse portfolio by which livelihood outcomes are produced. The key capitals or assets include human capital, physical capital, natural capital, financial capital and social capital. This process that households use to produce livelihood outcomes is described as diversified livelihoods for rural households (Ellis, 2000). A household's livelihood outcomes may include real incomes, educational attainment, access to water, credit, health services, and so on. Although livelihood outcomes are associated with improved living standards of the households, negative outcomes could be realised that affect the sustainability of the livelihood, mainly in terms of their effect to the environment.

Though the logic behind SLA has been shown above in a somewhat mechanical cause-effect lexicon, it can also be considered in many other different ways. Krantz (2001) contends that there are two ways of using SLA. On the one hand, there is the approach taken by DFID which considers SLA as a framework for analysis, while other agencies such as UNDP and CARE (an NGO) apply it to "facilitate the planning of concrete projects and programmes". However, Farrington (2001) presents an alternative and distinct view of the SLA aspects:

a. By way of set of principles guiding development interventions. Here, the major hypothesis is that an intervention has to be evidence-based rather than originated in a top-down approach without adequate knowledge of the beneficiaries.
b. As a formal analytical framework to help appreciate what "is" and what can be done.

   Therefore, framework aids in understanding the capitals that are accessible to households, their vulnerability and the involvement of institutions.

c. The framework is also seen as an overall developmental objective. Here development is considered as the improvement of livelihood sustainability, perhaps by making

capital less vulnerable or by enhancing the contributions that some capitals can make or even by improving the institutional context.

Based on the second Farrington (2001) proposal above, SLA in this study was used to analyse household assets and their effect on livelihoods at the household level. In this study, rural livelihoods approach was therefore used to explore the behaviour of rural households (Ayalneh, 2002). According to Long (2000), a livelihood best explains the idea of individuals and groups determined to make a living, endeavouring to meet their various consumption and economic requirements, managing with uncertainties, responding to new opportunities, and choosing between different value positions. On their part, Ellis (2000) and Ellis & Freeman (2005) define a livelihood as comprising the assets, the activities, and the access to these assets and activities as mediated by the social capital which together determine the living gained by the rural individual or household. These authors identify assets, mediating processes, trends and shocks, and activities as the critical components and processes that jointly contribute to rural livelihood strategies.

The rural livelihoods approach is thus essentially a micro-policy analysis framework in which the assets are the activity components that improve livelihoods. The framework (Ellis, 2000) encompasses four blocks, (a) the asset block, (b) the livelihood mediating processes block or the conditioning factors block, (c) the livelihood strategies and activities block, and (d) the outcomes/effects block. The assets block comprises capitals accessed in some way (owned, inherited, controlled or claimed) by the household. The assets here refer to stocks of capital that can be utilized directly or indirectly to generate livelihood of the household or to sustain its material well-being at different levels above survival. Different types of capitals are categorized and distinguished between five capital types as human, physical, financial, natural and social capital. The assets block is thus the basic building block upon which households are able to undertake production, engage in labour markets, and participate in exchange with other households.

The livelihood mediating processes block (Ellis, 2000) is characterized by factors that influence households' access to assets and pursuit of viable livelihoods. These mediating processes encompass the agencies that inhibit or facilitate the exercise of capabilities and choices by individuals and households. For example, participation in extension programmes at a particular moment in time may entail good determinants of access to extension services. This access can be defined in various ways like: number of visits by extension agency officers; participation in extension programmes; the social mechanisms for resolving disputes, among others. Ellis (2000) distinguishes mediating processes into two categories, that is, the transforming processes category and the vulnerability processes category. The transforming processes category comprises social factors that are predominantly endogenous to the social norms and structures of which households are part, for example, social relations, institutions and organizations. The vulnerability processes include conditions and trends in terms of history, politics, economic trends, climate, agro-ecology, demography and social differentiation.

The household livelihood strategies block (Ellis, 2000) is characterized by coping strategies and adapting behaviours of a rural household for its survival. It is a collection of activities made possible by the interaction of assets and opportunities accessible to the household (Ehebhamen et al., 2017). Two categories of activities that form potential components of a livelihood strategy are the natural resource-based activities and the non-natural resource-based activities. Natural resource-based activities include activities such as collection or gathering; cultivation of food and non-food; livestock keeping and pasturing; non-farm activities such as brick making, weaving, thatching and so on. Haggblade et al. (2010) reported that non-natural resource-based activities include activities such as rural trade and other non-farm activities such as wage work, remittances from urban and international sources and other transfers such as pension.

The livelihood outcomes block (Ellis, 2000) is characterized by some combination of attributes related to the level and stability of rural household income as well as access of the household to social services and basic needs including education, health, water and shelter. In certain cases and circumstances, some of the livelihood outcomes may be

negative, especially in the way the livelihood activities affect the environment. Where livelihood outcomes are negative, they may result in the reduction and quality of one of the capitals, that is natural resources, thus undermining the very basis of continued survival and hence sustainability.

2.3 Empirical Perspectives

The focus of this study was the impact of household livelihoods on environmental degradation as illustrated by the conceptual framework in Figure 2.2. This sub-section is a presentation of empirical evidence relating to rural livelihood activities adopted by households and their impact on environmental outcomes, in relation to the objectives of this study. The evidence is organised under sub-headings that reflect the four objectives of the study as outlined in Chapter One.

2.3.1 Socio-economic Characteristics of the Rural Poor

The first objective of the study was to identify the socio-economic characteristic features of Kieni East and Kieni West sub-counties. Evidence of the importance of socio-economic factors on rural household behaviour exists. Shiferaw et al. (2002) and Pattanyak et al. (2003) reported on six factors of the household head and other adult members of the family that were believed to influence preferences of rural households in production and consumption decisions. These included demographic features, labour, asset possession, age, gender and education. Also, the way households choose livelihoods evolves over time as their experience advances, the characteristics of their farms change, or their household resources increase or decrease as they age (Bannister & Nair, 2003). The objectives, knowledge and attitudes of household heads have an influence on household activities. In their study on the economics of farming systems, Naushad et al. (2015) stated that rural households normally have multiple objectives for choosing a livelihood (for instance livestock keeping for own consumption, source of cash and other service functions) and these are likely to influence the decision-making process. The farm experience and education (both formal education and informal

training) of the household head are also important characteristics that influence decisions made in livelihood diversification (Adesina & Chianu, 2002).

The likelihood of households choosing a particular livelihood for instance farming, is also dependent on their attitudes and perceptions, as are different socio-economic characteristics, which significantly influence the level of livelihood diversification (Dinku, 2018). Age of household head, farm input use, extension contact, market access, credit access and owned cattle size are the main factors. More importantly is also the perceived risk in the agricultural production system (Mahapatra & Mitchell, 2001; Bannister & Nair, 2003). Household's risk assessment, for instance crop farming, often also arises from tenure insecurity and production failures. Similarly, where households perceive uncertainties in land tenure, they do not show interest in investing in multiyear crops such as trees (Bannister & Nair, 2003). On the other hand, where farmers perceive possible failures in food crops, they tend to diversify their farming systems by incorporating other livelihood activities (Ellis, 2000).

Studies in forestry have shown the significant contribution of forests towards household economies. Some people depend solely on forests as their only source of subsistence, with its contribution sometimes being found to offset other household livelihood portfolios such as agriculture (McElwee, 2010). However, despite the contribution of forests on livelihoods, human dependence on forests is a multifaceted phenomenon and under the influence of various socio-economic factors (Jianhua & Bhanndari, 2017). The level of use and degree of reliance on forests and its importance as a source of subsistence varies geographically, over time and across communities (Babulo et al., 2008; Bwalya, 2013). Since communities are not homogenous in nature, variation on household reliance on forests is inevitable (Coomes et al., 2004; Córdova et al., 2013). Further drawing upon the forest dependency literature, Bhavannarayana et al. (2012) reported that reliance on forests is a function of various factors and key among them includes household socio-economic factors. For instance, higher education attainment was found to be associated with less reliance on forest resources (Panta et al., 2009; Fonta & Ayuk, 2013). This is so because education offers other alternative livelihood

opportunities which may generate significant returns compared to forest extraction activities (Masozera & Alavalapati, 2004).

Evidence of household size association with forest dependency exists as well. Mamo et al. (2007) showed that larger families have higher subsistence needs which necessitate them to depend more on forest resources. On the other hand, the age of household head has also been positively related with forest dependency, albeit with diminishing effect after reaching a peak of physical strength (Garekae et al., 2017). Nonetheless, older people might possess strong ecological knowledge about their proximate environment, a phenomenon which possibly could increase their likelihood of being more dependent on forest resources. Anantha et al. (2009) also demonstrated that baseline characterization is important to measure project performance before making any changes to project processes. Their study provided insight into the baseline characterization of watersheds with special reference to socio-economic aspects and proposed appropriate policy directions for enhancing productivity and sustainability in the semi-arid zone.

In summary, evidence is mixed in regard to the socio-economic contextualization of the rural poor. Studies cited generate mixed results, an observation also made by other researchers (Garekae et al., 2017; Ogbanje et al., 2015). Ample evidence points at socio-economic features of household heads as responsible for selected livelihood choices. While for instance age and education significantly influence household reliance on forests, other socio-economic factors are not significant. Ogbanje et al. (2015) attribute the mixed results to different methodologies and data sets used, though Akinwale (2011) attributes this to different conceptualizations and measures of socio-economic features. Given the contextual heterogeneity of rural areas and diversity of empirical methodologies used, this study sought to identify the rural socio-economic features of households in the Kenyan context by focusing on rural households in Kieni area of Nyeri County. Moreover, there is a dearth of studies specifically fixated on socio-economic characteristics of rural households. Additionally, a number of studies cited as empirical evidence in this review are from Asia and South American continents, and as Bannister & Nair (2003) argue, the context under which households live differs. Ifeanyi-

Obi & Matthews-Njoku (2014) also contend that many livelihood studies tend to ignore the socio-economic features such as marital status and labour proportion, among others.

2.3.2 The Effect of Rural Household Assets on Livelihood Choices

The second objective of this study was to determine the impact of household assets on livelihood choices.

a) Rural Household Assets

In the foregoing sub-sections of this chapter, it was established that household assets are a fundamental precondition that affect the basic rural livelihoods. By analyzing sustainable livelihoods, Praduman et al. (2006) show that livelihood assets play a pivotal role in sustainable development of rural areas to solve the inherent problems of rural livelihoods as well as to enhance their capacity for self-development. Furthermore, Barret et al. (2002) argue that all geographic locations do not have similar assets endowments, and so do not face similar level of constraints and do not necessarily employ similar strategies to solve their problems. Even within similar geographic locations, socio-economic factors pose a wide range of differentials among rural households which include demographic characteristics of households, well-being or economic and social status of households and the gender disparity perspective.

Consequently, capital assets are viewed as a basket of goods whose availability and access is directly related to the context in which they occur. A study by Heffernan and Misturelli (2000) identified four types of contextual environment comprising disabling, neutral, enabling and flourishing with regard to the manner in which they influence households' livelihood choices and outcomes. A disabling environment does not allow a household to meet subsistence requirements. A neutral environment may allow households to meet basic needs but not much else. An enabling environment allows households to exceed subsistence requirements and achieve sustainability in at least one aspect of their livelihood strategies. A flourishing environment allows households to

achieve a high level of well-being such that they are no longer vulnerable to poverty. Heffernan and Misturelli (2000) conclude by stating that if an environment is disabling, a capital asset type occurring in that environment is also considered disabling. A review of the five household assets as applied by households to identify livelihood activities for survival is done in the following sub-sections.

i) Human Assets

In their studies on human capital, ADB (2004) and Carney (2003) found that human capital is one of the assets the poor often makes trade-offs and choices around. Among others, it comprises of health, nutrition, labour, education, knowledge and skills, capacity to work, and capacity to adapt. The effectiveness of any one of these, however, is dependent on the other. For example labour, as an asset depends on good health and education. Also, when labour for instance is enhanced through training and other skills, it becomes a powerful tool for households to gain livelihoods. Besides, education in a household comprises of several components, including the overall level of education of the household, gender differences in educational access, and the overall literacy rates of adults in the household (Sarah & Mehrul, 2004). In recognition of the important role education and health play in the development of human capital, the Government of Kenya tremendously increased the budget allocations to these sub-sectors from KShs 16 billion for health in 2004/05 to KShs 33 billion in 2007/08 and from KShs 85 billion to KShs 130 billion for education over the same period (Republic of Kenya, 2008).

ii) Physical Assets

Physical capital is crucial in the development and maintenance of physical infrastructure in rural and urban areas. In developing countries, the physical infrastructure sector is a key pillar in the development of the economies, particularly the productive sectors such as agriculture, industry and tourism. The main sub-sectors of the physical infrastructure sector are roads, energy, housing, water and transport. Good infrastructure in rural areas is therefore critical to households' access to markets as well as lowering the costs of doing business.

In their study in rural Kenya, Heffernan & Misturelli (2000) described the feature of physical capital as ranging from enabling in some districts to disabling in others. Though there is no definite pattern of correlation between poverty and distribution of road network institutions, regions with lowest key road network institutions per capita have relatively lower welfare than their counterparts with more institutions. Therefore, transportation infrastructure facilitates household definition of livelihoods. For instance Kleih et al. (2004), found that lack of means of transportation was one of the key constraints to farmers' access to marketing opportunities in Uganda. In rural Kenya, head loading, in particular by women, is a common feature of rural transport (Heffernan & Misturelli, 2000). This includes transport of produce from the farm to the home and from there to the market. To demonstrate the importance of roads in the rural economy, Heffernan & Misturelli (2000) used the road network variable in their study of livelihoods in relation to veterinary services in six districts in Kenya. The authors found that households with access to transportation infrastructure received veterinary services more than their counterparts, thus leading to the enhancement of livestock production.

Since 2003, Kenya has made significant strides in enhancing the quality and quantity of infrastructure facilities and services delivery. The government budget allocation to the sector increased from Kshs 13.8 billion in 2002/03 to Kshs 57.3 billion in 2007/08 (RoK, 2007). Key reforms have also been carried out in the sector to increase efficiency in services and private sector participation through public private partnership (PPP). Key reforms in the roads sub-sector include establishment of three new autonomous agencies (Kenya National Highways Authority, Kenya Rural Roads Authority and Kenya Urban Roads Authority) to oversee the development and maintenance of roads in the country. Road network is a good proxy for physical capital in rural Kenya. This demonstrates the government of Kenya's recognition of transport infrastructure in improving household livelihoods, especially in the rural area.

iii) Financial Assets

Financial capital is the financial resources available to people either as savings, supplies of credit, regular remittances or pension providing them with different livelihood

options. In their study, Ellis & Freeman (2004) found that low household incomes in rural areas are associated with low land and livestock holdings, high reliance on food crop agriculture, and low monetization of the rural economy. The authors argue that better off households are distinguished by worthy accumulation characteristically involving diverse livestock ownership, engagement in non-farm self-employment, and diversity of on-farm and non-farm income sources. The main indicator of a livelihood process is the livelihood's portfolio or livelihood's outcome, which is most directly measured by the composition and level of incomes of the household. To illustrate the non-farm activities prominence in livelihood strategies, Ellis (2000) found that income composition of a rural household in developing countries comprises 40 per cent farm activities, 13 per cent off-farm activities and 47 per cent non-farm activities. This expounds the significance of income during household livelihood diversification process, often secured multiple sources.

iv) Natural Assets

Natural capital relates to the use and availability of natural resources including land, water, environmental resources like forests, and activities such as hunting wild animals and gathering wild vegetables. A household in Kenya is regarded as having no natural capital either because it has no landholding at all or where a landholding is owned, the household does not carry out any agricultural activity such as crop cultivation or livestock keeping (Republic of Kenya, 2008, 2007). Landless households include those engaged in non-agricultural activities, those practicing little agriculture on tiny pieces of land (less than 0.01 ha), and those rearing livestock on communal land. Republic of Kenya (2008, 2007) report shows that, on average, 30 per cent of rural households are landless and do not practice agriculture as an option for their livelihood.

The main feature of the environment in which natural capital occurs in rural Kenya is that about one-third of land is arable while the rest is arid and semi-arid lands (Mwang'ombe, et al., 2011). The arable lands have sustainable environment in terms of rainfall and fertility for crop and dairy production all year round. However, in the ASALs, rainfall is generally not adequate, and a majority of the households engage in

rearing of livestock as one of their key economic activity. The feature of natural capital in the arable lands can be described mainly as enabling while in the ASALs it is mainly disabling. These differences in the capital asset environment have implications on poverty. For example, the proportion of the households living in absolute poverty in arable lands is lower (for example 24.3 per cent in the Central Region) than the proportion of the households living in the ASALs (for instance 66.1 per cent in the North Eastern Region) (Republic of Kenya, 2007). Therefore land, as a natural resource in ASAL areas compared to arable land, is less productive leading to more incidents of poverty in marginal areas.

v) Social Assets

Social capital can best be understood as a means or a process for accessing various forms of resources and support through networks of social relations. According to Ellis (2000) rural households that are endowed with social capital will promote rural development and their welfare in terms of increased growth (for example incomes), positive changes including social (for example improved access to education, basic health, water and credit), political and cultural changes as well as traditions, customs, morals, ethics and attitudes. Social capital is thus important in improving the livelihoods of rural people directly and indirectly through increase in access to goods and services. Again, Ellis (2000) reveals the significance of various asset types, including social capital in underpinning the livelihood strategies of the individual and household. The access attribute of a livelihood, which includes rules and social relations subsumed under the asset type, is important in determining the ability of people in the rural areas to own, control, claim and make use of a resource as well as the ability to participate in and derive benefits from social and public services that are provided by the state such as education, health services, roads, water supplies and extension services. Social capital is therefore essential for facilitating and sustaining diverse income portfolios and access to opportunities and other resources to individual households (Bebbington & Perreault, 2008). Baron et al. (2000) emphasize that social capital is a useful resource that underpins the livelihood strategies of the rural households as it enables participants to

act together more effectively in pursuit of shared objectives. The authors explain that social capital enhances rural livelihood directly and also increases access by people to goods and services particularly those that exhibit public good characteristics.

It is thus concluded that households do access and possess resources based on which they apply to earn a living. However, there is limited knowledge on households in specific circumstances like ASAL conditions. This study endeavoured to fill in the gap by establishing household resource endowments in the study area. In the next section, previous studies are reviewed on how rural households use livelihood assets to diversify their livelihood choices.

b) Rural Livelihood Choices

Rural households engage in a variety of activities from which they choose to support their well-being. Various scholars have defined livelihood in different but related ways. Kgathi & Motsholapheko (2011) showed that livelihood activities are diversified with an average of four sources that jointly determine the living gained by the rural households. According to Loison (2015) livelihood activity is a means of gaining a living, while others view it as comprising capabilities, assets and activities required for a way of living. Often, households diversify livelihood activities to guarantee survival in case there is failure in one or the other. Again definition of livelihood diversification varies amongst scholars. It is defined as the course by which households establish progressively diverse livelihood portfolios (Niehof, 2004); adequate stocks and flows of cash to meet basic needs (Hilson, 2016); and as a form of self-insurance (Barret et al., 2001). ADB (2004) also explains that a livelihood is sustainable if it has capacity to meet the immediate needs and recover from shocks and stresses without undermining the natural resources base.

Recent studies have identified several types of livelihood diversification activities adopted by rural households in developing countries (Sherren et al., 2016; Hilson, 2016; Gebru & Beyene, 2012). The authors contend that there are four distinct rural livelihood

strategies, including on-farm agricultural production, unskilled on-farm or off-farm wage employment and non-farm earnings from trades, commerce and skilled employment and the fourth is a mixed strategy that combines all the three strategies. The components of rural livelihood diversification are also classified by sector as farm or non-farm, by function as wage employment or self-employment or by location as on-farm or off-farm (Bowen & De Master, 2011; Loison, 2015). Two opposing theories have been advanced with regard to the actual driving force that cause emergence of rural livelihood diversification, the "agriculture optimistic" and "agriculture sceptic" theories (Ellis & Freeman, 2005). According to the agriculture optimist stance, rural livelihoods diversification emerges as a result of success in agriculture, that is agriculture is the driver of on-farm opportunities in rural areas. The opposing view (agriculture sceptic) sees diversification as responding to the failure of agriculture to generate sufficient secure livelihoods for those in rural areas.

A study by Heffernan & Misturelli (2000) on livelihoods of ASAL communities in Kenya found that households in rural Kenya pursue a wide variety of activities. Over 30 activities were reported across six districts. On average, however, they found that rural households are involved in 3.6 different livelihood activities. The main livelihood activities include livestock related (livestock marketing, hides and skins, butchery, herding and sale of livestock products), fruit and vegetable, casual labour, firewood and charcoal, business, employment, kiosk and hotel, and handcraft manufacture. Based on these findings, two main categories of livelihoods relevant in the study area may be discerned, that is, on-farm and non-farm. On-farm activities are largely classified as crop and livestock activities; and non-farm as off-farm and forest-based activities. In the sections that follow, review of previous studies on these four livelihood activities has been done.

i) **Forest-based Activities**

Forests are an important resource as many people rely heavily on them for their livelihoods. Some use it for household use/subsistence, that is, timber, fuelwood, wild foods (animals and plants), medicinal plants, other non-timber forest products, grazing

for animals, forest-based agriculture, and nutrient supplements for agriculture. Others use forests for food, while, others use forest for income generation, that is, sale of the above products, or sale of agricultural or livestock production dependent on forests. Lastly, some people are dependent on income from forest-based labour by working in different forest-based works. Previous studies (Velded et al., 2007; WRI, 2007) indicate that as much as 20–25% of people's rural income may be derived from the environment in developing countries. Poor people typically engage more in low return forest activities, but often fail to accumulate capital from such activities.

ii) **Cropping Activities**

Crop expansion is one of the coping mechanisms for managing food security, production and market risks. For example, crop diversification was the single most important source of poverty reduction for small farmers in South and Southeast Asia (FAO & World Bank, 2001). In consistent with this finding, Winters et al. (2006) identified three key factors that drive farmers' motivation for crop diversity: i) managing risk, ii) adapting to heterogeneous agro-ecological production conditions, and iii) meeting market demands and food security. Degye et al. (2012) in their study also confirmed that households in Central and Eastern highlands of Ethiopia would be able to improve their food security conditions by enhancing their crop diversification. With heterogeneity in agro-ecological, social and economic conditions, farmers' agriculture in Kenya is also highly diversified to meet own consumption and market needs, to withstand price fluctuation and to manage income risks. Crop diversification is therefore considered as an important step in the transition from subsistence to commercial agriculture. As Minot et al. (2006) found out, a shift from food production for own consumption to a cash crop production contributes to improvement of income for smallholders. A number of studies have been carried out to analyse factors affecting the decision and level of crop diversification. Weiss and Briglauer (2000) found that farm size, part-time farming, education, family size and the location of the district are significant determinants of farm diversification in Australia. Furthermore, a study by Windle and Rolfe (2005), reported that debt, age,

education, number of children, off-farm income, farm size, start-up cost, net income, other crops grown and risk time are the most determinant factors.

iii) **Livestock-based Activities**

In many developing countries as is the case in Kenya, rural households earn a living from livestock farming and consider keeping livestock as a store of wealth (Mandleni & Anim, 2012). Livestock makes a multifaceted contribution to the social and economic development of the rural populations. It is also a fact that livestock farming is an important component of the agricultural economy, especially in most developing countries (Baker, 2012). Several factors have contributed both positively and negatively to changes in livestock numbers. Some of these factors are economic growth and increased incomes (Steinfeld et al., 2006a); increase in demand for livestock products arising from rapid growth in human population and urbanization (Delgado et al., 1999; Thornton, 2010); developments in breeding, nutrition and animal health (Thornton, 2010); rapid technology innovation (Rae, 2008; Nouman et al., 2014); changing food preferences (FAO, 2009); changes in climatic conditions (Mandleni, 2011), and genetic improvements (Adkinson & Adkinson, 2013). In West Africa, livestock plays an important role in the rural livelihoods by providing different functions, such as food, income, and other cultural and social functions. For the average rural farmer, livestock, at household level, contributes to poverty reduction (Truong et al., 2019). Mwangi (2013) also adds that socio-economic and environmental factors such as population growth, urbanization and economic development, changing livestock market demands, impacts of climate variability and science and technology trends have contributed to the changes in livestock numbers in Kenya.

iv) **Off-farm Activities**

In recent times, there has been an increasing recognition that the rural economy is not confined to the agricultural sector alone (Csaki & Lerman, 2000). This is because the number of poor people in rural areas exceeds the capacity of agriculture to provide sustainable livelihood opportunities in many parts of the world (Davis & Bezemer, 2004). Also as was found in Ghana (Bacho, 2004), the ability of agriculture alone to

continue sustaining livelihoods of farm households in some parts of the rural north was uncertain.

For most rural people in developing and transitional economies therefore, non-farm economic activities are part of a diversified livelihood portfolio (Davis & Bedemer, 2004). Especially, finding part-time or part-year local non-farm employment is vital for people living on small farms in zones with single agricultural seasons and relatively low agricultural productivity. Such employment provides vital income diversification, and therefore, harmonising new efforts to support household income diversification by enabling the growth and security of the household enterprise sector are central to this transformation process (Felicity, 2014). Gordon & Graig (2001) found that rural non-farm economic activities may among other things absorb surplus labour in rural areas, help farm-based households spread risks, offer more remunerative activities to supplement or replace agricultural income, offer income potential during the agricultural off-season, and provide a means to cope or survive when farming fails. Therefore, as in most rural areas, the main source of household enterprise set up capital is own savings from agricultural activities (39 per cent), followed by savings from proceeds from non-agricultural activities (17 per cent), loans from family and friends (5 per cent) and proceeds from another business (4 per cent) (Felicity, 2014). These are critical considerations for strategies to open up opportunities for off-farm activities.

The farm and non-farm economy may be linked directly through production activities, or indirectly through incomes or by investment (Saumya et al., 2011). These linkages are important in the development of non-farm enterprises in developing countries and transition economies (Davis & Bedemer, 2004). The potential role of the rural non-farm sector in sustaining rural livelihood which was not traditionally regarded as important, has attracted the attention of the Kenya government and other development organizations. Government policies and strategies are now focused on the development of the agricultural sector and the generation of non-farming opportunities in rural areas across the country (Government of Kenya, 2007). In the face of acute weather variability, off-farm activities could become attractive adaptation options to agricultural

activities. Although rural households tend to turn to off-farm activities to meet their needs and offset income shortfalls, participation appears to be constrained by capital assets – human, social, financial and physical. In their study of off-farm employment participation in Honduras, Ruben and van den Berg (2000) showed that educated and wealthier households take advantage of their human and physical capital by participating more in off-farm activities. The limitations from access to credit and lack of education are also highlighted by Escobal's (2001) study of income diversification in Peru.

It is thus concluded in this study that rural households are constantly involved in strategies to diversify livelihood activities as a way of securing lives by engaging in both farm and non-farm activities. Attention is now turned on previous work on livelihood assets and choices dependence.

c) Household Assets and Livelihood Choices

The theory of livelihoods places emphasis on the urgency for maintaining people's possessions including capital assets as a prerequisite for survival (Buckland, 2005). In rural Kenya, as in other rural areas, households depend for their livelihoods on five capital assets including natural capital, physical capital, human capital, financial capital and social capital. Access to all capital types is required for a sustainable livelihood (Heffernan & Misturelli, 2000). The analysis of rural livelihood choices is complex because households engage in a variety of economic activities. Underscoring the fact that livelihood is more than just a matter of finding food, shelter and clothing, Sandra Wallman (cited by Long 2000) states:

> *"Livelihood is never just a matter of finding or making shelter, transacting money, getting food to put on the family table or to exchange on the market place. It is equally a matter of ownership and circulation of information, the management of skills and relationships, and the affirmation of personal identity"*.

Taking the above broad perspective, livelihood approaches place "people and their priorities to choose activities as a means of living" at the centre of development efforts. Reviewing the literature, Scoones (2009) identified "livelihoods" as a mobile and flexible term, which can be related to locales (rural or urban livelihoods), occupations (farming, pastoral or fishing livelihoods), social difference (gendered or age defined livelihoods), directions (livelihood trajectories), dynamic patterns (sustainable or resilient livelihoods) and much more. People thus make their living by combining a complex web of activities and interactions. According to previous studies (Ellis & Freeman, 2004; Ellis, 2000; Barrett et al., 2001; Deininger & Olinte, 2001), rural households diversify their livelihood activities to generate income and better cope with adverse factors and events that affect agriculture. The strategies households adopt when choosing among livelihood options are determined by a range of socio-economic factors (Tesfaye et al., 2011; Eneyew, 2012). Although rural households in developing countries pursue a wide range of livelihood activities (Babulo et al., 2008), there is a common notion that there exists, to some degree, distinct livelihood strategies across rural households (van de Berg, 2010). However, while the relevant literature is growing because of its policy relevance, the number of relevant studies is still quite small (Ellis & Freeman, 2004).

In summary, the importance of livelihood assets in influencing the livelihood choices is thus found to be significant. The different assets are crucial factors behind livelihood diversification in the rural areas and their access by households determines the scale to which assets are employed to determine a particular livelihood choice. However, in reviewing literature there was limited knowledge on how each of the livelihood assets influences livelihood choice. Consequently, studies on rural household livelihood strategies, particularly on the types of strategies that rural households typically adopt and the factors that shape these strategies are rare. Understanding these relationships has important implications for realizing a win-win for rural environmental protection and rural household livelihood improvement. This study therefore set out to establish the

specific livelihood asset endowment in the study area, and determined how these assets affect livelihood choices of households in the study area.

2.3.3 The Impact of Rural Livelihood Choices on Environmental Degradation

Objective three of this study deals with the impact of livelihood activity choices on environmental degradation. Chopra (2016) defines environment as the physical surrounding of human beings of which they are a part and on which they are dependent for livelihoods. Their physical environment stretches from air, water and land to natural resources like energy carriers, soil and plants, animals and ecosystems. The relationship between physical environment and the well-being of individuals and societies is multifold and multifaceted with a qualitative as well as a quantitative aspect to it. According to Chopra (2016), the major causes of environmental degradation include modern urbanization, industrialization, over-population, deforestation among others, and the different kinds of human activities are the main reasons of environmental degradation. Such human activities include deforestation, that is destruction of the natural vegetation through farming, road construction and lumbering; use of fertilizers, pesticides and herbicides which may pollute water and even affect the soil; oil exploration which can lead to oil spillage thereby damaging farmlands, vegetation and aquatic lives; and agricultural practices such as overgrazing and bush burning (Ibimilua, 2011). Others are damming of rivers thereby interrupting natural flow; industrialization which leads to air, land and water pollution; hunting which has greatly contributed to biodiversity loss or extinction of some animals. Management and utilization of natural resources is often considered as the most critical environmental problem in developing countries. A rural poverty report (IFAD, 2001) shows that common environmental challenges in the study area are water scarcity, forest biodiversity loss (deforestation) and land degradation through soil erosion.

It is thus concluded that environment degradation is largely an artificial phenomenon occasioned by human beings. In the following section, a review of relevant literature on

the relationship between local livelihood choices and environmental degradation phenomena is carried out.

a) Rural Livelihoods Impact on Water Scarcity

i) Forest Activities and Water Scarcity

Loss of indigenous forests and their subsequent conversion to agricultural use in East Africa is one of the major threats to surface water quality (FAO, 2010). The World Development (World Bank, 2007) report indicates that major water catchment areas in Kenya have lost their forest cover over the years with the closed canopy forest cover currently standing at a paltry 2 per cent. Most of these forests are montane forests and they constitute the nation's water towers. The Mau Forest Complex, for instance, has witnessed considerable land use and land cover changes. According to Mati et al. (2008), between 1973 and 2000, there was a 32 per cent decrease in forest cover and a 203 per cent increase in agricultural cover in the Mara River basin. Other river catchments on the Kenyan side of the Lake Victoria basin have also undergone similar changes. Therefore, enhanced intensity of agriculture and deforestation have been linked to increasing magnitude and frequency of runoff events and reduced base flows, increased pesticide contamination, erosion and sedimentation of streams and rivers (Raini, 2009; Mati et al., 2008; Osano et al., 2003; Okungu & Opango, 2005), all of which have led to poor water quality unsuitable for human consumption.

ii) Cropping Activities and Water Scarcity

Agriculture, the largest industry in the world, is also the biggest threat to the environment. Inefficient food production and harmful agricultural subsidies are causing deforestation, water shortages and pollution. The main causes of water losses during farming according to Clay (2004) are leaky irrigation systems; wasteful field application methods; pollution by agrichemicals; and cultivation of thirsty crops not suited to the environment. In addition, agricultural activities involve opening and clearing of land which exposes the soil to evaporation that leads to water losses from the soil.

iii) Livestock Activities and Water Scarcity

Generally, use of water for livestock and its contribution to water depletion in developing countries are high. An increasing amount of water is needed to meet growing water requirements in the livestock production process, from feed production to product supply. For example, amongst past studies, water use per kilogramme of beef ranges from 27 to 200,000 L (Peters et al., 2010; Wiedemann et al., 2010). Water use for drinking and servicing animals is thus the most obvious demand for water resources related to livestock production. Livestock meet their water requirements through drinking water, the water contained in feedstuffs and metabolic water produced by oxidation of nutrients. Water is lost from the livestock bodies through respiration, evaporation, defecation and urination. Water losses increase with high temperature and low humidity (Schlink et al., 2010). According to Parker (2003), a wide range of interrelated factors influence livestock water needs. These include: the animal species; the physiological condition of the animal; the level of dry matter intake; the physical form of the diet; water availability and quality; temperature of the water offered; the ambient temperature and the production system. Water requirements per animal can be high, especially for those that are highly productive under warm and dry conditions. Production systems usually differ in their water use per animal and in how these requirements are met. In extensive systems, the effort expended by animals in search of feed and water increases the need for water considerably, compared to industrialized systems where animals do not move around much (FAO, 2018).

iv) Off-farm Activities and Water Scarcity

The non-farm economy has increasingly become the central focus of attention in rural development policy, due to its positive contribution to poverty reduction and food security (Davis, 2003; Lanjouw & Lanjouw, 2001). A study in Tanzania on determinants of rural labour market participation (Mduma & Wobst, 2005) shows partaking in non-farm activities is one of the livelihood strategies among poor rural households in many developing countries. Non-farm ventures like hotel business, among others require water to function and these do exert pressure on the water requirements. Households seeking

unskilled labour opportunities on irrigation farming enterprises also increases demand on water thus affecting its availability and adequacy. The construction industry associated with non-farm enterprises also exerts a further burden on the water requirement for construction and also personnel. Moreover agro-based industries like coffee, milk and fruit are heavily dependent on water availability, further straining on water availability for households. Therefore, engaging in the different livelihood activities, rural households' behaviour is partly responsible for water scarcity in the study area.

b) Rural Livelihoods Impact on Deforestation

i) Forest Activities and Deforestation

Evidence of rampant logging exists. A study on tropical forest management and biodiversity conservation (Putz et al., 2001) reported that logging, as one of the major forest activities, can seriously degrade forests. Also past studies (Margarida et al., 2014) found that fuelwood gathering is prevalent in tropical dry forests and degraded forest areas. In their study on deforestation in the tropics Chomitz et al. (2007), reported that logging and fuelwood results in deforestation and forest degradation in El Salvador. In the drier areas of tropics, fuelwood gathering can be a major cause of deforestation and degradation. Therefore, the rising demand for fuelwood and charcoal is also a major cause of deforestation and land degradation in this region where biomass is the main source of energy for domestic uses (Bensel, 2008). Babulo et al. (2009) and Thondhlana et al. (2012) have also argued that environmental resources provide a variety of life-supporting ecosystem services to rural households in developing countries such as timber, non-timber forest products and fish. Therefore extraction of environmental resources in rural areas is often considered an important source of income and a means of livelihoods for low income rural households (Kamanga, et al., 2009; Jansen et al., 2006), which results in the degradation of forests (Beck & Nesmith, 2001). Furthermore, fires are a major tool used in clearing the forest for shifting and permanent agriculture and for developing pastures. Although fire is a good servant in this regard, it has been a poor master. Fire used responsibly can be a valuable tool in agricultural and forest

management but if abused it can be a significant cause of deforestation (Chakravarty et al., 2012). Deforestation due to road pavements in Brazil has also led to higher incidences of forest fires (Nepstad et al., 2001; Carvalho et al., 2001).

ii) Cropping Activities and Deforestation

In most parts of the world, land degradation occurs due to human activities and natural factors. Ademiluyi et al. (2008) reported that Africa has among the fastest rates of deforestation in the world associated with competing land uses which are mainly agriculture and human settlements. In Kenya, strong competition for land has led to the clearing of forests for agricultural settlement (Stiftung, 2014; Oyono, et al., 2003) with logging and other reasons like roads, urbanization and fuelwood accounting for a substantial portion. Tropical forests are one of the last frontiers in the search for subsistence land for the most vulnerable people worldwide. However, as the land degrades, people are forced to migrate, exploring new forest frontiers increasing deforestation (Amor, 2008; Amor & Pfaff, 2008; Wilkie et al., 2000). Shifting agriculture also called "slash and burn agriculture" has often been reported to be the main agent of deforestation. Previous studies have also shown that smallholder production results in deforestation (Pacheco, 2009).

iii) Livestock Activities and Deforestation

Forests are also increasingly being cleared to grow crops such as soy beans and cereals to feed livestock (FAO, 2006). The growth in cattle ranching has expanded rapidly in Brazil. Deforestation in this area is predominantly caused by livestock farming by small-scale traditional ranchers and by large-scale commercial intensive systems. Since 1988, the Brazilian Amazon has lost around 1.8 million ha per year to deforestation (Verweij et al., 2009). The role of cattle in deforestation varies, depending upon the type of production system. For example, large-scale "investment ranchers" utilize cattle as a financial investment among the available alternatives. Various studies (for example Lamy et al., 2012) have identified primary factors arising from livestock farming that causes deforestation and these include favourable markets for livestock products; government subsidies for livestock credit and road construction; land tenure policies that

promote deforestation to establish property rights; slow technological development that favours extensive systems; and policies which depress timber prices and make logging a poor alternative investment. Others are reduced violence which lowers the risk of ranching in remote frontiers; special characteristics of cattle such as low labour needs, limited supervision requirements in extensive systems, transportability, limited risk, prestige value, limited need for cash inputs, and biological and financial flexibility; indirect financial benefits of cattle production such as wealth maintenance, cash flow and risk reduction through diversification; and use of cattle as a production input for other farming activities, that is, manure for fertilization and provision of draft power (Thornton, 2010).

iv) Off-farm Activities and Deforestation

Expanding cities and towns require land to establish the infrastructure necessary to support the growing population to engage in off-farm activities, which is done by clearing the forests (Mather, 1991; Sands, 2005). Forests are a major target of infrastructure developments for oil exploitation, logging concessions or hydropower dam constructions, which inevitably calls for the expansion of the road network and the construction of roads in virgin areas (Tracy et al., 2017). The construction of roads, railways, bridges and airports opens up the land to development and brings increasing numbers of people to the forest frontier. Whether supported or not by the governmental programmes, these settlers have usually colonized the forest by using logging trails or new roads to access the forest for subsistence land (Wilkie et al., 2000; Amor, 2008; Amor & Pfaff, 2008). National parks and sanctuaries undoubtedly protect the forests, but unregulated opening of these areas to the public for off-farm activities like tourism is damaging. Unfortunately, the national governments of tropical and sub-tropical countries adopt tourism as an easy way of making money sacrificing the stringent management strategies. Further, many companies and resorts who advertise themselves as eco-tourist establishments are in fact exploiting the forests for profit. In fact, in the name of eco-tourism, infrastructure development is taking place mostly by the private players in these wilderness areas which are further detrimental in terms of attracting

people other than tourists also, causing deforestation especially deep in the forest. Therefore, different activities by household results in direct or indirect environmental degradation through deforestation.

c) Rural Livelihoods Impact on Soil Erosion

i) Forest Activities and Soil Erosion

Studies have shown that 40 per cent vegetation cover is considered critical, below which accelerated erosion dominates on sloping land (Van-Camp et al., 2004), which could be the case in arid and semi-arid areas. In the Chinese Loess Plateau, study findings show that an increase in grassland and forestland by 42 per cent and a corresponding decrease in farmland by 46 per cent reduced sediment production mainly due to gully erosion by 31 per cent in the catchment (Valentin et al., 2005). Moreover Fu et al. (2005), reported that the influence of human activities on the Loess Plateau were categorised as incessant and extensive pressures like overgrazing and large scale agriculture. Further, Zheng (2005) found that almost 70 per cent of the total area of the Loess Plateau was affected by soil erosion, which concurred with Fu et al., (2005) suggestion that soil erosion rate estimates on the Loess Plateau ranged from 5,000 to 25,000 Mg ha/1yr/1 as a result of human activities.

Studies by Johansson et al. (2002) in the semi-arid catchment of Lake Baringo show that the clearance of the forest resulted in a larger proportion of the rain surface runoff. Also findings by King (2008) in Baringo District showed that ground cover (*Aloe secundiflora* shrubs) prevented erosion, reduced surface water flow velocities and wind speed. Gicheru et al. (2012) in Narok observed that the loss of land cover (grass, bushes and trees) further reduced pasture availability for livestock, resulting in increased exposure of the soil to erosion. In a study by Fentahun et al. (2014) to examine the trend of land use and land cover changes in Bantinaka watershed in Southern Ethiopia, results showed that the expansion of cultivated land was at the expense of forest land.

Furthermore, cultivated lands were extended into fragile areas due to the shortage of land, resulting in soil erosion.

Zhou et al. (2009) in Shaanxi Province in China, showed that a 1.2 per cent conversion to forest per year may lead to a 10 per cent or more yearly reduction of the annual sediment volume delivered to the main rivers. In addition, Li et al. (2010) in China's Loess Plateau Region, showed that the total area of forestland and grassland increased from 27.4 per cent to 34.2 per cent, which resulted in a 3.6–35.3 per cent reduction in overland flow. These results suggest that the land use changes gave rise to a mean erosion reduction of 38.8 per cent. Also, Duvert et al. (2010) in their study in the Mexican Central Highlands, showed that traditional cropping practices with cattle grazing in the forest leads to severe soil degradation in the Cointzio basin. Favreau et al. (2009) in a study of Southwest Niger, showed that land clearing increased surface runoff volume by a factor close to 3 (runoff volume), with a 2.5-fold increase in gullies.

ii) Cropping Activities and Soil Erosion

A study on soil conservation and small-scale production in Ethiopia (Medhin & Khlin, 2008) showed that agriculture is characterised by one of the lowest productivity levels as a result of soil degradation. Agricultural practices can stimulate erosion through soil compaction, thereby reducing water holding capacity and increasing soil erodibility. A high degree of agricultural intensity without adequate soil conservation measures can be directly linked to greater water erosion in the high-risk areas. Slopes steeper than 10 to 30 per cent are however prone to water erosion when cultivated (Kodiwo et al., 2013).

Cultivation in steep slopes is widely practiced in Kenya, hence higher likelihoods of soil erosion. Conventional cultivation techniques (compared to no-till or minimum-till), expose bare soil to rain, which is more serious in arid and semi-arid areas. Mwangi et al. (2015) in a study in Sasumua catchment show that land management practices such as intensive cultivation of horticultural crops, overgrazing of pasture land and farming on steep areas were contributing to soil degradation. During dry years, farmers will generally have reduced cropping seasons (Frankl, 2012), therefore timing of cultivation

is critical. Farming practices associated with some crops encourage runoff and erosion. For example, cultivation of potatoes in rows and ridges channel runoff (Boardman et al., 2003). According to Forsyth (2007), erosion from rain-fed rice had the highest rates of erosion of 60 tons per hectare per crop cycle, while maize and beans were least erosive with median soil losses of 19 and 10 tons per hectare per crop cycle, respectively. Erosion in cabbage fields lay in between these two extremes.

Research by Turkelboom et al. (2008) in Northern Thailand showed that land-use changes at Pakha led to the concentration of agricultural activities in certain parts of the catchment, change in crop types, increase of tillage operations, and the expansion of paths and irrigation infrastructure. A research by Mugagga et al. (2010) in Mount Elgon, Eastern Uganda showed that slash and burn is a very common and rapidly expanding practice in the non-irrigated marginal cultivated uplands of the Mt. Elgon catchment area. As a result, various forms of erosion (including rills, gullies and sheet) were observed in the fields that have been prepared using this method. Slash and burn is common in the arid and semi-arid areas of Kenya and is therefore of concern. Soil losses by erosion on the fields ploughed on the upstream-downstream direction, which are cultivated with maize, are of 7.48 t/ha. In sunflower, cultivated with the conventional soil tillage system, the annual eroded soil was estimated at 3.044 t/ha, and by wheat straw and green fertilizer incorporation into soil, erosion has decreased at 2.327 t/ha and 0.937 t/ha, respectively (Mitova, 2006). Studies carried out on a 9 per cent slope of Luvisol, in the Centre of Croatia, have shown that ploughing on the upstream-downstream direction results in soil loss through erosion of between 38.18 and 5.10 t/ha, and in case of deep ploughing of between 5.25 and 0.18 t/ha (Kisic, 2006).

iii) Livestock Activities and Soil Erosion

In a study by Renison et al. (2010) in Central Argentina, results show that degradation of forests and their soils is triggered by domestic livestock rearing. Overgrazing is more common in drier areas of the tropics where pastures degraded by overgrazing are subject to soil erosion. Research in Zimbabwe by Makwara et al. (2012) showed that crop residue is either removed for storage as dry season fodder or it gets cleared by freely

moving livestock from May to mid-November. Therefore it was not surprising that over 25 per cent of the area was found to be seriously eroded as a result of livestock grazing.

Grazed fields and abandoned crop fields tend to be more susceptible to potential gully erosion. Also grazing intensity, duration and frequency, as well as timing of grazing relative to vegetation availability, has been identified as a factor affecting ecosystem and rangeland health (Veblen et al., 2014). Grazing intensity must be closely managed to maintain a ground cover of perennial grasses at 60 per cent or higher. If the grasses cover drops below this value, a key biophysical threshold is surpassed with potentially dire consequences involving reductions in grass cover, increase in bare soil, decrease in infiltration, and increase in soil erosion and further reductions in grass (Sannwald et al., 2006).

Research among the Gabbra and Samburu pastoral communities in Marsabit sub-county by Okoti et al. (2006), showed that there is increased soil erosion, especially in places near the mountain areas and near settlements due to animal trampling and cutting of vegetation. The same results were also observed in some places where people had settled. Gicheru et al. (2012) also observed that overgrazing, intensive cultivation and erosion by water affected soil quality in Sasumua Catchment. Furthermore, Amman et al. (2004) reported that high livestock levels resulted in degradation, especially during critical periods of drought in Narok. A study by Johansson et al. (2002) in the semi-arid catchment of Lake Baringo also illustrated that switching from livestock keeping to goats resulted in the goats eating much more bushes and twigs. But on the other hand this led to an even harder pressure on the remaining vegetation, leading to soil erosion. Also, as animals consume vegetation and trample, they break the lower vegetation and root system leading to gully erosion that is a common occurrence in the arid areas. Therefore, consumption of plant cover by livestock has a major impact and overgrazing is believed to contribute substantially to desertification and land degradation (Omar et al., 2013).

iv) Off-farm Activities and Soil Erosion

Non-farm infrastructure in eco-tourist hotels and national parks accompanying constructions entails vegetation clearing and soil excavation, both of which can accelerate soil erosion by wind and/or water. Furthermore, water harvesting from building roof tops would require structures without which leads to uncontrolled water runoff that leads to soil erosion.

From literature it is ascertained that household livelihood activities have negative impact on the environment. These activities cause environmental degradation by causing water scarcity, deforestation and soil erosion. Review of previous studies also reveals gaps in knowledge in regard to the extent of the impact, although the information on some of the activities' impact on the environment was scarce. For example, off-farm activities impact knowledge on the environment was limited, thus forming part of the rationale for the study to identify and fill in research gaps.

2.3.4 Moderating Effect of Extension Services on Livelihood Choices

The fourth objective of the study was to determine the moderating effect of rural extension services on livelihood choices. Rural extension and advisory services play an important role in agricultural development and can contribute to improving the welfare of households living in rural areas.

a) Rural Extension Services

In their study on rural extension services, Anderson and Feder (2003) define agricultural extension and advisory services as "the entire set of organisations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods". Extension can thus contribute to the reduction of the productivity differential by increasing the speed of technology transfer and by increasing farmers' knowledge and assisting them in improving farm management practices (Feder et al., 2004b). Additionally, extension

services also play an important role in improving the information flow from rural households to scientists (Anderson, 2007). As a system, adds Christoplos (2010), extension facilitates the access of farmers, their organizations and other market actors to knowledge, information and technologies. Also, extension facilitates farmers' interaction with partners in research, education, agribusiness and other relevant institutions; and assists them to develop their own technical, organizational and managerial skills and practices.

A range of approaches to extension delivery have been promoted over the years. Early models focusing on transfer of technology using a "top-down" linear approach were criticised due to the passive role allocated to farmers, as well as the failure to factor in the diversity of the socio-economic and institutional environments facing farmers and ultimately in generating behaviour change (Birner et al., 2006). A number of models have been implemented since the 1970s, combining approaches to outreach services and adult education, including the World Bank's Training and Visit (T&V) model (Anderson et al., 2006), participatory approaches (Wasudha et al., 2018), and farmer field schools (FFSs) (van den Berg & Jiggins, 2007). Additional extension modalities include ICT-based delivery which provides advice to farmers online and other approaches such as the promotion of model farms (Birner et al., 2006).

For decades now, the approach to extension service delivery has drawn increasingly on more participatory methods. The main objective of participatory approaches to agricultural extension is to empower rural households where the role of extensionists shifts from "teachers" to "facilitators" in the process. Unfortunately, evidence assessing impact of such methods appears limited at best, but initial searches identified an evaluation of a participatory group extension approach in Egypt (Hannover & El Wafa, 2003). In the past, extension services were taken to the rural households, whether in groups or individually through the training-and-visit approach. However, in recent times, and with the new agricultural policies, extension services are provided to farmers only upon request, using a demand-driven approach. The demand-driven approach assumes that farmers who are eager for agricultural advice will ask for it, unlike the training-and-

visit approach that imposes learning on the farmers without them seeing the need for it (World Bank, 2004).

b) Impact of Extension Programmes on Livelihood Choices

While there is a large literature dealing with issues related to agricultural extension in developing countries, rigorous impact evaluations of agricultural extension interventions are not common. This is partly due to the complexity of evaluating such interventions in the face of the wide range of additional factors that influence agricultural outcomes. Some of these factors include agro-ecological climate, weather events, availability and prices of inputs, market access and farmers' characteristics. In addition, biases inherent in attributing the impact of extension services on agricultural production mean that measured effects might result from pre-existing differences rather than the programme under evaluation (Wu et al., 2005). Romani et al. (2003) highlight three common types of bias. Endogenous placement bias may occur where programmes are situated in areas seen as more likely to be receptive to extension services. Selection bias occurs where skilled and knowledgeable farmers are more likely to seek out extension services, and although this source of bias may be reduced if extension agents initiate contact with the farmers, agents themselves may also rather work with more experienced farmers. Simultaneity bias arises in the sample of farmers visited by extension services if farmers only contact extension agents when they have problems. These biases are well known (Romani et al., 2003), but nevertheless, the analyses used in most evaluations do not allow for their control.

Nonetheless, evaluations and meta-evaluations have been conducted, as synopsised in a number of literature analyses (Anderson, 2007; van den Berg & Jiggins, 2007; Anderson & Feder, 2003) and one meta-analysis (Alston et al., 2000). Most of these studies draw on data that were not collected to high quality standards of impact evaluation, that is, utilising experimental or quasi-experimental design in attributing the impact of extension services on outcomes of interest. Nonetheless, Anderson & Feder (2003) assessed the impact of World Bank support to the development of national research and

extension systems in the 1980s and 1990s. The study concluded that, despite serious limitations in the systems receiving support, significant positive effects of World Bank interventions were identified. However, this is also based on a review of project completion reports rather than impact evaluative evidence.

Evidence exists supporting the role of extension services in rural livelihoods. Birner et al. (2006) found that agricultural extension encompasses the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods and well-being. Since a livelihood comprises the capabilities, assets and activities required for a means of living, it thus appears that agricultural extension intends not only to increase productivity and income (Waddington et al., 2010; Anderson & Feder, 2007), but also to improve multi-faceted aspects of rural life. Often times though, extension impacts have been associated with improvements in productivity and household income. However, a universal review of extension services shows that the impact of extension services on rural livelihoods is mixed (Anderson & Feder, 2007; Rivera et al., 2001). While high rates of return in some cases have been noted, negligible achievements in other cases have been reported. In coherence with these findings, Anderson & Feder (2007) also acknowledge that estimation of extension impact on rural livelihoods is challenging in terms of dealing with attribution issues and linking cause and effect quantitatively.

In summary, the literature review shows that there is limited knowledge of evaluation of impact of extension services on livelihood choices. Although the aim of extension services is to provide information to rural households to adopt livelihood activities in a sustainable manner, their impact is minimal. Therefore, the study endeavoured to find out the impact of extension in the study area in terms of its effect on livelihood choices in order to understand why in spite of the extension services in the area, environmental degradation on the study area continue unabated.

Based on the above literature review, a critique is provided on empirical evidence and identified research gaps addressed by this study. Also expounded in the following sections is the conceptual framework that was used for the study.

2.4 Critique of Empirical Evidence

Empirical perspectives reviewed above reveal mixed findings from studies related to the impact of rural livelihoods on environmental degradation, especially with regard to livelihood choices impact on water scarcity, deforestation and soil erosion alongside provision of extension services as per the objectives of this study.

In general, conclusions are based on studies carried out in different regions mainly in developing countries and employing varied approaches. Given the contextual diversity of socio-economic contexts and heterogeneity rural extension programmes, the conclusions arrived at from the literature review were not necessarily reflecting the Kenyan context. Moreover, measures of data sets applied in cited evidence was partially reported. Also, methods used in the reviewed literature were of a quantitative nature, yet most of the objectives would have been best answered using qualitative methods that were not fully operationalized through mixed approaches. Furthermore, most of the conclusions of the reviewed studies fell short of contribution to existing knowledge about the livelihoods and environmental degradation issues, signifying the inappropriateness of some of the research methods applied.

In literature, it is also shown that evaluating the impact of extension services is challenging because of the influence of other factors, though limited studies show that this is practically possible. Many studies cited as empirical evidence in this review come from the Asian continent and other parts of the African continent, whose context under which livelihood choices occurs may be different in the Kenyan context, hence the need for more evidence reflecting the Kenyan perspective. In literature also, common livelihood activities practices in rural areas are either farm or non-farm based. Studies show that in areas of similar conditions, households adopt one or a mix of various

livelihood choices. Furthermore, despite the availability of empirical evidence regarding the impact of local institutions on livelihood choices, there is a deficiency of evidence on social capital in relation to livelihood choices and environmental management. It is consequently important to establish the role of local institutions like self-help groups in enhancing the rural livelihood outcomes in ASAL areas, given that most households in these areas commonly access rural services like extension services through membership in local community groups.

2.5 Research Gaps

Livelihoods are necessary if rural households are to survive the vagaries of marginalised ASAL areas, but few studies have assessed the impact of rural livelihoods on environmental degradation in a single study, particularly in ASAL areas. Besides, other than contextual issues, methodologies used in previous studies were mainly quantitative, with data sets that fail to elucidate the rationale of livelihood choices that fall beyond quantitative justification. This study sought to fill this knowledge gap, and contribute to knowledge on impacts of rural livelihoods on environmental degradation in the ASAL areas in Kenya. In providing insights into the rural livelihood choices of Kieni East and Kieni West sub-counties, the study also sought to enrich existing knowledge on sustainable rural development outcomes by taking into consideration both livelihood choices and environmental degradation components, and a holistic approach to the concept of sustainable environmental management that defines sustainable development as a multi-dimensional model, especially in light of mixed empirical studies.

Moreover, the study area is uniquely contextualized, as it is sandwiched on the leeward sides of two water towers in Kenya (that is Mt. Kenya and the Aberdare Ranges). The area is identified as ASAL with immigrants from neighbouring counties which are agriculturally of high potential. Few, if not limited, livelihood/environment studies have been conducted in the area, which is important to policy and development practitioners involved in development and environmental conservation issues in the area. Also though in literature characterization of the households of the area exists, those that are relevant

in understanding the basis of livelihood adoption by households is extremely limited. While studies on how the livelihood activities impact on the environment are not evident, the moderating effect of extension services in the study area is a subject of concern since the local (and national) narrative in the area is that environmental degradation continues unabated despite the sustainable development initiatives being rolled out in the area.

Therefore the need for further understanding of rural livelihood choices and environmental degradation dependence is apparent as it will help to reduce and prevent livelihood stresses induced by the degradation of environmental resources during the development process, especially for these low income households. Details of the conceptual framework for investigating livelihood environmental nexus are expounded in the following section.

2.6 Conceptual Framework for the Study

The conceptual framework for this study was a modified version of the Sustainable Livelihood Approach (SLA), which has gained extensive appreciation as an investigative tool for understanding the dynamic dimensions of livelihoods, leading to interventions (Tao & Wall, 2009). Likewise, sustainable livelihood concept has been found to be a useful framework for studies that seek to balance conservation initiatives with development considerations in local communities. As argued earlier, focusing on assets, capabilities and activities, the approach underscores site specific enquiry of social agency based on local priorities and interpretation within a broader context of stresses, shocks and transforming structures and processes (Scoones & Wolmer, 2003). The DFID framework (DFID, 2000) looks at livelihood diversification through the lens of diversification based on household vulnerability context, asset base and policy processes. Therefore, the framework fits well with emphasis on the theoretical approaches described above (see Figure 2.2), with five key components: socio-economic context, livelihood assets, livelihood choices, extension service support activities and environmental degradation as part of livelihood outcome.

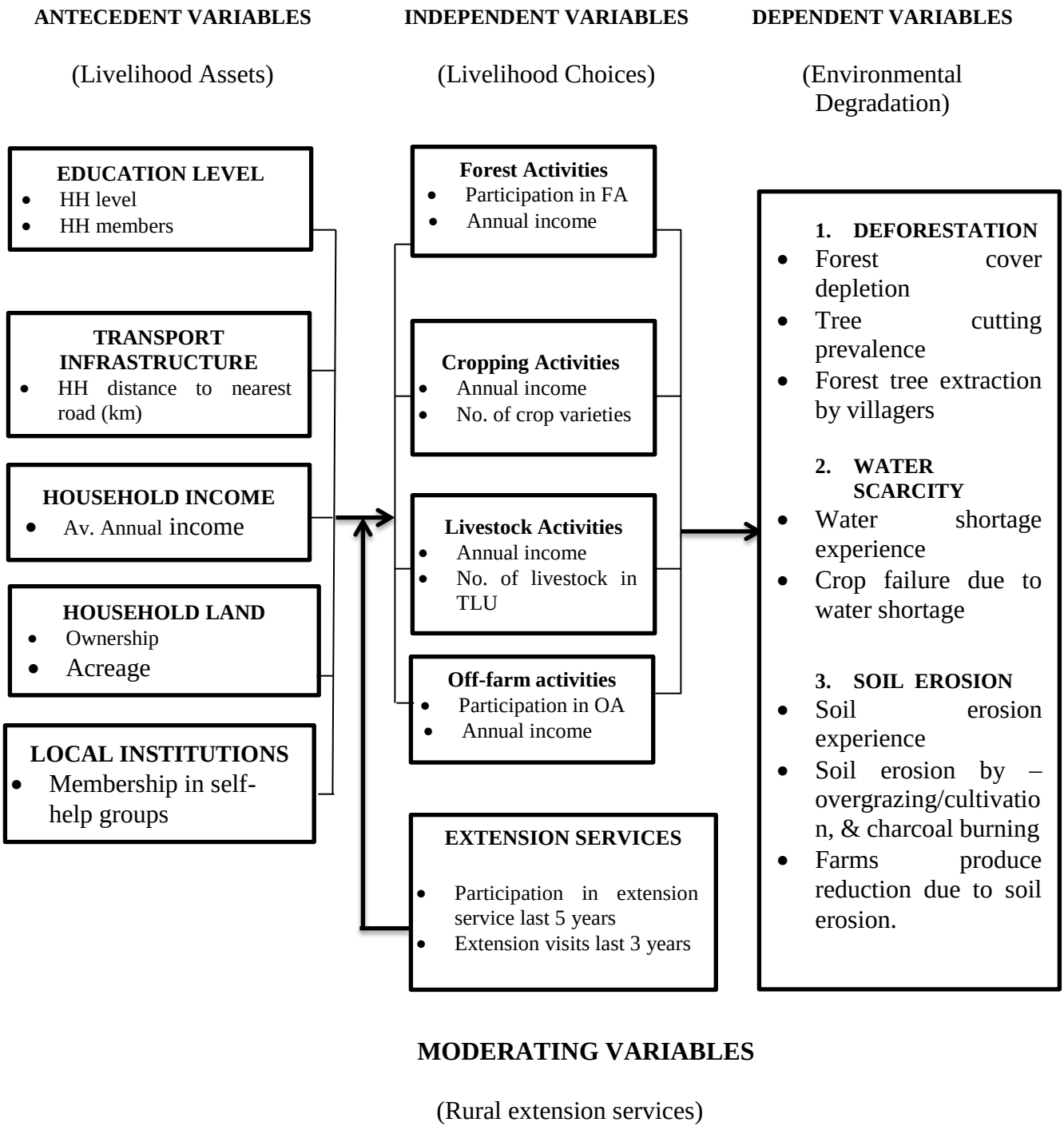

Figure 2.2: Conceptual Framework

Households in drylands are heterogeneous in nature in terms of land productivity, risk level and deficient soft (for example, education and health services) and hard (for example, roads and communication facilities) development infrastructure. Based on household asset endowment, among other socio-economic factors, the heterogeneous nature of Kieni households was determined during the household survey. Livelihood asset base was found to underpin household livelihood choices whose access is modified by social relations (like gender and age), institutions (rules and norms, tenure, and markets), and organizations (community groups, NGOs and government agencies) in the context of trends and shocks. In Figure 2.2, the five capitals (that is human, physical, financial, natural and social assets) are specified with indicators that were investigated at the household level during the study. Household education aspects were assessed as determinants of livelihood choices. Also household access to physical assets like rural infrastructure (roads), including financial assets (household income) were measured. Similarly, natural capital (land) influence on the household livelihood activity choices was assessed during the study; as was household social capital (in terms of group membership) that was also found to be central to livelihood activity definition and choice.

Depending on livelihood asset base, a number of livelihood activity options were available and hence shaped livelihoods in Kieni. Resultant livelihood activity choices were either farm (crop and livestock farming) or non-farm based activities, that is, forest-based (for example, logging, agricultural expansion and/or fuelwood collection), self-employment (small and micro enterprises like transport, shop keeping and recreational services) or formal employment were investigated during the study. Variables for measuring livelihood assets, livelihood choices and environmental degradation were articulated in the appropriate tools for the study.

The choice of livelihood activities by household was frequently under the influence of development interventions in Kieni. Key among these interventions was extension services whose aim was to support households to improve their living standards through

the adoption of sustainable livelihoods. The study found their influence to livelihood activity choices important for evaluation.

2.6.1 Household as a Unit of Observation

This study took the household as the unit of observation. In his study on household resources and livelihoods, Ontita (2007) defined a household as constituting a consumption group that is composed of relations essentially organised around a family who eat from the same kitchen. Similarly, Havilland (2003) argued that a household infers a domestic unit with decision-making autonomy about consumption. Thus a household may consist of one or more people who live in the same home and share meals or living accommodation. The concept of household in the African context is a challenging one and almost every study that takes it as a unit of observation has indicated a problem with defining its membership and in maintaining continuous records of highly mobile people (Ranasinghe & Hemakumara, 2018). Membership of households is particularly complex because a household may include a group of brothers, their families and parents living in a common compound, with varying levels of economic and social status. This is common in Kenya where the compound constitutes a homestead (Ontita, 2007). Also, according to Haviland (2003), a dwelling is considered to contain multiple households if meals or living spaces are shared. However, this does not imply membership or internal relationships can be taken as absolute. Rather they are negotiated and contested upon on a continuous basis. During fieldwork, it was observed that a homestead was usually home to a man and his wife or wives, married sons, their wives and children. It occasionally included married sons and their wives, unmarried sons and daughters and divorced or separated daughters, often with their children. The household model thus assumes that families have resources and make joint decisions about allocating them. However in practice, resources are not just commodities and so people have to continually invest in assuring their continued access to them because social and political resources are required to access material ones. This means that inter-household coalitions of diverse strengths can develop in the short-term and for strategic reasons.

This study used the group organised around a common kitchen as an entry point and constructs the actual composition of households (Havilland, 2003), over time in terms of the observed flows of information and resources. In tracing these compositions, significance was given to the connections that exist and are developed within and between households (Ranasinghe & Hemakumara, 2018), which is a useful way of estimating resource sharing. The livelihood activities take place within and between households via social networks. The units of observation were the individual adults in the households. As expected, some adults related to the study households live miles away in other counties or in cities, but have an influence in decision-making and provision of information and/or resources. Children and youth also initiate connections and ultimately resource flows within and between households and link up with their grandparents and other relations for assistance, sometimes without the knowledge of their parents. While the units of observation sometimes overflowed from the local setting, the local setting remained the research level. The household was therefore the basic unit of analysis as in many social, microeconomic and government models (Ranasinghe & Hemakumara, 2018) and was important to economics and inheritance (O'Sullivan & Sheffrin, 2003).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides the design and methodological approach that was used in the study to meet the objective of analysing the relationship between household assets and livelihood choices and their effect on environmental degradation. The first section of this chapter describes the study's research design followed by target population; sampling frame and technique; and instruments and data collection procedures. The final section of the chapter deals with the data organisation and diagnosis; and data analysis.

3.2 Research Design

According to Creswell (2009), research designs are plans and procedures for research that transverse decisions from broad assumptions to detailed methods of data collection. Bryman (2008) also suggests that research designs provide frameworks for data collection and analysis. Based on the positivity approach philosophy, this study used cross-sectional research design that involved the study of participants at the same time (Setia, 2016). In order to fully understand the study phenomena, a combination of quantitative and qualitative approaches was used. According to related past studies (Cruz-Trinidad et al., 2009; Simpson, 2007; Elliott et al., 2001), this approach was found more effective for livelihood investigations. The quantitative component of the survey was used to collect quantitative data to understand household functioning. The qualitative component that entailed focused group discussions and participant observations (Kanbur, 2003 & Rao, 2002) on the other hand, measured variables that generally were inappropriate to determine using quantitative techniques. The use of these approaches enhanced the quality of findings through triangulation of qualitative and quantitative data (Todd, 1979). This involved collection of information using questionnaires, interview guides for focused group discussions, and participant

observations from households of Kieni East and Kieni West sub-counties in Nyeri County.

3.3 Target Population

3.3.1 Profile of Area of Study

Two sites were used in this study, that is, Kieni East and Kieni West sub-counties, located in Nyeri County (KNBS, 2009). Due to early settlement of the 1960's, cultivation and logging, Kieni sub-region is one of the most degraded areas in the County (Jaetzold et al., 2010; Ekin et al., 2009). Scarcity of land, deterioration in soil fertility and unimproved agricultural technology has resulted in declining agricultural production of smallholder farmers in the area (Business Daily, 2014). The two sites depict similar farming systems and socio-cultural settings (Jaetzold et al., 2010). Food crop production is substantially commercialized in both sites where 40 per cent of the annual food crop production is used for household consumption. The study area is located in Mweiga, Mwiyoyo/Endarasha, Mugunda and Gatarakwa wards of Kieni West; and Naromoru/Kiamathaga, Thegu River, Kabaru and Gakawa wards of Kieni East sub-counties in Nyeri County. The geographic locations of the two sites are shown Figure 3.1.

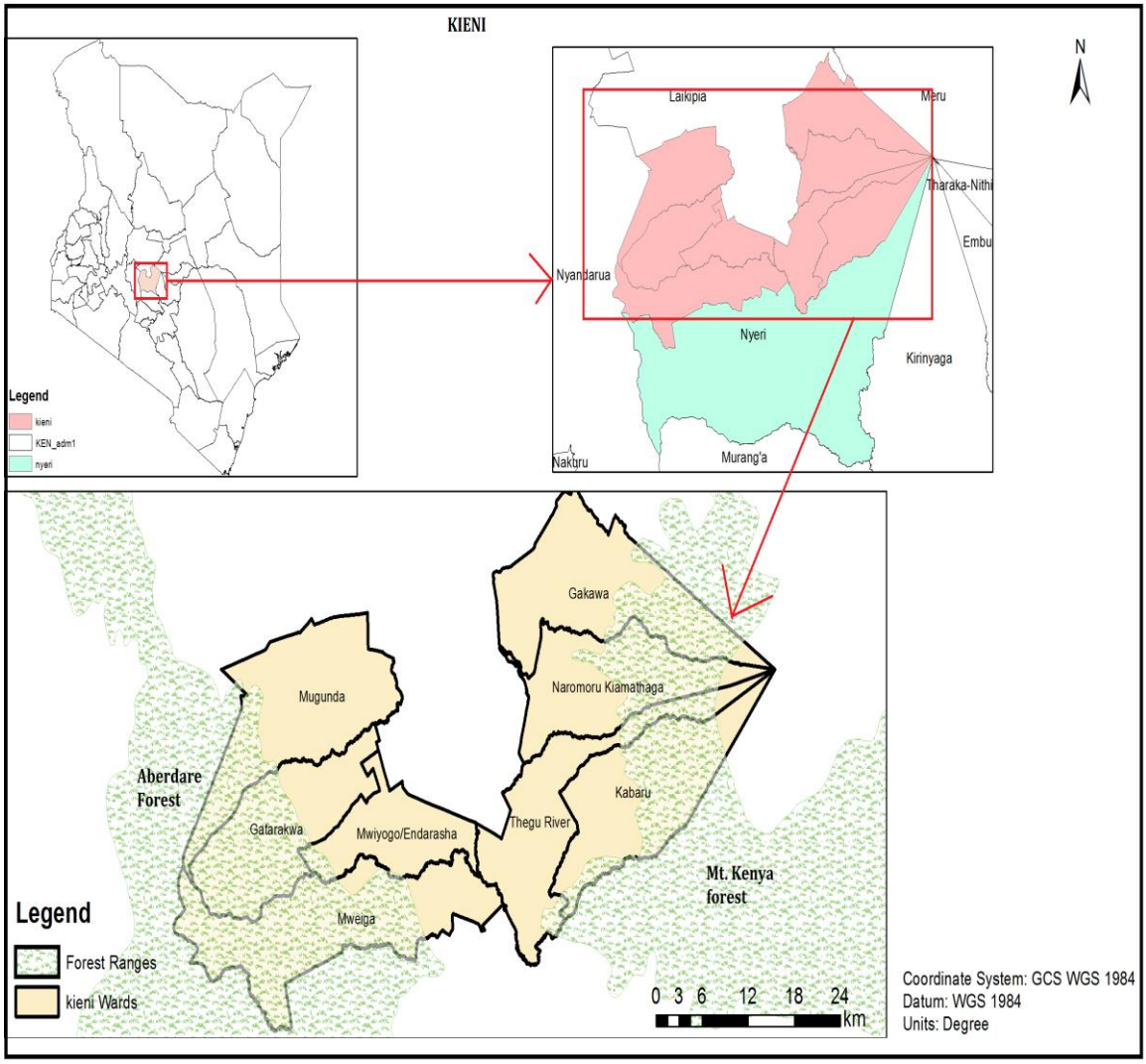

Figure 3.1: Geographical location of Kieni East and Kieni West sub-counties

The area of study lies within the longitudes of 36°40" East to 37°20" East. The northernmost point of Kieni just touches the Equator (0°) and then extends to 0°30" South. The region is served by two major trunk roads. One from Nyeri towards Nyahururu in Kieni West and the other from Nyeri towards Nanyuki in Kieni East. To the north is Laikipia County while to the south of the study area are Mathira (East) and Tetu (West) sub-counties of Nyeri County.

3.3.2 Agro-climates and Socio-economic Activities

Kieni plateau is sandwiched between the Aberdares and Mt. Kenya. It is characterized by high temperatures in low altitude areas and low temperatures in areas adjacent to the two water towers of Kenya. Kiganjo (1,830m) is the lowest area in Kieni East, from where the altitude increases northwards to the Equator at Nanyuki (2,300m), eastwards to Mt. Kenya (>4,000m) and westwards to Nyandarua (>3,000m) above sea level in Kieni West. Therefore, the altitudes are believed to influence the amounts of rainfall received in the area (Jaetzold et al., 2010). For example Kiganjo receives about 850mm of rainfall per annum. This increases eastwards to 2,300mm at Kabaru on the slopes of Mt. Kenya in Kieni East and westwards to 3,100mm in the Aberdare National Park in Kieni West. Mweiga (1,900m) in Kieni West is thus classified as warm and temperate with an average temperature of 16.2°C with an annual average rainfall of 964mm. Consequently, the driest areas are Kiganjo and Narumoru that are within agro-climatic zones (V) and (VI), respectively. Conversely the mountains (Kenya and Aberdare) within zone (I) are the wettest.

The main economic activity is subsistence mixed farming, where people plant maize, beans and potatoes, and practice animal husbandry. Because of the agricultural potential, people from other areas are buying land and migrating into the area (Jaetzold et al., 2010**)**.

3.3.3 Population

According to the 2009 population census (KNBS, 2010), the population of Kieni was estimated at 175,812 over an area of 1,321km² (see Table 3.1). The 1999 national population census indicated that the Kieni population was at 163,451, indicating an increase of 7.56 per cent in ten years. Populations are mainly immigrants from the higher potential area of Nyeri County and surrounding counties in the Mt. Kenya region. Land tenure and property rights assessment by Ekin et al. (2009), shows that local people are predominantly of Gikuyu ethnic community. However, this equation has

changed recently as a result of people's movement from one region to the next in search of employment. Moreover, the elevation of Dedan Kimathi University of Technology as a national institution just at the tip of the Kieni sub-counties has contributed to the settling of other communities in the area.

Table 3.1: Population Distribution by Sex, Household Sizes and Administration Units

Sub-county	Ward	Population			Households
		Male	Female	Total	
KIENI EAST	Naromoru/Kiamathiga	16,853	16,623	33,476	9,976
	Kabaru	11,263	10,821	22,084	6,205
	Thegu River	7,598	7,021	14,619	4,734
	Gakawa	13,283	13,038	26,321	8,097
Sub-total	**4**	**48,997**	**47,503**	**96,500**	**29,012**
KIENI WEST	Mweiga	8,501	8,763	17,264	5,260
	Gatarakwa	10,037	9,988	20,025	5,518
	Endarasha/Mwiyogo	14,600	14,823	29,423	8,070
	Mugunda	6,135	6,465	12,600	3,444
Sub-total	**4**	**39,273**	**40,039**	**79,312**	**22,292**
TOTAL	**8**	**88,270**	**87,542**	**175,812**	**51,304**

Source: KNBS, 2010.

3.4 Sampling Frame

The study populations included all the 51,304 households of both study sites. The individual farm household was used as the unit of analysis. The household list of each sub-location in the selected study locations constituted the sampling frame. Kieni East sub-county has ten locations and thirty-three sub-locations while Kieni West has six locations with twenty-six sub-locations. Ten sub-locations for the study were randomly sampled from the fifty-nine sub-locations.

3.5 Sample Size and Sampling Techniques

3.5.1 Sample Size

A suitable sample size should have all the salient characteristics of the population to an acceptable degree (Martínez-Mesa et al., 2014). The bigger the sample, the minimal is the sample error (that is the discrepancy between the characteristics of the population and the characteristics of the sample). The sample size for the study was determined using this formula as proposed by Yamane (1967) at 95% confidence level and P = 0.5, that is $n = N/[1 + N(e)^2]$; where: *n* = the desired sample size; N = population of study (51,304); and *e* = level of precision (sampling error), the range in which the true value of the population is estimated. In this study, the range was ±5%.

Substituting values in the equation: $\frac{51{,}304}{[1+51{,}304(.5)^2]} = 396$

Based on these values set for alpha, desired statistical power level, effect size and anticipated number of predictors, a sample size (n) of 396 (approximately 400) households of the study site (200 households for each of the two sites) was considered adequate to balance the required level of reliability and cost. The number of ten sub-locations was also considered to be sufficiently large for drawing valid statistical inferences and was also manageable to be surveyed with the available resources of finance and time.

3.5.2 Sampling Techniques

In order to represent the population with sufficient accuracy and to infer the sample results to the population, the target sample households were selected in a random two-stage sampling process. A reconnaissance survey of the two study sites indicated that there were eight (8) wards (with a total of 16 locations) and this formed strata for the selection of sub-locations.

In the first stage, the study sub-locations were randomly selected using Proportionate Stratified Random Sampling Technique (PSRST) to determine the number of sample sub-locations relative to sizes of each ward/stratum in the population. This resulted in the selection of ten sub-locations (see Table 3.2), each with 40 households according to their respective population strengths. The probability (based on population) of sampled sub-locations was established as follows (see also Table 3.2): Naromoru (32.4%); Kamburaini (35.3%); Kirima (29.3%); Thungari (35.3%); Gathiuru (31.4%); Bondeni (7.2%); Kamatongu (56.8); Embaringo (23.7%); Gakanga (11.1%); and Labura (29.1%). The chance of each household selection in each of the selected sub-locations based on the population was also determined (see Table 3.2). In Naromoru sub-location, the probability of selecting a household was 2.4%; Kamburaini (2.2%); Kirima (2.7%); Thungari (2.2%); Gathiuru (2.5%); Bondeni (10.9%); Kamatongu (1.4%); Embaringo (3.3%); Gakanga (7.0%); and Labura (2.7%). The constant overall weight of 1.3 demonstrated that each household in the population had an equal chance of being selected for the household survey interview.

In the second stage, using random sampling techniques, individual household units in the selected sub-locations were randomly selected in relation to population. Household lists provided by the local administrators (Area Assistant Chiefs) of the sampled sub-locations were used as sampling frame for selecting households. Accordingly, 400 households were randomly selected in each of the sub-locations (see Table 3.2). Depending on the population size of each cluster, the K value varied between 5 and 20.

Table 3.2: Sub-locations and Household Numbers Selected for Survey

	A	B	C	D	E	F	G	H
Strata/Ward	**Cluster/ sub-location**	**Sub-location size**	**Cumulative sum (a)**	**Clusters sampled**	**Probability 1**	**Household per sub-location**	**Probability 2**	**Overall weight**
Naromoru/ Kiamathiga	**Naromoru**	1161	1661	1200	32.4%	40	2.4%	1.3
	Ndiriti	1094	2755					
	Gaturiri	1063	3818					
	Rongai	989	4807					
	Kamburaini	1813	6620	6330	35.3%	40	2.2%	1.3
	Thigithi	666	7286					
	Murichu	762	8048					
	Gikamba	1098	9146					
	Kabendera	830	9976					
Kabaru	**Kirima**	1505	11481	11460	29.3%	40	2.7%	1.3
	Ndaathi	1719	13200					
	Kimahuri	1961	15161					
	Munyu	1020	16181					
Thegu	**Thungari**	1811	17992	16590	35.3%	40	2.2%	1.3
	Lusoi	605	18597					
	Thirigitu	1446	20043					
	Maragima	872	20915					
Gakawa	**Gathiuru**	1609	22524	21720	31.4%	40	2.5%	1.3
	Githima	1363	23887					
	Kahurura	5125	29012					
Mweiga	**Bondeni**	367	29379	26850	7.2%	40	10.9%	1.3
	Amboni	1194	30573					
	Njengu	784	31351					
	Kamatongu	2915	34272	31980	56.8%	40	1.4%	1.3
Gatarakwa	Watuka	1126	35398					
	Lamuria	1366	36764					
	Embaringo	1217	37981	37110	23.7%	40	3.3%	1.3
	Kamariki	1809	39790					
Endarasha/ Mwiyogo	Mitero	901	40691					
	Charity	1456	42147					
	Gakanga	569	42716	42240	11.1%	40	7.0%	1.3
	Endarasha	1907	44623					
	Kabati	701	45324					
	Muthuini	571	45895					
	Labura	1494	47389	47370	29.1%	40	2.7%	1.3
	Mwiyogo	471	47860					
Mugunda	Karemeno	538	48398					
	Ruirii	993	49391					
	Kamiruri	722	50113					
	Nairutia	1191	51304(b)					
TOTAL	**10**					**400**		

Survey data, 2017

3.6 Data Collection Instruments and Procedures

A survey using a structured questionnaire was the primary method of data collection employed for this study. However, focus group interviews and direct personal observations were also used in order to enrich the investigation with relevant qualitative information. Acquisition of background information started during the research preliminaries to assist the researcher to appreciate the context the households operate in.

The information was obtained through the review of secondary materials and key informant interviews.

3.6.1 Questionnaires

A common questionnaire was developed for both study sites (see Appendix C). The questionnaire (Kothari, 2004), was found to be an ideal instrument because it helped to gather descriptive information from a relatively large sample in a fairly short time. The questionnaire was administered in Gikuyu, the local language which households of both sites speak. Where households were not of Gikuyu ethnicity, some interpretation was done. A team of five enumerators was recruited for each study site to collect the data from the sampled households.

A pilot test was executed by administering the questionnaire to 20 households who were not part of the sample to measure reliability of the data collection instrument. The Cronbach Alpha was used to assess the reliability of the instrument by testing its consistency concepts under study. Since a reliability coefficient of .70 or higher is considered "acceptable" in most social science research situations (George and Mallery, 2003), the alpha coefficient for 187 questionnaire items of 0.831 suggested that the instrument had a relatively high internal consistency.

3.6.2 Household Questionnaire Survey

The enumerators conducted the questionnaire survey through house-to-house visits. Household heads were the primary respondents for the interview based on the presumption that the head makes production and consumption decisions and has the widest information regarding the farm management and the household livelihood activities. The survey was carried out in April–June, 2017 in both study sites with revisits of some households between 2nd and 13th July, 2017. With the relatively larger area and scattered locations of villages, the survey in Kieni East was a bit more demanding than that of Kieni West. The maximum length of time required to complete a

questionnaire was 2 hours. Nearly all questionnaires were completed in a one session interview with revisits for some questions that were not complete.

3.6.3 Focus Group Discussions

Two separate focus group discussions were conducted for each study site, with both male and female household members. The focus group discussions (FGDs), based on a set of guiding semi-structured questions (see Appendix E), were conducted in June 2017 after some preliminary findings from the questionnaire survey data were investigated. FGDs were particularly valuable to the study because they gave the researcher further opportunity to triangulate (Kitzinger, 2005) by seeking clarifications on livelihood choices and the local understanding of environmental degradation phenomena. The focus groups in Kieni West were composed of six and eight members of households, respectively, and those in Kieni East composed of seven and nine household members, respectively. The participants were identified in purposeful selection among the survey participants, especially those thought to express their views actively during interviews. The purpose of the focus group discussions was to generate in-depth information on some of the survey findings and perceptions of the households that may not have been adequately captured by the structured questionnaire survey. The discussions were facilitated by this author assisted by one note-taker. The guiding questions included trends and present status of household livelihood options, gender specific issues related to livelihoods and the environment and development issues (see Appendix D). Further discussions were made with agricultural and natural resource management experts and rural development experts of the sampled sub-locations.

3.6.4 Participant Observations

a) Market Visits

Villages and major town markets of Naromoru (Kieni East) and Mweiga (Kieni West) were visited to gather information on prices and off-farm activities. The objective of the market visit was to gather price and related information for major traded agricultural, livestock and wood products. The information gathered was triangulated with data obtained from the households on estimate incomes that was not clearly revealed in the questionnaire survey.

b) Farm Observations

Field observation was conducted on selected household farms following a survey that portrayed a clear picture on livelihood diversification by households. Livelihood activities, management practices, and spatial locations in the farmers' land holding were observed (Savage, 2000). This information was also used to assess the trend of livelihood activities over the recent years and to investigate if it had something to do with the rural development activities in the area over the last five years.

3.7 Data Processing and Analysis

3.7.1 Organising and Diagnosing Data

The data was coded and entered into SPSS in three separate data files; one for Kieni East, the second for Kieni West, and the third for pooled data. Initial data exploration using graphic analysis indicated the presence of outlying observations in the data sets from both sites. Using studentized residual criterion, three observations from each site were identified with multivariate outliers and were, therefore, removed from the data sets.

3.7.2 Data Analysis

Data analysis, an ongoing process starting from the field, involved three major steps, that is data preparation, description and hypothesis testing (Trochim, 2000). Variables for analysis according to objectives of this study are summarized respectively in Table 4.2 (antecedent and dependent variables), Table 4.8 (dependent variables), and Table 4.15 (moderating variables). Data generated for the first objective was largely descriptive and this helped the researcher understand respondent household characteristics. This information was analyzed using proportions/percentages to describe and show the emerging relationships between the predictor/independent variables, and the dependent variable indicators. Here, the interest was to get a general view of the socio-economic status of the respondents, and the relationships between livelihood choice indicators on environmental degradation, before subjecting the data to any statistical tests for the purpose of drawing final conclusions about the study.

Log linear analysis techniques were applied to determine statistical significance (Tabachnick & Fidell, 2012) for the second objective, typical in situations where none of the variables in the analysis was considered dependent, but all variables of interest were considered. The technique was helpful in handling "response variables" with no distinction between independent and dependent variables as the study was only interested in demonstrating the association of variables. The third objective elicited quantitative information on the relationship between livelihoods and environmental degradation.

Given the large sample involved, multiple regression analyses were performed using SPSS to analyze data. In this case, regressions were used to analyze *cause* (for example livelihood variables) and *effect* (environmental degradation variables) relationships among multiple variables (Engelsen et al., 2011), and involved making choices regarding what variable to include and evaluate. The fourth objective provided answers using intervening data that was quantitative in nature. Hierarchical multiple regression was applied to analyze data to determine the moderating effect of rural extension

services on household livelihood choices. Variable and model specifications for the empirical analysis descriptive statistics of the surveyed households in Kieni East and Kieni West sub-counties, and the pooled data from the two sites have been articulated in the relevant sections of Chapter 4.

A section of the analysis involved comparison of Kieni East and Kieni West households on some selected variables that were included in the various sections of the analysis. The independent sample t-tests were used to ascertain if there was any significant difference on household status at the two study sites. According to Winquist (2014), t-test helps in ascertaining whether the difference between means of two groups is brought about by the independent variable or the difference is simply due to chance. This comparison was in relation to all the four objectives of the study. The t-test formula was as in Equation 3.1.

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \quad \text{.....3.1}$$

Where:

N_1 = Sample size of Kieni East (Sample 1)

N_2 = Sample size of Kieni West (Sample 2)

S^2_1 = Sample variance of Sample 1

S^2_2 = Sample variance of Sample 2

Therefore, independent t-test was utilized to test for equality of site means for count averages (that is H_o: *mean [Kieni East] – mean [Kieni West] = 0*), whereas percentages or proportions test for equality was done using chi-square. The tests showed significant

differences between mean values of households of Kieni East and Kieni West in many of the characteristic variables (indicated with asterisks in relevant analysis tables).

In addition to quantitative data (Trochim, 2006), the survey questionnaire also generated qualitative data in this study. Moreover, additional qualitative data was created through qualitative approaches employed in the study, that is focused group discussions, in-depth interviews and participant observation. Written and existing documents like newspapers, magazines, books, Internet and annual reports, also formed part of qualitative data. As most of the qualitative data was collected through in-depth interviews, transcripts of interviewees formed the basis of textual analysis. Such data was classified and coded in a multistage process (Esterberg, 2002). Through constant comparison approaches (grounded theory approach), documents like field notes were examined by looking for indicators for categories and compared codes for differences and consistencies between codes to explore meaning of emerging concepts (Charmaz & Mitchell, 2001). Discourse was used to investigate the meaning of face to face conversations and nonverbal conversations in the field (Traynor, 2006), while narrative techniques were used to analyse information obtained on personal experiences and lived situations in the study area (Wengraf, 2006). Through discourse analysis,-records from group discussions were evaluated in regard to the research objectives to establish patterns of questions and so forth on the part of participants. For written and documented information from this study, content analysis was used to review documents, reports and texts during document reviews to establish themes that emerge. Based on Corbin & Strauss (2008), this assisted data interpretation that led to elicitation of meaning, gained understanding and developed empirical knowledge.

CHAPTER FOUR

RESEARCH FINDINGS AND DISCUSSION

4.1 Introduction

This chapter is a presentation of the findings from data collection and analysis of the four study objectives. The chapter includes the field research findings, starting with the first objective for socio-economic characteristics of household respondents interviewed during the household field survey. Research findings for the second objective include the emerging relationships between household assets (the antecedent variables of the study) and livelihood choice variables using log linear analysis. Also presented in this chapter are results of the multiple regression analysis to ascertain the impact of the predictor variables (forest, cropping, livestock and off-farm activities) on each of the selected environmental outcomes (deforestation, water scarcity and soil erosion). Finally, similarly presented are results for the fourth objective of the moderating effect of extension services (number of extension visits and participation in extension programmes) between household assets indicators and those of livelihood activity choices of surveyed households.

The results, by triangulation, from the analysis of qualitative data collected using focus group discussions and participant observations are also presented in the respective sections of the chapter to further explain the findings of the relationship between the predictor variables and dependent/outcome variable emergent from the quantitative analysis.

4.2 Characterisation of Socio-economic Indicators of Respondents

The first objective of this study was to establish the socio-economic characteristics of the study respondents. The 400 principal study respondents were surveyed using a questionnaire whose first part focused on the socio-economic aspects of households. Other sections of the questionnaire dealt with additional aspects of the study, that is,

household assets, livelihood choices and the moderating effect of extension activities on livelihood choices. Table 4.1 shows the socio-economic characteristics of Kieni East, Kieni West and Pooled Data for all surveyed households. It provides a brief description of the context of livelihoods in the area, including gender of household heads, their age and farming experience, and family size and labour. Other factors are level of education for household heads and members, and their occupations.

Table 4.1: Socio-economic characteristics of study participants

Variable	Kieni East[200]	Kieni West[200]	Pooled Data [400]	St. Dev
HH head marital status (Married)	63.1%	67.9%	65.5%	
Female headed HHs	24.3%	21.4%	22.8%	
AGE				
Av. HH head age**	54.83 yrs	56.5 yrs	54.57 yrs	15.00
0–14 years	21.1%	22.9%	22.1	
15–19 years	13.2%	11.1%	12%	
20–59 years[a]	56.8%	56.4%	56.5%	
60–69 years	2.9%	4.3%	3.6%	
70–79years	3.9%	3.6%	3.7%	
80≤	2.1%	1.8%	2.0%	
Av. yrs HH lived at present landholding***	23.53 yrs	34.69 yrs	28 yrs	17
Av. family size***	4.195	4.065	4.13 members	0.84
EDUCATION: NO FORMAL EDUCATION				
HH head	11.8%	10.5%	11.1%	
HH members	6.1%	6.3%	6.2%	
HH male members	51.3%	47.9%	49.4%	
OCCUPATION/LIVELIHOOD ACTIVITIES				
Forest***	39.2%	52.5%	45.8%	
Cropping /Farming***	64.5%	88.5%	76.5%	
Livestock ***	47.0%	32.5%	39.5%	
Off-farm***	55.0%	66.0%	60.5%	

Note: Sample size (N) = 400

Variables in which sample households of Kieni East have significant differences from those of Kieni West: *** = at 0.01 level of significance ** = at 0.05 level of significance. [a] = Adult labour force

Survey data, 2017

4.2.1 Gender and Marital Status of Household Heads

Data associated to gender and marital status of the respondents is presented in Table 4.1. Results show that out of the total respondents investigated for this study, a minority (22.8%) were female household heads whereas 77.2% was male. Also results show that 65.5% of respondents were married and 35.5% single. There was no significant difference at the two sites. According to FGD results, the female-headed households were mainly composed of divorcees, widowed and unmarried women. Results therefore show that over 20% of household heads were female and over 75% were married.

4.2.2 Age and Farming Experience of Household Heads

It is evident from the Table 4.1 that the average household head age of respondents was about 54.57 years. It was however significantly different at the two sites. While in Kieni East average household head age was 54.83 years, in Kieni West it was 56.5 years at $p<0.05$. The average number of years household head had lived and farmed on their present land holdings was 28 years with standard deviation of 17 years, which was also different at the two sites in the study area at $p<0.01$. In Kieni East, it was 24 years and in Kieni West [35 years]. The results imply that settlement in Kieni West commenced earlier than in Kieni East as corroborated by the group discussions and key informants. Furthermore, a high mean age for Kieni West household heads (56.5 years) might explain why there is more reliance on agriculture (88.5%) compared to Kieni East (64.5%).

The results(Kieni West with 56.5 years age average and 88.5% practice farming; Kieni East with 54.57 years and 64.5%, respectively) therefore show that the older age group in the study area rely more on farming activities for livelihood compared to the younger household heads. Coherent with these findings, previous studies have shown that age and farm experience of the household head are important factors that influence decisions made in livelihood diversification that includes participation in agricultural activities (Adesina & Chianu, 2002).

4.2.3 Family Size and Labour

Family size exhibited a wide variation ranging between one and seven persons. Results (Table 4.1) show that average family size was different at the two sites at $p<0.01$. It was 4.195 in Kieni East and 4.065 in Kieni West at $p<0.01$. The average family size in the study area was therefore 4 persons with standard deviation of 0.8 persons, which is below the national average of 6 members per household in Kenya (RoK, 2005).

As is often the case with rural economy, the household is the major source of the family labour supply supplemented to a limited extent by labour exchange and hiring of casual labour. The available labour force depends on the size, age structure and gender composition of the household (Table 4.1). Of the average family size indicated above, the adult labour force (20–59 years) was 56.5%. It is therefore concluded that the study area has an average family size of four and over 50% of the household members were in the adult labour force that provide labour within their farms/enterprises or outside to earn a livelihood.

4.2.4 Level of Household Head and Members Education

Results in Table 4.1 indicate that 11.1% of the household head respondents had no formal education, while the majority of the household respondents (48.1%) were educated up to primary level. About a quarter (24.5%) of respondent household heads was educated up to secondary school and fairly lesser number of respondents (16.1%) was educated up to tertiary level. Table 4.1 also shows that only 6.2% of household members of respondents were illiterate. Past studies have shown that higher education attainment is associated with less reliance on forest resources (Panta et al., 2009; Fonta & Ayuk, 2013), since it offers other alternative livelihood opportunities which may generate significant returns compared to forest extraction activities (Masozera & Alavalapati, 2004). Compared to the national illiteracy levels of 25% (KIPPRA, 2014), results further suggest that the level of education in the area is above the national

average. Results therefore show that the level of illiteracy at the household head level is higher than that of the members.

4.2.5 Household Head Occupation

It is evident from Table 4.1 that over half of the total respondents (76.5%) engage in agricultural activities. Whereas a large portion of 60.5% of the respondents were off-farm earners, the number of respondents who engage in forest and livestock activities was 48.5% and 39.5%, respectively. Results further show that livelihood activity choices at the two sites were significantly different. While households in Kieni East depended more on livestock activities ($p<.01$), dependency on forest, cropping, and off-farm activities was more in Kieni West ($p<.01$). The finding demonstrates that households engage in diverse activities to earn a living in the area. For instance to emphasize the importance of livestock activity for household income security, an FGD participant had this to say:

> … it helps us a lot. In this area ... "Livestock is our cash crop!"
>
> (FGD participant, Bondeni Sub-location, Kieni West).

It is thus concluded that although households in the study area engage in an average of four activities to earn a living, the most preferred activity is farming, followed by off-farm activities, forest and livestock activities, respectively. Also of the four household major occupations, the preferred activity in Kieni East was livestock production and farming in Kieni West.

In summary, 20% of household heads were female and over 75% were married; and the average household head age and farming experience was 55 and 28 years, respectively. The average family size was 4 with an adult labour force (20–59 years) proportion of 56.5%. Whereas illiteracy levels for household head and members was 11.5% and 6.2%, respectively, results show that household heads in the area engage in four types of livelihoods, that is, cropping (76.5%); off-farm (60.5%); livestock (48.5%); and forest

(39.5%) activities. Results therefore indicate the unique socio-economic features of the study area as envisaged in the first objective of this study.

4.3 Effect of Household Assets on Livelihood Choices

The second objective of this study was to evaluate the effect of household assets on livelihood activity choices. This sub-section deals with estimation of the effect of livelihood assets on livelihood choices for the households interviewed in the field survey. It includes a brief description of the household asset endowment, model specification for the log linear analysis, as well as the findings showing effects of household assets on the different livelihood choices. Additional information from the FGDs is used to expound on some of the findings presented in this sub-section.

4.3.1 Descriptive Statistics of Household Assets and Livelihood Choices

In this second part of the analysis, descriptive statistics tools are used to analyse household assets endowment, before inferential statistics is applied to measure the influence of assets on livelihood choices in the study area. Table 4.2 shows descriptive results for variables used in the log linear regression analysis model for the two sites and pooled data.

Table 4.2: Descriptive statistics results for antecedent and independent variables for Kieni East, Kieni West, and Pooled Data

Variable Description	Kieni East (N = 200)		Kieni West (N = 200)		Pooled Data (N = 400)	
	Mean	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Antecedent variables (livelihood assets)						
% household head with primary education and above [E]	88.2		89.5		88.9	
% household members with primary education and above [E]	93.9		93.7		93.8	
Household nearest average distance to all weather road in km*** [T]	.5578	1.11	1.36	2.05	0.97	1.70
Household average est. annual household gross income (KShs)*** [HI]	104,859.7	117,317.5	251,012.6	272,571.8	179,595.0	224,095.0
% household who own land** [L]	88.4		94.0		93.0	
Average size of landholding/household (Acre) [L]	1.80	2.53	2.24	3.57	2.0	3.1
% households who are members of self-help group***	52.6		81.9		67.5	
Independent variables (Livelihood choices/activities)						
Annual household income from forest activities (KShs)** [FA]	10,459.55	11,653.17	20,995.45	37,383.35	15,727.5	16,603.68
% household who depend on forest for a livelihood*** [FA]	88.2		100.0	94.8	91.5	
Annual household income from agriculture (KShs)*** [CA]	23,056.62	52,615.09	81,033.08	175,790.46	34,430.73	63,077.08
Average number of crop varieties grown per household [CA]	4.8		3.8		4.3	
Annual household income from livestock (KShs)** [LA]	29,064.89	37175.48	37,783.08	46,821.33	32,628.93	41,472.23
Average household livestock number in TLU*** [LA]	12.48	17.06	7.97	9.14	10.23	11.47
Average annual household income from off-farm activities (KShs)** [OA]	63,672.73	70,353.60	68,490.91	142,522.19	66,300.83	115,263.53
% of households who engage in off-farm activities** [OA]	55.0		66.0		60.5	

Variables in which sample households of Kieni East have significant differences from those of Kieni West: *** = at 0.01 level of significance; ** = at 0.05 level of significance

Survey data, 2017

a) Description of Household Assets

Table 4.2 indicates that 88.9% of household heads had attained education level of primary and above, which implies that about 11.1% of the household heads was illiterate. In regard to the rest of the household members, results show that 93.8% had attained education level of primary and above, leaving less than 7% of members who were illiterate. In terms of transport infrastructure, the average household distance to the nearest all weather road according to findings was 0.97km. Table 4.2 also shows that the average distance of farm households to the nearest all-weather road at both sites was significantly different (at $p<0.01$). It was 0.56km in Kieni East and more than twice (1.36km) in Kieni West.

Results (Table 4.2) further show that estimated average household income of the respondents in the study area was KShs 179,595.00 per annum, with a standard deviation of KShs 224,095.00. The main sources of income included farming, casual or formal employment, self-employment and livestock. Also data in Table 4.2 shows that on the average, households in Kieni East earned an annual gross income of KShs 104,859.69, which was less than half that of Kieni West (KShs 251,012.60). As far as household land ownership is concerned, Table 4.2 shows that a majority (93%) of the respondents own land. Therefore, only 7% of the respondents are landless. Household land ownership however was significantly different at the two sites – 88.4% (Kieni East) and 94.0% (Kieni West) at $p<0.05$. The results also show that the average land per capita is 2.0 acres. This implies, of the 7%, majority of the landless were in Kieni East. In terms of social capital, more than half of the respondents (67.5%) were members of local self-help groups. However, group membership was significantly ($p<0.01$) different at both sites. While in Kieni East the proportion of membership was 52.6%, it was higher at 81.9% in Kieni West.

b) Description of Livelihood Choices

Data in Table 4.1 shows that respondent households engage in four main activities in the study area. Whereas the majority of respondents (76.5%) practice farming for a living, 60.5% engage in activities off the farm, 45.8% in forest-based activities and 39.8% of respondents are livestock keepers. Table 4.2 shows variables used for the log linear regression analysis model and descriptive results for the two sites and pooled data.

i) Forest Activities

Results in Table 4.2 show that 91.5% of interviewed respondents in the study area depend on forest resources for their livelihood, and in Table 4.1, results indicate that 45.8% of the respondents engage in forest activities. Also Table 4.2 shows that the average household annual income generated from the sale of forest products was KShs 15,727.50, but varied at both sites ($p<0.05$). While annual average household forest income in Kieni West was more at KShs 20,995.45, it was just about half of this amount (KShs 10,459.55) in Kieni East. Table 4.3 shows the different forest activities households engage in the study area.

Table 4.3: Forest activities of respondents in Kieni East and Kieni West, and Pooled Data

Activity	Distribution of Respondents					
	Kieni East		Kieni West		Pooled Data	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Farming	72	46.2	20	9.5	92	25.1
Grazing	24	14.0	156	80.4	180	49.2
Charcoal burning	8	51	4	1.9	12	3.3
Fuelwood collection	62	39.7	14	6.7	72	20.8
Non-timber products collection	6	3.8	0	0	6	1.6
Total	**172**		**194**		**366**	**100**

Survey data, 2017

About half (49.2%) of the respondents depend on the forest for grazing their livestock compared to 25.1% who farm in the forest. Respondents also reported that they depend on the forest as a source of fuelwood (20.8%) and a smaller percent of respondents for charcoal burning (3.3%) and collection of non-timber products (1.6%). In Kieni East, 46.2% and 39.7% of surveyed households do farming and fuelwood collection, respectively as major activities in the forest while in Kieni West, the principle activities in the forest were farming (9.5%) and grazing (80.4%).

ii) Cropping Activities

Data in Table 4.4 shows that crops grown in the area include cereals (maize) and pulses (beans). Others are cassava and potatoes, fruits (oranges and bananas) and vegetables (onion, kales [*sukumawiki*], cabbages, tomatoes and pumpkins). On average, results (Table 4.2) show that the number of crops grown per households was four different crop varieties. Table 4.2 also shows that the average annual income earned from cropping activities was KShs 34,430.73. Mean annual income from the two sites was varied at $p<0.01$. In Kieni East, an average per household of KShs 23,056.62 was generated from the sale of crops, including potatoes, cabbage, maize, beans and cassava. The annual crop income from the sale of onions, maize, potatoes, beans and tomatoes in Kieni West was over twice the average in the area at KShs 81,033.08. Therefore, results show that cropping is an important livelihood activity, which was more commercialised in Kieni West compared to Kieni East.

Table 4.4: Average crop production in Kieni East and Kieni West, and Pooled Data

Crop	Production (kg)								
	Kieni East			Kieni West			Pooled Data		
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Beans	98	101.55	168.06	141	133.17	148.22	239	120.20	157.09
Maize	123	304.21	733.22	140	421.26	334.71	263	370.32	612.59
Cassava	4	165.00	86.60	13	516.92	351.81	17	434.12	343.38
Potatoes	132	1445.63	2250.54	145	731.59	1210.71	277	1071.86	1815.60
Cabbages	11	1600.27	1370.78	21	294.29	212.45	32	743.22	1016.09
Tomatoes	2	40.00	.00	11	288.18	236.00	13	250.00	234.73
Onions	2	3.00	.00	37	3357.83	16403.04	39	624.26	1523.02
Pumpkin	0	0	0	2	175.00	35.36	2	175	35.36
Sukumawiki	36	203.89	314.62	16	245.56	361.63	52	216.71	326.76
Bananas	1	25.00	0	4	112.50	101.04	5	95.00	95.85
Oranges	0	0	0	9	93.33	138.18	9	93.33	138.18

Survey data, 2017

iii) Livestock Activities

Results in Table 4.1 showed that 39.5% of respondents engage in livestock activities. Like in Kieni East, a majority of the household farmers in Kieni West were mixed crop–livestock producers. The major types of livestock in the area included cattle, goats, sheep and poultry. Data in Table 4.5 shows the distribution of livestock possessions in tropical livestock unit (TLU) (Ramakrishna & Demeke, 2002).

Cattle were the most preferred stock kept by respondents in both Kieni East and Kieni West (Table 4.5). Average income from livestock sale was KShs 32,628.93 per annum (Table 4.2). Whereas average annual livestock income was KShs 29,064.89 in Kieni East, it was KShs 37,783.08 in Kieni West. The average amount of livestock ownership (12.48 TLU per household) in Kieni East was much higher (at $p<0.05$) than in Kieni West (7.97 TLU).

Table 4.5: Distribution of livestock in TLU

Type of livestock	Kieni East	Kieni West
Cattle	6.18 (49.5%)	4.98 (62.5%)
Sheep and goats	1.63 (13.1%)	1.34 (16.8%)
Donkey	4.55 (36.5%)	1.44 (18.1%)
Chicken	0.12 (1.0%)	0.21 (2.6%)
Total	**12.48 (100%)**	**7.97 (100%)**

Survey data, 2017

Contrary to expectations, households in Kieni West with less livestock (7.97 TLU) raised more income from the sale of livestock than Kieni East (12.48 TLU). According to FGD results, donkeys that form a bigger proportion in Kieni East were used more for transportation purposes than in Kieni West. The finding therefore indicates livestock as an important livelihood option in both sites.

iv) Off-farm Activities

Table 4.1 data shows that 60.5% of households in the study area engage in off-farm activities. According to results in Table 4.6, households engage in different off-farm activities that include casual employment, formal employment, sale of forest products and trade. Table 4.6 further shows that the main source of off-farm income was formal employment at an average of KShs 125,018 per household head per annum. However, dependency on employment off-farm income was more in Kieni East with an annual average in household income of KShs 152,000, almost twice that in Kieni West of KShs 98,036. The average annual household income (Table 4.2) from off-farm activities was KShs 66,300.83, which was greater ($p<0.01$ significance) in Kieni West at KShs 68,490.91 compared to KShs 63,672.73 per household in Kieni East.

Table 4.6: Mean income from different sources in Kieni East, Kieni West, and Pooled Data

Off-farm activity	Income					
	Kieni East		Kieni West		Pooled Data	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Casual labour on other farms	51,974	103,605	27,206	32760	39,589	68,183
Food for work programme	3,800	2,155	3,000	693	3,400	1,424
Employment	152,000	162,496	98,036	143296	125,018	152,896
Collecting and selling forest products (fuelwood, poles & charcoal)	10,460	11,653	20,995	37383	15,728	24,518
Trade/business	82,171	82760	66,346	177529	74,259	130,145

Survey data, 2017

The results therefore show that both sites depend on off-farm income, with a bigger portion from formal employment than any other off-farm activity.

c) Estimation of Household Assets Effect on Livelihood Choices

i) Model Specification and Variables entered into the Log Linear Model

Log linear model, in this second part of the analysis, was used to determine the influence of household assets on livelihood activity choices. The main justification for applying this model was that variables were all treated as "response variables". The model was therefore only used to demonstrate association between the variables.

In the model below, the five livelihood asset categorical variables (E, T, HI, L and LI) were included in the model to observe the interaction with the four livelihood choices (FA, CA, LA and OA) (see Table 4.2). Hierarchical regression model approach was therefore adopted by including five variables at a time, that is, one household asset variables and four livelihood choice variables (Tabachnick & Fidell, 2012). To illustrate the hierarchical approach to log linear modelling, the chi-square test equation was used (see Equation 4.1).

$$Ln(F_{ij}) = \mu + \lambda_i^{A} + \lambda_j^{B} + \lambda_k^{C} + \lambda_l^{D} + \lambda_m^{E} + \lambda_{ij}^{AB}. + \lambda_{jk}^{AC} + \lambda_{il}^{BC} + \lambda_{il}^{AD} + \lambda_{im}^{AE} + \lambda_{ijk}^{ABC} + \lambda_{ijl}^{ABD} + \lambda_{ijm}^{ABE} + \lambda_{jkl}^{BCD} + \lambda_{jkm}^{BCE} + \lambda_{ijk}^{ABCD} + \lambda_{ijkl}^{ABCE} + \lambda_{ijklm}^{ABCDE} \quad \ldots\ldots\ldots\ldots\ldots\ldots 4.1$$

Where:

$Ln(F_{ij})$ = Log of the expected cell frequency of the cases for cell ij in the contingency table; μ = Overall mean of the natural log of the expected frequencies; λ = "Effects" terms the variables have on the cell frequencies; A, B, C, D and E = Variables; i and j = Categories within the variables; λ_i^{A} = Main effect for variable A; λ_j^{B} = Main effect for variable B; λ_{ij}^{AB} = Interaction effect for variables A and B; λ_{ij}^{AC} = Interaction effect for variables A and C; λ_{ij}^{BC} = Interaction effect for variables B and C; λ_{ij}^{AD} = Interaction effect for variables A and D; λ_{ij}^{AE} = Interaction effect for variables A and E.

In the above equation where a five-way interaction is present (ABCDE), the equation for the model must also include all two-way effects (AB, AC, BC, AD, AE) as well as the single variable effects (A, B, C, D, E) and the grand mean (μ). In other words, less complex models are nested within the higher order model (ABCDE) (Vanables & Ripley, 2002).

Therefore, for the model of [E] variable regression on (FA, CA, LA, OA), the model was re-written as follows for the first hierarchy (see Equation 4.2).

$$Ln(F_{ij}) = \mu+\lambda_i^{E} + \lambda_j^{FA} + \lambda_k^{CA} + \lambda_l^{LA} + \lambda_m^{OA} + \lambda_{ij}^{E*FA} + \lambda_{jk}^{E*CA} + \lambda_{il}^{E*LA} + \lambda_{im}^{E*OA} + \lambda_{ijk}^{E*FA*CA} + \lambda_{ijl}^{E*FA*LA} + \lambda_{ijm}^{E*FA*OA} + \lambda_{jkl}^{FA*CA*LA} + \lambda_{jkm}^{FA*CA*OA} + \lambda_{ijk}^{E*FA*CA*LA} + \lambda_{ijkl}^{E*FA*CA*OA} + \lambda_{ijklm}^{E*FA*CA*LA*OA} \quad 4.2$$

Where:

μ = Overall mean of the natural log of the expected frequencies; λ_i^{E} = Main effect for variable E; λ_j^{FA} = Main effect for variable FA; λ_k^{CA} = Main effect for variable CA; λ_l^{LA} = Main effect for variable LA; λ_m^{OA} = Main effect for variable OA; λ_{ij}^{E*FA} = Interaction effect for variables E and FA; λ_{jk}^{E*CA} = Interaction effect for variables E and CA; λ_{il}^{E*LA} = Interaction effect for variables E and LA; λ_{im}^{E*OA} = Interaction effect for variables E and OA; $\lambda_{ijk}^{E*FA*CA}$ = Interaction effect for variables E and CA; $\lambda_{ijk}^{E*FA*CA*LA}$ = Interaction effect for variables E, FA and LA; $\lambda_{ijkl}^{E*FA*CA*OA}$ = Interaction effect for variables E, FA and OA; $\lambda_{ijklm}^{E*FA*CA*LA*OA}$ = Interaction effect for variables E, FA, LA and OA.

In this study, the five household livelihood assets were considered as antecedent/explanatory category variables. As shown in Figure 2.2, livelihood assets included education [E], transport infrastructure [T], household income [HI], land ownership [L]) and local institutions [LI]). In respect to the above variables, the sub-variables category considered in the model comprised of education (level of education for household head and members proportions) [E] (see Table 4.2). The second category of livelihood assets was transport infrastructure [T] where average household distance to nearest all-weather road was measured. Household estimated average annual gross income [HI] sub-variable was studied as the third category while the fourth category of sub-variables involved household land size and ownership status proportion [L]. The last variable category considered in this model related to local institutions [LI] that involved investigation of proportion of household membership in self-help groups. The second response categorical variables involved livelihood choices (see Figure 2.2 and Table

4.2). Here, four categorical variables were considered, that is, forest activities [FA] (average annual gross income from forest products, and proportion of households who depend on forest resources for livelihood); cropping activities [CA] (household annual average crop sales income and number of crop varieties per household); livestock activities [LA] (household average annual estimated average livestock income, and average number of livestock owned per household); and off-farm activities [OA] (household annual average off-farm estimated income and proportion of household who engage in off-farm activities).

In using the log linear models, the simplest relationship among variables to test for fit was sought first by computing Likelihood-ratio chi-square (G^2). Computed G^2 values of 1245.549 and 756.942 where order of effects were significant ($p<0.05$) showed that interactions up to second order were sufficient to explain the variations in observed cell frequencies, implying model with the first and second order effects was adequate to represent data in this study (see Appendix A).

Based on computed G^2 values, only interactions up to the second order were considered, that is, [1st order – E, T, HI, L and LI, and 2nd order: [E*FA, E*CA, E*LA and E*OA], of which in this study, only second order interactions were relevant. The same model was used as subsequent hierarchies for (T), (HI), (L) and (LI) on (FA, CA, LA, OA). The data obtained from all respondents (200 from each site) were considered in the model. Therefore, explanatory variables (X_i) included in the model were E, T, HI, L and LI which are categorical variables. The dependent variable used in this log linear analysis was the adopted livelihood activities by households that included FA, CA, LA and OA, also categorical variables.

ii) Findings

Table 4.7 shows results of maximum likelihood estimation of the log linear regression model specified for the decision to adopt livelihood activity by the sampled households in Kieni East and Kieni West. Estimates for Pooled Data from the two sites are also shown in the table. The results suggest that the log linear model relating the households' choice of livelihoods to the various explanatory variables is well specified. For instance, as shown in Table 4.7, the overall model (E*FA) parameter estimate (**λ**) was 0.322 for Kieni East, 0.410 for Kieni West, and 0.470 for the Pooled Data, respectively and these were significant at $p<0.05$ level of significance. This implies that education variables, considered collectively, do influence the households' decision to engage in forest activity. The effects of the independent variables on the log linear of adopting livelihoods are reported as parameter estimates (λ).

Therefore, Table 4.7 outlines the parameter estimates for the second order interaction effects and their respective p-values. The p-values of 15 out of the 20 variables included in the model were found to significantly explain households' choice of livelihood activity in the study area. These included Education*Forest activities; Transport*Forest activities; Household income*Forest activities; Land*Forest activities; and Local institutions*Forest activities. Others were Education*Crop activities; Household income*Crop activities; Land*Crop activities; and Local institutions*Crop activities; Education*Livestock activities; Transport*Livestock activities; Household income*Livestock activities; Education*Off-farm activities; Transport*Off-farm activities; Household income*Off-farm activities of the second order interaction parameters were significant (p-value<0.05).

Table 4.7: Parameters estimates and respective z and p values

Parameter	Kieni East			Kieni West			Pooled Data		
	Estimate(λ)	Z	p-value	Estimate(λ)	Z	p-value	Estimate(λ)	Z	p-value
Education*Forest activities [**E*FA**]	0.322	3.076	0.002**	0.410	3.540	0.000**	0.470	8.363	0.000**
Transport*Forest activities [**T*FA**]	0.147	1.979	0.048**	0.221	2.877	0.004**	0.201	3.81	0.000**
Household income*Forest activities [**HI*FA**]	0.165	2.265	0.024**	0.131	1.728	0.084*	0.181	3.537	0.000**
Land*Forest activities [**L*FA**]	0.177	2.407	0.016**	0.313	4.023	0.000**	0.273	5.216	0.000**
Local institutions *Forest activities [**LI*FA**]	-0.104	-1.468	0.142	-0.026	-0.199	0.842	-0.159	-2.88	0.000**
Education*Crop activities [**E*CA**]	0.281	3.227	0.001**	0.205	2.296	0.022**	0.249	4.179	0.000**
Transport*Crop activities [**T*CA**]	0.033	0.396	0.692	0.14	1.606	0.108	0.095	1.572	0.116
Household income*Crop activities [**HI*CA**]	0.146	1.731	0.083	0.151	1.756	0.079	0.160	2.703	0.007**
Land*Crop activities [**L*CA**]	0.437	4.103	0.000**	-0.082	-0.897	0.370	0.171	2.873	0.004**
Local institutions*Crop activities [**LI*CA**]	-0.161	-1.985	0.047**	-0.051	-0.358	0.720	-0.142	-2.332	0.020**
Education*Livestock activities [**E*LA**]	0.168	1.917	0.055*	0.13	1.525	0.127	0.125	2.148	0.032**
Transport*Livestock activities [**T*LA**]	0.382	3.375	0.001**	0.252	2.985	0.003**	0.294	4.43	0.000**
Household income*Livestock activities [**HI*LA**]	0.263	2.723	0.006**	0.191	2.367	0.018**	0.200	3.363	0.000**
Land*Livestock activities [**L*LA**]	0.243	2.516	0.012**	-0.033	-0.391	0.696	0.073	1.266	0.205
Local institutions*Livestock activities [**LI*LA**]	-0.124	-1.465	0.143	-0.123	-0.949	0.343	-0.072	-1.17	0.242
Education*Off-farm activities [**E*OA**]	0.141	1.375	0.169	0.287	3.246	0.001**	0.175	2.708	0.007**
Transport*Off-farm activities [**T*OA**]	-0.016	-0.161	0.872	0.315	3.339	0.001**	0.160	2.319	0.020**
Household income *Off-farm activities [**HI*OA**]	0.321	2.598	0.009**	0.079	0.924	0.355	0.131	2.019	0.043**
Land*Off-farm activities [**L*OA**]	0.057	0.552	0.581	-0.198	-2.041	0.041**	-0.104	-1.595	0.111
Local institutions*Off-farm activities [**LI*OA**]	-0.182	-1.778	0.075*	0.305	1.4	0.162	0.018	0.248	0.804

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

4.3.2 The Effect of Household Assets on Forest Activities

a. Education

In Table 4.7, it is shown that the interaction of education and forest activities is positive indicating that the probability of engaging in forest activities was influenced by household head education status ($\lambda = 0.470$; $Z = 8.363$, $p<0.05$). The dependency of forest activities on education for both sites was also positive and significant as indicated in the results in Table 4.7 ($\lambda = 0.322$; $Z = 3.076$, $p<0.05$) for Kieni East and ($\lambda = 0.410$; $Z = 3.540$, $p<0.05$) for Kieni West. This finding implies that the higher the education status of household head, the higher the chances that households depend on forest resources for livelihood. This outcome is contrary to previous studies. Boli (2005) established that the human capital comprising of education and skills is an important asset that enables the household to pursue different livelihood strategies other than dependence on forest.

To explain this contrary observation, the issue was raised at the focused group discussions (FGDs). According to FGD results, educated household heads in the area still face challenges of securing employment that is attributed to the high unemployment rates. As such, exploration of forest resources continues to be an alternative livelihood activity. This situation may only be reversed if vocational training opportunities are increased in the area to promote acquisition of practical skills like carpentry and masonry to enhance self-employment. In the words of one FGD participant:

> … the youths are not being trained to take over from us, the older *fundis (local artisans)* … so the only *fundis* available in this area are old men!
>
> (FGD participant, Kamburaini Sub-location, Kieni East).

The results therefore show that contrary to expectations, education advancement increases dependency on forest resources in the area.

b. Transport Infrastructure

Table 4.7 shows that interaction coefficient for transport infrastructure and forest activities are also positive. This demonstrates that the prospect of engaging in forest activities is dependent on transport factors (λ = 0.201; Z = 3.81, $p<0.05$). Again, dependence of forest activities on household transport infrastructure for both sites was positive and significant as indicated in the results in Table 4.3 (λ = 0.147; Z = 1.979, $p<0.05$) for Kieni East and (λ = 0.221; Z = 2.877, $p<0.05$) for Kieni West. According to results in Table 4.2, the average distance to the nearest all-weather road was less than 1km. This confirms FGD results that road network in the area has improved over the last five years. This finding is strengthened by the work of Kleih et al, (2004) who, in their studies, corroborated the importance of roads in relation to farmers' access to marketing opportunities in Uganda; and Heffernan & Misturelli (2000) in Kenya. Similarly, good road network in the study area has facilitated access to forest by households thus saving households from head loading when transporting forest products either to the market or to their homes. Some of the roads, according to FGD results, have been constructed in the area previously designated as forest further aiding access to forest resources in the area. Results therefore show that good infrastructure promotes dependence on forest resources by households in the area.

c. Household Income

The results in Table 4.7 likewise showed that household income and forest activities overall interaction was positive. This reveals that the possibility of engaging in forest activities is dependent on households income status (λ = 0.181; Z = 3.537, $p<0.05$). Results however demonstrate that dependency of forest activities on income of the household for both sites was not the same. While in Kieni East, it was significant (λ = 0.165; Z = 2.265, $p<0.05$), it was insignificant for Kieni West (λ = 0.131; Z = 1.728, $p>0.05$). With an annual average household income of KShs 179,595.00 (that is 4.7 USD per day) (see Table 4.2), which is above the international poverty line estimates (of less than 2 USD per day) (UN, 2015). The findings possibly explains one of the factors behind local residents dependence on forest resources. This finding corroborates FGD

results which indicated that access to forest resources is subject to payment of requisite fees as per policy guidelines. Therefore, households with financial resources use it to access forest resources by engaging in forest activities.

d. Land

The results too show that interaction parameter of land resources and forest activities was positive. This signifies that the probability of engaging in forest activities for households is dependent on land ownership ($\lambda = 0.273$; $Z = 5.216$, $p<0.05$) (see Table 4.7). Again, dependency of forest activities on household natural resources for both sites was the same as indicated in the results in Table 4.7 ($\lambda = 0.177$; $Z = 2.407$, $p<0.05$) for Kieni East and ($\lambda = 0.313$; $Z = 4.023$, $p<0.05$) for Kieni West. Table 4.2 shows that 93% of households own land. Regression results show that household land ownership in the area increases the probability of household dependence on forest resources for livelihood. This finding is consistent with FGD results indicating that access to the forest for the local community require land ownership as proof of local residency. FGD outcome further indicated that due to the fragile nature of land in the area and unstable environmental conditions, farm production levels are low and unpredictable. Households therefore seek additional land for farming and grazing in the forest through the *shamba* system programme as a strategy to cover-up for the shortfall. Therefore land ownership in the area promotes dependence on forest resources in the area.

e. Participation in Local Institutions

According to results in Table 4.7, the interaction parameter for local institutions and forest activities is negative ($\lambda = -0.159$; $Z = -2.88$, $p<0.05$). The dependency of forest activities on local institutions for both sites was equally negative as shown in results in Table 4.7 ($\lambda = -0.104$; $Z = -1.468$, $p>0.05$) for Kieni East and ($\lambda = -0.026$; $Z = -0.199$, $p>0.05$) for Kieni West. Results in Table 4.2 likewise indicate that about 67.5% of surveyed respondents are members of self-help groups. These findings show that the association between membership in self-help groups and forest activities is negative implying that the probability of engaging in forest activities is unlikely for households who belong to community based organisations (CBOs). This means that the probability

of engaging in forest activities increases with weak household social capital. According to FGD results, members who join local CBOs do so mainly for social-cultural reasons like support during funeral or wedding ceremonies other than conservation or economic reasons. This implies that Community Forest Associations (CFAs) founded with the support of the Kenya Forest Service (KFS) to promote forest conservation are not a favourable choice for the local households. According to FGD results, CFA leadership is shrouded with poor governance issues and do not serve the interests of the local households. This was illustrated by the following comment:

> …the local forester often colludes with CFA officials to deny the community forest benefit!'
>
> (FGD participant, Gathiuru Sub-location, Kieni East).

Results therefore show that participation in self-help groups in the area has an inverse relationship with forest dependence.

4.3.3 The Effect of Household Assets on Cropping Activities

a. Education

Results show that the interaction parameter for education and cropping activities is positive suggesting that the prospect of engaging in crop growing activities is dependent on education status ($\lambda = 0.249$; $Z = 4.179$, $p<0.05$) (see Table 4.7). The dependency of crop activities on education of the household for both sites was also affirmative as indicated in the results in Table 4.7 ($\lambda = 0.281$; $Z = 3.227$, $p<0.05$) for Kieni East and ($\lambda = 0.205$; $Z = 2.296$, $p<0.05$) for Kieni West. Therefore, the level of education of household head has an influence on their participation in agricultural activities in both sites. Education often serves as an enabler for transmission of specific information needed for a particular task or type of work and shapes attitudes, beliefs and habits. With majority of the household heads (about 90%) and members (about 93%) having attained education of at least primary level (see Table 4.2), the linkage between education and

cropping activities is validated by this result. In line with this finding, Rosegrant & Cline (2003) reported that many farmers in rural areas do not have the up-to-date information on how to grow food efficiently and economically. This implies that improving household knowledge of new techniques and technologies, which are dependent on the level of education, can significantly increase the farmers' level of productivity. Therefore it is concluded from the findings that higher education promotes participation in farming activities in the area.

b. Household Income

Table 4.7 shows that overall interaction coefficient of household income and cropping activities is absolute. This demonstrates that the chance of engaging in cropping activities is also dependent on household income status ($\lambda = 0.160$, $Z = 2.703$, $p<0.05$). Results show that income plays a significant role in household participation in cropping/farming activities. Table 4.1 indicates that average household income in the area is KShs 179,595 from different sources of income, and local households engage in an average of four different crop varieties in the area. According to Windle & Rolfe (2005), household net income is one of the determinants of household decision to engage in crop diversification activities to increase farm income. Findings therefore suggest that household income plays a vital role in supporting households to improve farming practice through the purchase of farm inputs like fertiliser, certified seed and hiring of causal labour.

c. Land

Table 4.7 indicates that land ownership and cropping activities interaction parameter is also explicit indicating that the probability of engaging in cropping activities is dependent on land resources ($\lambda = 0.171$; $Z = 2.873$, $p<0.05$). However, it is demonstrated that dependency of cropping activities on land resources of the household for both sites was different. In Kieni East, dependency was significant ($\lambda = 0.437$; $Z = 4.103$, $p<0.05$) but insignificant for Kieni West ($\lambda = -0.082$; $Z = -0.897$, $p>0.05$). As a natural asset, land is a crucial resource to farming as a factor of production, to the extent that it is assumed that the inability to farm is synonymous to being landless in Kenya (RoK, 2008).

Therefore, with 93% land ownership, land possession is one of the determining factors behind the high proportion (over 70%) of the households engaged in farming in the area for both subsistence and commercial purposes. From these findings, it is concluded that land ownership is an important factor for participation in cropping activities by households.

d. Participation in Local Institutions

The relationship between local institutions and cropping activities was found to be negative but significant (λ = -0.142; Z = -1.985, $p<0.05$) (see Table 4.7). Therefore, the interaction parameter for local institutions and cropping activities is negative. This indicates that the probability of engaging in cropping activities was lower for households that enjoy membership of local self-groups, that is, probability of engaging in farming increases with weak social capital. Findings show that though local institutions in the study area are important, they play an insignificant role in the promotion of farming activities in the area. The findings were corroborated by FGD results that suggested households in the area prefer to pursue personal interests in farming matters. For instance, acquisition of certified seed and other farm inputs is a matter of individual household choice to improve farm production. So this has led individual household heads to only participate jointly in the provision of other public goods of various kinds, like the construction of social infrastructure like school and health facilities. Therefore, results are in variance with findings of previous studies on social capital. For example, it would be expected that extension services rolled out in the area find local organizations useful in the promotion of sustainable agriculture and livelihoods in the area. According to Zak & Knack (2001), social capital promotes shared norms which act as constraints on narrow self-interest and enhance public good. Also, Baron et al. (2000), reported that social capital is a useful resource that underpins the livelihood strategies of the rural household as it enables participants to act together more effectively in pursuit of shared objectives. Results therefore show that participation in self-help groups in the area has an inverse relationship with farming activities, contrary to expectations.

4.3.4 The Effect of Household Assets on Livestock Activities

a. Education

Relationship between education and livestock activities was also found to be definite (see Table 4.7) suggesting that the likelihood of engaging in livestock activities is dependent on human assets ($\lambda = 0.125$; $Z = 2.148$, $p<0.05$). Also, it is established that dependency of livestock activities on education of the household head for both sites was not the same. While it was significant in Kieni East ($\lambda = 0.168$; $Z = 1.917$, $p<0.1$), it was insignificant in Kieni West. Consistent with this finding, previous studies have indicated a positive impact of education on livestock keeping (Anaeto et al., 2012). The suggested reason for the positive influence of education is that smallholder livestock production depends on how farmers are able to adopt new innovations, which is dependent on the level of household education. Also how well educated households are determines their ability to apply the new ideas. Therefore with almost 90% of household heads educated up to and above primary level, the ability to adopt extension messages and work within requisite technology framework has proven useful. Furthermore, Thornton (2010) in his study on livestock production opined that future demand for livestock products will be heavily moderated by socio-economic factors such as education and this is corroborated by this finding. Therefore it is concluded from the finding that higher education promotes participation in livestock activities in the area.

b. Transport Infrastructure

Results of interaction coefficient for transport infrastructure and livestock activities demonstrates that the probability of engaging in livestock activities is dependent on household physical assets in form of transport infrastructure ($\lambda = 0.294$; $Z = 4.43$, $p<0.05$) (Table 4.7). It is also confirmed that dependency of livestock activities on physical infrastructure of the household for both sites was similar (Kieni East [$\lambda = 0.382$; $Z = 3.375$, $p>0.05$] and Kieni West [$\lambda = 0.252$; $Z = 2.985$, $p>0.05$]). Results in Table 4.2 indicate that the average household distance to the nearest all-weather road was 0.97km. As past studies have demonstrated (Heffernan & Misturelli, 2002), in Kenya, use of road network leads to improved access to veterinary services that has positive impact on

livestock production. The finding therefore shows that households with access to transport infrastructure are likely to keep livestock in the area. The need to transport livestock is a common occurrence in commercial agriculture, however to some extent too, it is vital in the rural or subsistence sector as well. FGD results also revealed the need for animals to be moved for a number of reasons including marketing, slaughter, restocking, moving from drought areas to better grazing and change of ownership. Typically, focused group participants averred that methods used to move animals in the study area include hoof driving and motor vehicle using the available road infrastructure. It can be concluded that improved rural road infrastructure facilitates movement of livestock to and from markets to enhance income generation for households. Better transport infrastructure therefore promotes farming activities in the area.

c. Household Income

According to results in Table 4.7, interaction coefficient for household income and livestock activities is explicit. This shows the probability of engaging in livestock activities is dependent on household financial resources ($\lambda = 0.200$, $Z = 3.363$, $p<0.05$). It is also shown that dependency on financial resources by livestock activities for both sites was consistent in Kieni East ($\lambda = 0.263$; $Z = 2.723$, $p<0.05$) and Kieni West ($\lambda = 0.191$; $Z = 2.367$, $p<0.05$). Table 4.2 shows that the average gross income for households in the study area was KShs 179,595, which is above the official Kenya poverty line of US$ 2 (UN, 2015). Past studies like Ellis & Freeman (2004) also demonstrate positive relationship between income and livestock production, which upholds the findings of this study. Livestock is invariably subject to negative impacts of disease and weather, a common occurrence in the study area. FGD results revealed that due to the harsh weather in the area like drought, disease and cattle thefts, farmers are occasionally compelled to dispose of their livestock at throw away prices or loose altogether through death. When the weather finally recovers, restocking of livestock becomes necessary, and only those households with sound financial power are capable of carrying on with livestock farming. Furthermore, management of disease and feeding are resource intensive and famers with limited financial power find disease control and

general livestock management difficult to cope with. The finding therefore implies household income is an important factor in promoting household animal husbandry activities in the area.

4.3.5 The Effect of Household Assets on Off-farm Activities

a. Education

From data in Table 4.7, household participation in off-farm activities is influenced by household education status. The results demonstrate that the probability of engaging in off-farm activities was contingent on education ($\lambda = 0.175$; $Z = 2.708$, $p<0.05$). It is also shown that dependency of off-farm activities on education of the household for both sites was different (Table 4.7). In Kieni East, dependency though positive, was insignificant ($\lambda = 0.141$; $Z = 1.375$, $p>0.05$) but was positively significant in Kieni West ($\lambda = 0.287$; $Z = 3.246$, $p<0.05$). Results in Table 4.2 indicate that both household head and members had an average illiteracy level of less than 9%, which is below the national average of 25% (KIPPRA, 2014). Therefore, positive association of education and off-farm activities by regression results is buttressed by this outcome. Whether it is formal employment or self-employment, the role of education in a person's ability to secure employment or run business, respectively, is fundamental. Formal employment both in public or private companies requires education achievement as a common practice. Existing studies corroborate the positive impact of education on off-farm activities. A study by Gordon & Graig (2001) reported that better educated members of rural populations have better access to non-farm employment on offer, and are also more likely to establish their own non-farm businesses. Consistent with this finding, De Janvry & Sadoluet (2001) further point out that education is a key determinant of participation in the remunerative non-farm sector, whereas Mecharla (2002) established a strong, significant association between traditional rural non-farm economy and human assets in India. The findings therefore show that the education achievements in the area may explain the reason why over 60% of the household respondents engage in off-farm activities.

b. Transport infrastructure

Transport infrastructure has an influence on off-farm activities (Table 4.7). Results show that the prospect of participating in off-farm activities is dependent on access to all weather roads ($\lambda = 0.160$; $Z = 2.319$, $p<0.05$). Results also show that dependency of off-farm activities on roads was different in both sites. In Kieni East, dependency was negative and insignificant ($\lambda = -0.016$; $Z = -0.161$, $p>0.05$) but positive and significant in Kieni West ($\lambda = 0.315$; $Z = 3.339$, $p<0.05$). Earlier results (Table 4.1) indicate that average nearest distance for respondent households was less than 1km. This result is consistent with the above regression analysis outcome showing that farm households with access to transport infrastructure are more likely to engage in off-farm activities in the study area. The positive sign of the coefficient implies that enhancing access to transport infrastructure increases the household probability of engaging in off-farm activities 0.160 times in the study area. Good road network has implications on the ease with which goods, services and activities can be reached, as well as access to markets and inputs for production (KIPPRA, 2014). Therefore, access to transport network is imperative for household heads involved in off-farm activities to expand their income horizon. The results therefore demonstrate the importance of rural economic infrastructure given the role it plays in movement to work as employee and casual worker, products movement to and fro the market, access of social amenities like education, among other important functions. Thus road infrastructure improvement, according to results facilitates participation of households in off-farm activities in the area.

c. Household Income

Household income and off-farm activities are positively associated according to results in Table 4.7. Data in Table 4.7 show that the probability of engaging in off-farm activities is dependent on financial resources of the household ($\lambda = 0.131$, $Z = 2.019$, $p<0.05$). It is also established that dependency of off-farm activities on household income for both sites was atypical (significant in Kieni East [$\lambda = 0.321$; $Z = 2.598$, $p<0.05$] and insignificant in Kieni West [$\lambda = 0.079$; $Z = 0.924$, $p>0.05$]). Results in

Table 4.2 show that household average income is about KShs 180,000 and over 60% of respondents engage in off-farm activities. Regression results therefore are indicative of the role played by financial resources in non-farm activities. During the FGDs, it was also revealed that one of the greatest challenges to local small scale entrepreneurs in the area was lack of financial capital. Results show that it is mostly those in access to requisite capital that are likely to participate in self-employment as entrepreneurs, partly explaining the reason for the 40% who are not involved in non-farm activities. For instance, lack of financial capital has been found in previous studies to be the main constraint to starting and running SMEs in rural areas. A study by Deininger & Olinto (2001) reported that investment in a single income source was most beneficial to capital constrained households, as was validated by Escobal (2001) that limitations from access to credit were detrimental to income diversification strategies in Peru. It is therefore concluded that household income is a determinant of participation in off-farm activities.

In summary, results show that FA was affected by education ($\lambda = 0.470$, $p<0.05$); transport infrastructure ($\boldsymbol{\lambda} = 0.20$, $p<0.05$); income ($\boldsymbol{\lambda} = 0.181$, $p<0.05$); land ($\boldsymbol{\lambda} = 0.273$, $p<0.05$); and participation in local institutions ($\boldsymbol{\lambda} = -0.159$, $p<0.05$). Cropping activities were affected by education ($\boldsymbol{\lambda} = 0.249$, $p<0.05$); income ($\boldsymbol{\lambda} = 0.160$, $p<0.05$); land ($\lambda = 0.171$, $p<0.05$); and local institutions ($\lambda = -0.142$, $p<0.05$). Livestock activities were influenced by education ($\lambda = 0.125$, $p<0.05$); transport infrastructure ($\lambda = 0.294$, $p<0.05$); and income ($\boldsymbol{\lambda} = 0.200$, $p<0.05$). Lastly, off-farm activities were influenced by education ($\lambda = 0.175$, $p<0.05$); transport infrastructure ($\boldsymbol{\lambda} = 0.160$, $p<0.05$); and income ($\boldsymbol{\lambda} = 0.131$, $p<0.05$).

In summary, results show that although all assets affect livelihood choices, household education and income are the most influential as they affect all the livelihood activities in the area. It is concluded that household assets affect livelihood activity choices and therefore the second null hypothesis of this study is rejected.

4.4. Impact of Livelihood Choices on Environment Degradation

The third objective of this study was to establish the impact of livelihood activities on the environment challenges in the area manifested in three common phenomena, that is, deforestation, water scarcity and soil erosion. In this third part of the analysis, descriptive statistical tools were used to analyse household livelihood choices, before inferential statistics was applied to measure the impact of livelihood choices on environmental degradation (water scarcity, deforestation and soil erosion) in the study area.

This sub-section includes firstly the descriptive statistics of the livelihood activities, secondly multiple regression model specifications for measuring the impact of livelihood choices on the three environmental degradation phenomena in the study area and thirdly results showing the impact at the two sites and pooled data. Also, FGDs results are used to provide further explanation of the outcome of the analysis.

4.4.1 Descriptive Findings on Environmental Degradation

Table 4.8 shows dependent variables (against independent variables in Table 4.7) used for the multiple regression analysis model and descriptive results for the two sites and pooled data.

Table 4.8: Descriptive statistics results for dependent variables for Kieni East, Kieni West, and Pooled Data

Variable Description	Kieni East (N = 200)		Kieni West (N = 200)		Pooled Data (N = 400)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Dependent variables (Environmental degradation)						
% of household who felt forest tree cover has been depleted over the last 5 years** [D]	26.6		18.9		22.8	
% of households who believe tree cutting is prevalent in the area** [D]	56.3		51.7		54	
% of households who believe timber extraction from forests is by villagers [D]	29.1		32.5		30.9	
% of households experiencing water shortage** [WS]	93.3		87.3		90.34	
% of households who experience crop failure due to inadequate water** [WS]	88.4		86.6		87.5	
% of households who perceive cause of soil erosion in the area as due to overgrazing, charcoal burning and over cultivation** [SE]	100		98.4		98.9	
% of households experiencing soil erosion on their farms*** [SE]	15.7		42.1		29.5	
% of households farm produce reduction due to soil erosion*** [SE]	34.7		85.2		59.95	

Variables in which sample households of Kieni East have significant differences from those of Kieni West: *** = at 0.01 level of significance; ** = at 0.05 level of significance.

Survey data, 2017

As far as water scarcity is concerned, Table 4.8 shows that 90.3% of respondents experience water shortage in their homesteads and farms. While perception of water scarcity was higher ($p<0.05$) in Kieni East (93.3%), it was slightly lower in Kieni West (87.3%). The effect of water scarcity on farm production was also found to be more in Kieni East (88.5%) compared to Kieni West (86.6%) at $p<0.01$ significance.

In terms of soil erosion phenomenon, 99% of household respondents reported that soil erosion in the area is caused by overgrazing, charcoal burning and over cultivation of the land (Table 4.8). Only 15.7% of household respondents reported to experience soil erosion on their farms in Kieni East compared to more than twice (42.1%) in Kieni West. On average 60% of households reported crop production reduction on their farms as due to the effect of soil erosion, with 85.2% in Kieni West and only 34.7% in Kieni East.

Results in Table 4.8 also show that 22.8% of respondents felt tree cover in forests has reduced over the last 5 years, with a higher proportion of households in Kieni East of 26.6% compared to 18.9% in Kieni West. On perception of tree cutting in the area, 54% of respondents believe that tree cutting is rampant with a higher percent of 56.3% in Kieni East compared to 51.7% in Kieni West. On average, 30.9% of interviewed respondents believe that timber extraction from the forest is by local villagers.

4.4.2 Impact Estimation of Livelihood Choices on Environmental Degradation

a. Model Specification and Variables entered into the Multiple Regression Model

Multiple regression analysis technique was used to predict the unknown values of environmental degradation variables (water scarcity, deforestation and soil erosion) from the known values of the four livelihood choice variables (forest, cropping, livestock and off-farm activities), also called the predictors. Multiple regressions were preferred for analysis because they permitted studying of joint effect of all livelihood activities on environmental degradation. The predictor variables are combined into the multiple regression equation that is used to predict scores on the criterion variable (*Y*) from scores on the predictor variables (X_is). The general form of this equation (4.3) is:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots + b_k X_k + \varepsilon \qquad 4.3$$

Where:

Y = Criterion variable; b_0 = Intercept coefficient; b = Regression coefficient; X = Predictor variable; ε = Error term.

Therefore, specifically overall/pooled regression of livelihood choices on environmental degradation is rewritten as follows:

$$Y_E = B_0 + B_{FA} X_{FA} + B_{CA} X_{CA} + B_{LA} X_{LA} + B_{OA} X_{OA} + \varepsilon \quad \text{.....} \quad 4.4$$

Where:

Y_E = Environmental degradation variables (water scarcity, deforestation and soil erosion); B_0 = Regression intercept coefficient; B_{FA} = Forest activity regression coefficient; X_{FA}= Forest activity variable; B_{CA} = Crop activity on regression coefficient; X_{CA} = Crop activity variable; B_{LA} = Livestock activity regression coefficient; X_{LA} = Livestock activity variable; B_{OA} = Off-farm regression coefficient; X_{OA} = Off-farm activity variable; and ε = Error term.

Considering the three environmental degradation phenomena factors identified in this study, regression coefficients for the four livelihood choice variables was computed as shown in the regression models (4.5, 4.6 & 4.7) below.

$$Y_{WS} = B_0 + B_{FA}X_{FA} + B_{CA}X_{CA} + B_{LA}X_{LA} + B_{OA}X_{OA} + \varepsilon \quad \text{.....} \quad 4.5$$

$$Y_D = B_0 + B_{FA}X_{FA} + B_{CA}X_{CA} + B_{LA}X_{LA} + B_{OA}X_{OA} + \varepsilon \quad \text{.....} \quad 4.6$$

$$Y_{SE} = B_0 + B_{FA}X_{FA} + B_{CA}X_{CA} + B_{LA}X_{LA} + B_{OA}X_{OA} + \varepsilon \quad \text{.....} \quad 4.7$$

Where:

Y_{WS} = Water scarcity variables; Y_D = Deforestation variables; Y_{SE} = Soil erosion variables; and $\mathcal{E}$ = Error term.

As shown in Table 4.7, the sub-variable for forest activities (FA) were annual average household income from forest products and the proportion of households who depend on forest resources for a livelihood. The second category of livelihood activities, cropping activities (CA) sub-variables consisted of average household annual crop income and average number of crop varieties per household. Household livestock activities (LA), annual income from livestock sales and livestock numbers in TLU variables were studied as the third category sub-variables. The fourth category involved off-farm (OA) sub-variables which included average annual household income from off-farm activities and proportion of households who engage in off-farm activities.

Dependent variables involving environmental degradation are also shown in Table 4.8. Here, three categorical variables were considered,, that is, water scarcity (WS) consisting of two sub-variables, proportion of household perception on water shortage experience and households perception on crop failure attributed to inadequate water; deforestation (D) which comprised of three sub-variables, that is, proportion of households who felt forest tree cover has reduced over the last 5 years, household proportion that believe tree cutting is prevalent in the area, and timber extraction from forest is by local villagers. The third and last variable was soil erosion (SE), where a proportion of the households perceive the cause of soil erosion (that has led to reduction in farm produce) in the area as due to overgrazing, charcoal burning and over cultivation.

Before multiple regression analysis was performed, the independent variables were examined for collinearity. Results of the variance inflation factor (all less than 2.0), and collinearity tolerance (all greater than .70) suggests that the estimated βs are well established in the regression model (see Appendix B). To check for fitness of the

regression model in terms of predictive ability, R^2 (coefficient of determination) for all the four models was between 0 and 1 (see Tables 4.9 to 4.14). Statistical significance was also tested using t-test; respective p values are also indicated in Tables 4.9 to 4.14.

Data obtained from all respondents (200 from each site including their livelihood activities and environmental degradation) were considered in the four models. The explanatory variables (X_i) included in the model were livelihood choices including forest activities (FA), cropping activities (CA), livestock activities (LA) and off-farm activities (OA). FA, CA, LA and OA are categorical variables. The dependent variable used in this multiple regression analysis included environmental degradation perceived by households, that is, water scarcity (WS), deforestation (D) and soil erosion (SE). Like explanatory variable, dependent variables were also categorized. Tables 4.9 to 4.14 show regression analysis results of livelihood activities on deforestation, water scarcity, soil erosion and pooled data for environmental degradation. It is therefore a 4-step multiple regression, which involved the interaction between four continuous scores. In this case, deforestation variables were entered at Step 1 (Model 1), water scarcity was added at Step 2 (Model 2), and the interaction between the soil erosion and livelihood activities scores were added at Step 3 (Model 3). The fourth model was pooled data for the first three models for the overall environmental degradation (deforestation, water scarcity and soil erosion).

b. Findings

Results of Model 1 in Table 4.9 show that the relationships between cropping and off-farm activities and deforestation were statistically significant at $p<0.01$, while between forest activities and deforestation was significant at $p<0.05$. Cropping activities was most influential in the model that causes deforestation ($B = 0.232$, t-values = 3.931, $p<0.01$); off-farm activities was second ($B = 0.192$, t-values = 4.132, $p<0.05$), and lastly forest activities ($B = 0.103$, t-values = 2.139, $p<0.05$).

Table 4.9: Deforestation regression coefficients

Variable	Model 1: Deforestation			
	B	**Std. Dev**	**t**	**Sig.**
Constant	-.336	.047	-7.166	.000***
Forest activities (F*A*)	.103	.048	2.139	.033**
Cropping activities (*CA*)	.232	.059	3.931	.000***
Livestock activities (*LA*)	.056	.047	1.181	.238
Off-farm activities (*OA*)	.192	.047	4.132	.000***
F		16.36		
Adjusted R^2		.133		
F for change in R^2		16.36		

Dependent variables: Deforestation
*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

In Model 2, results shown in Table 4.10 indicate that the relationships between forest, cropping and livestock activities and water scarcity were statistically significant at $p<0.01$. The relationship between off-farm activities and water scarcity was however insignificant. The impact of forest activities on water scarcity was strongest in the model (B = 0.264, t-values = 5.053, $p<0.01$), followed by livestock activities (B = 0.184, t-values = 3.579, $p<0.01$), and finally cropping activities (B = 0.169, t-values = 2.641, $p<0.\ 01$).

Table 4.10: Water scarcity regression coefficients

Variable	Model 2: Water scarcity			
	B	**Std. Dev**	**T**	**Sig.**
Constant	-.129	.051	-2.542	.011**
Forest activities (F*A*)	.264	.052	5.053	.000***
Cropping activities (*CA*)	.169	.064	2.641	.009***
Livestock activities (*LA*)	.184	.051	3.579	.000***
Off-farm activities (*OA*)	-.045	.051	-.897	.370
F		18.84		
Adjusted R^2		.152		
F for change in R^2		18.84		

Dependent variables: Water scarcity
*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Model 3 results in Table 4.11 show that the relationships between forest and cropping activities and soil erosion were statistically significant at $p<0.01$; but the relationship between livestock activities and soil erosion were significant at $p<0.05$. Cropping activities, according to results influenced soil erosion the most (B = 0.277, t-values = 4.457, $p<0.05$) followed by forest activities (B = 0.195, t-values = 3.844, $p<0. 01$). The least impact was realized from animal husbandry (B = 0.125, t-values = 2.502, $p<0.05$).

Table 4.11: Soil erosion regression coefficients

Variable	Model 3: Soil erosion			
	B	**Std. Dev**	**T**	**Sig.**
Constant	-.179	.049	-3.622	.000***
Forest activities (F*A*)	.195	.051	3.844	.000***
Cropping activities (*CA*)	.277	.062	4.457	.000***
Livestock activities (*LA*)	.125	.050	2.502	.013**
Off-farm activities (OA)	.033	.049	.669	.504
F		16.77		
Adjusted R^2		.137		
F for change in R^2		16.77		

a. Dependent variables: Soil erosion

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Results in Tables 4.12 and 4.13 shows that the relationship between livelihood choices and deforestation, water scarcity and soil erosion was both significant and insignificant in the two sites of the study area. In Kieni East, deforestation was only caused by cropping activities; water scarcity by forest activities; and soil erosion by forest and cropping activities. However, in Kieni West, deforestation was caused by cropping activities and off-farm activities; water scarcity by forest activities and livestock activities; and soil erosion by all activities, that is, forest activities, cropping activities, livestock activities and off-farm activities.

Table 4.12: Regression coefficients of livelihood activities predicting environmental degradation for Kieni East

	Deforestation			***Water scarcity***			***Soil erosion***		
Variables	**B**	**T**	**Sign.**	**B**	**T**	**Sign.**	**B**	**t**	**Sign.**
Const.		-6.817	.000***		-2.127	.035		-3.480	.001***
Forest activities (*FA*)	.110	1.369	.172	.313	4.092	.000***	.222	2.831	.005***
Cropping activities (*CA*)	.149	2.182	030 **	.112	1.718	.087	.194	2.892	.004***
Livestock activities (LA)	.118	1.476	.142	.154	2.021	.045	.183	2.342	.020
Off-farm activities (*OA*)	.123	1.599	.111	.009	.129	.898	-.082	-1.085	.279
F		4.98			10.51				
Adjusted R^2		.074			.160			.113	

b. Dependent variables: Deforestation, water scarcity and soil erosion

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Table 413: Regression coefficients of livelihood activities predicting environmental degradation for Kieni West

	Deforestation			Water scarcity			Soil erosion		
Variables	**B**	**T**	**Sign.**	**B**	**T**	**Sign.**	**B**	**t**	**Sign.**
Const.		-3.256	.001***		-1.403	.162		-7.741	.000***
Forest activities (*FA*)	.173	2.335	.021	.231	3.019	.003***	.220	8.517	.000***
Cropping activities (*CA*)	.236	3.593	.000***	.126	1.846	.066	.222	5.260	.000***
Livestock activities (*LA*)	-.023	-.305	.761	.233	2.962	.003***	.073	4.928	.000***
Off-farm activities (*OA*)	.274	3.799	.000***	-.107	-1.428	.155	.124	2.787	.000***
F		13.31			9.08			281.52	
Adjusted R^2		.198			.140			.413	

c. Dependent variables: Deforestation, water scarcity and soil erosion

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Overall pooled data results in Model 4 results (Table 4.14) show that pooled data relationships between livelihood choices and environmental degradation are statistically significant at $p<0.01$ for all activities. Forest activities was the most influential in the model that causes environmental degradation (B = 0.386, t-values = 8.517, $p<0.05$), followed by livestock activities (B = 0.224, t-values = 4.928, $p<0.05$), and cropping activities (B = 0.205, t-values = 5.260, $p<0.01$). The least influential livelihood activity on environmental degradation was off-farm activities (B = 0.122, t-values = 2.787, $p<0.01$).

Table 4.14: Environmental degradation (Pooled data) regression coefficients

Variable	Model 1: Deforestation		Model 2: Water scarcity		Model 3: Soil erosion		Model 4 (Pooled data): Environmental degradation			
	B	Sig.	B	Sig.	B	Sig.	B	Std. Dev.	t	Sig.
Const.	-.336	.000***	.129	.011**	-.179	.000**		.059	-7.741	.000***
Forest activities (*FA*)	-.336	.033**	.264	.000***	.195	.000**	.386	.060	8.517	.000***
Cropping activities (*CA*)	.232	.000***	.169	.009***	.277	.000**	.205	.074	5.260	.000***
Livestock activities (*LA*)	.056	.238	.184	.000***	.125	.013**	.224	.059	4.928	.000***
Off-farm activities (*OA*)	.192	.000***	-.045	.370	.033	.504	.122	.058	2.787	.006***
F	16.36		18.84		16.77		281.53			
Adjusted R^2	.133		.152		.137		.395			
F for change in R^2	16.36		18.84		16.77		66.15			

a. Dependent variables: Environmental degradation

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

4.4.3 Impact of Livelihood Choices on Deforestation

According to results (Tables 4.9) deforestation in the study area is caused by forest, cropping and off-farm activities. Table 4.8 also shows that 22.8% of respondents believe forest cover has been depleted over the last 5 years, and 54% and 30.9% are of the opinion that tree cutting is prevalent in the area and timber extraction is carried out by villagers, respectively.

Regression analysis (Table 4.9) shows that engaging in forest activities, for example crop cultivation, grazing or logging leads to deforestation (B = 0.192, t-values = 4.132, $p<0.05$). Also results in Table 4.12 and Table 4.13 show that the effect of forest

activities on deforestation in both sites was varied. Whereas it was insignificant in Kieni East (B = 0.110, t-values = 1.369, p>0.05), it was significant in Kieni West (B = 0.173, t-values = 2.335, p<0.05). These findings correspond with past studies showing that people cut down trees in the forest to harvest timber for wood, products or fuel, and are one of the primary drivers of deforestation (Buttler, 2012). The results were supported by evidence from the FGDs, as exemplified by this quote:

> "*... watu wa mbali walikuja wakakata miti, pia mimi siwezi lala njaa kukiwa na miti …"* (Loosely translated, people came from far and cut trees, and for me, I cannot sleep hungry and there are trees!)
>
> (FGD participant, Kamatongu Sub-location, Kieni West).

Also in apparent corroboration of the above finding, an aging FGD participant had this to say:

> … when we settled here in the sixties, the forest was full of trees, but now … it is empty!
>
> (FGD Participant, Kamburaini Sub-location, Kieni East).

Other studies (Mathias, 2014; Chen & Wang, 2012) also found that the use of cattle as a production input for other farming activities (manure for fertilization, provision of biogas) are the main factors that motivate households to overgraze in the forests, leading to deforestation.

Also, regression analysis (Table 4.9) shows that engaging in cropping activities on household farms and the forest leads to deforestation (B = 0.232, t-values = 3.931, p<0.05). Results in Table 4.12 and Table 4.13 also show that the effect of cropping activities on deforestation in both sites was significant (Kieni East [B = 0.149, t-values = 2.182, p<0.05], Kieni West [B = 0.236, t-values = 3.593, p<0.05]). The results are coherent with a study by Mullan et al. (2017) who reported that agricultural expansion

into tropical forests brings local economic benefits but at the expense of environmental costs. Past studies further show that such people use the slash-and-burn technique to clear the surrounding forest for short-term agriculture, but as the land degrades they are forced to migrate, exploring new forest frontiers thus increasing deforestation (Amor, 2008; Amor & Pfaff, 2008). In justifying these findings, it has been argued (World Bank, 2001) that more than 25% of the world's population, rely on forest resources for their livelihoods. This includes, among others, smallholder production in the forest that manifests in the growing number of such producers like shifting cultivators that is likely to remain the main cause of deforestation for a long time to come in the study area.

According to results in Table 4.9, it is also shown that engaging in off-farm activities leads to deforestation (B = 0.103, t-values = 2.139, $p<0.05$). Again, results in Table 4.12 and Table 4.13 show that the effect of off-farm activities on deforestation in both sites was mixed. While it was positive but insignificant in Kieni East (B = 0.123, t-values = 1.599, $p>0.05$), it was significant in Kieni West (B = 0.274, t-values = 3.799, $p<0.05$). Also results in Table 4.6 indicate that off-farm activities carried by local communities in the forest include collecting and selling forest products (fuelwood, poles and charcoal) that lead to deforestation. The results thus show that human activities like off-farm activities are the primary contributors to forest degradation. Previous studies also validate this finding where peasant farmers with few other economic opportunities tend to drive deforestation (Geist & Lambin, 2001; Zwane, 2002) by engaging in off-farm activities in the forest. As Sands (2005) found out, expanding cities and towns requires land to establish the infrastructure necessary to support growing population engage in off-farm activities, which is done by clearing the forests. Moreover, it can be argued that construction of infrastructure like roads which are determinants of non-farm activities lead to opening up of forests thus increasing the numbers of people to the forest frontier. This was confirmed by Christopher et al. (2014), who reported that roads have a major impact on the Amazon deforestation, observing that about 95% of deforestation, was within 5.5km of a road.

Findings in Table 4.9 therefore show that out of the four livelihood choices practiced in the area, only three contribute to deforestation in the study area. These activities included forest, cropping and off-farm activities.

4.4.4 Impact of Livelihood Choices on Water Scarcity

Results in Table 4.10 indicate that three out of four activities households commonly practiced in the study area lead to water scarcity. These activities are forest, cropping and livestock activities, and as results show, they have compounded the problem of water scarcity in the area. Also, Table 4.8 shows that 90.3% of respondents opined that they experience water shortage in their homes and farms, and 87.5% of the respondents believed that crop production had reduced due to water scarcity.

Firstly, as shown by regression results (Table 4.10), forest activities have the greatest impact on water scarcity ($B = 0.264$, t-values = 5.053, $p<0.05$). Results in Table 4.12 and Table 4.13 show that the effect of forest activities on water scarcity in both sites was positive and significant (Kieni East [$B = 0.313$, t-values = 4.092, $p<0.05$], Kieni West [$B = 0.231$, t-values = 3.019, $p<0.05$]). In line with this finding, past studies have shown that fuelwood collection is often found in tropical forests and degraded forest areas (Margarida et al., 2014; Woodwell, 2002) and increases water scarcity in affected areas. Trees help prevent excessive evaporation of water bodies, and so destruction of forests exposes soil moisture to the sun's intense heat, leaving them dried out. Also, farming in the forest involves clearing forest trees and bushes which in turn exposes the soil to direct sunlight leading to evaporation of water from the soil. As a result of these activities, one of the FGD participants aptly noted:

> … this area was named *Kamburaini* because those days it was a rainy place. But now, the name is meaningless because rain is no longer a frequent occurrence! … (FGD participant, Kamburaini Sub-location, Kieni East).

The results are consistent with findings of a World Bank (2007) report which showed that major water catchment areas in Kenya, including the Aberdare Ranges and Mt. Kenya have lost their forest cover over the years with the closed canopy forest cover currently standing at a dismal 2%. Furthermore, Mati et al. (2008) reported that between 1973 and 2000, there was a 32% decrease in forest cover and a 203% increase in agricultural cover in the Mara River basin in Kenya. This affects water source downstream due to exposure of the forest as water catchment. Also grazing of livestock, a common forest activity has a similar negative effect to water availability like cropping activities. This is because overgrazing leads to exposure of the soil in the forest resulting in water evaporation from the soil.

Secondly, regression results in Table 4.10 also show that livestock activities result to water scarcity ($B = 0.184$, t-values = 3.579, $p<0.05$). Results in Table 4.12 and Table 4.13 further show that the effect of livestock activities on water scarcity in both sites was significant (Kieni East [$B = 0.154$, t-values = 2.021, $p<0.05$], Kieni West [$B = 0.233$, t-values = 2.962, $p<0.05$]). The positive relationship of animal husbandry and water scarcity has been previously studied, in which it was shown that in extensive grazing systems, the water contained in forages is significantly lost to meeting water requirements for livestock upkeep (Schilink et al., 2010). In dry climates, the situation is even worse as water content of forages decreases from 90 per cent during the growing season to about 10 to 15 per cent during the dry season (Schilink et al., 2010). FGD results revealed that some of the households in the area practice zero grazing mode of livestock husbandry, mainly for milk production. Diets for these animals are water intensive because of the huge quantities of water required for their upkeep, exacerbating water availability challenges in the area. Similarly, Parker (2003) shows that water requirements per animal can be high, especially for highly productive animals under warm and dry conditions. Furthermore, water scarcity becomes worse in the study area where livestock are allowed to wander free in search of food and water. Therefore, in extensive livestock production systems like the area under study, the effort expended by

animals in search of feed and water increases the need for water considerably, compared to intensive systems where animals do not move around much.

Finally, results in Table 4.10 show that cropping activities cause water scarcity (B = 0.169, t-values = 2.641, $p<0.05$). As crop farming is mostly accomplished by opening up the soil in preparation of planting, it exposes the soil to water evaporation. Reports from key informants (MoA&LD) revealed that approaches that could minimise this loss like minimum tillage are hardly practiced in the area. By opening up the soils, farmers also destroy trees and bushes that provide cover to the soil as protection from evaporation. Some farming practices also encourage higher water losses (Clay, 2004) mainly through leaky irrigation systems; wasteful field water application methods; pollution by agrichemicals; and cultivation of 'thirsty' crops not suited to the environment. According to FGD results, the situation is even compounded by the fact that the area is ASAL where water scarcity is prevalent. Some innovative and resourceful household individuals and horticultural firms/farms have established minor and major irrigation systems, which abstract water from either the forest and under the ground. This has augmented the water scarcity problem in the area, FGD participants argued. However, with continuing population growth and limited potential to increase suitable cropland, as other studies have demonstrated, irrigation has become increasingly important to food security strategies (Wichelns & Oster, 2006). Unfortunately though, increasing levels of irrigation as practiced by horticultural farms and household farmers in the area augments the cost of water and this may escalate problems of water scarcity in the area further.

These findings (Table 4.10) therefore show that forest, cropping and livestock activities carried in the area contribute to the water scarcity situation in the study area.

4.4.5 Impact of Livelihood Choices on Soil Erosion

Data in Table 4.11 shows that the following three livelihood activities have a negative impact on the soil: forest, cropping and livestock activities. Earlier, data in Table 4.8 showed that 98.9% of respondent households believe that soil erosion is prevalent in the area and is caused by overgrazing, charcoal burning and over cultivation. In addition, results indicate that 29.5% and 59.95% of respondents were experiencing soil erosion on their farms and considered that farm produce on their farms had reduced due to soil erosion, respectively.

In the first place, regression analysis in Table 4.11 shows that forest activities like over cultivation and overgrazing cause soil erosion ($B = 0.195$, t-values = 3.844, $p<0.05$). Results in Table 4.12 and Table 4.13 further show that the effect of forest activities on soil erosion in both sites was significant (Kieni East [$B = 0.222$, t-values = 2.831, $p<0.05$], Kieni West [$B = 0.220$, t-values = 2.923, $p<0.05$]). The forest is one of the important sources of livelihood for local communities, according to FGD results. Earlier results in Table 4.3 showed that it was from the forests that households obtain fuelwood, food, medicine and construction materials. Studies in the past have shown that local households are almost fully dependent on the forests, relying especially on the woodlands for their subsistence that may lead to soil degradation. For instance, research conducted in southwest Niger by Favreau et al. (2009) showed that land clearing increased surface runoff volume by a factor close to three. Therefore, the removal of trees without sufficient reforestation, according to the authors, resulted in damage to habitat, biodiversity loss and drying of soils. Also, Gicheru et al. (2012) found in their study in Kenya (Narok), that the loss of land cover (grass, bushes and trees) exposed the soil to erosion.

FGD results also revealed that soil erosion and sedimentation are closely associated with forest activities. The participants observed that in recent times, the rivers in the area have filled with sediments as a result of flooding from the water catchment areas. This has been occasioned by the increasing demand for agricultural products, thus leading to

the conversion of forests into farm fields and pastures. Such a transition from natural vegetation to agriculture causes soil erosion. Kabanza et al. (2013) while working in South-Eastern Tanzania on forest land cover dynamics showed that as annual crops increased, natural vegetation lost large proportions of land that had been converted to cashew orchards. Therefore, forest land cover change can lead to an overall reduction of natural vegetation, which is a driver of soil erosion. During FGDs, it was also observed that most of the crop varieties when compared to indigenous plants cannot hold onto the soil, suggesting that current cropping patterns cannot withstand pressure from moving water.

Secondly, regression analysis shows that cropping activities cause soil erosion (B = 0.277, t-values = 4.457, $p<0.05$) (Table 4.10). Results in Table 4.12 and Table 4.13 further prove that the effect of cropping activities on soil erosion in both sites was significant (Kieni East [B = 0.194, t-values = 2.892, $p<0.05$], Kieni West [B = 0.222, t-values = 3.315, $p<0.05$]). Over-cropping reduces the soil's ability to produce valuable humus for soil fertility as it is constantly being ploughed or stripped for crop growth. One of the FGD participants summed it up thus:

> … because of land over use as a result of small plot sizes, the soil has become very weak thus susceptible to erosion and led to low farm produce! …
> (FGD participant, Kamburaini Sub-location, Kieni East).

With less humus, the soil dries out and becomes open for wind and rain erosion. In corroborating this finding, previous studies (Boardman et al., 2003) have reported that farming practices associated with some crops encourage runoff and erosion. For example, cultivation of potatoes in rows and ridges channel runoff. Also there are certain agricultural practices that are environmentally unsustainable and can be the single biggest contributor to the general increase in soil quality decline. Moreover, tillage on agricultural lands is acknowledged as one of the causal soil erosion factors since it breaks up soil into finer particles that increases erosion rates. The favourable influence of reduced tillage system and of crop residues on soil erosion was also suggested by Lal (2006), who showed that in no-tillage system, soil losses by erosion were close to the

ones found in case of soil protection with 6 tonnes per hectare of mulch. Furthermore, FGD results show that some households cultivate on sloppy grounds which enhances the rate of soil loss as a result of farming activities. For instance studies carried out on a 9% slope in Luvisol, in the centre of Croatia, showed that ploughing on the upstream–downstream direction resulted in losing soil by erosion (Kisic, 2006). Other improper cultivation activities such as farming on a steep slope and mono-cropping, row-cropping and surface irrigation wear away the natural composition of the soil and its fertility.

Thirdly, the regression analysis (Table 4.10) shows that livestock keeping causes soil erosion ($B = 0.125$, t-values = 2.502, $p<0.05$). Results in Table 4.12 and Table 4.13 show that the effect of livestock activities on soil erosion in both sites was not the same. It was significant in Kieni East ($B = 0.183$, t-values = 2.342, $p<0.05$) but insignificant in Kieni West ($B = 0.073$, t-values = 0.942, $p>0.05$). The higher B value in Kieni East means that the impact of livestock on soil erosion is more than twice in Kieni West. The possible explanation for the difference in significance may lie in livestock population in the two sites (Table 4.5). Household number of livestock (in TLU) in Kieni West [7.97] was almost half that in Kieni East [12.48] at $p<0.01$. This means that there is less trampling on the soil that leads to soil compaction which causes loss of soil through water runoff. Also, Okoti et al. (2006) showed that there is increased gully erosion, especially near the mountain areas due to animal trampling. Amman et al. (2004) also reported that high livestock levels result in degradation, especially during critical periods of drought in Narok. Johansson et al. (2002) found that in the semi-arid catchment of Lake Baringo, the change from cattle to goats resulted in the goats browsing on more bushes and twigs to survive in much harsher conditions, but leads to an even harder pressure on the remaining vegetation. Consequently, overgrazing destroys surface crop cover and breaks down soil particles, increasing the rates of soil erosion. Further, it is vital to note that when soil is loosened by overgrazing and vegetation trampling, it can be subject to wind and water erosion.

Findings in Table 4.10 thus demonstrate that of the four livelihood activities, three of them lead to soil erosion in the area. These include: forest, cropping and livestock activities.

4.4.6 Livelihood Choices and Environmental Degradation

Pooled data (Tables 4.13) shows that livelihood activities in the study area have a negative effect on the environment. The finding demonstrates that all livelihood activities, that is forest, cropping, livestock and off-farm activities in the study area contribute to environmental degradation through deforestation, water scarcity and soil erosion (forest activities [B = 0.386, t-value = 8.517, $p<0.05$]; cropping activities [B = 0.205, t-value = 5.260, $p<0.01$]; livestock activities [B = 0.224, t-value = 4.928, $p<0.01$]; and off-farm activities [B = 0.122, t-value = 2.787, $p<0.01$]). Consistent with these findings, Chopra (2016) demonstrated that the relationship between physical environment and the well-being of individuals and societies is multi-faceted, with qualitative and quantitative characteristics to it. The author further argues that the major causes of environmental degradation are modern urbanization, industrialization, over-population growth and deforestation, adding that the different kinds of human activities are the main reasons of environmental degradation. Furthermore, Foyeke (2011) found that such human activities include destruction of the natural vegetation through farming, road construction and lumbering; use of fertilizers which may pollute water and even affect the soil vegetation and aquatic lives; and agricultural practices such as overgrazing, bush burning, application of fertilizer, pesticides and herbicides. This was illustrated by the following comment:

> … when the big farms spray chemicals, the pests move from their farms and since we do not have a lot of resources like them, we survive under the mercy of the pests! …
>
> (FGD participant, Gathiuru Sub-location, Kieni East).

In summary, hierarchical multiple regression findings show that all the four livelihood activities cause environmental degradation (water scarcity, deforestation and soil erosion). Regression results indicate that deforestation was caused by cropping activities ($B = 0.232$, $p<0.05$); forest activities ($B = 0.192$, $p<0.05$) and off-farm activities ($B = 0.103$, $p<0.05$). Water scarcity was caused by forest activities ($B = 0.264$, $p<0.05$); cropping activities ($B = 0.169$, $p<0.05$) and livestock activities ($B = 0.184$, $p<0.05$). Soil erosion in the area was caused by cropping activities ($B = 0.277$, $p<0.05$); forest activities ($B = 0.195$, $p<0.05$); and livestock activities ($B = 0.125$, $p<0.05$).

It is concluded that livelihood activities lead to environmental degradation and therefore the second null hypothesis of this study is rejected.

4.5 Moderating Effect of Extension Services on Livelihood Choices

The fourth objective of the study was to establish the moderating effect of rural extension services between household assets and livelihood choices. This sub-section describes the results of the impact of extension services on household livelihood choices in the study area, in relation to the four selected livelihood choice variables. It includes descriptive results of extension services, and hierarchical multiple regression models to understand the moderating effect of extension services. It also presents results indicating the moderating influence of extension services on livelihood choices.

4.5.1 Descriptive Results for Rural Extension Services

Table 4.15 shows the moderating variables used for the log linear regression analysis model and descriptive results for the two sites and pooled data.

Table 4.15: Moderating variables descriptive statistics results of Kieni East, Kieni West, and Pooled Data

Variable Description	Kieni East (N = 200)		Kieni West (N = 200)		Pooled Data (N = 400)	
	Mean	**St. Dev.**	**Mean**	**St. Dev.**	**Mean**	**St. Dev.**
Moderating variables (Extension services)						
% of households visited by extension field officer over the last 3 years***	7.6		33.3		19.8	
% of households that have received assistance from extension organizations***	6.3		42.3		24.6	

Variables in which sample households of Kieni East have significant differences from those of Kieni West: *** = at 0.01 level of significance ** = at 0.05 level of significance.

Survey data, 2017

Results in Tables 4.15 showed that only 19.8% of the surveyed respondents have been visited by extension officers over the last three years. Responses from the two sites were however diverse at $p<0.05$ significance. Whereas only 7.6% of surveyed households in Kieni East confirmed visits by Extension Officers, a greater proportion (33.3%) of respondents in Kieni West testified to have been visited over the same period. Also overall, data in Table 4.15 indicate that 24.4% of the study respondents participated in local extension programs. Whereas 42.3% of surveyed households in Kieni West reported to have participated in rural extension activities in the past five years, only 6.3% households in Kieni East benefited over the same period.

4.5.2 Extension Services Moderating Effect Estimation on Livelihood Choices

a. Model Specification and Variables entered into the Hierarchical Multiple Regression Model

This part of the analysis involved moderation that entailed an interaction effect, where introducing a moderating variable changes the direction or magnitude of the relationship between two variables. In this case, the study was interested in finding out whether the effect of livelihood assets on livelihood choices depends on extension services provided in the study area.

To investigate the unique contribution of extension services on the explanation of livelihood choice, a hierarchical multiple regression analysis was performed. Based on the following general regression equation (4.8), a moderation model was developed.

$Y = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots\ldots\ldots + b_kX_k + \mathcal{E}$ ……...…..……...…. 4.8

To test moderation, the researcher first examined whether or not such an effect is significant in predicting Y for interactions X on Y without Z and Z on Y without X, see Equations 4.9 and 4.10, respectively.

$Y_x = B_0 + B_xX + \mathcal{E}$ ……..……..…….. 4.9

$Y_z = B_0 + B_zZ + \mathcal{E}$ ……..……...……...…. 4.10

Where:

$\boldsymbol{Y_x}$ = Livelihood choice after interaction of X; B_0 = Regression intercept coefficient; $\boldsymbol{B_x}$ = Livelihood asset regression coefficient; $\boldsymbol{X}$ = Livelihood assets variable; $\boldsymbol{B_z}$ = Extension services regression coefficient; $\boldsymbol{Z}$ = Extension services variable; and $\mathcal{E}$ = error term

Using log linear regression technique, the researcher secondly tested moderation of the interaction effect between X and Z and whether or not such an effect is significant in predicting Y (see Equation 4.11).

$Ln(Y_{XZ}) = B_0 + B_X + B_Z + B_{XZ} + \mathcal{E}$ ……..……..……... 4.11

Where:

$Ln(Y_{XZ})$ = Log of the expected cell frequency of the cases for cell XZ in the contingency table; B_0 = Overall mean of the natural log of the expected frequencies; B_X = Main effect

for variable X; B_Z = Main effect for variable Z; B_{XZ} = Interaction effect for variables X and Z; and $\mathcal{E}$ = Error term.

To test moderation, the researcher examined whether or not such an effect is significant in predicting Y for interactions X*Z on Y (see Equation 4.12).

$$Y_{x*z} = B_0 + B_{x*z} X*Z + \mathcal{E} \quad \ldots\ldots 4.12$$

Where:

Y_{x*z} = Livelihood choice after interaction of X*Z; B_0 = Regression intercept coefficient; B_{x*z} = X*Z regression coefficient; X*Z = Livelihood assets and livelihood activity choice interaction variable; and $\mathcal{E}$ = Error term.

Variables that explain livelihood choices were entered in two steps. In step 1, livelihood choice (Y) was the dependent variable and household assets were independent. Sub-variables (see Table 4.1) for household assets (X) included education (household head and members level of education), transport infrastructure (average household distance to all-weather road) and household income (average annual income). Others included were land (proportion of household who own land and amount of land in acres owned by household) and participation in local institutions (household membership in self-help groups). The dependent sub-variables, on the other hand, comprised of forest activities (household average annual income from forest activities), cropping activities (average annual income from crop sales and number of household crop varieties planted), livestock activities (average annual household livestock sale income and number of household livestock in TLU) and off-farm activities (proportion of households who engage in off-farm activities and average household annual income from off-farm activities). The final stage of step 1 regression was performed on Y as the dependent variable while extension services (Z) was the independent variable. Sub-variables for Z were household number of extension officer visits over the last three years and

household participation in extension programs during the last five years. The relevant models are shown in Equations 4.9 and 4.10. In step 2, the sub-variable of X*Z was determined using log linear analysis (see Equation 4.11).

Before the hierarchical multiple regression analysis was performed, the independent variables were examined for collinearity. Results of variance inflation factor (all less than 2.0), and collinearity tolerance (all greater than .70) suggested that the estimated βs are well established in the above regression models. The final stage of step 2 involved regression of X*Z on Y (see Equation 4.12).

b. Findings

Multiple regression models were tested to investigate whether the association between household livelihood assets (X) and household livelihood choices (Y) depends on the amount of extension services (Z) in the area. After centering household livelihood assets and extension services and computing the livelihood assets by extension interaction term (McCabe, Kim & King, 2018), the two predictors and the interaction were entered into simultaneous regression models. Tables 4.16, 4.17 and 4.18 show regression results for pooled data and the two sites (Kieni East and Kieni West), respectively.

Table 4.16: Regression coefficients for variables as predictor of livelihood choices for pooled data

Model	Pooled data					
1	**Variable**	***b***	***Se***	**Beta β**	**t-value**	**p-value**
	1 (Const.)	-.111	.049		-2.289	.023
	Livelihood assets (X)	.344	.049	.317	7.055	.000***
	Extension services (Z)	.284	.043	.297	6.604	.000***
2	1 (Const.)	-.119	-.119		-2.289	.015
	Livelihood assets (X)	.333	.333	.306	6.760	.000***
	Extension services (Z)	.286	.286	.299	6.660	.000***
	X*Z	.074	.074	.071	1.566	.118

a. Dependent variable: Livelihood choices. Where X = livelihood assets, Y = livelihood choices and Z = extension activities

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Table 4.17: Regression coefficients for variables as predictor of livelihood choices for Kieni East

Model	Kieni East					
1	**Variable**	***b***	***Se***	**Beta β**	**t-value**	**p-value**
	1 (Const.)	-.191	.075	.360	-2.545	.012
	Livelihood assets (X)	.446	.076	.324	5.844	.000***
	Extension services (Z)	.311	.059	324	5.261	.000***
2	1 (Const.)	-.226	*.075*		-3.005	.003***
	Livelihood assets (X)	.447	.075	.353	5.807	.000***
	Extension services (Z)	.063	*.063*	.264	4.039	.000***
	X*Z	.179	*.070*	.164	2.540	.012

a. Dependent variable: Livelihood choices. Where X = livelihood assets, Y = livelihood choices, and Z = extension activities

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Table 4.18: Regression coefficients for variables as predictor of livelihood choices for Kieni West

Model		Kieni West				
1	**Variable**	***b***	***se***	**Beta β**	**t-value**	**p-value**
	1 (Const.)	-.105	.077		-1.369	.173
	Livelihood assets (X)	.272	.077	.236	3.529	.001***
	Extension services (Z)	.234	.063	.248	3.705	.000***
2	1 (Const.)	-.104	.077		-1.345	.180
	Livelihood assets (X)	.276	.077	.241	3.567	.000***
	Extension services (Z)	.215	.070	.228	3.053	.003***
	X*Z	-.047	.076	-.046	-.614	.540

a. Dependent variable: Livelihood choices. Where X = livelihood assets, Y = livelihood choices and Z = extension activities

*** Significant at 1% level ** Significant at 5% level * Significant at 10% level

Survey data, 2017

Results (Table 4.16) indicate that higher level of extension services (Z) [b = .284, SE = .043, β = .297, p<.01] and more household assets endowment (X) [b = .344, SE = .049, β =.317, p<.01] were both associated with livelihood choices by households. However, the interaction between livelihood assets and extension services (X*Z) was insignificant [b = .074, SE = .048, β = .071, p>.01], suggesting that the effect of livelihood assets on livelihood choices was not dependent on the level of extension services. Similar results (Table 4.17 and Table 4.18) was observed for both sites, i.e. Kieni East [b = .179, SE = .070, β = .164, p>.01] and Kieni West [b = .-047, SE = .076, β = -.046, p>.01], where the relationship between household livelihood assets and livelihood choices was not dependent on the extension activities.

4.5.3 Extension Services Moderating Effect on Livelihood Choices

Results in Table 4.16 show that the interaction (X*Z) between livelihood assets and extension services was insignificant on livelihood activity choices [b = .074, SE = .048,

$\beta = .071$, $p>.01$]. The finding suggests that the effect of livelihood asset on livelihood choices was not dependent on extension activities. Table 4.15 shows that 19.8% of households were visited by extension agents over the last three years, and a proportion of 24.6% of households reported to have received assistance from extension organizations in the study area. According to FGD results, local extension programs aim to support target groups to adopt practices that are sustainable and yet maximise on output for the benefit of farm households. By introducing extension services in the area, key informant interview results show that the Ministry of Agriculture and Livestock overarching goal of extension services programs is to improve the living standards of the local population through increased productivity and income. This finding on extension service objective was a contradiction with the FGD outcome. FGD participants voiced disappointment that the extension services impact in the area has been below expectations. They claimed that extension services in the area were too little too late, in apparent reference to the low proportion of households targeted for the services. On the state agencies role to improve life in the area, one participant exclaimed:

> … *Sisi huku, nikama tumesahaulika na serikali*! … Loosely translated "As for us here, the Government has forgotten us!
>
> (FGD participant, Bondeni Sub-location, Kieni West).

Further the FDGs revealed that although there were a number of organizations (both state and non-state) working in the area to promote better living standards through extension services, the impact was not felt because of targeting only a selected few.

The regression findings are also not consistent with past studies. Waddington et al. (2010) study on Training and Visit Extension in Asia and Africa reported that since a livelihood comprises of capabilities, assets and activities required for a means of living, agricultural extension not only aims to increase productivity and income, but also to improve multi-faceted aspects of rural life. This implies agricultural extension encompasses the entire set of organizations that support and facilitate people engaged in

agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods and well-being (Birner et al., 2006). Quite often though, the impact of extension services has been associated with choices to improve productivity and household income. However, by corroborating with study findings of negligible extension services achievement, it demonstrates similar outcomes of previous studies (Rivera, Qamar & Crowder, 2001; Anderson & Feder, 2007).

In summary, results show that the interaction of extension services and household assets has insignificant effects on household livelihood choices ($b = .074$, $SE = .048$, $\beta = .071$, $p>.01$). It is therefore concluded that extension services do not moderate the relationship between household assets and livelihood choices, and therefore the third null hypothesis of this study is accepted.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study as guided by the specific objectives, derives conclusions from the findings, and gives recommendations on this. Recommendations include suggestions of further research.

The general objective of this study was to establish the impact of rural livelihood activity choices on environmental degradation in Kieni East and Kieni West sub-counties of Nyeri County, Kenya.

The specific objectives were:

a) To characterise households in Kieni East and Kieni West sub-counties based on the socio-economic factors.
b) To determine the effect of household assets on livelihood choices in Kieni East and Kieni West sub-counties.

   H_{01}: Livelihood assets do not affect household livelihood choices.
c) To determine the impact of livelihood activities on water scarcity and soil erosion in Kieni East and Kieni West sub-counties.

   H_{02}: Household livelihood activities do not have significant effect on water scarcity, deforestation and soil erosion.
d) To assess the moderating effect of extension services between household assets and livelihood activities in Kieni East and Kieni West sub-counties.

   H_{03}: Extension services do not moderate the relationship between household assets and livelihood activities.

The study was guided by sustainable livelihood theoretical approach, a research analysis framework in which the household assets are the activity components that improve livelihoods. The approach encompassed four blocks that comprised asset block, livelihood mediating processes/conditioning factors block, livelihood strategies and activities block, and the outcomes/effects block, theorized by the study as relevant in the context of livelihood activity choices and environmental degradation.

5.2 Summary of Key Findings

Overall, household survey results showed that although the four livelihood activity choice variables (independent variables of the study) were predictors of environmental degradation outcomes (water scarcity, deforestation and soil erosion), impacts were not uniform across all the dimensions of environmental degradation considered in this study. Therefore, all the four livelihood activity choice variables were in one way or the other associated with water scarcity, deforestation and soil erosion outcomes but at different degrees.

The first objective of the study was to identify the socio-economic characteristics of respondents in the study area as a way of underscoring the context in which the study respondents operate. This is because socio-economic factors play a significant role as impediments or enablers of household access to assets. Founded on results, socio-economic characteristics of study respondents were identified and categorised into household head gender and marital status; age and farming experience; and family size and labour. Other characteristics included household head and members' level of education; and occupation options of household heads.

The second study objective was to determine the effect of household assets (education, transport infrastructure, household income, land and local institutions) on livelihood choices (forest, cropping, livestock and off-farm activities). Findings indicate that all the four household livelihood activity choices are influenced by the five household assets. The type and degree of influence on the activity choices was however distinct for the

different household assets. Forest activities adopted by households in the study area are influenced by all the five household assets, that is, education, transport infrastructure, household income, land ownership and local institutions in that order. Four assets were found to have a significant influence on crop activities; these are education, household income, land ownership and local institutions, respectively. Livestock activities on the other hand were affected by three assets, that is, education, transport infrastructure and household income, respectively. Off-farm activities were affected by three household assets; that is education, transport infrastructure and household income in that order. It is thus revealed that household education and income influenced all the livelihood activity choices signifying the important role human and financial capital play in the survival of individual households in the area.

The third objective was to determine the impact of livelihood activity choices (forest, cropping, livestock and off-farm activities) on environmental degradation outcomes (deforestation, water scarcity and soil erosion). Pooled results show that all livelihood activities in the area cause overall environmental degradation, in which forest activities had the highest impact, followed by cropping activities, livestock activities and off-farm activities, respectively. Results also show that deforestation was caused by cropping, off-farm and forest activities, respectively, while water scarcity was triggered by forest, livestock and cropping activities in that order. On the other hand, the soil erosion dimension of environmental degradation was instigated, according to results by cropping, forest and livestock activities, respectively. Results therefore demonstrate that whereas all the four livelihood activity choices lead to various forms of environmental degradation, the degree of impact on the environment was however distinct for the different livelihood activities. It is thus established that forest activities and cropping activities have significant effect on all the three environmental degradation phenomena in the area. By implication, strategies to control environmental degradation (water scarcity, deforestation and soil erosion) in the area must of necessity focus on these two livelihood activity choices, that is, forest activities in the forest and cropping activities on the household farms.

The fourth objective was to determine the moderating effect of rural extension services between HH assets and livelihood choices. Findings revealed that the interaction of rural extension services and household assets was not a significant predictor of the four dimensions of livelihood activity choices (forest activities, cropping activities, livestock activities and off-farm activities) defined in the study area. However, household livelihood activity choices independently were influenced by household assets and extension services in the absence of moderating effect on household assets. This implies that extension services in the area do not respond to household needs, and this may explain why environmental degradation continues unabated in spite of extension efforts being rolled out in the area as a result of adoption of unsustainable livelihood activity choices.

The general findings of the qualitative study (FGDs) supported the findings of the quantitative analysis. Most of the participants reported to have experienced an increasing deforestation, water scarcity and soil erosion phenomenon as compared to previous years. Also, FGD results showed that households were not realising improved livelihood activity outcomes, mainly due to socio-economic and environmental related challenges that affect livelihood activity choices. The FGD participants, however, generally expressed optimism that they were likely to experience better quality of life if only challenges that affect their access to livelihood assets are addressed, despite the concern that interventions to minimise environmental degradation are inadequate, and sometimes comes in too little, too late.

The beliefs held by participants regarding the concept of sustainable rural livelihoods were largely integrated within the context of local household traditional roles in the community, implying that cultural values still abound in the community even as households embrace and pursue their livelihood choices. What clearly stood out from the focus group discussions was that the participants ascribed to a form of livelihood choices that was more geared towards their contribution to the well-being of their households and community in relation to households' culturally determined roles in a vulnerable environmental setting. In relation to this, and based on such findings, there is need to

empower households not entirely with the access to assets that concentrate on improved quality of life (as circumscribed by the sustainable livelihood approaches) but also one that encompasses the wider scope of addressing household environmental challenges with the ultimate result of promoting sustainable development in the area. Consequently, this would culminate in reduced poverty levels and foster general development, as hypothesized by the livelihood approach to sustainable development.

5.3 Conclusions

Firstly, with regard to rural characteristics, the study concluded that the study area households have unique characteristics that contextualise household asset endowment and livelihood choices. Some of the socio-economic factors were similar, while others were different at the two sites of Kieni East and Kieni West sub-counties. Whereas average proportion of female headed households, household marital status, and household head and members' illiteracy levels, had insignificant differences at the two sites; the difference for average household size, age of household head, experience of household head, age at present landholding, and household livelihood options was significant. These have implications for strategies that are meant to improve living standards and environmental conservation mechanisms in the area.

Secondly, it is also concluded that all the five livelihood assets owned/accessed by households have significant influence on the way households choose livelihood activities but at different levels in the study area. HH education and income assets affected all the four livelihood choices, and thus it implies that human and financial assets play a critical role in strategies that are formulated to improve the living standards and promote environmental conservation in the area. Further, it is deduced that recognition by policy makers of the relationship between household assets and livelihood choices is vital for the realization of a win-win for rural household livelihood improvement and rural environmental protection.

Thirdly, it is likewise concluded that all the four commonly practiced livelihoods in the study area contribute to environmental degradation, but at different levels for each of the environmental outcomes (water scarcity, deforestation and soil erosion). Forest and cropping activities impacted negatively on the environment by resulting into all the three environmental degradation outcomes. Whereas water scarcity is caused mainly by forest activities, the main cause for both deforestation and soil erosion was cropping activities. Consequently, it is concluded that forest and cropping activities are important targets in the efforts by policy making bodies that aim to promote sustainable environmental degradation in the study area.

Results based on the fourth objective illustrate that independently, extension services and household assets have significant effect on rural livelihood choices. However, the interaction between extension services and household assets had an insignificant effect on livelihood activity choices. Accordingly, it is concluded that activities of rural extension services have insignificant impact on the livelihood choices in the study area. The implication is that extension services in the study area do not address livelihood priority needs of households. Ultimately, households continue to make unsustainable choices for their livelihoods leading to environmental damage as currently being witnessed in the study area.

5.4 Recommendations

The findings of this study established that both household assets and livelihood choices are important in order for programmes to achieve the desired living standards and environmental conservation outcomes.

Centred on the first objective, the study identified socio-economic features that contextualize the study populations which could facilitate or impede access to household assets. These factors include household head gender and marital status; age and farming experience; family size and labour; level of household and member's education; and household occupation options. The study recommends that policies and strategies should

make a deliberate effort to appreciate these factors in their programming. These will enhance household access to assets in order to improve their living standards at minimum negative impact on the environment in the area.

Based on the second objective, it was established that households in the study area rely on the five household assets to diversify their livelihood activities. It was further ascertained that education and household income assets impact on all the livelihood activity choices, that is, forest, cropping, livestock and off-farm activities. This implies that household education and incomes are the most important determinants of livelihood choices in the study area. The study therefore recommends policies that improve household access to education and incomes should be enhanced. This is because improved access to these assets forms the basis of the sustainable livelihood choices, which in the long run results into a win-win situation for household livelihood improvement and rural environment protection. For instance, in terms of education, improved vocational training for the locals would increase employment opportunities in other sectors and thus reduce the dependence on forest activities. Also, improved HH incomes, through for instance support to engage in off-farm activities, will enable the household to access health services that enhances their quality of life.

Findings, according to objective three, indicate that all livelihood activities in the area cause degradation of the environment, albeit at different intensities for each of the environmental degradation outcomes. Of the four livelihood choices, forest and cropping activities resulted in all the environment outcomes (water scarcity, deforestation and soil erosion). These activities are therefore manifest as critical for interventions to mitigate environmental degradation. Therefore policies that target the regulation of these activities would contribute immensely towards environmental control in the area. These may be achieved by focusing interventions in the forest and on farms of households, respectively.

Finally, based on the fourth objective, results illustrate that there is no moderating effect of extension services on household livelihood activity choices in the study area. Accordingly, the finding suggests that activities of rural extension services at the time of the study had insignificant impact on the livelihood choices in the study area. The implication is that extension services programs at the time of study area did not address livelihood priority needs of the households. Ultimately, households continue to make unsustainable livelihood choices that are detrimental to the environment. These choices persist to have a negative impact on the environment in spite of extension services whose overall objective is to improve community living standards while promoting environmental conservation in the area. The study therefore recommends the deepening of extension services in the area by both state and non-state providers, ensuring that a demand driven approach is adopted. This will result in more impact on the living standards as a result of sustainable activity livelihood choices and ultimately lead to sustainable environmental management by local households.

Furthermore, in one study, the effect of all HH assets on livelihood choices has been successfully explored, including measurement impact of livelihood choices on the different dimensions of environmental degradation. However, from a scholarly point of view, need for further research is apparent to establish other contributing factors to the social capital outcomes observed, as the study did not present evidence to conclusively attribute the livelihood choice presented by the findings to social capital asset household endowment.

REFERENCES

Achalu, D. N. (2004). *Farm forestry decision making strategies of the Guraghe households, Southern-Central highlands of Ethiopia*. Unpublished PhD Dissertation, Dresden: Technische Universitat Dresden.

ADB. (2004). Tonle Sap Initiative Brochures: Tonle Sap Sustainable Livelihoods. Manila. Retrieved from www.adb.org/projects/tonle_sap/tonle-sap-200412.pdf.

Ademiluyi, I. A., Okude, A. S., & Akanni, C. O. (2008). An appraisal of land use and land cover mapping in Nigeria. *African Journal of Agricultural Research*. *3*. 581–586.

Adesina, A. A., & J. Chianu. J. (2002). Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. *Agroforestry Systems. 55*, 99–112.

Adkinson, A., & Adkinson, R. (2013). The FecB (Booroola) gene and implications for the Turkish sheep industry. *Turkish Journal of Veterinary and Animal Science*. *37*, 621–624.

Admassie, A. (2002). *Allocation of children's time endowment between schooling and work in rural Ethiopia*, ZEF Discussion Papers on Development Policy No. 44, Bonn, Centre for Development Research

Ahmed, F., Chamhuri, S. & Idris, N. A. H. (2011). *The sustainable livelihood approach: Reduce poverty and vulnerability*. *7*, 810–813.

Akinwale, A. A. (2011). Livelihoods and environmental challenges in coastal communities of Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*. *11*(7) 820–823..

Akiyode, O. O. (2009). Gender, sustainable peace, and development in the Niger Delta region of Nigeria. *J. Sustain. Develop. Africa. Pennsylvania*, *11*(2), 224–236

Alkire, S., & Santos, M. E. (2010). *Acute multidimensional poverty: A new index for developing countries*. (OPHI working paper no. 38). Oxford: Oxford Poverty & Human Development Initiative.

Allison, E. H., & Ellis, F. (2001). The livelihoods approach and management of small-scale fisheries. *Marine Policy, 25*, 377–388.

Alston, J. M., Wyatt, T. J., Pardey, P. G., Marra, M. C., & Chan-Kang, C. (2000). *A meta-analysis of rates of return to agricultural R&D – Ex Pede Herculem*, Washington D.C: IFPRI.

Amevenku, F. K. Y., Asravor, R. K., & Kuwornu, J. K. M. (2019). Determinants of livelihood strategies of fishing households in the Volta Basin, Ghana. *Cogent Economics & Finance*, *7*(1), 1595291.

Amman, H. M. A., & Duraiappah, A. K. (2004). Land tenure and conflict resolution: A game theoretic approach in the Narok district in Kenya. *Environment and Development Economics. 9*, 383–407.

Amor, D. (2008). *Road impact on deforestation and jaguar habitat loss in the Selva Maya*. Unpublished PhD. Dissertation, Duke, USA: Duke University.

Amor, D., & Pfaff, A. (2008). *Early history of the impact of road investments on deforestation in the Mayan forest*. Working Paper, Nicholas School of the Environment and Sanford School of Public Policy, Durham, NC, USA.: Duke University.

Anaeto, F. C., Asiabaka, C. C., Nnadi, F. N., Ajaero, J. O., Aja O. O., Ugwoke, F. O., Ukpongson, M. U., & Onweagba, A. E. (2012). The role of extension

officers and extension services in the development of agriculture in Nigeria. *Woodpecker Journal of Agricultural Research, 1*(6), 180–185

Anantha, K. H., Wani, S. P., & Sreedevi, T. K. (2009). *Baseline socio-economic characterization of watersheds.* In: Best-bet Options for Integrated Watershed Management, 25–27 July 2007, Patancheru: ICRISAT.

Anderson, J. R. (2007). *Agricultural Advisory Services*, Background Paper for the World Development Report. Retrieved from: http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1191427986785/Anderson_AdvisoryServices.pdf

Anderson, J. R., & Feder, G. (2003). *Rural extension services*. Agriculture and Rural Development Department. World Bank Policy Research Working Paper 2976, Washington, DC.: World Bank.

Anderson, J. R., & Feder, G. (2007). Handbook of Agricultural Economics, vol. 3. Chapter 44: *Agricultural Extension.* In R. Evenson and P. Pingali (Eds.). *Agriculture and Rural Development Department* (pp. 2344–2367). Washington, DC: World Bank.

Anderson, J. R., Feder, G., & Ganguly, S. (2006). *The rise and fall of training and visit extension: An Asian mini-drama with an African epilogue*. World Bank Policy Research Working Paper 3928, Washington, DC.: World Bank.

Angelesen, A., Lassen, H. O., Lund J. F., Smith-Hall, C., & Wunder, S. (2011). *Measuring livelihoods and environmental dependence: Methods for research and field work*. Bogor, Indonesia: CIFOR.

Apollo, M., Andreychouk, V., & Bhattarai, S. S. (2018). Short-term impacts of livestock grazing on vegetation and track formation in a high mountain environment:

A case study from the Himalayan Miyar Valley (India). *Sustainability*. *10*(4), 951.

Avila, M., Atchoarena, D., & Gasperini, L. (2005). *Agency approaches to skills development for rural people. In the proceeding of the debates in skills development conference of FAO*. Rome: FAO.

Ayalneh, B. (2002). *Land degradation, impoverishment and livelihood strategiesof rural households in Ethiopia: Farmers' perception and policy implication* (Vol. 8), Germany: Institutional Change in Agriculture and Natural Resources.

Ayele Z. E. (2008). *Smallholder farmers' decision making in farm tree growing in the Highlands of Ethiopia.* Unpublished PhD. Dissertation, Oregon: Oregon State University.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., & Mathijs, E. (2008). Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems. 98.* 147–155.

Bacho, F. Z. L. (2004). An exploratory survey of small scale off-farm economic activities and sustainable household livelihoods in the Bongo District of Ghana. *Ghana Journal of Development Studies*. *1*(2), 27–48.

Baker, D. (2012). ILRI. Livestock farming in developing countries: An essential resource. Derek Baker International Livestock Research Institute 19th World Meat Congress. Paris, France 4–6 June 2012.

Bamidele, M. O. (2013). Analysis of the socio-economic characteristics and housing condition in the core neighbourhood of Akure, Nigeria. *Journal of Geography and Regional Planning*. *6*(6). 229–236.

Bannister, M. E., & Nair, P. K. R. (2003). Agroforestry adoption in Haiti: The importance of household and farm characteristics. *Agroforestry Systems. 57*, 149–157.

Barber, C. P., Cochrane, M. A., Souza, C. M., & Laurance, W. F. (2014). Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation*. *Elsevier. 177*, 203-209.

Barbier, E. B. (2003). Habitat-fishery linkages and mangrove loss in Thailand. *Contemporary Economic Policy*. *21*(1), 59–77.

Barbier, E. B. (2008). Poverty, development, and ecological services. *InternationalReview of Environmental and Resource Economics. 2*(1), 1–27.

Barbier, E. B. (2010). Poverty, development, and environment. *Environment and Development Economics. 15*(6), 635–660.

Barbier, E. B. (2013). Wealth accounting, ecological capital and ecosystem services. *Environment and Development Economics. 18*, 133–161.

Baron, S., Field. J. & Schuller, T. (2000). *Social capital: Critical perspectives,* Oxford: Oxford University Press.

Barraclough, S., & Ghimire, K. B. (2000). *Agricultural expansion and tropical deforestation*. New York: Earth-scan.

Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Food Policy. 33*, 299–317.

Barrett, C. B., Place, F. & Aboud, A. A. (2002). *Natural resources management in African agriculture: Understanding and improving current practices*. Oxon and New York: CABI publishing.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy. 26.* 315–331.

Baumann, P. (2002). *Improving access to natural resources for the rural poor: A critical analysis of central concepts and emerging trends from a sustainable livelihoods perspective.* Rome: FAO.

Bawa, K. S., Nadkarni, N., Lele, S., Raven, P., Janzen, A., Lugo, A., Ashton, P., & Lovejoy, T. (2004). Tropical ecosystems into the 21st Century. *Science. 306*, 227–230.

Bebbington, A. & Perreault, T. (2008). Social capital, development, and access to resources in Highland Ecuador. *Economic Geography*. *75*, 395–418.

Beck, T., & Nesmith, C. (2001). Building on poor people's capacities: The case of common property resources in India and West Africa. *World Development. 29*(1), 119–133.

Bensel, T. (2008). Fuelwood, deforestation, and land degradation: 10 years of evidence from Cebu province, the Philippines. *Land Degradation & Development*. *19*, 587– 605.

Bhavannarayana, C., Saritha, V., Usha P. & Rao, B. P. (2012). Dependency and usage pattern of forest-dwellers on non-timber forest products. *Erudite Journal of Ecology and Environment*. *1*(1), 1–5.

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., … & Kisamba-Mugerwa, W. (2006). *From best practice to best fit: A framework for designing and analyzing agricultural advisory services.* ISNAR Discussion Paper No. 5. Washington, DC: IFPRI.

Boardman, J., Evans, R., & Ford, J. (2003). Muddy floods on the South Downs, southern England: Problem and responses. *Environ. Sci. Policy. 6* (1), 69–83.

Boli, R. (2005). *Livelihood assets of rural Kenyans'*. Final Seminar Paper in International Development Studies (IDS), University of Winnipeg.

Bollen, K. A., Glanville, J. L., & Guy, S. (2007). Socio-economic status, permanent income, and fertility: A latent-variable approach. *Population Studies*. *6*(1), 15–34.

Bowen, S., & de Master, K. (2011). New rural livelihoods or museums of production? Quality food initiatives in practice. *Journal of Rural Studies. 27*, 73–82.

Bradford, A. (2015). Deforestation: Facts, causes & effects. Retrieved from: Livescience.com.

Bryman, A. (2008). Of methods and methodology, qualitative research in organizations and management. *An International Journal. 3*(2), 159–168.

Buckland, P. (2005). *Reshaping the future: Education and post conflict reconstruction*, Washington, DC: World Bank.

Business Daily. (2014). Retrieved from http://www.businessdailyafrica.com/ Food-prices-up-as-crop-failure-hurts-harvests/539552- 2247708-cgy5qwz/index.html

Butler, R. (2012). *A desperate effort to save the rainforest of Borneo.* Yale Environment 360 (360). Yale: Yale School of Forestry & Environmental Studies.

Bwalya, S. M. (2013). Household dependence on forest income in rural Zambia. *Zambia Social Journal. 2*(1), 67–86

Carney, D. (2003). *Sustainable livelihoods approaches: Progress and possibilities of change*; Toronto, Canada: DFID.

Carvalho, G., Barros, A. C., Moutinho, P., & Nepstad, D. (2001). Sensitive development could protect Amazonia instead of destroying it. *Nature. 409* (131), 8765-8775.

Cavendish, W. (2000). Empirical regularities in the poverty-environment relationship of rural households: Evidence from Zimbabwe. *World Development, 28*(11), 1979–2003.

Chakravarty, S., Ghosh, S. K., Suresh, C. P., Dey, A. N., & Shukla, G. (2012). *Deforestation: Causes, effects and control strategies. Global perspectives on sustainable forest management*. India: In Tech.

Chao, S. (2012). *Forest people: Numbers across the world, forest peoples program,* UK: Moreton-in Marsh.

Charmaz, K., and Mitchell, R. G. (2001). Grounded theory in ethnography. In P. Atkinson, A. Coffey, S. Delamont, J. Lofland and L. Lofland, (Eds.), *Handbook of ethnography*. 160–176.

Chen, L., Ren, C., & Wang, F. (2012). The progress and prospects of rural biogas production in China. *Energy Policy*. *51*, 58–63.

Chertow, M. R. (2001). The IPAT equation and its variants. *Journal of Industrial Ecology*. *4* (4), 13–29.

Chomitz, K. M., Buys, P., Luca, G. D., Thomas, T. S., & Wertz-Kanounnikoff, S. (2007). At loggerheads? Agricultural expansion, poverty reduction and environment in the tropical forests. *World Bank Policy Research Report*. Washington DC. Colchester, M: World Bank.

Chopra R. (2016). Environmental degradation in India: Causes and consequences. *International Journal of Applied Environmental Sciences*, *11*(6), 1593–1601

Christoplos, I. (2010). *Mobilizing the potential of rural and agricultural extension* Neuchatel: Neuchatel Group.

Clay, J. (2004). *World agriculture and the environment a commodity-by-commodity guide to impacts and practices*. Island: Island Press

Comim, F., Kumar P. & Sirven, N. (2009). Poverty and environment links: An illustration from Africa. *Journal of International Development*, 2*1*(3), 447–469.

Coomes, O. T., Barham, B. L., & Takasaki, Y. (2004). Targeting conservation-development initiatives in tropical forests: Insights from analyses of rainforest use and economic reliance among Amazonian peasants. *Ecol Econ. 51*(1), 47–64.

Corbin, J. & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage.

Córdova, J. P. P., Wunder, S., Smith-Hall, C., & Börner, J. (2013). Rural income and forest reliance in highland Guatemala. *Environ Manag*. *51*(5), 1034–1043

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd edition). Los Angeles: Sage Publications.

Cruz-Trinidad, A., Geronimo, R. C., & Aliño, P. M. (2009). Development trajectories and impacts on coral reef use in Lingayen Gulf, Philippines. *Ocean & Coastal Management*. *52*(3–4), 173–180.

Csaki, C., & Lerman, Z. (2000). *Agricultural transition revisited: Issues of land reform and farm restructuring in East Central Europe and the former USSR*. Washington, DC,: World Bank.

Dasgupta, S., Deichmann, U., Meisner, C. & Wheeler, D. (2005). Where is the poverty – environment nexus? Evidence from Cambodia, Lao PDR, and Vietnam, *World Development. 33*(4), 617–638.

Davidar, P., Sahoo, S., Mammen, P. C., Acharya, P., Puyravaud, J. P., Arjunan, M., Garrigues, J. P., & Roessingh, K. (2010). Assessing the extent and causes of forest degradation in India: Where do we stand? *Biological Conservation*. *143*, 2937–2944

Davis, J. R. (2003). *The rural non-farm economy, livelihoods, and their diversification: Issues and options*. Report prepared for Natural Resources Institute, Department for International Development, and World Bank. Chatham Maritime, Kent, UK: NRI.

Davis, J. R., & Bezemer, D. (2004). *The development of the rural non-farm economy in developing countries and transition economies: Key emerging and conceptual issues*. Chatham, UK: Natural Resources Institute.

de Faria, M. L., Ferreira, P. M., Melo, J. B., & Vasconcelos, M. J. (2014). A social assessment of forest degradation in the Cacheu Mangroves Natural Park, Guinea-Bissau Margarida Lima. *Forests*, *5*, 3327–3343.

de Haan, L., & Zoomers, A. (2003). Development geography at the crossroads of livelihood and globalisation. *Tijdschrift voor Economische en Sociale Geografie*, 94(3), 350–362.

de Haan, L., & Zoomers, A. (2005). Exploring the frontier of livelihood research. *Development and Change*, *36*(1), 27–47.

de Janvry, A., & Sadoulet, E. (2001). Income strategies among rural households in Mexico: The role of off-farm activities. *World Development, 29*(3), 467–480.

Degye, G., Belay, K., & Mengistu, K. (2012). Does crop diversification enhance household food security? Evidence from rural Ethiopia. *Advances in Agriculture, Sciences and Engineering Research, 2*(11), 503–515. Retrieved from http://www.ejournal.sedinst.com

Deininger, K., & Olinto, P. (2001). Rural nonfarm employment and income diversification in Colombia. *World Development, 29*(3), 455–465.

Dercon, S., Gilliga N. D. O., Hoddinott, J., & Woldehanna, T. (2009). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages. *American Journal of Agricultural Economics, 91*(4), 1007–1021.

DFID. (2000). *Sustainable livelihoods guidance sheets sections 1–5*. London: DFID.

DFID. (2001). *Poverty and the environment: What the poor say; An assessment of poverty-environment linkages in participatory poverty assessments*. Environment Policy Department, Issues Paper No. 1, October 2001, Department for International Development: London.

Dinku, A. M. (2018). Determinants of livelihood diversification strategies in Borena pastoralist communities of Oromia Regional State, Ethiopia. *Agricultural and Food Security, 7*(41), 875 892.

Duvert, C., Gratiot, N., Evrard, O., Navratil, O., Némery, J., Prat, C., & Esteves, M. (2010). Drivers of erosion and suspended sediment transport in three headwater catchments of the Mexican Central Highlands. *Geomorphology, 123*(3), 243–256.

Ehebhamen, O. G., Obayelu, A. E., Vaughan, I. O., & Afolabi, W. A. (2017). Rural household's food security status and coping strategies in Edo State Nigeria. *International Food Research Journal*, *24*(1), 333–340.

Ekin, T. K., Odenda, L., & Wamalwa, B. (2009). *Land tenure and property rights assessment*. Nairobi, Kenya: United States Agency for International Development.

Elliott, G., Mitchell, B., Wiltshire, B., Manan, I. A., & Wismer, S. (2001). Community participation in marine protected area management: Wakatobi National Park, Sulawesi, Indonesia. *Coastal Management*, *29*(4), 295–316.

Ellis, F. & Freeman, H. A. (2004). Rural livelihoods and poverty reduction strategies in four African countries. *The Journal of Development Studies*, *40*(4), 321-332.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford: Oxford University Press.

Ellis, F. (2000b). The determinants of rural livelihood diversification in developing countries. *Journal of Agricultural Economics*, *51*(2), 289–302.

Ellis, F., & Freeman, H. A. (eds). (2005). *Rural livelihoods and poverty reduction policies*. London and New York: Routledge.

Eneyew, A. (2012). Determinants of livelihood diversification in pastoral societies of southern Ethiopia. *Journal of Agriculture and Biodiversity Research*, *1*. 43–52.

Escobal, J. (2001). The determinants of nonfarm income diversification in rural Peru. *World Development, 29*(3), 497–508.

Escobal, J., & Aldana, U. (2003). Are non-timber forest products the antidote to rain forest degradation? Brazil nut extraction in Madre De Dios, Peru. *World Development*, *31*(11), 1873–1887.

Esterberg, K. G. (2002). *Qualitative methods in social research. Boston*, MA: McGraw-Hill.

Evenson, R. E. (2001). Economic impacts of agricultural research and extension. In B. L. Gardner & G. C. Rausser (Eds.), *Handbook of agricultural economics* (Vol. 1, pp. 573–628). Amsterdam, the Netherlands: Elsevier Science.

FAO & ILO. (2009). *The livelihood assessment tool-kit. Analysing and responding to the impact of disasters on the livelihoods of people (1st ed)*. Rome: FAO& ILO.

FAO & World Bank. (2001). *Farming systems and poverty – improving farmer's livelihoods in a changing world*. Rome and Washington DC: FAO & WB.

FAO. (2003). Forests and poverty alleviation. *State of the World's Forests 2003*, (pp. 61–73). Rome: FAO.

FAO. (2006). *Livestock's long Shadow. Environmental Issues and Options*, Rome: FAO.

FAO. (2009). *The state of food and agriculture—Livestock in the balance*, Rome: FAO.

FAO. (2010). Global forest resources assessment main report. *FAO Forestry Paper 163*. Rome: FAO..

FAO. (2012). *Coping with water scarcity*. *An action framework for agriculture and food stress*. Rome: FAO.

FAO. (2018). Water use of *livestock production systems and supply chains – Guidelines for assessment* (Draft for public review). Livestock Environmental Assessment and Performance (LEAP) Partnership, Rome: FAO.

Farhan, Y., Zreqa, D., & Nawaysa, S. (2014). Assessing the influence of physical factors on spatial soil erosion risk in northern Jordan. *J Am Sci*, *10*, 29–39.

Farrington, J. (2001). Sustainable livelihoods, rights and the new architecture of aid. *Natural Resource Perspectives 69*. Overseas Development Institute, London.

Favreau, G., Cappelaere, B., Massuel, S., Leblanc, M., Boucher, M., Boulain, N., & Leduc, C. (2009). Land clearing, climate variability, and water resources increase in semiarid southwest Niger: A review. *Water Resources Research*, *45*(7), 10.-29.

Feder, G., Murgai, R., & Quizon, J. B. (2004b). The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. *Journal of Agricultural Economics*, *55* (2), 221–243.

Felicity, J. P. (2014). *Rural economic diversification in sub-Saharan Africa*. Working Paper, Rome: FAO.

Fentahun, T., & Gashaw, T. (2014). Evaluation of land use/land cover changes of Bantneka Watershed, Ethiopia. *Journal of Agricultural Science and Soil Sciences, 2*(7), 08–085.

Ferguson, B., Murray, C., Tandon, A., & Gakidou, E. (2003). Estimating permanent income using asset and indicator variables. In C. Murray & D. Evans (Eds.), *Health systems performance assessment debates, methods and empiricism* (pp. 747–760). Geneva: World Health Organization.

Filmer, D., & Pritchett, L. (2001). Estimating wealth effects without expenditure data – or tears: An application to educational enrolments in states of India. *Demography*, *38*(1), 115–132.

Flavin, C. (2002). *Starea lumii (The world state)*, Edit. Tehnică, Bucureşti, Romania.

Fonta, W. M., & Ayuk, E. T. (2013). Measuring the role of forest income in mitigating poverty and inequality: Evidence from south-eastern Nigeria. *Forests, Trees and Livelihoods*, *22*(2), 86–105.

Foodnet & Natural Resources Institute. (2002). Transaction cost analysis. Study undertaken for the PMA. *NRI Report No: 2708*. Kampala.

Forsyth, T. (2007). Sustainable livelihood approaches and soil erosion risks. *International Journal of Social Economics*, *34*(1/2), 88–102.

Frankl, A. (2012). Gully development and its spatio-temporal variability since the late 19th century in the northern Ethiopian Highlands. *Afrika Focus*, *25*(2), 121–131

Fu, B. J., Zhao, W. W., Chen, L. D., Zhang, Q. J., Lü, Y. H., Gulinck, H., & Poesen, J. (2005). Assessment of soil erosion at large watershed scaling using RUSLE and GIS: A case study in the Loess Plateau of China. *Land Degradation and Development*. *16*, 73–85.

Garekae, H., Thakadu, O. T, & Lepetu, J. (2017). Socio-economic factors influencing household forest dependency in Chobe enclave, Botswana. *Ecological Processes*, *2*(6), 40

Gebru, G. W., & Beyene, F. (2012). Rural household livelihood strategies in drought-prone areas: A case of Gulomekeda District, eastern zone of Tigray National

Regional State, Ethiopia. *Journal of Development and Agricultural Economics, 4*, 158–168.

Geist, H. J., & Lambin, Eric F. (2001). *What drives tropical deforestation? A meta-analysis of proximate and underlying causes of deforestation based on subnational case study evidence*. Louvain-la-Neuve: LUCC International Project Office.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference 11.0 update* (4th ed.). Boston: Allyn & Bacon.

Gicheru, P., Makokha, N., Le, C., Gachimbi, L. N., Wamuongo, J. W., McNeil, D., & Brouwer, F. (2012). Land subdivision and degradation in Narok, Kenya. *Land use policies for sustainable development: Exploring integrated assessment approaches*, 148. Edward Elgar Publishing Limited, Cheltenham, UK

Gordon, A. & Craig, C. (2001). *Rural non-farm activities and poverty alleviation in Sub-Saharan Africa*. Policy Series 14. Chatham, UK: Natural Resources Institute.

Government of Ghana. (1997). *Ghana Vision 2020: The First Term – Medium Term Development Plan (1997–2000)*. Accra, Ghana: National Development Planning Commission.

Government of Ghana. (2002). *Ghana Poverty Reduction Strategy 2002–2004: An Agenda for Growth and Prosperity*. Ghana: Analysis and Policy Statement.

Government of Kenya, (2005). *Forests Act 2005*. Nairobi: Government Printers.

Government of Kenya. (2003). *Economic Recovery Strategy for Wealth and Employment Creation 2003–2007*. Nairobi: Ministry of Planning and National Development.

Government of Kenya. (2007). *Kenya Vision 2030.* Ministry of State for Planning, National Development, & Vision 2030 and Office of the Deputy Prime Minister and Ministry of Finance. Nairobi: Government of Kenya.

Government of Kenya. (2007). *Regional Development Policy*. *Ministry of Regional Development Authorities,* Nairobi: Government of Kenya..

Government of Kenya. (2007). *Sessional Paper No. 1 of 2007 on Forest Policy. Ministry of Environment and Natural Resources.* Nairobi: Government Printers.

Government of Kenya. (2009). *Kenya National Bureau of Statistics. Kenya Population and Housing Census*. Nairobi: Government of Kenya.

Government of Kenya. (2010). *Agricultural Sector Development Strategy 2010–2020*. Nairobi: GoK.

Government of Kenya. (2012). *Consultative workshop on the development of a National Climate Change Response Strategy Action Plan*. Nairobi: GoK.

Haggblade, S., Hazel, P., & Readon, T. (2010). *World Development, 38*(10), 1429–1441.

Hannover, W., & El Wafa, M. A. (2003). *Impact assessment of the participatory group extension approach supported by the IPM-Project in the horticultural sector in Egypt,* Cairo: Egyptian- German IPM Project.

Heffernan, C., & Misturelli, F. (2000). *The delivery of veterinary services to the poor: Preliminary findings from Kenya.* (Report for DFID's Animal Health Programme), London: DFID.

Hersperger, A. M., Gennaio, M. P., Verburg, P. H., Burgi, M. (2010). Linking land change with driving forces and actors: Four conceptual models. *Ecology and Society*, *15* (4), 567- 571.

Hilleris L. R., Rietkerk, M. F., van den Bosch, H. H. T., Prins, & de Kroon, H. (2001). Vegetation pattern formation in semi-arid grazing systems. *Ecology*, *82*, 50–61.

Hilson, G. (2016). Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: A critical overview. *The Extractive Industries and Society*. *3*. 547–563.

Hogarth, N. J., Belcher, B., Campbell, B., & Stacey, N. (2012). The role of forest-related income in household economies and rural livelihoods in the border-region of Southern China. *World Development, 43*, 111–123.

Hosonuma, N., Herold, M., Sy, V. D., Fries, R. S. D., Rockhaus, M. L., Verchot, L. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, 7, 044009 .

Howe, L. D., Hargreaves, J. R., & Huttly, S. R. (2008). Issues in the construction of wealth indices for the measurement of socio-economic position in low-income countries. *Emerging Themes in Epidemiology*. *5*, 1–14.

Humphreys, D. (2006). *Forest politics*. London: Earthscan Publications Ltd.

Ibimilua, F. O. (2011). Linkages between poverty and environmental degradation. *International Multi-Disciplinary Journal*, *5* (1/18), 475–484

IFAD (2001). *Rural poverty report 2001: The challenge of ending rural poverty*. Oxford: Oxford University Press for IFAD.

IFAD. (2001). *Socio economic reconnaissance study for the proposed Mt. Kenya East and Tana River catchment conservation, land use and water management pilot project.* Nairobi: IFAD.

Ifeanyi-Obi, C. C., & Matthews-Njoku, E. C. (2014). Socio-economic factors affecting choice of livelihood activities among rural dwellers in Southeast Nigeria.*Journal of Agriculture and Veterinary Science*, *7*(4), 52–56.

Itanna, F., Olsson, M., & Karl, S. (2011). Effect of land use changes on soil carbon status of some soil types in Ethiopian Rift Valley. *Journal of Drylands*, *1*, 289–299.

Jaetzold, R., Schmidt, H., Hornetz, B., & Shisanya, C. (2010). *Farm management handbook of Kenya, Vol. II – Natural conditions and farm management information (2nd ed.).*

Jansen, H. G. P., Damon, A., Rodríguez, A., Pender, J., & Schipper, R. (2006). Determinants of income earning strategies and sustainable land use practices in hillside communities in Honduras. *Agricultural Systems*, *88*, 92–110.

Jian hua, Z., & Bhandari, D. (2017). Household dependency on buffer zone community forest and its implication for management of Chitwan National Park, Nepal. *International Journal of Science*, *6*(03).

Jianchu, X., Fox, J., Vogler, J. B., Peifang, Z., Yongshou, F, & Lixin, Y. (2005). Land-use and landcover change and farmer vulnerability in Xishuangbanna Prefecture in South-western China. *Environmental Management*, *36*(3), 404–413.

Jiboye, A. (2009). The socio-cultural responsiveness of household-size on housing quality in Osogbo, Nigeria. *Anthropologist*, *6*(3), 169–174.

Jodha, N. S. (2000). Common property resources and the dynamics of rural poverty: Field evidence from dry regions of India. In Hyde & Amacher (Eds), *Economics of Forestry and Rural development – An Empirical Introduction from Asia,* Michigan: University of Michigan Press.

Johansson, J., & Svensson, J. (2002). *Land degradation in the semi-arid catchment of Lake Baringo, Kenya.* Sweden: Earth Sciences Centre, Goteborg University.

Joshi, P. K., Gulati, A., Birthal, S., & Tewari, L. (2004). Agriculture diversification in South Asia: Patterns, determinants, and policy implications. *Economic and Political Weekly, 39*(4), 2457–2467.

Kabanza, A., Dondeyne, S., Tenga, J., Kimaro, D., Poesen, E., Kafiriti, E., & Deckers, J. (2013). More people, more trees in South Eastern Tanzania: Local and global drivers of land-use/cover changes. *African Geographical Review, 32*, 44–58.

Kamanga, P., Vedeld, P., & Sjaastad, E. (2009). Forest incomes and rural livelihoods in Chiradzulu District, Malawi. *Ecological Economics, 68*(3), 613–624.

Kanbur, R. (2003). *Qualitative and quantitative poverty appraisal: Complementarities, tensions, and way forward.* New Delhi: Permanent Black Publishers.

Kenya National Bureau of Statistics (KNBS). (2010). *Statistical Abstract, 2009*, Nairobi: Government Printers.

Kenya National Bureau of Statistics. (2013). *Statistical Abstract, 2012*, Nairobi, Government Printers.

Kgathi, D. & Motsholapheko, M. (2011). Livelihood activities and income portfolios in rural areas of the Okavango delta, Botswana. *Rural livelihoods, risk and political economy of access to natural resources in the Okavango Delta, Botswana*. 35–54.

Kimhi, A., & Chiwele, D. (2000). *Barrier for development in Zambian small-and medium size farms: Evidence from micro data*. Paper presented at the 2000 Annual Meeting of the American Agricultural Economics Association. pp. 1–27.

King, E. G. (2008). Facilitative effects of *Aloe secundiflora* shrubs in degraded semi-arid rangelands in Kenya. *Journal of Arid Environments*, *72*, 358–369.

KIPPRA – Kenya Institute for Public Policy Research and Analysis. (2014). *Kenya Economic Report 2013*. Nairobi: KIPPRA.

Kisic, I., Basic, F., Mesic, M., Butorac, A., & Othmar, N. (2006). *Water erosion under different crops in Croatia, International Soil Tillage Research Organisation 17th Triennial Conference.* Kiel, Germany

Kitzinger, J. (2005). Focus group research: Using group dynamics to explore perceptions, experiences and understandings. In: Holloway, I., (Ed.), *Qualitative research in health care*. Open University Press, Maidenhead, 56–70.

Klaus, D. P., Sebastian, O., Johannes, B. R., Irene, M., & Ali, A. H. (2014). Soil erosion in gulley catchments affected by land leveling measures in the Souss Basin, Morocco, analyzed by rainfall simulation and UAV remote sensing data. *Catena*, *113,* 24–40.

Kleih, U., Kaira, C., Iga, H., & Kwamusi, P. (2004). Rural transport and livelihoods in Uganda. *Uganda Journal of Agricultural Sciences*, *9*, 56–63.

Kodiwo, M. O., & Okere, F. A. (2013). Analysis of spatial variations of agricultural land use intensity and land degradation in different physiographic regions. *Asian Journal of Humanities and Social Sciences (AJHSS), 1*(1), 3-9.

Kothari, C. R. (2004). *Research methodology: Methods and techniques, (2nd Ed.).* New Delhi: New Age International Publishers.

Kremen, C. (2007). Managing ecosystem services: What do we need to know about their ecology? *Ecology Letters*, *8*, 468–479.

Kuyvenhoven, A., Pender, J., & Ruben, R. (2004). Development strategies for less-favored areas. *Food Policy, 29* (4), 295–302

Laird, S. E. (2006). Social work practice to support survival strategies in Sub-Saharan Africa. *British Journal of Social Work*, pp. 1–17.

Lal, R. (2006). Enhancing crop yields in developing countries through restoration of the soil organic carbon pool in agricultural lands. *Land Degrad. & Develop*, *17*, 197–209.

Lamy, E., Van Harten, S., Baptista, E., Guerra, M. M., & Almeida, A. (2012). *Factors influencing livestock productivity*.

Lanjouw, J., & Lanjouw, P. (2001). The rural nonfarm sector: Issues and evidence from developing countries. *Agricultural Economics, 26*(1), 1–23.

Lim, K. J. L., Myung S., Bernard A. E., Zhenxu T., Joongdae, C., & Ki-Sung K. (2005). GIS-based sediment assessment tool. *Catena, 64*, 61–80.

Liu, J., Zhang, Z., Xu, X., Kuang, W., Zhou, W., Zhang, S., Li, R., Yan, C., Yu, D., Wu, S., & Jiang, N. (2010). Spatial patterns and driving forces of land use change in China during the early 21st century. *Journal of Geographical Sciences, 20*(4), 483–494.

Loison, S. A. (2015). Rural livelihood diversification in sub-Saharan Africa: A literature review. *Journal of Development Studies*, 51(9), 1125–1138.

Long, N. (2000). Exploring local/global transformations: A view from anthropology. In A. Arce & N. Long (Eds.) *Anthropology and Modernities*. London: Routledge.

Lufumpa, C. L. (2005). The poverty-environment nexus in Africa. *African Development Review*, 17(3), 366–381.

Mahapatra, A. K., & Mitchel, C. P. (2001). Classifying tree planters and non-planters in a subsistence farming system using a discriminant analytical approach. *Agroforestry Systems, 52,* 41–52.

Maharjan, S., Cherrier, J., & Maharjan, K. (2018). Shifting cultivation: Misconception of the Asian Governments. *Journal of International Development and Cooperation*, *24*, 71–82.

Maitima, J., Reid, R., Gachimbi, L., Majule, A., Layaruu, H., Pomery, D., Mugatha, S., Mathai, S., & Mugisha, S. (2004). *A methodological guide on how to identify trends and linkages between changes in land use, biodiversity and land degradation*. LUCID working paper series (Vol. 43). Nairobi: International Livestock Research Institute.

Makwara, E. C., & Gamira, D. (2012). About to lose all the soil in Zaka's Ward 5, Zimbabwe: Rewards of unsustainable land use. *European Journal of Sustainable Development, 1*(3), 457–476.

Maloney, K. O., Feminella, J. W., Mitchell, R. M., Miller, S. A., Mulholland, P. J., & Houser, J. N. (2008). Land use legacies and small streams: Identifying relationships between historical land use and contemporary stream conditions. *Journal of the North American Benthological Society, 27*, 280–294.

Mamo, G., Sjaastad E. & Vedeld P. (2007). Economic dependence on forest resources: A case from Dendi District, Ethiopia. *Forest Policy Econ., 9*(8), 916–927.

Mandleni, B. (2011). *Impact of climate change and adaptation on cattle and sheep farming in the Eastern Cape province of South Africa*. Unpublished PhD thesis, Pretoria: University of South Africa.

Mandleni, B., & Anim, F. D. K. (2012). Climate change and adaptation of small-scale cattle and sheep farmers. *African Journal of Agricultural Research, 7*(17), 2639–2646.

Martínez-Mesa, J., González-Chica, D. A., Bastos, J. L., Bonamigo, R. R., & Duquia, R. P. (2014). Sample size: how many participants do I need in my research?. *Anais Brasileiros de dermatologia*, *89*(4), 609–615.

Masozera, M. K., & Alavalapati, J. R. R. (2004). Forest dependency and its implications for protected areas management: A case study from the Nyungwe Forest Reserve, Rwanda. *Scand J For Res*., *19*(4), 85–92

Mathias, J. F. C. M. (2014). Manure as a resource: Livestock waste management from anaerobic digestion, opportunities and challenges for Brazil?. *Anais Brasileiros de dermatologia*, *9*(4), 619–625.

Mati, B. M., Mutie, S., Gadain, H., Home, P., & Mtalo, F. (2008). Impacts of land-use/ cover changes on the hydrology of the transboundary Mara River, Kenya/Tanzania. Lakes and Reservoirs. *Research and Management, 13*, 169–177.

McCabe, C. J., Kim, D. S., & King, K. M. (2018). Improving present practices in the visual display of interactions. *Advances in Methods and Practices in Psychological Science*, 25(15), 2459-2477.

McElwee, P. D. (2010). Resource use among rural agricultural households near protected areas in Vietnam: The social costs of conservation and implications for enforcement. *Environ Manag. 45*(1), 113–131.

Mduma, J., & Wobst, P. (2005). Determinants of rural labor market participation in Tanzania. *African Studies Quarterly.* 8(2). Retrieved from: http://www.africa.ufl.edu/asq-/v8/v8i2a2.htm.

Mecharla, P. (2002). *The determinants of rural non-farm employment in two villages of Andhra Pradesh (India).* PRUS Working Papers 12, Poverty Research Unit at Sussex, University of Sussex.

Medhin, H., & Köhlin, G. (2008). *Soil conservation and small scale food production in Highland Ethiopia: A stochastic meta-frontier approach*. Environment for Development, Discussion Paper Series EfD DP 08–22.

Minot, N., Epprecht, M., Anh, T. T., & Trung, L. Q. (2006). *Income diversification in the northern uplands of Vietnam*: IFPRI Research Report No.145. pp. 1–137.

Mitova, T., Rousseva, S., & Tzvetkova, E. (2006*). Conservation agricultural practices for soil erosion protection in Bulgaria – A brief review, International Soil Tillage Research Organisation 17th Triennial Conference*. Kiel, Germany, 1053.

Mogagga, F., Buyinza M., & Kakembo, V. (2010). Livelihood diversification strategies and soil erosion on Mount Elgon, Eastern Uganda: A socio-economic perspective. *Environmental Research Journal*, *4*(4), 272–280.

Moges, A., & Holden, N. M. (2009). Land cover change and gully development between 1965 and 2000 in Umbulo Catchment, Ethiopia. *Mountain Research and Development*, *29*(3), 265–27

Morse, S., McNamara, N., & Acholo, M. (2009). *Sustainable livelihood approach: A critical analysis of theory and practice.* Geographical Paper No. 189. University of Reading

Moyo, B. H. Z. (2010). *The use and role of indigenous knowledge in small-scale agricultural systems in Africa: The case of farmers in northern Malawi.* Unpublished PhD thesis, Glasgow: University of Glasgow.

Muhammad, I., Humayun, K., Dawood, J., & Nafees, A. (2014). Livelihood diversification: A strategy for rural income enhancement. *Journal of Finance and Economics*. 2(5), 194–198

Mullan, K., Sills, E., Pattanayak, S., & Caviglia-Harris, J. (2017). Converting forests to farms: The economic benefits of clearing forests in agricultural settlements in the Amazon. *Environmental and Resource Economics,* 1–29 - 140.

Murray, C. (2002). Livelihoods research: Transcending boundaries of time and space. *Journal of Southern African Studies,* 28(3), 489–509.

Muukkonen, P., Hartikainen, H., Lahti, K., Särkelä, A., Puustinen, M., & Alakukku, L. (2007). Influence of no-tillage on the distribution and lability of phosphorus in Finnish clay soils. *Agriculture, Ecosystems & Environment*, *120*, 299–306.

Mwang'ombe, A. W., Ekaya, W. N., Muiru, W. M., Wasonga, V. O., Mnene, W. M., Mongare, P. N., & Chege, S. W. (2011). Livelihoods under climate variability and change: An analysis of the adaptive capacity of rural poor to water scarcity in Kenya's drylands. *J. of Environ. Sci. and Tech., 4,* 403–410.

Mwangi, J. G. (2013). Developing a vibrant livestock industry in East Africa through market driven research. *Journal of US-China Public Administration, 10*(6), 608–617.

Mwangi, J., Shisanya, C., Gathenya, J., Namirembe, S., & Moriasi, D. (2015). A modeling approach to evaluate the impact of conservation practices on water and sediment yield in Sasumua Watershed, Kenya. *Journal of Soil and Water Conservation, 70*(2), 6755 - 6876.

Narain, U., Gupta, S., & Veld, K. (2005). *Poverty and the environment: Exploring the relationship between household incomes, private assets and natural assets* (Working Paper no. 134), Centre for Development Economics, Delhi.

Nasri, M., Sadat, F., Mohammad, J., & Hassan, A. (2009). *Using field indices of rill and gully in order to erosion estimating and sediment analysis (Case study: Menderjan Watershed in Isfahan province, Iran)*

Naushad, K., Mayank, D., & Tiwari, U. S. (2015). Integrated farming systems: An approach for livelihood security of small and marginal farmers. *International Journal of Science and Nature*. *6*(3), 515–520.

Nepstad, D. C., Carvalho, G., Barros, A. C., Alencar, A., Capobianco, J. P., Bishop, J., Moutinho, P., Lefebvre, P., Lopes Silva, Jr. U., & Prins, E. (2001). Road paving, fire regime and the future of Amazon forests. *Forest Ecology and Management, 154*, 395–407.

Niehof, A. (2004). The significance of diversification for rural livelihood systems. *Food Policy,* 29(4), 678- 687.

Nooteboom, G. (2003). *A matter of style: Social security and livelihood in Upland East Java.* Unpublished PhD Thesis, Nijmegen: Catholic University of Nijmegen.

Nouman, W., Basra, S., Siddiqui, M., Yasmeen, A., Gull, T., & Alcayde, M. A. C. (2014). Potential of *Moringa Oleifera L.* as livestock fodder crop: A review. *Turkish Journal of Agriculture and Forestry, 38*(1), 1–14.

Nunan, F. U. G., Bahiigwa, G., Muramira, T., Bajracharya, P., Pritchard, D., & Vargas, M.J. (2002). *Poverty and the environment: Measuring the links: A study of poverty-environment indicators with case studies from Nepal, Nicaragua and Uganda,* Environment policy department, issue paper 2.

Nyakatawa, E. Z., Mays, D. A., Tolbert, V. R., Green, T. H., & Bingham, L. (2006). Runoff, sediment, nitrogen, and phosphorus losses from agricultural land converted to sweet gum and switch grass bioenergy feedstock production in north Alabama, *Biomass and Bioenergy*, *30,* 655–664.

O'Sullivan, A., & Steven M. S. (2003). *Economics: Principles in action.* Upper Saddle River, New Jersey: Pearson Prentice-Hall.

Ogbanje, E. C., Chidebelu, S. A. N. D., & Nweze, N. J. (2015). An evaluation of off-farm work and household income among small-scale farmers in North Central Nigeria. *Journal of Agriculture and Sustainabilit, 7*(2), 227–244

Okoti, M., Keya, G. A., Esilaba A. O., & Cheruiyot, H. (2006). Indigenous technical knowledge for resource monitoring in Northern Kenya. *J. Hum. Ecol., 20*(3), 183–189

Okungu, J., & Opango, P. (2005). Pollution loads into Lake Victoria from the Kenyan catchment. In G. A. Mallya, F. F. Katagira, G. Kang'oha, S. B. Mbwana, E. F. Katunzi, J. T. Wambede, N. Azza, E. Wakwabi, S. W. Njoka, M. Kusewa, & H. Busulwa (Eds.), *Knowledge and experiences gained from managing the Lake Victoria ecosystem.*

Omar, A. A., Edinam K. G., & Olavi, L. (2013). Causes and impacts of land degradation and desertification: Case study of the Sudan. *International Journal of Agriculture and Forestry*, *3*(2), 40–51.

Omole, K. F. (2010). An assessment of housing condition and socio-economic lifestyles of slum dwellers in Akure, Nigeria. *Contemporary Management Research*, *6*(4), 272–290.

Ontita, E. (2008.) *Creativity in everyday practice rural household resources and livelihoods in Nyamira, Kenya*. Unpublished PhD Thesis, Netherlands: Wageningen University and Research Centre.

Orre, S., Muriithi, B., & Obondo, V. (2013). *Nyeri County 2013 long rains food security assessment report 29th July –2nd August 2013*.

Osano, O., Nzyuko, D., & Admiraal, W. (2003). The fate of chloroacetalinide herbicides and their degradation products in the Nzoia Basin, Kenya. Ambio: *Journal of the Environment*, 32, 424–427.

Oyono, P. R., Kouna, C., & Mala, W. (2003). *Benefits of forests in Cameroon. Global structure, issues involving access and decision-making hiccoughs*. Cameroon, Yaounde/Messa, Cameroon: Center for International Forestry Research.

Pacheco, P. (2009). Smallholder livelihoods, wealth and deforestation in the Eastern Amazon. *Hum. Ecol.*, *37*, 27.

Panta, M., Kim, K., & Lee, C. (2009). Households' characteristics, forest resourcesdependency and forest availability in central Terai of Nepal. *Journal of Korean Forest Society*, *98*(5), 548–557.

Parker, D. (2003). *Water consumption for livestock and poultry production*. Pattanayak, S. K., Sills, E. O., Mehta, A. D., & Kramer, R. A. (2003). Local uses of parks: Uncovering patterns of household production from forests of Siberut, Indonesia. *Conserv Soc.*, *1*(2), 209–222.

Peters, G. M., Wiedemann S. G., Rowley H. V., & Tucker R. W. (2010). Accounting for water use in Australian red meat production. *Int. J. Life Cycle Assess*. *15*, 311–320.

Putz, F. E., Blate, G. M., Redford, K. H., Fimbel, R., & Robinson, J. (2001). Tropical forest management and conservation of biodiversity: An overview. *Conservation Biology*, *15*, 7–20.

Rae, A. (2008). China's agriculture, smallholders and trade: Driven by the livestock revolution? *Australian Journal of Agricultural and Resource Economics*, *52*(3), 283–302.

Raini, J. A. (2009). Impact of land use changes on water resources and biodiversity of Lake Nakuru catchment basin, Kenya. *African Journal of Ecology*, *47*, 39–45.

Ranasinghe, W. C., & Hemakumara, G. P. T. S. (2018). Spatial modelling of the householders' perception and assessment of the potentiality to improve the urban green coverage in residential areas: A case study from Issadeen Town Matara, Sri Lanka. *Ruhuna Journal of Science*, 9(1). , 39–45.

Rao, V. (2002). Experiments in participatory econometrics: Improving the connection between economic analysis and the real world. *Economic and Political Weekly*, 1887–91.

Renison, D., Hensen, I., Suarez, R., Cingolani, A. M., Marcora, P., & Giorgis, M.A. (2010). Soil conservation in Polylepis mountain forests of Central Argentina: Is livestock reducing our natural capital? *Austral Ecology*, *35*(4), 435–443

Republic of Kenya. (2007). *Economic Survey. Kenya Bureau of Statistics*, Ministry of Planning and National Development. Rivera, W. M., Qamar, M. K., & Crowder, L.V. (2001). *Agricultural and rural extension worldwide: Options for institutional reform in developing countries.* Rome: FAO.

Republic of Kenya. (2008). *Well-being in Kenya: A socio-economic profile*. Nairobi: The Kenya National Bureau of Statistics

Republic of. Kenya, (2009b). *Particular assets and vulnerabilities of rural women within the agricultural sector in Kenya*. Nairobi: Ministry of Agriculture.

Republic of. Kenya, (2005). *Geographic dimensions of well-being in Kenya: Who and where are the poor?* A Constituency Level Profile, Vol. 2. Nairobi: Ministry of Planning and National Development, Central Bureau of Statistics.

Republic of. Kenya, (2007). *The Third Annual Progress Report (2005/2006) of the Economic Recovery Strategy for Wealth and Employment Creation, 2003–2007*. Nairobi: Ministry of planning, National Development and Vision 2030.

Republic of. Kenya, (2008). *Economic Survey 2008*. Central Bureau of Statistics, Ministry of Planning and National Development. Nairobi: Government Printers.

Romani, M. (2003). *The impact of extension services in times of crisis: Cote d'Ivoire (1997–2000),* CSAE WPS/2003-07, Centre for the Study of African Economies, University of Oxford. Retrieved from: http://ideas.repec.org/p/wpa/wuwpdc/0409053.html

Rosegrant, M., & Cline, S. (2003). Global food security: Challenges and policies. *Science,* 1917–1919.

Ruben, R., & Van Den Berg, M. (2001). Nonfarm employment and poverty alleviation of rural farm households in Honduras. *World Development, 29*(3), 549–60.

Ruben, R., & Van den Berg, M. M. (2000). *Non-farm employment and rural poverty alleviation in rural Honduras*. Development Economics Group, Department of Social Sciences, Wageningen: Wageningen University.

Rutstein, S. O., & Kiersten J. (2004). *The DHS wealth index* [DHS Comparative Reports No. 6]. Calverton, Maryland, USA: ORC Macro.

Sabatini, F. (Ed.). (2007). *Social capital gateway: Resources for the study of social capital*. Rome: University of Rome La Sapienza and University of Cassino.

Salam, M. A., Noguchi, T., & Moike, M. (2000). Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforestry System, 50,* 77–93.

Samani, A. N., Ahmadi, H., Jafari, M., Boggs, G., Ghoddousi, J., & Malekin, A. (2009). Geomorphic threshold conditions for gully erosion in Southwestern Iran (Boushehr-Samal watershed). *Journal of Asian Earth Sciences, 35,* 180–189

Sands, R. (2005). *Forestry in a global context*. London: CABI Publishing.

Sannwald, E. H., Maestre, F. T., Herrick, J. E., & Reynolds, J. F. (2006). Ecohydrological feedbacks and linkages associated with land degradation: A case study from Mexico. *Hydrol. Process, 20*, 395–3411.

Sarah, G., & Mehrul, I. (2004). *Measuring livelihood impacts: A review of livelihoods indicators.* Livelihood Monitoring Unit (LMU) Rural Livelihoods Program of CARE. Bangladesh

Saumya, C., Anirban, K., & Alok, K. N. (2011). Farm–non-farm linkage in India: A structuralist perspective. *Ind. Jn. of Agri. Econ*. *66*(2), 989 1012.

Savage, J. (2000). Participative observation: Standing in the shoes of others? *Qualitative Health Research, 10*(3), 324–339.

Scoones, I. (2009). Livelihoods perspectives and rural development. *J. Peasant Stud*., *36*, 171–196.

Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology, 61*(3), 261–264.

Shackleton, C. M., & Shackleton, S. E. (2007). Household wealth status and natural resource use in the Kat River Valley, South Africa. *Ecological Economics*, *57*(2), 306–317.

Shackleton, C., & Shackleton, S. (2004). The importance of non-timber forest products in rural livelihood security and as safety nets: A review of evidence from South Africa. *South African Journal of Science*, 100(11–12), 658–664. View at Google Scholar View at Scopus.

Shankland, A. (2000). *Analysing policy for sustainable livelihoods.* Research Report 49, Sustainable Livelihoods Programme, IDS, India: University of Sussex.

Sharda, V. N., Mandal, D., & Ojasvi, P. R. (2013). Identification of the soil erosion risk areas for the conservation planning in different states of India. *J. Environ Biol*., *34*, 219–226.

Shepherd, A., Lucy, S., Chiara, M., Flora, K., Raghav, G., da Corta, L., Katharina, H., … & Leni, W.(2014). *The Chronic Poverty Report 2014−2015: The Road to Zero Extreme Poverty (*Report of the Chronic Poverty Advisory Network). London, Overseas Development Institute. *Retrieved from:* http://www.pardee.du.edu/sites/default/files/Povertyreport.pdf

Sherren, K., Loik, L., & Debner, J. A. (2016). Climate adaptation in new world cultural landscapes: The case of Bay of Fundy agricultural dykelands (Nova Scotia, Canada). *Land Use Policy, 51*, 267–280.

Shiferaw, B., Anupama, G. V., Nageswara R. G. D., & Wani, S. P. (2002).*Socioeconomic characterization and analysis of resource-use patterns in community watersheds in semi-arid India.* Working Paper Series no. 12. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 44 pp.

Shiva, M. P., & Verma, S. K. (2002). *Approaches to sustainable forest management and biodiversity conservation: With pivotal role of non-timber forest products*. Dehra Dun: Centre for Minor Forest Products, Valley Offset Printers.

Shyamsundar, P. (2002). *Poverty-environment indicators.* Environment Department, Geneva: World Bank.

Simpson, M. C. (2007). An integrated approach to assess the impacts of tourism on community development and sustainable livelihoods. *Community Development Journal*, *44* (2), 186–208.

Smith, D. R., Gordon, A., Meadows, K., & Zwick, K. (2001). Livelihood diversification in Uganda: Patterns and determinants of change across two rural districts. *Food Policy*, 421–435.

Smith, G. C., Savell, J. W., Morgan, J. B., Montgomery, T. H., Belk, K. E., Brooks, J. C., Carpenter, Z. L., … & Scanga, J. A. (2001). *Improving the quality, consistency, competitiveness and market share of beef – The final report of the third blueprint for total quality management in the fed-beef (slaughter steer/helfer) industry*. National Beef Quality Audit – 2000. Final Report to the National Cattlemen's Beef Association. New York: Colorado State University; Oklahoma State University; Texas A&M University, and West Texas A&M University.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & De Haan, C. (2006a). *Livestock's long shadow: Environmental issues and options*, Rome: FAO.

Stiftung, B. (2014). *El Salvador Country Report*. Gütersloh: Bertelsmann Stiftung.

Sunderland, T. C. H., Cunningham, A. B., Tchoundjeu, Z., Ngo-Mpeck, M. L., & Laird, S. A. (2004). Yohimbe. (Pausinystalia johimbe), In L. E. Clark, & T. C. H. Sunderland (Eds.), *The key non-timber forest products of Central Africa: State of the Knowledge*. (pp. 121–140) Technical Paper No. 122, USAID.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics* (6th ed.). Boston, M.A: Pearson.

Tao, T. C., &Wall, G. (2009). A livelihood approach to sustainability. *Asia Pacific Journal of Tourism Research*, *14*(2), 137–152.

Tesfaye, Y., Roos, A., Campbell, B. M., & Bohlin, F. (2011). Livelihood strategies and the role of forest income in participatory-managed forests of Dodola area in the bale highlands, southern Ethiopia. *Forest Policy Economics*, *13*(4), 258–265.

The World Bank. (2007). Strategic environmental assessment of the Kenya Forests Act 2005. In E. P. N. Udayakumara, R. P. Shrestha, L. Samarakoon, & D. Schmidt-Vogt. (2010). People's perception and socioeconomic determinants of soil erosion: A case study of Samanalawewa watershed, Sri Lanka. *International Journal of Sediment Research*, 25, 1–18.

Thondhlana, G., Vedeld, P., & Shackleton, S. (2012). Natural resource use, incomes and dependence amongst the San and Mier communities bordering Kgalagadi Transfrontier Park in the southern Kalahari, South Africa. *International Journal of Sustainable Development & World Ecology*, *19*(5), 460–470.

Thornton, P. K. (2010). Livestock production: Recent trends, future prospects. *Philosophical Transaction: Biological Sciences*, *365*(1554), 2853–2867.

Titolola, T. S., & Jeje, L. K. (2008). Environmental degradation and its implications for agricultural and rural development: The issues of land erosion. *Journal of Sustainable Development in Africa*, *10*(2), 116–146.

Todd, D. J. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, *Qualitative Methodology*. 24(4), 602–611.

Toner, A., Franks, T., Goldman, I., Howlett, D., Kamuzora, F., Muhumuza, F., & Tamasane, T. (2004). Translating sustainable livelihoods into practice: A comparison of livelihoods-oriented development interventions in Tanzania, South Africa and Uganda. In: Kamuzora (Ed.) *Understanding complexities of livelihoods systems for sustainable poverty reduction.* Bradford: Bradford Centre for International Development.

Toufique, K. A. (2001). *Sustainable rural livelihoods in Bangladesh*. Research Report 45, Sustainable Livelihoods Programme, IDS, India: University of Sussex.

Toulmin, C. (2009). *Climate change in Africa*. UK: IDS.

Tracy, E., Shvarts, E., Simonov, E. & Babenko, M. (2017). China new Eurasian ambitions: The environmental risks of the silk road economic belt. *Eurasian Geography and Economics*, 58, 10 -18.

Traynor, M. (2006). Discourse analysis: Theoretical and historical overview and review of papers. *Journal of Advanced Nursing, 54*(1), 62–72

Trochim, W. (2000). *The research method knowledge base* (2nd Ed.). Cincinnati: Atomic Dog Publishing.

Truong, L. D., Trung, T. N., & Ulrike, G. (2019). Livestock production, rural poverty, and perceived shocks: Evidence from panel data for Vietnam. *The Journal of Development Studies, 55*(1), 99-119.

Turkelboom, F., Poesen, J., & Trébuil, G. (2008). *The multiple land degradation effects caused by land-use intensification in tropical steep lands: A catchment study from northern Thailand,* Thailand: Catena

Valentin, C., Agus, F., Alamban, R., Boosaner, A., Bricquet, J. P., Chaplot, V., de Guzman, T., … & Vadari, T. (2008). Runoff and sediment losses from 27 upland catchments in Southeast Asia: Impact of rapid land use changes and conservation practices. *Agriculture, Ecosystems and Environment, 128*, 225–238.

Van den Berg, H., & Jiggins, J. (2007). Investing in farmers – The impacts of farmer field schools in relation to integrated pest management. *World Development*, *35*(4), 663–686.

Van den Berg, M. (2010). Household income strategies and natural disasters: Dynamic livelihoods in rural Nicaragua. *Ecological Economics, 69*, 592–602.

Van Kooten, G. C., & Bulte, E. H. (2000). *The economics of nature: Managingbiological assets*. Oxford, UK: Blackwell Publishers.

Van-Camp. L., Bujarrabal, B., Gentile, A-R., Jones, R. J. A., Montanarella, L., Olazabal, C., & Selvaradjou, S. K. (2004). *Reports of the technical working groups established under the thematic strategy for soil protection.* (EUR 21319 EN/2, 872 pp). Luxembourg: Office for Official Publications of the European Communities.

Veblen K. E., Pyke, D. A., Aldridge, C. L., Casazza M. L., Assal, T. J., & Farinha M. A. (2014). Monitoring of livestock grazing effects on bureau of land management land. *Rangeland Ecology & Management*, *67*(1), 68–77.

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Kobugabe, B. G. (2007). Forest environmental incomes and the rural poor, *Forest Policy and Economics, 9*(7), 869–879.

Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S* (4th Ed.). Ch. 7.

Verweij, P., Schouten, M., van Beukering, P., Triana, J., van de Leeuw, K., & Hess, S. (2009). *Keeping the Amazon forests standing: A matter of values*. A report commissioned by Worldwide Fund for Nature, Netherlands: Worldwide Fund for Nature.

Viswanath, S., Nair, P. K. R., Kaushik, P. K., & Prakasam, U. (2000). *Acacia nilotica* trees in rice fields: A traditional agroforestry system in central India. *Agroforestry systems, 50,* 157–177.

Waddington, H., Snilstveit, B., White, H., & Anderson, J. (2010). *The impact of agricultural extension services. International initiative for impact evaluation.* 3ie Synthetic Reviews – SR009, Protocol.

Wambugu, K. (2014). Kenya: 150,000 starving in Nyeri, says Kieni Member of Parliament. *The Star*. Retrieved from: http://allafrica.com/stories/201409111332.html

Wasudha M. S., Ori, L., Wolfgang, J., Vanwing, T. (2018). Agricultural extension services using a participatory approach in vegetable growing areas. *Suriname. International Journal of Agricultural Extension and Rural Development Studies,* 5(1), 20–33.

Water Resources Institute. (2005). *The wealth of the poor: Managing ecosystems to fight poverty*. New York: WRI Publication.

Weiss, C. R., & Briglauer, W. (2000). *Determinants and dynamics of farm diversification.* Department of Food Economics and Consumption Studies, University of Kiel. Working Paper EWP 0002, 1–20

Wengraf, T. (2006). *Interviewing for life-histories, lived situations and personal experience*. The biographic-narrative interpretive method (BNIM) on its own and as part of a multi-method full spectrum psychosocial methodology. Retrieved from http://www.uel.ac.uk/cnr/Wengraf06.rtf

Wichelns, D., & Oster, J. D. (2006). Sustainable irrigation is necessary and achievable, but direct costs and environmental impacts can be substantial, *Agric. Water Manage*. 86, 114–127

Wiedemann, S. G., Davis, R. J., Zadow, E. N., McGahan, E. J., Watts, P. J., Nielsen, W. M., Cottle, D., & Martin, P. (2010). *Review of GHG and water in the red meat industry—Report 1*. Meat and Livestock Australia, North Sydney, New South Wales, Australia

Wilkie, D., Shaw, E., Rotberg, F., Morelli, G., & Auzels, P. (2000). Roads, development and conservation in the Congo Basin. *Conservation Biology, 14,* 1614–1622.

Windle J., & Rolfe, J. (2005). Diversification choices in agriculture: A choice modelling case study of sugarcane growers. *Australian J. Agric. Res. Econ*., *49*(1), 63–74.

Winquist, J. (2014). Independent samples t-Test: Assessing differences between two independent group means. In D. Arkkelin, *Using SPSS to understand research and data analysis*. Psychology Curricular Materials. Book 1 (Chapter 9). Valparaiso University, Indiana. Retrieved from: http://scholar.valpo.edu/psych_oer/1

Winters, P., Cavatassi, R., & Lipper, L. (2006). *Sowing the seeds of social relations: The role of social capital in crop diversity*. ESA Working Paper No. *6*(16), 1–40.

Woodwell, J. (2002). *Fuelwood and land use in West Africa: Understanding the past to prepare for the future*. Washington, DC: International Resources Group.

World Bank. (2004). *Demand-driven approaches to agriculture extension: Case studies of international initiatives.* Agriculture and Rural Development Discussion Paper 10 Extension Reform for Rural Development. Edited by William Rivera and Gary Alex (3rd Ed.). Washington, DC: WB.

World Bank. (2007). World Development Report 2008: *Agriculture for Development*. Washington, DC: WB.

World Bank. (2008). World development report. *Agriculture and development*. 177–179

WRI (World Resources Institute). (2007). *Nature's benefits in Kenya: An atlas of ecosystems and human well-being*. Washington, DC, and Nairobi: WRI.

Wu, L., Praneetvatakul, S., Waibel, H., & Wang, L. (2005). The impact of FFS on yield, pesticide cost and gross margin in Shandong Province, P.R. China: An

econometric approach. In P. A. C. Ooi, S. Praneetvatakul, H. Waibel, & G. Walter-Echols (Eds.), *The Impact of the FAO-EU IPM Programme for Cotton in Asia*, Pesticide Policy Project Publication Series, Special Issue No. 9, University of Hannover, Germany. Retrieved from http://vegetableipmasia.org/Crops/Docs/Cotton/4/PPP%20Cotton%20IPM%20Asia2-CD.pdf

Yamen, T. (1967). *Statistics: An introductory analysis, (2nd Ed.)*, New York: Harper And Row.

Zak, P., & Knack, S. (2001). Trust and Growth. *Economic Journal 111*, 295–321.

Zhang, W. J., Zhuang, G. S., Guo, J. H., Xu, D. Q., Wang, W., Baumgardner, D., & Yang, W. (2010). Sources of aerosol as determined from elemental composition and size distributions in Beijing. *Atmospheric Research, 95*(2–3), 197–209.

Zheng, F. L. (2005). Effects of accelerated soil erosion on soil nutrient loss after deforestation on the loess plateau. *Pedosphere*, *15*, 707-715.

Zhou, H., & Anton, V. R. (2009). Detecting the impact of the Grain for Green program on the mean annual vegetation cover in the Shaanxi province, China using SPOT-VGT NDVI data. *Land Use Policy, 26*(4), 954–960.

Zikmund, W. G., Babin, J., Carr, J., & Griffin, M. (2012). *Business research methods: with qualtrics printed access card*. London: Cengage Learning.

Zwane, A. P. (2002*). Does poverty constrain deforestation? Econometric evidence from Peru.* California: University of California Berkeley, Mimeo.

APPENDICES

Appendix I: Log Linear Regression Test

K	df	G^2 (Likelihood ratio)	p-value
1	511	1245.549	.000
2	502	756.942	.000
3	466	424.248	.918
4	382	223.665	1.000
5	256	47.413	1.000
6	130	3.119	1.000
7	46	.710	1.000
8	10	.260	1.000
9	1	.000	1.000

Appendix II: Results of the Variance Inflation Factor and Collinearity Tolerance

Variable description	Kieni East		Kieni West	
	Collinearity Statistics		Collinearity Statistics	
	Tolerance	Variance inflation factor (VIF)	Tolerance	Variance inflation factor (VIF)
	Water scarcity			
(Constant)				
Forest activities	.723	1.384	.736	1.359
Cropping activities	.991	1.009	.930	1.075
Livestock activities	.731	1.368	.701	1.426
Off-farm activities	.790	1.266	.775	1.290
	Deforestation			
(Constant)				
Forest activities	.723	1.384	.736	1.359
Cropping activities	.991	1.009	.930	1.075
Livestock activities	.731	1.368	.701	1.426
Off-farm activities	.790	1.266	.775	1.290
	Soil erosion			
(Constant)				
Forest activities	.723	1.384	.736	1.359
Cropping activities	.991	1.009	.930	1.075
Livestock activities	.731	1.368	.701	1.426
Off-farm activities	.790	1.266	.775	1.290
	Environmental degradation (Water scarcity, deforestation & soil erosion)			
(Constant)				
Forest activities	.791	1.386	.739	1.353
Cropping activities	.991	1.009	.931	1.074
Livestock activities	.731	1.368	.702	1.425
Off-farm activities	.789	1.267	.776	1.289

a. Dependent variables: Water scarcity, deforestation, soil erosion and environmental degradation

Appendix III: Survey Household Questionnaire

SUB-LOCATION: …… Questionnaire Serial Number: …… Date: ……

Name of interviewer: …….. Starting time: ……. …… End Time: …….

Age of respondent: …… Gender: 1 ( ) Male 2 ( ) Female

Marital Status: (Married/single/divorced/widowed): ……..

PART A. HOUSEHOLD CHARACTERISTICS

A1 Household composition

A1.1 Who lives in this house? (List nuclear, as well as extended family members, including those who are entirely dependent on the household for food and clothing but temporarily leaving elsewhere for example high school students leaving in town).

No.	Sex (M/F)	Age (Years)	Relation to HH Head/Spouse				
			Household head	Spouse	Child	Hired labour	Other (Specify)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

A1.2 For how many years have you lived on your present land holding?

As member of household? …… years

As head of household? ..... years

PART B. HOUSEHOLD LIVELIHOOD RESOURCES

B1. Financial Capital

Assistance

B1. Income

B1.1 Please tell me the main income sources and amounts of your family in the last year. Read all the options to the interviewee.

Sources of Income	**Tick (√)**	**Amounts (KShs)**	**Seasonality***
1. Wage/salary			
2. Farming/crops			
3. Husbandry/livestock			
4. Wood and wood products (timber)			
5. Tourism, e.g. tour guide, hotel, etc.			
6. Self-employment, e.g. trading/business, mason, carpenter, *boda boda*, etc.			
7. Rental income – house/land			
8. Assistance of relatives – remittances			
9. Pensions			
10. Govt poverty funds, e.g. Youth Development Enterprise Fund, Bursaries, etc. (State which one …….)			
11. Other governmental assistance (Specify ……..……)			
12. In-kind aids from the government (food donation, etc.)			
13. Assistance from NGOs			
14. Allowances for elderly			
15. Mining, e.g. quarry stones, etc.			
16. Other (please specify)			

*** 1** = seasonal **2**= permanent

B1.2. What is the average **monthly** income of your household? KShs ……

B1.3. What is the average **yearly** income of your household? KShs ……..…

B2. Natural Capital

B2.1 Land

B2.1.1 Do you own land or rent it? 1( ) Own 2( ) Rent

B2.1.2 Number of years since your present land was acquired? ..... years.

B2.1.3 What is the size of the total land that your household presently owns? …… acres

B2.1.4 How much land do you rent? ..... acres

B3. Physical Capital

B3.1 Transport

B3.1.1 How far is your household located from:

B3.1.1 .1 The nearest all-weather road? .....km

B3.1.1 .2 The nearest market centre? .....km

B3.1.4 What means of transport do you use most to go to the market? Choose only one from the following.

1( ) *Matatu* 2( ) Motorcycle 3( ) Car 4( ) Bicycle 5( ) Footing 6( ) Other (specify) ……

B4. Human Capital

B4.1 Education

Please indicate in the column provided the level of education attained of each household member listed in A1 above. (Read all the options to the interviewee. **1** Pre-school **2** Lower primary **3** Upper primary **4** High school **5** Vocational training/college **6** University **0** No education)

No.	Highest level of education
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

B4.1.1 How far is your household located from:

B4.1.1 The nearest public primary school? .....km

B4.1.2 The nearest private primary school? .....km

B4.1.2 Are you satisfied with the education facilities in the area? 1( ) Yes 2( ) No? Please explain.

……

B5. Social Capital

B5.1 Group Membership

B5.1.1 Are you a member of any organisation(s)/group(s)? 1( ) Yes, (to B5.3.2) 2( ) No, (go to part C)

B5.1.2 Name of organization/group you are a member of

Name of organization	Organization status [a]	Membership since	Description of activities

a 1 = formal, 2 = informal

B5.1.3 Reason(s) for not belonging to local organisation/group.

……
……
……

PART C: HOUSEHOLD LIVELIHOOD CHOICES

C1. Forest Activities

C1.1 What activities do you do in the forest? Please choose all that apply.

1( ) Farming 2( ) Grazing 3( ) Harvesting or hunting forest products 4( ) Charcoal burning 5( ) Fuelwood collection 6( ) Collection of timber products 7( ) Non-timber products collection 8( ) Other (specify) ……

C1.2. What are some of the important non-timber products you collect from the forest? Please choose all that apply.

1( ) Wild fruits and roots 2( ) Grasses 3( ) Vines 4( ) Gums 5( ) Honey 6( ) Game meat 7 ( ) Leaves for roofs 8 ( ) Vegetables 9 ( ) Medicinal plants 10 ( ) Other (specify) ……

C1.3 Have you sold any forest products in the last 3 years? 1( ) Yes, (go to C1.4) 2( ) No, (go to C1.5)

C1.4 Indicate which of the following forest products you sold and the average annual income you earned inthe past 3 years.

Type of forest product sold	**Source (tick)**		**Unit**	**Quantity**	**Income earned (KShs)**
	Own farm	Other			
Fuelwood					
Poles					
Round logs					
Wood/timber (lumber)					
Charcoal					
Other (specify)					

C1.5. What is the total income from the sale of forest products during the last year for your household? KShs

C2. Cropping Activities

C2.1 What crops does your household grow and how much of each crop did you produce per year over the past 3 years? Please indicate the estimated quantities of each crop produced for own household consumption and for sale.

Crop		**Unit**	**Total**	**Distribution**		**Income earned**
				Consumed (kg)	**Sold** (kg)	(KShs)
Annual crops	Beans	kg				
	Maize	kg				
	Cassava	kg				
	Potatoes	kg				
	Cabbage	kg				
	Tomatoes	kg				
	Onions	kg				
	Pumpkin	kg				
	Sukumawiki	kg				
	Other vegetables	kg				
Perennial crops	Bananas	kg				
	Oranges	kg				
	Mangoes	kg				
	Sugarcane	kg				
	Pineapples	kg				
	Other fruits	kg				
Others						

C2.2 What is the total income from sale of agricultural produce during the last year for your household? KShs ……..……..

C2.5. Have you noticed any changes in the use of land for cultivation in the past 5 years? Please choose only one of the following. 1( ) No 2( ) Yes, increasing 3( ) Yes, decreasing

C3. Livestock

C3.1 How many heads of the following animals does your household own?

No.	Type of animal	Number
1	Oxen	
2	Cows	
3	Heifers	
4	Calves	
5	Sheep	
6	Goats	
7	Chicken	
8	Donkeys	
9	Beehives	
10	Dogs	
11	Pigs	
12		

C3.2 Did you sell any of these animals as part of generating income for your household in the last one year? 1( ) Yes, (please go to C3.3) 2( ) No, (please go to C3.5)

C3.3 How many animals per year did you sell in the last three years?

No.	Type of animal	Number of animals sold	Income earned (KShs)
1	Oxen		
2	Cows		
3	Heifers		
4	Calves		
5	Sheep		
6	Goats		
7	Chicken		
8	Donkeys		
9	Beehives		
10	Dogs		
11	Pigs		
12			

C3.4 What is the total income from sale of livestock produce during the last one year for your household?

KShs ……..

C3.5. Have you noticed any changes in the use of land for grazing in the past 5 years? Please choose only one of the following. 1( ) No 2( ) Yes, increasing 3( ) Yes, decreasing

C4. Off-farm Activities

C4.1. Which of the following off-farm activities do you engage in? Please choose all that apply

No.	Off-farm activity	Est. annual income (KShs)
1	Wage work on other farms	
2	Food for work program	
3	Project or town employment	
4	Collecting and selling fuelwood, poles and charcoal	
5	Trade	
6	Other (specify)	

C4.2 What is the total income from off-farm activities during the last year for your household?

KShs ……..

C4.3. Have you noticed any changes in off-farm activities in the past 5 years? Please choose only one of the following. 1( ) No 2( ) Yes, increasing 3( ) Yes, decreasing

PART D: ENVIRONMENTAL DEGRADATION

D1. Water Scarcity

D1.1.1 How concerned are you about the lack of water in this area?

1( ) Extremely concerned 2( ) Very concerned 3( ) Moderately concerned 4( ) Slightly concerned 5( ) Not at all concerned 6( ) Don't know

D1.1.2 Are you experiencing water shortages in this area? 1( ) Yes 2( ) No 3 ( ) Don't know

D1.1.3 Is water available (from your main source) throughout the year? 1( ) Yes 2( )No

D1.1.4 Which months do you face water scarcity?

1( ) Jan. 2( ) Feb. 3( ) Mar 4( ) Apr 5( ) May 6( ) Jun 7( ) July 8( ) Aug 9( ) Sept. 10( ) Oct 11 ( ) Nov 12( ) Dec

D1.1.5 Have you noticed any changes in water availability in the past 5 years? Please choose only one of the following. 1( ) No 2( ) Yes, increasing 3( ) Yes, decreasing

D2. Soil erosion

D2.1 In your opinion, is soil erosion prevalent in this area?

1( ) No 2( ) Yes, (go to D3.2) 3( ) Don't know

D2.2 What is causing soil erosion in the area? Choose all that apply.

1( ) Overgrazing 2( ) Charcoal making 3( ) Over-cultivation 4( ) Fuelwood 5( ) Other (specify)

D2.3 Do you have a problem of erosion in your farm? 1( ) Yes 2( ) No

D2.4 What do you believe is the impact of soil erosion on crop yields in your farm?

1( ) Large decrease 2( ) Moderate decrease 3( ) No change 4( ) Moderate increase 5( ) Large increase

D2.5 What are the main causes of soil erosion on your farm?

1( ) Lack of conservation structures 2( ) Steep land without conservation structures 3( ) Damaged conservation structures 4( ) Lack of diversion ditch 5( ) The land is under steep ridges 5 ( ) Others (Specify) ……

D3. Deforestation

D3.1. Have you noticed any changes in the availability of forestland that can be cleared in the past 5 years? Please choose only one of the following. 1( ) No 2( ) Yes, increasing 3( ) Yes, decreasing

D3.2. Have you noticed any forest cover changes, e.g. biodiversity in the past 5 years? Please choose only

one of the following. 1( ) No 2( ) Yes If yes, please explain why

…….

D3.3. Are the changes in forest you have noticed mainly human-related? Please choose only one of the following. 1( ) No 2( ) Yes If yes, please explain why

……..

D3.4. In your opinion, are the changes you noticed mainly related to timber extraction from forest by outsiders? 1( ) No 2( ) Yes

D3.5. In your opinion, are the changes you noticed mainly related to timber extraction from forest by villagers? 1( ) No 2( ) Yes

D3.6. In your opinion, is tree cutting prevalent in this area? 1( ) No 2( ) Yes, (go to D4.8)

D3.7. Why are trees cut in the area? Choose all that apply.

1( ) Selling timber 2( ) Charcoal making 3( ) For construction work at home 4( ) Fuelwood 5( ) Other (specify) ……

PART E: EXTENSION SERVICE ACTIVITIES

E1 Extension visits

E1.1 Have you been visited by an NGO or government field officer in the past three years? 1( ) Yes, (go to E1.2) 2( ) No, (go to E2).

E1.2 Field workers that visited your household over the last three years.

NGO field workers	**Extension topic**	**Frequency ***
Agricultural officer		
Livestock officer		
Family planning officer		
Forestry/environment officer		
Other		

***Per year**

E2 Rural extension services

E2.1 Have you ever participated in a rural extension programme undertaken by an NGO or government?

1( ) Yes, (go to E2.2) 2( ) No, (go to E3)

E2.2 Participation in rural extension programs in the past 5 years

Year	Name of programme/organization	Organization focus	Description of activities	Level of success [a]

a 1 = very successful, 2 = successful, 3 = somewhat successful, 4 = not very successful, 5 = not at all successful

E3. Livelihood and environment problem perceptions

E3.1 In your perception, what are the most important four livelihood problems (agriculture, livestock and off-farm issues) in this sub-location?

1……

2…….....**.....**

3……

4…….

E3.2 In your perception, what are the most important four environment problems (deforestation, agroforestry, water and soil issues) in your sub-location?

1……

2…….....

3……..

4……..

E3.3 Is there anything else you would like to tell me about livelihood activities and the environment or other aspects of your livelihood strategies?

……
……

Appendix IV: Guiding Questions Used for Focus Group Discussions

Introductory remark about:

- Personal introduction of participants and facilitators
- The objective of the focus group interview and about what we will do
- The composition of the group and why they were specifically selected
- Confidentiality of views

1. Status of household livelihoods and environmental degradation

1.1 What does the trend of livelihood activities look like in your sub-location over the last 3–5 years? Has it changed in any way? If so, in what way and what do you think are the reasons for the change?

1.2 What does the trend of environmental degradation (water scarcity, deforestation and soil erosion) look like in your sub-location over the last 3–5 years? Has it changed in any way? If so, in what way and what do you think are the reasons for the change?

1.3 My recent survey shows that about 64.5% of the households in Kieni East (88.5% in Kieni West) engage in farming activities and the rest do not. What do you think are the reasons why many farmers carry out farming and the others do not?

1.4 The survey also shows that water scarcity is the predominant challenge experienced by nearly all households in the area. What do you think is/are the reason(s) for such a high prevalence?

2. Household assets specific issues

2.1 What types of educational institutions do you have here (government, private, NGOs). Do people migrate to earn wages from employment? Do women face challenges earning wages? How?

2.2 How would you describe road, transport and market facilities in this area over the last 5 years. Has there been any changes? Why, why not?

2.3 Land, type, soil fertility, ownership of land, size

2.4 Sources of income, trades and access

2.5 In the past 1 year, have you been involved in community development work, e.g. infrastructure development? What are some of the community-based organisations/self-help groups (service and pattern) in this area?

2.6 My recent survey shows that about 46.2% of the households in Kieni East (9.5% in Kieni West) farm in the forest. What do you think are the reasons why more households farm in the forest in Kieni East than in Kieni West? Also survey results show, 5.1% households in Kieni East (81.9% in Kieni West) graze in the forest. What do you think are the reasons why fewer households graze in the forest in Kieni East than in Kieni West?

3. Household livelihood choices

3.1 On-farm activities: a) crop/farming activities – opportunities & challenges, subsistence or cash crops (why, why not?), cultivation land; b) livestock-opportunities/challenges, grazing land

3.2 Non-farm activities: a) forest activities – activities in the forest, constraints/opportunities, income sources, forest access regulations, who access –

women/men/both; b) off-farm activities – challenges/opportunities, trade, business, employment (formal/casual).

4. Environmental degradation issues

4.1 What is the status of open water, e.g. dams, rivers, water pans, etc. over the last 10 years? Are the levels decreasing, increasing or constant? Why/why not?

4.2 Is the forest tree population density decreasing or increasing over the last 10 years? Why and why not? Availability of forest land that can be cleared in the last 10 years. Increasing or decreasing. Why?

4.3 What are some of the changes of land for cultivation and grazing in the past 5 years? Density of farm trees during the last 5 years. Is it decreasing or increasing? Why, why not?

5. Rural extension services issues

5.1 Types of organizations working in the sub-location. Government, private, NGOs.

Extension services offered. Who benefits. Women, men, youth, people with disabilities or children. Types of services important to livelihoods. Which organizations are addressing those? How useful are these organizations in terms of service delivery? How frequent do they visit you.

5.2 What type of training and extension services do you receive? How does the training change or improve your livelihoods? Which organizations help you during disaster like drought, pest, diseases, flooding, etc.? What are some of the most important livelihood and environment challenges that need to be address by extension organizations?

6. Other issues

6.1. A great majority of the interviewed farmers are of the opinion that crop production and off-farm activities are less risky than animal production and forest activities. Do you agree? Why, why not?

6.2. Some studies made elsewhere in the country indicate that livelihood diversification could be more reliable for households than depending on growing only food crops. Do you think this may be the case here in your area too? Do you think that household farmers in this area would also agree with you?

6.3. Can you tell us about any constraint – policy, extension (e.g. supply of extension services), cultural (e.g. beliefs) or social (e.g. neighbour's resistance) – that influences farm household decision on:

a) whether or not to diversify livelihood activities

b) selection of livelihood activity?

6.4. What do you think about the future trend of livelihood choices in this area?

Appendix V: NACOSITI Research Permit

THIS IS TO CERTIFY THAT:
MR. FRED KHISA WAMALWA
of JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, 7606-200 Nairobi ,has been permitted to conduct research in *Nyeri County*
on the topic: *RURAL LIVELIHOOD CHOICES AND THEIR IMPACT ON ENVIRONMENTAL DEGRADATION IN KIENI SUB-COUNTIES, KENYA.*
for the period ending:
22nd December,2017

Permit No : NACOSTI/P/16/29158/15118
Date Of Issue : 22nd December,2016
Fee Recieved :ksh 2000

.....
Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

HARAMBEE

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 12447

CONDITIONS: see back page