ANALYSIS OF HOUSEHOLD SOCIO - ECONOMIC DRIVERS OF CATTLE GRAZING AND GRASS HARVESTING IN THE MOUNT KENYA WEST PROTECTED FOREST, KENYA

MAINA PAUL MWARI

PDSLMR304316

A PHD THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN DEVELOPMENT STUDIES OF ST. PAUL'S UNIVERSITY

28 March 2022

Analysis of Household Socio-Economic Drivers of Cattle Grazing and Grass Harvesting in Mount Kenya West Protected Forest, Kenya

Maina Paul Mwari

PDSLMR304316

Supervised by

Dr. Daniel Muasya Nzengya

Prof. Gilbert Mbaka Nduru

A PhD Thesis Submitted in Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy Degree in Development Studies of St. Paul's University

DECLARATION FORM

Candidate's Declaration

This PhD thesis is my original work and it has not been presented in any other University/ Institution or learning institution for examination and/or certification.

SIGNATURE OF THE STUDENT DATE: 21st September 2021

PAUL MWARI MAINA

PDS/LMR/3043/16

Supervisor's Declaration

This is to confirm that the PhD thesis submitted for examination was done under my/our supervision

Sign: ..... Date: 21st September 2021

Dr Daniel Muasya Nzengya, (PhD)



Sign: ..... Date: 21st September 2021

Prof Gilbert Mbaka Nduru

Approved by

Sign .....Date.....

Dr. Julius Kahuthia Mwangi, (PhD)

DIRECTOR POST GRADUATE STUDIES

ABSTRACT

Protected forests in the Mount Kenya region are increasinglythreatened with degradation, posing a challenge to the conservation of the country's largest water tower. Prudent management of forest resources utilization by communities living adjacent to the protected mountain a forest is required to ensure sustainability of livelihoods without compromising the long-term persistence of these forests. The objectives of this research were: to assess the significance of household characteristics in driving smallholder farmers dependence on protected forest for pasture; to assess the significance of household characteristics in driving smallholder farmers dependence on protected forests for grass harvesting for cattle; to analyse seasonality patterns of smallholder dependence on protected forest for livestock grazing; and to examine the perceptions of the smallholder farmers towards the use of a ban to regulate access to the protected forest for pasture. The research followed a mixed-method research design to allow for triangulation of quantitative data with in-depth qualitative data. The target population were smallholder farmers living adjacent to three forest blocks namely, Kahurura, Hombe, and Chehe forests. Questionnaires were used to collect data from a sample of 453 participants. A follow-up in-depth survey was conducted among234 participants. Primary data was complemented with analysis of cattle grazing records from the three forest blocks. Quantitative survey data was analysed using descriptive statistics and multiple logistic regression. Secondary data was analysedusing time series for seasonality trends and patterns in forest dependence. Qualitative data was content analysed for themes and categories. Results revealed that significant household characteristics driving forest dependence for pasture were the ownership of a zero-grazing unit ($p=0.03 < 0.05$), the proportion of cattle under zero-grazing ($p=0.04 < 0.05$) and proximity to the forest ($p=0.08 <0.1$). Significant household characteristics driving smallholder famers' dependence on protected forest for grass harvesting for cattle included: a household's socio-economic status ($p=0.06<0.1$), a household's total size of land owned ($p= 0.02 < 0.05$), and proportion of cattle kept under a zero-grazing unit ($p=0.07<0.1$). Results of the time series analysis revealed significant monthly and seasonality patterns in cattle grazing in all three forest blocks. Key themes from the analysis of qualitative data revealed that participants perceived that a forest ban would remarkably reducethe land available for pasture. In line with the livelihood transformation theory used in the study, study findings reveal how a forest ban might disrupt households' livelihoods. These findings contribute to knowledge on the significant micro-level characteristics driving the two forms of forest dependence. Future studies are needed to explore the meso-and- macro-level factors that interact with household characteristics identified to drive forest dependence for livestock grazing and grass harvesting.

DEDICATION

This thesis is dedicated to my wife Jane Wairimu and my sons, Raymond Maina and Ronald Wanyika, for their moral support and encouragement during the whole process of carrying of carrying out this research.

ACKNOWLEDGEMENTS

The completionof this PhD thesis would not have been possible without material and moral support from various people and institutions. It is, therefore, my obligation to extend my gratitude to them. First, I thank God the Almighty for giving me good health and protecting me throughout the process.

I am greatly indebted and will be eternally grateful to my supervisors and mentors, Dr. Daniel Muasya Nzengya and Prof. Gilbert Mbaka Nduru, for the great intellectual stimulation, support, encouragement, and guidance they wholeheartedly gave throughout the entire research period including field visits to the research areas. Special thanks go to Dr. Daniel Muasya Nzengya, the lead supervisor, for the great insights he brought into this thesis right from inception as well as for going beyond the call of duty to assist in the revision of the study questionnaires. Dr. Daniel Muasya also offered guidance on the best approach to undertake systematic literature review and application of research methodology with emphasis on quantitative data analysis, interpretation, and presentation of results. To Prof Gilbert Mbaka Nduru, many thanks for helping me approach the problem under the study and justification. Your guidance on how to bring out my contribution to the thematic area more critically and deeply is indispensable.

Besides my immediate supervisors, I got invaluable comments from many members of the academic staff. I sincerelyextend my gratitude to all my lecturers and other members of staff at the St Paul's University for guiding me at different stages of the research process. I would also to appreciate the leadership of the Community Forest Associations led by Mr David Ngichunga and the community in Mt Kenya West Forest region for their support during my research. I would like to sincerely appreciate the financial support from Mary Stusek of Kenya Works - USA.

Finally, special thanks go to my research assistant for the support during data collection as well as to the Kenya Forest Service led by Esther Mugo and to the respective forest managers in Hombe, Chehe and Kahurura for allowing me to access official records during the study. To everyone else who helped in one way or the other during my study and not mentioned by name here, thank you very much, and may God bless you all.

TABLE OF CONTENTS

ABSTRACT ..... **II**
DEDICATION ..... **III**
LIST OF FIGURES ..... **VIII**
LIST OF TABLES ..... **IX**
LIST OF APPENDICES ..... **X**
LIST OF ABBREVIATIONS AND ACRONYMS ..... **XI**
CHAPTER ONE **1**
INTRODUCTION **1**
1.1 Chapter Introduction 1
1.2 Background 1
1.2.1 Conceptualization of socio-economic status 4
1.2.2 Threats to Forest Ecosystems 7
1.2.3 Kenyan policies regarding forest management 11
1.2.4 Communities and conservation of mountain ecosystem services in Kenya 11
1.2.5 Participatory Forest Management and rural community development 17
1.3 Statement of the Problem 22
1.4 Purpose of the Research 24
1.4.1 Specific research objectives 24
1.4.2 Research Hypotheses 25
1.4.3 Research question 25
1.5 Justification of the study 25
1.6 Scope of the research 27
1.7 Limitations of the research 27
1.8 Assumptions of the research 28
1.9Definition of key terms and concepts 28
1.10 Structure of the thesis 30
1.11 Chapter Summary 31
CHAPTER TWO **32**
LITERATURE REVIEW **32**
2.1 Chapter Introduction 32
2.2 Theoretical review 32
2.2.1 The common pool resources theory 32
2.2.2 Access theory 34
2.2.3 Theory of livelihood transformation 35
2.3 Empirical review 36
2.3.1 The influence of household size, gender, level of education, age, and socio-economic status, on forest dependence 36
2.3.2 The influence of household size of land and smallholder agricultural practices and forest dependence 40
2.3.3 The influence of a household number of cattle and land holding on forest dependence 41
2.3.4 Trends of Livestock Grazing in Protected Forests: Implications on forest ecosystems service provisioning 47
2.3.5 Community perceptions towards restriction of access to protected forest 52
2.4 Summary of Literature Review and Research Gaps 56
2.5 The conceptual framework 65
2.6 Chapter Summary 66
CHAPTER THREE **67**
RESEARCH METHODOLOGY **67**
3.1 Chapter Introduction 67
3.1 Philosophical foundation informing the research design 67
3.2 Research design 68

3.3 The study area 69
3.4 Overview of changes in socio-demographic and livelihood strategies in the study site 70
3.5 Implications of population growth in Nyeri County over the years on natural resources 71
3.6 Community Forest Associations & Implications on livestock keeping 72
3.7 Target population 73
3.8 Sampling, sample size and sampling frame 73
3.9 Data collection and analysis 74
3.9.1 Quantitative survey data collection and analysis 74
3.9.2 Operationalization and measurement of study variables 74
3.9.2 Application of principal component analysis in computing SES 78
3.9.3 Model description of logistic regression 80
3.9.4 Conducting logistic regression models 82
3.9.5 Reliability and validity 84
3.9.6 Secondary data collection and analysis methods 85
3.9.7 Qualitative data collection and analysis methods 85
3.10 Ethical issues in research 89
3.11 Chapter Summary 90
CHAPTER FOUR 91
RESULTS AND INTERPRETATIONS ON HOUSEHOLD FACTORS INFLUENCING FOREST DEPENDENCY 91
4.1 Introduction 91
4.2 Demographic Information of Respondents 91
4.3 Diagnostic Statistics for logistic regression model 114
4.4 Cross tabulation analysis of forest dependency 119
4.3.1 Forest dependency through cattle grazing in protected forests 119
4.3.2 Forest dependency through grass harvesting from protected forests 121
4.5 Logistic regression results: Relationship between smallholder farmers household socio-economic characteristics and dependence on protected forest for pasture 122
4.6 Logistic regression results: Relationship between smallholder farmers household socio-economic characteristics and dependence of protected forest for grass 128
4.7 Seasonality patterns on forest dependence for pasture 133
4.8 Perceptions of participants towards a ban to regulate grazing activities in the protected forest ... 137
4.9 Chapter Summary 153
CHAPTER FIVE 155
SUMMARY OF DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS 155
5.1 Chapter Introduction 155
5.2Household socio-economic characteristics and dependence of protected forest for pasture 155
5.3Household socio-economic characteristics and dependence on protected forest for grass 159
5.4Seasonal variation of smallholder dependence on protected forest for livestock grazing in West Mt. Kenya. 161
5.5Perceptions towards the use of a ban to regulate access to protected forest for pasture in Mount Kenya West 164
5.6 Coping mechanisms with a ban on livestock grazing in protected forest 167
5.7 Conclusions 169
5.8 Contribution of the study to knowledge 170
5.9 Policy recommendations 171
5.10 Recommendations for further research 172
REFERENCES 173
APPENDICES 188
APPENDIX 1: Questionnaire for Smallholder farmers 188
APPENDIX 2: Interview Guide 192
APPENDIX 3: Demographic Characteristics for three Forest Blocks 193
APPENDIX 4: Tables for specific forest blocks on feed sources 194

APPENDIX 5: Time series of plot of seasonal patterns of forest dependence for pasture: West Mt Kenya Protected Forest 196
APPENDIX 6: Monthly seasonality indices observed rainfall at the Chehe forest block over the study period (2009 to 2018) 197
APPENDIX 7: Scatterplot showing relationship between cattle grazing and rainfall over Chehe forest block 197
APPENDIX 8: Rainfall Monthly Seasonality patterns for Chehe Forest Block – 2009 to 2018 198
APPENDIX 9: Intercorrelations between Variables 199
APPENDIX 10: Relationship between smallholder household size and household SES forest dependence for pasture 199
APPENDIX 11: Sequential logistic regression models for cattle grazing in Mt Kenya West 199
APPENDIX 12: Multinomial Logit Model for Household SES and dependence of forest for pasture202
APPENDIX 13: Marginal Effects: Relationship between smallholder farmers household characteristics and forest dependence for pasture 203
APPENDIX 14: Relationship between smallholder farmers household size and SES wealth index and forest dependence for grass harvesting 204
APPENDIX 15: Multinomial Logit Model for Household SES and Grass Harvesting Levels 204
APPENDIX 16: Sequential logistic regression models for grass harvesting in Mt Kenya West 205
APPENDIX 17: Marginal Effects: Relationship between smallholder farmer household characteristics and forest dependence for grass harvesting in (Chehe, Hombe & Kahurura) 206
APPENDIX 18: Tests for Multicollinearity Assumption for Sequential logistic regression for Cattle Grazing across Forest Blocks 208
APPENDIX 19: Tests for Multicollinearity Assumption for Sequential logistic regression for Grass Harvesting across Forest Blocks 209
APPENDIX 20: Forest dependency by cattle grazing in protected forests 210
APPENDIX 21: Forest dependency by grass harvesting in protected forests 211
APPENDIX 22: A Sample of a Translated Interview from Kikuyu to English: Chehe Forest Block 212
APPENDIX 23: Standard Data Transcription Grid 216
APPENDIX 24: Initial Codes 217
APPENDIX 25: Data Collection Sample Sheet: Cattle Payment Receipt 219
APPENDIX 26: Sample Excel Spread Sheet 220
APPENDIX 27: Krejcie and Morgan (1970) Sample Size Determination 221
APPENDIX 28: Table of random numbers 222
APPENDIX 29: Research Authorization Documents 223

LIST OF FIGURES

FIGURE 2.1: Conceptual Framework 65

FIGURE 3.1: Area of Study 70

FIGURE 4.1: Clustered Bar Charts for Household Wealth Classes in Three Forest Blocks 113

FIGURE 4.2: Test for Normality for Selected Socio-Economic Factors 115

FIGURE 4.3: Boxplot for Testing Outlier Datapoints in The Data 118

FIGURE 4.4: Monthly and Seasonality Patterns - Dependence on Protected Forest for Pasture 133

FIGURE 4.5: Monthly and Seasonality Patterns - Dependence on Protected Forest for Pasture 136

LIST OF TABLES

TABLE 4.1: Demographic Information of Respondents 92

TABLE 4.2: Description of the Sample that Participated in the Survey (n= 453) 93

TABLE 4.3: Major Categories of Sources of Cattle Feeds in Study Sites (n=453) 105

TABLE 4.4: Source of Income (Number of mentions) 112

TABLE 4.5: Test for Linearity Between Household Socio-Economic Factors and Forest Dependence 116

TABLE 4.6: Test for Multicollinearity for Household Socio-Economic Factors 116

TABLE 4.7: Summary of Diagnostic/Preliminary Tests 118

TABLE 4.8: Logistic Regression for Cattle Grazing In Mt Kenya West Protected Forest 126

TABLE 4.9: Marginal Effects: Combined Model for Forest Dependence on Pasture 128

TABLE 4.10: Logistic Regression for Grass Harvesting in Mt Kenya West Protected Forest 131

TABLE 4.11: Marginal Effects: Combined Model for Forest Dependence on Grass Harvesting 132

TABLE 4.12: Monthly Seasonality Indices on Smallholder Farmers' Dependence on Forest for Pasture 134

TABLE 4.13: Smallholder Farmers' Perceptions of How a Ban Would Affect Livelihoods 137

TABLE 4.14: Smallholder Farmers' Livelihood Strategies to Cope With a Ban on Cattle Grazing 144

LIST OF APPENDICES

APPENDIX 1: Questionnaire for Smallholder Farmers 188
APPENDIX 2: Interview Guide 192
APPENDIX 3: Demographic Characteristics For Three Forest Blocks 193
APPENDIX 4: Tables For Specific Forest Blocks On Feed Sources 194
APPENDIX 5: Time Series Of Plot Of Seasonal Patterns Of Forest Dependence For Pasture: West Mt Kenya Protected Forest 196
APPENDIX 6: Monthly Seasonality Indices Observed Rainfall At The Chehe Forest Block Over The Study Period (2009 To 2018) 197
APPENDIX 7: Scatterplot Showing Relationship Between Cattle Grazing And Rainfall Over Chehe Forest Block 197
APPENDIX 8: Rainfall Monthly Seasonality Patterns For Chehe Forest Block – 2009 To 2018 198
APPENDIX 9: Intercorrelations Between Variables 199
APPENDIX 10: Relationship Between Smallholder Household Size And Household Ses Forest Dependence For Pasture 199
APPENDIX 11: Sequential Logistic Regression Models For Cattle Grazing In Mt Kenya West 199
APPENDIX 12: Multinomial Logit Model For Household Ses And Dependence Of Forest For Pasture 202
APPENDIX 13: Marginal Effects: Relationship Between Smallholder Farmers Household Characteristics And Forest Dependence For Pasture 203
APPENDIX 14: Relationship Between Smallholder Farmers Household Size And Ses Wealth Index And Forest Dependence For Grass Harvesting 204
APPENDIX 15: Multinomial Logit Model For Household Ses And Grass Harvesting Levels 204
APPENDIX 16: Sequential Logistic Regression Models For Grass Harvesting In Mt Kenya West 205
APPENDIX 17: Marginal Effects: Relationship Between Smallholder Farmer Household Characteristics And Forest Dependence For Grass Harvesting In (Chehe, Hombe & Kahurura) 206
APPENDIX 18: Tests For Multicollinearity Assumption For Sequential Logistic Regression For Cattle Grazing Across Forest Blocks 208
APPENDIX 19: Tests For Multicollinearity Assumption For Sequential Logistic Regression For Grass Harvesting Across Forest Blocks 209
APPENDIX 20: Forest Dependency By Cattle Grazing In Protected Forests 210
APPENDIX 21: Forest Dependency By Grass Harvesting In Protected Forests 211
APPENDIX 22: A Sample Of A Translated Interview From Kikuyu To English: Chehe Forest Block 212
APPENDIX 23: Standard Data Transcription Grid 216
APPENDIX 24: Initial Codes 217
APPENDIX 25: Data Collection Sample Sheet: Cattle Payment Receipt 219
APPENDIX 26: Sample Excel Spread Sheet 220
APPENDIX 27: Krejcie And Morgan (1970) Sample Size Determination 221
APPENDIX 28: Table Of Random Numbers 222
APPENDIX 29: Research Authorization Documents 223

LIST OF ABBREVIATIONS AND ACRONYMS

ARCOS	Albertine Rift Conservation Society
BNS	Basic Necessity Survey
CFA	Community Forest Associations
CITES	Convention on International Trade in Endangered Species
DFID	Department for International Development
EMCA	Environmental Management and Coordination Act
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GFRA	Global Forest Resources Assessment
GOK	Government of Kenya
IEBC	Independent Electoral and Boundaries Commission
ILRI	International Livestock Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KeFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KNBS	Kenya National Bureau of Statistics
KNFP	Kenya National Forest Policy
KWS	Kenya Wildlife Service
MEA	Millennium Ecosystem Assessment
MRD	Mountain Research and Development
NACOFA	National Alliance of Community Forest Association
NACOSTI	National Commission for Science, Technology, and Innovation
NEMA	National Environment Management Authority
NTFPs	Non-timber forest products
PCA	Principal Component Analysis
PELIS	Plantation Establishment and Livelihood Improvement Scheme
PFMA	Participatory Forest Management Agreements
PFMP	Participatory Forest Management Plan
SDGs	Sustainable Development Goals
SES	Social Economic Status
SFM	Sustainable Forest Management
SDG	Sustainable Development Goal
SIDA	Swiss Agency for Development Cooperation
SLF	Sustainable Livelihood Framework
SPSS	Statistical Package for Social Scientists
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
UNFCCC	United National Framework Convention on Climate Change
VCF	Village Common Forest
WMF	World Mountain Forum
WRA	Water Resources Authority
WRUA	Water Resource Users Associations

CHAPTER ONE

INTRODUCTION

1.1 Chapter Introduction

This chapter explores the context of the study by providing a global, African, and Kenyan overview of forest ecosystems, forest dependence and the concept of Joint Forest Management. The chapter also outlines the statement of the problem, purpose, and the specific objectivesof the study, as well as the significance and scope of the study. The final section provides definitions of key terms and concepts.

1.2 Background

Globally, forest ecosystems cover 24% of the earth's land surface and approximately 2 billion of the world population depend on forests for their livelihoods (Kumar & Schei, 2016). Demographic projections estimate that worldwide, forest ecosystems are home to over 900 million people, and provide more than half of the world's population with important ecosystem services (Romeo et al., 2015). According to the Global Commission of Ecosystem Management (2018), forest ecosystems are home to 12% of the world's population and another 14% of the population resides in their immediate vicinity, a fact also supported by the Food and Agricultural Organization publication (FAO, 2015). Further evidence in the research conducted by Beech et al. (2017) confirmed that half of the world's population depends on forests since they provide 60% of the world's fresh water and are the sources of all worlds' major rivers. Other scholars have emphasised that forest ecosystems are the sources of the world's major rivers and in semi-arid and arid regions as noted by Viviroli et al. (2011) whose work confirmed that over 90% of the world's rivers comes from forests.

The forest ecosystem offers services that include providing, regulating, and supporting variousservices as well as direct and indirect economic benefits to forest-dependent communities and to the national economy, especially in developing countries (Jannat et al., 2018). Forest ecosystems are a source of food, fibre, water, genetic resources, and medicine whiletrees in the forest ecosystem regulate water regimes by intercepting rainfall and regulating its flow through the hydrological system, maintenance of soil quality and the provision of organic materials through leaf and branch fall (Mengist & Soromessa, 2019).

Forest ecosystems are habitats for flora and fauna and trees found in the forest play the role of carbon sequestration which mitigates the effects of climate change, which contributes to unpredictable weather patterns, affecting the livelihoods of millions of communities (Nunes et al., 2019). Tropical forest ecosystems absorb 1.4 billion metric tons of carbon dioxide out of the global absorption of 2.5 billion metric tonnes (Shahsavari & Akbari, 2018). Cultural services provided by the forests are related to spiritual, aesthetic and ecotourism aspects as supported by the study done by Nepal (2002) on Forest Ecotourism and Sustainable Development. Tourists are mainly attracted to forests due to suitable climate and clean air, varied topography, beautiful scenery, local traditions, and sports (Rama et al., 2018). Worldwide, an average of 50 million tourists visits forest ecosystems every year with their activities supporting the livelihood of the forest-adjacent communities (Zhao & Li, 2018).

Globally, 8200 dams that are used to generate hydropower are supported by rivers from the forest ecosystems, accounting for approximately 16% of world electrical energy production which is the largest renewable energy source (Kumar & Schei, 2016; Owusu & Sarkodie, 2016). The sub-Saharan Africaforest provides fresh water to more than half of the population in Africa for domestic, irrigation, and industrial use (Bunyasi, 2012). Africa forests are a source of green renewable energy for many developing cities and settlement centres around the forest regions whilehydropower is the main source of clean energy in Africa. The sub-Saharan Africa forests support agriculture where farming is allowed in the forest under certain conditions since forests have reliable rainfall and excellent volcanic soils. According to the Forest Act (2005), in Kenya, for example, forests support livestock farming since it is a source of fodder obtained through cattle grazing and grass harvesting. African forests play a role in biodiversity conservation since they have different ecosystems such asforest, grasslands, dry lands, rivers, and wetlands with Mount Kenya being among the most biologically diverse forests with respect toplant and animal species (Maselli & Kohler, 2013).

Sub-Saharan forests provide non-timber forest products such aswild food stuffs, medicines, fruits, vegetables, nuts, and fodder for livestock (Mugagga et al., 2012). In addition, forests are tourist attraction sites because of the pristine landscapes and high biological diversity. In sub-Saharan Africa, forests sequestered about 30 billion tonnes of carbon dioxide in 2010 and

further studies noted that forests play an ecological service role in hazard prevention, climate change modulation and carbon sequestration (Shahsavari & Akbari, 2018). Increasing efficiency in the forest sector could cut greenhouse emissions by 27% and this can help the sub-Saharan countries to earn nearly $200 million per year through the carbon market scheme. In the year 2012, African forests attracted over 36 billion US Dollars from tourism and directly contributed 2.8% to the region's Gross Domestic Product (GDP) according to Mutana & Mukwada (2018). Forests contribute up to 3.6% to Kenya's GDP (KFS, 2018). The ecosystem data shows that Mount Kenya had 25,000 tourists in 2018 which it was a major boost to the sector (KWS, 2018). In sub-Saharan Africa, the forests support over 70% of the total power supply with an estimated 160 million electricity consumers. As of 2018, 60% of Kenyan households were connectedto grid electricity through hydro power generation supported by forests.

Over the years, the environmental agencies, for example, Kenya Forest Service (KFS), National Environment Management Authority (NEMA) and Kenya Wildlife Service (KWS) have dealt with concerns of perceived threats posed by community activities to the Mount Kenya ecosystem (Kinoti & Mwende, 2019). Implementing the forest ban has been one of the strategies over the years. The ban on the use of forest products is not a new phenomenon in Kenya. In 1986, the *Shamba* system and cattle grazing in protected forest zones in Mount Kenya was banned due to mismanagement and failure by the communities to establish new plantations. The practice had contributed to an increase in cases of deforestation. The ban was executed through a presidential decree in 1986 and in 1987, and all forest residents were evicted from the forest. Over the years, cattle grazing in protected forests have been blamed for the destruction of tree seedlings in nurseries and failure of the plant propagules to regenerate hence affecting reforestation efforts. After the ban, no arrangements were put in place to continue with plantation establishment and management.

Re-afforestation programmes stagnated, and illegal cattle grazing increased in Mt Kenya west ecosystem. What followed were years of heavy harvesting of mature trees in the plantations without a replanting programme. There were no willing communities to replant and maintain the trees and there was no budget for proper planting and maintenance. Less than 20% of clear-felled areas were replanted and 80% of replanted areas were not weeded. The situation was aggravated by the 1994 civil service retrenchment programme leading to an acute

shortage of labour in forest stations. In response to the increasing backlogs and inadequate resource capacity within the forest department, the ban on cattle grazing and farming in the forest was lifted in 1994. Non-residential cultivation faced many challenges due to strong influence from politicians. In 1999, large areas unsuitable for plantation establishment were cleared for cultivation with little meaningful replanting of trees. The Ministry of Environment and Natural Resources banned cattle grazing and non-residential cultivation in 2003. Practice of grass harvesting, and cattle grazing continued unregulated in the protected forest. Since KFS staff were too few to enforce laws, illegal activities continued in the forest. However, some farmers started planting their own fodder and the concept of zero-grazing was introduced by the Ministry of Agriculture.

In 2010, the Kenya Government by a legal notice in the Kenya Gazette and through the NEMA under the Ministry of Environment imposed a ban on cattle grazing in protected forests in Mt Kenya West by enforcing the Environmental Management and Coordination Act (EMCA, 1999). The reasons behind the ban included grazing of goats in the forest, cattle grazing in wetlands and lack of defined cattle carrying capacity leading to overgrazing. Other reasons that necessitated the ban included lack of clear zonation areas for cattle grazing and lack of re-afforestation programmes by KFS. This was caused by the failure by KFS to conduct Environmental Impact Assessments (EIA) before logging and lack of clear reforestation programme.KFS and the community appealed the decision in an environment court and won, which led to resumption of cattle grazing in the protected forests.

1.2.1 Conceptualization of socio-economic status

Socio-economic status (SES) is the position or social standing of a person in a society or class of an individual or group determined by a combination of social and economic factors that are crucial to an individual's upward mobility. It isan examination of socio-economic status that often reveals inequalities in access to resources, as well asissues related to privilege, power and control (Arsonson et al., 2018). Besides, SES encompasses not just income but also perceptions of social status and social class. It further encompasses quality of life attributes as well as the opportunities and privileges afforded to people within the society. According to Corwyn & Bradley (2002), poverty specifically is not a single factor but rather is characterized by multiple physical and psychosocial stressors across the life span.

SES isveryrelevant to thisstudy because of its role in the analysis of household drivers of cattle grazing and grass harvesting in protected forests. In this study, socio - economic status was broken into five levels namely: poorest; poorer; poor; less poor; and least poor. The study focused on the relationship between smallholder farmer's household characteristics that included proximity to the forest, size of land, ownership of zero-grazing units and dependence on protected forest for pasture through cattle grazing and grass harvesting.

1.1.2 Forest degradation: Implications on rural economies and livelihoods

Sub-Saharan Africa has one of the highest rates of deforestation and according to Rudel (2013) and forest cover may disappear completely by 2050 if no strategies are put in place. Deforestation is not just an environmental concern but also a rural development issue. This is probably one of biggest challenges to development of rural economies in the sub-Saharan Africa. The most commonchallenges facing rural dwellers includes lack of access to clean water, food insecurity among others hence the contention that deforestation contributes to these socio-economic hardships faced by rural citizens. According to Mapulanga & Naito (2019), increased deforestation negatively impacted access to clean drinking water in Malawi. The authors observed that after controlling for population and variance in temperatures, a 1.0 percentage point increase in deforestation decreases access to clean drinking water by 0.93 percentage points.

A similar study by Maseko et al. (2017) in Malawi noted that deforestation in the last decade in Malawi was at 14% and this contributed to the challenge of access to clean drinking water and decrease in rainfall. The study noted that there is significant effect of deforestation on access on clean drinking water with important policy implications. In addition, deforestation has been reported to have far reaching implications on the malnutrition amongst rural children since forests contributes to local diets and nutrition as they are sources of wild fruits. Maseko et al. (2017) examined the frequency of consumption of wild foods by children, the reasons children consume wild fruits, and how deforestation influences these patterns. The authors reported a correlation between wild food species and forest cover indicating that highly deforested areas had the least number of wild foods. Their findings suggested that deforestation reduces the availability of wild foods which is important to supplement children diet and prevent diseases by providing energy, proteins and essential vitamins. Similarly, Acharya et al. (2020) contends that deforestation is responsible for both household and

individual level burden of malnutrition in sub-Saharan Africa. The authors argued that while deforestation does not seem to be an important driver of the double burden of malnutrition, it influences several intermediate factors which in turn influence the double burden malnutrition. Galway et al. (2018) further argued that deforestation has consequences on child diet diversity. Using data from 15 sub-Saharan countries, Galway et al. (2018) showed that deforestation negatively impacts diet diversity, for instance, consumption of legumes and nuts, fresh foods, and fruits and vegetables among children aged 6 months to 24 months. Thus, forests and forest-based ecosystems are associated with diet quality and nutrition.

Rural communities from developing nations are faced with the worst vulnerability of malaria pandemics. According to a study in 160 countries across the world by Pattanayak et al. (2006), deforestation and poverty worsen the incidences of malaria illnesses. According to the study by Pattanayak et al. (2006) on forest loss at the country level between 1990 and 2000, change in forest cover had implications on malaria risk. Specifically, the authors showed correlation between village level forest protection and the incident of malaria and demonstrated how forest protection may offer health benefits to nearby communities. Recent studies by Bauhoff & Busch (2019) have further supported the claims by Pattanayak et al. (2006) demonstrating that deforestation indeed exacerbates malaria prevalence amongst rural households using data from 17 countries in sub-Saharan Africa.

Forests have been reported to have positive benefits of buffering forest-adjacent communities from extreme temperature associated with climate change. Increase in changes in climate and land cover has been reported to expose millions of people to an increased likelihood of heat illness which is related to effects of on-going tropical deforestation. Wolff et al. (2018), work in India foundthat villagers were more likely to report the cooling effect if they were from villages with higher or more variable temperatures than in recently deforested or fragmented landscapes.

Women, especially those from rural settings, bear a disproportionate burden of deforestation. Several studies have demonstrated the connections between deforestation and employment, income, energy use and nutrition. A study by Mishra & Mishra (2017) foundthat deforestation increases women's work in forest related collection and gathering activities, emphasizing that the quality of village forests is a strong factor in reducing women's total work burden. According to Duguma et al. (2019), there are many contextual socio-

demographics, productions as well as policy and governance linkages between rural poverty and deforestation.

The causes of deforestation and degradation can be viewedas necessity driven, market driven, and governance driven. Enbakom et al. (2017) argued that deforestation negatively affects livelihoods through decline in land productivity, agriculture, and livestock productions. The authors contended that large scale natural resource management approaches such as incorporating community-based watershed management can reduce the adverse impact of deforestation. In Uganda, Kutiote et al. (2019), who analysed deforestation of Igwe forest and its effects on livelihood patterns of peripheral communities in Burigi, Uganda, showed that deforestation had affected crop production in the areas that haddelayed planting seasons. Deresa & Legesse (2015) noted that in Ethiopia, deforestation had contributed to the impoverishment of communities in rural areas through increased soil erosion, reduction of farm productivity, reduction of pastureland and farmland size, a similar impact noted in Kenyan mountain ecosystems. Similarly, research by Aliyu et al. (2014) in Nigeria underlined and supported the viewthat deforestation is a major contributor to rural poverty.

1.2.2 Threats to Forest Ecosystems

Forests are under threat from increasing temperatures and wildfires, population growth and demand for food and fuel (Cramer et al., 2018). Population pressure and the expansion of intensive agriculture have forced smallholder farmers to depend on forests for livestock pasture, food, water, and medicine (Bernués et al., 2016). According to a study by Gioli et al. (2019) on understanding and tackling poverty and vulnerability in forest livelihoods in the Himalayas, the forest is highly threatened due to high dependence levels by vulnerable communities. The researchers further reported that human interaction with forest included farming in the forest causing ecosystem imbalance, and the emergence of pests and diseases that destroy plantations.

Many towns and cities in the world depend heavily on forest water for domestic use through state-regulated water and sanitation companies (Bunyasi, 2012). According to Bunyasi (2012), water from Mount Kenya generates 97% of the country’s hydroelectric power and if the ecosystem is not conserved the energy sector can be affected in a significantway. Surprisingly, Africa has lost 3.9 million hectares of forests in the last decade, which is the

largest amount of forest cover lossall over the world (Moon & Solomon, 2018). According to Slaymaker (2016), one major threat to sub-Saharan Africa forests is the overexploitation of water resources. The critical importance of these forest ecosystems is regulating water quality and quantity. The competition for the resource has caused conflict between upstream and downstream communities due to diminishing water levels in rivers. In sub-Saharan Africa, deforestation has been on the rise in the last decade (Moon & Solomon, 2018). There has been encroachment of forest land to extend agricultural land as population pressure mounts. Another threat is the increase in mining activities due to increasing demand of raw materials in the construction and manufacturing industries hence resulting to pollution that affect flora and fauna that depend on the forest ecosystems (UNESCO, 2014).

The increase in the number of tourists in sub-Saharan Africa forests is also a threat due to high influx of tourists leading to anthropogenic pollution. Local forest-adjacent communities have traditionally grazed their cattle in forest areas and due to increase in demand of milk and meat, the cattle stocking levels are rarely regulated which is a seriousthreat to forest ecosystems (UNEP, 2014). Sub-Sahara Africa forestsare particularly threatened by climate change and are unique hotspots due to over-dependence, hence severely affecting the vegetation and hydrology (Mugagga et al., 2012). Other threats include population growth since forest areas are currently most the densely populated compared to arid and semi-arid lowlands in many regions of Africa (UNESCO, 2014). Poverty and lack of alternative livelihoods is a threat to forest ecosystems due to increased levels of dependence on the readily available, accessible, and affordable natural resources, a view that issupported by the United National Framework Convention on Climate Change (UNFCCC, 2013).

The sub-Saharan Africa region forests include Mount Kenya, Mt Kilimanjaro in Tanzania, the Drakensberg Range in South Africa, the Fouta Djallon Forests in Guinea, and the Madagascar highlands (Alweny et al., 2014). According to UNEP (2014), 19% (equivalent to 88 million people in sub-Saharan Africa) of the population live adjacent to forest ecosystems. Mount Kenya, for example, is an important water reservoir for a population of about seven million people who live on its foothill and adjacent areas (Bunyasi 2012; UNEP, 2014). Besides, Mount Kenya is the largest forest ecosystem in Kenya, comprising the largest protected forest and wildlife area (KFS, 2017). The Mount Kenya ecosystem provides more than half of the country's water for irrigated agriculture and supports the largest amountof

hydro-electric power generation. The areas adjacent to the Mount Kenya forest ecosystem protected areas support over a million smallholder farmers in Central Kenya (Bunyasi, 2012).

Forests are under threat of extinction from deforestation, soil erosion, increasing temperatures, wildfires, population growth and demand for food and energy (Change et al., 2010). The Mount Kenya ecosystem, in particular, has become increasingly threatened by widespread environmental degradation caused by wildfires, deforestation, soil erosion, alien invasive species, overexploitation of water resources, clearing land for farming in the forest through Plantation Establishment and Livelihood Improvement Scheme (PELIS), increased number of tourists, population pressure, increase in cattle stocking hence posing threat to livelihoods and loss of ecosystem services.

There are many global actors who are concerned with mountain ecosystem such as Mt Kenya includingthe Commission on Ecosystem Management that provides expert guidance on the integrated approaches to the management of natural and modified ecosystems to promote diversity conservation and sustainable development. Other actors include Mountain Institute which is also a major global actor that focuses on the challenges faced by remote forest communities and the fragile environment that supports them. Another global actor is the Mountain Research and Development (MRD) whose role is to foster sustainable development in mountain support mainly on research in the major mountains globally. MRD offers support in developing scientific capacity capitalizing on development experiences, promoting policy dialogue, and strengthening networks within the forest communities and are instrumental in informingsome of the recommendations of this study.

Food and Agricultural Organisation (FAO) of the United Nations is a partner in conservation efforts in Mt Kenya Ecosystem and has supported various NTFPs projects. FAO outlines the importance of forests in sustainable development and their place on the global political agenda. The intervention of FAO in current and future projects in Mt Kenya will help to address aspects of forest resource overexploitation and therefore play a role in enhancing the resilience of the fragile ecosystem. The World Mountain Forum (WMF) is another global actor in the forest ecosystem which is uniquely positioned to provide a timely space for policy makers, scientists, and practitioners to share experiences and best practices. WMF is faced by the big challenge of developing integrated solutions to existing challenges that

hinder sustainable development of forested regions. The Mountain Partnership is an important forest ecosystem actor which is an alliance of governments and organizations committed to working together with the common goal of achieving sustainable forest development around the world. The Mountain Partnership aims to address threats of ecosystem degradation such as logging, overgrazing and over exploitation of NTFPs to sustain healthy environments in the world's forest regions.

In sub-Saharan Africa, the United Nations Environmental Programme's (UNEP) role in forest ecosystems is to set the environmental agenda, provide leadership and encourage partnership in caring for the forest ecosystems. The main challenge faced by UNEP is how to come up with the best strategies to ensure communities improve their quality of life without compromising that of the future generations as noted in the conservation projects that they support in Kenya. The Albertine Rift Conservation Society (ARCOS) is a conservation organisation in sub-Saharan Africa with the mission to enhance biodiversity conservation of African forests. The main challenge faced by ARCOS is how best to promote collaborative conservation for nature and forest-adjacent communities and these institutions can provide best practices to balance conservation and livelihood support in Mt. Kenya.

The Swiss Agency for Development Cooperation (SIDA) has been a development partner in conservation projects in Kenya. SIDA focuseson climate change and is committed to the sustainable development of forested regions in sub-Saharan Africa. The challenges faced by SIDA include how best to support strategies to improve the living conditions of forest-adjacent communities and simultaneously to strengthen resilience against climate change.

In addition, the role of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) is to assess the impact of climate change on fragile forest ecosystems, using mountain biosphere reserves as sites for study and monitoring. The challenges that UNESCO works on include addressing the threats caused by climate change, loss of rare and endangered species and improving the socio-economic conditions and the livelihoods of forest-adjacent communities. UNESCO is mandated to name world heritage sites which are landmarks of collective interest to humanity, selected because of their cultural, historic, and scientific importance. Mount Kenya covers a total area of 3000 km^2 and was named by UNESCO as a world heritage site in 1997 due to its uniqueuniversal value.

1.2.3 Kenyan policies regarding forest management

The main policies that guide forest management in Kenya include the Forest Act (2005), Forest Management and Conservation Act (2016) and Environment Management and Co-ordination Act (1999). The main objective of forest policies is to increase and maintain tree forest cover to 10% by year 2022, to establish an enabling legislative and institutional framework and to support forestry research. Besides, these policies are imperative in promoting community participation through Participatory Forest Management Plan (PFMP) in forest sector development and enhancing management of forest resources for biodiversity. The enactment of Forest Act 2005 (revised in 2016) provides a legal framework with a wide stakeholder's involvement in forest management. The Forest Act (2005) provides for Participatory Forest Management (PFM) that allows local communities to form Community Forest Associations (CFAs) and participate in preparation of Participatory Forest Management Plans (PFMP), which provides a platform for engagement with the KFS.

This arrangement provides for conditions under which the CFA can sign a formal agreement with KFS. The Kenya Gazette notice (2014) specified forestry functions to the County governments which include implementation of national policies that are applicable to county forests and formulation of county level specific by-laws and legislation. Besides, counties have the mandate to develop and implement county forest management plans in consultation with the stakeholders and encourage public private partnership management practice in county forests. According to the Fourth Schedule of the Constitution of Kenya (2010), the County Assemblies of Kenya have the mandate to establish the legal and regulatory framework for the conservation and participatory management of forests. In the year 2021, Nyeri County where the study was conducted passed the Nyeri County Forest Management and Conservation Bill (2021) with a lot of emphasis on management of community forests, community participation and issues related to licenses, concessions, permits, financial provisions, enforcement, and compliance provisions.

1.2.4 Communities and conservation of mountain ecosystem services in Kenya

Between 1990 and 2012, Kenya lost 6.5 per cent of itsforest cover, which poses a major environmental challenge in the country (Ongugo et al., 2014). A 2018 survey conducted

countrywide by the KFS, and the Kenya Forestry Research Institute (KeFRI) foundthat forest cover was 7.4%, which was way below the UN recommendation of 10%. There are several community-based approaches that the government of Kenya has adopted in the recent pasttowards community engagement in the conservation of mountain ecosystem services, while promoting rural development. These include Community Forest Associations (CFA), Community-Based Wildlife Management and Community Water Users Associations. These community-based efforts are a part of the strategy the governmenthas put in place towards achieving 15 per cent tree cover by the year 2022. Kenya has close to 300 registered Community Forest Associations that work with the Kenya Forest Service towards the conservation of the country's forest cover. Currently, 177 forest management plans have been approved by KFS to enable the CFAs to participate in forest conservation and management. According to KFS records, other CFAs in Kenya are found in Coast region conservancy (17), Central highlands (44), Eastern conservancy (21), Mau Conservancy (19) and North rift region (20). All the CFAs operate under the umbrella organization National Alliance of Community Forest Association (NACOFA). The PFMP facilitates development partners and other stakeholders to support the local communities through the CFA to address challenges that may hamper the conservation and sustainable management of the forest.

In most of the forest conservancies, there are high rates of unemployment and increase in poverty levels among the youth hence creating pressure on forest resources. Members of CFAs face challenges in the establishment and promotion of income generating activities. For example, in Mt Kenya region, communities practicing beekeeping have challenges related to insecurity of hives, poor market of honey, lack of knowledge and limited capacity for adding value to honey as well aslack of adequate quality beehives. Forest-adjacent communities are also faced with challenges in tree nursery establishment and management that include difficulties in obtaining agroforestry seeds and lack of seed storage facilities. Forest-adjacent communities practicing farming in the forest under PELIS face challenges related to insecurity from wild animals and thieves and lack of certified farming seeds. Community members undertaking extraction of herbal medicine are faced by various challenges that include lack of knowledge to process and pack medicine. Forest-adjacent communities interested in exploring ecotourism activities are faced by limited finances and capacity of local community in tourism development andmanagement. These communities also lack

adequate supportive tourism infrastructure such as access roads, established nature trails andotheressentialfacilitiesthatarerequiredforsuccessfulimplementation of ecotourism-based income generating activities (Mutana & Mukwada, 2018).

According to KFS (2018), the wildlife conservation and tourism development in Lower Imenti Forest in Mt. Kenya ecosystem is faced by several challenges such aslimited appreciation of the role of wildlife and their habitat in socio-economic development of the local community. Similarly, in Mount Kenya, Mau hill, Cherangany and Mt Elgon, community forest associations lack infrastructure to support their operations such asstaff, offices, and computers, which has given CFA challenges in terms of resource mobilization. CFAs also lack a resource centre and have limited means of transport and communication with stakeholders. Other challenges faced by community-based approaches to mountain protected forests in Kenya include over exploitation of forest products challenges. For example, in Mt Kenya, the most important products for income generation from forest include timber, grass and firewood. Some of these and other products are not well developed and face many challenges in their development. Most of the challenges are related to marketing ofnon-timber forest products. Community-based approaches are faced by various constrains related to forest conservation.

Majority of the CFAs in respective ecosystems are faced withorganization complexity since they lack defined structures and established hierarchy at the local level hence causing mistrust and suspicion among members related to benefit sharing challenges (Ongugo et al., 2014). Other challenges include conflict among parties and lack of cooperation among CFA members. There are also challenges related to forest conservation that include hindrance in joining a CFA due to inadequateinformation and frustration of CFA's efforts to protect the forests. CFAs have limited capacity to enhance governance and change in attitude among different players to ensure that the participatory forest management approach is adopted. Majority of the CFAs are weak and need strengthening to address this challenge in implementation of CFA related activities.

According to the Mt Kenya Forest Reserve Management Plan (2010-2019), there are threats and challenges faced by community-based approaches in different protected wildlife parks and reserves in Kenya. Community-based challenges have been experienced in Aberdare and Mount Kenya over the years. However, it is important to note that KWS has an elaborate

community wildlife programme that encourages biodiversity conservation by communities living on land essential to wildlife such as wildlife corridors and dispersal lands outside parks and reserves. The premise is that if communities' benefit from wildlife and other natural resources, they are likely to conserve them. The protection and conservation of the National Parks and Reserves is guided by the Wildlife Policy and the Wildlife Conservation and Management Act (2013), which governs conservation of wildlife within and outside protected areas. It also supports community initiatives towards conservation and plays an advisory role to the local communities by providing regulations that enable the generation of optimum returns from wildlife. However, according to KWS (2018), the policy does not allow consumptive utilization of wildlife resources within the parks; only non–consumptive uses such as recreation and tourism are allowed. Although the forests have several uses to the local community, some of the major reasons mentioned to be of value to the local community include being a source of habitat for wildlife as noted by Nunes et al. (2019).

Forest management plans have wildlife protection programme that provides actions and measures that address human-wildlife conflicts as a result of elephant-related destruction of crops and loss of human life, issues related to electric fences and wildlife damage to plantations and community farms in the forest (Schieltz et al., 2016). For example, in Mt Kenya and Aberdares forests, there are threats to protected wildlife parks and reserves since it is a habitat for large mammals. The most prominent is the African elephant which is one of species listed as endangered, which is one of the over 100 animals listed as threatened in Kenya according to CITES (2018). Elephants are one of the major causes of human-wildlife conflict in Mt Kenya and Aberdares forest. This has necessitated erection of an electric fence in the area though inadequate. Another important threatened large mammal is African antelope Bongo in Mt Kenya west ecosystem which is extremely rare and has been threatened by both hunting and habitat shrinkage. There are a number of challenges that are encountered in forest management with the most common being human-wildlife conflict and poor roads access according to KFS (2019). Communities do not appreciate the role of wildlife in economic development and maintenance of the ecological balance, and they find wildlife more of a nuisance as they are largely associated with crop damage, human injuries and/or death and damage of infrastructure according to Nelson et al. (2015). In addition, livestock grazers in the forest are attacked by wild animals, and experience animal theft, poor forest roads and increase in cases of pests and diseases. According to KWS (2019) majority of the

CFAs in Kenya experience challenges related to the human-wildlife conflicts which are highly prevalent in Mau, Aberdares and Mt Kenya forest where there are no electric fences, and this has created conflicts between communities and KWS.

According to KWS, despite these efforts, there has been increase in poaching of wildlife for their bush meat for the local and regional markets and large mammal poaching for international commercial purposes (Change et al., 2010). Over the last 10 years, Mt Kenya and Aberdare have all experienced rising degradation of wildlife migration and dispersal corridors affecting large mammals such as elephants. At times the elephants break the fence and access settlement areas since most of the wildlife corridors have been encroached through human settlement, for example, Aberdare to Mt Kenya Elephant corridor hence interfering with wildlife watering places and the elephant maternity sites (KWS, 2018). It is important to note that in the pastoral rangelands of Northern Kenya, there are no electric fences; in fact, it is one of the few places left in Africa that allow for the free movement of wildlife and livestock across a vast area where wild animals and communities live together. There has been increase in unsustainable use, demand, and exploitation of natural resources, mainly water abstraction and livestock grazing by communities surrounding protected areas and this has led to habitat degradation.

Other challenges faced by community-based approaches to mountain protected wildlife areas isinvolvement of community in forest management without adequate resources and this has resulted to an increase in conflicts as a constrain to forest conservation. The long history of human habitat through agriculture has pushed most animals to isolated pockets of protected areas. One of the wildlife areas management challenges is that communities have limited capacity for compensation negotiation with KWS despite the existence of wildlife compensation committee in all the regions as supported by the Wildlife Act (2013). Another threat to protected wildlife parks and reserves in Kenya include management challenges.

For example, in Mt Elgon, there is limited appreciation of wildlife and their habitat in socio-economic development of the localcommunity due to limited awareness on wildlife, their habitat conservation and their economic importance to thecommunity. Capacity of communities on wildlife related ecotourism is very low hence increase in the cases of poaching in the region. In all the mountain ecosystems in Kenya, there has been

low public sensitization and awareness on values of wildlife and the potential for ecotourism as argued by Willcox & Giuliano (2011).

According to Kenya Water Towers Agency, (KWTA, 2018), there are documented threats to different mountains in Kenya water towers and there are challenges faced by community-based approaches in the water towers. KWTA (2019) confirmed that there are 88 water towers in Kenya and out of these, 18 are gazetted while 70 are non-gazetted. Among the gazetted water towers, there are fivemajor ones, namely Mt. Kenya, Cherangani hills, Mt. Elgon, Mau Forest and the Aberdares forest. The natural forest conservation and management programme in Kenya has a chapter on water resource management under the Ministry of Water and Sanitation and Irrigation (MoWSI). The trends in water levels across the water towers in Kenya indicated high water level in 1970s with scarce water levels in 2000s (Ongugo et al., 2014) and this trend calls for immediate and continued effort in the conservation of the forest resources in order to secure the water sources in as there is rapid reduction in water level across the years. This is therefore guided by the WaterAct (2016) that lays out a mechanism for development of national water resources management strategy for the protection, management, use, development, conservation and control of water sources.

The strategy devolves the authority over conservation of water catchments areas to local stakeholders to manage them in collaboration with Water Resources Authority (WRA) and Water Resources Users Associations (WRUAs) established under the Act. Mt. Kenya ecosystem forms important water catchment areawith thousands of water intakes erected by communities in consultation with water management authorities. Aberdare ranges are an important water catchment region with rivers and streams originating from the forest supplying water to urban areas like Nairobi. There have been challenges faced by community-based approaches to water towers and consequently no sound measures to control water abstractions and protection of riverineareas.

There have been no clear strategies to conserve catchment areas to ensure communities get clean water and enhance promotion of water harvesting initiatives within the community. There has been limited empowerment of communities in the management of water resources through dissemination of new water policies, an argument supported by Bunyasi, (2012). Although WRUAs in Kenya are community-based natural resources

management institutions that link between environmental services from the river and livelihoods of local communities, they lack the capacity to assess and monitor water resources in terms of quality and quantity. The capacity of streams and rivers originating from the forest to adequately meet the ever-increasing water demand is a huge challenge. The threats to mountains in Kenya water towers exacerbate since the WRUAs have limited capacity to regulate and control direct abstraction of water and are unable to effectively control farming in riparian areas and catchment leading todegradation. Besides, the WRUAs have limited understanding and enforcement of water sector reforms and waterlaws. There have been limitations in community sensitization on water sector reforms and sustainable use of water resources through meetings for local leaders. Other challenges include lack of awareness on water sector reforms and sustainable use of water resources and lack of joint monitoring and enforcement of existing water policies between communities and stakeholders. WRUAs have limited financial resources to address degradation of water catchment areas and encroachment of riparian lands, for example, through bamboo planting.

1.2.5 Participatory Forest Management and rural community development

The forest sector in Kenya has undergone a major transformation in management with increased involvement of a wide range of stakeholders in forest management under participatory forest management (Thenya et al., 2017). This change was necessitated by a paradigm shift in natural resources management within the country following agitation for change in forest management in late 1990. This new management approach has been facilitated by legal requirements as stipulated in the Forest Act (2016), which allows the local community to form and register community forest associations. The association enables the forest-adjacent communities to participate in Participatory Forest Management Plans (PFMP) which is a form of decentralization aimed at enhancing forest conservation and sustainable rural livelihoods (Somanathan et al., 2009; Moktan et al., 2016). The approach therefore gives the forest-adjacent communities user rights aimed at enhancing ecosystem conservation and local community livelihoods. In Kenya, access to protected forest is facilitated by the formation of forest user groups, a role co-ordinated by the umbrella Community Forest Associations. The socio-economic objectives targeted through PFMP are sustainable forest resources exploitation, forest conservation awareness and conflict resolution (Ongugo et al., 2008).

Currently, 177 joint forest management plans have been approved in Kenya by KFS to enable the CFAs to participate in forest conservation and management. Hombe forest block has 23 active user groups, while Chehe and Kahurura have 18 and 21 respectively undertaking various activities in the protected forests. Each user group has an average of 80 members. The Community Forest Associations and its members have the right to enter the forest area for the purposes of carrying out user rights activities as supported by the Forest Act (2005). The CFA has the right to carry out the following user rights: collection of medicinal herbs; harvesting of honey; fuel wood collection; grass and fodder harvesting; livestock grazing; ecotourism; and recreational activities. Other activities include PELIS, contracts to assist in carrying out specific silvicultural activities, seedling production, seed collection, butterfly farming and collection of fruits, berries and vegetables. Besides, the CFA have the right to undertake fish farming, mushroom farming, water abstraction and quarrying, as well as murram and ballast collection. In consultation with stakeholders, the CFA has the mandate to undertake carbon business, extraction of woodcraft materials, harvesting of timber and collection of forest produce for community-based industries. CFA are also allowed to enhance development of community wood and non-wood forest-based industries and scientific and education activities.

However, grant of the user rights by KFS does not exclude the CFA and the user groups from paying fees, taxes and levies required for the exercise of the right or carrying out of the activity. KFS monitor, evaluate and offer technical expertise on the exploitation of the user rights. The CFAs according to the Forest Act (2016) have an obligation to protect sacred groves and protected trees, and to conserve and manage the forest. CFAs assist KFS in enforcing the provisions of the Forests Act and any rules and regulations, in relation to illegal harvesting of forest produce and hunting of game. CFAs take precautions against occurrence of fire and where it occurs and help in firefighting. KFS may withdraw a particular user right where the CFA breaches any of the terms related to forest products utilization. These provisions, however, do not create any kind of joint venture or partnership between the parties and KFS can effect a ban on the user rights without consultations.

Communities in the three-forest block studied (Hombe, Chehe and Kahurura) access the forest due to the existence of Participatory Forest Management plan (PFM) and forest management agreements. This is supported by scholars who noted that participation of communities in forest management for conservation and livelihood benefits is today being

recognized as a global trend (Moktan et al., 2016). Participatory Forest Management (PFM) as opposed to top-down state management is part of the decentralization process that has occurred in Africa over the past few decades. According to the study by Adhikari et al. (2004), over the last two decades, there has been an increasing emphasis on community-based forest management with transference of forest management responsibility into the hands of local communities supported by legal frameworks such as the Forest Act (2005) in Kenya.

Research by Achreckenberg & Luttrel (2009) investigated whether Participatory Forest Management is a routeto poverty reduction or not. The researchers undertook study in Kenya, Tanzania, and Nepal, representing very different stages in and approaches to the implementation of PFM. The study noted that PFM typically provides a new dimension and provide direct household benefits to the user group at community level. The researchers emphasised that the PFM interventions should provide rural people with a sustainable and equitably distributed stream of net benefits and one of the strategies is to adopt poverty reduction to allow for both subsistence and commercial use of forest products, empower local institutions and introduce transparent and equitable means of benefit sharing. This is supported by the theory of access which was used to support part of the discussion in this research. PFM processes and mechanism should enable the people who have a direct stake in forest resources, mainly communities, to be part of the decision making in all aspects of forest management.

PFM may be considered pro-poor if it achieves an absolute improvement in the lives of the poor people, but this has been a challenge according to Achreckenberg & Luttrel (2009). The sustainable livelihood frameworkhelps to organize the factors that constrain or enhance livelihood opportunities and shows how they relate to one another as well as how to embrace and expand the sustainable livelihood approach. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in future without undermining natural resource base. As forest-adjacent communities acquire more assets, they will become more empowered to influence the next component of the framework, the structures and processes that affect them. In the three-forest blocks involved in the study, forest-adjacent communities have the user right to access the forest provided they meet the conditions as per the forest Act (2005). However there have been cases where the livelihood activities are restricted as the government enforces laws and

regulations, for example, the current moratorium being enforced by the Kenyan government on logging that commenced in the year 2018. The socio-economic objectives targeted through PFM are sustainable forest resources exploitation, forest conservation awareness, conflict resolution, forest production and equity (Ongugo et al., 2008; Koech et al., 2009; Matias et al., 2018). The extent of influence on forest-adjacent communities to engage in forest protection and conservation is dependent on their level of participation in the PFM implementation process (Koech et al., 2009).

Previous scholars such as Achreckenberg & Luttrel (2009) have outlined the different capitals from a livelihood framework perspective that make implementation of PFM to result in poverty reduction among communities living adjacent to protected forests where PFM has been implemented. The sustainable livelihood framework focuses on the sustainable daily livelihood based on capitals mainly natural, physical, social, financial, and human capitals. According to the framework, the people with more assets have a better livelihood, a concept also supported by Ribot & Peluso (2003). As discussed by Mahanty et al. (2006), PFM is considered pro-poor if it enhances the assets and capabilities of poor men and women, supporting more productive and sustainable livelihoods. In Kenya, PFM, for example, has its own challenges since there are no measures to wean out households that build asset portfolio from forest dependence. Strengthening of forest law enforcement is likely to impact negatively on the livelihood of forest communities, which varies by social groups withthe impoverished groups expected to be more affected in comparison to the wealthier groups. Furthermore, PFM is considered equitable if the costs and benefits are apportioned between different participants. The benefits and costs of PFM implementation are grouped under different facets of poverty, based on the sustainable livelihood's framework. Some impacts of PFM may be felt at the household level while others are enjoyed by the whole community, and it is imperative to understand whether the overall benefits can be made sustainable in the long term.

The loss of cash income from forest related activities can be striking for the poor and the very poor as reported by scholars. Forests are a natural capital and the dependence on forest resources is overwhelming (Appiah, 2009). This capital is associated with the theory of access that argues that creating sustainable forestry requires sharing the benefits of the forest with the local communities where local communities directly participate. Access is the ability to derive benefits from things using all possible means (Neale 1998; Das, 2019).

The components of the theory of access includes the availability of the resource, ability to access it and affordability characteristics as supported by the Forest Act (2005). Previous scholars have noted that any activity that depletes natural resources such as massive deforestation can indeed put the lives of forest-adjacent communities at risk. With all the benefits of indigenous forests outlined in the earlier section, this should inform a healthy balance between the need to giveforest-adjacent communities user right to access the forest and the requirement that they meet the conditions of conservation as per the Forest Act (2005). Nawrotzki et al. (2012) noted that access to natural capital may facilitate improvements to other livelihoods assets such as financial capital to enhance income generation, which was an important component noted from the respondents in this research.

Physical assets consist of the basic infrastructure and producer goods needed to support livelihoods (Martindale, 2014). In a farming community, physical assets will include livestock, farm structures and equipment's. The impact of PFM on household assets contributes to the increase in physical assets which is mainly attributed to the role of PFM in the joint forest management. The forest-adjacent communities use new PFM institutions to negotiate with external service providers to improve community infrastructure. Social capital includes the ability of the communities to work in groups to achieve specific objectives. According to Achreckenberg & Luttrel (2009), one of the most obvious impacts of PFM is a change in community level governance and social cohesion, which can be enhanced by networking at local, regional and national level. Generally, improved forest conditions can lead to enhanced food security. A well conserved forest is critical in the contribution of human capital, and this is evidence by the participation of communities of farming in the forest through PELIS system which is supported by the PFM through the Forest Act (2005).

The livestock sector is labour intensive, and the practice of grazing and grass harvesting has a direct influence on milk production which is currently being driven by availability of an attractive market in the region. A study by Nawrotzki et al. (2012) outlined the role played by human capital in rural livelihoods and argued that to understand the sustainable livelihood framework, there must be insights on how best to apply human capital to determine livelihood potential. The study noted that livelihoods are composed of capabilities and human capital can play a role to enhance sustainable livelihood. Nawrotzki et al. (2012) also framed human capital to be composed of the skills and knowledge to undertake various livelihood strategies. In the context of grass harvesting and livestock grazing study, there is the concept

of human intervention which includes taking animals to graze in the forest and harvesting grass and transporting it to the farms.

Social capital enhances the potential to form community forest associations and user groups to facilitate access to forest resources. Most of the interventions in Mt Kenya especially on the implementation of PFM have been supported by corporate organizations and donors to conserve the threatened ecosystem. Nawrotzki et al. (2012) definedfinancial capital as the direct resources available to individuals and households. The financial capital indicates the potential of the farmer to procure fodder from non-farm sources.

1.3 Statement of the Problem

According to the United Nations Food and Agriculture Organization (FAO, 2015), the world loses 18 million acres through destruction of forest cover each year. Between 1990 and 2012, Kenya lost 6.5 per cent of her forest cover which poses the country with a major environmental challenge according to the Global Forest Resources Assessment Report (2015). Forest ecosystems are very fragile habitats (Zhu, 2015; Chaudhary et al., 2017). These ecosystems are faced with numerous environmental threats including excessive use of non-timber forest products (NTFPs) by forest-adjacent communities according to Shackleton et al. (2018). Despite the environmental threats, government policies, particularly here in Kenya, continue to support local community access of NTFPs including harvesting grass for cattle as well as grazing in the protected forest. These activities, though well-intended, increase the severity of environmental threats to the forest ecosystem. These practices have the potential to exacerbate forest degradation by removing the undergrowth and encouraging soil erosion, biodiversity losses and impaired infiltration rates (Harden, 2001). Degradation of forests not only threatens to trigger far-reaching implications on the national and regional economies but also predisposes communities living adjacent to such forests to various vulnerabilities, including unsustainable livelihoods.

Previous studies in other countries have focused on the drivers of other forms of forest dependence, for instance, dependence on protected mountain forest for bush meat, medicinal plants, forest nuts among others (Schaafsma et al., 2014). However, there is limited focus on the drivers of dependence on forests in the Eastern African region for pasture and fodder. In addition, very few studies have been conducted to evaluate the household socio-economic factors that favour forest conservation along with influencing the livelihoods of forest-

dependent communities. Moreover, there are contradictions from previous researchon the significance of different variables, for example, land use, household size, proximity to the forest, number of cattle a household owns and socio-economic status. There are noted diverse drivers of forest dependence whichhighlights limitations on the generalizability of factors to the various forms of forest dependence in different social-ecological and institutional contexts.

Furthermore, there are contradictions in terms of the drivers of cattle grazing. For example, cattle numbers were noted as insignificant in the research done by Lepetu et al. (2009) in Kasane Forest Reserve in Botswana. The impacts of cattle grazing and factors that drive the forest dependence were one of the gaps sought to be addressed by this study. According to Nyongesa & Vacik (2019), during the last ten years, the Mount Kenya forest zone has become increasingly threatened by wide-spread degradation due to prolonged droughts associated with climate change which has implications on forest cover and forest sustainability. Government policies allow communities living adjacent to protected forests access to and utilization of a variety of non-timber forest resources and this approach has continued to attract conflicts between environmental conservation agencies and communities, with the former being concerned that allowing extractive practices such as livestock grazing and grass harvesting further exacerbates forest vulnerability to degradation. However, significant socio-economic drivers of livestock grazing and grass harvesting practices in the region are poorly researched based on literature review.

There are conflicting interests from other stakeholders besides the community and this serves as a real challenge to maintain the community sustainable forest dependence, a concept supported by Lepetu et al. (2009). Thus, this research aims to fill the gap discussed in the foregoing section by relating and predicting socio-economic drivers of dependence onthe Mt Kenya forest. Socio-economic factors which formed the core focus of this study were household size, household socio-economic status, proximity to the forest, number of cattle owned, investment in zero-grazing, proportion of land under fodder production and proportion of cattle kept under zero-grazing. These factors were not well researched by previous scholars, and this is what the researcher sought to clarify through this study. The research sought to analyse the relationship between smallholder farmer household characteristics and forest dependence for pasture, examined seasonality patterns on forest

dependence for pasture and focused on perceptions of the smallholder farmers towards a ban to access the protected forest.

1.4 Purpose of the Research

The purpose of the research was to analyse the socio-economic factors influencing smallholder farmers' dependence on protected forests for pasture and grass harvesting in West Mt Kenya region. This study provides insightful and evidence-based recommendations on forest management dilemmas in the contemporary Kenyan society that would protect both forest ecosystem and livelihood in line with the UN Sustainable Development Goals (SDGs 15), in which the world leaders affirmed their determination to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations. The study is relevant because rural development agencies in government and private sector will benefit from data generated, research findings and recommendations towards design of evidence-based advocacy and pro-poor policies that promote sustainability of rural livelihoods particularly measures that mitigate over-reliance on forest dependent livelihoods. Research findings will further advance knowledge and theoretical perspectives on Africa's Forestecosystems research and development, particularly the contextual factors and dynamics of NTFPs forest dependence in the region.

1.4.1 Specific research objectives

1) To assess the significance of household characteristics in driving smallholder farmers dependence on protected forest for pasture in West Mount Kenya
2) To assess the significance of household characteristics in driving smallholder farmers dependence on protected forests for grass harvesting for livestock fodder in West Mount Kenya.
3) To analyse seasonality patterns of smallholder dependence on protected forest for livestock grazing in West Mt Kenya.
4) To examine the perceptions of the smallholder farmers towards the use of a ban by KFS to regulate access to protected forest for pasture in the West Mount Kenya.

1.4.2 Research Hypotheses

Hypotheses tested inthisstudy were:

1) Household socio-economic status (SES) is positively associated with smallholder farmers dependence on protected forest for pasture.
2) After controlling for household SES, there is no statistically significant relationship between smallholder farmer's household characteristics (proximity, size of land, ownership of zero-grazing units) and dependence on protected forest for pasture.
3) Household socio-economic status (SES) is positively associated with smallholder farmers dependence on protected forest for grass for cattle.
4) After controlling for SES, there is no statistically significant relationship between smallholder farmer's household characteristics (proximity, size of land, ownership of zero-grazing unit) and dependence on protected forest for grass harvesting for cattle.
5) There are no statistically significant seasonality patterns on forest dependence for pasture in the region.

1.4.3 Research question

What are the perceptions of the smallholder farmers towards the use of a ban by KFS to manage grazing activities in the protected forests?

1.5 Justification of the study

Many studies have been conducted on socio-economic drivers that influence community participation in forest conservation. There have also been several studies that have demonstrated the role of forest resources in strengthening the economic conditions of forest-dependent communities globally (Shackleton et al., 2008, Asfaw et al., 2013, Adam & Tayeb, 2014). The research conducted by Sarmah et al., (2011) noted that forests have a significant influence on the socio-economic and cultural life of forest-adjacent communities in terms of meeting their subsistence needs. This research focused on the Mt Kenya Ecosystem since it is one of the five main water towers that is listed by the United Nations Education, Scientific and Cultural Organization (UNESCO) as a World Heritage in 1997 and it is also the largest ecosystem carbon sink compared to Cherangani hills, Mt Elgon, Mau Forest and the Aberdares (Ongugo et al., 2014). The forest blocks were identified for the study because they were among the first to develop community-based joint forest management plans. The

selection was also based on their variance on forest characteristics and unique seasonality patterns in cattle grazing and grass harvesting. In Mt Kenya West region, forest blocks characteristics vary depending on how individual communities live and accrue benefits from the forest. Besides, the three forest blocks had proper records on user rights utilization including documentation of user rights groups which provided great support to the research.

KFS and other government agencies will benefit from data generated to inform better design of evidence-based policies that can improve forest management practice, particularly the management of cattle grazing and grass harvesting in protected forest zones. There are many community enterprise and poverty alleviation programmes in Kenya aimed at addressing the forest dependence problem in forest ecosystems. In Kenya, the concept of joint forest management has faced many challenges in an effort to balance conservation efforts and livelihood gains and these are some of the interventions addressed by the findings of this study. Similar programmes in sub-SaharaAfrica in form of integrated conservation and development programmes aimed at addressing poverty to reduce biodiversity loss have not been successful. As Kenya strives to achievesustainable development goals agenda particularly on environmental conservation, policy makers may find themselves in a delicate situation as they try to strike a balance between environmental conservation and protecting of community livelihoods. There is, therefore, a gap between policy proposals and the actual socio-economic drivers of consumption of forest resources which must be understood and acted upon, Thus, this study was motivated by the need to bridge the existing disconnect.

Despite the fragility of the forest ecosystem, cattle grazing by forest-adjacent communities is permitted as supported by the participatory joint forest management concept that allows user groups to access NTFPs. In 2016, KFS started promoting cut and carry the concept to the community forest associations where farmers were allowed to cut grass to support zero-grazing units in the households. This study is relevant since government bans on grass harvesting and cattle grazing still remain a characteristic strategy to mitigate degradation of forest ecosystems. Rural development agencies will therefore benefit from data generated in thedesign of evidence-based advocacy and pro-poor policies that promote sustainability of rural livelihoods particularly measures that mitigate over-reliance of forests to support livelihoods. This research presents an important pioneer step in taking a holistic view of the forest-adjacent communities and their dependence on forest resources. This will be helpful in

ensuring sustainable forest management and conservation in forest ecosystems in future. Thefindings will further advance knowledge and theoretical perspectives on Africa's forest research and development particularly with respect to contextual factors and dynamics of forest dependence in the region.

1.6 Scope of the research

The geographical scope of this research was limited to the Mount Kenya West protected ecosystem. The research focused on smallholder farmers who were involved in cattle grazing and grass harvesting in the Mt Kenya protected forest hence there was limited information on the perceptions of professionals and other stakeholders towards forest restrictions through a ban. The study site was composed of the three protected forest blocks namely, Hombe (part of the expansive Mt Kenya Forest Reserve located in Mathira West Sub-County), Chehe (in Mathira East Sub-County, Nyeri County and is situated about 16 Km from Karatina Town. It borders Ragati Forest Station to the West and Kangaita Forest Station in Kirinyaga County to the East) and Kahurura (in Kieni East Sub-County). All the three forest blocks are protected under the Kenya Forest Act (2016) and are managed by the Kenya Forest Service (KFS). The threeforest blocks were identified due to their unique characteristics and the diverse geographic location. Monthly records of cattle grazing for each forest were obtained from the Kenya Forest Service from the year 2013 to 2018.

1.7 Limitations of the research

Limitations of the research included limited data for the analysis ofseasonality of forest dependence for pasture. Available records only covered a 6-year span, that is, 2013-2018. This period might not necessarily reflect the long-term effects and dynamic of climate variability and influence on forest dependence. A longer period would be necessary to assess seasonality patterns of cattle grazing versus the effects of climatic variability overtime to provide more detailed perspectives. Nevertheless, a six-year period analysed here still offers insights into seasonality patterns of smallholder dependence of protected forest for cattle grazing. In addition, rainfall data was not available for two forest blocks, that is, Kahurura, and Hombe, hence it is necessary for future studies to explore how this correlates with patterns of forest dependence for pasture.

1.8 Assumptions of the research

The assumptions of this research included the fact that communities living adjacent to protected forests have access to the forest for a variety of legally authorized forms of NTFPs. Given the affordability offees charged by KFS to access forest for cattle grazing and grass harvesting, the research assumedthat farmers were to be motivated by some socio-economic pressures to pay in order to access the forest. The research assumed that there are cattle farmers who graze throughout the year or part of the year, and farmers who harvest grass part of the year or throughout the year. The assumption was that this category of the farmers would give diverse views on perceptions, challenges and opportunities related to forest dependence. The research assumed that the respondents in the household survey understood the socio-economic factors underlying the practice of cattle grazing and grass harvesting. The researcher assumed that the three forest blocks had active cattle grazing and grass harvesting user groups registered under the Community Forest Associations and were likely to share accurate information voluntarily.

1.9Definition of key terms and concepts

The section presents the key terms and concepts used in the thesis. The definitions are based on the study context to give better and broader understanding of the entire thesis.

Community Forest Association: In the study context, it is a group of persons who are registered under the Societies Act (Cap 108) and who are resident in an area close to the specified forest. Each forest block can register only one CFA to allow membersto participate in the management of the forest for livelihoods and conservation efforts. Forest ecosystems in Kenya region have the highest number of CFAs.

Ecosystem services: In this context, it refers to the many and varied benefits to humans provided by the natural environment, for example, the role played by forest ecosystems that include provisioning, supporting, regulating and cultural activities. This concept is also supported by Millennium Ecosystem Assessment (MEA, 2005) that also links ecosystem services and human wellbeing.

Forest ban: This refers to stringent environmental policies invoked by a government forest management agency such as KFS when it perceives that resource overutilization poses

serious ecological consequences such as species depletion and extinction. The current moratorium on firewood implemented in 2017 can be perceived as a ban on firewood collection.

Forest dependence: In the context of this study, it refers to the income or gains derived from the forest**.** This includes all forms of NTFPs which are forest products obtained from the forest other than timber such as nuts, herbs, fruits, spices. In the study context the NTFPs forest dependence is based on forest pasture obtained through cattle grazing and grass harvesting.

Forest user groups: It refers to a group of individuals, formal or informal, who collect, harvest, or utilizes any part of or products from a forest for subsistence or commercial purposes. In the context of this study, grass harvesters and cattle grazers are categorized as forest user groups and operate under the umbrella of the Community Forest Associations.

Household Assets: In this research, it refers to productive assets (ownership of zero-grazing unit, milk cans, chaff cutter, hay baler among others). These assets can be considered as constituting the physical capital of the household.

Household size: It refers to the number of persons living in a household. In this study context, the average household size of smallholder farmers living in the neighbourhood of Mt Kenya West protected forest was an average of 4 persons.

Household: It refers to a family or group of people who may not share blood relations but have the same housekeeping arrangements or dwelling under the same roof. Therefore, in the study context, it did not include family members who were away or work in other places.

Participatory Forest Management Agreement: It refers to an agreement between the Kenya Forest Service and a Community Forest Association. The document is signed in the presence of a community lawyer and a KFS lawyer to be implemented for a period of five years and must be renewed once the term expires.

Participatory Forest Management Plan: This is a framework that shows the kind of organizational set up for carrying out a sustainable management of a forest ecosystem. It is usually a five-year plan and after the expiry of the term, the document must be revised.

Participatory Forest Management: In the study context, it is an approach which

deliberately involves the forest-adjacent communities and other stakeholders in the management of forests within a framework that contributes to community livelihoods.

Protected forest: In this context, it refers to a forest with some amount of legal and constitutional protection where the government has property rights. Main purpose is to reduce further forest depletion

Proximity to the forest: It refers to the time one takes from the household to reach the forest boundary. In this study, time to the forest boundary was estimated in minutes for grass harvesters and cattle grazers.

Seasonality patterns in forest dependence: In this research context, it refers to the monthly trends derived from the analysis of long-term secondary data collected and documented by KFS on the number of cattle grazed in the protected forest.

Smallholder farmers: It refers to rural farmers who rely on a mix of small-farm crop farming and also keep livestock on small scale and excludes commercial large-scale farmers.

Socio-economic characteristics: This is the construct describing interactions of social factors such as attitudes, education attainment and economic factors such as income, and that have the potential to influence household choices and quality of life.

Wealth index: In this study, refers to the measure of the living standards or as an indicator of the socio-economic status (SES) of a household. It was calculated using total size of land, ownership of zero-grazing, total income, total expenditure, household assets such as cattle sheds, hay balers etc.

1.10 Structure of the thesis

The thesis is organised into five chapters. Chapter one presents a general introduction and background of the study and has outlined the statement of the problem, research objectives, study justifications and operational definition of key terms and concepts used in the study. Chapter two provides a comprehensive literature review focusing on theoretical and empirical review. Chapter two highlightsthe knowledge gaps and the conceptual framework used in the study. Chapter three presents the research methodology underlining the philosophical foundation, research design and overview of the study area. The chapteralsopresents the target population, sampling procedure, data collection methods, data analysis and the ethical

issues that guided the research. Chapter four presentsthefindings and their interpretation and discussion, specifically, demographic information of the respondents as well as results and discussions of those results according to the respective objective of the study. Chapter five presents discussions, conclusions and policy recommendations on smallholder farmers' household socio-economic characteristic and forest dependence for pasture and for grass. The last section on chapter five provides the discussions, conclusions and policy recommendations on patterns and seasonality variations and the perceptions and coping strategies of smallholder farmers towards a ban to regulate access to protected forest in Mt Kenya west.

1.11 Chapter Summary

This chapter focused on the context of the research in forest ecosystems and the global relevance ofecosystem conservation and livelihood improvement. Reference was made to global, regional and local literatureon latest forest management concepts that embrace community participation in the extraction of non-timber forest products. The chapter outlined the influence of the drivers of change in ecosystems and biodiversity as reported in the Millennium Ecosystem Assessment (MEA, 2005) report. The chapter elaborated the statement of the problem focusing on global evidence on forest destruction and the need for respective governments to increase forest cover. The chapter also outlined the overall objective which focused on the assessment of the socio-economic drivers that influence cattle grazing and grass harvesting practices in Kahurura, Hombe and Chehe forest in a protected forest in Mt. Kenya. The purpose of the study has also been discussed. The chapter focused on the study area, which is the Mt Kenya west ecosystem, noting that it is currently one of the five main water towers in Kenya with an area of 213,082 Ha and that it is also listed by UNESCO as a World Heritage site (1997). The chapter also noted that worldwide the demand for forest products has increased over the years threatening the forest ecosystem. The chapter ends with a discussion on thelimitations of the study, the scope, and assumptions of the study as well as definition of terms used.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter Introduction

This chapter discussesthe theoretical framework informing the research and anempirical review of previous literature on forest dependence. The theoretical review is organized into three sections focusing on what the theories posit, the components of the theories relevant to this research and how the theories complement each other. The empirical review section is organized into three sections as well, namely, previous research on factors influencing household dependence on protected forest, seasonality patterns in livestock grazing in the protected forest and empirical review on community perceptions towards restriction of communities from protected forest zones. The final sections of the chapter include the summary of gaps in knowledge identified from the empirical literature review and also the conceptual framework used in the research.

2.2 Theoretical review

2.2.1 The common pool resources theory

The main proponents of the theory are Hardin (1968) and Ostrom (2008) who positsthat communities come together through legal institutions such as community forest associations to access forest products. The common pool resources (CPR) theory seeks to avert the destructive effects of 'the tragedy of the commons concept' where individuals act independently according to their own self-interest, behave contrary to the common good of all users and end up depleting or spoiling the shared resource through their collective action. In other words, communities may focus only on extracting the resources maximally without sustainability concerns (Saunders, 2014), and due to lack of regulation, the approach is likely to cause environmental degradation resulting in adverse effects on livelihood outcomes.

The main components of the common pool resource theory that are relevant to this research put emphasis on the shared resources, which are scarce and in finite supply. The reference is to the destructive human behaviour where everybody acts towards his or her own benefits and over-consumes the resource, depleting it for all. In this research context, the common resource is the forest owned by the government and which, when exploited unsustainably,

affects the larger population including those living downstream and far from the forest ecosystem. Thus, the common pool resources theory is about the conditions under which open access management of common-pool resources can be managed through collective action.

The concept of joint forest management allows communities to access the forest through user groups without any clear exit strategy when an individual has met livelihood objectives over time. Subject to individualistic motivations, such a provision is likely to lead to consequences such as the destruction or degradation of forest resources through overexploitation. However, to avert this, governments can intervene through restrictions or bans on access to the respective forest zones where concerns of overexploitation are eminent.

Critics of CPR such as Choe and Yun (2017) contend that re-conceptualization of the theory should be done in the context of excludability and rivalry as social attributes, rather than as physical attributes. In particular, the question of excludability is more legitimate than excludability itself in the quest for sustainability. One may find this explanation surprising since policy directives by the government are conventionally deemed legitimate. Further, Saunders (2014, p.647) argues that the individual 'rational resource user', encapsulated in the CPR design principles, struggles to provide clear direction for meaningful consideration of local norms, values, and interests in commons projects. The focus of CPR theory on efficiency and functionality results in a tendency in commons projects to overlook how local conditions are forged through relations at multiple scales. Commonly politically complex and changing relations are reduced to institutional design problems based on deriving the incentives and disincentives of 'rational resource users.'

However, in the context of Mt. Kenya West protected forest, unsustainability of some policy directives such as those that ban forest access have substantial weaknesses when it comes to public participation during their formulation stage. In the rapidly changing societal needs and demands, CPR must be continually studied to reposition government policy and strengthen sustainable use of mountain forest ecosystem. While numerous studies have been conducted to achieve this goal by exploring possibilities of alternative source of energy to ease pressure on demand for timber, this study focuses on non-timber forest products (NTFP). Exploitation of NTFP is, in fact, among the core focal point of CPR because it brings into focus the widespread appeal of both state and community-based resource control. An empirical

understanding of drivers ofthese forest dependencies in the context of theoretical underpinnings of CPR will lead to the development of more responsive policy formulation and implementation in the forestry sector.

2.2.2 Access theory

Access theory posits that creating sustainable forestry requires shared benefits of the forest with the local communities where local communities directly participate. Access is the ability to derive benefits from things using all possible means (Neale 1998; Das, 2019). The components of the theory of access include the availability of the resource, ability to access it and affordability characteristics. For example, the Forest Act (2005) supports access to natural resources as far as one can afford to pay for them. According to Neimark (2010), access theory discusses what happens to people or institutions when new regulations governing natural resources are put in place. Some of the participation required by the local community includes accessing NTFPs such as forest grass, firewood and livestock grazing. From this perspective, policies and other regulatory frameworks need to be formulated to guide forest utilization by the local community (Nawrotzki et al., 2012). Given the high forest dependence by the local communities around them, it has been found in many areas across the globe that forest dependent communities give too much pressure to natural resources which is destructive to ecosystems. From this perspective, policies need to be put in place to safeguard forests' existence.

The ability to benefit from the forest has changed because of the implementation of PFMP giventhat the CFA's play a role in joint forest management and access to benefits from forest resources. Therefore, access and utilization of forest resources bestows a sense of empowerment on the society since products obtained play a crucial role in the sustenance of livelihoods (Lachapelle et al., 2004). The value of the theory of access to thisstudy is that it supports the Forest Act (2016) and the concept of Participatory Forest Management (PFM) that allows legal access to NTFPs legally through the registered CFA provided they pay for the services.

Critics of access theory such as Tuo & Li (2018) argue that the theory has been largely used by practitioners and theorists to influence policy without taking cognizance of participant perspective. For this reason, value-free, objective solutions to policy problems do not exist. In response to this dilemma and need, this study contains a significant objective area on user

perception which is aimed at providing sharper insights into participant-preferred forest management directions. To this extent, access theory from participant perspective will contribute to better policy problem identification and definition, estimation and specification of policy options and selection, implementation and evaluation of policies to compliment the posits of the CPR described in the previous section.

2.2.3 Theory of livelihood transformation

The theory posits that livelihood interventions must be based on the appreciation of what underpins livelihoods according to the Department for International Development (DFID, 2000) and Nawrotzki et al. (2012). The theory of livelihood transformation is about drawing on capabilities and assets to develop livelihood strategies (Chamshama et al., 2014). The argument is that as far as natural resources are available, the strategy to access them will always be there hence behaviour is likely to contribute to ecosystem degradation. The theory supports the link between the vulnerability context and accumulation of assets using natural capital. The main components of the livelihood transformation theory include the community's capabilities, availability of natural resources and the actions required to access the resources.

Forests are a source of NTFPs and constitute an integral component of household economic activities (Chamshama et al., 2014). As Chamshama et al. noted, households derive their livelihoods by drawing from capabilities and assets to develop livelihood strategies composed of a range of activities required for a sustainable means of living, whether in the short or long term. Livelihood transformation theory recognizes the role of stakeholders and the processes and connections among them. Livelihood transformation results in more income, better health care, and more access to quality education, reduced vulnerability to shocks, improved food security and more sustainable use of natural resource base. One of the limitations of this theory is the fact that efforts to benefit more from NTFPs can lead to overexploitation of resources, triggering a spiral of forest degradation and rural poverty cycle.

Pant et al. (2015) are identified as one of the main critics' livelihood transformation theory in contemporary literature. These scholars argue that the livelihood transformation theory positsattributes of socio-ecological and socio-technical systems. However, none of these attributes sufficiently informs transformations to sustainability in developing countries. In response to this, the current study introduced a new paradigm to examining sustainable

livelihood in the face of CPR and access theory, the focus of household socio-economic analysis. This is a more responsive assessment for forest-adjacent communities in developing countries in sub-Saharan Africa such as Kenya.

2.3 Empirical review

2.3.1 The influence of household size, gender, level of education, age, and socio-economic status, on forest dependence

Duguma et al. (2019) research in Ethiopia and theMau Forest in Kenya noted socio-demographic factors including rising demand for forest products due to increasing population as a driver of forest dependence. The most significant drivers of this dependence were classified as market demand and governance issues. However, the study failed to look at the socio-economic drivers that are likely to have influenced deforestation and forest degradation in the two forest blocks. Research by Ouko et al. (2018) investigated community perceptions of ecosystem services and the management of the Mt Marsabit forest in Kenya, a protected area in northern Kenya covering 1100 hectares. Forests in Kenya cover 37.6 million ha of which 940,423 ha are protected areas. According to the research by Ouko et al. (2018), family size, education level and age were noted as important predictors of the level of involvement in forest management. The insignificant drivers were existence of local institutions and land use. One of the criticisms of the study is that the authors focused more on socio-demographic and ignored socio-economic predictors of forest dependence factors in Marsabit forest.

The research by Mishra & Mishra (2012) done in Eastern Himalayas in India focused on deforestation and women's work burden in a region with forest cover at 22%. The focus was on gender division of labour in the collection of forest products. The significant variables were distance to the forest, occupation of the respondent and the dependence on animal husbandry. On the other hand, education level of the female member and the tribe were statistically insignificant. The critique of the research is that the authors failed to factor in some relevant drivers such as the household size and income levels. The findings suggested that although deforestation increases women's work in forest related collection and gathering activities, the net impacts are also mediated through processes of commercialization of the subsistence economy. The research concluded that the quality of village forest is a strong factor in reducing women's total work burden hence gender was a significant driver. A study by Enbakom et al. (2016) in Woreda Southern Ethiopia focused on the impact of deforestation on

the livelihood of smallholder farmers. The research focused on sources of income, farmer's access to forest utilization and ownership and major causes of forest degradation. The study noted socio-demographic variables, mainly age of the respondents and household size as significant drivers ofdeforestation However, the research did not focus on the household socio-economic drivers that influence women work burden.

Olarewaju et al. (2017) work in the government reserves of Ogun State, Nigeria focused on forest degradation and livelihood in a region with a forest cover of 9.9 %. Millions of households in Nigeria depend on forests because ofits products and benefits which they also harvest, process and trade. The key factors noted to drive forest dependence were gender of household head, number of household members working, number of children and youth in the household. The insignificant drivers were income, livestock numbers and age. However, the work failed to hypothesis other relevant variables such as education level and household socio-economic status which may have played a role in forest degradation. Olarewaju et al. (2017) research indicated that there is disparity in the livelihood returns across the non-degraded and degraded forests. The research concluded that gender, number of household members working and earning an income, number of children in the household, earning income from trees and earning from hunting were statistically significant factors influencing forest dependence.

Jannat et al. (2018) work in Bangladesh investigated people's dependence on forest resources and contributions of forests to the livelihoods in a country with low forest cover of 15.7%. The study revealed that people's income from forest and forest-related occupation was positively correlatedwith their forest dependence. According to Jannat et al. (2018), education level significantly reduced their dependence on forest resources. The insignificant drivers were family size, occupation, and age. One of the critiques of these findings is that respondent's education level failed to consider gender and marital status which are relevant socio-demographic factors of forest dependence because both males and females can be dependent on the forest at different levels. Lepetu et al. (2009) researched on forest dependence and its implication for protected areas management in Kasane Forest Reserve, Botswana. The country faces severe forest degradation, and the current forest cover stands at 20% with significant deforestation that leads to a loss of 0.86% per year. Lepetu et al. (2009) work noted that forest dependence was positively and significantly associated with family size; however, rich households were less dependent on forest resources. The insignificant variables were gender, age, education, and residency. The major critique on the findings is that the authors focused

mainly on socio-demographic characteristics and failed to consider socio-economic factors that influence forest dependence such as occupation, alternative income sources, and proximity to the forest and land size which could have been possible predictors to guide in the conservation of Kasane Forest Reserve.

Tripti et al. (2015) investigated the livelihood dependence of rural people utilizing non-timber forest products in Bengal, India, a region with national forest cover at 21.6 %. The researchers noted that NTFPs are an integral part of development and survival of people living in and around forests and depending on them and their potential is often underestimated or unknown. The main determinants of forest dependence were lack of awareness, limited scientific knowledge, inadequate market information and low income through species commercialization influenced forest dependence. The research noted that NTFPs are important tools for addressing poverty issues for the marginalized forest dependent communities, and concluded that food security, income obtained from forest and household wealth were significant drivers of forest dependence. Market information and limited scientific knowledge did not feature as significant factors. The main critique of the research is that there was no focus on socio-demographic characteristics such as age, gender, education level which could have played a role in predicting forest dependence.

Kumar (2015) work was done in Gujarat, India. It analysed the impact of NTFPs on food and livelihood security, a country with forest estimated at 21.6%. The author focused on the contributions of NTFPs to income and employment by ensuring food and livelihood security for the tribal economy. Kumar (2015) work concluded that alternative sources of income to the rural communities are significant drivers of forest dependence since they help in the improvement of their socio-economic conditions and help to increase income level and employment opportunities. The insignificant drivers noted were land holdings and ownership of livestock. The research, however, failed to analyse socio-demographic characteristics such as age, gender, education levels which could have been relevant predictors based on the context of the study.

Research by Adam & Tayeb (2014) investigated forest dependency and its effect on conservation in Gadarif, Sudan, protected forest which has a national forest cover of 29.4 %. The research context of development was on forest dependence and households' attitudes towards forest conservation. The studynoted that agricultural income, age of the household

members, access to outside market and household size were major determinants of forest dependence. The insignificant predictors were residency, distance to the nearest market and land area. One of the main critiques of the study findings is that the computation of household income and assets did not consider wealth levelsto determine the role of poverty in predicting forest dependence.

The work by Jain & Sajjad (2016) in Sariska Tiger Reserve in Bangladesh which has a forest cover of 15.7 % investigated forest dependence and conservation attitude of indigenous communities. In terms of development, the authors investigated the forms of dependence that included food products, household building materials and medicinal plants. The study noted that livestock population and the agricultural land per household as the two major determinants of forest dependence. The insignificant drivers were age, size of household's landholdings, education level and market access. Main critique of the findings is that some important socio-demographic characteristics such as gender could have been significant factors. Other socio-economic factors such as proximity to the Tiger Reserve and household income levels should have been documented as potential predictors of forest dependence.

Chakma et al. (2020) work investigated forest dependence and conservation attitude of indigenous communities of Chittagong Hills in Bangladesh. It concluded that forest dependence exists in all socio-economic groups, but the poor are highly dependent hence lack of alternative income by the poor was a significant driver. Gender, education status and family size were not significant predictors. One of the shortcomings of the findings is that age of the respondents was not factored as a predictor considering the correlation between young people and forest degradation. In Rwanda, Munanura (2014) and other scholars investigated household poverty dimensions influencing forest dependence at Volcanoes National Park. Rwanda has about 29.8 % forest cover. The study focused on bush meat and medicinal plants. Using the sustainable livelihoods framework, the scholars examined the influence of household's poverty on forest dependence and the significant drivers were food insecurity and health security risks. The insignificant factors were economic and educational insecurity. Main critiques of the research are that the analysis by the authors did not control for household size and socio-economic status and left out socio-demographic characteristics which are likely predictors of forest dependence.

2.3.2 The influence of household size of land and smallholder agricultural practices and forest dependence

Pouliot et al. (2012) conducted research in Burkina Faso and Ghana which has aforest cover at 20.6 % and 40 % respectively, and the focus was on deforestation and the limited contribution of forests to rural livelihoods. Their research confirmed that agricultural land size and the non-forest environmental activities as significant drivers of deforestation. The predictors that were noted to be insignificant were income earned from the forest and non-farm income share. The research, however, failed to factor in socio-demographic predictors of forest dependency and focused only on socio-economic factors hence limiting the outcome in terms of the role of age, gender and household size in contributing to rural livelihoods.

Chakraborty et al. (2018) did work in the central Himalayan region which has an estimated national forest cover of 15.7%. The study explored the nexus between forest and local communities through participatory assessments and household surveys. The significant variables were major source of income, age group of the respondents, household size, total land holdings, the number of livestock and usage of alternative fuels. Insignificant variables were gender and household education status. One of the critiques of the finding is that the independent variable total land holding focused on the entire land and not the actual land set aside by the household for land use to determine forest dependency.

Nelson et al. (2015) work in Malaysia, a county with an average forest cover of 62.3%, examined community's forest dependence and its effects towards forest resources and wildlife with the aim of identifying types of community's forest dependencies. According to thisresearch, the significant drivers were land use, distance or proximity to the forest resources and hunting of wildlife. Insignificant drivers were private land ownership, agricultural activities and income earned. One of the critiques of the findings is that although the authors discussed the socio-demographic profile of the respondents, they did not use them in the prediction of the variables of forest dependence.

Adhikari et al. (2004) work in Nepal, a country with 37.4 % forest cover noted the significant drivers of forest dependence as land and livestock holdings, caste, education of family members and household economic status. One of the critiques of this research is that socio-demographic factors were not factored as potential predictors of forest dependence. Research

by Widiyanto (2019) in Java, Indonesia, a country with a forest cover of 52.1% investigated factors influencing farmer's decision in community-based forest management and the research confirmed the significant drivers as geographical conditions, land use, farmers skills in crop selection and availability of alternative occupations. Market prices were noted as an insignificant driver influencing forest dependency. The maincritique of these findings is that age and education level were not factored as potential predictors even though data on the same was collected from the respondents.

Work done by Mutune et al. (2015) investigated the local participation in community forest association in Eburu forest, Kenya, a region with highforest deforestation. Significant drivers in the study were gender, group membership, ownership of tree nursery, wealth status, percentage share of wage income and farm size allocated for tree nursery. Insignificant drivers in the study were age, education, household size and proportion owned by household heads. One of the limitations of the study by Mutune et al. (2015) was that the focus was on only two forest blocks considering the region hasnine blocks hencethis approach could have reduced variability and inferences.

2.3.3 The influence of a household number of cattle and land holding on forest dependence

Buffum et al. (2009) investigated forest grazing and natural regeneration in a community forest in Bhutan, South Asia, a country with one of the highest forests covers at 83.9%. This research confirmed that the number of cattle grazing inside the community forest was significant driver that impacted negatively on ecosystem degradation. The insignificant drivers noted were location of grazing and livestock holdings. Main critique of these findings is that the analysis failed to reveal the monthly or yearly seasonality patterns when there were peak and low seasons to help inform policy. Tucker (1986) work in Punjab Himalayas Mountains in Asia focused on the evolution of transhumant grazing which is a region with an average forest cover of 12.8 %. The region is characterised by seasonal movement of livestock in the mountain regions. The critique on the study is that the author failed to provide data on the impact of migratory herders indicating grazing seasonality patterns outlining the severe and less severe periods to help the Indian Forest Service to make informed forest grazing land regulations.

Shrestha et al. (2004) work examined soil erosion caused by cattle grazing in Nepal which was motivated by an increase in soil erosion caused by cattle steps and paths during grazing in hilly forests. The authors noted the massive soil loss from the forest to the valleys especially during rains, a process exacerbated by cattle grazing in the hilly forests. They concluded that cattle numbers and land use were significant drivers that contributed to soil and vegetation loss. The study however did not analyse other socio-economic factors that influence soil erosion in hilly mountain ecosystems. Belsky & Blumental (1997) investigated the effects of cattle grazing on the soils in the forest in Interior West forests in America, a country with average national forest cover at 36.2%. The research noted that livestock grazing, forest fires and logging were significant drivers that influence the changes in forest cover and tree species composition. However, vegetation type and seasons of use were noted as insignificant drivers. Belsky & Blumental (1997) research however failed to outline the actual number of herd sizes which could have played a role to determine the recommended herd carrying capacity in the region in an effect to reduce impact of livestock grazing on vegetation.

Silori and Mishra (2001) work was done in Mudumalai Wildlife Sanctuary, South India, and focused on livestock grazing pressure in and around elephant corridors. The habitat linkage is crucial for large ranging animals such as elephants which use these forest corridors for migration, and livestock grazing was noted as a major biotic interference in forest corridors. The study noted that livestock grazing was a significant driver that negatively influencedforest regeneration and also promoted proliferation of invasive weed species in the forest through livestock dung. Human population was an insignificant factor. The limitation of the study by Silori & Mishra (2001) was that the focus was on the number of residents conducting migratory livestock who were the grazers and not the actual number of livestock entering the forest corridors. The research, therefore, had a challenge to determine the appropriate livestock population to enhance long term conservation of elephant population. The work by Doggart et al. (2019) investigated main drivers of deforestation in Tanzania, a region with national forest cover at 55%. The global analysis indicates that 93% of tree cover loss experienced in Tanzania between 2010 and 2015 was associated with shifting cultivation. Doggart et al. (2019) work noted that livestock farming as an agricultural activity was a significant driver and the main insignificant drivers were charcoal burning and timber harvesting. The main critique of these findings is based on the fact that in the analysis of the

driver's category, livestock farming was operationalized as percentage of ground survey point and not number of livestock influx into the protected forest.

Research by Hosonumal et al. (2012) conducted an assessment of deforestation and forest degradation in 46 countries. The research noted that the deforestation drivers are similar in Africa and Asia, while degradation drivers were more in Latin America and Asia. The most significant drivers of forest dependence were timber extraction, fuel wood collection, charcoal production, uncontrolled fire and livestock grazing. The research noted insignificant drivers of forest degradation as mining, urban expansion and infrastructural development. One of the critiques of the study is that livestock grazing as a forest degradation driver was classified as both large and small scale with no actual numbers as operationalized by previous researchers to indicate grazing intensities. Ratovonamana et al. (2013) work was done in Madagascar, a country with average of 21.6% forest cover. The research investigated the impact of livestock grazing on forest structure, plant species and composition in Madagascar. The work noted that plant diversity decreased with livestock grazing pressure making it significant drivers in the landscape. The insignificant driver was species composition which has no effect on livestock grazing. The critique of the findings is based on the fact categories of grazing pressure was based on seasons, type of animal and consumption rate per unit livestock per day. There was no quantitative data to determine animal influx in the forest and seasonality patterns and trends over the years.

2.5.4 The influence of household proximity to protected forests on dependence of protected forests

Matiku et al. (2013) work in Arabuko-Sokoke Forest in Kenya analysed the impact of participatory forest management on local community livelihoods. The research noted that there is a strong positive correlation between forest-adjacent community's closeness to the forest and exploitation the natural resources and that fact that majority of communities living in forest proximity live in poverty (MEA, 2005; Shackleton, 2017). Other significant drivers in the research were education level and income, adoption of joint forest management concept and alternative sources of livelihood. However, forest ecosystem services were not predictorsinthe research. One of the critiques of this study is the conclusion that participatory forest management is a tool that can help Arabuko-Sokoke forest win the support of the adjacent communities. The tool though well intended has its challenges since it promotes

access to the forest by communities indefinitely with no exit strategies once conservation and livelihood objectives are met by forest-adjacent communities hence making forest management unsustainable.

A similar outcome was noted by the research by Piana and Masden (2014) research in Peru which has a national forest cover at 53.1%, and the region has the largest tract of forest remaining in that part of the country. Cattle density was identified as the most significant driver. The study further noted that distance from the forest as an insignificant driver and neither was there any significant correlation between cattle density and the average distance from the forest. The research, however, failed to capture cattle density in numbers asit was estimated using defecation and dung decay piles and there was no conversation on seasonality trends and patterns. The study by Hartter (2009) around Kibale National Park, Uganda which has a national forest cover estimated as 24%, investigated the attitudes of rural communities towards forest fragments. The significant drivers from the research were proximity to the forest, gender and wealth status. Majority of the respondents preferred to live closer to forest fragments and wetlands because of greater access to natural resources despite the challenge of human-wildlife related conflicts. The research failed to consider age in socio-demographic factorsgiven the influence of youth in human-wildlife conflict. Besides, the research was done only in Kibale National Park so there was no comparative analysis with other parks in the region to enhance variability and inferences in the findings. Miah et al. (2012) work examines the contribution of forests to the livelihoods of the Chakma tribe in Bangladesh Hill tracts, a country with low forest cover of 15.7% and a centre of biocultural diversity because of its richness in natural resources. The research noted that forest income, quantity of forest products harvested from the forest and household proximity to the natural resources were significant predictors of forest dependence. Access to alternative sources of income was an insignificant driver in the study. The research did not analyse socio-demographic predictors of forest dependence.

Forest ecosystems act like a safety net to prevent adjacent communities from sliding into poverty (FAO, 2016). Chakraborty et al. (2018) work explored the nexus between forest and local communities through participatory assessments and household surveys in the central Himalayan region. The research was motivated by limited knowledge in terms of variations in forest dependence among local communities in relation to the on-going changes in climate and forest in the Himalayan region. The authors observed that forest dependence was largely

subsistence oriented for meeting basic household requirements. Uberhuaga et al. (2011) work in Bolivia focused on forest income and forest dependency in a country with high forest cover of 52.7%. The research found determinants of absolute forest income to be household size, gender of household head and area of cultivated land. The significant determinants offorest dependence were level of education, whether household head was born in village and whether the household was food sufficient. Uberhuaga et al. (2011) noted significant drivers of forest dependence as level of education and socio-economic status of a household. The limitation of Uberhuaga et al. (2011) study was that despite having significant qualitative research that indicates forest are important as part of diversified livelihood strategies, there was limited quantitative evidence. Further, the authors observed that there are many studies on forest valuation and income related issues that do not report household level total absolute and relative forest income estimates. It was also reported that there were very few published studies that present results on total household income and distinguishing cash and subsistence income, thus necessitating their research. The authors reported that household size, gender of household head and area of cultivated land are significant determinants of forest income. The research noted that level of education, whether the household head was born in the village and whether household was food self sufficient were significant determinants for forest dependence. The research noted that the better off households were able to realise cash income from forest while the poorer households were more reliant on subsistence forest income. However, the study failed to operationalize the income levelsand establish how poverty levels influence forest dependence.

Jannat et al. (2018) work explored the socio-economic factors that favour forest conservation and affect people's dependence on forest resources and livelihood in Bangladesh. The research investigated the socio-economic factors that favour forest conservation and affect people's dependence on forest resources and livelihood which was motivated by a realization that very few studies were conducted to evaluate the socio-economic factors that favour forest conservation along with influencing the livelihoods of forest dependent communities. The research identified two major variables as the significant drivers of forest dependence which were income and forest related occupations. In the study, household size was an insignificant driver but the respondent's education level significantly reduced their dependence on forest resources (Jannat et al., 2018). The study noted that the attractive income obtained from the forest related activities contributed significantly to increase in

forest dependence. The study concluded that educating the forest-dependent people and supporting alternative livelihoods could be the best option for effective forest management and conservation. The authors suggested that further research should focus on how socio-environmental benefits from the forest influence the negative attitudes towards forest conservation.

Chakma et al. (2020) work focussed on forest dependence and conservation attitude of indigenous communities. The researchers provided an account of the socio-economic condition, forest resource extraction and community perceptions towards the conservation and management of the Village Common Forest (VCF). The work analysed annual incomes of the communities that included income from forest, wages, business and livestock farming. Chakma et al. (2020) study found that income level indicates to some extent the standard of livelihood and status of food security existing among the households. The research also indicated that socio-economic stratification has a strong association with the extent of different forest resources extraction from VCF. The results provide significant implications for forest and biodiversity conservation through socio-economic development of the local community, raising awareness about forest conservation and strengthening individual and institutional capacity. The research shows that forest dependence exists in all socio-economic groups but the poor people are highly dependent on forests and thus are vulnerable as availability and supply of forest resources may be impaired. Policymakers therefore should come up with interventions targeting the poor to reduce and mitigate forest dependence.

Lepetu et al. (2009) in Botswana focussed on forest dependence and its implication for protected areas management. Conservation of biodiversity in protected areas noted that conservation goals become a challenged to achieve if local communities are heavily dependent on them for various products and subsistence needs. Thus, the research estimated forest dependence and identified factors influencing dependence for households living around protected forest reserves. The study suggests that forest dependence is positively and significantly associated with family size. The study noted that there is a positive association between household size and forest income indicating that larger households tended to derive more income from the forest. However, as indicated by other researchers, asset-rich households were less dependent on forest resources. The research noted that there is a need to consider the economic alternative strategy for forest protection to create a win-win relationship between conservation and local rural development options.

2.3.4 Trends of Livestock Grazing in Protected Forests: Implications on forest ecosystems service provisioning

Belsky & Blumental (1997) investigated the effects of cattle grazing on the soils in the forest in America. The research was motivated by concerns raised by the public in relation to the continueddecline in forest health caused by forest fires, logging, and cattle grazing. The authors noted that cattle grazing contribute to the changes in forest cover and tree species composition. They further confirmed that cattle grazing alter ecosystem processes by disturbing and impacting soils, hence reducing water infiltration rates, and increasing soil erosion. The research noted that cattle grazing in most forest receive little attention although the practice plays a major role in altering the natural forest. Increase in cattle directly correlates with forest biomass decrease. Belsky & Blumental (1997) work argued that cattle grazing affects tree regeneration, suppresses tree growth, and increases tree vulnerability to insects and pathogens. The authors further emphasized concerns that cattle's grazing makes forest to be less resilient to natural disturbances such as fire and disease hence affecting future changes due to expanding population and global climate change.

Willcox & Giuliano (2011) research on cattle rancher and conservation agency personnel perceptions of wildlife management and assistance programmes in Alabama focused on the management of the threatened and endangered species on grazing allotments in Arizona. The authors were concerned about the increased destruction of the endangered tree species and the negative impacts on the ecosystem. The authors pointed that forest custodians and stakeholders must be educated on the forest sustainability parameters to reduce forest exploitation. Willcox & Giuliano (2011) research concluded that highlight that it is imperative to develop cattle grazing programmes that define the recommended cattle carrying capacity.

Buffum et al. (2009) investigated forest grazing and natural regeneration in a community forest in Bhutan and the research noted the challenges of combining forest grazing and timber harvesting. The research was motivated by the trend in which the number of cattle grazing inside the natural forest significantly decreased as the number of naturally regenerated tree seedlings increased. The authors hypothesized that decrease in natural regeneration in forest was influenced by the increase in the number of cattle in the forest. The research concluded that moderate intensities of forest grazing (0.4 cattle per ha) and timber harvesting (4.64 m^3per ha) can be combined without negative impacts on forest regeneration. The research

confirmed that the number of cattle grazing in the forest is a driver that impacts negatively on ecosystem degradation and there is need to enhance adoption of improved breeds to reduce animal forest entry levels. Buffum et al. (2009) concluded that forest grazing in protected forest can be sustainable if grazing intensity is regulated and controlled.

Tucker (1986) work focused on the impacts associated with allowing grazing activities in the Himalayas Mountains in Asia. The authors noted the impact of overgrazing and the dispute between forest custodians and the migratory grazers. This problem has been noted in the protected forests in Mt. Kenya region in the recent years. The researchers were concerned about the decline of forest and pasture resources associated with the cattle economy. The author noted that number of cattle over the years had risen creating pressure on the forest. The findings of the authors indicated that cattle grazing was responsible for a significant deterioration in quality of vegetation, destruction of plant species and poor tree regeneration. Tucker (1986) recommended that forest custodians should work with communities to manage forest through taking active responsibility.

Scherr & McNeely (2008) work in South Africa investigated the increasing vulnerability to resource overexploitation and the recent challenges of integrating biodiversity conservation and sustaining livelihoods especially for resource dependent rural communities. The authors noted that unsustainable exploitation of the species represents a grave threat to sustaining viable populations. Scherr & McNeely (2008) work highlights that where enforcement of species protection is low and local knowledge of formal nature protection is poor, then governments require to step up efforts to enhance species protection.

Afforestation and reduced deforestation have been touted as activities which can enhance carbon sequestration and storage, thereby gaining recognition as suitable means by which to mitigate the effects of climate change since they have the potential to sequester large amounts of carbon (Mugido & Shackleton, 2017; Chechina et al., 2018). Deforestation has an impact on community livelihoods and accounts for at least 11 per cent of global greenhouse emissions (Pearson, Brown, Murray & Sidman, 2017). Forest forms the basis for a variety of commercial industries which include timber andnon-timber forest products such as fruits, wild nuts, herbal medicine and wild fodder which are necessary for livelihood improvement of forest-adjacent communities and they play a significant role in livelihood transformation (Ameha et al., 2016). Kenya gazetted forest through the joint forest management plan allows the Community Forest

Associations to engage in farming within the forest as they implement conservation efforts which area significant economic activity. Forests are home to millions of people worldwide who depend on the forest entirely for survival.

Awono et al. (2010) used livelihood gain trends to understand the perceptions of change of quantity and income obtained from NTFPs in Cameroon. The authors focused on the socio-demographic and socio-economic activities among the communities living around these forests that drive harvesting of forest grass (Awono et al., 2010). Another research by Tripti et al. (2015) in India noted that NTFPs are important tools for addressing poverty issues for the marginalized, forest dependent communities by contributing to livelihoods, including food security, income, and health. Chelestino et al. (2016) conducted an economic valuation of NTFPs under the changing climate, focused on the appropriate measure to increase people's adaptive capacity against adverse effects of climate change and narrowed down to sustainable collection of NTFPs. The authors examined the factors influencing supply of NTFPs at household level and identified the NTFP in the ecosystem and their main uses. Ndeinoma & Wiersum (2017) work focused on the governance of indigenous natural products in Namibia. The authors noted that conservation of the ecosystem has long term benefits to the vulnerable communities. Gillet et al. (2016) reported existence of a strong link between the forest transition curve and the decline in the importance of NTFPs in village production and livelihoods. The work by Kumar (2015) has shown that alternative sources of income to the rural communities contribute significantly to the improvement of their socio-economic conditions and help to increase income level and employment opportunities.

Das (2012) investigated the impact of participatory forestry programmes on sustainable rural livelihoods in India. The author estimated that in a decade between two and five per cent of all rain forest species will become extinct, largely as a result of habitat loss caused by deforestation. This is what Munanura et al. (2014) described as the loss of biodiversity which has always been a constant nature of evolution, that in at least every century a given species of a mammal becomes extinct. Presently, the quest for farming in the forest through the PELIS system is a threat to the ecosystem if not regulated (Munanura, et al., 2014). The research noted that monoculture pastures are unfriendly to many species of birds and invertebrates that require diverse habitats. The studies by Das (2012) &Munanura et al. (2014) empirical evidence shows that loss of biodiversity is one natural capital that is drastically diminishing due to human activities in protected forest.

Loss of or diminishing forest land implies economic costs of forest resources foregone, biodiversity degradation and reduction of other forest-related public goods in addition to substantial economic distributional effects (Kamanga et al., 2009). The research pointed that forest do not only provide timber and fuel wood and other material resources, but also a wider set of public goods and services. Forest plays a role in water retention, soil erosion prevention, biodiversity conservation, carbon sequestration and recreation which are diminishing with time due to high forest dependence by poor farmers living in the neighbourhood of protected forest areas. Furthermore, environmental degradation arising from unsustainable agricultural practices has resulted in the creation of poor and infertile soil and the changes in the micro-climatic patterns of forested areas (Appiah, 2009).

Cattle grazing in forest ecosystems results in changes in vegetation structure and has serious impacts on vegetation composition (Deng et al., 2014; Kikoti & Mligo, 2015). It is a challenge to balance obtaining forest benefits by forest-adjacent communities and forest conservation which compromises effective implementation and achievement of a sustainable forest ecosystem regime. These issues have continued to complicate effective forest cover management in the Kenyan forest. To achieve restoration of indigenous forest and to get sustained benefits, issues of policies and empowerment of grass root institutions must be addressed. There is need to identify and develop the best forest benefit sharing mechanisms and models aimed at reducing degradation, end poverty and household vulnerability as enshrined in the Sustainable Development Goals (SGD) and Vision 2030.

Silori &Mishra (2001) work focussed on livestock grazing pressure in and around the elephant corridors in India. Livestock grazing negatively impacted on forest regeneration, and also, promoted proliferation of invasive weed species in the forest through livestock dung. The findings of the study recommended measures to reduce livestock population and implement the eco-development to ensure long term conservation of the wildlife population. Silori &Mishra (2001) research did not however investigate the required thresholds in the number of livestock that influence forest regeneration and seasonality patterns in vegetation degradation that could inform decisions on enforce livestock carrying capacity limits.

Kikoti & Mligo (2015) further investigated the impact of livestock grazing on Montane Forest in Mt Kilimanjaro of Tanzania, which was motivated by the ecology value of forests and the negative effect of livestock grazing on plant species in the hilly forest. The research noted that

there has been loss in ecological services of forest due to overgrazing caused by prolonged drought and increasing demand for livestock grazing land. Kikoti & Mligo (2015) research established that livestock grazing on protected forest have serious impacts on vegetation community composition and if measures were not taken, the entire forest ecosystem can be destroyed, a fact also supported by Rosenthal (2010) study. The concern for the research was that the demand for livestock products is increasing which is a big threat since the protected forest act as safety nets for the forest-adjacent communities. Kikoti & Mligo's (2015) research however did not focus on seasons in a year when livestock grazing is less or more intense on plant species destruction. The research did not acknowledge the relevance of the rainy and the dry season in an ecosystem. The period of study was limited and did not measure seasonality patterns and threats over the years to inform decision making.

Soofi et al. (2018) work focussed on livestock grazing in protected areas and its effect on wildlife in Iran. Livestock grazing intensity was cited as one causes of increasing threats on wildlife species. The researchers investigated the impact and effects of livestock grazing and how the practices influence distribution of animal species in protected forest. The authors reported protected areas in the forest require priority actions in assessment of grazing capacities through better co-ordination of the forest custodians and the community. Soofi et al. (2018) research however did not address destruction intensity periods and whether weather patterns influenced the distribution or reduction of wildlife in the forest. The study confirmed that livestock intensity was a threat but there were no seasonality patterns to confirm the fact.

The work by Rosenthal (2010) examined the role of protected areas in conserving rich ecosystem diversity in national parks across several countries. The author noted that there was need to give incentive to livestock farmers to reduce pressure on grass in government national parks. The author concluded that there is need to provide alternative to livestock farmers by breed improvement and to embrace commercial marketing opportunities. The research concluded that in order to conserve wild species the forest must be protected due to the rising cases of over exploitation. Rosenthal (2010) study did not spread the analysis per country over a number of years. Generally, biodiversity threats vary on intensity and can be expressed differently based on season and the prevailing socio-economic drivers in order to get accurate information to guide in future decision making.

Godde (2018) investigated livestock grazing practices in West Africa on the national gazetted forest and its effects on natural ecosystem conditions. The researchers sought to identify the effect of natural conditions by livestock grazing practices on government protected forest. The authors suggested the need to determine proper grazing capacity and the methods of monitoring livestock threats. The research did not consider the periods when destruction of forest is less or more intense which may be determined by the variance of livestock intensity in the forest. Besides, the study did not consider the periods when destruction of forest was less or more intense.

Further, research by Mbiba et al. (2019) on the influence of livestock grazing on small animals in Brazil forest was motivated by how the activity affects habitat characteristic changing the structure of the vegetation and reducing biomass cover. The objective of the study was to establish the impact of livestock grazing on small forest wildlife. The study concluded that the presence of livestock in the forest negatively affect the natural habitat of small mammals in the forest. The research, however, did not take into consideration seasonality patterns and livestock intensity. There was need to confirm if increase in the number of livestock in the forest correlated with the decline in forest natural habitat characteristic.

Schieltz & Rubenstein (2016) work on effects of livestock grazing on wildlife in North America documented the negative effects of the practice effects of livestock grazing. The study was motivated by the fact that livestock grazing changes the vegetation structure and cover, and this causes interference competition and change in forage quantity and quality. The study by Schieltz & Rubenstein (2016) documented the negative effects of livestock grazing in natural ecosystems noting that the negative effects of livestock grazing on forest ecosystems outweighed positive results due to increased habitat destruction. The research however did not focus on the seasons in a year or month when the effects are mostly experienced and if weather patterns are significant in any way. Also, there was no data on peaks and off peaks season to guide on policy formulation.

2.3.5 Community perceptions towards restriction of access to protected forest

Governments encourage participatory forest management with the hope that inclusion of local communities in the management of forests will reduce tensions between the rural poor living adjacent to protected forests and the forest managers through reduction in illegal harvests and enhance inclusivity and socio-economic benefits (Musyoki & Mugwe, 2013).

However, because of pervasive poverty and consequently rising demands for forest access in developing nations, community integration can, on the contrary, result in overexploitation of forest resources. There are broad ranges of forest management policies to regulate forest use and mitigate forest degradation. The world over, forest bans are used by governments when there is evidence that overutilization threatens forest ecosystem health, for instance, species depletion and extinction. Several scholars have investigated stakeholder perceptions towards forest bans, including attitudes of forest fridge communities towards forest bans.

Lachapelle et al. (2004) investigated the perceptions of the local community's inability to exercise power in forest management among forest users in Nepal. The researchers were concerned about the perceptions of local community's inability to exercise power in forest management among diverse forest users in Nepal. The authors used forest user groups to identify case historical contexts and across-forest user groups to identify shared themes across the three study sites. The study reported that narratives by forest related to inferiority were based caste, gender or literacy levels. In addition, there were narratives related to feelings of vulnerability particularly amongst the poorer households. Other narratives identified by the researchers included lack of transparency in which forest users were concerned about issues of information sharing and trust by the conservation agency.

Tumusiime & Svarstad (2011) also used narrativesapproach to examine how communities living adjacent to protected forest ecosystems narrate their experiences with regards to conservation agencies' exclusionary and protectionist approaches to forest conservation. The authors pursued two narratives, namely, the 'win–win narrative' which indicates positive outcomes for both conservations and local communities, and secondly, the traditionalist narrative which is critical of gorilla tourism that involves tracking the animals, a critical area of conservation according to the study. The authors sought to ascertain whether local people who live adjacent to the Bwindi National Park narrate about their relation to the park in line with the win-win narrative or the traditionalist narrative. Narratives emerging from Tumusiime & Svarstad (2011) work included: hopes associated with the existence of the park; disappointments with present economic benefits through revenue sharing and employment' disappointments with lack of compensation for costs of animal raiding; disappointments with restrictions on access to natural resources in the park; and dissatisfaction with lack of influence on decision making.

Research work by Fairhead & Leach (1995) was motivated by to the need to provide alternative explanations to the environmental degradation in Africa using narratives in form of simple stories of apparently incontrovertible logic which provide scripts and justifications for development actions. The narrative focused on population growth and the breakdown of past authority and community organizations which once maintained original forest vegetation guides policy. According to the study, in both cases, history sharply contradicts the deforestation analysis and thus exposes the assumptions in its supporting social narratives. The narratives were used to justify policies of external repression or policies of social reorganization and participatory development making an imperative role in the control of rural resources. Fairhead & Leach (1995) identified themes as assumptions from the western literature which stated that African vegetation was once original consisting of climax vegetation and that prevailing ecological conditions were unchanging. The authors argued that most natural vegetation can be used to judge levels of degradation and that African agricultural practices and population increase have contributed significantly to the degradation of the original vegetation.

Rice (2012) examined the narratives surrounding indigenous rights and conservation in India's tiger reserves with the aim of grappling with the disparity between laws which guarantee indigenous people's rights to forest resources and the reality of loss of access in tiger reserves. The author focused on different narratives done by popular magazines, newspapers and NGOs about indigenous people and tiger conservation. In addition, they focused on narratives in the context of the recent legislative reforms and law narratives. Emerging themes from thisresearch) on the narratives surrounding indigenous rights and conservation in India's tiger reserves included: tigers versus tribal eco-development misreading the law; forest people versus government; and essentialism in the counter-narrative. The forest people versus government counter-narrative blames the government for tigers and indigenous people's suffering and recommends indigenous management of tiger reserves as a solution

Dong et al. (2007) investigated the farmers and professional attitudes to the large-scale ban on livestock grazing of grasslands in China. The study noted that most farmers changed their livestock production systems from grazing to stall feeding after the implementation of the grassland ban policy. According to Dong et al. (2007), farmers reported high input cost in establishment and maintenance of stall-feeding system. The authors concluded that incentives

were necessary to provide sustainable implementation of the ban and the need for stakeholders to work together for technology transfer and policy implementation.

Gurung et al. (2009) investigated the impact of grazing restrictions on livestock composition and husbandly practices in Nepal sought to understand the influence of grazing restrictions considering the high livelihood dependence on cattle pasture. The study used quantitative household survey to obtain information on livestock holdings, seasonal husbandry practices and perception on policies. The study noted that although most households practiced zero-grazing as an adjustment to the new policy, about 30 % depend on community forest fodder for sustainability. The research noted the increase in adoption of zero-grazing units reduced grazing pressure and increased forest cover but increased demand for grass harvesting. Gurung et al. (2009) study noted that livestock rearing practices changed from transhumance grazing to stall feeding. Communities were able to adjust to grazing restrictions policies by reducing livestock number, changing livestock composition and increasing zero-grazing units and reducing the number of large ruminants.

Mullan et al. (2009) work evaluated natural forest protection programme on rural household livelihoods estimated the impact of logging ban programme in water sheds and natural forest emphasizing on local livelihoods. The research noted that natural forest protection programmes had a negative impact from timber harvesting but had a positive impact on total household income. Mullan et al. (2009) pointed that a ban on logging does not necessarily decrease household income overall although it can be argued that itinfringes on the rights that households hold to forest land. The authors further noted that if land use rights are denied without compensation, it may have negative implications due to lack of incentives to manage forest and this may have adverse effects on ecosystem sustainability. Kunwar et al. (2020) researched on the non-timber forest regulatory challenges in Nepal by examining regulatory issues and practical challenges that deter key processes of NTFPs enterprise development. The study by Kunwar et al. (2020) explored directions of policy change and possible strategies. The authors' conclusion suggests that proactive involvement of civil society groups, including networks of forest dependence people is important in addressing the local level policy challenges and can significantly influence national policy and regulations.

Madegowda & Rao (2013) work focussed on the ban of non-timber forest products collection in India. The researchers noted that a ban on the collection of NTFPs in 2006 and it severely

affected the livelihood of the local communities as they did not have any alternative employment and caused communities to migrate affecting children education, culture and health. Their work recommended that the government should provide alternative employment in the native places to help the communities to continue earning their livelihood after the ban and to continue to conserve their traditional tribal culture. The work by Acheampong & Marfo (2011) on the impact of the tree tenure and access of chainsaw milling in Ghana investigated the perceptions of the communities and the success on the implementation of the ban. The authors noted that the implementation of the ban was very difficult and largely unsuccessful due to lack of clarity over forest land and tree tenure. They suggested that forest management systems should be developed to sustain and develop the value of forest for people living near them to gain support for long term sustainable management by providing incentives and involvement of local communities in forest management.

In 1986, mismanagement and failure by the communities to establish new plantations led to the banning of the *shamba* system and livestock grazing in protected forests in Mount Kenya through a presidential decree. In 1987, all forest residents were evicted from the forest since livestock grazing was blamed for the destruction of tree seedlings, nurseries and regenerating of propagules, affecting afforestation efforts. In 2003, the Ministry of Environment and Natural Resources banned livestock grazing and non-residential cultivation following unregulated grass harvesting and livestock grazing in the protected forests. The coming decades are likely to see forest ban becoming more prevalent due to multiple stresses in the Mount Kenya ecosystem that might be exacerbated by overdependence in forest utilization including livestock grazing.

2.4 Summary of Literature Review and Research Gaps

The study by Chakma et al. (2020) focused on forest dependency and conservation attitude of indigenous communities: Lessons from Komolchari Village Common Forest of Chittagong Hill Tracts, Bangladesh. The research noted that forest income, quantity of forest products harvested from the forest and household proximity to the natural resources were significant predictors of forest dependence. The households were selected through random sampling and households categorized into 3 groups. The study was done in 3 villages. A questionnaire was used to collect primary data. The research however did not analyse socio-demographic

predictors of forest dependence. This research analysed all the drivers using 3 models to ascertain significant levels of the factors.

Widiyanto (2019) study was on factors influencing farmer's decision in community-based forest management programme. The research confirmed the significant drivers as geographical conditions, land use, farmer's skills in crop selection and availability of alternative occupations. Deductive approach was used with quantitative and qualitative methods. Data collected through questionnaires from 90 respondents and 3 farmer groups from 3 villages, 30 respondents of each group respectively. The researcher interviewed 9 key informants. Gap noted in the study was that age and education level were not factored as potential predictors even though data on the same was collected from the respondents. This research focused on socio -demographic factors which are important predictors of forest dependence.

Duguma et al. (2018) work focused on deforestation and forest degradation as an environmental behaviour: unpacking realities shaping community actions. The study noted that there was rising demand for forest products due to increasing population as a driver. The significant drivers were classified as market demand and governance issues. The study used behavioural sciences approach to capture data from smallholder farmers. Data was collected using household surveys and FGDs. A survey case study was used. The study failed to look at the socio-economic drivers that are likely to have influenced deforestation and forest degradation in the two forest blocks (Ethiopia and the Maasai Mau Forest). This study focused on the socio - economic drivers that influence forest dependence. This study used 3 forest blocks to increase on inferences.

Ouko et al. (2018) research was on community perceptions of ecosystem services and the management of Mt Marsabit Forest in Northern Kenya. Family size, education level and age were the significant drivers noted as important predictors of the level of involvement in forest management. The insignificant drivers were existence of local institutions and land use. Using stratification, participants from 11 administrative locations adjacent to the forest were selected. A total of 265 households were interviewed using semi – structured questionnaires. Ouko et al. (2018) focused more on socio-demographic and ignored socio-economic predictors of forest dependence in Marsabit forest. This study emphasized more on socio –

economic drivers that influence forest dependence. In this study quantitative survey data was analysed using sequential binary logistic regression and captured the marginal effects.

Jannat et al. (2018) study topic was on socio-economic factors of forest dependency in developing countries. The study noted that education level significantly reduced dependence on forest resources. The insignificant drivers were family size, occupation, and age. The study used a case study for the three hill Districts of Bangladesh. Data analysis was done using logistic regression and the researchers investigated socio-economic factors on forest dependence. One of the critiques of these findings is that respondent's education level failed to consider gender and marital status which may be relevant socio-demographic factors of forest dependence. This study focused on major socio-demographic characteristics which are important in understanding their significance on forest dependence.

Chakraborty et al. (2018) investigated forest dependency in the central Himalayan region. The significant variables were major source of income, age group of the respondents, household size, total land holdings, the number of livestock and usage of alternative fuels. The study explored the nexus between forests and local communities through participatory assessment and household surveys. The study used both descriptive and inferential statistics for data analysis. Gap noted in the study wasthat the independent variable total land holding focused on the entire land and not the actual land set by the household for land use to determine forest dependency. In this study, the independent variables were focused, e.g., the proportion of land under fodder. In the logistic regression marginal effect model was ignored which is important to inform policy.

The study by Soofi et al. (2018) focused on livestock grazing in protected areas and its effects on large mammals in the Hyrcanian forest, Iran. The key findings of the study indicated that protected areas in the forest require priority actions in assessment of grazing capacities through better co-ordination of the forest custodians and the community. The study used surveys to collect data on Hyrcanian forest by randomly selecting 18 protected and non-protected sites. The study used Bayesian occupancy modelling to measure the effects of livestock grazing. The study however failed to address destruction intensity periods. The study confirmed that livestock intensity was a threat but there were no seasonality patterns to confirm the fact. The current study outlined the intensity periods and used seasonality patterns to confirm the facts.

Research by Godde (2018) focused on grazing systems expansion and intensification. The key findings confirmed that to understand forest dependence levels, there is need to determine proper grazing capacity and the methods of monitoring livestock threats. The study focused on describing global trends and the dynamics of grazing systems. The gap noted in the research was that it failed consider the periods when destruction of forest is less or more intense or periods when destruction of forest was less or more intense. The current study emphasized on monthly seasonality indices on smallholder farmer's forest dependence for pasture to enhance seasonality data interpretation.

Mishra & Mishra (2017) study topic was on deforestation and women's work burden in the Eastern Himalayas, India. The significant variables were forest distance, occupation of the respondent and the dependence on animal husbandly. The insignificant variables noted were education level of the female member and the tribe. The study used primary field survey in three villages in Pradesh, India. The critique of the research is that the authors failed to factor in some relevant drivers such as the household size and income levels. In this study, household size was used as control variables since they were noted as potential drivers likely to affect both the dependent and independent variables.

Study by Olarewaju et al. (2017) focused on forest degradation and livelihood: A case study of government forest reserves of Ogun state, Nigeria. The key factors noted to drive forest dependence were gender of household head, number of household members working, number of children and youth in the household. Primary data used in the study were obtained through random sampling procedure across the non-degraded and degraded forests . The work failed to hypothesis other relevant variables such as education level and household socio-economic status which may have played a role in forest degradation. This study focused on major demographic factors and went further to analyse socio-economic drivers of forest dependence which were left out by other scholars.

Work by Enbakom et al. (2016) investigated the impacts of deforestation on the livelihood of smallholder farmers in Southern Ethiopia. The study noted socio-demographic variables, mainly age of the respondents and household size as significant drivers influencing deforestation. The study used household survey tool to collect data from 180 randomly selected households from each study sites. The study did not focus on the socio-economic drivers that influence forest dependence by smallholder farmers. This study used SES which

was quite relevant to the study on the analysis of household drivers that influence the practice of cattle grazing and grass harvesting in protected forests.

The research by Schieltz & Rubenstein (2016) focused on the evidence-based review: Positive versus negative effects of cattle grazing on wildlife. What do we really know?The research findings noted that negative effects of livestock grazing on forest ecosystems outweighed positive results due to increased habitat destruction. The design involved literature review on the effects of livestock grazing in wildlife areas. The study used controlled and natural experiment. The research gap noted was that there was no focus on the seasons in a year or month when the effects were mostly experienced and if weather patterns are significant in any way. Also, there was no data on peaks and off peaks season to guide on policy formulation.The current research focused on the seasons in a year or month when the effects are mostly experienced and provided data on peaks and off peaks season.

Tripti et al. (2015) study investigated livelihood dependency of rural people utilizing non-timber forest product (NTFP) in a moist deciduous forest zone. Research findings noted that the determinants of forest dependence were lack of awareness, limited scientific knowledge, inadequate market information and low income through species commercialization influenced forest dependence Information about NTFPs was collected in 14 villages using a survey tool. Data analysis approach was purely descriptive. The main gap in the research is that there was no focus on socio-demographic characteristics such as age, gender, education level which could have played a role in predicting forest dependence. This study used binary logistic regression model since the dependent variable (forest dependence) had only two possible outcomes and there was deep emphasis on inferential statistic focusing on socio-economic drivers.

Kumar (2015) study focused on the impact of non-timber forest products on food and livelihood security: An economic study of tribal economy in Dang's district of Gujarat, India.The insignificant drivers noted were land holdings and ownership of livestock. Purposive sampling method was used in the study. Study collected both primary and secondary data. Primary data collected using a questionnaire tool. The research however failed to regress on the socio-demographic characteristics such as age, gender, education levels which could have been relevant predictors based on the context of the study. This study

extensively analysed both demographic and socio-economic drivers including interpretation of the marginal effect models.

Study by Jain & Sajjad (2015) was on household dependency on forest resources in the Sariska Tiger Reserve (STR), India. The key findings noted that livestock population and the agricultural land per household as the two major determinants of forest dependence. The insignificant drivers were age, size of household's landholdings, education level and market access. 11 villages were selected considering variation in location in terms of access to market and livelihood sources. Questionnaire was administered randomly in selected villages. Logistic regression model was used to analyse the data. The main critique of the findings is that some important socio-demographic characteristics such as gender could have been analysed as factors influencing forest dependence. Other socio-economic factors such as proximity to the Tiger Reserve and household income levels should have been tested as potential predictors of forest dependence. This study looked at the critical independent factors of forest dependence including the control variables such as SES.

Research by Nelson et al. (2015) in Malaysia focused on community's forest dependency and its effects towards the forest resources and wildlife abundances. The significant drivers were the land use, distance or proximity to the forest resources and hunting of wildlife. Data were collected using the self-administered questionnaire involving 204 community members. The research used frequency data analysis method. One of the gaps noted in the study is that although the authors discussed the socio-demographic profile of the respondents, they did not use them in the prediction of the variables of forest dependence. In this study, socio-demographic profile of the respondents was used to predict variables of forest dependence, a concept supported by Awono et al. (2010).

The study by Mutune et al. (2015) investigated the local participation in Community Forest Associations: A case study of Sururu and Eburu Forest, Kenya. The key findings of the research noted that gender, group membership, ownership of tree nursery, wealth status, percentage share of wage income and farm size allocated for tree nursery were significant drivers of forest dependence. The design was a case study. The probit model was used to access the socio-economic factors. The study used household survey tool to collect data. One of the limitations of the study was that the focus was on only two forest blocks considering the region had nine blocks, therefore this approach could have reduced variability and

inferences. This research focused on 3 forest blocks, and this increased the variability and inferences. Also, cross tabulation gave more insights to the forest dependence scenario.

The study by Kikoti & Mligo (2015) focused on the impacts of livestock grazing on plant species composition in Montane Forest on the Northern Slope of Mount Kilimanjaro, Tanzania. The key finding was that there has been loss in ecological services of forest due to overgrazing caused by prolonged drought and increasing demand for livestock grazing land. This was a case study done in Montane forests in Kilimanjaro. Plant species diversity was determined from raw data using Shannon's diversity index. One way ANOVA was used to compare plant species diversity and richness among areas with different grazing intensities. The research however did not focus on seasons in a year when livestock grazing is less or more intense on plant species destruction. The period of study was limited and did not measure seasonality patterns and threats over the years to inform decision making. This study captured data over 6 year's period. Focus was on monthly seasonality indicating periods of influx and lows to categorically inform policy.

Adam & Tayeb's (2014) research investigated the forest dependency and its effect on conservation in Sudan. The research findings noted that agricultural income, household age, access to outside market and household size were major determinants of forest dependence. Samples of 300 households were randomly selected. Data were collected using survey questionnaire and data analysis was done using descriptive and logistic multiple regressions. Gap noted in the study is that the computation of household income and assets did not outline the wealth quartiles to determine the role of poverty levels in predicting forest dependence. This study operationalized the income quartiles and established how poverty levels influence forest dependence in respective forest blocks.

Research by Munanura (2014) focused on the household poverty dimensions influencing forest dependence at volcanoes National Park, Rwanda. The insignificant factors that influence forest dependence were economic issues and educational insecurity. The study was done in 3 phases using exploratory sequential mixed methods design. Target population was the poor, extremely poor and the poor living adjacent to the National Park. Main gap noted in the research is that the analysis did not control for household size and socio-economic status and left out socio-demographic characteristics which are likely predictors of forest

dependence. This research controlled for household size and socio-economic status to effectively reject or fail to reject the hypotheses that were being tested.

Pouliot et al. (2012) research on deforestation and the limited contribution of forests to rural livelihoods in West Africa. The key findings noted that agricultural land size and the non-forest environmental activities as significant drivers of deforestation. Data were collected through household surveys from 1014 households. Data collection on household sources was done on a quarterly basis. Data analysis was purely descriptive statistics. The research failed to factor the socio-demographic predictors of forest dependency and focused only on socio-economic factors hence limiting the outcome in terms of the role of age, gender, and household size in contributing to rural livelihoods. This research focused both on demographic predictors of forest dependency and socio-economic factors. Research undertook logistic regression to understand better levels of forest dependence per independent variable tested.

Rosenthal (2010) study topic was on the review of the role of protected areas in conserving global domestic animal diversity. The key findings noted that there is need to give incentives to livestock farmers to reduce pressure on grass in government national parks. There is need to provide alternative to livestock farmers by breed improvement and to embrace commercial marketing opportunities. The study used content analysis methods to analyse qualitative data targeting 167 countries. The gap noted is that the study did not spread the analysis per country over several years. Biodiversity threats vary on intensity and can be expressed differently based on season and the prevailing socio-economic drivers. Cattle entry monthly and seasonality data was collected for a period of 6 years in this research in 3 forest blocks. The elaborate trends can help to inform appropriate decision making by policy makers.

The study by Lepetu et al. (2009) investigated forest dependence and its implication for protected areas management in Kasane Forest Reserve, Botswana.Forest dependence was positively and significantly associated with family size. The researchers used a case study. Data were collected from 237 households and were analysed using logistic regression model. The study failed to consider socio-economic factors that influence forest dependence such as occupation, alternative income sources, and proximity to the forest and land size which could have been possible predictors to guide in the conservation of Kasane Forest Reserve. This study focused on key socio - economic drivers derived from literature review and the author's

contribution. It is imperative to explore beyond demographic characteristics to indeed understand drivers of forest dependence.

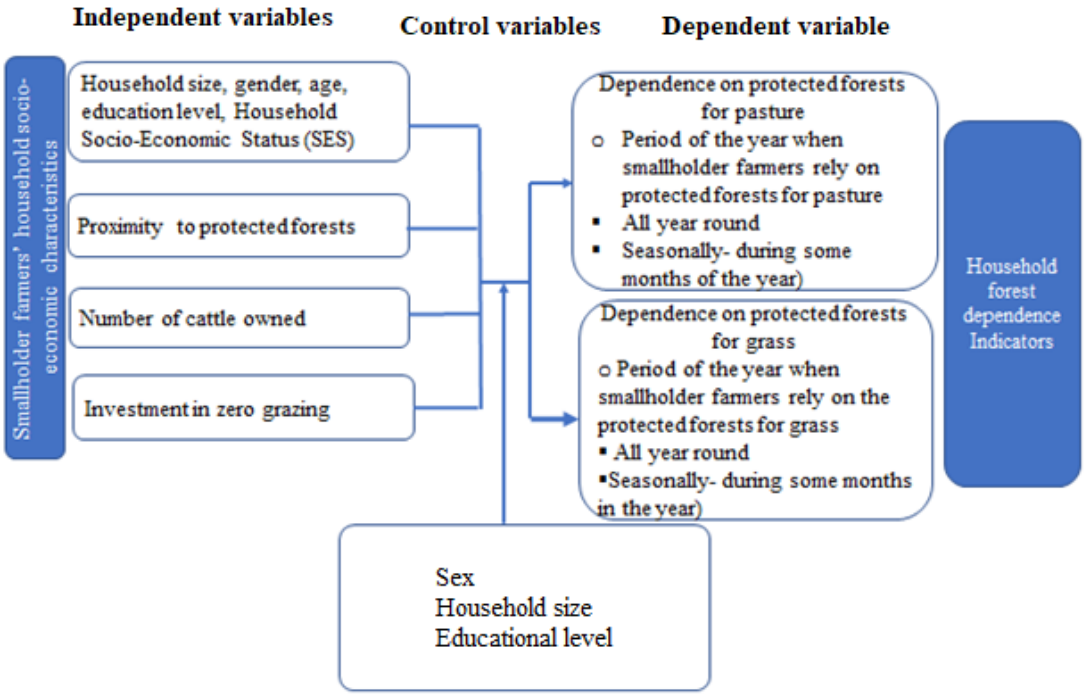
Buffum et al. (2009) research focused on forest grazing and natural regeneration in a late successional broadleaved community forest in Bhutan. The key finding was that the number of cattle grazing inside the community forest was significant driver that impacted negatively on ecosystem degradation. The study was based on a comparison of 2 forest inventories during a 5-year period to assess changes in livestock holdings and grazing patterns. Household survey was done randomly to 113 households. The gap noted in these findings is that the analysis failed to reveal the monthly or yearly seasonality patterns when there were peak and low seasons to help inform policy. The current study revealed the monthly or yearly seasonality patterns when there were peak and low seasons to help stakeholders to make an informed decision.

The study by Adhikari et al. (2004) in Nepal focused on household characteristics and forest dependency. The study concluded that the significant drivers of forest dependence as land and livestock holdings, proximity to the forest, caste, education of family members and household economic status. The study used case study design. The researchers collected both qualitative and quantitative data using questionnaire tool. The gap noted in the study is that socio-demographic factors were not factored as potential predictors of forest dependence. This research analysed gender, age and education level as the main demographic factors which are important predictors. The researcher went further to do cross tabulations across the 3 blocks.

Tucker's study (1986) was on the evolution of Transhumant Grazing in The Punjab, Himalaya. The key finding was that cattle grazing was responsible for a significant deterioration in quality of vegetation, destruction of plant species and poor tree regeneration. Qualitative research methods were used to collect data from migrating households from the 6 villages. A semi-structured household survey was used to collect data from 75 households. Major study gap noted was that the study failed to provide data on the impact of migratory herders indicating grazing seasonality patterns outlining the severe and less severe periods to help the Indian Forest Service to make informed forest grazing land regulations. The current research provided data on cattle entry per month for a period of 6 years indicating influx and low reasons to help inform decisions and regulations on livestock carrying capacity.

2.5 The conceptual framework

Objective 3 on trend analysis and objective 4 on smallholder farmers perception described the context within which NTFP are practised. As brought out in the literature, the relationship between household socio-economic characteristics and forest dependency is as shown in the conceptual framework in **Figure 2.*1***.



Source: (Author)
Figure 2.1: Conceptual framework

In this study, the independent variables, which were household size, gender, age, education level, household socio-economic status, size of land owned, number of cattle a household owns, proximity to the forest and ownership of a zero-grazing unit are derived from the review of previous literature as hypothesized to influenced dependence on protected forest for pasture and grass harvesting. In addition, the following variables: size of land available for fodder production and the proportion of cattle kept under zero-grazing are added by the researcher to examine their influence on dependence on protected forest for pasture and grass harvesting. Gender of respondents, household size and educational level were classified as control variables. Control variables describes the underlying conditions which could potentially affect both the dependent and independent variables.

2.6 Chapter Summary

The chapter focused on the threats to forest ecosystems and noted the major threats globally, in Africa and sub-Saharan Africa as well as in Kenya as outlined by scholars in the previous research studies. The chapter has examined forest ecosystem services and the well-being of adjacent communities; participatory forest policies and their implications on forest dependence while also outlining the theoretical approaches under focus namely, the common pool resources theory, the access theory, and the livelihood transformation theory. Discussion on each of the theories have expoundedon what each theory posits, major components, their relevance to the current research and how they complement each other. The chapter further outlined the summary of knowledge gaps from the empirical review of previous literature focusing on study limitations on seasonality, contradictions on the drivers of forest dependencesuch as livestock numbers, household size, proximity to the forest and socio-economic status. The chapter has provided the conceptual framework constructedafter reviewing literature, and the independent variables hypothesized to understand the relationship between smallholder farmers' household characteristics and dependence on protected forest for pasture and grass harvesting for cattle.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Chapter Introduction

This chapter presents the methods, materials and processes used in gathering and processing data. The chapter begins by introducing the research design that was adopted for this study before proceeding to describe the overview of research areas in terms of demography, biophysical aspects, and geography. Administratively, the study was conducted in Kieni East and Mathira west sub-counties of Nyeri County. The chapter ends with a discussion of data collection instruments, procedures and analysis approaches taken for both qualitative and quantitative data.

3.1 Philosophical foundation informing the research design

Within the epistemological and ontological framework of development, there are three major philosophies of rural community development namely resource access, resource pooling and livelihood transformation. Against the background of common resource pooling, farmers in the study area came together through CFA as a legal institution to access forest products and exploit forest resources oblivious of the sustainability concerns. The emphasis was on how to guarantee community sustainability by harmonizing sustainability issues and localisation of community challenges. Given the context of the study, uncontrolled exploitation of forest resources was attributable to availability, accessibility, affordability of forest grass. While forest dependence for livestock sustainability was by means of cattle grazing or grass harvesting, with the challenge of how to balance natural resource utilization and livelihood improvement.

The Kenyan government's response to rapidly increasing forest degradation has involved authoritative approaches such as bans on forest access as well as plans to increase forest cover to 15% by the year 2022. The concept of Forest Management Plan started in 2007 in Kenya and was supported by establishment of Community Forest Associations (CFA), which are legally registered forest access groups comprising of the cattle keepers in particular. This informed the choice of the research design and the target population.

The study used a combination of two paradigms. The first round of data collectionwas informed by positivism paradigm. Positivism advocates for a realist ontology, and an objectivist epistemology. Positivists use sampling, hypothesis testing and falsification, priori theory, neutrality, statistical analyses among other tenets. Structured survey was used to collect primary data. The researcher ensured the sample size is of a reasonable size. Logistic regression wasused to conduct analysis of primary datawhile trend analysis was used to analyse secondary data methods that fall under positivism tradition (Gray, 2013).

The second round of data collection followed the interpretivism paradigm. The researcher sought to understand the phenomena in detail by following some of the participants who had filled the survey with in-depth interviews which were tape-recorded and transcribed. Since the interviews were short, thematic analysis was used to identify categories/themes. The study supported the categories with thick descriptions from the participants. This allowed the participants' voices to be heard, and their different perspectives to be captured-multiple realities (Creswell 2013; Gray, 2013).

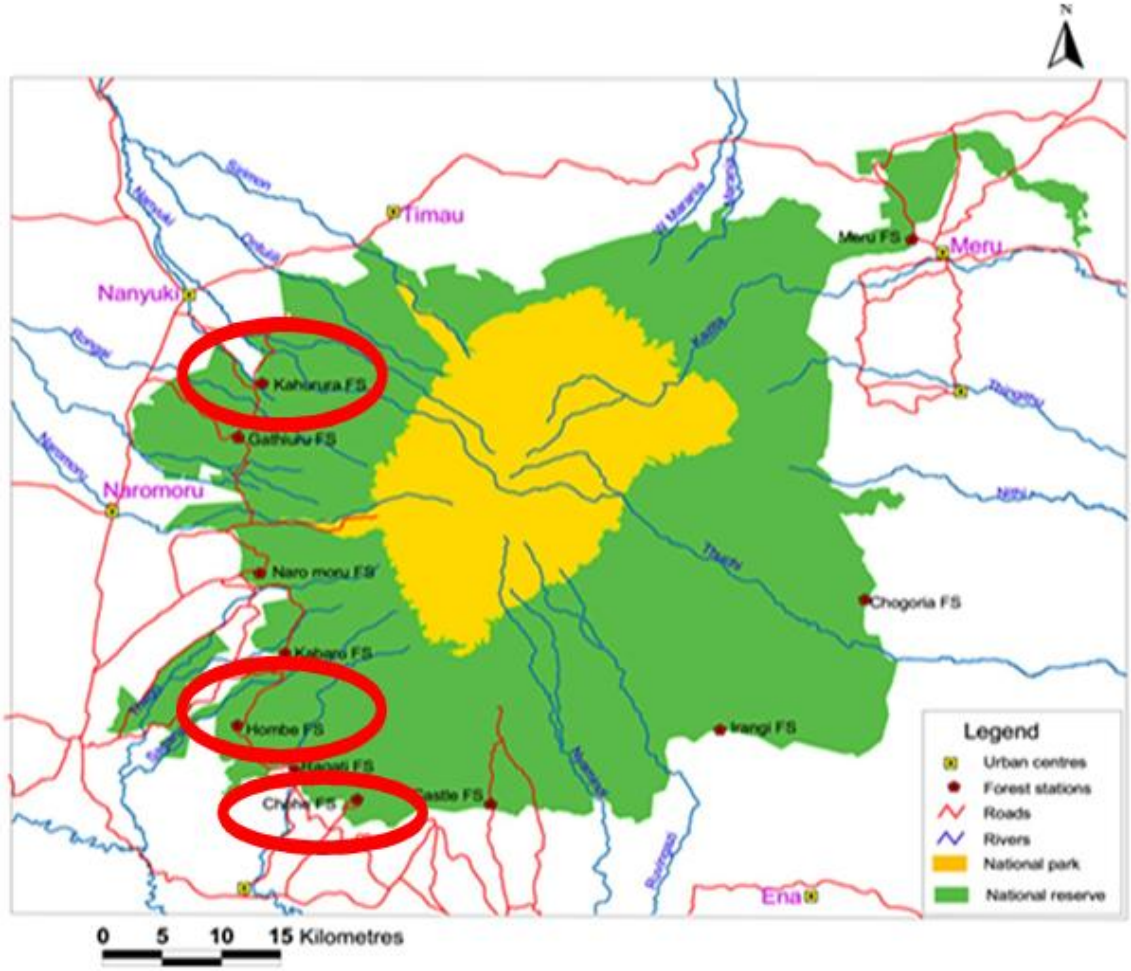
3.2 Research design

This research used a mixed method research design that involved collection and analysis of both quantitative and qualitative data. According to Creswell (2013), a mixed method research design allows extensive data collection on a large population at one point in time, enabling, establishing, and describing a situation as it is. Thus, it is normally adopted as a suitable method in addressing issues for vulnerable and marginalized populations. Further, Klassen et al. (2012) observed that mixed method research design is a suitable methodology in research that involves forest-adjacent communities and exploitation of natural resources. The advantage of using a mixed methods research design is that it provides a broader perspective and brings out a deeper understanding of the subject being studied (Schoonenboom & Johnson, 2017). According to Greene et al. (1989), the mixed method design brings out a complementarity that produces an enriched and expanded understanding of various aspects of a study. Schoonenboom & Johnson (2017) further point out that this design is ideal for bringing in new perspectives by modifying questions from one method to another, thereby extending the range of inquiry. The mixed method research design used enabled the researcher to expand and strengthen the study's conclusions, which increased the validity of the results.

3.3 The study area

The study site comprised three protected forest blocks, namely, Hombe, Chehe and Kahurura. All the three forest blocks are protected under the Kenya's Forest Act of 2005 and are managed by KFS. As previously mentioned in the justification of the study section, the three forest blocks were chosen for the study because they were the initial blocks in the region to embrace the concept of participatory forest management by developing and implementing a forest management plan. Besides, the three forest blocks have unique characteristics and are of diverse geographic locations which was ideal for the study. The Hombe forest block was gazetted as a protected forest in 1932 and occupies an estimated area of 3618.7 ha. The Chehe forest was gazetted as a protected forest in 1943 and occupies an area of 4945 ha. while Kahurura was gazetted as a protected forest in 1943 and occupies an area of 9855 ha according to the Kenya Forest Service (2016) records. The Mt. Kenya region where these three forest blocks are located receives a bimodal rainfall, with long rains during the months of March to July and short rains during the months of October to December.

According to the Mt Kenya Forest Reserve Management Plan (2010-2019), large mammals inhabiting the three forest blocks include elephants, rhinos, and leopards. Endangered wildlife species include the mountain bongo, black rhinoceros, grevy'szebra, African elephant, giant forest hog and the black fronted duiker. Endangered species of higher plants found in the three forest blocks include bamboo, camphor, cedar, podos, Meru oak and *olea africana*. Each forest block has a community forest association that works collaboratively with KFS to regulate forest utilization activities, which include cattle grazing and grass harvesting in the protected forest. Communities pay a very modest fee to graze in the protected forest (See Figure 3.1).



Source: Kenya Forests Working Group, East African Wildlife Society, 2014

Figure 3.1: Area of Study

3.4 Overview of changes in socio-demographic and livelihood strategies in the study site

The population growth rate in Nyeri County is estimated at 2.2 per cent against the national average of 2.6 per cent. The county is estimated to have a population of 845,863 persons comprising 414,329 males and 431,535 females in 2018 as projected from the 2009 population and housing census. The highest and the lowest population for 2018 are the age cohort of 10-14 and 75-79 respectively. Ages 10-14 represent 11.4 per cent, while 75-79 comprise of just one per cent of the total population. Over 60 per cent of the population is below 30 years, portraying a youthful population which is more productive and thus the need to consider them in development activities.

In Nyeri County, the population has been increasing steadily. In 1979 the population was 486,677 while in 1989, it was 607,292. In the year 1999, it was 661,156. Interestingly, the population increased from 693,558 in 2009 to 759,164 in 2019 (KNBS, 2019). In the study areas, Kahurura, Hombe and Chehe, the farmers directly involved in the practice of grass harvesting and cattle grazing in protected forests ranged from 20 years to over 61which is the productive population of the county. However, community members 18 years and below may visit the forest accompanied by their parents. There was a projected total labour force of 505,140 persons comprising 48.8 per cent males and 51.2 per cent females in 2018. This number is expected to rise to 551,694 by 2022. The area of the research was Mathira East, Mathira West and Kieni East with 44, 31 and 33 locations respectively. In Mathira sub-county which hosts Chehe and Hombe forest blocks, the population was 69,392 persons in 2009 and by the year 2019, it had increased to 99,497 persons. In Kieni where Kahurura forest is located, the population in 2009 was 81,963 but as of 2019, it had risen to 109,001(KNBS, 2019).

3.5 Implications of population growth in Nyeri County over the years on natural resources

Population increase in Nyeri County over the years has brought changes in the natural resource's management because of collection of firewood, timber grass, medicinal plants, water, as well as poaching among others. There have been cases of cutting down of indigenous trees for human settlement and burning of charcoal in the two-county gazetted, that is the Aberdare ranges and the Mt. Kenya according to KFS (2017). Due to population increase, there has been increase in environmental threats including uncontrolled logging and the subsequent threat of loss of biodiversity in the forests. Loss of tree cover has also affected rainfall patterns and food security. It is important to note that before independence in 1963, forest cover was at 12 %, but has declined to 7.4 % by the year 2019 due to population change, to illegal logging, charcoal production and human encroachment (KFS, 2019). Increase in demand for natural resources in the last 20 yearshas led to an increase in drought, which has subsequently led to loss of biodiversity, drying up of water bodies, water pollution, human-wildlife conflict, increased distance to water points and community conflicts. Due to population increase, all the forests in the region whether gazetted or non-gazetted have been under threat by community members who mainly target them for timber, poles and firewood. Over the years, poaching has been on the increase threatening endangered species such as the

bongo. The increase in population and the emergence of the new forest management approach introduced Participatory Forest Management (PFM) that allows the local community to access forest resources without limitations (Thenya et al., 2017)

Population increase has led to the increase in demand in the collection of medicinal herbs and harvesting of wild honey which have caused wildfires in some forest blocks. Fodder harvesting and livestock grazing have been on the increase due to the current demand for milk and meat within and without the forest zone. Due to prolonged drought and limited land for farming owingto population pressure, there has been an increase in the number of community members cultivating in the forest through PELIS. Demand for water for irrigation has also increased over the years due to increase in water projects. This has severely affected farmers downstream and contributed to perennial conflicts over natural resources. Other forest-based activities that have attracted farmers due to population increase include fish farming, seedling production and collection of fruits, berries and vegetables to enhance nutrition and food security.

3.6 Community Forest Associations & Implications on livestock keeping

The emergence of CFAs during the last 12 years in Nyeri County has shaped livelihood strategies in the region. The number of CFAs has increased from 3 to 13 in the last 12 years (2007-2019). The region currently has 7 CFAs in Mt. Kenya West (Kahurura, Gathiuru, Narumoru, Kabaru, Hombe, Ragati and Chehe) and 6 CFAs in the Aberdare ecosystem (Zuti, Muringato, Zaina, Kiandongoro, Kabage and Embaringo). Forest dependence has grown rapidly, and this is supported by the fact that all the CFAs have developed forest management plans and signed 5 years joint forest management agreements with the KFS. This legal approach has made forest user groups, which are around 145, to focus intensively on user rights associated with collection of medicinal herbs, harvesting of honey, fuel wood collection, grass and fodder harvesting, livestock grazing, ecotourism and recreational activities, PELIS, silviculture activities, seedling production, seed collection, collection of fruits, berries and vegetables, fish farming, water abstraction, quarrying as well as murram and ballast collection. The Hombe forest block has 23 active user groups, Chehe has 18 and Kahurura 21 and eachuser group has an average of 80 members. According to the law, KFS has the right to withdraw a particular user right where the CFA breaches any of the terms related to forest products utilization. These provisions however do not create any kind of joint

venture or partnership between the parties. The government has the mandate to conserve and manage the utilization of Kenya forest resources for equitable benefit sharing of present and future generations hence the institution can affect a ban on the user rights without consultation with the CFAs or the user groups. For example, in 2018, the government imposed a moratorium on logging in public forests.

The forest user groups have shaped forest dependence in the study sites by organizing themselves into groups regulated by the umbrella CFA. Each user group has a constitution that guides the level of engagement of the member and the statutory requirements as stipulated in the Forest Act, (2016). Different user groups use different mechanisms to regulate resource harvest and to ensure that every member has paid for the forest resource. Compliance is however enforced by KFS rangers by insisting that users produce evidence of payment for forest product use. Similarly, there is a mechanism in place to monitor the operations of user group members who go against the laid down guidelines and in most cases, they are punished or expelled from the group and eventually from the CFA. The research on the analysis of socio-economic drivers of cattle grazing and grass harvesting focused on the user groups specifically involved in livestock grazing and harvesting of animal fodder as per the Forest Act (2016) list of approved and gazetted user rights.

3.7 Target population

The target population of this study were smallholder farmers living adjacent to Hombe, Kahurura and Chehe forest blocks located within Mt. Kenya West and involved in cattle grazing and grass harvesting in protected forests. According to Kenya Forest Service (KFS) of Mt. Kenya, there were 501 registered smallholder farmers in Chehe, 516 in Hombe and 513 in Kahurura, giving a total target population of 1,530 smallholder farmers. The farmers were classified depending on their farming activities with 779 registered as those carrying out cattle grazing while the rest (751) registered as those carrying out grass harvesting.

3.8 Sampling, sample size and sampling frame

The lists of smallholder farmers obtained from KFS were used as the primary sampling frame from which samples were drawn. According to Orodho (2013), when the study population is less than 10,000, a sample size of between 10% and 30% is a good representation of the target population, hence in this study, 30% of the target population was selected (1,530 x

30% = 459). This sample size determination approach was similar to Krejcie and Morgan (1970) and Nassiuma (2000) approach. Since there were minor variations in the number of registered farmers across the three forest blocks, homogeneity was assumed, and thus an equal sample (153) was drawn from each block using random tables. Farmers in each of each block were serialized using digit format such that the first one on the list would read 001, the second would read 002, till the last one; 501 for Chehe, 516 for Hombe and 513 for Kahurura. This serialization corresponds to the numbers in the random table (Shown in Appendix 28). Listing the names of the forest blocks alphabetically, Chehe comes first, followed by Hombe and last is Kahurura. This listing was important in establishing the starting point in the random table. Sampling from Chehe, the number in the first row and first column was used as a random start. For Hombe, the number in the second row and second column was used as a random start. In Kahurura, the number in the third row and third column was used as a random start. In all the three instances, the random numbers were read in triple in a horizontal format so that each random number that corresponded to the serialized digit represented a successfully sampled smallholder farmer.

3.9 Data collection and analysis

3.9.1 Quantitative survey data collection and analysis

To analyse the relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for pasture and grass harvesting, data was collected using questionnaires. A structured questionnaire was constructed and pre-tested before data collection.

3.9.2 Operationalization and measurement of study variables

a) Smallholder farmer's dependence on protected forest for pasture

This is a dependent variable in the study. Respondents were asked to indicate whether they had relied on protected forest during part of the year, for instance, in the dry season months, or whether they entirely depended on the forest for pasture throughout the 12 months of the year. A follow-up question asked respondents how many months in a year they relied on the protected forest for pasture. The level of forest dependence for pasture was coded as 1 = relies on forest for pasture during most months of the year, and 2 = relies on the forest for pasture during dry season months of the year only. Frequency of grazing in the forest was

considered a comprehensive indicator of forest dependence. Grazing in the forest more frequently regardless of the herd size is a proxy to lack of options hence, high forest dependence.

b) Smallholder farmers' dependence on protected forest for grass harvesting

This is a dependent variable in the study. The respondents were asked to indicate whether they had relied on protected forest for grass harvesting for cattle during part of the year, for instance, dry season months, or whether they entirely depended on the forest for grass for cattle through-out the 12 months of the year. A follow-up question asked respondents how many months in a year they relied on the protected forest for grass harvesting. The level of forest dependence for grass harvesting was coded as 1 = relies on forest through grass harvesting during most months of the year, and 2 = relies on the forest through grass harvesting during dry season months of the year only.

c) Educational level

This is an independent variable in the study. To measure this variable, a closed ended questionnaire items with specific options were used where a respondent would only select one option that best described their highest academic level completed as of the time of the data collection exercise (Questionnaire for smallholder farmers shown Appendix 1 question 23c).

d) Household size

This is an independent variable that reported the number of individuals living in a homestead. Study participants were asked to record the number of persons who live in their homestead as shown the questionnaire for smallholder farmers in Appendix I Question 24.

e) Household socio-economic status (SES)

Household SES was used to measure wealth index. This variable was computed based on a set of household total monthly income, expenditure, and other assets such as cow shades, water storage tanks, watering thoughts, and milk containers. A single index was computed based on PCA ranking each respondent based on relative wealth index and classified into 5 equal wealth quintiles from the lowest to the highest: 1= Poorest, 2= Poorer, 3=Poor, 4=Less

poor and 5= Least poor. The SES index was constructed based on respondent's self-reported income, expenditure and assets as shown in Appendix I Question 18, 20 and 21.

f) Number of cattle in a homestead

This is an independent variable, a self-reported number of cattle kept on the homestead (excluding calves). The Cattle kept in a homestead were measured by reporting the actual numbers. Respondents were asked to enumerate the total number of mature cattle in the homestead ash shown in Appendix I Question 2.

g) The proportion of cattle under zero-grazing

The proportion of cattle under zero-grazing was measured as a percentage (%). The number of cattle under zero-grazing was the numerator while the total number of animals in the homestead was the denominator. The quotient between the two numbers was expressed as a percentage, hence the proportion of cattle under zero-grazing. The number of cattle kept under zero-grazing relative to the total number of cattle as shown in Appendix I Question 8.

h) Proximity to the forest

This is an independent variable measured in minutes taken to walk from a residence to the forest boundary. The respondents were asked to estimate the number of minutes an adult person would take to walk to the forest boundary as shown in Appendix I Question 16.

i) Total land size

This variable describes the size of land legally owned by the respondent. Household size of land was measured in acres. Smallholder farmers were asked to state the size of land they legally own. The land that is legally owned was operationalized to mean a piece of land the farmer bought or inherited family land. As shown in Appendix I Question 1, study participants were asked to state the size of their land.

j) Proportion of land under fodder production

Size of land used for fodder production relative to total land size. Size of land under fodder production was measured in acres. Farmers were asked to state the size of their land set aside for fodder production as shown in Appendix I Question 9.

k) Proportion of land rented for fodder production purposes

Size of land rented for fodder production purposes was measured in acres. The farmers who indicated that they had rented land for fodder production were asked to indicate the size of land rented in acres as shown in Appendix I Question 10.

l) Ownership of a zero-grazing unit

This is an independent variable that indicates presence or absence of an established zero-grazing unit in a homestead. Data was collected using a YES-NO response. It was found that some farmers had invested in zero-grazing units in their homestead as shown in Appendix I Question 7. The number of "YES" was then expressed as a percentage of the total response rate.

m) Quantity of grass harvested from the forest per month

Farmers were asked to state the number of 50 kg bags of grass they harvest from the forest. This variable was recorded separately as follows; number of 50kg bags of grass harvested during the dry season and number of 50kg bags of grass harvested during rainy season as shown in Appendix I Question 11.

n) Involvement in value addition of grass harvested from the forest

The variable was measured using the number of mentions (actual number counts) by the farmers involved in grass value addition activities by grass harvesting farmers as shown in Appendix I Question 12.

o) Making silage from forest harvested grass

Famers were asked if the grass obtained from the forest was used to make silage and the answer was YES-NO as shown in Appendix I Question 13 and results reported in percentage (%).

p) Quantity of fodder produced per acre

Farmers indicated the quantity fodder they produced in both dry season and rainy seasons by approximating the number of bundles. This variable was measured by recording the actual number of fodder bundles as shown in Appendix I Question 15.

3.9.2 Application of principal component analysis in computing SES

Principal Component Analysis (PCA) provides sound theoretical methodologies for construction of indexes based on several input parameters such as household characteristics. While PCA is primarily used for dimensionality reduction, several scholars have used this methodology to construct indexes such as SES wealth index, a concept adopted by this study. Socio-economic characteristics such as income level, different sources of income, education attainment, and employment status were collected from each household. Socio-demographic characteristics included farmer's age, gender, education and marital status. The study of socio-economic characteristics is important in understanding respondent's perceptions regarding subject under study. The respondents' perceptions on issues such as policy shocks, and climate change are likely to be influenced by such underpinning social-economic and socio-demographic characteristics.

The researcher used the Principal Component Analysis (PCA) to create an index of the socio-economic status (SES) of each farmer (representing a household). The variables used to create SES index were size of land owned, proportion of land under fodder, total household income and expenditure, ownership of zero-grazing, and key household assets such as watering troughs, water tanks, hay structure and the number of calves. Factor scores coefficients for each component were estimated using regression method (which is available in SPSS) for each case, and factor scores were saved in the data file. Each of these variables was multiplied by the corresponding PCA loadings and the values summed up to form a single index - the wealth index which relative wealth of each household. To simplify the interpretation of wealth index, 453 were clustered into equal number of respondents of 91 to produce 5 wealth quintiles classified as poorest, poorer, poor, less poor, and least poor. This approach concurs with previous study by Uberhuaga et al. (2011) that classified poverty levels as poorest, poor, medium, and less poor.

SES uses a Basic Necessity Survey (BNS) to compute wealth score (Davis & Smith, 1998). The model was used as a basis for an index of wealth for every household in the sample. The concept of BNS has been applied both in developed and developing countries (Mutune et al., 2015; Nikolaev et al., 2018). Wealth index computed from PCA ranks each individual household from the wealthiest to the poorest in the available sample. Computation of SES categories assumes that each wealth quintile represents 20% or 1/5 of the sample available (Faust et al., 2017).

Socio-economic status categories of respondents were computed using the concept of wealth quintile which is a relative measure or indicator of the economic status of a household based on selected parameters (Faust et al., 2017). Data from YES-NO questions related to household ownership of different assets related to livestock keeping was used to construct SES. These included: ownership of cattle shed; calves; hay structures; hay baler; chaff cutter; water tank; watering troughs; milk containers; television and solar panels. The asset-based measures were used to construct wealth indices of household for farmers involved in either cattle grazing or grass harvesting. In addition, other measures used included: the proportion of income spent on paying bills; total land size in acres; number of cattle in the homestead; ownership of a zero-grazing unit and proportion of cattle kept under zero-grazing units. For asses-based measures relating to ownership of property such as cattle sheds, hay structure, calves, milk containers, watering troughs, and solar panel among others were binary responses indicating presence or absence of the said property. PCA was used to construct a single index based on Eigen values of between 2.43 and -6.77. An eigenvalue was associated with one household to indicate their wealth measure that were classified as poorest, poorer, poor, less poor, and least poor in ascending order.

Social scientists have sought ways to measure living household standards. This can be done through two different ways. First, they compare income and expenditure for different household. In this method, it is assumed that a household with more income and/or expenditure has better living standard than the one with less. The other approach is to compare household assets and facilities. In this method, it is assumed that a household with better assets and facilities such as a car and piped water have a better living standard compared to those without. However, there is no single household characteristic or asset that gives us enough information to determine living standard of a household. Therefore, a wealth index is created based on a variety of household characteristics and assets that are relevant for

a particular context. A wealth index is used an unbiased indicator of a household wealth, in this case each household has a unique wealth index.

There are many statistical methods that can be used to calculate wealth index based on several household characteristics and assets, popular technique being the PCA used in this study. PCA technique uses complex matrix algebra to combine several household characteristics and assets to produce one value which is then called a wealth index. A wealth index output is produced in form of decimal numbers (*e.g., 1.325, 2.458, -3.125 etc*.), each number representing one household. Thesmallest wealth index represents the poorest household while the biggest wealth index represents the wealthiest household. The dataset is then ranked based on the wealth index from lowest to the highest. The data is then grouped into 5 equal portions. For example, if the sample size is 1,000, there will be 5 portions each comprising 200. These portions are called wealth quintiles. Each wealth quintile represents households whose living conditions are approximately the same, hence can be described using a single terminology such as '*poorest*', '*poor'* etc.

In this research on "Analysis of Household Socio-Economic Drivers of Cattle Grazing and Grass Harvesting in Mount Kenya West Protected Forest, Kenya", it was important to establish household socio-economic status (SES). To construct SES, total income and expenditure, total land size and ownership of zero-grazing, cattle shed, hay structure, water tanks, watering troughs, milk containers and functional biogas were used. Using SPSS program, the data of the variables from a sample of 453 smallholder farmers was used to compute a wealth index. The data was then ranked based on wealth index from smallest wealth index to the biggest. The data was then divided into 5 quintiles, approximately 91 farmers each (435/5=90.6). The first (lowest) quintile was described as '*Poorest*', the second quintile was described as '*Poorer*', the third quintile was described as '*Poor*', the fourth quintile was described as '*Less poor*' while the fifth quintile was described as '*Least poor*'. This variable was then coded as 1= *Poorest, 2= Poorer, 3= Poor, 4= Less poor* and 5= *Least poor* and used a categorical variable in conducting logistic regression analysis.

3.9.3 Model description of logistic regression

Logistic regression is a regression model where the dependent variable is categorical in nature. The logistic function is used to predict the probability of membership into a given category based on a set of independent variables. The independent variables can take

different measurement scale. According to Park (2013), there are three types of logistic regression models depending on the number of values the dependent variable can take. In binary logistic regression, the dependent variable takes only two possible outcomes such as Male-Female or Yes-No among others. Multinomial logistic regression is a model used when the dependent variable has three or more possible outcomes such as 'Blue-Red-Yellow'. The output values in a multinomial logistic regression model do not appear in any specific order. Ordinallogistic regression is a model used when the dependent variable has three or more possible outcomes such as 'Agree-Strongly-Agree-Disagree'. The output values in an ordinal logistic regression model have a connotation of ordering in that the responses are ordered. In this study, binary logistic regression model was used because the dependent variable (*forest dependence*) had only two possible outcomes. Forest dependence was defined in two ways based on the specific activities carried out by the farmer. First, grazing levels where a farmer could either graze in the forest throughout the years implying high forest dependence or graze in the forest only during dry seasons implying low forest dependence. Second, grass harvesting levels where the farmer could cut throughout the year from the forest implying high forest dependence or cut grass only during dry season implying low forest dependence.

To model a binary logistic regression for forest dependence Y (0 or 1), $\mathrm{E}(Y) = \mathrm{P}(Y = 1)$, the dependent variable Y is transformed into a logit form which describes the probability of presence of the character of interest, in this case is high forest dependence. Thus,

$$\mathrm{logit}(p) = \beta_0 + \beta_i X_i$$

Where $\mathrm{logit}(p) = \ln\left(\frac{p}{1-p}\right)$ which is a log of the odds for success and $\beta_i X_i$ describes a linear combination of a set of household socio-economic factors used as drivers of forest dependence.

The logistic regression model was used as an analytical model for the objective areas on determining significant drivers of forest dependency. To assess the significance of household characteristics in driving smallholder farmers dependence on protected forest for pasture in West Mount Kenya, a null hypothesis was made that household socio-economic characteristics has no significant effect on forest dependency for pasture. Three sequential logistic regression models were produced labeled 'model 1, model 2, and model 3'. Model 1 presents summary results of relationship between forest dependency for pasture and the first

2 predictor namely gender and household size. Model 2 presents the results of model 1 after adding household SES in the model while model 3 shows the final logistic model results for previous 2 models after addition all other factors outlined.For each of the sequential model produced, take note of model coefficients (β_i) and marginal effectsdy/dx. According to Meyer, Van and Beugelsdijk (2017), Fisher (1925) suggested, somewhat arbitrarily, using p = 0.05 as the most appropriate cut-off level in hypothesis testing (Meyer et al., 2017). The study further noted that advances in statistical methodologies and practice emerged to report p-values (particularly p = 0.10, p = 0.05, and p = 0.01) with respect to p=0.05 benchmark (e.g., p = .05), and to indicate the significant estimates with *, ** or *** (Meyer et al., 2017). The confidence levels of a regression coefficients and hypothesis testing were evaluated at 95% (p=0.05) or 90% (p=0.1) confidence levels depending on the nature of association presented by the p-value.If $p<0.05$ reject the null hypothesis with reference to the coefficient β_i in the logistic model. A positive dy/dx in the marginal effects model shows that the driver increases forest dependency while a negative driver shows that a driver reduces forest dependency.

To assess the significance of household characteristics in driving smallholder farmers dependence on protected forests for grass harvesting for livestock fodder in West Mount Kenya, a null hypothesis that household socio-economic characteristics has no significant effect on forest dependency for grass harvesting. Three sequential logistic regression models are produced labeled ‘model 1, model 2, and model 3’. Model 1 presents summary results of relationship between forest dependency for grass harvesting and the first 2 predictor namely gender and household size. Model 2 presents the results of model 1 after adding household SES in the model while model 3 shows the final logistic model results for previous 2 models after addition all other factors outlined. For each of the sequential model produced, take note of model coefficients (β_i) and marginal effectsdy/dx. If $p<0.05$ reject the null hypothesis with reference to the coefficientβ_i in the logistic modelA positive dy/dx in the marginal effects model shows that the driver increases forest dependency while a negative driver shows that a driver reduces forest dependency.

3.9.4 Conducting logistic regression models

Regression analysis is used to study the relationship between a set of independent variables and a dependent variable. Logistic regression analysis is a special form of regression analysis

which is applied if and only if the dependent variable is a binary variable. A binary variable is a variable that has only two possible outcomes e.g., Gender (0=*Male, 1=Female*), etc. In this study, dependence on forest was the dependent variable which was binary variable defined in two forms, that is, for farmers involved in grass cutting (1 = relies on grass cutting during most months of the year, and 2 = relies on grass cutting ONLY during dry seasons months of the year only) and for farmers involved in cattle grazing (1 = relies on forest for pasture during most months of the year, and 2 = relies on the forest for pasture ONLY during dry seasons months of the year only)

The independent variables used in this study were gender, household size, education level, SES wealth index, proximity to the forest, total land size, proportion of land under fodder production, own zero-grazing unit, number of cattle in a homestead and proportion of cattle in zero-grazing unit. The study had only one dependent variable defined as forest dependency; however, two logistic regression models were conducted one for involvement in grass cutting and the otherfor cattle grazing. To conduct a logistic regression analysis in SPSS, a researcher selected 'binary logistic' option under regression analysis options. The researcher proceeded to declare the dependent variable and a set of independent variables (may be one or more) in the appropriate boxes. Before running the logistic regression, the researcher declared the categorical variables in this study. "Education Level" and "SES wealth index" were specified categorical variables.

The above approach produces final results ofthe logistic regression model, treating each independent variable as equal. However, in cases where we would like to give priority to some specific variables, sequential logistic regression becomes critical. Every sequence produces its own independent results. In this study, the researcher conducted 3-level sequential logistic regression analysis. The first sequence was conducted by entering the first three variables namely gender, household size and education level, and the researcher named this 'Model 1'. The second sequence involved adding SES wealth index in the model and named this 'Model 2' while the third and last sequence involved adding the rest of the variables namely proximity to the forest, total land size, proportion of land under fodder production, own zero-grazing unit, number of cattle in a homestead and proportion of cattle in zero-grazing unit and named this 'Model 3'.

Conventionally, a logistic regression model is useful in identifying independent variables that are significantly related to the dependent variable. This conclusion is arrived at by looking at the *p-values* associated with each of the independent variable. This is very important information, but it does not provide a comprehensive understanding of '*by how much*' is each independent variable related to the dependent variable. To understand '*by how much*' does each of the independent variable is associated with the dependent variable; a marginal effects model was conducted. A marginal effects model is a continuation of the logistic regression model analysis rather than an independent methodology. For ease of interpretation, the coefficients of the marginal effects model can be converted into percentages. This way, we can explain the '*by how much*' does the dependent variable either increase or decrease by a unit increase in the independent variable, holding other factors constant. A positive coefficient in the marginal effects model shows that when an independent variable is increased, a dependent variable increases proportionally. On the other hand, a negative coefficient in the marginal effects model shows that a unit increase in the independent variable causes a reduction in the dependent variable proportionally.

3.9.5 Reliability and validity

Prior to the commencement of field work, the study instrument was pretested and revised to check if the questions really captured what they were meant to measure. The questionnaire was pre-tested using 46 farmers involved in cattle grazing and grass harvesting in the Aberdare ecosystem forest blocks in Nyeri County. The farmers who participated in the pre-test were identified through snowballing and were excluded from the main survey. Data collected during the pre-testing stage was analysed for evaluation of item reliability and validity. According to Bonett & Wright (2015), Cronbach's alpha value of at least 0.7 and above indicates a satisfactory level of internal reliability while an alpha value of below 0.7 makes the scale to be considered unreliable. Reliability assessment of questionnaire items provides "Cronbach's alpha if item deleted" which informs the researcher on the new Cronbach's alpha in case a given questionnaire item is deleted. To improve reliability of some of items, the following actions were taken based on individual item's content and construct validity. First, the initial tool had several questions on the Likert scale with response categories, but these were removed to emphasize on getting the facts. The initial tool also had questions on climate and energy which were dropped because the pilot confirmed that they were not relevant to the research objectives. The researcher adjusted the

sentence structure after the pilot and all the questionnaire items were re-structured into short and simple statements. It was observed during the pilot that questionnaire items with compound statements therein posed challenges to the respondents. A simple and straightforward sentence structure was adopted as a means of improving construct validity of individual test items. The words that seemed to be unfamiliar within the context of smallholder farmers in Mt Kenya West were removed and replaced with words that resonated with the specific context of the study. The purpose of adopting alternative terms was to eliminate possible linguistic ambiguity to eliminate error in the data collected.

3.9.6 Secondary data collection and analysis methods

To examine seasonality patterns on smallholder dependence on the protected forest in the Mt Kenya West region for pasture, the researcher obtained monthly records of the number of cattle grazing in the protected forest from January 2013 to December 2018. Monthly records were obtained from KFS for each block. The data was sorted using MSExcel Spread sheet while missing data points were filled with the help of KFS forest reserve officers who retrieved from older catalogues and accurately filled. Data was entered into MSExcel and analysed for seasonality patterns using time series analysis. Time series uses seasonality and random components in the analysis of time series data, making the data stationary (Park et al., 2007). Making time series stationary is a statistical technique of accounting for the recurring patterns in the data over the period under investigation, in this case, the 6 years period. The research followed the decomposition method of aggregating monthly data to create annual data. This decomposition method is important in making the time series data smooth by minimizing data aggregation which transforms monthly data into annual data. To analyse seasonality patterns, the months were averaged to give an averagely 12 month long repeating pattern.

3.9.7 Qualitative data collection and analysis methods

To examine the perceptions of the smallholder farmers towards the use of a ban to regulate access to protected forest for pasture, the researcher conducted a follow-up in-depth interview with 234 smallholder farmers which was purposive design. The sample of 234 participants was drawn from the 453 contacted during the first round of quantitative data collection and who expressed interest in being re-contacted for an in-depth survey. The sample for the in-depth survey comprised 131 males and 103 females. The sample comprised 66 from Chehe,

54 from Hombe, and 114 from Kahurura, respectively. In-depth interviews sought to understand farmer perceptions towards a ban on cattle grazing in the protected forest, and what participants thought would be household ways of coping with a ban in cattle grazing.

a) Qualitative data collection, recording and transcription

In the follow-up of the quantitative study, a short in-depth interview was conducted. The interview guide comprised two main questions: "What are your perceptions towards a KFS forest management strategy that included a ban on livestock grazing? How would the ban affect the livelihood of your household?" and "How would your household cope with a KFS ban on livestock grazing in the protected forest?" The research assistants who carried out this exercise were trained to observe the qualitative interviewing guidelines proposed in qualitative research (Kvale, 1994) which include avoiding the use of leading questions, debriefing of the participant before the interview and debriefing at the end of the interview and ensuring the interview remains more of a conversation. The research assistant introduced himself and held a brief conversation with the participants before the interview to make them comfortable. Since the participants were farmers, some interviews took place at their home or in their fields. They also sought participants' permission to record the interview and explained to them how the data was going to be analysed and reported. Once the participants were comfortable the researcher asked the two questions. On average it took 20 minutes for each interview. After the interview was done, the researcher stopped the recording tape then the debriefing process would begin. The participants were asked if they had questions and any clarifications to be made. In addition, the researchers were observant of any subtle behaviours and reactions of the participants.

The participants' responses were recorded verbatim in theirvernacular language and almost all participants gave their responses in their first language, which is Kikuyu. The participants' responses to the first question varied by forest block as well as by gender and age. An observation in the field indicated that most of the participants were surprised by the first question and pausedfor a while before narrating how such a ban would impact the livelihoods of their households. After the completion of the interviews, a standard data transcription grid was used to record farmers' voices verbatim in written form.

The grid used helped in recording the responses in a consistent manner for each question asked across the three forest blocks. Participants were assigned pseudo codes to enhance anonymity of data while maintaining data integrity and reducing the chances of mixing them up during the data analysis process. After the first transcription, the second stage of data transcription took place, which involved translating the Kikuyu scripts into English. At this stage, the researcher observed due diligence to ensure that the translated work did not mute the respondent's voice in any manner. Due diligence during data transcription and translation ensured the work reflected the opinion of the participants and not that of the researcher (Austin & Sutton, 2014).

b) Reliability and validity in qualitative research

The protocols of qualitative research insist on ensuring that the work depicts a high level of reliability and validity. Reliability in research is concerned with consistency, repeatability and stability of the participants' responses and the ability of the researcher to collect and record information accurately. It is important to note that validity has to do with accuracy and truthfulness of research findings. The results should represent the participants' reality and this representation of reality should be applicable across groups (Brink, 1993). In qualitative research, reliability and validity are represented with terms such as credibility, trustworthiness, truth, applicability consistency and conformability (Brink 1993; Lincoln & Guba, 1985). Threats to validity and reflexivity may arise from the researcher, the participants, the situation or social context, and the method of data collection and analysis. The researcher may introduce bias if the participants do not trust him or her, thus the researcher must interact with the participants so that they become free.

The research assistant who helped in data collectedwas drawn from the same locality as the study respondents. During the interview process, the research assistant ensured friendliness and adequately briefed the participants to ensure that they (respondents) were comfortable and free to give their honest opinions. During analysis, the researcher exercised self-reflexivity through bracketing his own experiences, assumptions, and opinions about the subject matter to ensure the participants voices were heard (Brink, 1993, Lincoln & Guba

1985, Austin & Sutton, 2014). Self-reflexivity is in relation to the researcher's experience with the topic, expectations, and relationship with the participants especially regarding power differentials and ethical concerns (Gilgun, 2014).

After developing the initial codes of data analysis, the researcher discussed them in detail with one of the thesis advisors before embarking on a full coding process. To fully represent the participants' multiple realities, the researcher used thick description from the texts to support the different interpretations and dimensions found in research (Gilgun, 2014). Another tool to increase validity and reliability is through member checking. Member checking allows the researcher to correct errors of translation, and to check whether what was transcribed reflects participants' intentionality (Guba & Licoln 1985). The researcher shared some of the transcriptions and findings with the participants to get a glimpse of their reaction and feedback.

c) Content analysis of qualitative data

The researcher used the content analysis method, which researchers use to generate frequencies in quantitative data, generate categories in qualitative data, and at other times combine both features of quantitative and qualitative frequencies and categories (Hsieh & Shannon 2005; Berg & Lune 2012). This study identified frequencies within the categories. The unit of analysis was the participants; each with a short story on what they thought would be the impact on their household if cattle grazing in protected forest was banned and the measures, they would take to mitigate such impact on their household. A total of 41 stories weighted across the sample strata were used for initial categories: Cheche (11 stories); Hombe (10 stories); and Kahurura (20) stories. These stories were chosen using systematic random sampling. In addition, for each sample strata two to three extreme and negative cases were added.

There were two coding cycles. The first cycle was to identify initial categories, then these categories were uploaded in an excel spread sheet and more codes were added in the process of coding. The second coding cycle was to combine the codes generated in the first cycle to identify categories. According to Tracy (2013), the first cycle is to describe the data and the second cycle is to organize the codes into categories. For research question one, the initial

codes were 28 and in the first cycle, six more codes were added to 34. For the second research question, the initial codes were 23, and in the first cycle, three more codes were added, making them 26. Since the stories were short, all stories were coded, and those with thick descriptions identified. The researcher sought disconfirming evidence to avoid forcing stories into categories. The codes, categories and coding procedures were peer reviewed and discussed in detail to enhance credibility. In developing categories, the researcher used Strauss and Corbin's (1998) method of constant comparison, where codes and incidences are compared. In the first coding cycle, the researcher used the inductive coding method while in the second coding cycle; the researcher used deductive coding derived from the sustainable livelihood framework to group the codes into categories.

3.10 Ethical issues in research

The researcher obtained a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). The permission to collect data was obtained from the Nyeri County Education office and the County Commissioner. During the actual process of data collection, the researcher presented and explained fully the content of the letter of consent to all the participants every time before the actual data collection exercise. Respondents were informed in advance that they could answer voluntarily without force or coercion. Through this letter, the researcher clearly explained the purpose and objectives of the research. This created the necessary atmosphere for rapport building. Participants were helped to understand the nature of the research as well as their personal responsibility and the possible impacts the research may have in future on the respondents. The researcher ensured that the participants input their signatures voluntarily on the consent forms as an indicator of their willingness to participate in the entire process of data collection.

Further, another ethical consideration during the study involved the process of enhancing and assuring the confidentiality of the data provided by the respondents either through the questionnaire or interview recording. Consent was sought before the interview commenced and those who declined were not interviewed. Apart from confidentiality of data, anonymity and privacy of the data collected were clearly observed. The data collected was not disclosed to other respondents or to other individuals. Consequently, in writing this thesis, the data collected from the participants were not attributed to any specific participant but was analysed using identification codes to ensure anonymity.

3.11 Chapter Summary

The chapter has elaborated on the philosophical foundation informing research design and noted that there three major philosophies of rural community development, namely resource access, resource pooling and livelihood transformation. This chapter also presented the mixed method research design that was used in the collection and analysis of both quantitative and qualitative data as well as the dependent, independent and control variables ofthe study. The chapter also focused on the data collection, transcription, translation, analysis and general handling procedures in view of ethical considerations and the maintenance of validity and credibility expectations.

CHAPTER FOUR

RESULTS AND INTERPRETATIONS ON HOUSEHOLD FACTORS INFLUENCING FOREST DEPENDENCY

4.1 Introduction

This chapter presents the findings of the study and their interpretations. The chapter starts by giving the relationship between smallholder farmer's household socio-economic characteristics and dependence of protected forest for pasture. The chapter then outlines the demographic information of respondents and presents the descriptive statistics for cattle grazing and grass harvesting. Further, the chapter focuses on farmer's perceptions on affordability of different sources of cattle feeds, and goes on to give detailed results, analysis and interpretation on logistic regression and marginal effects for forest pasture and grass harvesting activities indicating the relationship between household socio-economic characteristics and forest dependence as well as the results, analysis, and interpretation of seasonality patterns for pasture. Finally, the chapter concludes by presenting the perception and coping mechanisms of respondents towards grazing regulation through a ban.

4.2 Demographic Information of Respondents

The four types of demographic data collected from smallholder farmers who participated in this study weregender, age, marital status and education level attained. The gender distribution of the farmers was 60.9% maleand 39.1% female. The age of farmers was approximately normally distributed between 20 and 83 years with the majority (60.7%) aged between 41 and 60 years as presented inTable 4.1. Regarding marital status, farmers were classified into three groups; single (never married), married and widowed and the distribution was as follows: 82.3% were married; 8.2% single and 9.5% widowed. On education level attained, farmers were classified into four distinct groups: no formal education; primary; secondary and post-secondary, with 8.4% having had no formal education, 44.2% having primary education, 39% with secondary education and 8.4% with post-secondary education.

Table 4.1: Demographic Information of Respondents

Demographic Characteristic	Frequency	Per cent
Gender		
Male	276	60.9%
Female	177	39.1%
Age (years)		
20 – 30	7	1.5%
31 – 40	69	15.2%
41 – 60	275	60.7%
61 & above	102	22.5%
Marital Status		
Married	373	82.3%
Single	37	8.2%
Widowed	43	9.5%
Highest Education Level		
No formal education	38	8.4%
Primary	200	44.2%
Secondary	177	39.1%
Post-secondary	38	8.4%

Source: Author's survey data

To further understand the demographic characteristics of respondents, a frequency table with specific forest block was conducted and results presented in Table 4.1, whereby Hombe and Kahurura had a higher representation of female farmers at 44% while Chehe had the smallest representation of female farmers at 28.5%. Chehe had the highest proportion of younger farmers while Hombe and Kahurura forest blocks had higher proportion of farmers who were fairly aged. Marital status was fairly distributed across the three forest blocks. The proportion of farmers who were married ranged between 77.5% and 86.6% and for singles, it was between 3.4% in Kahurura and 12.6% in Chehe forest block while farmers who were widowed ranged between 8.5% in Hombe and 10.1% in Kahurura. Kahurura forest block had the highest proportion of farmers with primary education at 71.8% while Chehe has the smallest proportion of farmers with primary education at 34.4%. In addition, Chehe has the highest proportion of farmers with secondary and post-secondary education at 50.3% and 15.2% respectively while Kahurura had the smallest proportion of farmers with secondary and post-secondary education at 26.2% and 2% respectively. In Hombe the proportion of farmers with primary education was at 51.6% and those with secondary and post- secondary education stood at 40.5% and 7.8 % respectively.

Descriptive statistics for cattle grazing and grass harvesting

This section presents descriptive statistics of key indicators in the sample such as proximity to the forest (in minutes), total size of land owned (in acres), proportion of land under fodder, number of cattle in the homestead and proportion of cattle under zero-grazing. In reference to Table 4.2relevant discussions regarding farmers involved in cattle grazing and/or grass harvesting arealso presented.

Table 4.2: Description of the sample that participated in the survey (n = 453)

	CHEHE - (n=151)	HOMBE –n =153	KAHURURA –n= 149
VARIABLE	MEAN ± SD/ (%)	MEAN ± SD/ (%)	MEAN ± SD/ (%)
Household size	4.17 ± 1.58	4.03 ± 1.47	4.32 ± 1.76
Household SES			
Poorest	0.70%	9.80%	50.30%
Poorer	4.60%	36.60%	18.80%
Poor	22.50%	21.60%	15.40%
Less poor	31.80%	20.30%	8.10%
Least poor	40.40%	11.80%	7.40%
Graze in the forest most part of the year (YES)	48.30%	77.10%	67.10%
Household relies on Grass harvesting for the better part of the year (YES)	87.20%	32.70%	43.90%
Size of Land Owned	1.02 ±0.94	1.74 ± 1.56	1.22 ± 1.49
Proportion of Land under Fodder Production	26%	17%	16%
Number of Cattle in a Homestead	5.08 ±3.40	5.56 ± 4.36	4.89 ± 5.27
Proportion of cattle under zero-grazing	41%	17%	12%
Proximity to Forest	46.12 ±31.41	29.02±29.49	26.09±21.71
Household has invested in zero-grazing unit (YES)	81.50%	36.20%	22.60%
How many months in a year farmers graze in the forest	10.0±2.1	10.5±1.4	10.2±2.1
How many months in a year grass is harvested from the forest	9.5±2.72	5.3±3.51	6.5±3.99
Farmers with rented land for fodder production	23.1%	7.5%	6.8%
Size of land rented for fodder production (acres)	1.1±4.24	0.5±0.52	0.9±1.39
Approximate quantity (number of 50 kg bags) of grass obtained from the forest per month	36.4±25.6	63.0±74.15	36.0±27.31
Number of mentions in involvement in grass value addition activities by grass harvesting farmers	40	2	20
Is the grass obtained from the forest used to make silage? YES	1.6%	1.9%	4.5%
How many bags of fodder are produced per acre (dry season)	9.7±8.92	-	100±133.42
How many bags of fodder are produced per acre (dry season)	19.4±31.40	-	42.5±71.82

Source: Author's Survey Data (2019)

a) Household Size

The average household size of smallholder farmers living in the neighbourhood of Mt Kenya West protected forest was an average of 4 persons with the highest being Kahurura (*M=4.32, SD=1.76*) with a range of between 1 and 10 persons followed by Hombe (*M=4.03, SD=1.47*) with a range of between 2 and 10 persons. The results show that Chehe had the smallest

household size on average (*M=4.17, SD=1.58*) with a range of between 1 and 8 persons as presented in Table 4.2. Differences in household size were not statistically different considering the mean of household size ($F_{2, 451} = 1.23$, $p=0.29 > 0.05$) among the forest blocks. According to the Kenya Population and Housing Census and Kenya National Bureau of Statistics (KNBS, 2019) the average household size in Kenya is 4.4 persons, with urban populations having a smaller household size of 3.5 persons while the rural population has an average of 4.7 persons. While the average household size for Chehe, Hombe and Kahurura was in tandem with the national household average, it was significantly lower compared to the rural household average size. The implication of these results is that the region is not densely populated compared to other rural regions where the average household sizes are significantly higher than the national averages.

b) Level of dependence on forest for cattle pasture

Table 4.2shows that the highest proportion of smallholder farmers reported cattle grazing in the forest and were distributed among the blocks as follows; Hombe (77%), followed by Kahurura (67%), and the least being Chehe (48.30%) then this indicates that forest dependence for cattle grazing was higher in Hombe and Kahurura compared to Chehe. It is imperative to note that these results are supported by the analysis in the same Table 4.2which also shows that Hombe farmers had the highest number of cattle in the homestead at 5.56. Chehe had the lowest number of cattle in the homestead at average of 5.0, indicating the least grazing pressure in the forest for the better part of the year. A similar study conducted in Iran on livestock grazing in protected areas and its effects on large mammals in the forest found that grazing dependence by more than 66% of the population in the protected areas amounted to high grazing intensity (Soofi et al., 2018). According to the study, evidence of high grazing intensity in protected forests urgently requires priority actions in assessment of grazing capacities, allocation and enforcement of grazing quotas, and better coordination between governmental conservation and natural resource management organizations (Soofi et al., 2018). Going by the conclusions drawn by Soofi et al. (2018) it can be concluded that the high grazing intensity in Hombe and Kahurura forest blocks (77% and 67%, respectively) calls for pragmatic steps by the KFS and other stakeholders within the forest management structure to contain the impending forest depletion.

c) Level of dependence on forest for grass harvesting

The practice of grass harvesting involves individuals gaining legal access to the forest, cut and carry grass for use as animal feeds. While this may slightly differ from direct cattle grazing in the forest, it is essentially the same since it amounts to the utilization of forest resources for livestock sustainability. The resultshowed that Chehe forest block had the highest proportion (87.2%) followed by Kahurura at 43.9% and the least was Hombe at 32.7% of farmers harvesting grass from the forest. Further, this study revealed a close relationship between the number of zero-grazing units and the level of grass harvesting from the forest. The direct proportionality is that the forest block with the highest proportion of farmers with zero-grazing units also had the highest number of those who harvested the most grass.

Currently, there is limited empirical literature that directly examines grass harvesting as an independent NTFP activity in the context of rural community sustainability but the study by Soofi et al., (2018) provides useful insights to the implications of the findings in this subject. As earlier discussed earlier, dependence by over 66% of the community on forest resources for their sustainability suggests a possible overreliance (Soofi et al., 2018). With the findings of this research indicating a possible overreliance on grass harvesting by farmers in the proximity of Chehe forest block, there is need for a robust and sustainable, yet community responsive, forest management design as proposed by Soofi et al. (2018).

d) Total size of the land owned by farmers

The results presented in Table 4.2indicate that on average, farmers in Hombe forest block had the biggest land size (*M=1.74, SD=1.56*) with range of between of 0.13 and 12 acres, (an average of 1.74 acres) followed by Kahurura forest block (*M=1.22, SD=1.49*) with a range of between 0.6 and 11 acres (an average of 1.22 acres) while farmers in the Chehe forest block had the smallest land sizes (*M=1.04, SD=0.91*) ranging between 0.12 and 5 acres (an average of 1.02 acres). However, earlier results under Table 4.2indicated that the proportion of land under fodder production was highest in Hombe at 26% despite the forest block having the lowest average acreage. This is also supported by the high level of investment in zero-grazing unit where Hombe was at 81.5 % which was the highest compared to the other blocks which had 36.2% and 22.6% for Hombe and Kahurura respectively. Differences in the size of land

owned by farmers was a significant factor across the three forest blocks ($F_{2, 451} = 11.14$, $p=0.00 < 0.05$).

Work done by Xia et al., (2020) reported a significant inverse relationship between land size and the number of livestock per hectare. The inverse relationship is explained by negatively correlating labour input intensity with land size which is used to show how labour input intensity varies with farm size (Uleri, 2019). The current research has shown evidence of ownership of small pieces of land across the three forest blocks. The implication of these results in the context of the similar studies in other parts of the world reveals that small pieces of land do not necessarily lead to lower productivity. In fact, the evidence of inverse relationship between land size and productivity in the livestock sector imply that most farmers in Mt. Kenya West who have smaller pieces of land have the potential for high livestock productivity if they find more modern and innovative livestock rearing approaches and methodologies.

e) Proportion of land under fodder production

The proportion of land under fodder production is a percentage of a farmer's land that is utilized for the purpose of producing fodder. The results presented in Table 4.2revealed that farmers in the Chehe forest block allocated the highest proportion of their land for fodder production at 26%. This means that theaverage farmer in Chehe set aside about a quarter of their land for fodder production. This was followed by farmers in Hombe at 17% while farmers in Kahurura forest block set aside on average 16% of their land for fodder production. The Chehe block seemed to have invested a lot in zero-grazing units at 81.5 % being the highest as evidenced by Table 4.2. Differences in the proportion of land under fodder production was statistically significant across the three forest blocks ($F_{2, 451} = 11.28$, $p=0.00 < 0.05$).

Dagar (2017) conducted a study on the potentials for fodder production in degraded lands in New Delhi. The study acknowledged that in the modern world, we have limited arable land to produce food crops hence cannot spare it for production of fuel wood, fodder, and other products (Dagar, 2017). This may partly explain why most farmers could hardly set aside a significant portion of their land for fodder production purposes and this can be confirmed by the findings of this study (Chehe 26%, Hombe 17% and Kahurura 16%). Additionally, the

study found that fodder production in the country varied widely, and its utilization depended on the cropping pattern, climate, socio-economic conditions and type of livestock (Dagar, 2017). The implication of the findings to the livestock sector in Kenya is that the size of land under fodder production is not the only factor in the successful production of fodder. Instead, other factorssuch as cropping patterns and quality of fodder crops can be considered to improve fodder production and reduce overreliance on forest pasture.

f) Number of cattle in the homestead

The findings shown on Table 4.2indicate that the number of cattle kept in a homestead in Chehe ranged from 1 to 15 cattle with an average of 5 cattle (*M=5.08, SD=3.40*) per homestead while that in a homestead in Hombe ranged from 1 to 30 cattle with an average of 6.0 cattle (*M=5.56, SD=4.36*) per homestead. The number of cattle kept in a homestead in Kahurura ranged from 1 to 50 cattle with an average of 5 cattle (*M=4.89, SD=5.27*) per homestead. The results indicated that Hombe had the highest number of cattle at 5.56 followed by Chehe at 5.08 and the least was Kahurura at 4.89. The highest number of cattle in Hombe is consistent with the high grazing pressure noted in Hombe, as indicated in the records (KFS, 2019). Differences in the number of cattle in the homestead across the three forest blocks was not statistically significant ($F_{2, 451} = 0.93$, $p=0.40 > 0.05$).

A previous study by Adhikari et al. (2003) in Nepal noted that the number of cattle in the homestead was a significant driver of forest dependence. However, the findings obtained by Adhikari et al. (2003) did not concur with the findings of this study. The implication of these findings is that high number of cattle in the homestead only increases the cost of production, increases pressure on protected forest but does not increase productivity or improve animal quality.

g) Proportion of cattle under zero-grazing units

As presented in Table 4.2, 41% (*M=0.41, SD= 0.41*) of cattle in the Chehe forest block were kept under zero-grazing units while 17% (*M=0.17, SD= 0.32*) of cattle in Hombe and 12% (*M=0.12, SD=0.17*) of cattle in Kahurura were under zero-grazing units. This suggests that most farmers in Chehe had embraced zero-grazing practices, making most of them to keep a significant proportion of their cattle under zero-grazing compared to those in Hombe and

Kahurura. The differences in the proportion of cattle under zero-grazing were statistically significant across the three forest blocks ($F_{2, 451} = 31.66$, $p=0.00 < 0.05$). The results are consistent with earlier results in Table 4.2that indicated that levels of forest dependence of grass indicate that Chehe was the highest at 87.2 %.

h) Proximity to the forest boundary

The proximity from individual farmer's residence to the nearest forest boundary was measured in terms of the time taken to walk from home to the forest boundary in minutes. Evidence on Table 4.2 showed that farmers in Chehe took between 2 minutes and 140 minutes to walk to the forest with an average of 46 (*M=45.96, SD=31.23*) minutes. Farmers in Hombe took between 2 minutes and 180 minutes to walk to the forest with an average of 29 (*M=29.02, SD=29.49*) minutes while those in Kahurura took between 1 minute and 120 minutes with an average of 26 (*M=26.09, SD=21.71*) minutes. Farmers in Chehe took the longest period that is 46 minutes to access the forest followed by Hombe (29 minutes) and then least being Kahurura 26 minutes). The challenge to access the Chehe forest may be attributed to the existence of cash crops and the location of the forest's main entrance in relation to where majority of the farmers lived. Hombe had the highest number of animals as indicated in Table 4.2, therefore ease of access may have contributed to the likelihood of farmers grazing in the forest for the better part of the year which was at 77.1% followed by Chehe at 67.1%. Differences in proximity to the forest boundary was statistically significant across the three forest blocks ($F_{2, 451} = 22.38$, $p=0.00 < 0.05$).

i) Investment in zero-grazing units

It was found that some farmers had invested in zero-grazing units in their homestead. As shown in Table 4.2, Chehe had the highest number of households that had invested in a zero-grazing unit at 81.5 % followed by Hombe at 36.7% while Kahurura had the least at 22.6%. It can be deduced from these observations that establishment of zero-grazing units tends to reduce cattle grazing in protected forest by direct cattle grazing but increases forest dependence on pasture through grass harvesting. Investment in zero-grazing is an expensive and costly venture. It is not surprising that Chehe had the least high poor participants also had the highest number of households who had invested in zero-grazing units at 81.5%.

j) Number of months farmers graze in the forest

It was found that 67% of farmers interviewed grazed in the forest with 96% of them indicating that they grazed in the forest for the greater part of the year while only 4% said they grazed in the forest during dry seasons only. This implies that the number of months in which farmers grazed in the forest varied individually and also across the different forest blocks. Overall, the average number of months of grazing in the forest was 10.3 months (*M=10.3, SD=1.84*) with a minimum of 2 months and a maximum of 12 months. As presented in Table 4.2, the average number of months of grazing in Chehe forest was 10 months (*M=10.0, SD=2.1*), 10.5 months in Hombe (*M=10.5, SD=1.4*) and 10.2 months in the Kahurura forest block (*M=10.2, SD=2.1*). These results suggest high forest dependence in all the three-forest blocks, with the highest being in the Hombe forest block since the average number of months of forest grazing is 10.5, higher than the overall average of 10.3 months.

A study similar to this research was conducted by Alcañiz at al. (2020) to understand the effects of prescribed fires and livestock grazing on soil chemical properties in Tivissa. The study contended that while livestock grazing has generally been perceived as negative due to problems of overgrazing, under-grazing is in fact more of a problem in the Mediterranean. The heavy grazing of woody vegetation in the Mediterranean region constitutes one of the most efficient management techniques for preventing fire and maintaining habitat diversity (Alcañiz et al., 2020). The implication of the results of high dependence on protected forest by means of livestock grazing in Mt Kenya did not necessarily result in negative impact on the forest. In fact, the high forest dependence on livestock grazing can be used as an effective forest management strategy provided the dependence level does not lead to overgrazing. This can be done by carefully monitoring forest carrying-capacity of each forest block on a regular basis by the KFS team in the region.

k) Number of months farmers harvest grass from the forest

It was found that 54% of the farmers interviewed harvested grass from the forest, with 64% of them indicating that they harvested grass from the forest almost throughout the year while only 36% said they did so only during the dry seasons. This implies that the number of months in which farmers relied on grass harvesting from the forest varied individually and

also across different forest blocks. Overall, the average number of months of grass harvesting from the forest was 7.8 months (*M=7.8, SD=3.73*) with a minimum of 1 month and a maximum of 12 months. As presented in Table 4.2, the average number of months of grass harvesting from the Chehe forest was 9.5 months (*M=9.5, SD=2.72*), 5.3 months from Hombe (*M=5.3, SD=3.51*) and 6.5 months from the Kahurura forest block (*M=6.5, SD=3.99*).

These results suggest high forest dependence on grass harvesting in all the three-forest blocks, with highest being in the Chehe forest block since the average number of months of grass harvesting is 9.5 which is higher than the overall average of 7.8 months. Earlier studies (Forti et al., 2020; Cosarinsky at al., 2020) that examined the issues of grass harvesting focused primarily on the impact of grass harvesting on forest soil structure rather than socio-economic and livelihood dimensions of grass harvesting. The implication of the results of this study, therefore, introduces a new paradigm in scholarly literature on the importance of examining the impact of grass harvesting on the forest sustainability of local communities.

l) Proportion of farmers with rented land for fodder production

Farmers were asked ifthey had rented land for fodder production purposes. Overall, only 12.5% of the farmers interviewed indicated that they rented land for fodder production. The results presented in Table 4.2showed that 23.1% of farmers in the Chehe forest block had rented land for fodder production as well as 7.5% in Hombe and 6.8% in Kahurura, respectively. The results showed that, in general, there was a small number of farmers with rented land for fodder production purposes in Mt Kenya West. While Chehe had the highest proportion of farmers with rented land at 23.1%, this number was still less than a quarter of the whole population. Similarly, the proportion of farmers with rented land for fodder production was less than 10% for the two biggest forest blocks namely Hombe and Kahurura as suggested by the results in Table 4.2.

A study on land tenure issues was conducted in Austria to examine whether ownership status of agricultural land determined farmers' soil use behaviour (Leonhardt et al., 2019). The study revealed that the negative effect of rental on investments appeared to be more robust for sharecropping arrangements than for cash rental, although evidence was not fully

conclusive, and impacts may depend on supervision by landowners. The study by Leonhardt et al., (2019) noted that the effects of rented land on investments appeared to be more pronounced where rental was insecure and/or short-term. The implication of these results in the context of this earlier literature is that thereis a plausible explanation why few farmers would rent land for the purpose of fodder production. In fact, this confirms the field experiences where individuals who rented land for fodder production did so for commercial purposes and not primarily for feeding their livestock.

m) Size of land rented for fodder production

The farmers who indicated that they had rented land for fodder production were asked to indicate the size of land rented in acres. The study found that on average, the land size was 0.96 acres. However, this parameter was characterized with high variations because some farmers had rented big tracts of land while others had rented just small pieces of land. For instance, some farmers had rented 0.1 acres while others had rented from 2 to as high as 25 acres of land. As presented in Table 4.2, the average size of land rented by farmers in the Chehe forest block was 1.1 acres (*M=1.1, SD=4.23*) with the minimum of 0.1 acres and maximum of 25 acres, 0.5 acres in Hombe (*M=0.5, SD=0.52*) with the minimum of 0.2 and maximum of 2 acres while in Kahurura, the average size of rented land was 0.9 acres (*M=0.9, SD=1.39*) with a minimum of 0.1 acres and a maximum of 5 acres. As earlier noted, this parameter is characterized by high variations as indicated by standard deviations (SD) which are significantly higher than their corresponding means across the forest blocks except for the Hombe forest block.

The plausible reasons for the high variations can be attributed to household socio-economic status and also the tendency by some individuals to venture into production of fodder for business reasons. The results of this study corresponded with what Leonhardt et al. (2019) found in their research that while security of rental and ownership tends to have positive effects on investments in most cases, there is also contradictory evidence owing to weaker institutional backgrounds in developing countries. Uptake of rented land by farmers is a good thing for the general good of environmental sustainability. This implication is supported by the evidence presented by Ervin (1982) as cited in Leonhardt et al. (2019) that in North America, from the 1980s there were high instances of soil erosion and fewer conservation

practices on rented fields than it was noted on owned fields. This means that farmers apply less care on rented land compared to what they would do on their own land. Therefore, since farmers in Mt. Kenya West hardly rent land, and if they do, then they rent small portions of land for fodder production, we canconclude that farmers are likely to practice more of environmental conservation measures since the land in question is theirs.

n) Quantity of grass harvested from the forest per month

Farmers who indicated that they harvested grass from the forest were asked to give an approximate quantity of such grass obtained from the forest per month. For consistency in approximation, farmers were asked to state the number of 50kg bags of grass they harvested from the forest. The average number of 50kg bags of grass harvested from the forest per month by each household was 42.5 bags. However, some farmers harvested less than one bag while others harvested up to 400 bags of grass. As presented in Table 4.2, the average number of 50kg bags of grass harvested by each farmer in Chehe was 36.4 bags (*M=36.4, SD=25.6*) with a minimum of 0.5 bags and a maximum of 150 bags. In Hombe the average number of bags was 63 (*M=63.0, SD=74.15*) with a minimum of 1 bag and a maximum of 400 bags while in Kahurura, the average was 36 bags (M=36.0, SD=27.31) with a minimum of 2 bags and a maximum of 140 bags per month.

In the same way, it can be observed that the quantity of grass harvested from the forest is characterized by high variances with some farmers harvesting fewer bags than. A plausible reason for such distribution is thepossible commercialization of grass harvesting activities especially by individuals who do not live in the immediate neighbourhood of the forest. Garekae et al. (2020) conducted a study on the relationship forest resource utilization and rural livelihoods in Botswana. The study contended that the majority of people in developing countries have been immensely dependent on environmental resources, particularly forests. Forest resources form part of livelihood diversification, but they may also serve as the only source of livelihood, especially for the poorest households. The implication of the findings of this study in Mt. Kenya west in the context of existing literature reveals a possibility of high incidences of large amount of grass harvested from protected forests by the middle level economy farmers since access to the forest products is based on affordability which is a threat to forest sustainability. This concept of exploitation of forest products specifically grass

harvesting in protected forests is supported by Mutune et al. (2015) who observed that better SES (income) increases possibilities to access and exploit forest resources.

o) Involvement in value addition of grass harvested from the forest

Farmers who indicated that they harvested grass from the forests were asked whether they are involved in any value addition activities. The results showed that out the 243 farmers who were involved in grass harvesting; only 62 were involved in value addition activities accounting for only 25.5% of farmer's population. This implies that a larger majority were not involved in grass value addition activities. As presented in Table 4.2, involvement in value addition was mentioned 40 times by farmers in Chehe, 2 times in Hombe, and 20 times in Kahurura. These results indicate that the Hombe forest block had the least number of farmers involved in grass value addition activities.

According to the research done by Wilkinson and Lee (2018), improving animal feeds by means of value addition has received considerable research attention as it contributes to productivity. The results presented in this study suggested that rural farmers who lived within forest proximity had not embraced value addition of animal feeds from the forest. As earlier noted, most the farmers could not afford commercial feeds due to high costs. One would expect that value addition of cheaply obtained forest grass would have been a better substitute. However, the evidence from this study suggested otherwise.

The farmers were asked to describe some of value addition services they were involved in. The descriptions provided by farmers were centred on three themeswhich are moisture reduction methods such as drying, adding flavours such as molasses and preparation of hay and silage for future use. A study by Wilkinson and Lee (2018) showed that value addition of animal feeds increased productivity in terms of not only increased milk and beef productivity but also improved animal health. The implication of the results of this study that there were low levels of involvement in value addition of the harvested feeds imply the possibility of low animal production in terms of milk and beef productivity. Again, lack of initiatives in value addition may contribute to challenges of fodder during the dry seasons and raise the cost of production, and this may encourage increased dependency on forest fodders as a safety net.

p) Making silage from forest harvested grass

The 54% of the farmers who indicated that they participated in grass harvesting were asked whether the grass they harvested from the forest was used to make silage. Overall, only 2.5% of the farmers involved in grass harvesting said they used the grass to make silage. As presented in Table 4.2, only 1.6% of farmers in Chehe made silage out of forest harvested grass, 1.9% in Hombe and 4.5% in Kahurura. This suggests that the making of silage out of forest harvested grass was generally low across the three forest blocks.

A study by Maleko et al. (2018) in Tanzania investigated smallholder dairy cattle feeding technologies and practices to examine the failures, successes, challenges and prospects for sustainability. The study found that adoption of improved feed production, conservation and utilization technologies and practices in dairy farming communities was poor. The study further noted that lack of adoption of proper supplementation practices had hindered milk production to further below the animal's genetic potential. The reasons for failure for smallholder farmers to adopt supplementation practices included higher prices of the concentrates and unreliable supply of, for instance, dairy meals, molasses, cotton seedcakes and sunflower seedcakes often not being available in areas located farther from their production places (Maleko et al., 2018). The implication of the findings of the current study is the potential for low animal productivity due to low uptake of improved animal feeds as evidenced by few farmers who were involved in silage making.

q) Quantity of fodder produced per acre

Farmers who indicated that they were involved in fodder production on their farm were asked to indicate the quantity of fodder they produced in both dry and rainy seasons by approximating the number of bundles. On overall, the number of bundles did not differ significantly in both dry and rainy seasons because the average number of bundles was 22.1 in dry and 22.6 in rainy seasons. As presented in Table 4.2, responses emanated from Chehe and Kahurura forest blocks alone. During the dry seasons, the average number of bundles of fodder produced per acre in Chehe were 9.7 (*M=9.7, SD=8.92*) with minimum of 4 bundles and maximum of 47 bundles per acre while in Kahurura the average was 100 (*M=100, SD=133.42*) with minimum of 30 and maximum of 300 per acre. It should be noted that although it may appear that, on average, farmers in Kahurura produced more fodder per acre,

there was too much variation within this forest block as indicated above. During the rainy season, the average number of bundles in Chehe was 19.4 (*M=19.4, SD=31.40*) which represented 100% improvement in fodder production during the rainy season compared to the dry season. This implies that farmers still relied on rain for fodder production which was, indeed, a reflection of advanced vulnerability context of smallholder farmers. On the other hand, during the rainy season, the average number of bundles produced in Kahurura was 42.5 (*M=42.5, SD=71.81*) indicating high variation.

r) Farmer perceptions on affordability of different sources of cattle feed

Respondents were asked to describe sources of cattle feeds or means of sustaining cattle particularly regarding the relative cost or affordability of each source. The sources of cattle feeds included grazing in the forest, purchasing grass from the forest, purchasing commercial feeds, silage, fodder, collecting feeds from the roadside, hay, full zero-grazing and the use of peels and vegetable waste and banana leaves. Nineteen (19) test items were used to test farmers' perception on affordability of animal feeds. The 19 test items were classified into five distinct categories which are forest-based feeds, farm-based feeds, feeds bought from neighbours, commercial feeds and feeds bought from other sources as shown in Table 4.3.

Table 4.3: Major categories of sources of cattle feeds in study sites (n=453)

Category	Exact test item	Cheap	Moderate	Expensive
Forest based sources	Grazing in the forest during Dry season months	80%	3%	17%
	Grazing in the forest during most part of the year	79%	2%	19%
	Purchasing Grass from the forest during most part of the year	44%	10%	46%
	Purchasing Grass from the Forest during Dry season months	46%	8%	46%
	Obtaining Forest leaves and shrubs	92%	4%	4%
Farm - based Feeds	Maize stalk from your own farm	93%	1%	5%
	Growing Napier grass on my own farm	89%	3%	8%
	Lucerne from your own farm	47%	2%	52%
	Making your own Silage to feed your cattle	20%	2%	78%
Bought from neighbours	Purchasing Maize stalk from other farmers	46%	6%	47%
	Purchasing Napier grass from another famer, neighbours	29%	8%	63%
	Purchasing Lucerne from other farmers	10%	3%	88%
Commercial Feeds	Purchasing silage to feed your cattle	8%	2%	90%
	Relying on full time Zero grazing	7%	7%	87%
	Purchasing Commercial feeds for your cattle	4%	5%	91%
	Buying hay (grass cut and dried)	4%	4%	92%
Others	Using peels and vegetable waste to feed cattle	96%	2%	1%
	Using banana leaves to feed cattle	95%	3%	2%
	Harvesting*Magutiani*(*Hyparrhenia*	93%	3%	5%

	*spp)*and*Mandara*(*Discopodium penninervium)*from the roadside			

Source: Author's survey data

a) Forest based sources

Forest feeds include cattle grazing in protected forest and purchasing grass from the forest all year round or during the dry season. From Table 4.3, grazing in the forest for the better part of the year and during most part of the year was identified as 79% and 80% respectively as was viewedas cheap compared to 44% and 46% of farmers, respectively, who reported purchasing grass from the forest for the better part of the year and during dry seasons respectively.. Table 4.3shows that the highest proportion of smallholder farmers who reported cattle grazing in the forest were the highest Hombe (77%), followed by Kahurura (67%), and the least in Chehe (48.30%). This indicates that forest dependence is higher in Hombe and Kahurura compared to Chehe regarding cattle grazing. Grazing of cattle was considered cheap and constant throughout the year at Ksh 100 per cow per month. Chehe had the highest proportion (87.2%) of farmers grazing in the forest followed by Kahurura at (43.9%) and the least was Hombe at (32.7%). With regard to grass harvesting, it can be deduced that Chehe has the highest forest dependence compared to Hombe and Kahurura as indicated in Table 4.3.

Responses obtained from the respondents on grazing in the forest, purchasing grass from the forest and obtaining forest leaves were summed up into one variable as an indicator of forest-based sources of pasture and cross-tabulated with forest block. The results showed that a large number of farmers across the three forest blocks perceived forest-based sources of pasture as cheap with majority from Chehe at 81% followed by Kahurura and Hombe at 67% and 65% respectively. These results are supported by the outcome in Table 4.3that indicated Chehe households had 81.5 % who had invested in zero-grazing units. Forest grass is easily affordable and accessible provided a farmer paid for the service as supported by the study by Sattler et al. (2018) in South Brazil. Comparatively, it can be concluded that farmers perceive cattle grazing as cheaper compared to grass purchasing from the forest hence those who graze throughout the year experience higher coststhan those who graze seasonally as confirmed by this study. Similarly, as noted in this study, Caviglia-Harris, (2018) found that extensive

cattle system practices are the method of choice because they are cost effective, and the study confirmed that forest pasture is relatively cheap compared to other sources.

The implication of perception thatgrazing in the forest to be cheap will have the incentive of keeping more animals since forest fodder is accessible and affordable, a concept supported by the theory of access and the common pool resources theory. The existing KFS policy on livestock fees therefore incentivises these perceptions due to its affordability. Study by Munanura et al. (2017) noted that conservation incentives may significantly increase demand for forest products, forest dependence and biodiversity loss. KFS should, therefore, think of reviewing fees on the forest to reduce pressure on forest pasture and enhance sustainability.

b) Other source of cattle feeds

There were other unclassified sources of cattle feeds such as obtaining leaves and shrubs from the forest, collecting feeds from the roadsides, using peels, vegetable wastes and banana leaves to feed cattle. The results indicated that there was variability in cost due to the cost incurred by the farmer in obtaining them which may be related to transport costs. Ordinarily, obtaining leaves and shrubs has no cost implication since they are obtained from free land. Peels, vegetable waste and banana leaves are sometimes obtained from marketplaces or institutions and may be obtained at little cost and were noted to have been cheap by an average of 95% of the farmers across the three forest blocks. Harvesting of *Magutiani* (*Hyparrhenia spp)* and *Mandara* (*Discopodium penninervium)* leaves and shrubs from the roadside was noted as being cheap by 93% of the smallholder farmers since they have less competition, and the sources of feeds is not regulated. In some cases, farmers are able to obtain forest leaves and shrubs at no cost as confirmed by 92% of the farmers since only grass is charged under the Kenya Forest Act (2005). As earlier presented in Table 4.3over 90% of farmers interviewed reported that these sources of cattle feeds were cheap.

c) Feeds from own farm

It was also found that some farmers grew or prepared some cattle feeds on their own farms such as homemade silage, Napier grass, lucerne and maize stalk. Table 4.3indicates that 78% of farmers said that making own silage was expensive, 89% said growing Napier grass was cheap, 93% said obtaining maize stalks from own farm was cheap. Growing lucerne was

reported to be cheap by 47% of the farmers while 52% said it was expensive. Napier grass production in the region was heavily dependent on rain hence 89% of the farmers had a perception that it was cheap. Napier grass is one of the most important fodder crops and it is easy to propagate compared with other farm grown fodder sources (Negawo et al. (2017).

Silage making was cited as expensive because the construction of the required structures is usually capital-intensive. In addition, raw materials to make silage are relatively expensive to cultivateand may require irrigation for maximum output which was noted as a challenge bymajority of the farmers. The process of making silage is also labour intensive and may require fodder value addition tools such as the chaff cutter and power supply. Growing of lucerne was noted as expensive by 52% of the farmers due to cost of planting seeds and the fact that fodder irrigation is a requirement for maximum output. Maize stalks as a source of farm feed were noted to be cheap by 93% of the farmers across the three forest blocks; however, this was noted as a seasonal source of fodder mainly during the maize harvesting months. The possible reasons for variability on farm feed sources, that are maize stalks (93%), Napiergrass (89%) and lucerne (47%) is the cost of propagation materials, need for irrigation and value addition requirements associated with the fodder crop.

In Chehe, the main sources of farm-based feeds noted in the study were lucerne grass, Napier grass, and silage making. The results in Chehe are supported by the fact that farmers had a relatively higher socio-economic status and fodder production on farm was supported by availability of water for partial irrigation and the favourable climate compared to Kahurura and Hombe. Among the farm-based feeds, in Kahurura, the main sources of livestock feed wereNapier grass since the region is highly dependent on rain-fed agriculture most preferred for Napier grass production. In Kahurura, silage making was the least preferred due to cost. Chehe and Hombe had similarities in the sources of farm-based feeds such as lucerne, Napier grass and silage making. All the responses relating to feeds from own farms were summed up into one variable and cross-tabulated against the forest blocks. The results show that most farmers across the three forest blocks indicated that feeds from own farm were cheap with majority from Hombe at 72% and the least from Kahurura and Chehe at 63% and 60% respectively. The plausible reasons for a significantly higher proportion in Hombe may be attributed to the fact that farmers in Hombe forest block have access to water for irrigation

and own more land (*M=1.72, SD=1.56*) compared to Chehe and Kahurura which had an average of 1.2 acres.

d) Feeds bought from Neighbours

Interviews with farmers revealed that some purchased cattle grass from their neighbours. Some of the feeds commonly purchased from neighbours were Napier grass, lucerne, and maize stalks. As shown in Table 4.3, 63% of farmers said purchasing Napier grass from neighbours was expensive, 88% said lucerne was expensive, and 47% said purchase of maize stalks was expensive. This means that among the cattle feeds that can be bought from the neighbourhood, maize stalks were more affordable compared to Napier grass and lucerne. The results show that the proportion of farmers who perceived purchase of feeds from neighbours as cheap, moderate and expensive was approximately equallydistributed, thus, cheap (27%), moderate (38%) and expensive (35%). At least 55% of farmers in Hombe and 51% in Kahurura said it was expensive to purchase maize stalks, Napier grass, lucerne and silage from neighbours. Aplausible reason for this is the observed high number of farmers with poorer SES in Kahurura. This means that they had low ability to purchase feeds from their neighbourhood. This is in contrast with Chehe which had a considerably higher proportion of farmers with better SES, which implies that they had better ability to purchase feeds from their neighbours.

e) Commercial feeds

Some of the commercial feeds purchased by farmers in Mt Kenya West included dairy meal, silage, and hay particularly for the purpose of rearingcattle under full zero-grazing units. For this category of cattle feeds, Table 4.3shows that between 87% and 92% of farmers reported that commercial feeds were expensive and less than 8% of these farmers said commercial feeds were cheap. The ability to access commercial feeds was associated with the household's socio-economic status. The farmers felt that buying hay (grass cut and dried) was the most expensive at 92% followed by purchasing commercial feeds for cattle and purchasing silage. A study by Connor (2015) found similar results on high cost of commercial feeds accounting for an average of 60% of the total production cost in the United States of America. Purchase of commercial feeds (silage, zero-grazing and hay) was cross-tabulated with forest blocks andresults showi that the highest proportion of farmers across the

three forest blocks indicated that commercial feeds were expensive with the majority being in Hombe at 91%, Kahurura 77% and the least in Chehe at 66%. This variation can be attributed to household SES in each of these forest blocks. This evidence is further complemented by a relatively higher proportion of farmers in Chehe at 13% who said that commercial feeds were cheap compared to significantly lower numbers in Hombe at 4% and Kahurura at 7%. As earlier noted, majority of farmers in Chehe had better SES compared to those in Hombe and Kahurura respectively. This means that, based on SES, farmers in Chehe had higher purchasing power compared to those in Hombe and Kahurura.

f) Major categories of sources of cattle feeds in Hombe forest block

In relation to forest-based resources, grazing in the forest during most parts of the year and during dry seasons was foundto be cheap source cattle feeds by 88% of the respondents. These results concurwith the outcome that the high number of farmers who depend on grazing he larger part of the year as 78 % (Table 4.3). This indicates high demand for forest-based resources in Hombe through cattle grazing which may be a threat to ecosystem sustainability.

Purchasing grass in general was, however noted to be expensive especially for those who did it most parts of the year in Hombe (43%) and during the dry season (41%). The priceof a 50 kg bag of grass is Ksh 50 compared to grazing in the forest per day at Ksh 3. The likelihood of attracting farmers to focus on more grazing in Hombe is high and may pose a serious threat to the forest. In addition, findings on the relationship between socio-economic status and forest dependenceshow that Hombe had a higher percentage of poorest people in the sample at 9.8 % compared to Chehe (0.70%). However, obtaining leaves and shrubs from the forest was viewedas cheap due since there is less cost implication related to the activity.

In Hombe, maize stalk was the cheapest source of farm-based feed (98%) compared to Napiergrass (95%), lucerne (57%) and making own silage (38%). Maize stalks are available in almost all homesteads across the three forest blocks since growing maize as staple food is a common practice in the region. Besides, Hombe farmers have some water for irrigation and sometimes maize is planted as a wind breaker and is subsequently used as animal fodder. Growing Napier grass in Hombe was noted as a cheaper option by 95% of the respondents. However, lucerne growing was considered relatively expensive by 23 % of the respondents, a

finding that is like that of a study by Kimitei et al. (2011). Given these findings, it can be concluded that lucerne growing was considered cheap by more respondents in Hombe compared to Chehe (52%) and Kahurura (42%) due to availability of water for irrigation, which is ideal for maximum outputs. This study concurs with the previous study by Mutavi & Amwata (2018) which confirmed that making own silage is expensive as noted by 51% of the farmers in Hombe but cheaper than Kahurura farmers (66%) due to better socio-economic status in the region.

In Hombe, buying cattle feed from neighbours confirmed that maize stalk was the cheapest compared to Napier grass and lucerne. This finding is supported by the earlier argument that maize stalk is common due to maize farming across the region. 40 % of the respondents confirmed that Napier was expensive due to aspects related to propagation materials, possibility of costly irrigation and cost of transport from other farmers to own farm. Lucerne buying from neighbours was the most expensive feeding approach in this category as noted by 85% of the respondents. Since lucerne is one of the most nutritious fodder crops (Kimitei et al., 2011), interventions should be put in place to make the fodder affordable to reduce reliance on forest-based resources.

Access to commercial feeds by farmers in Hombe is a challenge by majority of the farmers in the region. Purchasing silage however was noted as the cheapest by 88% of the respondents compared to commercial feeds (90%) and buying hay (93%). Making of silage is expensive and possibilities of getting farmers willing to sell is rare, and those willing to sell do it at exorbitant prices hence other cheaper options to make silage such as use of polythene papers should be encouraged by stakeholders. Commercial feeds such as daily meal are expensive and retail agro vets sell at high prices even when the quality is compromised. Hay in the region is not common due to limited land sizes at an average of 1.7 acres compared to Kahurura 1.22 acres (Table 4.2); hence obtaining it from other farmers was noted as expensive by 93% of the respondents.

In Hombe, obtaining banana leaves as other sources of animal feed was noted as the cheapest (98%) compared to using peels and vegetable waste (97%) and harvesting*Magutiani* (*Hyparrhenia spp)* and *Mandara* (*Discopodium penninervium)* fodderfrom the roadside (95%). Hombe is known as a banana producing region due to suitable soils and climate hence availability of banana leaves is high. Hombe is a horticultural zone hence availability of

vegetable waste is common especially when crop market is unfavourable, making it cheap and affordable. Harvesting *Magutiani* (*Hyparrhenia spp)* and *Mandara* (*Discopodium penninervium)* from the roadside comes with low cost since the products are not regulated by any institution.

Smallholder farmers sources of income

Participants were asked what activities generated income for the household. Sale of milk was mentioned 430 times, sale of cash crops 204 times, while table banking as a source of income was mentioned 172 times. Income from sale of livestock was mentioned 163 times, and income from running small businesses, 104 times. However, it seems several households relied on remittances from family members working outside of the study area. This was mentioned 91 times as a source of income for households. The less frequently mentioned sources of income for households were formal employment, mentioned only 63 times as presented inTable 4.4.

Table 4.4: Source of Income (Number of Mentions)

Source of Income	**Combined**	Chehe	Hombe	Kahurura
Milk Sales	430	146	150	134
Cash Crops	204	134	69	1
Table Banking	172	94	41	37
Livestock Sales	163	53	76	34
Small Businesses	104	45	34	25
Remittances	91	20	37	34
Formal Employment	63	21	29	13

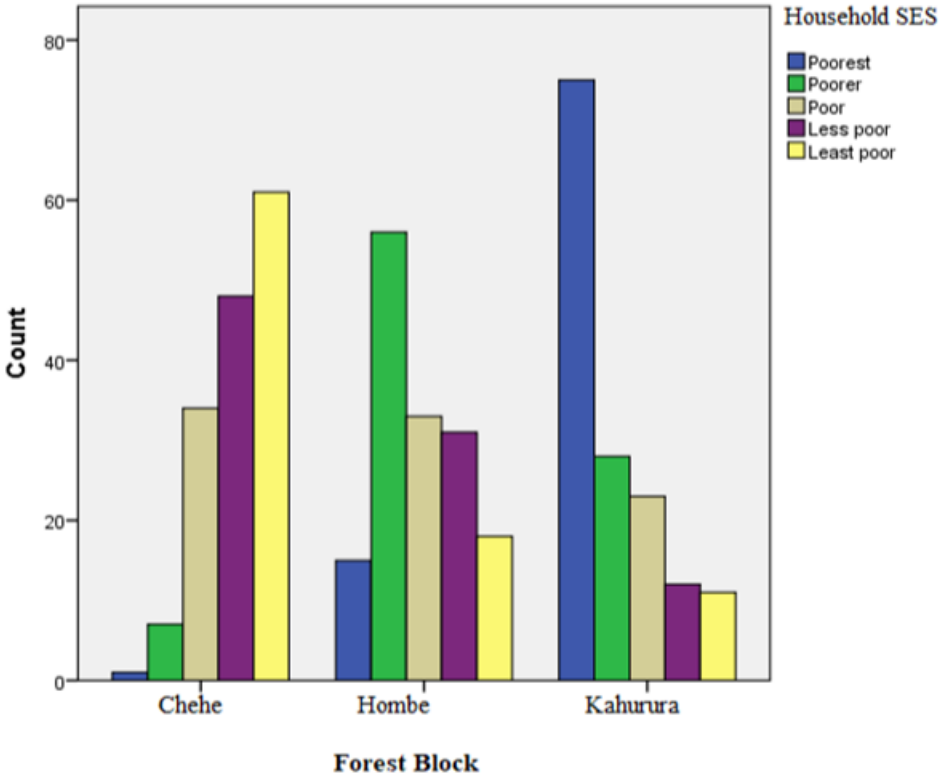
Source: Author's survey data

Sale of milk was mentioned 146 times in Chehe, 150 in Hombe and 134 times in Kahurura forest blocks. Sale of cash crops was mentioned 134 times in Chehe, 69 times in Hombe and only once in Kahurura. A probable reason for this kind of observation is that Kahurura forest block lies on the leeward side of Mt Kenya which therefore receives the least amount of rainfall annually. For this reason, farmers in this region may not grow manycash crops such as tea and coffee compared those in Chehe and Hombe forest blocks. Table banking as a source of income was mentioned 94 times in Chehe, 41 times in Hombe and 37 times in Kahurura.

Income from sale of livestock was mentioned 53 times in Chehe, 76 times in Hombe and 34 times in Kahurura and income from running small businesses was mentioned 45 times in Chehe, 34 times in Hombe and 25 times in Kahurura. Remittances from family sons and daughters working outside the study area was mentioned 20 times in Chehe, 37 times in Hombe and 34 times in Kahurura as a source of income for households.

Association between Forest block type and Household SES

The researcher investigated the association between the households' SES statusamongst the three forest blocks. Figure 4.1shows the distribution of the wealth classes in the three different forest blocks.



Source: (Author's survey data)

Figure 4.1: Clustered bar charts for household wealth classes in three forest blocks

Results revealed that the number of households in the poorest category was smallest in the Chehe forest block, followed by Hombe, but highest in the Kahurura forest block. A Chi-square test was performed to analyse the association between the wealth classes and the different forest blocks. Since these p-values were smaller than the test significance level (α)

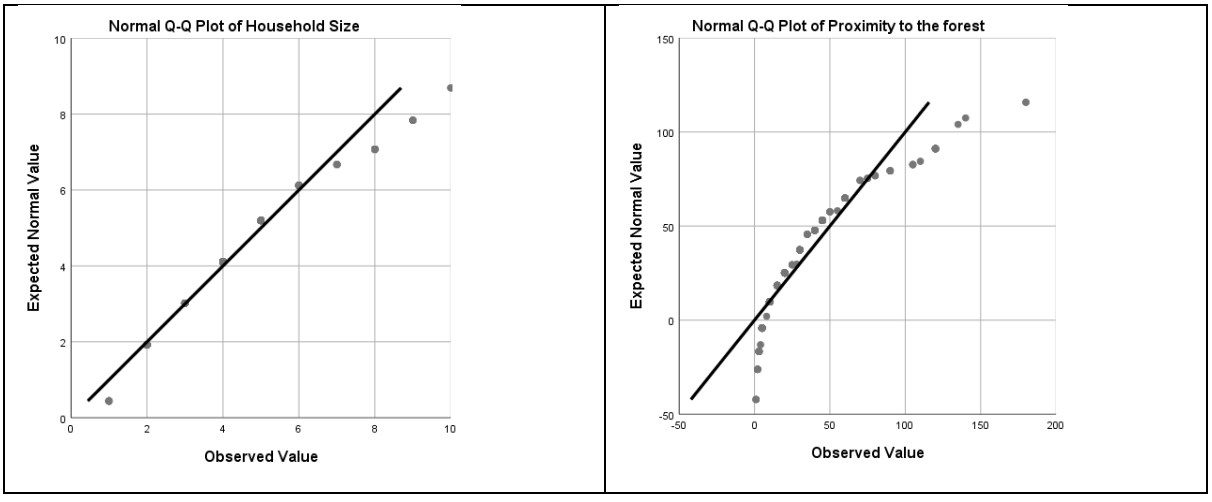
of 0.05, the null hypothesis was rejected because there exists enough evidence to support existence of an association among wealth classes and the different forest blocks.

4.3 Diagnostic Statistics for logistic regression model

Logistic regression is an efficient and powerful way to analyse the effect of a group of household socio-economic factors on a binary outcome described as forest dependency by quantifying each factor's unique contribution. However, before conducting a logistic regression analysis, basic assumptions of independence of errors, linearity in the logit for continuous variables, absence of multicollinearity, and lack of strongly influential outliers must be met (Stoltzfus, 2011). Continuous household socio-economic factors included household size, proximity to the forest, total size of land owned, proportion of land under fodder production, number of cattle and proportion of cattle under zero-grazing.

a) Test for normality

Figure 4.2presents diagnostic graphs for normality assumption for five continuous socio-economic factors. The purpose of test for independence is to ascertain potential deviation from normal distribution of the variable based on scatter plot of observed and expected values. The results show normal distribution for household size, proximity to the forest, total land size owned and proportion of land under fodder production. However, it was observed that the portion of cattle under zero-grazing did not follow normal distribution.



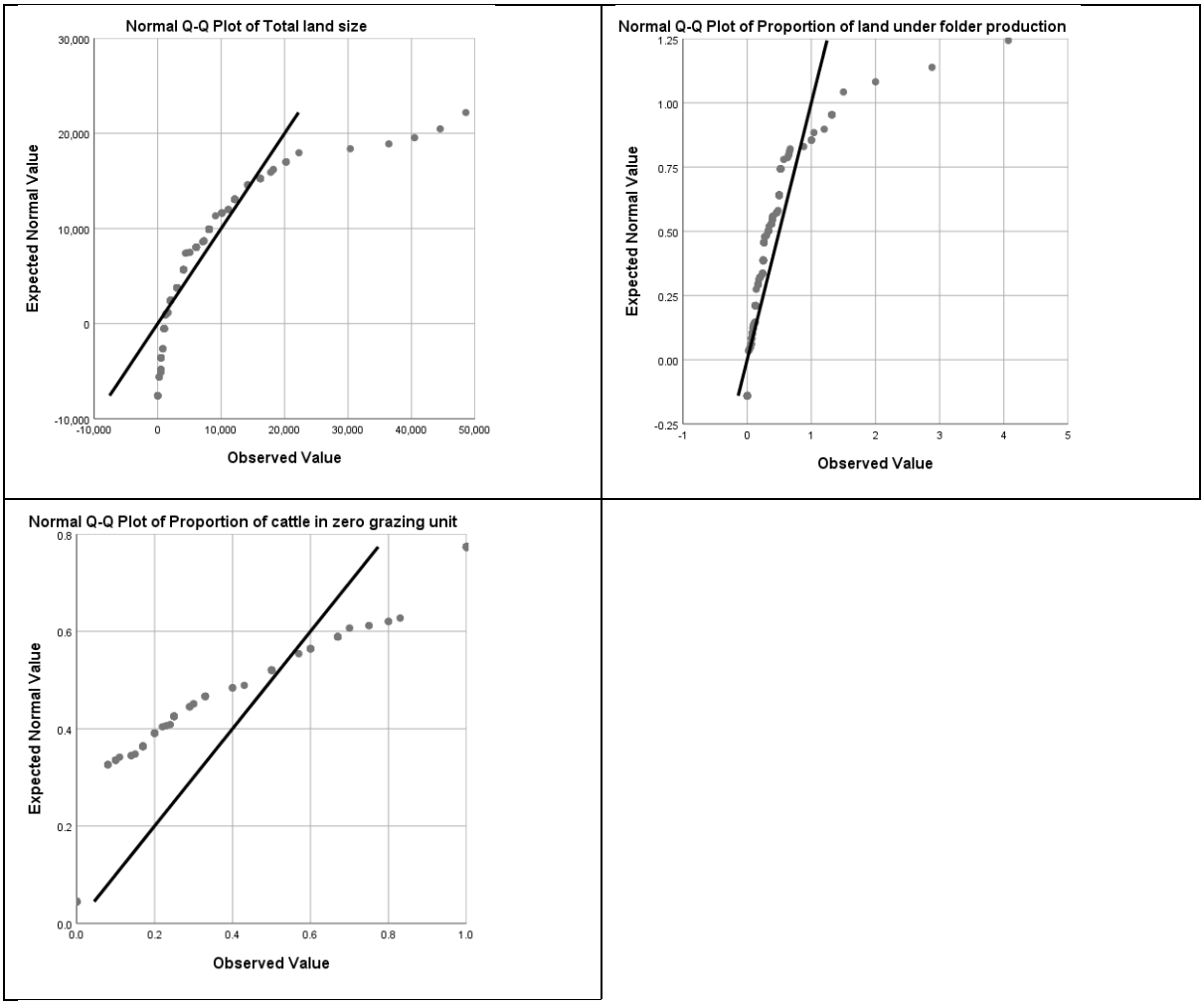


Figure 4.2: Test for normality for selected socio-economic factors

b) Test for linearity

The linearity assumption of the linear model assumes that the dependent variables (forest dependency) can be expressed as a linear combination of the set of independent variables (household socio-economic factors). While logistic regression model does not assume linearity of log of odds ratio with independent variables, Steyerberg, (2019) recommends test for linearity as a critical pre-diagnostic statistic. In this study therefore, we assume that forest dependency can be expressed as a linear combination of the household socio-economic factors. Deviation from linearity test was used to check the linearity assumption and results presented in Table 4.5.

Table 4.5: Test for Linearity between household socio-economic factors and forest dependence

			Sum of Squares	Df	Mean Square	F	P-value
Household Socio-economic factors *Forest dependence	Between Groups	(Combined)	225.56	5	45.11	1.74	0.08
		Linearity	37.51	1	37.51	9.56	0.00
		Deviation from Linearity	188.05	24	7.84	2.71	0.98
	Within Groups		341.31	422	0.81		
	Total		1437.92	452			

Interpretation of these results is based on a null hypothesis that there no linear relationship between the dependent and the independent variables. The results suggest that there is a linear relationship between household socio-economic factors and forest dependence of smallholder farmers $p=0.00<0.05$.

c) Test for multicollinearity

Multicollinearity is a statistical property whose presence gives an indication of significant correlation between independent variable, which is undesirable in logistic regression analysis. Thus, to perform logistic regression analysis, there should be no multicollinearity in the data. To check the multicollinearity assumption in the set of household socio-economic factors, the variance inflation factor (VIF) value was used, and results presented in the Table 4.6.

Table 4.6: Test for Multicollinearity for household socio-economic factors

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	10.30	0.34		30.23	0.00		
Household Size	-0.01	0.07	-0.01	-0.15	0.88	0.96	1.04
Proximity to the forest	0.00	0.00	0.05	0.81	0.42	0.99	1.01
Total land size	0.00	0.00	-0.04	-0.62	0.54	0.87	1.15
Proportion of land under folder production	-0.01	0.43	0.00	-0.03	0.98	0.98	1.02
Number of cattle in a homestead	0.01	0.02	0.03	0.45	0.65	0.90	1.11
Proportion of cattle in zero-grazing unit	-0.83	0.56	-0.09	-1.50	0.13	0.94	1.06

Dependent Variable: Forest dependence

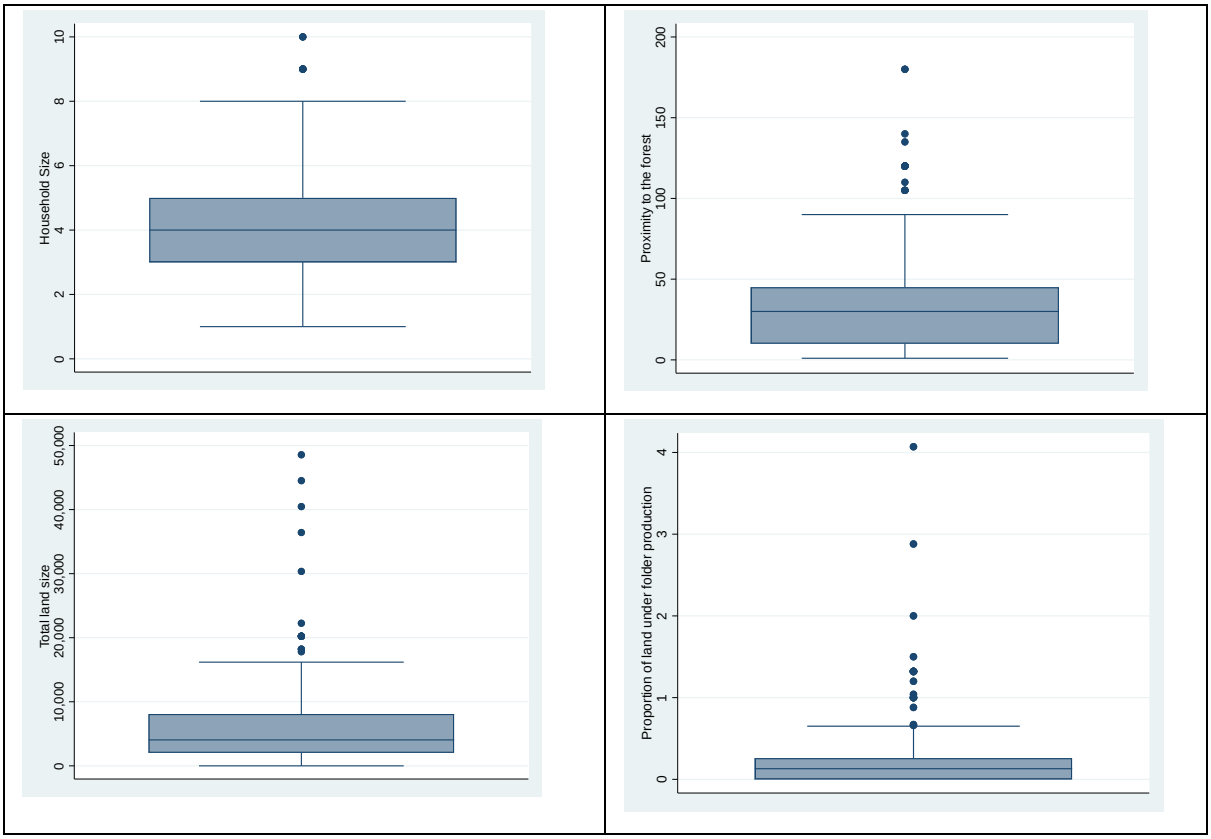
According to Steyerberg (2019), the tolerance value greater than 0.3 indicates absence of multicollinearity. The results presented in the Table 4.6, the independent variables show tolerance value of at least 0.87, hence theconclusionthat there were no statistically significant multicollinearity challenges in the data and thatlogistic regression analysis can be performed.

d) Test for outliers

The Chebyshev's theorem was used to detect extreme values in the dataset

$$Pr(|X - \mu| \geq k\sigma) \leq \frac{1}{k^2}$$

Where X is the random entry datapoint of the socio-economic factor, μ is expected value, σ is standard deviation and k the number of standard deviations from the mean. Based on this approach, outlier values were detected in all continuous variables except for the proportion of cattle under zero-grazing unit. However, it was verified that the outlier data points were not a result of error but in fact actual data values as presented in boxplots in Figure 4.3.



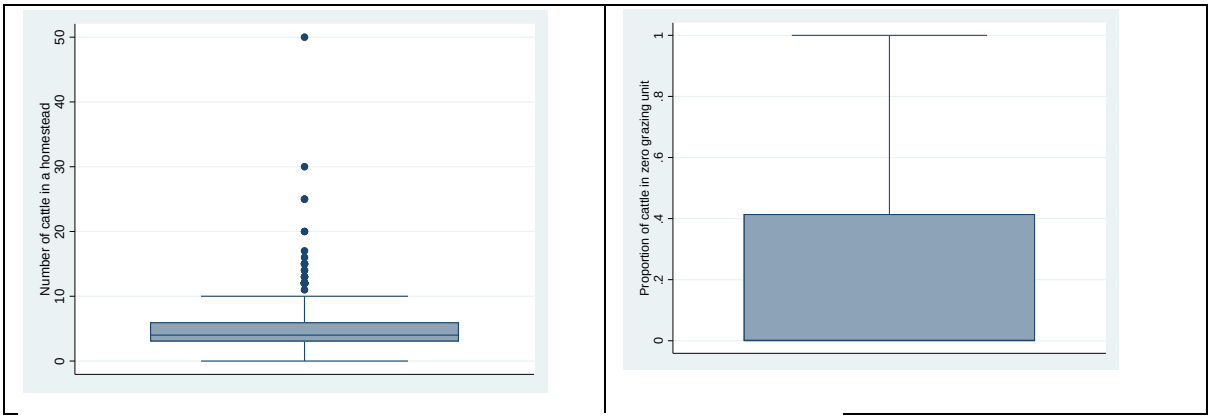


Figure 4.3: Boxplot for testing outlier data points in the data

Table 4.7 presents a summary of diagnostic statistics and preliminary tests used in this study. These diagnosticsinclude those used in authenticating the data collection tool as reliability test, those used in hypothesis testing, and testing logistic regression model assumptions. The assumptions for normality, independence of errors, linearity and multicollinearity tests as shownin Table 4.7.

Table 4.7: Summary of Diagnostic/Preliminary Tests

Purpose	Test	Decision criteria	Authors who recommended
Test for reliability	Cronbach Alpha	If a set of test items in a tool gives an alpha value of greater than 0.7, the tool is considered reliable	
Hypothesis test	T-test F-test	If $p \leq 0.05$ reject the null hypothesis If $p \leq 0.05$ reject the null hypothesis	Jones et al. (2017) and Schnuerch et al. (2020)
Test for normality	Scatter plots	If the scatter plot derives an approximately normal distribution of data points along a hypothetical line of symmetry, the normal distribution is assumed	Mishra et al., (2019)
Test for linearity test	F-test	A null hypothesis that assumes non-linearity is assumed. When the p-value for the computed F is less than 5% ($p<0.05$), the null hypothesis is rejected, thus assuming linearity of independent variables with the dependent variable	Steyerberg, (2019)

Purpose	Test	Decision criteria	Authors who recommended
Test for multicollinearity test	Variance Inflation Factor (VIF)	If the tolerance value greater than 0.3, there is no multicollinearity.	Steyerberg (2019) and Senaviratna et al (2019)

4.4 Cross tabulation analysis of forest dependency

This section presents results of cross-tabulation of forest dependency and smallholder farmers' demographic characteristics such as gender, level of education, socio-economic status (SES) and ownership of zero-grazing unit. Forest dependency for smallholder farmers involved in cattle grazing was based on whether an individual farmer grazes only during dry season (*low forest dependency*) or graze most parts of the year (*high forest dependency*). Forest dependency for smallholder farmers involved in grass harvesting was based on whether an individual farmer harvests grass only during dry season (*low forest dependency*) or harvest grass most parts of the year (*high forest dependency*).

4.3.1 Forest dependency through cattle grazing in protected forests

Results shows that there were 57% male and 43% female smallholder farmers involved in cattle grazing (*See appendix 20*). The results also show that 98% of these farmers pose high forest dependency because they graze in the forest most part of the year, out of which 56% were male and 44% were female smallholder farmers. Person's chi-square p-value ($p=0.116>0.05$) for testing the strength of association shows that there is no statistically significant association between smallholder farmers gender and forest dependency through cattle grazing at 95% confidence level. Study by Tangka et al. (2000) on gender roles in livestock production systems in developing countries indicated that cattle's grazing is a preference for men based on gender orientation and direct economic gains. Another plausible reason is that grazing in the forest is a risky undertaking considering the existence of wild animals and possibilities of human attack in the forest hence male gender most preferred.

Results shows that 9% of smallholder farmers involved in cattle grazing had no formal education, 51% had primary education, 33% had secondary education, and only 7% had post-secondary education (*See appendix 20).* This implies that less than 10% of the farmers involved in cattle grazing holdcollege certificate, diploma, or degree. The results also show

60% of smallholder farmers who graze in the forest most part of the year had either no formal education or had only primary level of education compared to their counterparts with secondary and post-secondary education at 33% and 7% respectively. The Person's chi-square test ($p=0.715>0.05$) shows that there is no statistically significant association between smallholder farmers level of education and forest dependency through cattle grazing at 95% confidence level.

Results shows that 45% of smallholder farmers involved in cattle grazing were categorized in the poorer wealth quintile, 34% were in the middle wealth quintile described as poorer while the rest at 21% were in the wealthiest quintile described as not poor (*See appendix 20).* The results shows that 45% of smallholder farmers in the lowest wealth quintile (poorer SES) graze in the forest most parts of the year, which is a significantly higher proportion compared to farmers classified as poor and not poor at 34% and 21% respectively. Similarly, in the category of smallholder farmers who only graze in the protected forest only during dry season, a significant majority at 86% were in the wealthiest quintile described as not poor. This shows that on average, poorer farmers tend to exhibit high forest dependency through cattle grazing compared to farmers who are less poor. The Person's chi-square p-value ($p=0.001<0.05$) for testing the strength of association shows that there is statistically significant association between smallholder farmers SES and forest dependency through cattle grazing at 95% confidence level.

Results shows that only 32% of farmers involved in cattle grazing own zero-grazing units while a large majority at 68% do not have zero-grazing unit (*See appendix 20).* Further, results show majority of smallholder farmers (69%) who exhibit high forest dependency through cattle grazing do not have zero-grazing unit, compared to only 31% who have zero-grazing unit yet exhibit high forest dependency. This shows that a high proportion of farmers without a zero-grazing unit tend to graze in the forest throughout the year. The Person's chi-square p-value ($p=0.002<0.05$) for testing the strength of association shows that there is statistically significant association between smallholder farmers ownership of zero-grazing unit and forest dependency through cattle grazing at 95% confidence level.

Results shows that only 25% of smallholder farmers involved in cattle grazing in protected forest were from Chehe, 39% from Hombe and 35% from Kahurura (*See appendix 20).* Hombe and Kahurura have the highest percentage of farmers who graze in the forest most

parts of the year at 40% and 36% respectively, leaving Chehe with only 24%. On the other hand, among farmers involved in cattle grazing only during dry season, 71% were from Chehe which is significantly higher compared to those from Hombe and Kahurura. The Person's chi-square p-value ($p=0.019<0.05$) for testing the strength of association shows that there is statistically significant association between forest block and forest dependency through cattle grazing at 95% confidence level.

4.3.2 Forest dependency through grass harvesting from protected forests

Results shows that there were 69% male and 31% female smallholder farmers involved in grass harvesting (*See appendix 21*). Results also show that 65% of these farmers pose high forest dependency because they harvest grass from the forest most part of the year, out of which 71% were male and 29% were female smallholder farmers. The Person's chi-square p-value ($p=0.369>0.05$) for testing the strength of association shows that there is no statistically significant association between smallholder farmers gender and forest dependency through grass harvesting at 95% confidence level. A plausible reason why male gender dominates in the activity is that grass harvesting is by means of bicycles, motorcycles and vehicles which is a dominant for men in rural areas.

Results that 5% of smallholder farmers involved in grass harvesting had no formal education, 32% had primary education, 48% had secondary education and only 11% had post-secondary education (*See appendix 21*). This implies that slightly more than 10% of the farmers involved in grass harvesting holdcollege certificate, diploma, or degree. The results also show 6% of smallholder farmers who harvest grass from the forest most part of the year had no formal education compared to their counterparts with secondary and post-secondary education at 48% and 15% respectively. On the other hand, 7% of farmers involved in grass harvesting from protected forest only during dry seasons had no formal education, 47% had primary education, 43% had secondary education, and 15% had post-secondary level of education. The Person's chi-square p-value ($p=0.016<0.05$) for testing the strength of association shows that there is statistically significant association between smallholder farmers level of education and forest dependency through cattle grazing at 95% confidence level.

Results shows that 24% of smallholder farmers involved in grass harvesting were categorized in the poorer wealth quintile, 28% were in the middle wealth quintile described as poor while

the rest at 47% were in the wealthiest quintile described as not poor (*See appendix 21*). The results shows that 54% of smallholder farmers classified in the wealthiest wealth quintile (Not poor SES) harvest grass from the forest most part of the year, which is a significantly higher proportion compared to farmers classified as poor and poorer at 27% and 91% respectively. This shows that on average, farmers who we least poor tend to exhibit high forest dependency through grass harvesting compared to farmers who are less poor. The Person's chi-square p-value ($p=0.008<0.05$) for testing the strength of association shows that there is statistically significant association between smallholder farmers SES and forest dependency through grass harvesting at 95% confidence level.

Results shows that only 33% of farmers involved in grass harvesting own zero-grazing units while a large majority at 67% do not own zero-grazing unit (*See appendix 21*). Further, the results show that majority of smallholder farmers (74%) who exhibit high forest dependency through grass harvesting own zero-grazing unit, compared to only 26% who do not own zero-grazing unit yet exhibit high forest dependency. This shows that a high proportion of farmers with zero-grazing unit tend to harvest more grass from the forest throughout the year. The Person's chi-square p-value ($p=0.002<0.05$) for testing the strength of association shows that there is statistically significant association between smallholder farmers ownership of zero-grazing unit and forest dependency through grass harvesting at 95% confidence level. The plausible reason is that for zero-grazing system of farming to succeed, there must be consistent supply of affordable fodder.

Results shows that 51% of smallholder farmers involved in grass harvesting from protected forest were from Chehe, 21% from Hombe and 27% from Kahurura (*See appendix 21*). Chehe had the highest percentage of farmers who harvest grass from protected forest most parts of the year at 71% while Kahurura and Hombe hadthe lowest percentages at 18% and 11% respectively. The Person's chi-square p-value ($p=0.001<0.05$) for testing the strength of association shows that there is statistically significant association between forest block and forest dependency through grass harvesting at 95% confidence level.

4.5 Logistic regression results: Relationship between smallholder farmers household socio-economic characteristics and dependence on protected forest for pasture

This section presents results logistic regression analysisof household socio-economic factors for forest dependence for pasture in the three forest blocks under study: Chehe, Hombe and

Kahurura. A logistic regression technique allows the researcher to specify the order in which the predictor variables enter the model and capitalize on them as prior information. Logistic regression also provides this mechanism through a comparison of coefficients in front of each variable in the model, allowing for a calculation of the size of the effect of each variable. In this section, three logistic regression models (*Model 1, Model 2, and Model 3*) were run, with the first step involving entering gender, household size and education level. The second modelinvolved addition of SES (wealth index) as prior control variables and the final model involved addition of the original predictor's namely: proximity to the forest; total land size; proportion of land under fodder production; ownership of a zero-grazing unit; number of cattle in thehomestead and proportion of cattle in a zero-grazing unit. The dependent variables in this study were two binary variables that indicated levels of forest dependence either by means of direct forest grazing or reliance on grass harvesting as livestock sustainability means.

Gender, education level, SES index and ownership of zero-grazing units were categorical variables, thus were treated as dummy indicators. For gender, female respondents were treated as a reference category against which male respondents were compared. For education level, respondents with no formal education were treated as a reference category against which all other categories were compared. For SES wealth index, respondents who were least poor were treated as a reference category against which all other categories were compared while for ownership of zero-grazing units, farmers who did not own a zero-grazing unit were treated as the reference category against which those who owned zero-grazing units were compared.

Results of the logistic regression revealed that after controlling for gender, household size, education level and SES, the total land size owned was a statistically significant ($p=0.06$) driver for grazing in the Chehe forest block at 90% confidence level. The significance at 90% confidence level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). In this study, the other drivers such as proximity to the forest, proportion of land under fodder production, ownership zero-grazing unit, number of cattle in a householdand proportion of cattle in a zero-grazing unit were found to be statistically significant. A similar outcome was noted in a study by Piana & Masden (2014) in Peru that highlighted distance from the forest as an insignificant driver. This implies that in Chehe, a unit change in total

land size owned would have a significant impact on the level of dependence on the forest for pasture while other farmer socio-demographic characteristics such as gender, educational level, household size and SES would not significantly influence smallholder's level of dependence on the forest for pasture. While the issue of household SES did not seem to influence cattle grazing levels in the Chehe forest block, it can be deduced from the other forest blocks that farmer with the lowest household SES exhibited the highest dependence on forest for pasture relative to farmers with improved household SES.

Logistic regression results indicated that after controlling for gender, household size, education level and SES, all the drivers except proximity to the forest boundary were statistically insignificant. As presentedin Appendix 11 (Part B), proximity to the forest was a statistically significant ($p=0.04<0.05$) predictor of grazing levels in the Hombe forest block at 95% confidence level. The negative coefficient (-0.01) on the significant drivers' 'proximity' to the forest boundary suggests that there was an inverse association between proximity to the forest and levels of cattle grazing in protected forest areas for smallholder farmers in the Hombe forest block. This implied that when the distance from the forest boundary increased, the levels of cattle grazing in protected forest for smallholder farmers in Hombe forest block reduced significantly. However, it should be noted that other than proximity to the forest boundary, the influence of other socio-economic drivers in Hombe was statistically insignificant as suggested by the p-values of greater than0.05.

Results suggested that after controlling for gender, household size, education level and SES for the Kahurura forest block, all the drivers except proportion of land under fodder production were statistically insignificant. The findings of this study concur with previous study done by Ecker (2018) in Ghana that found that in the era of agricultural transformation in Africa, land utilization was more important than land size. It is no wonder that a mere proportion of land set aside for a particular task is not necessarily a significant driver for production. As presented in Appendix 11 (Part B), the proportion of land under fodder production was a statistically significant (p=0.00) predictor of grazing levels in the Hombe forest block at 95% confidence level. The negative coefficient on the significant drivers (-9.22) suggests that there is an inverse association between proportion of land under fodder production and the levels of cattle grazing in protected forest for smallholder farmers in Kahurura forest block. Similar conclusions can be deduced on other insignificant drivers with negative coefficients such as total land size, and the proportion of cattle under zero-grazing

units. A positive coefficient such as on the number of cattle on homestead suggests that there exists direct association between the variables. For instance, it can be said that when the number of cattle in a homestead increase, the levels of cattle grazing in protected forest for smallholder farmers in Kahurura increases. It should be noted, however, that this relationship is insignificant in the forest block as suggested by the p-value of greater than 0.05.

To assess individual contribution of each variable in explaining the overall likelihood of cattle grazing in protected forest in the Chehe, Hombe and Kahurura forest blocks, marginal effect models of each of the logit models were analysed. After controlling for household size and household SES for the Chehe forest block, it was observed that a unit increase from a poorer SES wealth quintile to a better quintile reduced cattle grazing in protected forest by 14%, a unit increase in the size of land decreased cattle grazing in protected forest by 7% (-0.07) while a unit increase in the proportion of land under fodder production reduced cattle grazing in protected forest by 3%. A unit increase in the proportion of cattle under zero-grazing units reduced cattle grazing in protected forest by 21%. This means that an intervention aimed at increasing the number of cattle under fodder production was likely to reduce overreliance on protected forests for cattle grazing.

After controlling for gender, household size, education levels and SES in the Hombe forest block, it was found that a unit increase of distance from the forest boundary reduced cattle grazing in protected forest in Hombe forest block by 11%, a unit change in the rest of drivers such as total land size, proportion of land under fodder, and number of cattle in thehomestead changed the level of forest dependence in Hombe forest block by negligible margins of 3% or less. In Kahurura forest block, it was found that a unit increase in proportion of land under fodder reduced cattle grazing in protected forest in Kahurura forest block by 20%. It was also found that ownership of a zero-grazing unit reduced cattle grazing in protected forest in Kahurura by 13% and a unit increase of proportion of cattle under zero-grazing reduces cattle grazing in protected forest in Kahurura by 12%. This implies that intervention aimed at increasing smallholder farmers' capacity to produce more fodder, own zero-grazing unit, and increase the proportion of cattle under zero-grazing would significantly reduce over cattle grazing in protected forest in Kahurura forest block.

Combined logistic model: Relationship between smallholder farmers' household socio-economic characteristics and dependence on protected forest for pasture

As presented inTable 4.8, the results of the model revealed that after controlling for gender, household size, education level and SES, ownership of zero-grazing unit (p=0.03) and the proportion of cattle in zero-grazing unit (p=0.04)were statistically significant at 95% confidence level. Further, proximity to the forest was found to be a statistically significant (p=0.08) driver for grazing at 90% confidence level. The significance at 90% confidence level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). All other variables were identified as statistically insignificant drivers to forest grazing.

The negative coefficients on drivers such as ownership of zero-grazing unit suggested an inverse relation with cattle grazing levels in protected forest for smallholder farmers in Mt Kenya West. An inverse association implies that an increase in the independent variable such a distance between forest and household location reduces the level of forest dependence by a certain margin. On the other hand, positive coefficients on drivers such as the proportion of land under fodder production and the proportion of cattle under zero-grazing suggested that there was a direct association between the drivers and the levels of cattle grazing in protected forest for smallholder farmers in Mt Kenya West. For instance, an increase in the number of cattle in the homestead increased the levels of cattle grazing in protected forest for smallholder farmers in Mt Kenya West protected forest by a certain margin as discussed in the marginal effect model. However, it should be noted that the effect was insignificant for the number of cattle and total land size.

Logistic regression model for cattle grazing

Relationship between smallholder Farmers' household socio-economic characteristics and dependence of protected forest for pasture

Table 4.8: Logistic regression for cattle grazing in Mt Kenya West protected forest

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male /Female)	-1.52	0.17	-1.58	0.2	-1.54	0.28
Household size	0.07	0.81	0.28	0.36	0.38	0.28
Education Level		0.98		0.99		0.99
(No formal education)	-0.08	1.00	2.71	1.00	2.93	1.00
Primary	-0.39	1.00	14.28	1.00	15.41	1.00

Secondary	-17.72	1.00	-0.49	1.00	0.86	1.00
Post-secondary	-6.03	1.00	12.56	1.00	14.95	1.00
Household SES				0.98		0.99
(Poorest)			19.32	1.00	17.53	1.00
Poorer			19.51	1.00	17.71	1.00
Poor			19.56	1.00	19.82	1.00
Less poor			0.66	0.5	0.64	0.56
Proximity to the forest					0	0.08*
Total land size					0	0.58
Proportion of land under fodder production					6.1	0.96
Own zero-grazing unit (Yes)					-16.31	0.03**
Number of cattle in a homestead					0.06	0.69
Proportion of cattle in zero-grazing unit					2.62	0.04**

Notes: Reference category in bracket

**Significant at p<0.1 | **Significant at p<0.05*

Source: Author's survey data

Marginal effects: Combined logistic regression model for dependence on forest for pasture

To assess individual contribution of each variable in explaining the overall cattle grazing in protected forest in the protected forest in Mt Kenya West, a marginal effect model of the logit model was performed, and results presented inTable 4.9. After controlling for gender, household size, education level and SES, it was found that a unit increase in distance away from the forest reduced cattle grazing in protected forest by 3%, a unit increase in the proportion of land under fodder production reduced cattle grazing in protected forest in Mt Kenya West by 4% and ownership of zero-grazing unit reduced cattle grazing in protected forest by 5%. Additionally, a unit increase in the proportion of cattle under zero-grazing units reduced cattle grazing in protected forest by 7%. The results implied that the closer smaller holders are to the protected forest, the higher likelihood to increase forest dependency, increasing smallholder farmers' capacity to produce more fodder, own zero-grazing units and increasing the proportion of cattle under zero-grazing units may significantly reduce cattle grazing in protected forest without interfering with either user rights policies or damaging sustainable livelihoods. It was noted that the total size of land and the number of cattle in homestead were insignificant drivers in determining the levels of cattle grazing in protected forest in Mt Kenya West protected forest.

Table 4.9: Marginal Effects: Combined model for forest dependence on pasture

	dy/dx	Std. Err.	z	P>|z|	[95% C.I]		x
Gender	0.02	0.02	1.19	0.23	-0.01	0.06	2
Household size	0.00	0.01	0.19	0.85	-0.01	0.01	4.2
Education Level	0.01	0.01	0.95	0.34	-0.01	0.03	0
Household SES	-0.02	0.01	-1.76	0.08	-0.04	0.00	5
Proximity to the forest	-0.03	0.00	-0.07	0.95	0.00	0.00	33.7
Total land size	0.02	0.00	-0.49	0.63	0.00	0.00	1.30
Proportion of land under fodder production	-0.04	0.04	1.04	0.30	-0.03	0.11	0
Own zero-grazing unit	-0.05	0.03	1.88	0.06	0.00	0.11	0
Number of cattle in a homestead	0.00	0.00	0.53	0.60	0.00	0.00	5.5
Proportion of cattle in zero-grazing unit	-0.07	0.06	1.25	0.21	-0.04	0.18	0.13

Source: Author's survey data

4.6 Logistic regression results: Relationship between smallholder farmers household socio-economic characteristics and dependence of protected forest for grass

This section presents results of logistic regression analysis of the relationship between smallholder farmers' household socio-economic characteristics and dependence on protected forest for grass. Independent logistic regression models for grass harvesting activities were conducted for each forest block. In each of these regression models, the influence of control variables on the models was first ascertained and controlled, forest differentiated models were run and then compared with overall models for forest dependence on grass harvesting.

For each of the logistic regression models, there was an accompanying marginal effect model after the model explaining the marginal changes in the level of forest dependence level with a unit change in the selected independent variable. Proximity to forest block, total size of land owned, proportion of land under fodder production, ownership of zero-grazing unit, number of cattle in a homestead and proportion of cattle kept under fodder production were used to predict a binary response, an indicator of forest dependence on pasture where grass harvesting throughout the year =1 indicated higher level of forest dependence and grass harvesting during dry season only =2 indicated lower dependence on forest for grass harvesting.

Results of logistic regression revealed that after controlling for gender, household size, education level and SES, only proportion of cattle in zero-grazing unit can be said to be statistically significant ($p=0.08$) at 90% confidence level. The significance at 90% confidence

level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). The rest of the drivers were found to be statistically insignificant drivers in the Chehe forest block. While SES was statistically insignificant, there seems to be evidence that farmers who were less poor in Chehe (p=0.06) posed the minimal forest dependence through grass harvesting. The positive coefficient (2.02) on the significant drivers suggested a direct association between the proportion of cattle under zero-grazing and the level of forest dependence on grass harvesting in the Chehe forest block. This implies that when the proportion of cattle under zero-grazing increased, the level of forest dependence on grass harvesting in Chehe forest block increased with a certain margin. Negative coefficients on the rest of the drivers suggested an inverse relationship between the variables and the level of forest dependence on grass harvesting in the Chehe forest block. For instance, an increase in the distance from the forest block led to a corresponding decrease in the level of forest dependence on grass harvesting in the Chehe forest block. However, it should be noted that these relationships were insignificant as suggested by the p-values of greater than 5%.

The results of the logistic regression model for the Hombe forest block revealed that after controlling for gender, household size, education level and SES, only proximity to the forest was a statistically significant driver (*p=0.09*) at 90% confidence level. The significance at 90% confidence level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). All the other drivers were found to be statistically insignificant in predicting forest dependence by means of grass harvesting. Positive coefficient on drivers such as proportion of cattle under zero-grazing suggested a direct association between the drivers and the level of forest dependence on grass harvesting in the Hombe forest block. This implies that increasing the proportion of cattle under zero-grazing resulted in a corresponding increase in the level of forest dependence on grass harvesting in the Hombe forest block. On the other hand, negative coefficient on drivers such as proportion of land under fodder production suggested an inverse association between the drivers and the level of forest dependence on grass harvesting in the Hombe forest block. However, it should be noted that the association so referred to was statistically insignificant as suggested by the p-value of less than 0.05.

The results of the logistic regression model revealed that after controlling for gender, household size, education level and SES, only proximity to the forest was a statistically significant ($p=0.01<0.05$) predictor for grass harvesting in the Kahurura forest block at 95% confidence level. Total land size was a statistically significant driver ($p=0.08$) at 90% confidence level. The significance at 90% confidence level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). All the other drivers were found to be statistically insignificant drivers for grass harvesting in the Kahurura forest block. Positive coefficient on drivers such as proximity to the forest (0.06) and ownership of zero-grazing unit (1.30) implied that a unit increase distance between households and forest block and a change in the status to having a zero-grazing unit increased proportionately the level of dependence on forest for grass harvesting in the Kahurura forest block.

After controlling for gender, household size, education level and SES in Chehe, it was observed that a unit increase in the proportion of land under fodder production reduced dependence on forest for grass harvesting by 9% while ownership of a zero-grazing unit increased dependence on forest for grass harvesting by 11%. Further, it was observed that unit increase in the proportion of cattle under zero-grazing increased dependence on forest for grass harvesting by 13%in the Chehe forest block. On the other hand, a unit change in the total land size, proximity to the forest and number of cattle in a homestead had negligible changes of less than 3% on dependence on forest for grass harvesting. Hombe, it was observed that a unit increase in the proportion of land under fodder reduced forest dependence for fodder by 12% while ownership of zero-grazing unit increased dependence on forest for grass harvesting by 11%. Kahurura, it was observed that a unit increase in the proportion of land under fodder reduced dependence on forest for grass harvesting by 13%, ownership of zero-grazing increased forest dependence for grass harvesting by 15% while a unit increase in the proportion of cattle under zero-grazing increased dependence on grass harvesting by 11% in the Kahurura forest block.

Combined logistic regression model: Relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for grass for cattle

Table 4.10 presents result of logistic regression for grass harvesting in Mt Kenya West. The results of the model revealed that after controlling for gender, household size, education level

and SES, only total size of land owned was a statistically significant (p=0.02<0.05) driver at 95% confidence level while the proportion of cattle in zero-grazing unit was also statistically significant driver at 90% confidence level. Additionally, SES came out as a critical variable with its statistical significance evident (p=0.06) at 90% confidence level. The significance at 90% confidence level suggests a weaker association between variables compared to the conventional 95% confidence level benchmark provided by Fisher in 1925 (Meyer et al., 2017). Similarly, the negative coefficient suggested an inverse association between the associated driver and the level of forest dependence for grass harvesting in protected forest in Mt Kenya West. Positive coefficients, on the other hand, suggested a direct positive relationship between the drivers and the level of forest dependence on grass harvesting in protected forest in Mt Kenya West.

Table 4.10: Logistic regression for grass harvesting in Mt Kenya West protected forest

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-0.03	0.91	-0.21	0.53	-0.14	0.68
Household size	0.12	0.19	0.11	0.27	0.11	0.27
Education Level		0.11		0.2		0.41
(No formal education)	-0.15	0.10	-0.13	0.11	-0.12	0.11
Primary	-0.79	0.40	-0.71	0.44	-0.61	0.51
Secondary	-0.93	0.42	-1.23	0.31	-1.24	0.33
Post-secondary	6.96	0.72	6.69	0.71	6.41	0.73
Household SES				0.01		0.06*
(Poorest)			-1.4	0.05	-1.29	0.11
Poorer			0.15	0.77	0.42	0.49
Poor			-0.18	0.69	-0.18	0.74
Less poor			0.87	0.06	0.61	0.23
Proximity to the forest					0.01	0.24
Total land size					0	0.02**
Proportion of land under fodder production					-0.39	0.39
Own zero-grazing unit (Yes)					0.19	0.68
Number of cattle in a homestead					0.03	0.56
Proportion of cattle in zero-grazing unit					1	0.07*

Notes: Reference category in bracket

**Significant at p<0.1 | **Significant at p<0.05*

Source: Author's survey data

Marginal effects combined model: Relationship between smallholder farmers' household socio-economic characteristics and dependence of protected forest for grass for cattle

After controlling for gender, household size, education level and SES in the whole study region, it was found that a unit increase the total size of land owned reduced dependence on forest for grass harvesting by 14% as shown inTable 4.11. It was also found that a unit increase in the proportion of cattle in zero-grazing unit increased forest dependence through grass harvesting by 17%. Further, the study found that ownership of zero-grazing unit increased dependence on forest for grass harvesting by 5% while a unit increase in the proportion of cattle kept under zero-grazing increased dependence on forest for grass harvesting in Mt Kenya West protected forest by 9%.

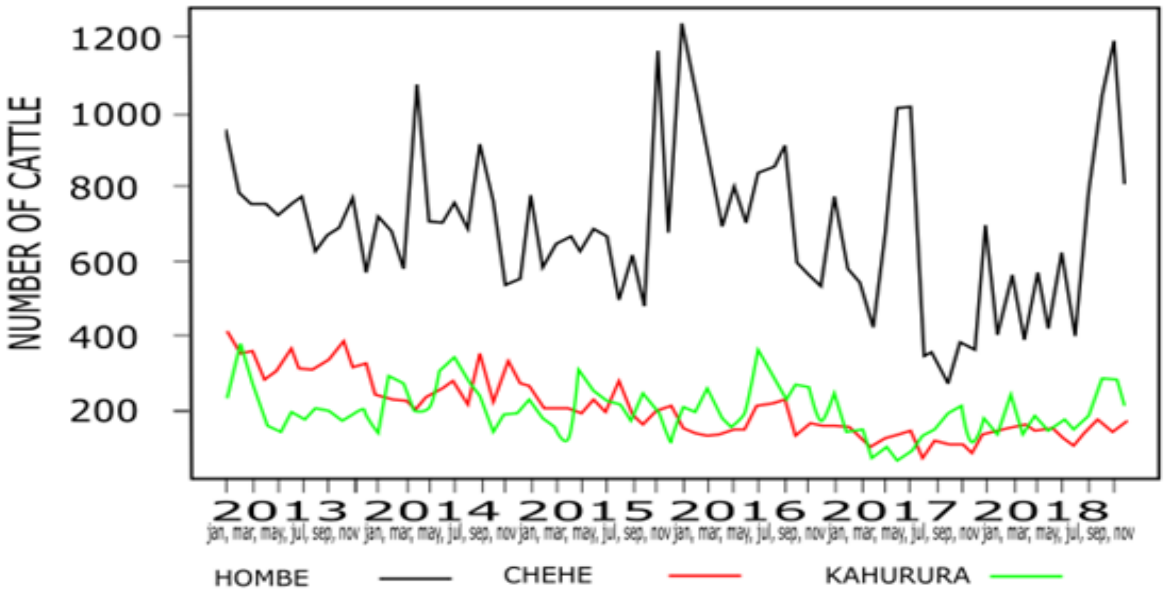
Table 4.11: Marginal Effects: Combined model for forest dependence on grass harvesting

	dy/dx	Std. Err.	Z	P>|z|	[95% C.I]		x
Gender	0.00	0.07	0.06	0.95	-0.13	0.14	2
Household size	0.02	0.02	1.13	0.26	-0.02	0.06	4.2
Education Level	0.07	0.04	1.78	0.08	-0.01	0.14	0
SES Wealth Index	-0.04	0.03	1.04	0.30	-0.03	0.10	5
Proximity to the forest	0.00	0.00	1.44	0.15	0.00	0.00	33.7
Total land size	-0.14	0.00	-2.97	0.00	0.00	0.00	1.30
Proportion of land under fodder production	0.00	0.08	-0.52	0.61	-0.21	0.12	0
Own zero-grazing unit	0.05	0.09	-0.49	0.62	-0.23	0.14	0
Number of cattle in a homestead	-0.02	0.01	0.71	0.48	-0.01	0.02	5.5
Proportion of cattle in zero-grazing unit	0.17	0.10	1.65	0.10	-0.03	0.38	0.13

Source: Author's survey data

4.7 Seasonality patterns on forest dependence for pasture

The results of analysis of data from KFS on livestock grazing in the protected forest for seasonality of forest dependence are summarized in Figure 4.4.



Source: (Author)

Figure 4.4: Monthly and seasonality patterns of smallholder farmers' dependence on protected forest for pasture

Results revealed that the three forest blocks experienced seasonality patterns in forest dependence for pastureFigure 4.4. Comparatively, Hombe had the highest number of cattle entries to the forest throughout 2013 to 2018. Minimum cattle counts were observed in the year 2017, while maximum counts were observedin the early months of the year 2016 and in 2018 as shown in Figure 4.4. In general, the early months of the year (January) and middle year (July) exhibited peaks in cattle grazing whilst August, October and December had a low count in cattle numbers recorded.

The months February, March, April and May were noted to have the lowest influx of forest dependence for pasture. Generally, these four months had comparable figures of about seven hundred cattle. Cattlegrazing activities began peaking again in June and capped in July such that the following two months, that is June and July showed an average of eight hundred cattle. On the other hand, the figures dropped in the following month of August where they were continually observed to be below the previous low of seven hundred, albeit the numbers in these months (August, September, October, November and December) varied between six

hundred and four hundred or even lower (three hundred) such as those observed in the year 2017. The cycle repeated itself throughout the study period.

Hombe seemed to record the highest influxes beginning in January of each year (Table 4.12). Grazing activities tended to decline in the subsequent months of February, March, April and May. The period around the middle of the year, July, exhibited influxes in cattle grazing whilst August, October and December hadlower numbers(Figure 4.4). The seasonality in forest dependence for pasture was probably influenced by rainfall seasons where the heavy downpours of long rains in March, April and May was associated with minimum cattle grazing while the lighter rains of the short rain season in September through December favourable for grass growth, coincided with peak cattle grazing in the blocks. One approach to a manage influxes in peak seasons could be by closing some sections of the forest block to allow for grass to recover.

Table 4.12: Monthly seasonality indices on smallholder farmers' dependence on forest for pasture

FOREST BLOCK	Month											
	Jan	Feb	Mar	April	May	June	Jul	Aug	Sep	Oct	Nov	Dec
Hombe	179	0.3	-18	-11.5	4.6	29.5	116	-83	13	-116	13	-127
Chehe	-7.2	-21	-20	-26.2	-13	3.2	13.1	9.8	35	-1.9	17	11.3
Kahurura	2.2	-8.7	18.9	-5.3	-5.5	-4.9	38.3	26.6	2.8	9.4	12	-38

Source: (Author)

Note: *Negative indices indicate activities drop in the month relative to other months on average through 2013 to 2018 period (that is a low season)*

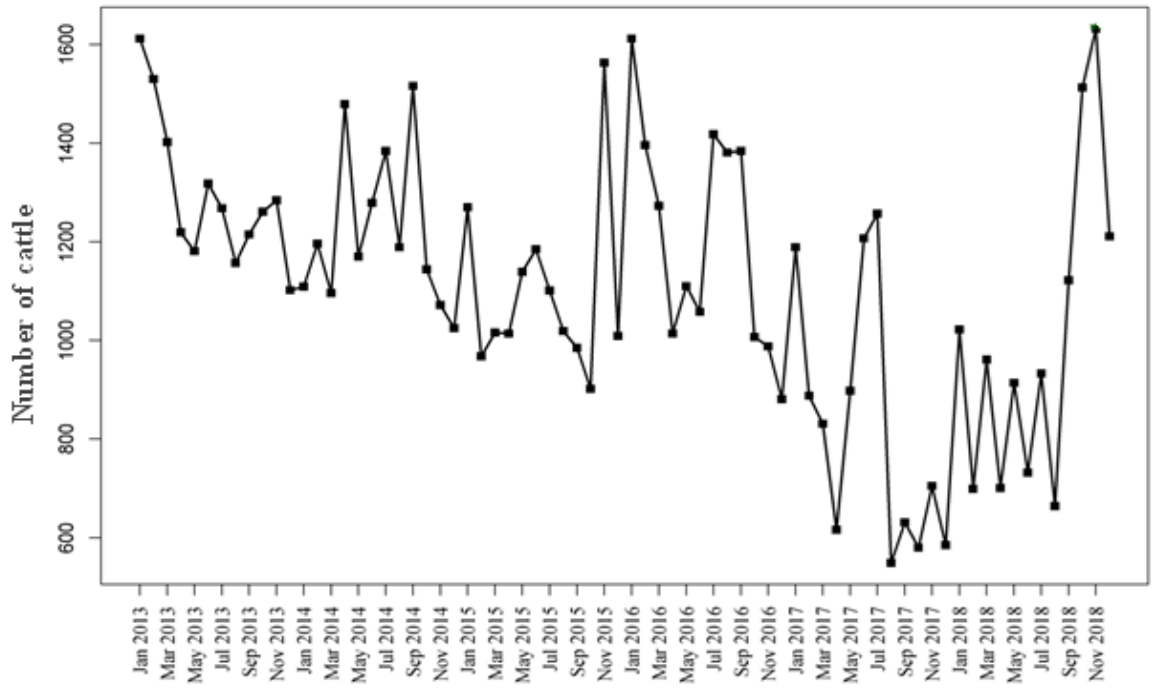
Figure 4.4 and Table 4.12indicate that Chehe and Kahurura had relatively low numbers of animals entering the forest compared to the Hombe forest. In Chehe, the first half of the records showed low forest dependence for pasture compared to the rest of the year (July through December). In Chehe, results revealed that in general, the last half of the year months exhibited peaks in cattle grazing whilst the first half months (January through June) had a characteristic low count in cattle numbers recorded (See Table 4.12).

In summary, Chehe experienced the lowest forest dependence in the month of April, with the peaks and the lows in Chehe representing a change of about 50 cattle up or down and the cycle repeated itself throughout 2013 -2018. Results on seasonality patterns analysis revealed repeating seasonality on forest dependence for pasture. In Chehe, the observed rainfall data was obtained from a meteorological weather station within the forest block managed by KFS and the adjacent community for the years 2009 to 2018. In Chehe, the years 2012 through 2016 had an apparent suppressed rainfall compared to the other years in study period althoughthe peak seasons of March to May and October to November were maintained. The better part of December to February months during those years observed zero rainfall. Generally, the region hastwo rainy seasons and two dry seasons that coincide with rainfall regimes of the East African highlands.Heavy downpours of the long rains areexperiencedin March to May and lighter showers in October to December in some years.

The rainfall data analysis indicated that an increase in the amountof rainfall was likely to lead to lowergrazing activities over the Chehe forest block by a unit value about a month or two later while a decrease in the amountof rainfall was likely to lead to increased grazing activities in the Chehe forest block by a unit value, about a month or two, later. A possible reason for this relationship is that light shower rains in the short rain season favour grass growth, leading to enhanced grazing, or suppressed rainfall leads to reduced pasture for farmers, hence they flock to this forest reserve for grazing. The peak season in the January of each year is followed by a decline in cattle numbers, the lowest being in the month of April. Therefore, the seasonality patterns on livestock grazing in Chehe are apparently influenced by rainfall patterns.

In general, Kahurura seemed to experience two seasons of high influxes and two low seasons. The month of April and the month of December experienced extremely low cattle grazing activities in Kahurura while March and July exhibited characteristic high peak season. Comparatively, the high and the low seasons, the numbers did not change so rapidly from one season to the other as compared to the seasonality patterns in Hombe. Kahurura seemed to experience influxes in the month of May, June and July and August and eventually dropped back into a low in December. Generally, the low season of January to March and September to November were months having stable figures while the other months had varied numbers.

A change in cattle number from low to high season seemed to average around 80 cattle. July seemed to be the major peak season with 350 cattle followed by another in March with an average of 300 cattle. The seasonality patterns in forest grazing in Kahurura were apparently influenced by rainfall seasons. This is strongly associated to rainfall seasons where the heavy downpours of long rain season of March, April and May reflected minimum cattle grazing while the lighter rains of the short rain season in September through December, which are favourable for grass growth, coincided with peak cattle grazing in the blocks. Eventually these favourable conditions manifested in that part of the farmers, directly switched to minimal or maximum cattle grazing activities.



Source: (Author)

Figure 4.5: Monthly and seasonality patterns on smallholder farmers' dependence on protected forest for pasture

Results of the combined data for the 3 forest blocks revealed that in general, the first half of the year experienced a low number compared to the later part of the year. Comparing the two, the high and low seasons within which the figures are comparable, cattle numbers did not change rapidly from one season going to the other. For example, the peak season in September was followed by a low season in January with a drop of about 150 cattle. Seasonality in forest dependency for pasture for the three forest blocks combined revealed a

low season in the month of April. Grazing activities tended to increase in the months of July, August, September, October, November and December.

4.8 Perceptions of participants towards a ban to regulate grazing activities in the protected forest

This section presents results of objective four that sought to examine the perceptions of the smallholder farmers towards regulation of grazing activities in the protected forest through a ban. Results obtained from qualitative analysis showed that disruption of household natural assets for livestock keeping, disruption of the number of cattle the family keeps, disruption of family cash flows, disruption of household's ability to pay school fees for children and disruption in quality of life in general themes emerged as summarized inTable 4.13.

Table 4.13: Smallholder farmers' perceptions of how a ban would affect livelihoods

Perceived livelihood disrupted	**No. of Mentions**
Disruption of household natural asset for livestock keeping	
Reduction of available pasture	56
No land or less land for grazing	44
Divert cropland for fodder	6
	106
Disruption of cattle farming activity	
Household reduced cattle herd	68
Reduced quality of animal health – cattle would suffer from hunger	16
Reduced quantities milk production by a household	55
Reduced sources / quantities of manure	9
	148
Disruption of family cash flows	
Reduced income from the sale of cattle products	41
Loss of cattle farming jobs	6
Increased household expenses due to rise in the cost of pasture	19
Households' increased cost of buying milk	3
	69
Disruption of household's ability to pay school fees for children	**14**
Disruption in quality of life in general	
Worsen poverty levels	11
Worsen economic hard times in the households	78
Trigger insecurity	8
Trigger conflicts	3
Increase uncertainty with the future	7
	107
Disruption in social relations with the Kenya Forest Services	
Benefits of forest membership	7
	7

Source: Author's survey data

A forest management strategy that bans livestock grazing was shown to have potential to trigger several disruptions to smallholder livelihood assets farmers in various ways as discussed in subsequent sections.

Disruption of the household's natural assets available for cattle grazing

This category shows how access to forest land increased the household land and resources for cattle grazing. Most farmers around Mt Kenya West have small land parcels which pose challenges to livestock keeping and livelihoods, and if these farmers relied only on their resources, they would keep a limited number of cattle. This category had three subcategories; reduction in available pasture, no land or less land for grazing and diversion of cropland to fodder land.

Reduction in available pasture

The forest is considered a source of pasture in the area especially during the dry months. If this activity was banned, this source of pasture for the area would be lost. Other farmers would experience a decline in pasture as C150 alluded:

"I think the consequences would not be favourable because at first, we depend on the grass... so I can say the forest means a lot to us because, for instance, if you buy 8 bags of grass, the cows will consume about2 bags in the morning and just a little Napier grass."

Less or no land for grazing

To some farmers, a ban would mean no land at all to keep animals or very limited land for grazing as echoed by C28:

"It would be a bit difficult because we don't have anywhere else, we can do grazing".

Diversion of cropland to fodder land

Farmers would experience a lower crop harvest since in an effort to increase grazing land, more land would be diverted from food and cash crops cultivation to growing fodder for the cows as H133 mentioned:

"I think people would interfere with the already growing crops such as maize plants to feed the cows."

Disruption of family cash flows

This category shows how a banongrazing in the forest or grass harvesting is likely to lead to a decline in the family income. It had four subcategories: reduced income from the sale of cattle products, loss of cattle farming jobs, increased costs of pasture, and increased household costs of buying milk.

Reduced income from the sale of cattle products

In this subcategory, the household would experience reduced income from the sale of cattle products such as milk, beef, skins, and manure. H134 asserted:

"I think if they ban cutting grass in the forest, it will lead to low milk and meat production and other things like skins as well. There would be disease outbreaks."

Loss of cattle farming jobs

This subcategory shows that disruption in forest grazing and grass harvesting would lead to loss of jobs for people such as those who cut and sell grass, those who milk and attend to cattle in one way or another on a daily basis. 10H said:

"We do even employ gardeners to help in grazing activities, so their contracts would come to an end."

Increased household expenses as cost of pasture increases

This subcategory depicts how the family cash flows would decrease due to increased costs of buying expensive animal feeds. For those who would opt for zero-grazing, that would be even more expensive to maintain as C164 put it:

"One of the problems we are facing is that we don't have huge tracts of land so I don't think it would be a favourable decision because we cannot do zero-grazing."

Increased household costs of buying milk

This subcategory shows how the family cash flows would reduce due to increased cost of buying milk. It is assumed that if a family keeps cows, it will be able to have enough

quantities of milk at a lower cost. However, if the family buys milk, it will be at market price, thus costing more for the same quantity of milk consumed. This concern was raised by 19H:

"I would sell the cows because there is nowhere else to do the grazing as a result. I would be forced to buy milk for home consumption (of) which would not be easy."

Disruption of the cattle farming activity

This category shows how a ban in forest grazing and grass harvesting would affect the number of animals kept around the Mount Kenya ecosystem. This category had four subcategories: reduced household cattle herd, animals suffering from hunger, reduced household milk production and reduced amount of household manure production.

Reduced household cattle herd

This subcategory depicts how a ban on grass harvesting and forest grazing would eventually reduce a significant size of a household's herd especially those with small farm sizes. They may also alter the animals they keep from large animals to small animals such as goats as H124, narrated:

"You will be forced to sell the cows and remain with just a few of them that you can handle - like if you had two cows, you would be forced to sell one and remain with one."

Reduced quality of animal health - animals suffering from hunger

This subcategory shows how animals health would be affected if they are not well fed due to limited affordable pasture from the ecosystem. During droughts there is usually reduced pasture, and these households rely on the forest for supply of additional affordable feeds. If this source of pasture is gone, animals may suffer from malnutrition especially during the dry spells. Poor feeding will lead to animals being prone to sicknesses and deaths as opined by 54K:

"We would suffer as we do rely on the forest especially during the dry seasons. The cows would suffer and maybe as a result die of hunger."

Reduced household sources of manure production

This subcategory depicts how a ban in cattle grazing and grass harvesting in the Mount Kenya West forests would lower the level of manure that households produce as was anticipated by C165:

"*If I don't have grass for my cows to feed on, I don't expect manure in return".*

A recent study on technical, environmental and cost-benefit assessment of manure management chain revealed that production and utilization of manure improves crop production, farm income and can be a source for clean, renewable energy (Sefeedpari et al., 2019). In the context of this research, reduced household production of manure would imply a possibility of low crop production of both cash crops and food crops. Reduced farm productivity would further lead to both reduced cash flow from the sale of cash crops and also a situation of reduced food production, which would then increase food insecurity.

Reduced quantities of milk produced

This subcategory demonstrates how a ban in grazing and grass harvesting would eventually lead to lower milk production among households as C164 asserted:

"It could affect me because here at home, I don't have enough grass for the cows which could affect milk production as well."

Disruption of households' income / ability to pay school fees for their children

This category captured how disruption in family income due to loss of grass harvesting and lack of grazing would eventually affect the education sector. Rural households normally use the proceeds from the sale of milk /animals to educate their children. Thus, a disruption in their livestock farming activities would adversely curtail their ability to pay school fees as participant K90 asserted:

"It is through the cows we are able to educate our children, which is after selling milk so it would lead to some problems because during the dry seasons, milk production is always low, and if grazing activities in the forest were banned, it would be stressful."

Failure ofchildren to access good quality schooling implies that future generations will also, most likely, lack access to the opportunities that good education offers. This would further lead to a vicious circle of poverty inthe community.

Disruption of social relations with the Kenya Forest Services

This category explored how a ban in the Mt. Kenya West forest would significantly affect the farmers' relations with the Kenya Forest Services and it had no subcategories. Banning the forest-adjacent communities from benefiting from the forest would be interpreted as a breach of trust and loyalty between the farmers and the forest agents, leading to conflicts according to participant C49:

"My cows would die of hunger which would be a loss. It would be a problem because we cannot do zero-grazing for more than two cows and conflict or a confrontation would arise between the KFS and the community."

Participant C147 added:

"That would be nonsense because I am a member (of a CFA). We have been working hard to make sure that we take good care of the forest. We used to plant trees because of we were told that we would be allowed to do some cultivation in some parts of the forest."

Participant C160 also said:

"I don't think that would be possible because we do have license to do forest grazing."

Participant C48 added:

"What I can say is that when you are in a (CFA) group, you cannot be told to keep off the forest because we do even pay but there is a formality you cannot come from anywhere and bring your cows into the forest. You must be a member of a group so that you can be given license and a membership ID."

Disruption in the quality of life in general

This category focused on how a ban on forest access would generally lead to adecline in the quality of life among the people. These farmers and their households would be affected in various ways. This category had five subcategories namely: worsening poverty levels;

economic hard times in the households; insecurity in the area and uncertainty about the future. Each subcategory is discussed in detail in the subsequent sections.

Worsening poverty levels

This subcategory explored the poverty spiral that would result from losing a major source of livelihood. There would be a downward poverty spiral as 187K asserted:

"There would be several consequences, one of them being lack of enough pasture. Second is low income and third, it would lead to high level of poverty because in this community livestock keeping is our cash crop."

Economic hard times in the households

This sub-category focuses on the effects of a ban on forest access on income sources for households. Most farmers were of the opinion that they would be adversely affected to the point of being unable to meet basic obligationssuch as educating their children and putting food on the table. Participant H128 had this concern:

"I think it would be challenging because I would not be in a position to educate my children and even provide (the) basics such as food and clothing".

Insecurity in the area

This subcategory focused on the likelihood of insecurity triggered by poverty and high unemployment levels in the area. Some farmers suggested that cases of people stealing Napier grass from their neighbours would go up as participant H11 reported:

"Milk production would go down and I think high level of insecurity because most people would abandon livestock keeping, because we do even employ gardeners to help in grazing activities, so their contract could come to an end."

Conflicts in the area

This subcategory explored the type of conflicts that might arise from reduced resources such as competition and strife for the limited grazing land within their neighbourhood such as the grass along the road reserves. Participant H123 asserted:

"Things would be difficult for us as we rely on the forest to feed our livestock. It would also cause conflicts within the community members because everyone wants to benefit from the little pasture that we would be having in the community."

This conflict could be exacerbated to the forest authorities, as these farmers would resist the move as participant K205 commented:

"It would not be easy because it could even cause riots. I think we have a right to use the forest as we are not destroying the forest. We could even burn it down if such a decision was made."

Uncertainty about the future

This sub- category focused on the emotional and psychological effects that would result from loss of livelihoods. Loss of income and work would make a number of farmers and their households lose the hope of a bright future that the forest promises them, leading to hopelessness as echoed by C162 and K 228:

C162: If we were denied access to the forest, it would be challenging because we do depend on the forest for pasture. It would be a problem because at times you might have an idea of keeping some cows to help you in future, maybe you can sell and start a business. If all of a sudden, they decided on such an action, it might even affect some of our future plans."

K228: "It would affect food production, especially milk. We do rely on grazing so if the operations were closed, I think it would affect income as well, that could be our end."

Participants' strategies to cope with a ban on livestock grazing in protected forest

Table 4.14: Smallholder farmers' livelihood strategies to cope with a ban on cattle grazing

Strategy	**No of Mentions**
Option 1: Diversify partially from cattle farming:	
Reduce herd	49
Zero grazing/tethering	22
Making silage	8
Begin poultry / change from cows to goats	6
	85
Option 2: Diversify completely from cattle Farming:	
Sell all animals	40
Do something else …. "not specified"	10

Pursue other forms of employment	7
Pursue trade	6
Grow crops	3
Buy milk for households needs	1
	67
Option 3: Try to seek alternative pasture without reducing herd	
Buy animal feeds	19
Graze on the roadside	5
Lease more land for fodder	5
Convert cropland to fodder	1
	30
Option 4: Other sources	
Renegotiate with KFS	9
Rely on children	2
Illegal business	2
Use compost manure	1
	14
Option 5 Do nothing	8

Source: Author's survey data

The second research question focused on ways in which the smallholder farmers in Chehe, Kahurura and Hombe would handle a government ban on grazing or harvesting grass from the Mt Kenya West Forest blocks. It had five categories: diversify partially from cattle farming, diversify fully from cattle farming, seek alternative pasture without reducing their herds, and other sources of income (See Table 4.14).

Option 1: Diversify partially from cattle farming

This was the largest category and sought option. These farmers did not want to leave cattle farming but just reduce the scale of cattle farming operations to fit their available means of pasture. These farmers thought they would reduce the herd to a manageablenumber. It had four subcategories namely: reduce herd, zero-grazing or tethering, poultry farming or changing from cow to goats, and making silage. While some of these options may be feasible in reducing overreliance on forest, each of these options may be faced with sustainability challenges and related barriers of implementation.

Reduce herd: In this sub-category, a good number of farmers suggested they would reduce the number of cows they keep to a manageable size without relying on the forest. Farmer K198 had this to say.

"I would sell some of the cows and remain with a few for zero-grazing; I have the land where I can satisfy such as one cow".

Others who supported this move included Farmer C151 who would reduce from five cows to two cows and farmer H121 who would sell 18 of these 20 cows and remain with 2.

However, such reduction of herd size would make farmers sell their animals at non-competitive pricesthus losing more of their resources, sentiments that H97 raised.

"I would reduce the number of cows that I am keeping of which it could be at a throw away price."

Zero grazing/tethering: In this subcategory, farmers reported that they would opt to make a zero-grazing unit or tether their animals. Farmer K98 commented:

"I would plant Napier grass to do zero-grazing. These farmers must have some land to plant Napier grass".

H23 added:

"*Maybe I would remain with just one cow of which I can even do tethering. Tethering can be a feasible solution to a few cows*."

Holding other factors constant, adoption of zero-grazing can be considered as among the best practices in ensuring the sustainability of animal production. To this end, adoption of zero-grazing as a mitigation strategy resulting from forest ban can be deemed a sustainable approach. However, there is an element of cost that comes with it which can be a barrier to farmers with poorer socio-economic status. In fact, this study found that only 1 in 4 farmers had established a zero-grazing unit, most of which were not functional. Additionally, only a few of the cattle on the farm were under zero-grazing. Farmers who did not have zero-grazing units cited high initial cost as the greatest barrier while a few of them also mentioned inadequate skills. Thus, while resorting to zero-grazing as a shock mitigation strategy, financial and training interventions may be required to empower the farmers and ensure sustainability and productivity. This empowerment role could be carried outby the government in collaboration with other development partners such as civil society organizations and private investors in agriculture.

Begin poultry or change from cows to goats. In this subcategory, some farmers reported that they would opt to diversify from large animals to smaller animals which would require less land or food to keep. Participant C45 said.

"Suppose I have like 20 cows, and I rely on the forest, so if you serve me with a notice to keep off the forest, I will be forced to sell the cows and keep goats for milk."

Others would opt for chicken farming as the case of participant H110:

"After selling three of them maybe I could chip into poultry farming because chicks don't feed on grass."

A change of farming approaches from cows to goats or a complete shift to poultry production may be a sustainable mitigation strategy. By law, the Kenya Forest Service does not allow access of goats and donkeys into the protected forests. When farmers choose to shift from rearing cattle and begin to rear goats, this may be an indication of surrender to the extent that they find alternative sources of feeds for the goats. Indeed, the consumption levels of a goat by volume may be significantly lower compared to those of cattle. For this reason, goat rearing could possibly reduce pressure on the forestbecausethese animals could be fed on much less home-grown fodder or roadside grass. On the other hand, while poultry farming may have completely new dimensions in terms of approach that may be beyond the scope of this study, it can be thought to be a sustainable mitigation strategy in future. For instance, poultry farming will not pose pressure on protected forests since birds do not depend on grass as their primary source of feeds. Secondly, the demand for poultry products such as eggs is equally rising as fastas milk products. For this reason, farmers who venture in poultry farming will in all likelihood have increased cash flow from the sale of poultry and poultry products. However, it must be noted that poultry farming has different dynamics that traditionally dairy farmers in Mt Kenya West may need to learn first to make it a meaningful venture.

Making silage: In this category, some farmers reported that they would opt to make silage for their cows rather than rely on grass harvesting or grazing in the forest.

Participant H104 said:

"So, when there is surplus pasture, I would make silage. I also have a good area of land where I can plant grass for the cows."

Participant H133 added:

"Maybe you can store silage so that you can be on a safer side during the dry seasons."

One of the limiting aspects of this coping mechanism is that it requires resources and only rich farmers are likely to afford it. Resource-poor farmers are likely to be more affected by forest ban as they have no resources to invest in this alternative coping mechanism. Again, this study has shown that a negligible proportion of farmers in the three forest blocks are involved in production of fodder. Indeed, most of them rely on grass harvesting from the protected forests for their silage making process. Clearly, a ban that prohibits forest access would also lead to failure in silage making before these farmers stabilise their production. Finally, the silage making process may also require purchase of additional farm inputs for mass production yet most farmers in the study were smallholder farmers of low socio-economic status. This further complicates the sustainability of silage making as an alternative mitigation strategy to forest ban.

Option 2: Diversify completely from cattle farming

This was the second sought option for farmers. Farmers reported that they would seek to pursue alternative income generating ventures completely away from cattle rearing. This category had six subcategories: selling all animals, doing something else not specified, pursuing other forms of employment, pursuing trade, growing crops and buying milk for household needs.

Selling all animals: In this subcategory, a significant number of farmers suggested selling all the cows and not to relying anymore on cows as an income generating activity.

Participant K199 commented:

"I would sell my cows as I do depend on the forest fully. There is nowhere else I can do grazing."

This could be an option especially those who do not have large sizes of land to cater for cattle farming as the case of farmer K 231;

"I think it would be a puzzle because nowadays we don't have land for lease and the land we own cannot be of help because you cannot even do poultry farming. I think I would sell the livestock."

Similarly, participant H77 commented thus:

"I would sell the cows and keep off from livestock keeping because during the dry season, you cannot even get anywhere to buy grass."

Selling all the animals without an alternative income generating activity as suggested by some of the farmers may not be a suitable approach to mitigate against policy shock from forest bans. Gorbenkova, Shcherbina & Belal (2018) conducted a study in Mogilev rural areas in Russia on the critical drivers of sustainable development and concluded that agriculture was among them. In the context of this study therefore, selling all the animals as a result of forest ban may not be the best mitigation strategy as this would lead to reduced household cash flow, thus increasing family vulnerabilities to poverty.

Do something else: In this subcategory, a significant number of farmers suggested that they would do something else. However, these farmers did not figure out exactly what they would do. This could suggest they have never thought of themselves having a livelihood that is not dependent on the forest as reiterated by participant C164:

"I would just quit from the business and look for something else to do instead."

Pursue other forms of employment: In this subcategory, farmers reported that they would seek alternative employment such as being casual workers or run a business as is the case of H106:

"*I think I would sell the cows and look for something else to do. I would just convert them to cash and start another business because I would not be able to afford buying feeds for them. You can start a business-such as poultry farming, shop, butchery or even look for employment."*

Grow crops: In this category farmers reported that they would opt to crop farming partly or wholly and diversify from cattle farming which may demand them to rely on the forest for fodder. This was the position of respondents H53 and K231:

H53: *"... I would also sell some of the cows and keep just one which I can manage to feed. For income, I could grow crops."*

K 231: "There is nothing we can do not unless we graze along the roadsides at the reserves. I could also do crop farming, but you see it would not be enough as well."

Buying milk for the family: This was the least sought category where farmers reported that they would opt to buy milk for their households rather than keep animals for milk as mentioned by participant M231:

"I would sell the cow and start buying packet milk."

Option 3: Try to seek for alternative sources of pastures without reducing herd.

In this category, farmers suggested they would seek alternative sources of pasture/animal feeds without necessarily reducing their herds. It had four subcategories namely; buying animal feeds, grazing on the road sides, leasing more land for fodder, and converting cropland for fodder production.

Buying animal feeds: In this subcategory farmers reported that they would opt to buy animal feeds from elsewhere to sustain their present cattle herds as was the option for K 114:

"I think if they banned grass harvesting, I would go, such as we have places where they plant maize, I could go and buy animal feeds from those places or get grass from other areas although it is a bit expensive because you have to cater for transport and things of that sort. I think the immediate idea would be buying because you cannot think of leasing at that time."

The immediate effect of this decision would be an increase in the cost of keeping cattle due to expensive feeds. The forest enables the farmers to cut cattle feeding costs and also give a readily available source of feeds in all seasons including dry and drought season, and where KFS fees applies, it has always been farmer friendly.

Graze on the roadside: In this category, some farmers saw the roadside as a viable place to graze their animals. Roads usually have some reserve land alongside them where farmers can graze their animals. This could be an option as is the case of farmer H134:

"Maybe I could try to graze on the roadsides."

Lease more land for fodder: In this subcategory, the farmers reported that they would opt to hire land to grow fodder from those farmers with larger pieces of land as farmer H127 commented:

"Not unless I work hard and buy my own land there is nothing else that I can do. Maybe I could lease or buy more land so that I can plant forage."

Convert cropland for fodder: This was the least suggested option that farmers would pursue, where they would turn part of their crop land to growing fodder for their cattle. This was the position of some farmers such as 155C:

"I think most of our land is occupied by tea growing, so we would uproot tea for fodder crops."

Option 4: Rely on external support

This category was the least favouredoption farmers would follow to cope with a forest ban on grass harvesting or cattle grazing. It had four subcategories namely: renegotiating with KFS, relyingon children for remittances, starting an illegal business, and use compost manure.

Renegotiating with KFS

In this subcategory, the famers still had some hope that in the case of any stalemate between the farmers and the forest, they would result to dialogue with the KFS authorities to resolve it rather than suffer losses from being banned from using the forest Moreover, this decision to ban grass harvesting and grazing in the forest would be a loss to both parties the farmers and KFS as farmer C145 posited:

"Nothing we can do…something else KFS could also be affected in terms of revenue collected because we also do pay for grass harvesting and grazing. The loss to KFS would be loss of income as well as goodwill from the farmers."

To resolve the stalemate, then, the farmers would stage a demonstration as participant C29 pointed out:

"I think we could come together and protest. There would be nothing else to do."

The community may have a chance to renegotiate with KFS through the Forest Conservation Committee and community forest association have a representative in the committee and this

can enhance relations with KFS to form social capital. At county level, there are efforts to devolve forest functions and this will enhance closer conversations between communities and KFS, and this approach may help to mitigate vulnerability to policy shocks.

Rely on children

In this subcategory, farmers reported that would opt to rely on their children for remittances to sustain their livelihoods. Participant H111 had this to say:

"I would just keep all my hope on my kids, because after selling them (cattle) you would remain with nothing - just poor."

Illegal business

In this subcategory, farmers with limited options reported that they would be forced to resolve to illegal businesses within and around the forest such as burning charcoal and cutting grass for sale. Participants K178 and H107 had these to comment on the issue:

K178 *"I think I would be resistant to that decision. I would go cutting the grass against their wish and if going there by force does not work, I would then sell the cows of which it would lead to a high level of poverty. I would also try on how to benefit from the forest either legally or illegally."*

H107 *"For sure I don't know what we would do because we rely on the forest. You know, it is just next to us. Secondly if that decision was made, most of us would divert to illegal business of charcoal burning so that we can satisfy our needs and provide for the family."*

Use compost manure

In this subcategory, farmers who rely on cattle manure would opt for compost manure for their manure needs. Participant K224 asserted this position as follows:

"First I would sell the cows… for manure I could embrace use of composed manure."

Livestock farming has played a major role in enhancing food security in the region. Availability of farmyard manure from animals improves soil fertility, texture and structure. Lack of reliable farmyard manure due to the sale of animals may increase the cost of food production since farmers may be forced to buy fertilizer. Making compost may be an option

but its time consuming and sometimes it is a challenge to obtain the required quality and quantities.

Option 5: Do nothing

In this category a number reported that they would do nothing about their situation but only wait for fate to take its course. These people seemed to be unsure of which decision they would take in handling the disruption, thus showing helplessness. Participant H15 said:

"Okay, I don't know because it has never been like that before. I don't know what the reactions would be, but it would not be that good."

Participant C162 added:

"Not unless people like you to come with solutions. For me I would just survive with the challenges, but I don't know what exactly I would do."

Old people from households that depend on forest for livelihoods are likely to be helpless to forest policies such as policy ban and this is supported by the work done by Amaike (2016) on the livelihoods and quality of life of old people in Nigeria. The livelihoods of the disabled, people living with HIV and other vulnerable groups will apparently be at risk.

4.9 Chapter Summary

The chapter presentedasummary of demographic information of respondents and outlined the descriptive statistics for cattle grazing and grass harvesting focusing on household size, level of forest dependence on cattle pasture and the level of forest dependence for grass harvesting. The chapter also reported the findings on total size of the land owned by farmers, proportion of land under fodder production, number of cattle in the homestead, proportion of cattle under zero-grazing unit, proximity to the forest boundary (measured in minutes) and investment in zero-grazing units

Concerning the major categories of sources of cattle feeds, the chapter highlighted sources such as forest-based sources, unclassified cheap sources of cattle feeds such as grazing on the roadsides, using peels, vegetable wastes and banana leaves, feeds from own farm, feeds bought from neighbours and commercial feeds. The chapter also captured the logistic regression findings and their interpretations on the relationship between smallholder farmer's

household socio-economic characteristics and dependence of protected forest area for pasture and grass harvesting, seasonality patterns on forest dependence for pasture as well as the monthly seasonality indices on smallholder farmer's forest dependence for pasture. Rainfall data analysis was also presented in an attempt to show the influence of rainfall patterns on seasonality patterns oflivestock grazing. The chapter concluded by examining the perceptions of the smallholder farmers towards regulation of grazing activities in the protected forest through a ban and the subsequent disruptive effect on natural assets for livestock keeping, the number of cattle the family keeps, family cash flows, household's ability to pay school fees for children and the general quality of life.

CHAPTER FIVE

SUMMARY OF DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter Introduction

The chapter provides a summary of the discussions of key findings, conclusions, and recommendations. Discussions of key findings are organized according to theresearch objectives, beginning with discussions on findings relating to relationship between smallholder farmers household socio-economic characteristics and dependence of protected forest for pasture; relationship between smallholder farmers household socio-economic characteristics and dependence of protected forest for grass for cattle; seasonality patterns on smallholder dependence on protected forest in West Mt Kenya region for pasture; and lastly the perceptions of the smallholder farmers towards the use of a ban to manage access to protected forest for pasture. The chapter includes that study conclusions and recommendations and possible policy interventions. Recommendations for further researcher also discussed in the chapter

5.2Household socio-economic characteristics and dependence of protected forest for pasture

It was concluded based on cross-tabulation analysis that there is no statistically significant association between smallholder farmers gender and forest dependency through cattle grazing at 95% confidence level. These results contradict the previous findings by Tangka et al. (2000) on gender roles in livestock production systems in developing countries which indicated that cattle's grazing is a preference for men becauseon gender role differentiationand direct economic gains. On the other hand, the study found that there is a statistically significant association between smallholder farmers SES and forest dependency through cattle grazing at 95% confidence level. This inference was based on evidence that more farmers who were involved in cattle grazing were mainly inthe poorest wealth quintiles.

Results shows that only 32% of farmers involved in cattle grazing own zero-grazing units while a large majority at 68% do not have zero-grazing unit. There is a statistically significant association between smallholder farmer's ownership of zero-grazing unit and forest dependency through cattle grazing since most of the smallholder farmers involved in cattle grazing did not have functional zero-grazing unit. Across forest blocks, it was found

that Hombe and Kahurura has the highest percentage of farmers who graze in the forest most parts of the year while Chehe forest block had the least percentage of farmers involved in cattle grazing throughout the year. The association between forest block and cattle grazing in protected forests was found to be influenced by many other factors including household wealth profiles described earlier.

Across the three forest blocks, there was a statistically significant relationship between SES and household size and dependence on protected forest area for pasture. However, after controlling for gender, household size, education level and SES, only a proportion of land under fodder was significant in Kahurura forest block ($p=0.00<0.05$). These results are consistent with outcome of this research because the marginal effects of dependence on cattle grazing reduces by 20%, 13% and 12% with a unit change in the sizeof land under fodder, ownership of a zero-grazing unit and proportion of cattle under a zero-grazing unit. Aplausible reason is that majority of the farmers who utilized sections of their land for fodder production were least dependent on cattle grazing. However, there are limited empirical research that identified the proportion of land under fodder production as a significant driver of dependence on cattle grazing, hence, the relevance of this research in contributing to new knowledge. In Chehe, only total land size was significant ($p=0.06<0.1$) after controlling for gender, household size, education level and SES. This result is supported by a similar study carried out in India that established that ownership of agriculture land was a significant driver of forest dependence (Jain & Sajjad, 2016).

The findings indicated that farmers with more than average land sizes in Chehe (1.02 acres) were least dependent on cattle grazing. This can be further observed in the marginal effects model that indicates that a unit increase in land size in Chehe reduce dependence on cattle grazing by 7%. After controlling SES and household size for Chehe, the marginal effects of dependence on cattle grazing reduces by 3%, 1% and 21%. A unit increase in proportion of land under fodder production, number of cattle in homestead and proportion of cattle in zero-grazing unit respectively. This result concurs with the previous study donein India (Jain & Sajjad, 2016) that established that agriculture land ($p=0.000<0.01$) and livestock population ($p=0.008<0.01$) as significant drivers of forest dependency for Sariska Tiger Reserve. Piana and Masden (2013) study in Peru also noted cattle densities as a threat to the ecosystem. Much earlier still, Adhikari et al. (2004) in Nepal had identified land and livestock holdings among others as key drivers of forest dependency. This study also concurs with previous

studydone in Bolivia on forest income and dependency which established that the area of cultivated land was a statistically significant driver for forest dependency.

Proximity to the forest was a significant driver ofdependence on cattle grazing in Hombe forest block($p=0.04<0.05$). The results showed that farmers who lived in closer proximity to the forest tended to practice cattle grazing in the forest most parts of the year compared to those who lived relatively far away from the forest boundary. The results presented in the descriptive statistics identifies Hombe as the one with the highest dependence on forest with 77.1% of farmers grazing in the forest throughout the year compared to Chehe at 48.3% and Kahurura 67.1%. Further still, these findings were supported by the highest average number of cattle per household by farmers in Hombe 5.56 (approximately 6 animals).

High forest dependence coupled with higher number of animals in homestead poses the highest threat to forest ecosystem sustainability. Adhikari et al. (2004) and Chakraborty et al., (2018) established that distance between community and forest (in km) is a significant (p=0.03<0.05) driver to forest dependency. After controlling for gender, household size, education level and SES for Hombe, the marginal effects of dependence on cattle grazing reduces by 11%, 3% and 5% with a unit increase in proximity to the forest, proportion of land under fodder production and proportion of cattle in zero-grazing units respectively.

Results of the combined sequential logistic regression model revealed that there was a statistically significant relationship between dependence on protected forest for pasture and proximity to the forest ($p=0.08$<0.1), proportion of cattle under zero-grazing ($p=0.04$<0.05) and ownership of zero-grazing unit ($p=0.03$<0.05). The study found that a unit change increase in the time it takes to the forest reduces forest dependence by 5%, meaning smallholder farmers closer to the protected forest are exploiting the forest for pasture compared to smallholder farmers living fartheraway from the forest. Similarly, given that household size averaged at 4 persons, households living far from the forest may lack a person dedicated to taking animals to the forest, especially if they cannot hire labour. It was not clear to what extent households living away from the forest leveraged on social capital to pool resources and network to engage individuals who can take cattle from three or four households to graze in the forest. Proximity to the forest as brought out in this study carries a potential risk to forest sustainability and it concurs with previous study done by (Adhikari et al., 2004) in Nepal and Chakraborty et al. (2018) study in Himalayan and Asfaw et al. (2013)

work in Ethiopia who also found out that distance to the forest ($p< 0.05$) was a determinant variable that significantly affected forest income out of the eight explanatory variables considered in the regression model. The findings seem to corroborate with the previous work by Miah et al. (2012) in Bangladesh Hill tracts who reported that household proximity to forest had significant influence on dependence on forest products.

On average, farmers set aside at an average 20% of their land for fodder production purposes which appears to be relatively low. A unit increase in the proportion of land under zero-grazing reduces forest above the average farmer would lead to 10% reduction in forest dependence. There is limited empirical research on the contribution of proportion of land under fodder production on forest dependence making this study an important starting pointin fillingthis gap. Adoption of zero-grazing units across the three forest blocks was identified as a significant driver of dependence on cattle grazing. There was a positive correlation between SES and investment in zero-grazing. Zero-grazing units are capital intensive; therefore, it was not surprising that only wealthy households have invested in this option. Strategies to encourage poorer households to transition towards ownership of zero-grazing units may include targeted microfinance, and also subsidies, as zero-grazing unit was shown to have significant reduction on dependence of protected forest for pasture.

Adhikari et al. (2004) also identified livestock holdings as statistically significant drivers of forest dependency in Nepal and in addition the work by Nalunkuuma et al. (2013) confirmed that adoption of zero-grazing is possible for farmers who are above the poverty line due to cost implications. On average, 23% of the farmers kept less than a quarter of their cattle under zero-grazing while the larger percentage (77%) of the cattle herd depended on forest pasture for their sustainability. A unit increase in the numberof cattle under zero-grazing above the average of 23% resulted into a decrease in forest dependence by 16%. Farmers oflow SES struggledto practice cattle grazing and keeping cattle under a zero-grazing unit, and this concurs with the findings of the previous study done by Adhikari et al. (2004) who in a similar way identified livestock holding as significant driver of forest dependence. Previous researchers have not investigated the significance of proportion of cattle under zero-grazing as a significant driver of forest dependence, thus this research contributes to new knowledge. The research did not find a statistically significant relationship between total land size and number of cattle in the homestead on the one hand and dependence on forest for grazing on

the other. Consequently, further research is needed on what other factors might influence dependence of forest for pasture.

5.3Household socio-economic characteristics and dependence on protected forest for grass

The findings of this study have demonstrated an association between gender and involvement in grass harvesting. It was found that that there were 69% male and 31% female smallholder farmers involved in grass harvesting A plausible reason why males dominate in the activity is that grass harvesting is by means of bicycles, motorcycles and vehicles which is a dominant for men in rural areas. Similarly, the results showsthat there is statistically significant association between smallholder farmers' level of education and forest dependency through cattle grazing. The results showed that smallholder farmers with lower education attainment were less involved in grass harvesting compared to their counterparts with higher education attainments. This is a multifaceted concept that might be interconnected with individual resource capacity such as ownership of a zero-grazing unit.

The results shows that 54% of smallholder farmers classified in the wealthiest (Not poor SES) harvest grass from the forest most part of the year, which is a significantly higher proportion compared to farmers classified as poor and poorer at 27% and 91% respectively. This shows that on average, wealthier farmers tend to exhibit high forest dependency through grass harvesting compared to farmers who are less poor. The results show that there is statistically significant association between smallholder farmers SES and forest dependency through grass harvesting as poorer.

Household socio-economic status had a statistically significant relationship with dependence on protected forest for pasture across the three forest blocks. However, after controlling for gender, household size, education level and SES, only the numberof cattle under zero-grazing unit and total land size owned were the statistically significant drivers. In Kahurura, the study found that a unit increase in the proportion of land under fodder production reduced grass harvesting by 13%. The study noted that Kahurura had the highest number of farmers with lower SES who would rely heavily on the forest for grass harvesting to sustain their cattle kept under zero-grazing units. This is because farmers of such status were unlikely to afford commercial feeds. These findings concur with previous study done by Nalunkuuma et al. (2013) who noted that there is a negative correlation between poverty level and adoption of

zero-grazing. As part of contribution to new knowledge, this study explored the proportion of cattle under zero-grazing units as a unique variable with limited research in forest ecosystem.

Chehe had the highest proportion of cattle under zero-grazing units which can be attributed to their relatively higher SES. In Chehe, the study found that a unit increase in the proportion of land under fodder reduced level of grass harvesting by 9%, an increase in ownership of zero-grazing increased grass harvesting by 11% and a unit increase in the proportion of cattle under zero-grazing unit increased level of grass harvesting by 13%. Since most farmers had better SES and lived relatively further from the forest boundary, they relied on commercial methods to harvesting grass making it a more attractive NTFP compared to cattle grazing. This is supported by Mutune et al. (2015) who observed that better SES (income) increases possibilities to access and exploit forest resources. Mutune et al. (2015) concluded that poorer households were facing more restricted access to the forest than the less poor due to high costs. Due to affordability of forest grass, increase in the proportion of cattle under zero-grazing unit was likely to encourage farmers to harvest more grass from the protected forest.

Similar results on affordability of forest resources were reported by Chakma et al. (2020) who found that poor peoplewere more dependent on forest resources than the higher income groups. The concept is also supported by the findings of a study by Kamanga et al. (2009) which noted that the poorest segment in a population depended more on forest resources than the least poor in the society. Therefore, farmers with lower SES might be the major target group for further development to reduce their levels of forest dependency. In Hombe, a unit increase proportion of land under fodder and proportion of cattle under zero-grazing unit reduced dependence on grass harvesting by 12% and 25% respectively. This suggests that when effort is made to encourage farmers in Hombe to invest more in setting up and putting more cattle under zero-grazing units, dependence on grass harvesting was noted to have a significant margin of at least 25%.

The results of the combined sequential logistic regression model revealed that there was a statistically significant relationship between dependence on protected forest for grass and the proportion of cattle under zero-grazing ($p=0.07<0.1$); total size of land owned ($p=0.02<0.05$) and household SES ($p=0.06<0.1$). The study found that a unit increase in the proportion of cattle under zero-grazing units resulted in an increase in grass harvesting by 17% across the three forest blocks. Farmers should be encouraged to set more land aside for fodder

production since the average allocation was hardly more than 21%. Proposals for encouraging smallholder farmers to set aside land for fodder may include providing them with suitable fodder planting materials and supporting them with water harvesting technologies to enhance small-scale fodder irrigation. Encouraging adoption of zero-grazing units in Hombe and Kahurura might be a challenge because results revealed high proportions of poorer households in these forest blocks; Hombe had 9.8 % poorest; 36.6 % poorer, 21.6 % poor, 20.3 % less poor and 11.8 least poor. Kahurura had 50.3 % poorest; 18.8 % poorer, 15.4 % poor, 8.1 % less poor and 7.4 % least poor. In the two-forest blocks, Hombe and Kahurura, this displayed lower SES which is likely to make it difficult to invest in zero-grazing.

Previous studies have shown that establishment of zero-grazing units is capital intensive; henceit is not surprising that wealthy households have invested in this option. Strategies to encourage poorer households to transition to zero-grazing is important and may include very targeted micro financing and subsidies, as zero-grazing unit was shown to have significant reduction on dependence of protected forest for pasture. Investment in zero-grazing is a possible intervention in reducing forest dependence on grass harvesting. However, more interventions should be made to enable farmers to establish fodder on their farms. This will ease the pressure in the forest due to affordability concerns of forest fodder. To reduce dependency of the portion of cattle under zero-grazing units, more interventions should be made to encourage on farm-fodder production or alternative affordable sources of feeds. The results of this study are similar to work done by Mishra and Pathak (2015) in Himalayas who observed that supply and production of quality animal products was a challenge faced by farmers and entrepreneurs due to lowavailability of quality fodder and trained labour. The research did not find any statistically significant relationship between proximity to the forest, total land size and number of cattle in the homestead and dependence on forest for grazing. Consequently, further research is needed on what other factors might influence forest dependence for pasture.

5.4Seasonal variation of smallholder dependence on protected forest for livestock grazing in West Mt. Kenya.

The findings of this study revealed that there were significant seasonality patterns in forest dependence for pasture in all the forest blocks. However, there were significant differences in the magnitudes (seasonality indices) across the three forest blocks, with Hombe showing the

highest numbers of influxes. In addition, there were differences in high and low peak seasons inthe three forest blocks. Hombe forest block seemed to have two distinct peak seasons, with a primary peak season occurring in January and a secondary peak season occurring in June and July of each year. Chehe seemed to experience remarkably low seasons during the first months of the year, (January to May), with influxes during the later months of the year. Kahurura seemed to experience low influxes during the first months of the year, with the exception of January and March; however, influxes began to manifest during the latter part of the year, that is, July to November. All the three forest blocks seemingly experienced low seasons during April and peak seasons during July, September and November.

Although all the three forest blocks are within the West Mt Kenya region, there were differences in the seasonalitypatterns and also in the magnitudes of forest dependence for pasture. This implies complex interactions of socio-ecological and socio-environmental factors influencing smallholder farmers' choice of switching from cattle grazing in the protected forest. Rainfall patterns are a possible factor influencing these decisions. However, there are time lags because on-set of rains may not necessarily imply a switch away from grazing in the protected forest since it takes time for alternative grazing sources to pick to sustain significant quantities of pasture. The findings of this study concur with previous study done by Giridhar and Samireddypalle (2015) work in New Delhi that established that seasonality fluctuations affect availability of forage for livestock. An on-set of a dry seasondoes not necessarily imply an immediate switch to grazing into the forest. This is because after rainfall cessation, farmers still have alternative sources of pasture still available, such as crop waste that may be significant to sustain cattle before theyare faced with shortages to trigger switching into the protected forest. Similar results were found in Nepal, that climatic fluctuations make it difficult to switch between forest dependence and reliance on fodder (Gurung, Nelson & Smith, 2009).

As Murray et al. (2017) havepointed out, climate change has interrupted the cycles of wet-and-dry seasons. There is, therefore, significant year-to-year variability on the on-set and cessation of rainfall. This variability may further complicate farmers' responses to switching between forest dependence for pasture and other alternative but theoptions mentioned by respondents such as grazing on the roadside and seeking for available crop wastes for sustaining livestock. Poor rainfall patterns trigger crop failures and also interfere with the quantities of fodder produced and also quantities of crop waste from farms, implying

extended decisions to rely on forest for pasture. Conversely, extended periods of rainfall may be accompanied by huge quantities of pasture availability outside of the protected forest, and also huge and significant availability of farm waste that are able to sustain cattle for long periods without the need to depend on the forest for pasture. Furthermore, behaviour such as harvesting and purchasing crop waste for feeding cattle during the months of the dry season further complicates seasonality behaviours on forest dependence observed inthe three forest blocks. Further research is needed to investigate how smallholder farmer practices such as harvesting and purchasing farm waste such as maize to sustain cattle during dry spells influences seasonality patterns and decisions to graze in the protected forest.

This finding seems to concur with the results of analysis of rainfall at Chehe forest block (2009 to 2018) using time series that revealed that evidently, the area experiences dry seasons some of the year characterized by least rainfall compared to other months. Low rainfall months areDecember to February and June to September of every year. In some years, these months seemed to experience a completely dry spell, with zero observed rainfall during some months. The high rainfall peaks were noticeable from March to May and October to November. Results corroborate with the Kenya Meteorological report (2019) in this region which noted that generally, the Mt Kenya region exhibits two rainy seasons and two dry seasons that coincide with rainfall regimes of the East African highlands. Heavy down pours are characteristic of the long rains from March to May and lighter showers fromOctober to December in most of theyears. In between those seasons are the drier seasons of June to September and a shorter one of January to February. The lighter rains of the short rain season are favourable for grass and leguminous crops' growth. Results of the scatters plot revealed a negative correlation between livestock grazing data and rainfall data. This suggests that lower rainfall values are associated with increases in cattle grazing in protected forest.

Several authors have noted extreme climate changes events such as prolonged droughts to be associated with farmers and pastoral communities opting to graze on protected forest and protected wildlife areas (Munanura et al., 2018). The Kenyan print media has also further reported influxes of pastoral communities moving to graze animals in protected forest and national parks as noted in the year 2017. Areas reported to be affected by this phenomenon include wildlife sanctuaries and also forest in the central Kenya region including Mt. Kenya forest (Boles et al., 2019).

5.5Perceptions towards the use of a ban to regulate access to protected forest for pasture in Mount Kenya West

Smallholder farmers' perceptions towards the use of a ban to manage access to protected forest for pasture can be understood from the perspective PFM and its role in rural poverty reduction and sustainable livelihoods as pointed out by Achreckenberg & Luttrel (2009). One of the components of this framework is the vulnerability context that takes many forms depending on rural context (DFID, 2000). Smallholder farmers are faced with numerous shocks to their livelihoods that include rainfall failures, crop failures, different forms of epidemics etc., which disrupt their household's livelihoods (Mbiba et al., 2019). Protected forest has been known to comprise an important buffer to households particularly when there is rainfall and crop failures, as farmers switch to graze in the forest or collect nuts and tubers for food. The themes emerging from participants' responses in relation to effects of regulating access suggested that a ban would most likely have consequently disrupted the following livelihood assets:

Shortage of land for grazing

Grazing in the protected forest comprises an important natural asset to keeping livestock especially where land shortages are prevalent. As discussed in results section (Table 4.13), farmers in the study area had very small parcels of land to accommodate both crop and livestock production. Thus, a ban to graze in the forest implies less land for grazing. Ownership of land resources is important for livestock-dependent livelihoods and land could facilitate improvements of other livelihood assets to enhance income generationand this concurs with previous studydone by Nawrotzkiet al. (2012). The forest is a natural capital that communities living adjacent to leverage to sustain livestock grazing (Appiah, 2009). Therefore, the ban on cattle grazing can significantly reduce access to pasture, particularly given the realities of rising rural population against the backdrop of diminishing land sizes for farming and livestock keeping.

A KFS ban is likely to have devastating effect on the livelihoods, including triggering potential KFS-community conflicts. Illegal grazing and illegal grass harvesting would increase as well as the arrests and prosecutions, thus bringing disharmony between KFS and the community. As noted in the results presented earlier, majority of smallholder farmers particularly in Kahurura are poor, and may not afford alternatives such as commercial feeds.

Disruption of sources of household income

Rural households derive income from sale of farm and crop produce, savings, wages, remittances, and credit facilities (Serrat, 2017). Regulating access to protected forest for pasture via a ban would lead to a decrease in household income for a significant number of smallholder farmers. The sale of milk, animals, and manure gives a stream of income. It also offers employment to people engaged in farming, grazing, and grass harvesting. Families would have to spend more resources to purchase pasture and milk for family consumption as well as reducing their income. A ban on cattle grazing in the protected forest would lead to increased prices of feeds from neighbours due to increased demand for commercial feeds. This would force farmers to keep a smaller herd or keep no animals at all leading to more loss of resources and socio-economic vulnerability. The standards of living would decline since farmers normally use the revenue from milk and other farm products to pay school fees, buy food, clothing, medicines, and pay for medication and rent.

Currently, the available financial capital has enabled smallholder farmers to establish zero-grazing units and acquire more assets. Farmers in Chehe were leading in the establishment of zero-grazing units as compared to other forest blocks. Banning forest products would deny farmers capital to seek alternative feed preservation technologies including silage and haymaking. According to KARLO (2018), dairy farming is rated as a significant value chain in the region asit provides regular cash flow essential for households. From the SLF framework, financial capital contributes to positive livelihood outcomes, leads to an increase in income and wellbeing and reduced vulnerability in times of economic shock and enables farmers to accumulate other assets. A ban on access to forest resources will affect these financial flows.

Disruption of physical assets for livestock dependent livelihoods

Physical assets consist of the basic infrastructure and producer goods needed to support livelihoods (Martindale, 2014). In a farming community, physical assets include dairy infrastructure, cattle, tools and farm equipment. If KFS implemented a ban on livestock grazing, livestock farmers would be forced to reduce cattle herds, a very important physical capital according to Mwebaze et al. (2010). The forest ban would force them to reduce their

herd since a large herd would suffer from hunger and malnutrition and gradually die. This would lead to a drop in milk production which is the major source of income in the region. Fewer animals would produce less manure as well which is instrumental in enhancing crop productivity and link directly to food security interventions. This phenomenon was experienced in 2016 when there was an influx of pastoralists from Samburu and Laikipia counties to the Mt. Kenya West region leading to the loss of a huge amount of physical capital due to extreme weather changes in the forest zone. Some pastoralists even committed suicide due to frustrations.

Accumulation of livelihood assets under the sustainable livelihood framework contributes to physical assets in the dairy sector infrastructure, for example, ownership of a zero-grazing unit, chaff cutter, donkey cart, milking cans, silage silos and improved breeds are essential for a household. Bans on cattle grazing by KFS would deny forest-adjacent communities the opportunity to accumulate the assets and this would consequently result in serious economic shocks. The accumulation of physical assets has helped the smallholder farmers, for example, in Hombe to join water projects and connect water for irrigation. Physical assets therefore influence the achievement of livelihood strategies that play a role in human wellbeing. The economic stability of a household is determined by the availability of physical assets which can be converted to financial capital if need be, to cater forimmediate needs.

Disruption of household social capital necessary for livestock grazing

According to DFIDs (2000), social capital consists of networks and connections such as neighbourhoods and kinship, trust, and mutual understanding, formal and informal groups, shared values, sanctions, participation in decision making among others (Serrat, 2017). For peasants near Mt Kenya, who belong to forest associations, the feeling of being obliged to take good care of the forest, on one hand, and the forest management being obliged to reciprocate by allowing them to practice livestock farming through grazing in the protected forest cannot be overemphasised. Thus, smallholder farmers might leverage on their association to voice their concerns in the case of an imminent forest ban to avert its potentially disruptive socio-economic impacts on household capital necessary for livestock production.

Disruption of development of household human capital

According to the DFID (2000), human capital usually consists of things such as knowledge and skill, good health, nutrition, skills, ability to adapt and work, and education (Serrat, 2017). In these farming communities, farmers will be unable to feed their families and pay school fees for their children using the proceeds from the sale of milk, animals and their other products if a ban on grazing in protected forest area were imposed. This would further deny these rural households the opportunity to achieve their livelihood objectives accruing from an enhancement of their human capital (Teague, 2015).

5.6 Coping mechanisms with a ban on livestock grazing in protected forest

The coping mechanisms mentioned by participants suggested that effects of a KFS ban to regulate access to protected forest area would not be felt homogeneously among the smallholders in the three forest blocks studied. There seemed to be pockets of smallholder farmers who would be less vulnerable to such policy actions and have assets to diversify partially or even completely from keeping cattle to pursue alternative sources of livelihoods. However, there were some smallholder farmers who would face limitations to shiftcompletely from livestock related livelihoods and would only partially diversify and cope by reducing the numbers of dairy cows or construct zero-grazing units, which, unfortunately, require intensive physical and financial capital to accomplish it.

The research by Gurung et al., (2009), however, showed that switching from grazing inprotected forests did not significantly reduce pressure on the forest, as grass harvesting for fodder increased remarkably. Appropriate market interventions would, therefore, be necessary to ensure sustainability of smallholder farmers opting to reduce livestock numbers as a result of a forest ban. Some options mentioned by those who mentioned reduce number of cattle included, opting to keep smaller animals such as goats that require less feed, come up with better ways of preserving animal feeds such as hay and silage when the ban is affected. In addition, there is acategory of smallholder's farmer who would be resilient to policy actions such as a forest ban. Responses from the category were captured with respect to this theme can be summarised thus: *try to seek alternative pasture without reducing herd and strategies derived from the data included buy animal feeds, graze on the roadside, lease more land for fodder, and /or convert cropland to fodder.* Resilient strategies mentioned by this segment might have several social, economic and environment implications. For

instance, increase grazing on the roadside might contribute to increased conflicts with road uses, and probably potential degradation as well. This is a strategy that seeks to maximize on road reserves for private gain (Mosweu & Letshwenyo, 2013). Another strategy mentioned such as switching to purchasing commercial forest feeds might result in increased price hikes, and hurt poor farmers particularly those who have recently commenced zero-grazing motivated by affordable commercial feeds. Strategies such as leasing more land for fodder and /or divert land fromcrops to growing fodder are likely to further drive food insecurity as more land is lost to growing of fodder to support cattle keeping particular for milk production at the expense of food production (Dong et al., 2007).

There is, however, a segment of smallholder farmers who would be vulnerable to policy actions such as a forest ban. Responses from this segment included renegotiating with KFS, relying on children for income, and engaging in illegal business. Policy actions to affect a forest ban without complementary policies to provide alternative livelihoods for this segment might be very problematic, and probably unsustainable given the potential consequences mentioned.

Tumusiime and Svarstad (2011) argued about the importance of balancing conservation and livelihood gains in the win-win narrative since rural communities need basic needs for survival. The same discussion is supported by Munanura et al. (2014), who noted that livelihood determination in community-driven forestry programmes would sustain rural livelihoods and enhance sustainability. Without forest grass for their cattle, there are chances that communities can slide into poverty. In the study by Lachapelle et al. (2004) in Nepal, the community members complained that the forest was closed for subsistence gains because the forest user groups were unable to meet and revise their operational plans, hence they were unable to accumulate wealth enhancing the chances of sliding back to poverty. This discussion is supported by Quine & Humphrey (year?) who argued conflicts on natural resources have adverse effects on communities especially in areas where there are weak policies about benefit sharing. The discourse can be underlined by the fact that in Kenyan protected forest, there are challenges associated with benefit-sharing and cattle carrying capacity that can guide in regulations.

5.7 Conclusions

From the findings discussed above, it can be concluded that socio-economic status of the smallholder's farmers vary significantly across the three forest blocks investigated, and this has influence on the form of forest dependence for households keeping cattle. Importantdrivers for forest dependence for pasture include proximity to the forest, ownership of zero-grazing units, and the proportion of cattle a smallholder keeps under zero-grazing. However, for forest dependence for grass harvesting, significant drivers include a smallholder SES, total size of land a household owns, and proportion of cattle a smallholder farmer keeps under zero-grazing. A high proportion of the less poor smallholders' farmers living adjacent to the forestis correlated with dependence on forest for fodder as noted in Chehe forest block where grass harvesting for fodder was the predominant form of forest dependence for smallholder farmers keeping cattle for a livelihood. Where majority of smallholder farmers fell in the very poor category as was noted in Kahurura, the predominant form of forest dependence for smallholder famers was livestock grazing.

It can be further concluded that monthly and seasonal variation in livestock dependence for pasture exists across the three forest blocks butwith significant differences in the magnitude of peaks of cattle influxes. Of the three forest blocks investigated in this study, Kahurura was found to experience high cattle grazing influxes during most of the months of the year with characteristic primary peaks in January and secondary peaks in July respectively. On the contrary, Chehe was found to experience a low peak season during most of the early months of the year, with very marginal influxes experienced during the months of July. The magnitude of influxes during the month of July in Chehe was low compared to Kahurura which experienced almost nine times the number of cattle influxes reported in Chehe during the same period.

There were markeddifferences between the drivers of livestock grazing and grass harvesting in protected forests. Under cattle grazing, ownership of zero-grazing was noted as a significant driver of grass harvesting. The increase in the number of farmers owning zero-grazing units may trigger the increase in grass harvesting to support the zero-grazing units. Again, the proportion of cattle in zero-grazing unit was a significant driver under cattle grazing implying that if more animals are kept in the zero-grazing unit, there can be reduction

in grazing practice. However, increase in the number of animals under zero-grazing unit may subsequently increase dependence on forest grass. Proximity to the forest is a significant driver ofcattle grazing in thatfamers near the forest prefer to graze rather thancut grass from the forest because grass cutting is relatively expensive compared to cattle grazing implying that the least poor in the society are likely to focus more on cattle grazing hence threatening the forest ecosystem. Farmers who depend on grass harvesting use various transportation methods hence distance from the forest boundary is not a deterrent.

Under grass harvesting category, total size of land owned was a significant driver becauseany increase the total size of land owned reduced dependence on forest for grass harvesting. Land ownership is based on availability of resource and unless the people involved in cattle grazing accumulate assets, possibility of increasing land size to plant fodder remains a challenge. Proportion of cattle in a zero-grazing unit was a significant driver ofgrass harvesting and this has an association with cattle grazers since reduction in number of animals in zero-grazing unit means that farmers will opt to undertake cattle grazing which is the cheapest option.

There is a cause-effect relationship noted by themes on perceived the effect of forest ban. Forest ban is likely to result in reduced or limited availability of land for pasture leading to disruption of cattle farming activity, which in turn would lead to disruption of family cash flows, and ultimately disruption of household's ability to pay school fees for children among other household needs. This will consequently lead to overall disruption in quality of life in general, including disruption in social relations with the Kenya Forest Services. Coping strategies with a forest ban highlight heterogeneity amongst smallholders across the different forest blocks, in which some segments will be less vulnerable, others will be resilient, however there is significant segment that will be vulnerable to such policy actions and without complementary measures to the vulnerable category, a forest ban will not sustainable.

5.8 Contribution of the study to knowledge

Based on the findings of this study, the new knowledgegenerated is that socio-economic factors influence dependency on forest resources in quite different ways. Drivers of forest dependence identified can be tested in other forest blocks; however, they vary and cannot be generalized across other mountain ecosystems since household characteristics are likely to be different. This trend can be applicable to all other NTFP including those not covered by the study such as beekeeping in the forest and extraction of herbs. Therefore, this study has

proved that there should never be a blanket policy regarding NTFP. Every NTPF should have its own policy statement as informed by the socio-economic drivers for a particular NTFP. Seasonality trends noted for cattle entry in the forest was different per forest block. The new knowledge created is that NTFPs extraction and utilization trends cannot be generalized across the forest blocks even if they fall under the same ecosystem.

Another contribution to new knowledge is that constructingcategories based on wealth indices can predict livelihood dependence regardless ofthe form of forest dependence. This can help to prioritize interventions. There has been a conflict between the need for environmental sustainability and existing policy on utilization of natural resources. In response to the above dilemma, the government of Kenya has been shifting policy positions over time by banning access to protected forests and withdrawing the policy after realizing that it is unsustainable. The well-established theories such as the Access and the Common Pool Resource theories which inform local policy formulations and international best practices inforest conservation are not responsive to the grim reality in Africa. As such mountainous forests are fading away at ahigh rate.

5.9 Policy recommendations

There are several policy implications of these findings. First, the heterogeneity ofsmallholder SES across different forest blocks is critical for any policy aimed at addressing challenges associated with sustainability of forest utilisationby communities living adjacent to protected forests. Secondly, the Kenya Forest Service needs to determine dry season carrying capacity when the forest blocks experience influxes to avoid overgrazing problems. KFS also need to devise ways of regulating grazing activities during high season peaks and ensure that cattle entry is reduced. The study identified high peak seasons across the three blocks, therefore, KFS can use these findings to manage high influxes. The government need to provide alternatives for rural households pressed to graze animals during the identified high peak months. Proper forest management is required to ensure the influx during the peak season is well-managed to minimize conflicts between cattle forest conservation benefits and costs. There is need for stakeholders to find ways to support smallholder farmers using holistic approaches to manage high peak influxes identified in the study.

There is need for the county, national government and other agencies to find ways to deal with the fact that majority of farmers in Kahurura are poor and come up with sustainable initiatives and interventions such as subsidies. National and county governments should also come up with policies to promote zero-grazing units, for example, through targeted microfinance. This will have a positive impact on forest dependence for pasture in Kahurura. Rural development agencies need to come up with ways of incentivizing alternative strategies of cheaper fodder production due to its implication on forest dependence.

There are opportunities for sustainable livelihoods that reduce forest dependence such as policies that encourage smallholder farmers to diversify totally or partially from cattle keeping. KFS and rural development agencies will, therefore, a need to experiment with different policy incentives and institutional support to steer rural development inthis trajectory. Finally, forest bans might not be a panacea to perceived forest overexploitation associated with livestock grazing. Enforcing forest bans might shift the problem to other protected forests in Mount Kenya West as revealed by the findings of this study. The alternative to forest ban is to enhance promotion of sustainable utilization of forest resources, for example, effectivemanagement of cattle grazing and grass harvesting in protected forests should be oversighted by a multi-agency team in a manner that is open, transparent, and accountable. Details and particulars on grazing and grass harvesting patterns should be documented in a well-documented monitoring framework.

5.10 Recommendations for further research

Further studies are needed to investigate macro-level factors that interact with household socio-economic characteristics identified in this study to drive dependence of the protected forest in West Mount Kenya for pasture and grass. In addition, there is need for research to determine the carrying capacity for each block during the identified high influx months so that proper management strategies can be put in place to avoid degradation. There is need to investigate the seasonality patterns in different blocks and understand to what extent household agricultural crop waste management influences the seasonality patterns and to what extent crop waste can be used to minimize high influxes. Further research should investigate the factors underlying the differences in smallholder SES across the threeforest blocks as revealed by this study since this has implications in addressing forest dependence for pasture and grass harvesting.

REFERENCES

Acheampong, E., & Marfo, E. (2011). The Impact of Tree Tenure and Access on Chainsaw Milling in Ghana. *Renewable Natural Resources & Forestry Research Institute of Ghana.*

Adam & El Tayeb (2014). Forest Dependency and its Effect on Conservation in Sudan: A Case of Sarf-Saaid Reserved Forest in Gadarif state. *Poljoprivreda Sumarstvo*, *60*(3), 107

Adhikari, B., Di Falco, S., & Lovett, J. C. (2004). Household Characteristics and Forest Dependency: Evidence from Common Property Forest Management in Nepal. *Ecological Economics*, *48*(2), 245-257.

Aisha-Lul, A. N., Nalumansi, P., & Nina, P. M. (2019). Deforestation of Igwe Forest and Its Effects on Livelihood Patterns of Peripheral Communities in Bugiri District, Uganda. *African Journal of Agriculture and Food Science*, *2*(1), 41-53.

Alcañiz, M., Úbeda, X., & Cerdà, A. (2020). A 13-Year approach to understand the effect of prescribed fires and livestock grazing on soil chemical properties in Tivissa, NE Iberian Peninsula. *Forests*, *11*(9), 1013.

Aliyu, A., Modibbo, M. A., Medugu, N. I., & Ayo, O. (2014). Impacts of deforestation on socio-economic development of Akwanga Nasarawa State. *International Journal of Science, Environment and Technology*, *3*(2), 403-416.

Alweny S, Nsengiyumva P, Gatarabirwa W. (2014). African Mountains Status Report: Technical Report No 1. *Kampala, Uganda: Albertine Rift Conservation Society (ARCOS).*

Amaike, B. (2016). Sustainability, Livelihoods, and Quality of Life of Older Retirees in Lagos State, Nigeria.

Ameha, A., Meilby, H., & Feyisa, G. L. (2016). Impacts of Participatory Forest Management on Species Composition and Forest Structure in Ethiopia. *International Journal of Biodiversity Science, Ecosystem Services & Management,*

Amwata, D. A., & Mutavi, S. K. (2018). Constraints and Opportunities Among Small Scale Peri-Urban Dairy Farmers in the South Eastern Kenya Rangelands.

Angelsen A., Jagger P., Babigumira R., Belcher B., & Darwin C. (2014) Environmental income and rural livelihoods: A global comparative analysis

Appiah, D. O. (2009) Personifying Sustainable Rural Livelihoods in Forest Fringe Communities In Ghana: A Historic Rhetoric. *Journal of food, agriculture & environment*, *7*(3&4), 873-877

Arsonson, Blignault, Milton, Elser (2018): Are Socioeconomic Benefits of Restoration Adequately Quantified? A Meta-analysis of Recent Papers (2000–2008) in *Restoration Ecology*

Asfaw, A., Lemenih, M., Kassa, H., & Ewnetu, Z. (2013). Importance, Determinants and Gender Dimensions Of Forest Income In Eastern Highlands Of Ethiopia: The Case Of Communities Around Jelo Afromontane Forest. *Forest Policy and Economics*, *28*, 1-7.

Awono, A., Ingram, V., Schure, J., & Levang, P. (2012). Guide for small and medium enterprises in the sustainable non-timber forest product trade in Central Africa Bogor. *Indonesia, CIFOR*.

Awono, A., Ndoye, O., & Preece, L. (2010). Empowering Women's Capacity for Improved Livelihoods In Nontimber Forest Product Trade In Cameroon.*International journal of social forestry*, 3(2), 151-163.

Bauhoff, S., & Busch, J. (2020). Does deforestation increase malaria prevalence? Evidence from satellite data and health surveys. *World Development*, *127*, 104734.

Beech, E., Rivers, M., Oldfield, S., & Smith, P. P. (2017). Global Tree Search: The First Complete Global Database of Tree Species and Country Distributions. *Journal of Sustainable Forestry*, *36*(5), 454-489.

Belsky, A. J., & Blumenthal, D. M. (1997). Effects of Livestock Grazing on Stand Dynamics and Soils in Upland Forests of the Interior West: Efectos del Pastoreo sobre la Dinámica de Árboles y Suelos en Bosques en el Altiplano del Occidente Interior. *Conservation Biology*, *11*(2), 315-327.

Berg, B.L., & Lune, H. (2012). *Qualitative research for the social sciences,* 8e. Pearson.

Bernués, A., Tello-García, E., Rodríguez-Ortega, T., Ripoll-Bosch, R., & Casasús, I. (2016). Agricultural practices, ecosystem services and sustainability in High Nature Value farmland: Unraveling the perceptions of farmers and non farmers. *Land use policy*, *59*, 130-142.

Boles, O. J., Shoemaker, A., Mustaphi, C. J. C., Petek, N., Ekblom, A., & Lane, P. J. (2019). Historical ecologies of pastoralist overgrazing in Kenya: long-term perspectives on cause and effect. *Human Ecology*, *47*(3), 419-434.

Bonett, D. G., & Wright, T. A. (2015). Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. *Journal of organizational behavior*, *36*(1), 3-15.

Buffum, B., Gratzer, G., & Tenzin, Y. (2009). Forest grazing and natural regeneration in a late successional broadleaved community forest in Bhutan. *Mountain Research and development*, *29*(1), 30-35.

Bunyasi, M. M. (2012). Vulnerability of Hydro-Electric Energy Resources in Kenya Due To Climate Change Effects: The Case Of The Seven Forks Project. *Journal of Agriculture and Environmental Sciences*, *1*(1), 36-49.

Caviglia-Harris, J. L. (2018). Agricultural Innovation and Climate Change Policy in The Brazilian Amazon: Intensification Practices and The Derived Demand for Pasture. *Journal of Environmental Economics and Management*, *90*, 232-248.

Chakma, D., Huda, S. S., Hossain, M. A., & Nath, T. K. (2020). Forest Dependency and Conservation Attitude of Indigenous Communities: Lessons from Komolchari Village Common Forest of Chittagong Hill Tracts, Bangladesh. *Asian Journal of Research in Agriculture and Forestry*, 46-58.

Chakraborty, A., Joshi, P. K., & Sachdeva, K. (2018). Capturing Forest Dependency in the Central Himalayan Region: Variations Between Oak (Quercus spp.) and Pine (Pinus spp.) dominated forest landscapes. *Ambio*, *47*(4), 504-522.

Chamshama, S. O., Skeie, K., Njana, M., Ngowi, S. E., Isango, J. a., & Burgess, N. D. (2014). Does Participatory Forest Management Promote.Sustainable Forest Utilisation in Tanzania? *International Forestry Review*, 16(1), 23–38.

Change, G. E., Change, G. E., Larson, A. M., Reform, F. T., Change, C., & Attribution, C. C. (2010). Forest Tenure Reform in the Age of Climate Change: Lessons for REDD+. *Journal of Global Environmental Change*, Volume 21(Issue 2), 540-549. Retrieved from https://doi.org/10.1016/j.gloenvcha.2010.11.008

Chaudhary, S., Tshering, D., Phuntsho, T., Uddin, K., Shakya, B., & Chettri, N. (2017). Impact of Land Cover Change on A Mountain Ecosystem and Its Services: Case Study from The Phobjikha valley, Bhutan. *Ecosystem Health and Sustainability*, *3*(9), 1393314.

Chechina, M., Neveux, Y., Parkins, J. R., & Hamann, A. (2018). Balancing Conservation and Livelihoods: A Study of Forest-dependent Communities in the Philippines. *Conservation and Society*, *16*(4), 420-430.

Chelestino, B., Suzana, A., Mwaiteleke, D., P, L., Lusambo, B, F., & S, M. (2016). Economic Valuation of Non-timber Forest Products under the Changing Climate in Kilombero District, Tanzania.

Choe, H., & Yun, S. J. (2017). Revisiting the concept of common pool resources: Beyond Ostrom. *Development and Society*, *46*(1), 113-129.

Chornesky, E. A., Collins, S. L., Dobson, A. P., Duke, C. S., Mappin, M. J., Palmer, M. A., & Bernhardt, E. S. (2005). Ecological Science and Sustainability for the 21st Century. *Frontiers in Ecology and the Environment*, 3(1), 4-11.

Clark, J. A., & Covey, K. R. (2012). Tree Species Richness and the Logging of Natural Forest: A meta-Analysis. Journal of Forest Ecology and Management, 276, 146-153.

Connor, E. E. (2015). Invited Review: Improving Feed Efficiency in Dairy Production: Challenges And Possibilities. *Animal*, *9*(3), 395-408.

Corwyn, R. F., & Bradley, R. H. (2002). Stability of maternal socioemotional investment in young children. *Parenting*, *2*(1), 27-46

Cosarinsky, M. I., Römer, D., & Roces, F. (2020). Nest turrets of Acromyrmex grass-cutting ants: micromorphology reveals building techniques and construction dynamics. *Insects*, *11*(2), 140.

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J. P., Iglesias, A., ...& Penuelas, J. (2018). Climate Change and Interconnected Risks to Sustainable Development in The Mediterranean. *Nature Climate Change*, *8*(11), 972-980.

Creswell, J. W. (2013). Steps In Conducting a Scholarly Mixed Methods Study.

Dagar, J. C. (2017). Potentials for fodder production in degraded lands. *Approaches towards fodder security in India. Studera Press, New Delhi*, 333-364.

Das, B. K. (2019). Denial of Rights Continues: How Legislation for 'Democratic Decentralisation of Forest Governance was Subverted in the Implementation Process of the Forest Rights Act in India. *The European Journal of Development Research*, *31*(4), 957-983.

Das, N. (2012). Impact of Participatory Forestry Programme on Sustainable Rural Livelihoods: Lessons from An Indian Province. *Applied Economic Perspectives and Policy*, *34*(3), 428-453.

Deng, L., Sweeney, S., & Shangguan, Z. P. (2014). Grassland Responses to Grazing Disturbance: Plant Diversity Changes with Grazing Intensity in a Desert Steppe. *Grass and Forage Science*, *69*(3), 524-533.

Deresa, F., & Legesse, T. (2015). Cause of land degradation and its impacts on livelihoods of the population in Toke Kutaye Woreda, Ethiopia. *International Journal of Scientific and Research Publications*, *5*(5), 1-9.

Devkota, B. P., & Mustalahti, I. (2018). Complexities in Accessing REDD+ Benefits in Community Forestry: Evidence from Nepal's Terai Region. *International Forestry Review*, *20*(3), 332-345.

Doggart, N., Morgan-Brown, T., Lyimo, E., Mbilinyi, B., Meshack, C. K., Sallu, S. M., & Spracklen, D. V. (2020). Agriculture is the main driver of deforestation in Tanzania. *Environmental Research Letters*, *15*(3), 034028.

Dong, S. K., Gao, H. W., Xu, G. C., Hou, X. Y., Long, R. J., Kang, M. Y., & Lassoie, J. P. (2007). Farmer and professional attitudes to the large-scale ban on livestock grazing of grasslands in China. *Environmental Conservation*, 246-254.

Downs, S. M., Payne, A., & Fanzo, J. (2017). The development and application of a sustainable diets framework for policy analysis: A case study of Nepal. *Food Policy*, *70*, 40-49.

Duguma, L. A., Atela, J., Minang, P. A., Ayana, A. N., Gizachew, B., Nzyoka, J. M., & Bernard, F. (2019). Deforestation and forest degradation as an environmental behavior: unpacking realities shaping community actions. *Land*, *8*(2), 26.

Ecker, O. (2018). Agricultural transformation and food and nutrition security in Ghana: Does farm production diversity (still) matter for household dietary diversity? *Food policy*, *79*, 271-282.

EMCA (1999). Environmental Protection in Kenya: Will the Environmental Management and Co-ordination Act (1999) Make a Difference. *SC Envtl.LJ*, *9*, 181.

Enbakom, H. W., Feyssa, D. H., & Takele, S. (2017). Impacts of deforestation on the livelihood of smallholder farmers in Arba Minch Zuria Woreda, Southern Ethiopia. *African Journal of Agricultural Research*, *12*(15), 1293-1305.

Fairhead, J., & Leach, M. (1995). False Forest History, Complicit Social Analysis: Rethinking Some West African Environmental Narratives. *World development*, *23*(6), 1023-1035. *for developing Grounded Theory*. Thousand Oaks, CA: Sage.

FAO (2015). Global Resources Assessment: Reducing Emissions from Deforestation and forest degradation

FAO (2016), GFRA - Global Forest Resources Assessment, Food Agriculture Organization of the United Nations (FAO), Rome.rank, J., & Bix, B. H. (2017). Law and the modern mind, Routledge.

Faust, L., Yaya, S., & Ekholuenetale, M. (2017). Wealth Inequality as a Predictor of HIV-related Knowledge in Nigeria. *BMJ Global Health*, *2*(4), e000461.

Forti, L. C., Rando, J. S., da Silva Camargo, R., Moreira, A. A., Castellani, M. A., Leite, S. A., ... & Caldato, N. (2020). Occurrence of Leaf-Cutting and Grass-Cutting Ants of

the Genus Atta (Hymenoptera: Formicidae) in Geographic Regions of Brazil. *Sociobiology*, *67*(4), 514-525.

Galway, L. P., Acharya, Y., & Jones, A. D. (2018). Deforestation and child diet diversity: A geospatial analysis of 15 sub-Saharan African countries. *Health & place*, *51*, 78-88.

Garekae, H., Lepetu, J., & Thakadu, O. T. (2020). Forest resource utilisation and rural livelihoods: insights from Chobe enclave, Botswana. *South African Geographical Journal*, *102*(1), 22-40.

Gautam, A. P. (2009). Equity and Livelihoods in Nepal's Community Forestry *International Journal of Social Forestry*, *2*(2), 101-122.

Gillet, P., Vermeulen, C., Doucet, J. L., Codina, E., Lehnebach, C., & Feintrenie, L. (2016). What are the Impacts of Deforestation on the Harvest of Non-timber Forest Products in Central Africa? Forest, 7(5), 106.

Gioli, G., Thapa, G., Khan, F., Dasgupta, P., Nathan, D., Chhetri, N., ...& Scott, L. M. (2019). Understanding and tackling poverty and vulnerability in forest livelihoods in the Hindu Kush Himalaya.In the Hindu Kush Himalaya Assessment (pp. 421-455). Springer, Cham.

Giridhar, K., & Samireddypalle, A. (2015). Impact of climate change on forage availability for livestock. In *Climate change Impact on livestock: adaptation and mitigation* (pp. 97-112). Springer, New Delhi.

Godde, C. M., Garnett, T., Thornton, P. K., Ash, A. J., & Herrero, M. (2018). Grazing systems expansion and intensification: Drivers, dynamics, and trade-offs. *Global food security*, *16*, 93-105.

GOK (2009). Report of the Government's task force on the conservation of the Mau Forest Complex, Nairobi Kenya.

GOK (2010). Constitution of Kenya: The Government Printer, Nairobi, Kenya

GOK (2012). Kenya's Climate Change Action Plan: Mitigation Forestry Seton Stiebert, Deborah Murphy, Jason Dion and Scott McFatridge (IISD)

GOK (2014). National Forest Policy: The Government Printer, Nairobi, Kenya

GOK (2014). Ministry of Environment, Water and Natural Resources; Kenya National Forest Policy

GOK (2016). Forest Conservation & Management Act: The Government Printer, Nairobi, Kenya

GOK (2018). Kenya Agricultural and Cattle Research Organization Report on Smallholder Farmers Milk Production

GOK (2018). National resource benefit sharing bill: The Government Printer, Nairobi, Kenya

GOK (Government of Kenya) - (2005); Forest Act: The Government Printer, Nairobi, Kenya

GOK, (2016). Land Degradation and Assessment Report, (2016); Land Degradation Assessment in Kenya-March 2016; The Need for Land Degradation Assessment (LADA) for Kenya; www.environment.go.ke › uploads › 2018/08 › LADA

GOK, MKE (2010); Mt Kenya Ecosystem Management plan

GOK. (2018). Report on Kenyan Livestock Sector to Grow 'Exponentially" by International Livestock Research Institute (ILRI & KNBS).

Gorbenkova, E., Shcherbina, E., & Belal, A. (2018). Rural areas: critical drivers for sustainable development. *IFAC-PapersOnLine*, *51*(30), 786-790.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward A Conceptual Framework for Mixed-Method Evaluation Designs. *Educational evaluation and policy analysis*, *11*(3), 255-274.

Gurung, B., Nelson, K. C., & Smith, J. L. (2009). Impact of Grazing Restrictions on Livestock Composition and Husbandry Practices in Madi Valley, Chitwan National Park, Nepal. *Environmental Conservation*, 338-347.

Harden, C. P. (2001). Soil erosion and sustainable mountain development. *Mountain Research and Development*, *21*(1), 77-83.

Hardin G., (1968). Tragedy of the Commons.Kluwer Academic Publishers.

Hartter, J. (2009). Attitudes of rural communities toward wetlands and forest fragments around Kibale National Park, Uganda. *Human Dimensions of Wildlife*, *14*(6), 433-447.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., ...& Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, *7*(4), 044009.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research*, *15*(9), 1277-1288.

Issaka, B. Y., & Richard, Y. N. (2016). non-timber forest products and Climate Change Resilience: The Case of the Savannah Woodlands Northern Ghana, 8.

Jagger, P, Luckert, M. M. K., Duchelle, A. E., Lund, J. F., & Sunderlin, W. D. (2014). Tenure and forest income: Observations from a global study on forest and poverty. *World Development*, *64*, S43-S55.

Jain, P., & Sajjad, H. (2016). Household Dependency on Forest Resources in the Sariska Tiger Reserve (STR), India: Implications for management. *Journal of Sustainable Forestry*, *35*(1), 60-74.

Jannat, M., Hossain, M. K., & Uddin1&2, M. M. (2018) Socio-economic Factors of Forest Dependency in Developing Countries: Lessons Learned from the Bandarban Hill District of Bangladesh. *Am. J. Pure Appl. Sci*, *2*(3), 77-84.

Jones, M. P., Beath, A., Oldmeadow, C., & Attia, J. R. (2017). Understanding statistical hypothesis tests and power. *The Medical Journal of Australia*, *207*(4), 148-150.

Kamanga, P., Vedeld, P., & Sjaastad, E. (2009). Forest Incomes and Rural Livelihoods in Chiradzulu District, Malawi. *Ecological Economics*, *68*(3), 613-624.

KFS. (2015). *Friends of Karura Forest Community Forest Association.* Nairobi: KFS-CFA. Retrieved from http://www.friendsofkarura.org/wp-content/uploads/2016/05/Annual-Report-2015_reduced.pdf

Kikoti, I. A., & Mligo, C. (2015). Impacts of Livestock Grazing on Plant Species Composition in Montane Forest On The Northern Slope Of Mount Kilimanjaro, Tanzania. *International Journal of Biodiversity Science, Ecosystem Services & Management*, *11*(2), 114-127.

Kimitei, R., Kirwa, E., Kidake, B., Kubasu, D., Manyeki, J., & Mnene, W. N. (2011). Community based forage seed system approaches in southern Kenya rangelands. In *Kenya Arid and Semi-Arid Lands Research Program (KASAL) End of*

ProgramConference held on 9 th to 11 th august 2011 at KARI Headquarters conference Hall, Kenya.

Kinoti & Mwende (2019). Spatial-Temporal Assessment of Forest Rehabilitation along Mt Kenya East Forest Buffer Zone Using Remote Sensing: Department of Social Sciences, Chuka University, Kenya

Kiplagat, A. K., Mburu, J., & Mugendi, D. N. (2008). Consumption of Non-timber Forest Products (NTFPs) in Kakamega Forest, Western Kenya: accessibility, role and value to resident rural households.

Klassen, A. C., Creswell, J., Clark, V. L. P., Smith, K. C., & Meissner, H. I. (2012). Best Practices in Mixed Methods for Quality-of-Life Research. *Quality of Life Research*, *21*(3), 377-380.

Koech, C. K., Ongugo, P. O., Mbuvi, M. T. E., & Maua, J. O. (2009). Community Forest Associations in Kenya: Challenges and Opportunities. *Kenya Forestry Research Institute*.

Koyuncu, C., & Yilmaz, R. (2009). The impact of corruption on deforestation: A cross-country evidence. *The Journal of Developing Areas*, 213-222.https://doi.org/10.1353/jda.0.0010

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and psychological measurement*, *30*(3), 607-610.

Kumar, D., & Schei, S. S. (2016). Environmental Sustainability of Run of The River Hydropower Projects: A Study from Western Himalayan Region of India. *Renewable Energy*, *93*, 599-607

Kumar, V. (2015). Impact of Non-Timber Forest Produces (NTFPs) on food and livelihood security: An economic study of tribal economy in Dang's district of Gujarat, India. *International Journal of Agriculture, Environment and Biotechnology*, *8*(2), 387-404.

Kunwar, R. M., Adhikari, Y. P., Sharma, H. P., Rimal, B., Devkota, H. P., Charmakar, S., ... & Thapa, S. (2020). Distribution, use, trade and conservation of Paris polyphylla Sm. in Nepal

Lachapelle, P. R., Smith, P. D., & McCool, S. F. (2004). Access to power or genuine empowerment? An analysis of three community forest groups in Nepal. *Human Ecology Review*, 1-12…

Langat, D. K., Maranga, E. K., Aboud, A. A., & Cheboiwo, J. K. (2016). Role of Forest Resources to Local Livelihoods: The Case of East Mau Forest Ecosystem, Kenya. *International Journal of Forestry Research*, *2016*.

Leonhardt, H., Penker, M., & Salhofer, K. (2019). Do farmers care about rented land? A multi-method study on land tenure and soil conservation. *Land use policy*, *82*, 228-239.

Lepetu, J., Alavalapati, J., & Nair, P. K. (2009). Forest Dependency and its Implication for Protected Areas Management: A Case Study from Kasane Forest Reserve, Botswana. *International Journal of Environmental Research*, *3*(4), 525-536.

Madegowda, C., & Rao, C. U. (2013). The ban of non-timber forest products collection effect on Soligas migration in Biligiri Rangaswamy temple wildlife sanctuary, India. *Sociology*, *105*, 114.

Mahanty, S., Gronow, J., Nurse, M., & Malla, Y. (2006). Reducing poverty through community-based forest management in Asia. *Journal of Forest and Livelihood*, *5*(1), 78-89.

Maleko, D., Msalya, G., Mwilawa, A., Pasape, L., & Mtei, K. (2018). Smallholder dairy cattle feeding technologies and practices in Tanzania: failures, successes, challenges and prospects for sustainability. *International Journal of Agricultural Sustainability*, *16*(2), 201-213.

Mapulanga, A. M., & Naito, H. (2019). Effect of deforestation on access to clean drinking water. *Proceedings of the National Academy of Sciences*, *116*(17), 8249-8254.

Martindale, T. (2014). Heritage, Skills and Livelihood: Reconstruction and Regeneration in A Cornish Fishing Port. In *Social issues in sustainable fisheries management* (pp. 279-299). Springer, Dordrecht.

Maseko, H., Shackleton, C. M., Nagoli, J., & Pullanikkatil, D. (2017). Children and wild foods in the context of deforestation in rural Malawi. *Human Ecology*, *45*(6), 795-807.

Maselli, D., & Kohler, T. (2013). Mountains: Our Life, Our Future. Progress and Perspectives on Sustainable Mountain Development from Rio 1992 to Rio 2012 and Beyond. *A global synthesis based on 10 regional reports*. Geographica Bernensia.

Matias, D. M. S., Tambo, J. A., Stellmacher, T., Borgemeister, C., & von Wehrden, H. (2018). Commercializing Traditional non-timber forest products: An Integrated Value Chain Analysis of Honey From Giant Honey Bees In Palawan, Philippines. *Forest Policy and Economics*, *97*, 223-231.

Matiku, P., Caleb, M., & Callistus, O. (2013). The Impact of Participatory Forest Management on Local Community Livelihoods in The Arabuko-Sokoke Forest, Kenya.*Conservation and Society*, 11(2), 112-129.

Mbiba, M., Collinson, M., Hunter, L., & Twine, W. (2019). Social capital is Subordinate to Natural Capital in Buffering Rural Livelihoods from Negative Shocks: Insights from rural South Africa. *Journal of rural studies*, *65*, 12-21.

McCartney, M., & Boelee, E. (2015). Understanding the Links Between Agriculture and Health: Agriculture, Malaria, and Water-Associated Diseases.

MEA. (2005). Ecosystems and Human Well-Being.*World Resources Institute.* Retrieved from https://www.millenniumassessment.org/documents/document.356.aspx.pdf

Mengist, W., & Soromessa, T. (2019). Assessment of forest ecosystem service research trends and methodological approaches at global level: a meta-analysis. *Environmental Systems Research*, *8*(1), 22.

Meyer, K. E., Van Witteloostuijn, A., & Beugelsdijk, S. (2017). Reassessing best practices for conducting and reporting hypothesistesting research.

Miah, M. D., Chakma, S., Koike, M., & Muhammed, N. (2012). Contribution of Forest to the livelihood of the Chakma community in the Chittagong Hill Tracts of Bangladesh. *Journal of forest research*, *17*(6), 449-457.

Mishra, A., & Mishra, D. K. (2012). Deforestation and Women's Work Burden in the Eastern Himalayas, India: Insights from a Field Survey. *Gender, Technology and Development*, *16*(3), 299-328.

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of cardiac anaesthesia*, *22*(1), 67.

Mishra, S., & Pathak, P. S. (2015). Fodder Production and Conservation: A Potential Source of Livelihood for Women.

Moktan, M. R., Norbu, L., & Choden, K. (2016). Can community forestry contribute to household income and sustainable forestry practices in rural area? A case study from Tshapey and Zariphensum in Bhutan. *Forest Policy and Economics*, *62*, 149-157.

Moon, H., & Solomon, T. (2018). Forest decline in Africa: Trends and impacts of foreign direct investment: A review. *Int. J. Curr. Adv. Res*, *7*.

Mosweu, S., & Letshwenyo, M. (2013). Is roadside grass suitable for use as livestock forage in Botswana? *Journal of Environmental Chemistry and Ecotoxicology*, *5*(10), 265-268.

Mugagga, F., Kakembo, V., & Buyinza, M. (2012). Land use changes on the slopes of Mount Elgon and the implications for the occurrence of landslides. *Catena*, *90*, 39-46.

Mugido, W., & Shackleton, C. M. (2017). The contribution of NTFP trade to rural livelihoods in different agro-ecological zones of South Africa. *International Forestry Review*, *19*(3), 306-320.

Mullan, K., Kontoleon, A., Swanson, T., & Zhang, S. (2009). An evaluation of the impact of the natural forest protection program on rural household livelihoods. In *an Integrated Assessment of China's Ecological Restoration Programmes* (pp. 175-199).Springer, Dordrecht.

Munanura, I. E., Backman, K. F., Moore, D. D., Hallo, J. C., & Powell, R. B. (2014). Household poverty dimensions influencing forest dependence at Volcanoes National Park, Rwanda: an application of the sustainable livelihood's framework. *Natural Resources*, *5*(16), 1031.

Munanura, I. E., Backman, K. F., Sabuhoro, E., Powell, R. B., & Hallo, J. C. (2018). The perceived forms and drivers of forest dependence at Volcanoes National Park, Rwanda. *Environmental Sociology*, *4*(3), 343-357.

Murray-Tortarolo, G., Jaramillo, V. J., Maass, M., Friedlingstein, P., & Sitch, S. (2017). The decreasing range between dry-and wet-season precipitation over land and its effect on vegetation primary productivity. *PloS one*, *12*(12), e0190304.

Musyoki, J. K., & Mugwe, J. M. (2013). Determinants of household decisions to join community Forest Association.A case study of Kenya. *Forestry*.

Mutana, S., & Mukwada, G. (2018). Mountain-route tourism and sustainability.A discourse analysis of literature and possible future research. *Journal of outdoor recreation and tourism*, *24*, 59-65.

Mutune, J. M., Wahome, R. G., & Mungai, D. N. (2015). Local Participation in Community Forest Associations: A Case Study of Sururu and Eburu Forest, Kenya.

Mwebaze, P., Marris, G. C., Budge, G. E., Brown, M., Potts, S. G., Breeze, T. D., & MacLEOD, A. (2010). Quantifying the value of ecosystem services: a case study of honeybee pollination in the UK. *Contributed Paper*.

Nalunkuuma, J., Affognon, H., Kingori, S. W., Salifu, D., & Njonge, F. K. (2013). Adoption of zero-grazing and impact on livestock keepers' knowledge of cattle reproductive parameters in Western Kenya. *Age*, *1*, 0-32.

Nawrotzki, R. J., Hunter, L. M., & Dickinson, T. W. (2012). Rural livelihoods and access to natural capital: Differences between migrants and non-migrants in Madagascar.

Ndeinoma, A., & Wiersum, K. F. (2017). Diversity of governance arrangements for indigenous natural products in communal areas of Namibia. *Forest, Trees and Livelihoods*, *26*(2), 124-141.

Neale, W. C. (1998). "Property: Law, Cotton-pickin' Hands, and Implicit Cultural Imperialism." Pp. 47–66 in Property in Economic Context, edited by Robert C. Hunt and Antonio Gilman. Lanham: University Press of America: Monographs in Economic Anthropology, No. 14

Negawo, A. T., Teshome, A., Kumar, A., Hanson, J., & Jones, C. S. (2017). Opportunities for Napier grass (Pennisetum purpureum) improvement using molecular genetics. *Agronomy*, *7*(2), 28.

Neimark, A. V. (2010). *Deformation of coal induced by methane adsorption at geological conditions. Energy & Fuels*,

Nelson, J., Muhammed, N., & Abdul Rashid, R. (2015). Community's Forest Dependency and its Effects Towards the Forest Resources and Wildlife Abundances in Sarawak, Malaysia. *International Journal of Sustainable Development & World Ecology*, *22*(5),

Nepal, S. K. (2002). Tourism as a key to sustainable mountain development: the Nepalese Himalayas in retrospect. *UNASYLVA-FAO-*, 38-45.

Nikolaev, B. N., Boudreaux, C. J., & Palich, L. (2018). Cross-country determinants of early-stage necessity and opportunity-motivated entrepreneurship: accounting for model uncertainty. *Journal of Small Business Management*, *56*, 243-280.

Nunes, L. J., Meireles, C. I., Pinto Gomes, C. J., & Almeida Ribeiro, N. (2019). The Evolution of Climate Changes in Portugal: Determination of Trend Series and Its Impact on Forest Development. *Climate*, *7*(6), 78.

Olarewaju, T. O., Orumwense, L. A., Agbor, C. F., & Awe, F. (2017). Forest degradation and Livelihood: A case study of government forest reserves of Ogun state, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, *10*(2), 137-150.

Ongugo, P. O., Langat, D., Oeba, V. O., Kimondo, J. M., Owuor, B., Njuguna, J., & Russell, A. J. (2014). *A review of Kenya's national policies relevant to climate change adaptation and mitigation: Insights from Mount Elgon* (Vol. 155). CIFOR.

Ongugo, P. O., Mogoi, J. N., Obonyo, E., & Oeba, V. O. (2008). *Examining the Roles of Community Forest Associations (CFAS) in the Decentralization Process of Kenyan Forest.*

Orodho, A. J. (2013). *Essentials of Educational and Social Sciences Research Method.* Nairobi: Masola Publishers.

Ostrom, E. (2008). Tragedy of the Commons. *The new palgrave dictionary of economics*, *2*.

Ouko, C. A., Mulwa, R., Kibugi, R., Owuor, M. A., Zaehringer, J. G., & Oguge, N. O. (2018). Community perceptions of ecosystem services and the management of Mt Marsabit Forest in Northern Kenya. *Environments*, *5*(11), 121.

Owusu, P. A., & Asumadu-Sarkodie, S. (2016). A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering*, *3*(1), 1167990.

Pant, L. P., Adhikari, B., & Bhattarai, K. K. (2015). Adaptive transition for transformations to sustainability in developing countries. *Current Opinion in Environmental Sustainability*, *14*, 206-212.

Park, H. A. (2013). An introduction to logistic regression: from basic concepts to interpretation with particular attention to nursing domain. *Journal of Korean Academy of Nursing*, *43*(2), 154-164.

Pattanayak, S., Dickinson, K., Corey, C., Murray, B., Sills, E., & Kramer, R. (2006). Deforestation, malaria, and poverty: a call for transdisciplinary research to support the design of cross-sectoral policies. *Sustainability: Science, Practice and Policy*, *2*(2), 45-56.

Pearson, T. R., Brown, Murray, L., & Sidman, G. (2017) *Greenhouse gas emissions from tropical forest degradation: An underestimated source*, *Carbon balance and management*, 12(1), 3

Piana, R. P., & Marsden, S. J. (2014). Impacts of cattle grazing on forest structure and raptor distribution within a neotropical protected area. *Biodiversity and Conservation*, *23*(3), 559-572.

Pouliot, M., Treue, T., Obiri, B. D., & Ouedraogo, B. (2012). Deforestation and the limited contribution of forests to rural livelihoods in West Africa: evidence from Burkina Faso and Ghana. *Ambio*, *41*(7), 738-750.

Quine, C. P., & Humphrey, J. W. (2010). Plantations of exotic tree species in Britain: irrelevant for biodiversity or novel habitat for native species? *Biodiversity and Conservation*, *19*(5), 1503-1512.

Rama, D., Durán-Sánchez, A., Álvarez-García, J., De la Cruz, M., & Oliveira, C. (2018). Religious tourism and pilgrimage: Bibliometric overview. *Religions*, *9*(9), 249.

Ratovonamana, Y. R., Rajeriarison, C., Roger, E., Kiefer, I., & Ganzhorn, J. U. (2013). Impact of livestock grazing on forest structure, plant species composition and biomass in southwestern Madagascar. *Scripta Botanica Belgica*, *50*, 82-92.

Ribot, J. C., & Peluso, N. L. (2003). A theory of access. *Rural sociology*, *68*(2), 153-181.

Rice, M. W. (2012). In the Name of the Tiger: *Narrative Analysis on Conservation and Indigenous Forest Rights in India*.

Romeo, R., Vita, A., Manuelli, S., Zanini, E., Freppaz, M., & Stanchi, S. (2015). Understanding Mountain Soils: A contribution from mountain areas to the International Year of Soils 2015. *FAO, Rome*.

Rosenthal, J. S. (2010). A review of the role of protected areas in conserving global domestic animal diversity. *Animal Genetic Resources/Resources génétiques animals /Recursos genéticos animales*, *47*, 101-113.

Rudel, T. K. (2013). The national determinants of deforestation in sub-Saharan Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *368*(1625), 20120405.

Ruwanza, S., & Shackleton, C. M. (2017). Ecosystem-scale impacts of non-timber forest product harvesting: effects on soil nutrients. *Journal of Applied Ecology*, *54*(5), 1515-1525.

Sarmah, R., Arunachalam, A., & Melkania, U. (2011). Utilization Pattern of non-timber forest products (NTFPs) by the Tribal People in Changlang District of Arunachal Pradesh, India. . *Journal of non-timber forest products*,18(2), 105-118.

Sattler, D., Seliger, R., Nehren, U., de Torres, F. N., da Silva, A. S., Raedig, C., ... & Heinrich, J. (2018). Pasture degradation in Southeast Brazil: status, drivers and options for sustainable land use under climate change. In *Climate Change Adaptation in Latin America* (pp. 3-17). Springer, Cham.

Saunders, F. (2014). The Promise of Common Pool Resource Theory and The Reality of Commons Projects. *International Journal of the Commons*, *8*(2).

Schaafsma, M., Morse-Jones, S., Posen, P., Swetnam, R. D., Balmford, A., Bateman, I. J., & Geofrey, V. (2014). The Importance of Local Forest Benefits: Economic Valuation of non-timber forest products in The Eastern Arc Mountains in Tanzania. *Global Environmental Change*, *24*, 295-305.

Scherr, S. J., & McNeely, J. A. (2008). Biodiversity Conservation and Agricultural Sustainability: Towards A New Paradigm Of 'Ecoagriculture'landscapes. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 477-494.

Schieltz J. M., & Rubenstein, D. I. (2016). Evidence Based Review: Positive Versus Negative Effects of Cattle Grazing on Wildlife. What Do We Really Know? *Environmental Research Letters*, *11*(11), 113003.

Schnuerch, M., Erdfelder, E., & Heck, D. W. (2020). Sequential hypothesis tests for multinomial processing tree models. *Journal of Mathematical Psychology*, *95*, 102326.

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, *69*(2), 107-131.

Schreckenberg, K., & Luttrell, C. (2009). Participatory forest management: a route to poverty reduction? *International Forestry Review*, *11*(2), 221-238.

Sefeedpari, P., Vellinga, T., Rafiee, S., Sharifi, M., Shine, P., & Pishgar-Komleh, S. H. (2019). Technical, environmental and cost-benefit assessment of manure management chain: A case study of large-scale dairy farming. *Journal of cleaner production*, *233*, 857-868.

Senaviratna, N. A. M. R., & Cooray, T. M. J. A. (2019). Diagnosing multicollinearity of logistic regression model. *Asian Journal of Probability and Statistics*, 1-9.

Serrat, O. (2017). *Factors that help households to engage in sustainable livelihood strategies*

Shackleton, C. M., Ticktin, T., & Cunningham, A. B. (2018). Nontimber Forest Products as Ecological and Biocultural Keystone Species. *Ecology and Society*, *23*(4).

Shackleton, S., Campbell, B., Lotz-Sisitka, H., & Shackleton, C. (2008). Links Between the Local Trade in Natural Products, Livelihoods and Poverty Alleviation in A Semi-Arid Region Of South Africa. *World Development*, *36*(3), 505-526.

Shahsavari, A., & Akbari, M. (2018). Potential of Solar Energy in Developing Countries for Reducing Energy-Related Emissions. *Renewable and Sustainable Energy Reviews*, *90*, 275-291.

Shrestha, B. M., Sitaula, B. K., Singh, B. R., & Bajracharya, R. M. (2004). Soil Organic Carbon Stocks in Soil Aggregates Under Different Land Use Systems in Nepal. *Nutrient cycling in agroecosystems*, *70*(2), 201-213.

Silori, C. S., & Mishra, B. K. (2001). Assessment Of Cattle Grazing Pressure in And Around The Elephant Corridors In Mudumalai Wildlife Sanctuary, South India. *Biodiversity & Conservation*, *10*(12), 2181-2195.

Slaymaker, O. (2016). Mountain geomorphology. *International Encyclopedia of Geography: People, the Earth, Environment and Technology: People, the Earth, Environment and Technology*, 1-6.

Smith, A. C., Harrison, P. A., Soba, M. P., Archaux, F., Blicharska, M., Egoh, B. N., ...& Li, S. (2017). What Natural Capital Delivers Ecosystem Services: A Typology Derived from A Systematic Review. *Ecosystem Services*, *26*, 111-126.

Somanathan, E., Prabhakar, R., & Mehta, B. S. (2009). Decentralization for cost-effective conservation. *Proceedings of the National Academy of Sciences*, 106(11), 4143-4147.

Soofi, M., Ghoddousi, A., Zeppenfeld, T., Shokri, S., Soufi, M., Jafari, A., ...& Chahartaghi, N. R. (2018). Livestock grazing in protected areas and its effects on large mammals in the Hyrcanian forest, Iran. *Biological Conservation*, *217*, 377-382.

Steve, N. (2017). Monitoring Non-timber Forest Products Using Forest Inventory Data: An example with Slippery Elm Bark.*Journal of Forestry*, 115(4), 292-299.

Steyerberg, E. W. (2019). Assumptions in regression models: Additivity and linearity. In *Clinical Prediction Models* (pp. 227-245). Springer, Cham.

Stoltzfus, J. C. (2011). Logistic regression: a brief primer. *Academic Emergency Medicine*, *18*(10), 1099-1104.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research techniques*. Thousand Oaks, CA: Sage publications.

Sunderland, T., Achdiawan, R., Angelsen, A., Babigumira, R., Ickowitz, A., Paumgarten, F., ...& Shively, G. (2014). Challenging Perceptions About Men, Women, And Forest Product Use: A Global Comparative Study. *World Development*, *64*, S56-S66.

Tangka F.K., Jabbar M.A. and Shapiro B.I. (2000). Gender roles and child nutrition in livestock production systems in developing countries:

Teague, W. R. (2015). Toward Restoration of Ecosystem Function and Livelihoods on Grazed Agro Ecosystems. *Crop Science*, *55*(6), 2550-2556.

Thenya, T., Ngatia, J., & Ngecu, W. M. (2017). High Community Expectation Against Low Societal Transformation Through Community-Based Income Generating Activities. Analysis Of Participatory Forest Management in Kenya 2005-2013.*International Journal of Scientific Research and Management*, 5(6).

Tracy, S. J. (2013). *Qualitative research methods*, UK: Wiley Blackwell.

Tripti, K., Bauri, T., Palit, D., & Mukherjee, A. (2015). Livelihood dependency of rural people utilizing non-timber forest product (NTFP) in a moist deciduous forest zone, West Bengal, India.*International Journal of Advanced Research*, 3(4), 1030-1040.

Tucker, R. P. (1986). The Evolution of Transhumant Grazing in The Punjab Himalaya. *Mountain Research and Development*, 17-28.

Tumusiime, D. M., & Svarstad, H. (2011, November). A Local Counter-narrative on the Conservation of Mountain Gorillas.In *Forum for Development Studies* (Vol. 38, No. 3, pp. 239-265).Routledge.

Tuo, Q., & Li, C. (2018). Research progress, theories review and academic criticism on civilized tourism in China. *Tourism Tribune*, *33*(4), 90-102.

Uberhuaga, P., Smith-Hall, C., & Helles, F. (2011). Forest income and dependency in lowland Bolivia. *Environment, Development and Sustainability*, *14*(1), 3-23.

Uleri, F. (2019). Capitalism and the peasant mode of production: A Chayanovian analysis. *Крестьяноведение*, *4*(3), 43-60.

UN Environment Annual Report. (2018). Annual Report highlighting the organization's work The UN-REDD Forest Degradation. The UN-REDD Programme.

UNEP. (2015). *Annual Report*. Nairobi: United Nations Environmental Programmeme.

UNESCO (1997). Mount Kenya National Park/Natural Forest: UNESCO World at 5,199 m, Mount Kenya is the second highest peak in Africa. Retrieved from https://whc.unesco.org

Viviroli, D., Archer, D. R., Buytaert, W., Fowler, H. J., Greenwood, G. B., Hamlet, A. F., ... & Lorentz, S. (2011). Climate change and mountain water resources: overview and recommendations for research, management and policy. *Hydrology and Earth System Sciences*, *15*(2), 471-504.

Widiyanto, A. (2019). Factors Influencing Farmers Decision in Community-Based Forest Management Programme, KPH Ciamis, West Java. *Indonesian Journal of Forestry Research*, *6*(1), 1-16.

Wilkinson, J. M., & Lee, M. R. F. (2018). Use of Human-edible Animal feeds by ruminant livestock. *Animal*, *12*(8), 1735-1743.

Willcox, A. S., & Giuliano, W. M. (2011). Cattle Rancher and Conservation Agency Personnel Perceptions of Wildlife Management and Assistance Programmes in Alabama, Florida, Georgia, And Mississippi. *Wildlife Society Bulletin*, *35*(2), 59-68.

Wolff, N. H., Masuda, Y. J., Meijaard, E., Wells, J. A., & Game, E. T. (2018). Impacts of tropical deforestation on local temperature and human well-being perceptions. *Global Environmental Change*, *52*, 181-189.

World Bank Report (2009). 'Reshapes Economic Geography': Geographical Reflections. *Transactions of the Institute of British Geographers*, 34(2), 128-136.

Wunder, S., Angelsen, A., & Belcher, B. (2014). Forest, Livelihoods, And Conservation: Broadening the Empirical

Wunder, S., Noack, F., & Angelsen, A. (2018). Climate, crops, and forest: a pan-tropical analysis of household income generation. *Environment and Development Economics*, *23*(3), 279-297.

Xia, F., Hou, L., Jin, S., & Li, D. (2020). Land size and productivity in the livestock sector: evidence from pastoral areas in China. *Australian Journal of Agricultural and Resource Economics*, *64*(3), 867-888.

Zhao, J., & Li, S. M. (2018). The Impact of Tourism Development on the Environment in China. *Acta Sci. Malays*, *2*, 1-4.

Zhu, H. (2015). Ecological Restoration Strategies in Fragile Subtropical Mountain Ecosystems in China Based On Long-Term Research In Changting County. *Journal of Resources and Ecology*, *6*(3), 139-145.

APPENDICES

APPENDIX 1: Questionnaire for Smallholder farmers

Dear participant,

Re: Request to participate in the survey on socio-economic drivers of livestock grazing and grass harvesting at Mount Kenya Forest Blocks

My name is Paul Mwari Maina, a PhD candidate at St. Paul's University, Limuru, Kenya. I am conducting research to examine stakeholder perceptions towards potential ban on cattle grazing in protected forest areas, and I am inviting you to participate in the interviews. Participation in the research is entirely voluntary. Data collected will be integrated into a single report for my doctoral thesis. There are no direct benefits for participation in the interview. However, data generated will be useful in ensuring community voices are considered in decisions that may inform a ban on cattle grazing in protected forests. Permission to conduct the research has been granted by the National Commission for Science, Technology and Innovation (NACOSTI). I have also obtained permission from the Nyeri County Commissioner and the County Director of Education. If you have any questions about this survey, please contact pdslmr304316@spu.ac.keor my supervisors: Dr. Muasya on dmuasya@spu.ac.ke or Prof. G. Nduru on gilnduru@gmail.com .

Respondent consent:

Having understood the above information and knowledge of the interview, confidentiality and anonymity guaranteed, I hereby consent to participate in the interview.

Participant's signature: _____ Date:_____

Thank you very much for your participation.

Questions

1) What is the total size of land in acres that you legally own? …**Acres**
2) What is the number of cattle in the homestead? _____
3) Does your household graze in the forest during MOST months of the year, or does your household ONLY graze livestock in the forest during dry season's months only? (Yes or NO). Tick one Box

Grazing cattle in the forest during MOST PART OF THE YEAR	Grazing cattle in the forest DURING DRY seasons of the year ONLY

4) Do you purchase grass from the FOREST for your livestock during most months of the year, or do you ONLY purchase grass during the DRY season months? (Yes or NO). Tick one Box

Purchase grass for cattle from the FOREST during MOST months of the YEAR	ONLY purchase grass for cattle during the DRY season months

5) How many months in a year do you graze in the forest? _____

6) How many months in a year do you rely on grass harvested from the forest to feed your cattle? _____
7) Does your household have a Zero-grazing UNIT? **YES [ ] NO [ ]**
8) How many cows do you keep full-time UNDER ZERO-GRAZING unit only? ……..
9) Do you have a section of this land set aside for fodder production? **YES/ NO**

   If, yes, what size of land in acres is under fodder production? …… **Acres**
10) Do you have land rented for fodder production? **YES [ ] NO [ ]**

   If, yes, what size of rented land in acres is under fodder production? ……. **Acres**

11) What is the approximate quantity **(number of 50 kg bags)** of grass you obtain from the forest per month? ……

12) Are you involved in value addition of grass harvested from the forest? **YES / NO**

If yes, please explain briefly.
……
……
……

13) Is the grass obtained from the forest used to make silage? **YES [ ] NO [ ]**

14) How many bags of fodder are produced per acre in your farm during dry season (Number of bundles) …….?

12) How many bags of fodder can be produced per acre in your farm during the rainy season?

15) How many minutes does it take you walking from your household to the nearest point of the forest boundary? .....

16) I will read statements that describe sources of livestock feeds/ or means of sustaining livestock particularly cattle. Please indicate the Affordability of each livestock feed or means of raising livestock using a Scale of 1 = Very cheap to 7 = Very Expensive, based on your experiences.

		CHEAP						EXPENSIVE
a.	Grazing in the forest during most part of the year	1	2	3	4	5	6	7
b.	Grazing in the forest during Dry season months	1	2	3	4	5	6	7
c.	Purchasing Grass from the forest during most part of the year	1	2	3	4	5	6	7
d.	Purchasing Grass from the Forest during Dry season months	1	2	3	4	5	6	7
e.	Purchasing Commercial feeds for your livestock	1	2	3	4	5	6	7
f.	Making your own Silage to feed your cattle	1	2	3	4	5	6	7
g.	Purchasing silage to feed your cattle	1	2	3	4	5	6	7
h.	Growing Napier grass on my own farm	1	2	3	4	5	6	7
i.	Purchasing Napier grass from other famer, neighbours	1	2	3	4	5	6	7
j.	Lucerne from your own farm	1	2	3	4	5	6	7
k.	Maize stalk from your own farm	1	2	3	4	5	6	7
l.	Purchasing Lucerne from other farmers	1	2	3	4	5	6	7
m.	Purchasing Maize stalk from other farmers	1	2	3	4	5	6	7
n.	Obtaining Forest leaves and shrubs	1	2	3	4	5	6	7
o.	Harvesting *Magutiani* (*Hyparrhenia spp)* and *Mandara* (*Discopodium penninervium)*	1	2	3	4	5	6	7
p.	Buying hay (grass cut and dried)	1	2	3	4	5	6	7
q.	Relying on FULL time Zero grazing	1	2	3	4	5	6	7

r.	Using peels and vegetable waste to feed cattle	1	2	3	4	5	6	7
s.	Using banana leaves to feed cattle	1	2	3	4	5	6	7

18) Does your household have any of the following?

	YES (Available) (Tick)	NO (Not available)
Cattle Shed		
Calves		
Hay structure / shed		
Hay grass		
Hay bailer (manual)		
Chaff cutter machine		
Water storage tank		
Watering trough		
Milk containers		
Biogas unit		
Operational Biogas cooking /lighting system		
Television		
Solar panel		
Cash crops		

19) What are the main sources of your household income?

20) On average how much do your household pay for electricity?

21) On average how much does your household pay for piped water consumed, if any?

22) Gender of the Respondent **Male [ ]** **Female [ ]**

23) Age, Marital status and highest formal educational attainment

Age of respondent	Marital status **(TICK ONE)**	Highest level of education completed**(TICK ONE)**
Age in years_____	1= Married **[ ]** 2= Single **[ ]** 3= Widowed **[ ]** 4= Divorced	0= No **formal** education **[ ]** 1= **Primary** education **[ ]** 2= **High** school education **[ ]** 3= Holds a college **certificate [ ]** 4= Holds a **Diploma[ ]** 5= Holds a **Degree [ ]**

24) How many people live in this household (that is, the number of people typically living in the home most days of the week)? …….

APPENDIX 2: Interview Guide

Dear participant,

Re: Request to participate in the Survey on smallholder perceptions towards use of a ban to regulate access to protected forest area(s) for livestock grazing

My name is Paul Mwari Maina, a PhD candidate at St. Paul's University, Limuru, Kenya. I am conducting research to examine stakeholder perceptions towards potential ban on cattle grazing in protected forest areas, and I am inviting you to participate in the interviews. Participation in the research is entirely voluntary. Data collected will be integrated into a single report for my doctoral thesis. There are no direct benefits for participation in the interview. However, data generated will be useful in ensuring community voices are considered in decisions that may inform a ban on cattle grazing in protected forests. Permission to conduct the research has been granted by the National Commission for Science, Technology and Innovation (NACOSTI). I have also obtained permission from the Nyeri County Commissioner and the County Director of Education. If you have any questions about this survey, please contact pdslmr304316@spu.ac.keor my supervisors: Dr. Muasya on dmuasya@spu.ac.ke or Prof G. Nduru on gilnduru@gmail.com .

Respondent consent:

Having understood the above information and knowledge of the interview, confidentiality and anonymity guaranteed, I hereby consent to participate in the interview.

Participant's Signature: _____ Date:_____

Thank you very much for your participation.

We can now begin the interview.

1) Suppose KFS banned cattle grazing in the protected forest. What consequences would such a decision have on your household?

2) What measures would your household take to cope with the consequences of a ban on livestock grazing in the protected forest?

APPENDIX 3: Demographic Characteristics for three Forest Blocks

Demographic Characteristic	Forest Block			
	Chehe (n=151)	Hombe (n=153)	Kahurura (n=149)	Total (n=453)
Gender				
Male	71.5%	55.6%	55.7%	60.9%
Female	28.5%	44.4%	44.3%	39.1%
Age (years)				
20 – 30	3.3%	0.0%	1.3%	1.5%
31 – 40	25.2%	9.2%	11.4%	15.2%
41 – 60	59.6%	62.1%	60.4%	60.7%
61 & above	11.9%	28.8%	26.8%	22.5%
Marital Status				
Married	77.5%	83.0%	86.6%	82.3%
Single	12.6%	8.5%	3.4%	8.2%
Widowed	9.9%	8.5%	10.1%	9.5%
Highest Education Level				
No forma education	4.6%	6.5%	14.1%	8.4%
Primary	29.8%	45.1%	57.7%	44.2%
Secondary	50.3%	40.5%	26.2%	39.1%
Post-secondary	15.2%	7.8%	2.0%	8.4%

APPENDIX 4: Tables for specific forest blocks on feed sources

Chehe Forest blocks

Category	Exact test item	Cheap	Moderate	Expensive
Forest-based sources	Grazing in the forest during most part of the year	87%	2%	11%
	Grazing in the forest during Dry season months	87%	2%	11%
	Purchasing Grass from the forest during most part of the year	70%	12%	18%
	Purchasing Grass from the Forest during Dry season months	66%	17%	18%
	Obtaining Forest leaves and shrubs	95%	2%	3%
Farm-based feeds	Maize stalk from your own farm	87%	5%	8%
	Growing Napier grass on my own farm	81%	10%	9%
	Lucerne from your own farm	47%	1%	52%
	Making your own Silage to feed your cattle	23%	3%	74%
Bought from neighbours	Purchasing Maize stalk from other farmers	40%	48%	12%
	Purchasing Napier grass from other famer, neighbours	15%	53%	32%
	Purchasing Lucerne from other farmers	28%	13%	60%
Commercial feeds	Purchasing silage to feed your cattle	23%	3%	74%
	Relying on FULL time Zero grazing	15%	33%	52%
	Purchasing Commercial feeds for your livestock	7%	40%	53%
	Buying hay (grass cut and dried)	8%	28%	64%
Others	Using peels and vegetable waste to feed cattle	98%	1%	1%
	Using banana leaves to feed cattle	99%	1%	0%
	Harvesting *Magutiani* (*Hyparrhenia spp)*and *Mandara*(*Discopodium spp)* from roadside	91%	4%	5%

Hombe forest block

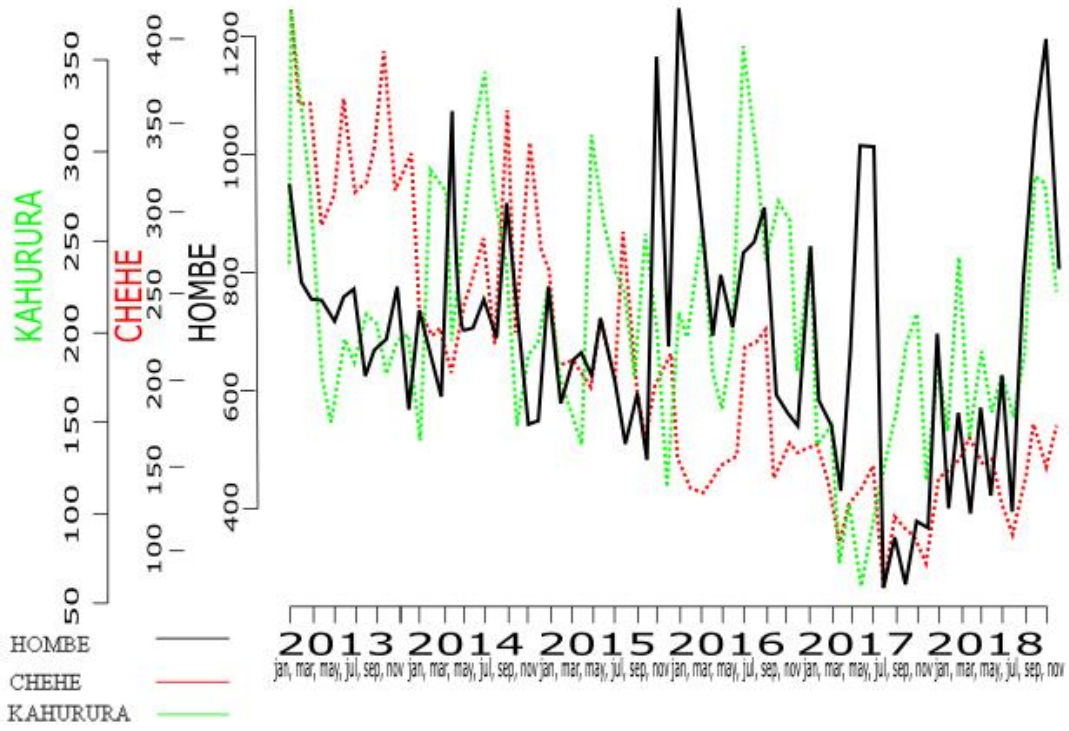
Category	Exact test item	Cheap	Moderate	Expensive
Forest-based sources	Grazing in the forest during most part of the year	88%	4%	8%
	Grazing in the forest during Dry season months	88%	7%	5%
	Purchasing Grass from the forest during most part of the year	26%	31%	43%
	Purchasing Grass from the Forest during Dry season months	33%	26%	41%
	Obtaining Forest leaves and shrubs	90%	9%	1%
Farm-based feeds	Maize stalk from your own farm	98%	1%	1%
	Growing Napier grass on my own farm	95%	1%	4%
	Lucerne from your own farm	57%	20%	23%
	Making your own Silage to feed your cattle	38%	11%	51%
Bought from	Purchasing Maize stalk from other farmers	46%	14%	39%

neighbours	Purchasing Napier grass from other famer, neighbours	31%	29%	40%
	Purchasing Lucerne from other farmers	5%	10%	85%
Commercial feeds	Purchasing silage to feed your cattle	7%	5%	88%
	Relying on FULL time Zero grazing	2%	7%	91%
	Purchasing Commercial feeds for your livestock	4%	6%	90%
	Buying hay (grass cut and dried)	3%	4%	93%
Others	Using peels and vegetable waste to feed cattle	97%	1%	1%
	Using banana leaves to feed cattle	98%	1%	1%
	Harvesting *Magutiani* (*Hyparrhenia spp)*and *Mandara*(*Discopodium spp.)* from the road side	95%	5%	1%

Kahurura Forest Block

Category	**Exact test item**	**Cheap**	**Moderate**	**Expensive**
Forest-based sources	Grazing in the forest during most part of the year	74%	10%	16%
	Grazing in the forest during Dry season months	75%	11%	13%
	Purchasing Grass from the forest during most part of the year	48%	18%	34%
	Purchasing Grass from the Forest during Dry season months	49%	20%	31%
	Obtaining Forest leaves and shrubs	90%	9%	1%
Farm-based feeds	Maize stalk from your own farm	95%	3%	2%
	Growing Napier grass on my own farm	92%	2%	6%
	Lucerne from your own farm	48%	11%	42%
	Making your own Silage to feed your cattle	16%	18%	66%
Bought from neighbours	Purchasing Maize stalk from other farmers	55%	5%	40%
	Purchasing Napier grass from other famer, neighbours	42%	17%	41%
	Purchasing Lucerne from other farmers	13%	15%	71%
Commercial feeds	Purchasing silage to feed your cattle	11%	19%	70%
	Relying on FULL time Zero grazing	8%	25%	67%
	Purchasing Commercial feeds for your livestock	2%	7%	91%
	Buying hay (grass cut and dried)	7%	14%	79%
Others	Using peels and vegetable waste to feed cattle	93%	5%	1%
	Using banana leaves to feed cattle	89%	9%	3%
	Harvesting *Magutiani* (*Hyparrhenia spp)*and *Mandara*(*Discopodium penninervium)* from the road side	93%	5%	3%

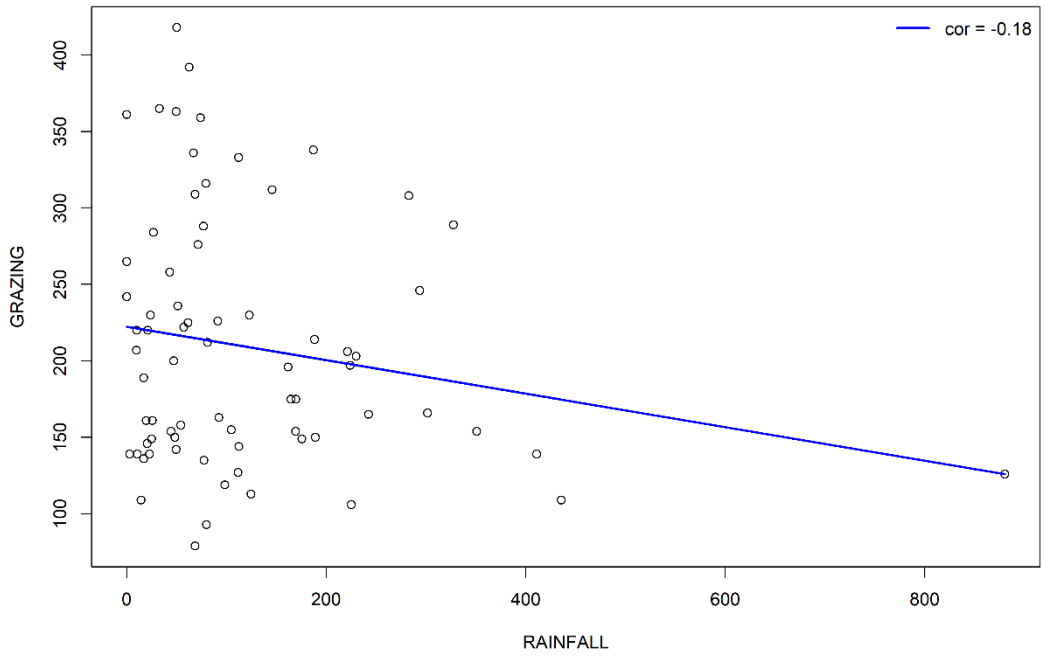
APPENDIX 5: Time series of plot of seasonal patterns of forest dependence for pasture: West Mt Kenya Protected Forest



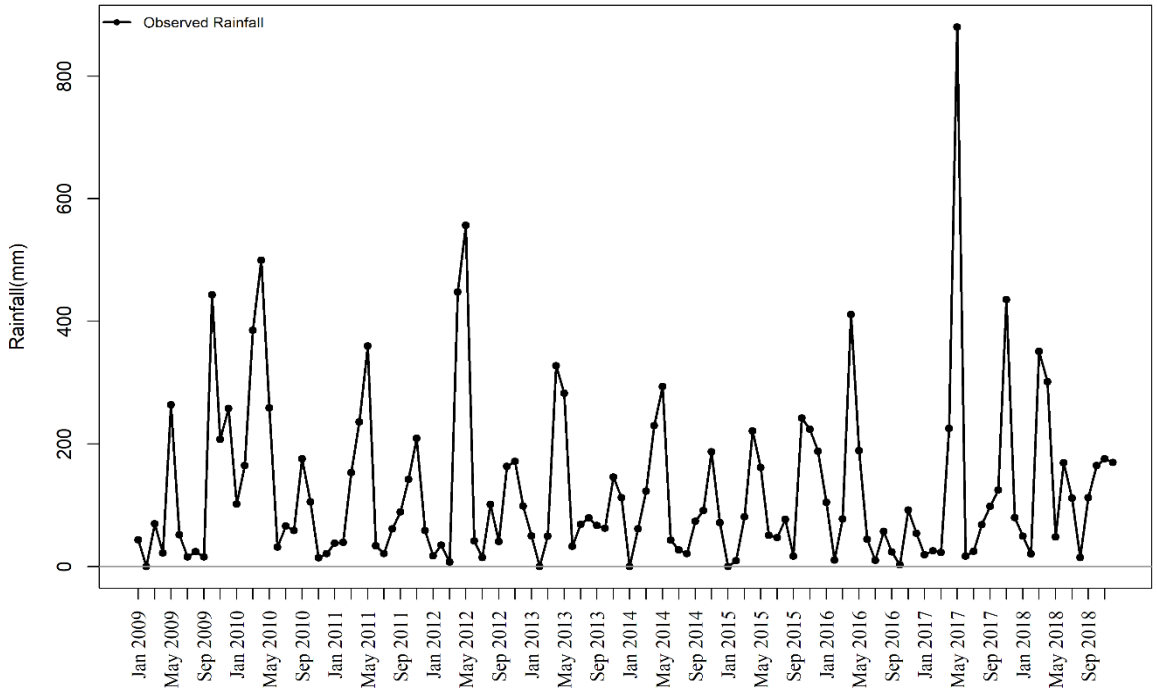
APPENDIX 6: Monthly seasonality indices observed rainfall at the Chehe forest block over the study period (2009 to 2018)

Month											
Jan	Feb	Mar	April	May	June	Jul	Aug	Sep	Oct	Nov	Dec
-87	-89	9	193	209	-76	-92	-64	-60	24	58	-24

APPENDIX 7: Scatterplot showing relationship between cattle grazing and rainfall over Chehe forest block



APPENDIX 8: Rainfall Monthly Seasonality patterns for Chehe Forest Block – 2009 to 2018



APPENDIX 9: Intercorrelations between Variables

		1	2	3	4	5	6	7
1	Household Size	1						
2	SES Wealth Index	-0.01	1					
3	Proximity to the Forest	0.04	0.07	1				
4	Total land size	0.07	.27**	-0.1	1			
5	Prop. of Land Under Fodder Production	0.05	.23**	0.08	-.13*	1		
6	Ownership of Zero-grazing Unit	0.04	.75**	0.05	.21**	.24**	1	
7	Number of Cattle in Homestead	.18**	0.09	-0.01	.25**	-0.04	.13*	1
8	Prop. of Cattle Kept under Zero-grazing Unit	0.06	.55**	-0.02	.19**	0.09	.66**	-0.03

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 10: Relationship between smallholder household size and household SES forest dependence for pasture

Control Variables	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Household Size	-0.19	0.16	1.29	0.26	-0.51	0.14
SES Wealth Index	-0.42	0.23	3.38	0.04	-0.87	0.03
Constant	5.23	1.10	22.55	0.00		

APPENDIX 11: Sequential logistic regression models for cattle grazing in Mt Kenya West

Part A: Results of sequential logistic regression for grazing levels in Chehe forest block

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-1.25	0.29	-1.36	0.29	-53.04	1.00
Household size	-0.02	0.96	0.42	0.34	11.49	0.99
Education Level		0.97		0.85		1.00
Primary	0.01	1.00	18.84	1.00	149.33	1.00
High school	-19.54	1.00	-1.44	1.00	107.99	1.00
College certification	-18.79	1.00	0.13	1.00	162.21	1.00
Diploma	-0.16	1.00	19.48	1.00	182.67	1.00
Degree	-	-	-	-	-	-
SES Wealth Index				0.98	63.61	1.00
Poorest			21.75	1.00	94.13	1.00
Poorer			20.38	1.00	73.99	1.00

Poor	20.08	1.00	-0.74	1.00
Less poor	0.73	0.52	0.40	1.00
Proximity to the forest			-0.01	1.00
Total land size			74.64	0.06
Proportion of land under fodder production			-29.55	1.00
Own zero-grazing unit (Yes)			7.58	1.00
Number of cattle in a homestead			79.15	0.99
Proportion of cattle in zero-grazing unit				1.00

**Significant at p<0.1 | **Significant at p<0.05*

Part B: Results of sequential logistic regression for grazing levels in Hombe forest block

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-17.55	1.00	-18.38	1.00	0.69	0.84
Household size	1.28	0.35	15.47	0.99	6.94	0.39
Education Level		1.00		1.00		0.18
Primary	-16.46	1.00	-3.05	1.00	17.91	0.05*
High school	-0.07	1.00	27.61	1.00	68.11	0.29
College certification	-17.59	1.00	12.95	1.00	42.21	0.39
Diploma	1.55	1.00	32.07	1.00	112.56	0.59
Degree	-1.28	1.00	0.66	1.00	30.46	0.41
SES Wealth Index				1.00		0.27
Poorest			16.28	1.00	5.35	0.66
Poorer			29.97	1.00	18.16	0.61
Poor			16.14	1.00	15.03	0.27
Less poor			-2.55	1.00	-9.76	0.99
Proximity to the forest					-0.01	0.04**
Total land size					0.00	0.66
Proportion of land under fodder production					-23.69	0.59
Own zero-grazing unit (Yes)					-4.52	0.61
Number of cattle in a homestead					-4.68	0.28
Proportion of cattle in zero-grazing unit					-25.46	0.90

**Significant at p<0.1 | **Significant at p<0.05*

Part C: Results of sequential logistic regression for grazing levels in Kahurura

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-17.21	1.00	-16.74	1.00	-31.79	0.40
Household size	0.18	0.81	0.37	0.63	14.05	0.51
Education Level		1.00		1.00		0.32
Primary	0.07	1.00	17.73	1.00	106.77	0.83
High school	-17.15	1.00	0.76	1.00	21.07	0.42
College certification	-0.47	1.00	17.01	1.00	9.17	0.46
Diploma	0.81	1.00	18.89	1.00	53.44	0.60
Degree	-	-	-	-	-	-
SES Wealth Index				1.00		0.90
Poorest			-1.39	1.00	166.69	0.85
Poorer			-18.07	1.00	71.81	0.11

Poor	-0.15	1.00	-5.82	0.48
Less poor	-16.08	1.00	28.80	0.86
Proximity to the forest			-1.57	0.55
Total land size			0.00	0.70
Proportion of land under fodder production			-9.22	0.00**
Own zero-grazing unit (Yes)			26.30	0.94
Number of cattle in a homestead			0.66	0.27
Proportion of cattle in zero-grazing unit			-89.36	0.88

**Significant at p<0.1 | **Significant at p<0.05*

APPENDIX 12: Multinomial Logit Model for Household SES and dependence of forest for pasture

SES Wealth Indices	Grazing Level	**Observed**		**Expected**	
		Count	Percent	Count	Percent
1. Poorest	Grazing during dry season only	4.5	5.8	4.5	5.8
	Grazing throughout the year	73.5	94.2	73.5	94.2
2. Poorer	Grazing during dry season only	1.5	1.9	1.5	1.9
	Grazing throughout the year	78.5	98.1	78.5	98.1
3. Poor	Grazing during dry season only	0.5	0.7	0.5	0.7
	Grazing throughout the year	69.5	99.3	69.5	99.3
4. Less poor	Grazing during dry season only	2.5	4.8	2.5	4.8
	Grazing throughout the year	49.5	95.2	49.5	95.2
5. Least poor	Grazing during dry season only	5.5	20.4	5.5	20.4
	Grazing throughout the year	21.5	79.6	21.5	79.6

a Model: Multinomial Logit

b Design: Constant + SES Wealth Index * Grazing Level

APPENDIX 13: Marginal Effects: Relationship between smallholder farmers household characteristics and forest dependence for pasture

Marginal Effects for Chehe	dy/dx	Std. Err.	z	P>|z|	[95% C. I]		x
Household Size	0.00	0.02	-0.06	0.48	-0.04	0.04	4.2
SES Wealth Index	-0.14	0.04	2.85	0.01	-0.22	-0.06	1
Proximity to the Forest	0.00	0.12	-1.02	0.16	-0.23	0.24	46
Total land size	-0.07	0.03	1.89	0.02	-0.13	-0.01	1
Prop. of Land Under Fodder Production	-0.03	0.12	-0.3	0.39	-0.27	0.21	0.3
Ownership of Zero-grazing Unit	0.02	0.09	0.1	0.46	-0.15	0.18	0
Number of Cattle in Homestead	-0.01	0.01	-1.55	0.07	-0.03	0.01	5.1
Prop. of Cattle Kept under Zero-grazing Unit	-0.21	0.15	-1.76	0.02	-0.49	0.08	0.4
Marginal Effects for Hombe							
Household Size	-0.01	0.01	-1.01	0.16	-0.03	0.01	4
SES Wealth Index	0.02	0.01	0.58	0.28	0	0.03	1
Proximity to the Forest	-0.11	0.17	2.04	0.02	-0.44	0.23	29
Total land size	0.00	0.01	0.01	0.5	-0.02	0.02	1.7
Prop. of Land Under Fodder Production	-0.03	0.05	0.68	0.25	-0.14	0.07	0.2
Ownership of Zero-grazing Unit	0.04	0.03	0.86	0.2	-0.02	0.1	0
Number of Cattle in Homestead	0.00	0.11	1.08	0.14	-0.21	0.22	5.6
Prop. of Cattle Kept under Zero-grazing Unit	-0.05	0.07	-0.57	0.29	-0.19	0.1	0.2
Marginal Effects for Kahurura							
Household Size	0.02	0.01	0.9	0.19	0	0.03	4.3
SES Wealth Index	-0.03	0.03	-1.07	0.15	-0.09	0.03	1
Proximity to the Forest	0.00	0.12	-0.93	0.18	-0.24	0.24	26.1
Total land size	-0.01	0.02	-0.6	0.28	-0.05	0.03	1.2
Prop. of Land Under Fodder Production	-0.20	0.17	1.58	0.01	-0.54	0.14	0.2
Ownership of Zero-grazing Unit	-0.13	0.17	-1.04	0.02	-0.46	0.21	0
Number of Cattle in Homestead	0.00	0.11	-0.98	0.17	-0.21	0.22	4.9
Prop. of Cattle Kept under Zero-grazing Unit	-0.12	0.56	2.52	0.01	-1.21	0.98	0.1

APPENDIX 14: Relationship between smallholder farmers household size and SES wealth index and forest dependence for grass harvesting

Control Variables	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Household Size	0.03	0.09	0.12	0.73	-0.14	0.20
SES Wealth Index	0.40	0.10	14.90	0.00	0.20	0.60
Constant	-0.95	0.52	3.37	0.07		

APPENDIX 15: Multinomial Logit Model for Household SES and Grass Harvesting Levels

SES Wealth Indices	Grass Harvesting Level	Observed		Expected	
		Count	Percent	Count	Percent
1. Poorest	Grass harvesting during dry season only	15.5	62.0	15.5	62.0
	Grass harvesting throughout the year	9.5	38.0	9.5	38.0
2. Poorer	Grass harvesting during dry season only	16.5	47.1	16.5	47.1
	Grass harvesting throughout the year	18.5	52.9	18.5	52.9
3. Poor	Grass harvesting during dry season only	19.5	41.5	19.5	41.5
	Grass harvesting throughout the year	27.5	58.5	27.5	58.5
4. Less poor	Grass harvesting during dry season only	20.5	34.2	20.5	34.2
	Grass harvesting throughout the year	39.5	65.8	39.5	65.8
5. Least poor	Grass harvesting during dry season only	18.5	22.8	18.5	22.8
	Grass harvesting throughout the year	62.5	77.2	62.5	77.2

a Model: Multinomial Logit
b Design: Constant + SES_Wealth_Index* Grass_Harvesting_Level

APPENDIX 16: Sequential logistic regression models for grass harvesting in Mt Kenya West

Part A: Results of sequential logistic regression for grass harvesting in Chehe

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-0.44	0.56	-0.60	0.47	-0.54	0.56
Household size	0.13	0.54	0.20	0.40	0.25	0.34
Education Level		0.68		0.55		0.47
Primary	-21.49	1.00	-22.12	1.00	-22.02	1.00
High school	-19.49	1.00	-20.04	1.00	-19.52	1.00
College certification	-19.07	1.00	-19.37	1.00	-18.31	1.00
Diploma	-18.46	1.00	-18.69	1.00	-17.23	1.00
Degree	-0.05		0.07	1.00	0.24	1.00
SES Wealth Index				0.82		0.41
Poorest			20.32	1.00	20.33	1.00
Poorer			0.38	0.76	-0.91	0.64
Poor			0.51	0.59	1.35	0.21
Less poor			0.99	0.22	1.89	0.06
Proximity to the forest					-0.01	0.27
Total land size					0.00	0.27
Proportion of land under fodder production					0.58	0.48
Own zero-grazing unit (Yes)					-2.32	0.18
Number of cattle in a homestead					-0.12	0.27
Proportion of cattle in zero-grazing unit					**2.02**	**0.08**

Part B: Results of sequential logistic regression for grass harvesting in Hombe

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	-1.08	0.11	-1.05	0.14	-1.45	0.14
Household size	-0.01	0.96	-0.04	0.88	0.08	0.82
Education Level		0.81		0.73		0.58
Primary	20.68	1.00	20.87	1.00	23.67	1.00
High school	19.65	1.00	19.58	1.00	22.24	1.00
College certification	19.82	1.00	19.78	1.00	21.40	1.00
Diploma	21.24	1.00	21.40	1.00	24.23	1.00
Degree						
SES Wealth Index				0.48		0.41
Poorest			0.43	0.83	1.37	0.61
Poorer			0.93	0.49	1.64	0.42
Poor			1.74	0.18	3.05	0.12
Less poor						
Proximity to the forest					**-0.03**	**0.09**
Total land size					0.00	0.18
Proportion of land under fodder production					-13.29	0.04
Own zero-grazing unit (Yes)					-0.40	0.86
Number of cattle in a homestead					-0.20	0.25
Proportion of cattle in zero-grazing unit					3.03	0.16

Part C: Results of sequential logistic regression for grass harvesting in Hombe

	Model 1		*Model 2*		*Model 3*	
	Coef.	*P-value*	*Coef.*	*P-value*	*Coef.*	*P-value*
Gender (Male / Female)	0.56	0.35	0.18	0.80	0.94	0.30
Household size	0.19	0.27	0.11	0.56	0.17	0.49
Education Level		0.83		0.55		0.32
Primary	-19.98	1.00	-19.84	1.00	-21.50	1.00
High school	-20.78	1.00	-21.31	1.00	-23.42	1.00
College certification	-20.59	1.00	-20.88	1.00	-22.21	1.00
Diploma	-		-	-	-	-
Degree	-		-	-	-	-
SES Wealth Index				0.17		0.18
Poorest			-1.26	0.34	-0.84	0.65
Poorer			1.11	0.27	1.82	0.31
Poor			0.46	0.71	-0.05	0.97
Less poor			0.53	0.69	1.13	0.50
Proximity to the forest					**0.06**	**0.01**
Total land size					**0.00**	**0.08**
Proportion of land under fodder production					-2.05	0.46
Own zero-grazing unit (Yes)					1.30	0.29
Number of cattle in a homestead					0.08	0.34
Proportion of cattle in zero-grazing unit					0.74	0.64

APPENDIX 17: Marginal Effects: Relationship between smallholder farmer household characteristics and forest dependence for grass harvesting in (Chehe, Hombe & Kahurura)

Marginal Effects for Chehe	**dy/dx**	**Std. Err.**	**z**	**P>|z|**	**[95% C.I]**		**x**
Household Size	0.03	0.06	1.16	0.43	-0.09	0.14	4.2
SES Wealth Index	0.04	0.12	0.85	0.46	-0.19	0.27	1
Proximity to the Forest	0.00	0.02	0.8	0.18	-0.04	0.04	46
Total land size	0.01	0.1	0.45	0.25	-0.18	0.2	1
Prop. of Land Under Fodder Production	-0.09	0.1	0.91	0.95	-0.29	0.1	0.3
Ownership of Zero-grazing Unit	0.11	0.23	0.44	0.13	-0.35	0.57	0
Number of Cattle in Homestead	0.00	0.04	0.94	0.73	-0.07	0.08	5.1
Prop. of Cattle Kept under Zero-grazing Unit	0.13	0	-0.12	0.11	0.12	0.13	0.4
Marginal Effects for Hombe							
Household Size	-0.05	0.14	0.25	1.45	-0.32	0.21	4
SES Wealth Index	0.03	0.25	0.65	0.04	-0.47	0.53	1
Proximity to the Forest	0.00	0.02	1.54	0.55	-0.04	0.04	29
Total land size	0.01	0.14	0.57	0.09	-0.25	0.28	1.7
Prop. of Land Under Fodder Production	-0.12	0.65	1.51	0.26	-1.4	1.16	0.2
Ownership of Zero-grazing Unit	0.11	0.61	0.66	0.04	-1.08	1.3	0

Number of Cattle in Homestead	0.03	0.06	0.81	0.45	-0.09	0.14	5.6
Prop. of Cattle Kept under Zero-grazing Unit	-0.25	0.55	0.62	0.23	-1.33	0.82	0.2
Marginal Effects for Kahurura							
Household Size	-0.08	0.1	0.32	0.97	-0.27	0.11	4.3
SES Wealth Index	-0.04	0.18	0.39	0.08	-0.38	0.3	1
Proximity to the Forest	-0.01	0.02	0.33	0.94	-0.05	0.02	26.1
Total land size	-0.07	0.1	1.41	0.02	-0.26	0.12	1.2
Prop. of Land Under Fodder Production	-0.13	0.01	0.65	0.01	-0.15	-0.12	0.2
Ownership of Zero-grazing Unit	0.15	0.04	-0.06	0.06	0.07	0.23	0
Number of Cattle in Homestead	-0.03	0.06	-0.55	0.86	-0.14	0.09	4.9
Prop. of Cattle Kept under Zero-grazing Unit	0.11	0.38	-0.11	0.98	-0.64	0.85	0.1

APPENDIX 18: Tests for Multicollinearity Assumption for Sequential logistic regression for Cattle Grazing across Forest Blocks

Correlation Matrix

	Constant	Number of Cattle in the homestead	Total size of land	Size of land under fodder production	Proximity to forest	Farmers' socio-economic Status (SES)
Constant	1.000	-.451	-.129	-.149	-.424	-.185
Number of Cattle in the homestead	-.451	1.000	-.157	-.025	-.097	-.112
Total size of land	-.129	-.157	1.000	-.670	.066	-.083
Size of land under fodder production	-.149	-.025	-.670	1.000	.071	-.118
Proximity to forest	-.424	-.097	.066	.071	1.000	-.195
Farmers' socio-economic Status (SES)	-.185	-.112	-.083	-.118	-.195	1.000

APPENDIX 19: Tests for Multicollinearity Assumption for Sequential logistic regression for Grass Harvesting across Forest Blocks

Correlation Matrix

	Constant	Number of Cattle in the homestead	Total size of land	Size of land under fodder production	Proximity to forest	Farmers' socio-economic Status (SES)
Constant	1.000	-.327	-.281	-.024	-.565	-.290
Number of Cattle in the homestead	-.327	1.000	-.289	-.014	.002	-.151
Total size of land	-.281	-.289	1.000	-.512	.098	.125
Size of land under fodder production	-.024	-.014	-.512	1.000	-.008	-.316
Proximity to forest	-.565	.002	.098	-.008	1.000	-.108
Farmers' socio-economic Status (SES)	-.290	-.151	.125	-.316	-.108	1.000

APPENDIX 20: Forest dependency by cattle grazing in protected forests

	Grazing during dry season	Grazing most part of the year	Total	Chi square	P-value
Gender				2.470	0.116
Male	6 (86%)	165 (56%)	171 (57%)		
Female	1 (14%)	130 (44%)	131 (43%)		
Level of education				1.358	0.715
No formal education	0 (%)	27 (9%)	27 (9%)		
Primary	4 (57%)	150 (51%)	154 (51%)		
Secondary	3 (43%)	98 (33%)	101 (33%)		
Post-secondary	0 (0%)	20 (7%)	20 (7%)		
SES				18.005	0.001
Poorer	1 (14%)	134 (45%)	135 (45%)		
Poor	0 (0%)	103 (35%)	103 (34%)		
Not poor	6 (86%)	58 (20%)	64 (21%)		
Zero-grazing unit				9.282	0.002
Yes	6 (86%)	91 (31%)	97 (32%)		
No	1 (14%)	201 (69%)	202 (68%)		
Forest block				7.962	0.019
Chehe	5 (71%)	72 (24%)	77 (25%)		
Hombe	1 (14%)	118 (40%)	119 (39%)		
Kahurura	1 (14%)	105 (36%)	106 (35%)		
Total	**7 (2%)**	**295 (98%)**	**302 (100%)**		

APPENDIX 21: Forest dependency by grass harvesting in protected forests

	Grass harvesting during dry season	Grass harvesting most part of the year	Total	Chi square	P-value
Gender				0.806	0.369
Male	56 (65%)	111 (71%)	167 (69%)		
Female	30 (35%)	46 (29%)	76 (31%)		
Level of education				10.383	0.016
No formal education	6 (7%)	8 (5%)	14 (6%)		
Primary	40 (47%)	50 (32%)	90 (37%)		
Secondary	37 (43%)	76 (48%)	113 (47%)		
Post-secondary	3 (15%)	23 (15%)	26 (11%)		
SES				9.662	0.008
Poorer	29 (34%)	30 (19%)	59 (24%)		
Poor	27 (31%)	42 (27%)	69 (28%)		
Not poor	30 (35%)	85 (54%)	115 (47%)		
Zero-grazing unit				10.020	0.002
Yes	46 (54%)	115 (74%)	161 (67%)		
No	39 (46%)	40 (26%)	79 (33%)		
Forest block				67.489	0.001
Chehe	14 (16%)	111 (71%)	125 (51%)		
Hombe	35 (41%)	17 (11%)	52 (21%)		
Kahurura	37 (43%)	29 (18%)	66 (27%)		
Total	**86 (35%)**	**157 (65%)**	**243 (100%)**		

APPENDIX 22: A Sample of a Translated Interview from Kikuyu to English: Chehe Forest Block

M: Suppose KFS banned cattle grazing in the forest. What do you think the consequences of such a decision would be ?
R1: *No gukorwo na thiina muno tondu mahuti maria tuonaga tumarutaga kuu mutitu*
It could affect me because there would not be enough pasture.

M: So what measures would you take to cope with the situation as a farmer?
R1: *Ta murimi no nyedirie ngo'mbe ciakwa.*
As a farmer, I would sell the cows and may be remain with one cow which I can maintain.

M: What about if they banned grass harvesting in the forest? Do you think consequences would be the same?

R1: *No undu umwe, tareu mundu ucio uguikarite haha hindi iyo ingi ari na ngo'mbe 20 agiciedia ciothe agitiguo atari.*
I think it is just the same, such as there is a time they had closed the forest, my neighbour had 20 cows and he was forced to sell all of them.

M: Suppose KFS banned cattle grazing in the forest. What do you think the consequences of such a decision would be ?
R2: *Niui ni kuri andu mena migunda minene na wina mugunda munene no ukorwo na thaara muingi na nikuri andu maguraga hay no kungihinguo ni kuri na andu mangigia na thiina wa mahuti, mahuti no manyiihe.*
Some of the famers have enough area to plant fodder crops, some also can afford to buy hay but a good number could suffer from such a decision, it could be challenging due to lack of enough pasture.

M: Such as for your case what would you do to feed your cows?
R2: *Reu no uguriire thaara okorwo nguraga ta mirigo iiri ya thaara no nyongerere murigo umwe.*
I would buy Napier grass from the neighbourhood and also add more quantity of hay.

M: Suppose KFS banned cattle grazing in the forest, what do you think are the consequences of such decision?
R3: *Ii ngo'mbe ikahuuta, reu ngo'mbe ya huuta na iria riria ukamaga ritiakirehe thina.*
There would be insufficient pasture which could directly affect milk production.

M: What measures would you take to cope with the consequences caused?
R3: *No wedirie uikare uteri ngo'mbe.*
I would sell the cows.

M: So you told me that you are in both grass harvesting and cattle grazing, suppose KFS
banned grass harvesting in the forest, what do you think are the consequences of such a decision for your household?

R3: *Thiina uria denaguo niguo muingi tondu ingiiaga kuriithia ngombe ciakwa ni ciguukua ni*
ngaragu, wa keeri ariithi aria turihaga matiri giakuria makoraguo matutegemeeire, wa gatatu nie mwene ni dathie hathara, wa gatatu uria kungithie ni ati githaka ginya auni a ngu,.. tareu ithue tungithie kuuna nguri, ariithi nioi tuthiaga gutuguta nigetha tuone ha kuriithi rucio, reu kingihinguo githaka ni gitumanaga, tena ona gutingikorwo kwina nyeki ya kuigana, miccii-ini gwitu haria tukoraguo ni handu hanini, umenye ngombe iria tukoraguo nacio cikoraguo ci nyingi na cikoraguo cikiriithio githaka.
I think it would cause a lot of issues because if I stopped forest grazing my cows would die of hunger. Secondly there are those people who we employ to do grazing they would be Jobless. Thirdly, I would get a big loss. Something else is that back at the home compound we don't have enough grass to feed the cows.

M: So what could you do to cope with the situation?
R3: *Nikuedia tungiedia nigetha tukorwo ringi na kagombe kamwe na gatingiigana.*
I would sell the cows and keep just one cow, which would result to low milk supply.

M: Suppose KFS banned cattle grazing in the forest. What do you think the consequences of such a decision would be?
R4: *Tareu haha dina na go'mbe ithano, reu haaha tatiri handu ingiciriithiria, no nyumiririe bala.*
Such as for my case, I have five cows. I think if forest grazing activities were closed we could graze by the road sides.

M: Do you think that could be enough pasture?
R4: *Ndingituigana ithuothe*
It would not be enough for us all.

M: What measures would you take to cope with the situation other than selling the cows?
R4: *Ni kuedia tondu riri ingigiika atia*
I think it is just selling them because there is nothing else to do.

M: Anything else, maybe such as leasing for more land to grow fodder or anything of that
kind?
R4: *Gukobora mundu atuagire iri ohaha no harituhe,*
It may be a challenge to lease land and may be difficult

M: Suppose KFS banned cattle grazing in the forest, what do you think are the consequences of such decision?
R5: *Income to ikinyiihe muno.*
That could affect my income completely to make it too small.

M: What measures could you take to cope with the consequences caused?
R5: *Reu tungikirutaga kanyamu ku? Tondu reu niwona githaka gituteithagia tondu ri ni kinene,*
no kuume na baara nyoinge muno.

I think it is good when you are taking them to the forest because there will be no conflicts among the members of the community.

M: What kind of conflicts?
R5: *Ii tondu wa kuriithia nginya miguda-ini ya andu*
You see such as at times you will be forced to release the cows deliberately to your neighbour'sproperty.

M: Suppose KFS banned cattle grazing and grass harvesting in the forest, what do you thinkare the consequences of such a decision?
R6: *Mundu to akiedirie ngo'mbe, uteithio witu ni mutitu ini.*
I would reduce the number of cows from three to maybe one because I don't have enough source of pasture.

M: Suppose KFS banned cattle grazing and grass harvesting in the forest, what do you thinkare the consequences of such a decision, because you have told me that you are in bothgrass harvesting and cattle grazing?
R7F: *Gutikikorwo gwi kwega tondu guuku g utii na mahuti ma kuigana reu no tumunyiire kindu*
ta macaani nigetha mundu ahande thaara
The situation would not be favourable, because we would be forced to look for alternatives such asuprooting tea and plant fodder crops.

M: What do you think are the measures that your household would take to cope with the consequences caused other than uprooting tea to grow fodder? What else would you do?
R7: *Gutiri undu ungi ungihota gwika tondu reu nginya migunda ya gukombora gutiri tondu nayo ngo'mbe ya kuhingirwo itekuheo mahutiri, iria nario niriagiire mbeeca.*
I don't think there is anything else that one can do because we also don't have enough land for leasing and you know with zero-grazing, you must source for enough pasture and remember milk is poorly paid.
M: What would you do with the five cows? Would you still do zero-grazing or what would happen?
R7: *Reu mundu no akiedirie uikare uguo tondu reu gutire undu ungi mundu angikorwo agiteithika nacio*
If there is no pasture, the immediate reaction would be selling the cows and keeping off cattle farming.

M: Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such a decision for your household?
R8: *Hari nie dingiona tari uuru nonogukorwo kuri kuuru tondu ni hari andu mari na ngo'mbe*
nyingi na migunda minini, ringi wina ngo'mbe ta ithano, reu ni wona mundu ta ucio ni ona uuru tondu reu ngo'mbe icio dari na gwa gutuara, andu no medirie imwe
I don't think it would be too bad though the condition would not be favourable because we have people who have herds of cows so they would be forced to sell and remain with one cow so that you can be able to maintain it, and therefore there would be low milk production.

M: Okay, thank you.

M: Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such a decision for your household?

R9: *Tareu twi part yao tutungihingiruo twi gikudi, tareu umwe wiitu angikorwo dararihiira ngombe, tuguthie tumuire dagatuare ngo'mbe mutitu na uguo ni kuiiganu tondu ithue niithue ene mutitu, no gutiri hindi ungiuma ona kuuria uuke uingiritie ngo'mbe na dukiri na marua, no dungiuka wi mundu mweru, no nginya wambe uuke uingirio kuo ikundi ini niguo uheo gifaddi*

What I can say is that when you are in a group you cannot be told to keep off the forest because we even pay but there is a formality, you cannot come from anywhere and bring your cows in the forest, you must be a member of a group so that you can be given a license and a membership ID.

M: Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such a decision for your household?

R10: *Wambere no ngorwo na thiina muingi muno tondu diri na mahujti ma kuigana, gwa kuriithia diri, thiga ni kaweru gaka ngombe ingitiida haha thiku igiri weru niwathera, kamuguda ni kanini, wa keri dingihota kuguraga irio cia duka cina goro, urikoraga mundu muico muico ni kuedia edia kagombe gaake tondu duikireka ikorogocokane ituike mahindi matheri.*

First, it could be a serious problem because there is nowhere else to graze, we are not in a position to do zero-grazing because we don't have enough pieces of land to grow fodder crops. Secondly, I cannot afford commercial feeds so I would be forced to sell the cattle because one cannot wait and see it die.

APPENDIX 23: Standard Data Transcription Grid

RESPONDENTS CODED IDENTIFICATION	FOREST BLOCK					
	CHEHE		HOMBE		KAHURURA	
	Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such decision to your household?	What measures would your household take to cope with the consequences caused by the ban on cattle grazing?	Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such decision to your household?	What measures would your household take to cope with the consequences caused by the ban on cattle grazing?	Suppose KFS banned cattle grazing in the forest. What do you think would be the consequences of such decision to your household?	What measures would your household take to cope with the consequences caused by the ban on cattle grazing?
R1						
R2						

APPENDIX 24: Initial Codes

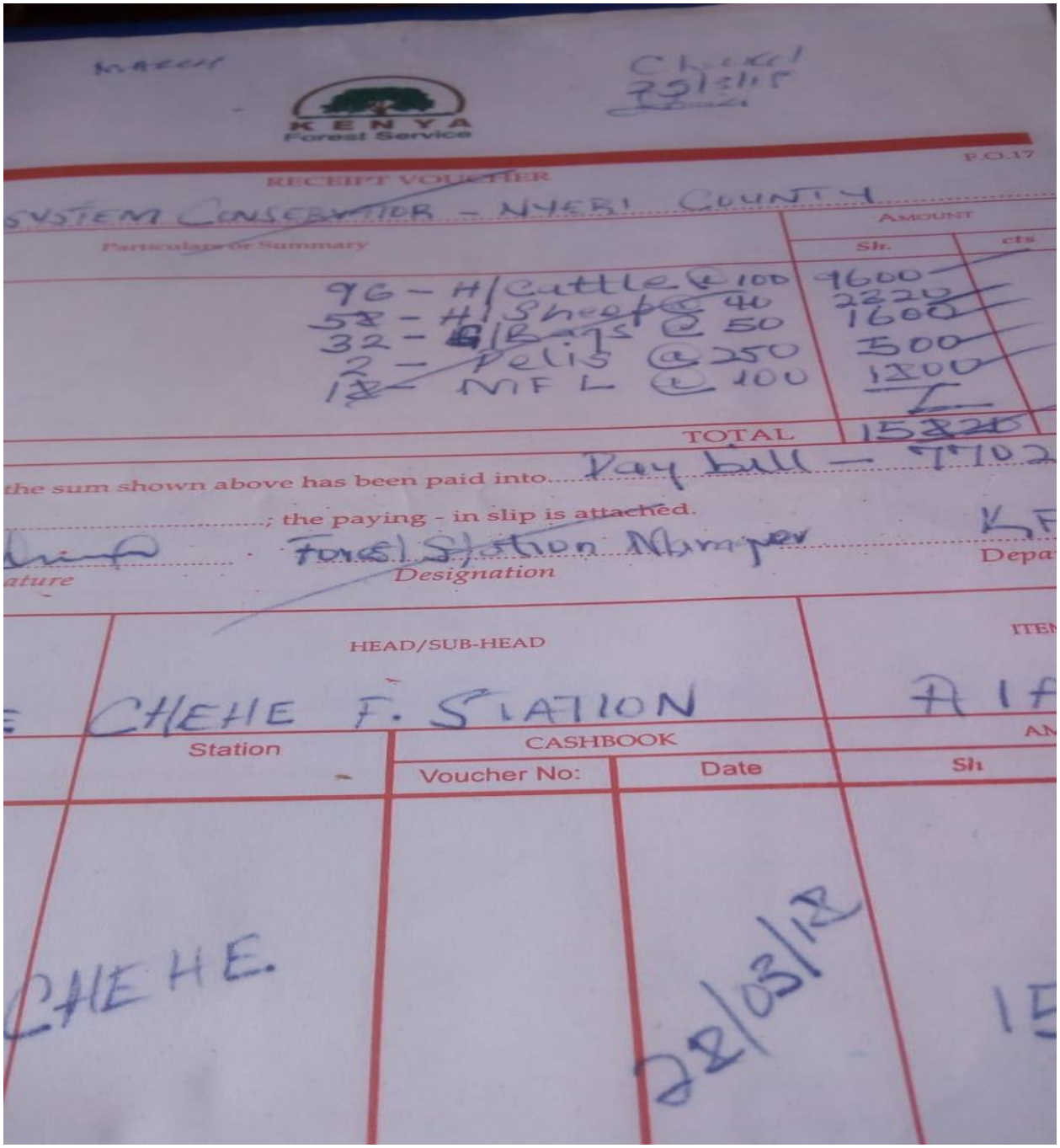
Question 1: First cycle Coding Codes

	Codes	**Tally/Mentions**
1	Reduced pasture	56
2	Reduced milk	55
3	Reduced herd	25
4	Less land for grazing	22
5	No land for grazing	22
6	No land for growing pastures	23
7	Low income	41
8	Loss of jobs/employment	6
9	Buy milk for the family	3
10	No manure	9
11	Forced sale of cows	43
12	Uncertain future	7
13	Unhappy with the decision	2
14	Buy fodder and commercial feeds	3
15	Lack of school fees	14
16	High cost of pasture	19
17	Government to offer alternative solution/land	2
18	Vulnerable to poverty	11
19	Hard time, affected, problematic	78
20	Drought/ dry season	10
21	Hire land for fodder	1
22	Divert cropland for fodder	6
23	Shift to other activities (unspecified)	16
24	Anticipate /aware of possible KFS Move	2
25	Optimistic/survive	4
26	Animals will suffer hunger	16
27	Insecurity	8
28	Graze along the roadside	8
29	Pray for daily bread	1
30	Have forest membership	5
31	Source of conflict	3
32	Buy gas cooker	2
33	Seek employment/other business	4
34	Government not to make such a decision	1
	Totals	**552**

Question 2: First Cycle Coding Codes

	Codes	**Tally/Mentions**
1	Change of business not specified	10
2	Trade	6
3	Buy milk	1
4	Sell all animals	46
5	Reduced herd	49
6	Silage	8
7	Grow crops	3
8	Use compost manure	1
9	Lease more land for fodder	5
10	Zero grazing	21
11	Seek employment	7
12	Buy animal feeds	19
13	Tethering	1
14	Change from cows to goats	3
15	Struggle/unprepared	8
16	Graze on the roadside	5
17	Illegal business e.g. charcoal	2
18	Negotiate with KFS	9
19	Bleak future and poverty	9
20	Demonstrations	1
21	Poultry	3
22	Rely on children	2
23	The ban has no effect	3
24	Convert cropland to fodder	1
25	Served a similar notice in the past/prepared	2
26	To be given a year’s notice	1
	Totals	**248**

APPENDIX 25: Data Collection Sample Sheet: Cattle Payment Receipt



APPENDIX 26: Sample Excel Spread Sheet

		6 Years /Monthly count (numbers) of cattle grazing (Cattle) KAHURURA											
Month / Year		January	February	March	April	May	June	July	August	September	October	November	December
2013	Cows	163	304	236	127	99	131	117	149	149	108	118	117
2014	Cows	95	187	214	135	149	236	261	196	148	120	107	153
2015	Cows	142	121	90	118	230	232	161	181	126	170	137	105
2016	Cows	154	149	166	116	112	136	275	201	175	195	180	124
2017	Cows	204	129	120	45	65	43	66	118	114	166	162	91
2018	Cows	136	116	170	98	128	99	111	107	127	151	166	150

APPENDIX 27: Krejcie and Morgan (1970) Sample Size Determination

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

APPENDIX 28: Table of random numbers

36518 36777 89116 05542 29705 83775 21564 81639 27973 62413 85652 62817 57881
46132 81380 75635 19428 88048 08747 20092 12615 35046 67753 69630 10883 13683
31841 77367 40791 97402 27569 90184 02338 39318 54936 34641 95525 86316 87384
84180 93793 64953 51472 65358 23701 75230 47200 78176 85248 90589 74567 22633
78435 37586 07015 98729 76703 16224 97661 79907 06611 26501 93389 92725 68158
41859 94198 37182 61345 88857 53204 86721 59613 67494 17292 94457 89520 77771
13019 07274 51068 93129 40386 51731 44254 66685 72835 01270 42523 45323 63481
82448 72430 29041 59208 95266 33978 70958 60017 39723 00606 17956 19024 15819
25432 96593 83112 96997 55340 80312 78839 09815 16887 22228 06206 54272 83516
69226 38655 03811 08342 47863 02743 11547 38250 58140 98470 24364 99797 73498
25837 68821 66426 20496 84843 18360 91252 99134 48931 99538 21160 09411 44659
38914 82707 24769 72026 56813 49336 71767 04474 32909 74162 50404 68562 14088
04070 60681 64290 26905 65617 76039 91657 71362 32246 49595 50663 47459 57072
01674 14751 28637 86980 11951 10479 41454 48527 53868 37846 85912 15156 00865
70294 35450 39982 79503 34382 43186 69890 63222 30110 56004 04879 05138 57476
73903 98066 52136 89925 50000 96334 30773 80571 31178 52799 41050 76298 43995
87789 56408 77107 88452 80975 03406 36114 64549 79244 82044 00202 45727 35709
92320 95929 58545 70699 07679 23296 03002 63885 54677 55745 52540 62154 33314
46391 60276 92061 43591 42118 73094 53608 58949 42927 90993 46795 05947 01934
67090 45063 84584 66022 48268 74971 94861 61749 61085 81758 89640 39437 90044
11666 99916 35165 29420 73213 15275 62532 47319 39842 62273 94980 23415 64668
40910 59068 04594 94576 51187 54796 17411 56123 66545 82163 61868 22752 40101
41169 37965 47578 92180 05257 19143 77486 02457 00985 31960 39033 44374 28352
76418

APPENDIX 29: Research Authorization Documents



NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/3482/29378**

Date: **24th April, 2019**

Paul Mwari Maina
St. Pauls University
P.O. Private Bag - 00217
LIMURU.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Socio - economic drivers of grazing and grass harvesting in Kahurura, Hombe and Chehe protected Forests in Mt Kenya, Nyeri County"*** I am pleased to inform you that you have been authorized to undertake research in **Nyeri County** for the period ending **23rd April, 2020.**

You are advised to report to **the County Commissioner and the County Director of Education, Nyeri County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GPKalerwa.
GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nyeri County.

The County Director of Education
Nyeri County.

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

REPUBLIC OF KENYA

MINISTRY OF EDUCATION
STATE DEPARTMENT OF EARLY LEARNING AND BASIC EDUCATION

E-Mail –centralpde@gmail.com
Telephone: Nyeri (061) 2030619
When replying please quote

OFFICE OF THE COUNTY
DIRECTOR OF EDUCATION
P.O. Box 80 - 10100,
NYERI

CDE/NYI/GEN/23/VOL.3/59

16th May, 2019

Paul Mwari Maina
St. Pauls University
P.O. Box Private Bag -00217
LIMURU

RE: RESEARCH AUTHORIZATION

Reference is made to Secretary National Commission for Science, Technology and Innovation letter Ref. NACOSTI/P/19/3482/29378 of 24th April, 2019 on the above subject.

Kindly note that you have been authorized to undertake the research on ***"Socio-economic drivers of grazing and grass harvesting in Kahurura, Hombe and Chehe protected Forests in Mt. Kenya, Nyeri County"*** for a period ending 23rd April, 2019.

NELLY MWANGI.
FOR: COUNTY DIRECTOR OF EDUCATION
NYERI

C.C.
National Commission for Science,
Technology and Innovation
P.O. Box 30623-00100
NAIROBI

THE PRESIDENCY
MINISTRY OF INTERIOR AND CO-ORDINATION OF NATIONAL GOVERNMENT

E-mail: nyericountycommissioner@yahoo.com
Telephone: 061 2030619/20
Fax: 061 2032089
When replying please quote

NYERI COUNTY COMMISSIONER
P.O. BOX 33-10100
NYERI

Ref. No. NYC/ADM 1/57.VOL.VII/35

16th May, 2019

Paul Mwari Maina
St. Pauls University
Private Bag – 00217
LIMURU

RE: RESEARCH AUTHORIZATION

Reference is made to your letter dated 16th May, 2019 on the above subject.

Approval is hereby granted to carry out research on "***Social- economic drivers of grazing and grass harvesting in Kahurura, Hombe and Chehe protected forests in Mt. Kenya***" in Nyeri County.

The period of the study ends 23rd April, 2020.

PAUL MUGO
FOR: COUNTY COMMISSIONER
NYERI COUNTY

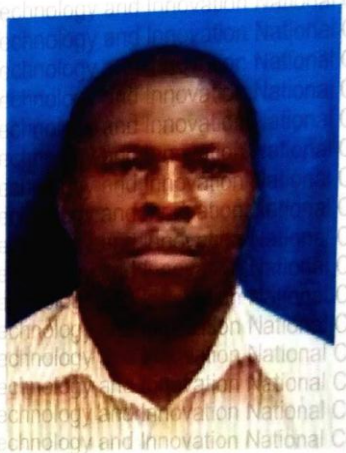
THIS IS TO CERTIFY THAT:
MR. PAUL MWARI MAINA
of ST PAUL UNIVERSITY LIMURU, 0-200
NAIROBI,has been permitted to conduct
research in *Nyeri County*

on the topic: *SOCIO - ECONOMIC DRIVERS OF GRAZING AND GRASS HARVESTING IN KAHURURA, HOMBE AND CHEHE PROTECTED FORESTS IN MT KENYA, NYERI COUNTY.*

for the period ending:
23rd April,2020

.....
Applicant's Signature

Permit No : NACOSTI/P/19/3482/29378
Date Of Issue : 24th April,2019
Fee Recieved :Ksh 2000



.....
Director General
National Commission for Science, Technology & Innovation

Scanned by TapScanner