VALUE OF ECOSYSTEM SERVICES AND SOCIO-ECONOMIC FACTORS THAT ENHANCE COMMUNITY PARTICIPATION IN FOREST MANAGEMENT IN ABERDARE FOREST, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

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

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Recommendation

This work has been presented with our approval as University Supervisors.

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DEDICATION

Dedicated to my late mother Peris Wanjugu Karaya - A *de facto* household head, my husband John Wambugu, my daughters Grace Anne and Faith Anne Wambugu, and my son Daniel Peter Wambugu.

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ABSTRACT

Forest ecosystems have been a valuable source of economic wellbeing of human populations for centuries, particularly to the forest adjacent communities. The relationship between human wellbeing and ecosystems consist of complex systems that are mostly nonlinear, uncertain and often not clearly understood. To enhance forest sustainability, the deliberate evaluation of ecosystem services, human interactions and appropriate ways to involve the public in management is imperative. However, little has been done to demonstrate how forest ecosystem services and public participation could contribute to forest conservation and socio-economic development of forest-dependent communities. This study therefore evaluated forest ecosystem services and socio-economic factors that influence community participation in forest management to enhance forest conservation while improving livelihoods. To achieve this objective, the study interviewed local communities bordering Aberdare forest ecosystem. The study was based on semi-structured questionnaires administered to a stratified random sample of 202 households, six focus group discussions and benefit transfer method. The data was analyzed using Chi square, Spearman's rho correlation and regression analysis. The findings of this study showed that the net annual benefit of ecosystem services was approximately KES 36.8 (US$ 0.37) billion where regulating services constituted 98%. The communities lost KES 172 (US$ 1.7) million annually to wildlife. The net annual return from forest conservation was higher as the opportunity cost of forest land conversion was approximately KES 4.2 (US$ 0.04) billion. The significant factors included forest management approach ($\chi^2 = 17.551$, $p < 0.001$), distance to the Forest Reserve ($\chi^2 = 29.071$, $p < 0.001$), distance to the National Park ($\chi^2 = 27.303$, $p = 0.008$), gender of household head ($\chi^2 = 10.719$, $p = 0.002$), land tenure ($\chi^2 = 34.313$, $p < 0.001$) and sources of income ($\chi^2 = 31.353$, $p < 0.001$). Economic factors that included farm size, household size, annual income, land tenure, and importance of the forest ecosystem were found to significantly influence the regression model with R^2 being 0.703. It can be concluded that if only provisioning ecosystem services are considered, there is a net loss arising from conservation. Therefore, it is imperative to encash all the ecosystem services to decrease forest conversion and depletion based on economic forces. Further, increasing economic benefits to the community will positively influence participatory forest management. This study recommends that to fully engage the community in participatory forest management, there is need to consider their basic livelihood strategies as well promote forest products availability on the farmlands to reduce pressure on the forest ecosystems.

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ABBREVIATIONS AND ACRONYMS

CFA	Community Forest Association
CIFOR	Centre for International Forestry Research
CVM	Contingent Valuation Method
df	Degrees of Freedom
FAO	Food and Agriculture Organization of the United Nations
FMA	Forest Management Approach
FUG	Forest User Group
GDP	Gross Domestic Product
GNP	Gross National Product
GOK	Government of Kenya
Ha	Hectare
HH	Household
IFRI	International Forest Research Institute
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KEFRI	Kenya Forestry Research Institute
KES	Kenya Shillings
KFMP	Kenya Forest Master Plan
KFS	Kenya Forest Service
Km	Kilometre
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
MENR	Ministry of Environment and Natural Resources
n	Sample population

NGOs	Non-Governmental Organizations
NPV	Net Present Value
PES	Payment for Environmental Services
PEV	Participatory Environmental Valuation
PFM	Participatory Forest Management
PELIS	Plantation Establishment for Livelihood Improvement Scheme
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SNA	System of National Accounts
SFM	Sustainable Forest Management
SOVCM	State of the Voluntary Carbon Markets
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
TLU	Tropical Livestock Unit
UNEP	United Nations Environment Programme
WRA	Water Resources Authority
WTA	Willingness to Accept
WTP	Willingness to Pay

CHAPTER ONE

INTRODUCTION

1.1 Background

Natural ecosystems have continued to be a valuable source of economic life for human populations for centuries, where they are particularly important for the socio-economic development of forest dependent communities. These ecosystems include forests, grasslands, wetlands and free-flowing rivers provide direct and indirect benefits that represent an essential component of human wellbeing (Costanza *et al*., 1997a; Fish *et al*., 2011; Gómez-Baggethun *et al*., 2014). The direct benefits are harvested largely from plants and animals in form of food and raw materials, which include fuel wood, fruits, timber, game, fodder, and raw materials for construction, art and craft (MEA, 2005a; Costanza, 2008; Daily *et al*., 2009; Kubiszewski *et al*., 2013).

The indirect benefits usually have an impact on environmental protection and improvement and they include reduction of greenhouse gas emissions (fixation, sequestration, warehousing and absorption), conservation and purification of water for urban, rural or hydroelectric use; biodiversity protection and conservation for scientific and pharmaceutical use, genetic research; improvement and protection of life forms, natural scenic beauty for tourism and scientific ends (Boyd & Banzhaf, 2007; Bhatnagar, 2008; Ruijs *et al*., 2013).

The "value" of ecosystems and their services have been categorized as use and non-use values which are expressed as ecological, socio-cultural and economic values (de Groot *et al*., 2010; Costanza *et al*., 2014a; Gómez-Baggethun *et al*., 2014). The sum of the total use and non-use values related to a resource or an aspect of the environment is termed as Total Economic Value (TEV). Conservation of these resources is critical because of their contribution particularly to the livelihoods of communities living adjacent to the forest by providing them with various ecosystem goods and services (de Groot *et al*., 2010; Biedenweg, 2012; Kubiszewski *et al*., 2013). This is possible through forest management approaches (FMAs) which aim to enhance the capacity of forests to provide the desired goods and services for improvement of the livelihoods of the current and future generations (World Bank, 2005; Kubiszewski *et al*., 2013; Costanza *et al*., 2014b).

Despite the economic potential, the connection between ecosystems and these services is at times neither readily apparent nor easy to measure and translate into market investments (de Groot *et al*., 2010; Kubiszewski *et al*., 2013; María *et al.,* 2015). As a result, these ecosystem services are often not taken into account and landuse and investment decisions have traditionally been based on a very limited view of the economic value of forests (Daily, 1997; MEA, 2003; 2005a; Boyd & Banzhaf, 2007; Kelemen *et al.*, 2016a). This disregard for the multiple uses and users have led to patterns of global forest degradation and losses with many detrimental environmental consequences (Lise, 2000; Pearce, 2001; Burke *et al*., 2015; de Groot *et al*., 2016). This calls for methods of managing forests in a way that preserves ecological integrity and human wellbeing while addressing their diverse demands (Salleh, 1997; Obati, 2007; Mbairamadji, 2009). These trade-offs shift the costs of degradation from one group of people or area to another or defer the costs to future generations.

To make better decisions on the trade-offs involved in land cover and sustainable ecosystem management, a systematic account of the relationships between the complete landscape assessment of the quantity, quality and value of an entire package of ecosystem services generated under different management approaches is essential (Gaveau *et al*., 2009; Nelson *et al*., 2009; Fisher *et al*., 2011a; Newton *et al*., 2016). This has given rise to development of forest management over the past decades based on sustainable forest management (SFM) concept that recognizes the need to balance the ecological, socio-cultural, economic objectives in management (Costanza, 2008; TEEB, 2010; Duncker *et al*., 2012). The choice between different forest management practices is fundamental in the short, medium, and long-term decision making in forestry when setting up measures to support SFM.

In many parts of the world as well as Kenya, the concept of SFM has therefore been adopted to improve forest ecosystem management to deal with various management challenges like excessive degradation (FAO, 2003; KEFRI, 2009; Mbairamadji, 2009). Since its emergence, forest management globally no longer focuses solely on commercial wood production but also on other ecosystem services (CBD, 2001; Bousson, 2003; de Groot *et al*., 2010; Burke *et al*., 2015). Use of different FMAs is considered a dynamic system differing from the traditional approach of forest management in its systemic approach and its integration of ecological, economic and social constraints of forest management (de Groot *et al.*, 2010; Duncker *et al*., 2012). Kenya has different

types of forests, ranging from the dry forests to the high montane forests, with each type necessitating a different management approach and providing a varied set of benefits to diverse stakeholders (Wass, 1995; IUCN, 1996; KFS, 2010). This is the scenario exhibited in Aberdare forest ecosystem where cold, dry and high montane forests under protection and conservation FMAs are exemplified.

Further, in spite of the economic potential of the tangible and intangible forest ecosystem benefits, their value is not captured in the national economic accounting system as well as their contribution to the local economies (Kubiszewski *et al.,* 2013; Costanza *et al*., 2014a; Obst & Vardon, 2014; Burke *et al*., 2015**)**. Forest valuation provides a means of quantifying the benefits that people obtain from forests, the costs associated with their loss, and the relative profitability of land and other resource uses which are compatible with forest conservation vis a vis those activities that contribute to their degradation (Manyido, 2003; UNEP, 2012). Valuation also enables prediction and better understanding of the economic motives, decisions and activities that impact on forest integrity and status (Bastian, 2013; Balvanera, *et al*., 2014; María *et al.,* 2015).

The fact that not all forest goods and services are traded in markets makes them particularly difficult to quantify in monetary terms (Costanza *et al*., 1997a; TEEB, 2010). Economists and decision makers tend to appreciate and measure the value of forests only in terms of raw materials and physical products that they generate for human consumption (Costanza *et al*., 1997a; FAO, 2006; Farley, 2012; Bull *et al*., 2016). This makes the economic benefits generated by forests and the economic costs associated with forest degradation or loss to be overlooked by governments, private industry and resource users.

The perceptions and values of forest resources are influenced by market accessibility since this is an institutional set-up that shapes the relationship between communities and the resource base (World Bank, 2005; Fisher & Turner, 2008; Daily *et al.,* 2009; TEEB, 2010; Kenter, 2017). Communities who have easy access to markets for forest products may view forestry as a major component for supplementing their cash income whereas those communities without access to markets may view forest resources as important sources of subsistence domestic products (Mwangi *et al*., 2011; Biedenweg, 2012; Mogoi *et al*., 2012; Musyoki *et al*., 2013). When attempting to put monetary values on forest goods and services, it is necessary to take into account the full range of

economic benefits associated with forest ecosystems as defined by the TEV (Daily *et al.*, 2009; TEEB, 2010; Gómez-Baggethun *et al.*, 2014; de Groot *et al*., 2016; Kenter, 2017). The concept of TEV is central to valuation as it captures all possible values of a forest ecosystem. The TEV approach goes beyond the traditional practice of valuation that captures only direct uses, by capturing other benefits and costs. All of these categories of benefits have a value as they contribute to economic activity and enhance human welfare (World Bank, 2005; Fisher *et al*., 2011a; Graham *et al*., 2016).

Although forest contribute significantly towards the diversification of livelihoods of communities adjacent to forest ecosystems, inadequate involvement of adjacent communities and other stakeholders in the management and governance of the forest resources, has been identified as a major cause for the escalation of ecosystem destruction (Lise, 2000; KEFRI, 2009; Biedenweg, 2012; Mogoi *et al*., 2012). Governments, funding agencies and civil society are in agreement that development cannot be sustainable unless people's participation is made central to the development process (Kumar & Kumar, 2008). Consequently, community participation in the management of state-owned forests is increasingly becoming a common phenomenon. Many countries in Africa and Asia are promoting the participation of rural communities in the management and utilization of natural forests and woodlands through some form of Participatory Forest Management (PFM) (Wily, 2001; Lund & Treue, 2008; Bush *et al*., 2011; Engida & Mengistu, 2013).

A study of forests and livelihoods in the context of sustainable management requires that we understand the links and interactions between the resource, users, and institutions that mediate between them (Ongugo *et al*., 2008; Fisher *et al*., 2009). In some instances, as Poffenberger (1994) observed, declaration of forest areas as protected lands in India eroded local community rights, and led to extreme conflicts between state agencies and villagers. This disagreement caused unsustainable forest utilization with gradual degradation and depletion of vast pristine forests. In spite of the fact that there is virtual unanimity about the need for people's participation in development, the concept of participation in forest management and conservation and the ways to achieve it has not been clearly defined (Fisher, 2004; Mbairamadji, 2009; Mutune *et al*., 2015).

1.2 Statement of the Problem

Forests ecosystems are multi-functional as they provide a wide range of ecosystem goods and services which form an important component of human economy, particularly contributing to the diversification of livelihoods of adjacent communities. The communities depend on the diversity of goods and services to meet diverse subsistence needs such as water, food, fuel, medicines, cultivation, building materials and livestock grazing. Besides, the environmental services, forests support local community livelihood activities. It is also important to recognize that decisions on the forest sector affect several other sectors such as wildlife, tourism, agriculture, settlements, energy and water.

In spite of the economic potential, the linkages between ecosystems and their services has not received adequate attention in the development discourse. The main problem is attributed to the fact that this value is scarcely understood, under-valued, poorly articulated, and as a result it is rarely taken into account by decision makers both at the policy and local levels. The other underlying factors leading to forest ecosystem loss and degradation in Kenya include population pressure; agricultural expansion; inequalities in land tenure; widespread poverty and lack of public participation. Under-valuation of the TEV of ecosystem services makes their conservation clearly inequitable with other sectors, sending unclear economic signals about their worth to policy and decision makers as well as forest adjacent communities. There is therefore, a dire need to provide baseline information regarding the value of complete bundle of services and involvement of adjacent communities.

The Aberdare forest consists of Aberdare Forest Reserve and Aberdare National Park which are managed by Kenya Forest Service and Kenya Wildlife Service respectively. Both the Park and the Reserve extend and border human inhabited farmlands with a growing population that is exerting great pressure on the ecosystem due to the increased demand for forest goods and services. The ecosystem is a major water catchment as it provides water to four out of the five major drainage basins in Kenya. Besides, the catchment supplies water to major urban areas such as Nairobi, the capital city of Kenya. The Aberdare forest ecosystem, contributes to hydroelectric power generation, agriculture, horticulture and tourism industry that are key economic sectors in Kenya.

The Aberdare Forest Reserve and Aberdare National Park are under different management approaches. The National Park is managed by Kenya Wildlife Service (KWS) under protection

management approach (allows mainly non-extractive use) whilst conservation FMA (allows some sustainable utilization) is applied in the Forest Reserve by Kenya Forest Service (KFS). The management approach in place influences forest products availability, access, control, utilization and conservation, level of community participation, threats and opportunities. The values of ecosystem services and the level of community involvement in participatory management were hypothesized to be at different scales, patterns and intensities depending on FMA.

Nonetheless, little has been done to demonstrate how evaluation of forest ecosystem services and community involvement in management could contribute to forest sustainability and socio-economic development of forest dependent communities. Thus, there is an empirical knowledge gap between human interactions with ecosystems and the causal socio-economic factors that can promote household participation in forest management. This study aimed at bridging the knowledge gap by assessing the value of ecosystems to communities adjacent to Aberdare forest, exploring the socio-economic factors that influence household involvement in PFM. This is because forest ecosystem uses and subsequent degradation are driven by household choices.

1.3 Objectives

1.3.1 Broad objective

To value the forest ecosystem services and assess the socio-economic factors that influence forest adjacent community's participation in forest management to enhance forest conservation while improving livelihoods.

1.3.2 Specific objectives

Specifically the study sought to:

i. Estimate the value of ecosystem services (provisioning, regulating, cultural and supporting) to communities adjacent to Aberdare forest ecosystem.
ii. Evaluate the effect of forest management approaches on the values local communities attach to Aberdare forest ecosystem and their involvement in PFM.
iii. Assess the socio-economic factors that influence community involvement in participatory forest management to enhance conservation and improve livelihoods

1.4 Research questions

i. What is the value of ecosystem services to communities adjacent to Aberdare forest ecosystem?
ii. What is the effect of forest management approaches on the values adjacent communities attach to forest ecosystems and their involvement in participatory forest management?
iii. What are the socio-economic factors that influence involvement of forest adjacent communities in participatory forest management?

1.5 Significance of the Study

Forests are among Kenya's most important natural resources and their sustainable management is an integral part of national development as they contribute significantly towards the diversification of livelihoods of local communities. Nevertheless, much attention is given to forest goods while the services derived from the forests are largely ignored. The major reason attributed to this is under-valuation or lack of valuation of forest ecosystem services, particularly those outside the formal market system (Langat & Cheboiwo, 2010; Kipkoech *et al*., 2011). Valuation provides a potentially powerful tool to justify investments and actions in support of forest ecosystem conservation goals. It provides a means of articulating the potential gains from undertaking such measures and the economic costs of failing to take action (Mbairamadji, 2009; Ruijs *et al*., 2013).

Disaggregated data and information on extractive and non-extractive uses from the Aberdare Forest Ecosystem, obtained in this study, is crucial for improving local communities' and resource managers understanding on the importance of forest ecosystems. By valuing the full range of benefits from ecosystems, the managers may not overlook non-marketed services by pursuing market-based ecosystem goods (Kumar *et al.*, 2010; Burke *et al.*, 2015; Bull *et al.*, 2016). On the part of communities, this would enhance their interest in PFM.

In order for PFM to succeed, it requires the inclusivity of all the relevant stakeholders especially the local communities (Plummer & Armitage, 2007; Musyoki *et al*., 2013). The study aimed to get information on how to achieve community involvement in PFM and conservation in the areas under Conservation and Protection FMAs. This is pursuant to the Constitution of Kenya, 2010

Article 69 (d) which "encourages public participation in the management, protection and conservation of the environment." This study is therefore contributes to ways which local communities can be involved in PFM and conservation in the areas under conservation and protection FMAs.

It was also important because many rural communities, especially in Kenya, generally are highly differentiated and stratified in terms of for example geographical location, gender, income and socio-economic status. Men and women have different approaches to environmental management, but their approaches are not necessarily contradictory (Kabutha & Humbly,1996; Wambugu, 1999; Reeves & Baden, 2000; Mwangi *et al*., 2011; Banana *et al*., 2012; Kelemen *et al*., 2016b). A gender-equitable perspective does not limit men's participation; it allows more balanced work between men and women, which leads to improved conservation outcomes (IUCN, 1996, Kumar *et al*., 2010; Mwangi *et al*., 2011). In such circumstances, the question of differential participation was especially important because the benefits associated with PFM policies are seen to improve with greater participation. This informs managers on involvement of different members of the community and forms a basis for appropriate community interventions that enhance forest conservation and subsequently improve livelihoods.

Aberdare forest ecosystem is in the middle of a densely populated region and the stream of economic benefits it provides to the local communities cannot be overstated. The current study discusses these values, detailing community interaction with the forest ecosystem. It is envisioned that an understanding of these economic benefits and community interaction with the forest ecosystem will promote their involvement in forest conservation and management as well as advance implementation of the current natural resources legislation in Kenya as stipulated in the Constitution of Kenya, 2010; Environmental Management and Coordination (Amendment) Act, 2015; Forest Conservation and Management Act, 2016; Wildlife Conservation and Management Act, 2013; and Water Act, 2016. This study, thus, contributes to the current literature and legislation on contribution on community involvement in environmental management based on the on influence of socio-economic factors derived from household level.

1.6 Scope and Limitations of the Study

Forest ecosystems provide a wide range of tangible and intangible goods and services to forest adjacent community. The study was based on 202 households and six conservation groups from two sample populations adjacent to Aberdare Forest Reserve and Aberdare National Park. Market price analysis was used to provide values for provisioning services that had locally traded products. Contingent Valuation Method (CVM) (Mitchel & Carson, 1989) and Participatory environmental valuation was applied to obtain other values, particularly regulating and cultural services (Whittington, 2002; Kenter, 2017). Willingness to Pay (WTP) was used in this study as Willingness to Accept (WTA) could raise respondents' expectations of monetary benefits. The study further employed benefit transfer method (BTM) (TEEB, 2010; Fish *et al*., 2011; Fisher *et al*., 2011a; Gómez-Baggethun *et al*., 2014) to obtain economic values for both regulating and cultural services regarded as important by the community. Logistic regression analysis and non-parametric tests Chi-square and Spearman rho correlation tests were used to explain associations and relationships between socio-economic factors as well as management approaches in terms of their economic use, household characteristics, variation in forest utilization and values.

The influence of FMA on overall community forest resource values as well as PFM involvement level was analyzed. Community interaction with the forest ecosystem and their level of involvement in PFM were solicited. The linkages between household socio-economic factors and their association, relationship and influence on household involvement PFM and conservation was described. Non-parametric tests (Spearman's rho correlation and Chi-square) were used to test the relationships and associations between the socio-economic factors and household level of involvement in PFM. The influence of the attributes was expressed through a regression model. The study analyzed various socio-economic factors to find out those that significantly influenced PFM so that they could be used to promote community involvement in management of forest ecosystems to improve conservation as well as improve their livelihoods.

The survey applied cross-sectional data with the results reflecting annual values of forest goods and services. The limitations of the study emanated from the fact that the survey applied the recall approach to capture data over a period of one year taking into account the seasonal variations and

respondents could fail to recollect everything. However, given that the survey was detailed, it was assumed the survey provided representative responses for the area.

The importance of this study was the contribution to developing an in depth understanding, in financial and economic terms, of the value of the benefits derived from protected areas at the household level. This is an important entry point as it attempts to focus attention on individual farmers or households as the principal agents of change in forest conversion. This analysis yielded an important insight into the position that national governments should take when developing national polices on protected area management. As observed by Fisher *et al*. (2008) and de Groot *et al*. (2010), the challenge in designing economically optimal FMAs is to estimate the loss of benefits (expected welfare loss or compensating deviation) to households from achieving a certain level of forest conservation.

1.7 Definition of Terms

Aesthetic – the beauty aspects of things, measured through visuals, emotions or pleasing combination of features, visual contrasts or dramatic elements like wildlife and scenic landscapes.

Amenity - the physical aspects of place that encourage people to experience and enjoy their surroundings.

Cultural services - services providing non-material benefits from ecosystems such as spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences.

Decentralization - downward redistribution of resources, responsibilities, and decision -making powers in a territorial and administrative hierarchy.

Deliberative monetary valuation - an analytic-participatory technique that employs a discussion process to express values for environmental change in monetary terms.

Ecosystem – The entire system of life, its environment and geographical factors that influence all life including the plants, the animals and environmental factors.

Ecosystem functions - intermediate between ecosystem processes and services and can be defined as the capacity of ecosystems to provide goods and services that satisfy human needs, directly and indirectly.

Ecosystem services - those aspects of ecosystems that are utilized, actively or passively, to produce benefits to human well-being.

Existence values - These are non-use values also known as preservation values which are placed by people who do not use the forest but value the fact that it exists as well as the value of being able to pass on the forest as an inheritance to future generations.

Market –a place where goods are bought and sold. As opposed to simple selling, it refers to any established means or exchange of goods and services between buyers and sellers, which has some regularity and regulation involving some competition.

Participation – a way of engaging stakeholders in decision making based on the exchange, interaction and reciprocity of information and ideas.

Participatory or deliberative techniques – the practical tools for involving stakeholders in a decision making process either through the solicitation of views or collaboration.

Provisioning services - the products extracted from ecosystems such as food, fibre and medicines.

Regulating services - the benefits derived from the way ecosystem processes are regulated such as water purification, air quality maintenance and climate regulation.

Supporting services – the ecosystem services necessary for the production of all other ecosystem services from which society benefits, such as soil formation and nutrient cycling.

Sustainable forest management - dynamic and evolving concept that aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations.

Total Economic Value – This is the sum of discounted net benefit streams stemming from extracted forest products, environmental services and non-use values.

Valuation - the process of expressing a value for a particular good or service in a certain context such as decision making, usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines such as sociology and ecology.

Voluntary carbon markets - all purchases of carbon offsets not driven by an existing regulatory compliance obligation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Forest Ecosystems and Ecosystem Services

A forest ecosystem is a dynamic complex of plant, animal and micro-organism communities and the non-living environment interacting as a functional unit (van Wilgen *et al.,* 1996). Forest ecosystems provide many direct and indirect benefits, which contribute to individual and societal wellbeing. Some of the well-known ecosystem services include food, fibre, fresh water, genetic resources and wood for fuel provision and construction. Others provide cultural services that benefit people through recreation and cultural appreciation of nature. Other services provided by ecosystems are not so well known. These include the regulation of the climate, purification of air and water, flood protection, soil formation and nutrient cycling (MEA, 2003, 2005c; Costanza, 2008; de Groot *et al.*, 2010).

The conceptual framework for the MEA (2005a) postulates that humans are integral parts of ecosystems and there is a dynamic interaction between them and other parts of the ecosystems. Consequently, the changing human condition causes, both directly and indirectly, changes in ecosystems and human well-being. Ecosystems can be terrestrial or marine, inland or coastal, rural or urban whereby humans are an integral part of them. Ecosystems can also vary in scale from the global to the local (van Wilgen *et al.,* 1996; MEA, 2005b; Burke *et al*., 2015).

In spite of the perceived ecological, environmental and socio-economic benefits of regulating services, there are many shortcomings in the management, utilization, conservation and protection of ecosystems that produce these services. The main reason associated with this being the inaccurate estimation of their true economic values (van Wilgen *et al.,* 1996; TEEB, 2010; Fish *et al*., 2011; Langat *et al.,* 2016). Further, many ecosystem services are not sold and bought in markets, so people do not pay for these services directly. Nevertheless, this does not mean that these services do not have value, just because they are not traded in the market. Traditionally, economists have found the non-market forest benefits and services considerably difficult to express in monetary terms (Fisher *et al*., 2008; Christie *et al*., 2012; Farley, 2012; Orchard-Webb *et al*., 2016). As a result, they have largely been omitted from decision-making. Calculations of

the contribution of forest goods and services to household-level production, sectoral output or national economic indicators have largely been based primarily on wood production (Fisher *et al*., 2009; Gundimeda & Sukdev, 2008; Bunse *et al*., 2015).

Therefore unsurprisingly, economic policy instruments and analysis of forest management options have had a clear tendency to favour commercial extraction, clearance for agriculture or modification for other seemingly lucrative options. Available information showed limited economic benefits to be gained from forest conservation or sustainable management, and little economic costs related to forest degradation and loss (Costanza *et al*., 1997b; de Groot, 2006; Farley, 2012). Nevertheless, with expansion of economic valuation techniques and change of human needs and demands from forest ecosystems, there has been an increasing acknowledgment of the importance of such values to commercial profits and trade, to national-level economic welfare, and to household production and consumption (Adhikari *et al*., 2004; Musyoki *et al*., 2013; Langat *et al*., 2016.

Cultural services are essential to generally understand how people benefit from goods and services from the natural environment (de Groot *et al.*, 2010; María *et al.*, 2015). They comprise cultural diversity, recreation, education art, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values and social relations (MEA, 2003; Bull *et al.*, 2016; Cooper *et al.*, 2016). Kenter *et al*. (2011) expanded this concept to include practices, legends, myths, knowledge, religious practices and skills that do not always imply a material representation and are summarized as intangible heritage. The MEA (2005a) and Kumar *et al*. (2010) defined cultural services in terms of the nonmaterial benefits people derive from ecosystems.

As stated by Gobster *et al*. (2007), most of these cultural services are directly experienced and intuitively appreciated unlike regulatory and provisioning services making them more complex to describe. Further, the Ecosystem framework, according to MEA (2003) and Daniel *et al*. (2012) attribute these differences in perception to the fact that ecological resources that contribute to cultural heritage are frequently common goods that are pooled rather than owned. This is further compounded by the fact that ecosystem services are inter-linked in nature (Everard *et al.*, 2016; Fish *et al.*, 2016; Kenter, 2017). Although, cultural ecosystem services are being consistently recognized, they have not yet been amply integrated within the ecosystem framework (de Groot *et al.*, 2002; DEFRA, 2007; Milcu *et al*., 2013; Kretsch & Kelemen, 2016).

There has been no particular, agreed method of categorizing all ecosystem services. However, the Millennium Ecosystem Assessment (MEA) Framework has been widely accepted and applied as the basis of evaluation ecosystem services (MEA, 2003). The MEA identifies four broad categories of ecosystem services which are provisioning, regulating, cultural and supporting as explained as shown in Table 2.1. Ecosystem services provide outputs or outcomes that directly and indirectly affect human wellbeing and these considerations relate well with the economic approach (MEA, 2005c).

Table 2.1: Categories of Ecosystem Services

Ecosystem Services		Examples of ecosystem services
	Provisioning	Food: crops, fruit, nuts, fish •Fibre and fuel - wood, wool •Biochemicals, natural medicines and pharmaceuticals •Genetic resources: genetic information for animal/plant breeding and biotechnology •Ornamental resources: shells, flowers •Water – domestic and irrigation
Supporting Services •soil formation and retention, •nutrient cycling, •water cycling, •production of atmospheric oxygen •provision of habitats	Regulating	Air-quality maintenance: •Climate regulation: moderation of local temperature and precipitation •Water regulation: timing and magnitude of runoff and flooding •Erosion control: soil retention/prevention of erosion •Water purification/detoxification: filter out/decompose organic waste •Natural hazard protection: storms, floods, landslides •Bioremediation of waste i.e. removal of pollutants through storage, dilution, transformation and burial.
	Cultural	•Spiritual and religious value •Inspiration: art, folklore and architecture •Social relations: establishment of hunting, pastoral and fishing societies •Aesthetic values: landscapes, natural features •Cultural heritage values: important landscapes or species •Recreation and ecotourism

Adapted from MEA (2005c) and Fish *et al*. (2011)

2.2 Conservation and Management of Forest Ecosystems

Forest management could be viewed as applied forest ecology where trees and other vegetation in a forest are managed in ways that reflect and exploit the ecological capabilities and tolerances of

diverse species and ecosystems (CIFOR, 1997; Knight *et al.*, 2006; Bush *et al*., 2011). The forest sites are managed to utilize and sustain their productive capacity and in ways that recognize the ecological association between survival and growth of different trees and site characteristics with an intent to attain sustainable forest management (Pearce, 2001; Sidle *et al.*, 2006).

Globally, the increasing pressures on tropical forests in the last decades led to the loss of 6.1 million hectares of forest from 1981 to 1990 (Singh, 1994) and more than 5.8 million hectares from 1990 to 1997 (Achard *et al*., 2002). The challenges brought by tropical deforestation, particularly regarding integration of forest-based economic development and biodiversity conservation, necessitated a review of the effectiveness of FMAs and policies (Ghai, 1994; Salleh, 1997; Harrington *et al.*, 2010). The concept of sustainable forest management (SFM) was therefore developed to contend with these challenges. Since its advent, forest management no longer focuses merely on commercial wood production but also on many other forest resources (Bousson, 2003; FAO, 2006). Thus, it differs from the traditional approach of forest management through its flexibility to integrate ecological, economic and social constraints of forest management (Gaveau *et al*., 2009; Duncker *et al.*, 2012; Fisher *et al*., 2011a).

Therefore, development in forest management over the past decades have focused on SFM as an approach based on the need to balance the ecological, socio-cultural, economic objectives in management as outlined by the Global Forest Principles (UNCED, 1992; Bousson, 2003; FAO, 2003; Gaveau *et al*., 2009; Fisher *et al*., 2011a; Duncker *et al.*, 2012; Newton *et al*., 2016). Similar efforts within the framework of environment conservation based on the Convention on Biological Diversity (CBD) led to the development of Ecosystem Approach as a framework and holistic approach to conservation and sustainable utilization of biological diversity and all its components in all types of forest ecosystems (UNCED, 1992; CBD, 2001; FAO, 2003; Nelson *et al.*, 2009; Ruijis *et al*., 2013).

2.2.1 Causes of forest degradation and depletion

Environmental and natural resource degradation is largely attributed to market and policy failures (Hauck *et al*., 2013; Jordan & Russel, 2014). Sectoral economic policies tend to emphasize activities that lead to unsustainable exploitation, clearance and degradation of forest areas (Nasi, *et al.*, 2002; Manyindo, 2003; Fisher *et al*., 2008). Many sectoral economic activities benefit from

use or degrade forest goods at low or zero costs (Beentje, 1990; IUCN, 1996; Fisher *et al*., 2011a). Research findings indicate that the underlying factors leading to tropical deforestation include agricultural expansion; population pressure; inequalities in land tenure; widespread poverty leading to over-reliance on forest resources; under investment in the forestry sector; and lack of integrated forestry, agriculture, energy and health sectors (Bussmann, 1994; Chakraborty, 1995; Carr *et al*., 2006; Dinerstein *et al*., 2014). FAO (1989) noted that the unprecedented rate of forest degradation and depletion in Africa is a critical environmental problem making conservation and sustainable management of forests an urgent priority.

According to Chakraborty (1995), there are two diametrically contrasting viewpoints to the cause of deforestation. One viewpoint states that the increased demand for fuelwood, timber, land for agricultural expansion and settlement leads to forest depletion. This uses the growth in population and livestock in combination with forest dependence and poverty as the root causes. The other viewpoint is the widely held perception that the chief cause of deforestation is embedded in the failure of the forest bureaucracy to secure people's participation in many countries (Lise, 2000; Agrawal & Gupta, 2005; Hage *et al.,* 2010). The forest bureaucracy has been largely characterized by centralized efforts, preset outcomes, and preoccupied with revenue collection. However, many studies have shown that in developing countries it is not possible to close the forest from the community because many people depend on the forest for basic needs like fuelwood, timber, fodder and medicines (Agrawal & Chhatre, 2006; Mogoi *et al*., 2012; Mutune *et al*., 2015; Langat *et al*, 2016). Unless poverty and people's dependence on the forest is reduced, by giving them alternatives, the only path to sustainable forest management is by seeking people's participation (Reed, 2008; Mbuvi *et al*., 2009; Musyoki *et al*., 2013; Ongugo *et al*., 2014).

2.2.2 Causes of forest degradation and depletion in Kenya

Forests in Kenya have experienced unprecedented degradation and destruction in the last few decades (KFMP, 1994; Wass, 1995, Matiru, 2005). This has been due to a complexity of factors whereby authorized and unauthorized forest clearing are the principal sources of forest loss. These losses include a total of 44,502.77 ha that were officially degazetted and cleared between 1995 and 1999 (Matiru, 2005). Natural forests shrank at an average annual rate of 2 per cent between 1972 and 1980 (Doute *et al.,* 1981), and later at an average of 3700–5000 ha per year (Wass, 1995).

In Kenya, despite various government efforts at the local and national levels, natural resource degradation and depletion has continued unabated (MENR, 2003; Matiru, 2005; Ongugo *et al*., 2008; Himberg *et al*., 2009). It was estimated in the 1980s and 1990s, Kenya was losing close to 6,000 ha of forests annually (KFMP, 1994; IUCN, 1996). Kenya Forest Master Plan (1994) pointed out that due to rising population, increase in demand for agricultural land; extractive uses of forest products was expected to continue not only in the short term but also in the medium and long term. These factors are associated with forest loss as the population pressure and demand for land have no corresponding technological developments and innovations in exploitation of forest resources. This is coupled with widespread poverty which increases dependence on natural resources as main source of food and energy.

Other challenges such as inadequate incentives that can make conservation profitable to communities and institutional set-ups that do not consider local values of forest resources in the planning and decision making processes exacerbate the problem (Mogaka, 2000; Agrawal & Chhatre, 2006; Mwangi *et al*., 2011). In addition, the rising population, increasing land scarcity, declining agricultural yields has caused tightening economic constraints that have resulted in the prevalent poverty (Cavendish, 1999; Ongugo *et al*., 2008; Mbuvi *et al.*, 2009). This has resulted in substantial increase of pressure on remaining stocks of forest (Wass, 1995; Kamugisha *et al*, 1997; FAO; 2006; Bush *et al*., 2011). The World Bank (2004a) observed that a large share of people suffering from extreme poverty live on fragile lands which include arid zones, slopes, poor soils and forest ecosystems. Therefore, with the growing population, the expansion of human settlement and agricultural activities has been achieved at the expense of the natural resources and degradation of fragile ecosystems.

2.3. Conservation and Management of Forest Ecosystems in Kenya

Kenya has a total of about 1.64 million ha of gazetted forest areas and about 100,000 ha of trust lands (Wass 2000). The country's closed canopy forests are concentrated in the moist central highlands where the human population and agricultural production are also concentrated (IUCN, 1996; Wass 2000; Burgess *et al.*, 2007). In the semi-arid region, there are closed canopy forests on isolated hills and along riverine. The history of forest management in Kenya dates back to 1895 when the country was declared a British Protectorate.

The management has passed through a series of stages – pre-colonial, colonial and post-colonial, and is now in a devolved system (Mugo *et al.,* 2010). Each stage was dependent on the social, economic and political realities of the time. The objectives of forest demarcation in the colonial period were to protect forests from destructive indigenous land use practices, to prevent European settlers from obtaining private ownership, and to generate revenue for the forest department through the sale of timber and minor forest products. Post-colonial objectives were catchment protection, industrial forestry development, and protection from encroachment by local communities (Mugo *et al.,* 2010; Kabugi, 2014). The current forest related legislative initiatives support PFM strategies based on benefit sharing with the forest adjacent communities (EMCA, 2015; Wildlife Conservation and Management Act, 2013; Forest Conservation and Management Act, 2016).

2.3.1 Pre-colonial and colonial management of forests in Kenya

Before the introduction of the protected area system of conservation, local and traditional institutions regulated and controlled forest resource ownership, access and exploitation (Doute *et al*., 1981; IUCN, 1996; Kamugisha *et al.*, 1997). Historically forests in Kenya have been managed under command and control through a system of legal provisions that have evolved over the years into Forests Act, 2005 and its recent successor, the Forest Conservation and Management Act, 2016 (Forest Act, 2016). According to Mugo *et al*. (2010), the command and control management system was in line with Forest Guard's recruitment Ordinances of 1915 and 1916. Since the mid-1890s the settlers had been clamouring for land in the mile zone, and their wishes were given priority. The first forestry legislation in Kenya is the Ukamba Woods and Forest Regulation of 1887. This was followed by East African Forestry Regulations in 1902. The 1902 regulations were followed by Forest Ordinances of 1911, 1915, 1916 and 1941 which expanded the provisions of the earlier law but all of them alienated the local community.

According to Kabugi (2014), forests alienated by the government through Forest Department either provided a home for forest-dwelling people (for instance the Dorobo), or had been utilized by non-forest dwellers for fuel, water, grazing, honey, salt-licks, refuge or territory for expansion and protection. The Forest Department claimed land without considering the rights of local inhabitants and imposed strict regulations on the use of forest products by forest-adjacent communities. Native rights to the forests were not recognized; instead they were deemed as either illegal squatters or

tenants-at-will of the Crown. The displaced indigenous people were restricted to native reserves, under the Native Lands Trust Ordinance of 1930 (Doute *et al*., 1981; IUCN, 1996; Emerton, 2001).

Under this Ordinance, forests within native reserves were declared as native forest reserves. An important consequence of confining indigenous populations to native reserves, restricting access to large forest blocks and charging for fuel, was the depletion and over-exploitation of forests within native reserves (Mugo *et al*., 2010; Ogada, 2012). Forest department attempts at instituting afforestation programmes in native reserves was met with hostile resistance since they were managed by local native councils. Later, however, the Chief Conservator of Forests gazetted forests within native reserves, effectively foreclosing the last opportunity for access to forest products by the indigenous population (Ongugo *et al*., 2002. Subsequently, the department made deliberate attempts to consolidate and concentrate control of forest resources by restricting entry, defining offenses, imposing fines and penalties for offences (Mugo *et al*., 2010; Kabugi, 2014).

2.3.2 Post-colonial Management of Forests in Kenya

The current status of forest resources in Kenya is a product of the transformations that characterized the forestry sector in the early parts of the 20th century. Kenya's first official forest policy was formulated in 1957, through White Pater No. 85 (IUCN, 1996; Mugo *et al*., 2010). This was subsequently restated by the Government of Kenya as Sessional Paper No. 1 of 1968 which remains the only official document to date. It set forth the basic principles under which forests were to be managed for the greatest common good. The 1968 Forest Policy aimed to reserve forest areas for catchment protection; to provide timber and other forest products; to protect forests from fire and grazing and eliminate private rights in gazetted forests; to promote sustained management; to develop industrial forestry; to provide funds for policy implementation; to provide employment, in particular under the *shamba system* for reforestation and forest maintenance; to designate county council forests; establishment of private forests for protection and production, recreation, conservation, research and education (Ongugo *et al*., 2002). The protected areas that were created refer to the current national parks, game reserves and forest reserves. In these areas, formal conservation interventions alienated forest-adjacent communities and disregarded the need to involve them in management. Under this Policy, communities were involved in forestry matters as forest workers on a works-paid basis or as cultivators who were instrumental in the

establishment of industrial plantations under the *shamba* system currently referred to as Plantation Establishment through Improved Livelihood System (PELIS) (Ongugo *et al*., 2008; KFS, 2010).

2.4 Forest Management Approaches (FMAs)

In each forest type, a range of silvicultural operations that range from intensive systems based on clear felling and artificial regeneration to the fostering of irregular stand structures based on natural regeneration can be applied. The choice between different forest management practices is an essential step in the short, medium, and long-term decision making in the forestry sector and when setting up measures to support SFM (Mbairamadji, 2009; Ruijis *et al*., 2013). However, assessing the overall sustainability of different types of forestry practices is complicated owing to variation in the nature of the forest resource as well as in the impacts of different management measures in space and over time (FAO, 2003; TEEB, 2010). All logical sets of silvicultural operations applied to a given forest forms a silvicultural system that is defined as "the process by which the crops constituting a forest are tended, removed, and replaced by new crops, resulting in the production of stands of distinctive form" (Matthews, 1989).

Various studies have classified silvicultural systems along two main axes. One, economic axis, where systems are categorized according to production factor utilization and economic return (Arano & Munn, 2006). Two, ecological axis, where the categories depend on the degree of modification of natural conditions (Shyamsundar & Kramer, 1996; Gamborg & Larsen, 2003; Silvano *et al*., 2005). Most classifications of this type have tended to adopt a three category system, which contrasts non-intervention reserves with intensively managed plantations and with a more extensive form of management that may seek to emulate natural disturbances or to practice close-to-nature forestry (Gamborg & Larsen 2003; Montigny & MacLean, 2006).

In a study undertaken by Duncker *et al*. (2012), a different framework for classifying silvicultural systems and practices in relation to management intensity was proposed. This framework was designed to be applied with criteria and indicators reflecting the full range of economic, ecological, and social components of sustainability. They argued that regardless of the particular objects of forest management, the actions taken (including no action) have consequences on forest ecosystem status and processes. Such actions influence the goods and services acquired from forests. Thus,

the provision of ecosystem goods and services can be both a consequence as well as a driver of forest management (Gaveau *et al*., 2009; Nelson *et al*., 2009; Fisher *et al*., 2011b).

As such, the Duncker *et al*. (2012) framework can be applied as the foundation of all analysis needed to explore the effect of changing policies and silvicultural operations using leading criteria and indicators of sustainability giving consideration to provision of ecosystem services. Based on the framework, a set of FMAs were developed, based on the silvicultural operations practiced and the intensity of human intervention in the processes of natural forest development. This framework included the detail of technological, economic, and ecological situations, whilst still being guided by existing policies at various levels. The FMAs are characterized by a coherent set of objectives and supporting practices, which resulted in a framework that enabled transnational, cross-regional, and within-region comparisons of different silvicultural systems. Furthermore, within any given FMA, a particular criteria of sustainability such as aspects of biodiversity, public preference for forest landscapes could change with different stages of tree growth.

Globally as well as in Kenya, the concept of sustainable forest management (SFM) is therefore being developed to improve forest ecosystem management and tackle various management challenges like excessive degradation. Using these attributes, Duncker *et al*. (2012) proposed and described five FMAs which were arranged along a gradient of intensity of resource manipulation (from "passive" to "intensive"). Therefore, it is assumed that the degree of naturalness of forest ecosystems reveals the intensity of human manipulation. Different levels of intensity can be characterized not only by changing stand structures but also by different species communities and, as a consequence, they influence the biodiversity and ecosystem services available for social wellbeing in an area (Berlyn & Ashton, 1996; María *et al.*, 2015). Table 2.2 shows the basic principles and how they relate to the five proposed FMAs.

The concept of SFM in line with the Forest Principles and Ecosystem Approach concepts has continued to evolve since 1992, stimulating changes in forest policy, legislation and management practices throughout the World (CBD, 2001). Public participation in forest management has increased in many countries and broader approaches in forest management are becoming more widely accepted and applied (Agrawal & Gibson, 1999; Kumar, 2002; Reed, 2008; Hage *et al*., 2010).

Table 2.2: Types of Forest Management Approaches

FMA	Naturalness species composition	Tree of improvement	Type of regeneration	Integration of nature protection	Tree removal No	Final harvest	Maturity
Passive - unmanaged forest nature reserve	Natural vegetation	None	Natural regeneration /succession	High	None	None	No interventi on
Low - close-to-nature forestry	Native or site-adapted	No genetical modification or tree breeding	Natural regeneration or planting	High	Stem	Single stem or group selection. Irregular shelter wood	Long rotation (MAI)
Medium - combined objective forestry	Tree species suitable for the site	Planting material from tree breeding but not genetically modified	Natural regeneration, planting and seeding	High	Stem and crown	All possible, Seed tree, strip or group shelter wood	Long rotation (MAI)
High - intensive even-aged forestry	Tree species suitable for the site	Tree breeding allowed no genetical modification	Natural regeneration, planting and seeding	Medium	Whole tree	All possible, clearcut, long rotation preferable	Short rotation (financial rotation)
Intensive - Short rotation forestry	Any species	Tree breeding and genetical modification used	Planting, seeding and coppice	Low	Whole tree and residuals	All possible (coppice, clearcut)	Short rotation (financial rotation)

Adapted from de Groot *et al.* (2010) and Duncker *et al.* (2012)

The neo-populist approaches to forest management, exemplified by the involvement of communities in forest management and feminist paradigm, has also contributed to some changes in the way classical foresters viewed good forest management practices (Ongugo *et al.*, 2002; Webbler *et al*., 2001; Agrawal & Gupta, 2005; Salam *et al*., 2005; Mbuvi *et al.*, 2009).

2.4.1 Forest management approaches in Kenya

Forest management in Kenya has been driven by utilitarian and preservationist philosophies. The preservationist approach is the exclusion of protected areas from extractive activities (KFMP, 1994; Ongugo *et al*., 2014). This falls under the passive "Unmanaged forest nature reserve"

category of FMA which largely applies to the National Park area within the Aberdare forest ecosystem. The Forest Reserve is managed under a conservation system that cuts across most of the FMAs where natural high forests fall under passive management, woodlands are between low to moderate whilst the objects of forest plantations are implemented under intensive-short rotation forestry. The approach to resource protection either through preservation or protection has constrained local communities' access, utilization and control of the very basic resource that supports their livelihoods. However, with the emerging FMA approaches that are supported by new legislation, forest management can be guided by the philosophy that behind true conservation lies in allowing sustainable direct (extractive and non-extractive) and indirect activities within designated ecosystems (UNCED, 1992; KFMP, 1994; Ongugo *et al*., 2014).

Based on that philosophy, an attempt to implement it in the area under Forest Reserve need to be made where natural forests could be managed under the Medium "combined objective forestry" whereas the plantation areas could be managed under the High "intensive even-aged forestry" tending to Intensive "short rotation forestry" FMA as outlined above. The new dispensation calls for improved forest governance, devolution, sustainable forest management, partnerships and collaboration with the state and non-state actors, including the adjacent communities (Costa *et al.*, 2017). This is in addition to efficient response to emerging issues to enable the sector contribute to meeting the country's growth and poverty alleviation goals in line with the global Forest Principles (UNCED, 1992; CBD, 2001; Musyoki *et al*., 2013).

This calls for decentralization of forest management and extensive support for public participation which implies the involvement of citizens in a wide range of policy making activities that include the determination of levels of service, budget priorities, and sharing of roles and responsibilities (Webbler *et al*., 2001; Agrawal & Gupta, 2005; Salam *et al*., 2005; Reed, 2008; Hage *et al*., 2010). Citizen participation in governance serves to establish the necessary sense of ownership, builds public support, contributes to the sustainability of development initiatives, strengthens local capacity, recognizes the poor and marginalized and links development to community needs. Moreover, it guards against abuse of office by public servants and political leaders, provides checks and balances against excessive political interference in service delivery even in management of natural resources in the public sector (Odhiambo & Taifa, 2009).

2.4.2 Participatory forest management in Kenya

Ecosystems, the goods and services they provide, and the people who interact with them consist of complex systems that are mostly nonlinear, uncertain and rarely predictable (Costanza *et al*., 1997a; de Groot *et al*., 2002; Tesfaye, 2017). A study of forests and livelihoods in the context of sustainable management requires that we understand the relation and interactions between the resource, users, and institutions that mediate between them (Ongugo *et al.*, 2002; Agrawal & Gupta, 2005; Max-Neef, 2005; Rita *et al.*, 2017). Thus, in recent years, there has been a growing appreciation that greater consideration must be given to community involvement in local resource management. This is because traditional preservationist techniques of forest management based on "command and control" or "fences and fines" (Ongugo *et al*., 2014) approaches are viewed as having failed to conserve forest biomes in the tropics (Barrett & Arcese 1995; Mogoi *et al*., 2012).

Therefore to enhance sustainability, the deliberate studying and understanding of the long history of human involvement and interactions with ecosystems is fundamental. The decentralized forest management regimes have gained currency particularly in developing countries in recent years (Agrawal & Chhatre, 2006; Young *et al*., 2013). The decentralization process is viewed as a means of enhancing economic efficiency and effectiveness, public accountability, community and individual empowerment in the natural resources sub-sector (Lise, 2000; World Bank, 2005). These reforms are anticipated to reconcile conservation and livelihood needs where forest decentralization, is specifically intended to enhance livelihoods, alleviate poverty and improve the forest condition (Temesgen *et al*., 2007; Mbairamadji, 2009; Newton *et al*., 2016; Tesfaye, 2017). The positive results attained from community involvement in forest conservation has also been extensively acknowledged by various studies (Mogoi *et al*., 2012; Matiku *et al*., 2013; Jordan & Russel, 2014).

PFM has demonstrated an increasingly sound development process that offer various opportunities that go beyond its focus which was intended to be on some of the poorest and most remote rural poor (Pearce 2001; Engida & Mengistu, 2013). Some of these opportunities include the fact that it embodies a high level of praxis of policy and practice and the steady maturation through learning by doing. The contention that PFM practice engenders from time to time indicates that is it making inroads and provoking substantive changes (Aretano *et al.*, 2013). Additionally, PFM has

challenged not only moribund norms and inequities between state and people, but also comparable inequities internal to the emergent forest managing community. Consequently, as also reported by Wily (2002), the gains from PFM go beyond forest conservation or livelihood issues to more inclusive and effective management of society itself.

The importance of involving communities in achieving positive results in forest conservation and management has also been widely acknowledged and draws on early experiences with other natural resource programmes (Matiku *et al.,* 2013; Ongugo *et al.,* 2014). Hence, communities' participation in the management of state-owned forests is increasingly becoming common phenomenon in the past three decades in many countries in Africa and Asia. The countries promote the participation of rural communities in the management and utilization of natural forests and woodlands through some form of PFM (Himberg *et al*., 2009). In order to institutionalize community involvement, these countries have formulated or are in the process of developing national policies and legislation.

Though, the emphasis on communities and their role in the management and use of forests is not misplaced, the modalities of community participation have not been well documented. For example, it is often unrecognized, though sometimes implied that communities are not homogeneous in FMAs (Bush *et al*., 2011; Engida & Mengistu, 2013). This means any intervention needs to take into account that the unsustainable resource extraction and depletion is often the result of many decentralized decisions made regularly by individuals and households concerning use of forest resources and not the consequence of collective decision-making (Hulme & Murphee, 2001; Fisher *et al*., 2009).

Thus, forest resource degradation is the cumulative impacts from decisions like cultivating crops in small areas, overgrazing and hunting of small game in the conservation area. It is therefore essential to understand the household-level socio-economic conditions and incentives that make the resource valuable to individual members of the community (Hulme & Murphee, 2001; Fisher, 2004; Langat *et al*., 2015). This therefore implies there are important degrees of variation in the benefits and costs of forest ecosystem resources and forest use restrictions across households. Lutz (1994) and Gaveau *et al*. (2009) further recommended that taking into consideration the benefits and costs at the household level is crucial because this is the level where conservation management

measures are undertaken. Additionally, there has been an increasing interest in the contribution that forests make as a source of local rural and urban income and employment. This is a result of the argument that the contribution is important in terms of both livelihoods and sustainable forest management (Cavendish, 1999; Lise, 2000; Karanja *et al.*, 2001; Vedeld *et al*., 2004).

Forest-adjacent communities operate behind a background of limited economic opportunities. Farmers are faced with multiple problems: scarcity of land, food, biomass and increased land degradation. As such, most rural poor maintain diversified livelihood strategies because they cannot obtain sufficient income from any single strategy and also to reduce risks (Kamugisha *et al*., 1997; World Bank, 2005; Yemiru, 2011; Langat *et al*., 2016). Many small-scale farmers are therefore not solely small agriculturists but many include forest products in their livelihood systems. Ellis (2000) defined livelihood as the access that individuals and households have to different types of capital (natural, physical, human, financial and social), opportunities and services. The rules and social norms that determine the ability of people to own, control or claim these resources further control access to them.

Decentralizing the management of natural resources is believed to increase not only efficiency because there is more local input resulting in better targeted policies and lower transaction costs, but also equity and democracy as more benefits are expected to accrue to the local communities (Roux *et al.*, 2006; Aretano *et al*., 2013). Decentralization in many parts of the world has taken many forms ranging from de-concentration, delegation, privatization to devolution of power (Meinzen-Dick & Knox 2001; Blaser *et al.*, 2005; Costa *et al.*, 2017). The implication of community involvement is often inferred in many contexts such as PFM, Joint Forest Management (JFM), Community Forest Management (CFM) and Community Based Forest Management (CBFM) (Kallert *et al.*, 2000; Holling, 2001; Mogoi *et al*., 2012). These involvement approaches are described as multi-stakeholder approaches that involve the private sector, institutions and local communities in both management activities and benefit sharing. As explained by Lise (2000), participation in this context consists of three components, namely, contribution to, benefiting from and involvement in decision making and evaluation.

Despite the recognition of community participation in the management and use of forests, the implementation of community based natural resource management initiatives have been criticized

(Hauck *et al*., 2013). With the increasing recognition of stakeholder involvement in natural resource management, problems, risks and critiques have grown (Agrawal & Gupta, 2005; Hauck *et al*., 2013). Some of those identified by various studies include: (i) the risk of working with particular people or organizations that are interested in the topic and consider collaboration beneficial (Hauck *et al*., 2015); (ii) unclear role of the representatives of stakeholder organizations (Young *et al*., 2013); (iii) sometimes the identified problems are not shared by all stakeholders; (iv) the risk of power imbalances within the process and some stakeholders having enough power to be on their own (Keune *et al*., 2013; Hauck *et al*., 2013). This is further compounded by the common problems of lack of resources such as time and money, or a clear mandate to resolve conflicts. This leads to watered-down version of the ideal and adequate stakeholder involvement and engagement.

That notwithstanding, the contemporary emphasis on community participation is not misplaced. The attention given to communities and the role they play in the conservation of protected areas is driven by a pragmatic assessment that they have the greatest impact on resources, either through direct unsustainable use or through poorly enforced institutional arrangements (Becker, 1999; World Bank, 2003; Mogoi *et al*., 2012). There is a broad supposition that the affected local communities may be less inclined to unsustainably or illegally use local environmental resources when rural poverty and development needs are addressed along with resource management issues (Hulme & Murphee 2001; Fisher, 2004; Vedeld *et al*., 2004). However, Hulme and Murphee (2001) cautions that any intervention must consider that unsustainable use of resource is not the outcome of communal decision-making. Instead, resource extraction and depletion is frequently as a result of decentralized decisions made regularly by individuals and households. An individual decision on its own is not necessarily critically damaging to forest resources but the cumulative effects of clearing small areas, overgrazing in the conservation area and hunting endangered species produce clear cumulative impacts (Agrawal & Gupta, 2005; Aretano *et al.*, 2013; Hauck *et al*., 2016). It is therefore imperative to comprehend the household-level socio-economic conditions and incentives that lead to households' dependence on forests.

In various countries, community involvement is being achieved through diverse arrangements but in Kenya, it is largely termed as PFM. This is defined variously but the basis of PFM discussion in this study was based on the definition that terms it as an arrangement where key stakeholders

enter into a mutually enforceable agreement that define their respective roles, responsibilities, benefits and authority in the management of defined forest resources (Springate *et al*., 2003).

The stakeholders comprise of many groups with varying degrees of involvement and expectations that no single formula can address. Within the same stakeholder group there are those whose survival are injured by changes in FMAs and need to be compensated (Reed, 2008; Hage *et al.*, 2010). The stakeholders involved are the interested individuals and groups in the management and utilization of forest goods and services. These include the private sector stakeholders coming in for commercial exploitation, Non-governmental organizations (NGOs) coming in for conservation and livelihoods improvement and the government who is the regulator (Thakadu, 2005; Reed, 2009; Hage *et al.*, 2010). The list also includes forest-adjacent communities who rely on forests for their livelihoods and are vulnerable to management changes undertaken without consultations.

In Kenya, other than the local communities, other stakeholders have clearly defined involvement arrangements in form of leases, licenses and agreements incorporating or with inbuilt benefit sharing components. For most of the stakeholders, their cost and benefit share is apportioned in the agreements signed in form of prices set for the goods and services traded (Maingi, 2014). Under PFM, communities or groups of people have partial to full rights over specific forests, including the rights to establish, implement, and enforce rules governing access and use of those forests. These rights may be formal legal rights, or traditional or customary rights: the latter may, or may not, be legally recognized by the State (Reed, 2009; Hage *et al.*, 2010; Ogada, 2012).

To reduce the complexity of apportioning involvement costs and benefits, the forest policy and legislation recommends formation of associations referred to as Community Forest Association (CFA) composed of different forest dependent groups. CFAs are supposed to represent members' or group's interests, ensure agreements are fair and operating, keep records to enable allocation of costs and benefits to individual members. Areas of participation includes collection of forest products like fire wood, grass/fodder, forest cultivation, grazing, water abstraction and use of forests for social activities. Some benefits are paid in kind by KFS in form of rights which communities have enjoyed for ages like grazing livestock and fuel wood collection.

2.4.3 Legal framework for public participation in forest management

The concept and practice of public participation in development discourses has significantly evolved in international law. The 1972 Stockholm Declaration on the Human Environment

highlighted the role of public participation in environmental management. This was further reiterated in the 1987 Report of the World Commission on Environment and Development report titled "Our Common Future" and well known as the Brundtland Report. The need for public participation in environmental management is also reinforced in the concept of sustainable development which revolves around the concept of integrating socio-economic development and environmental considerations. In return, this confers an obligation on people to participate in decision making over natural resource management. Since the Brundtland report, public participation in natural resource management and decision making has been an essential component of various international conventions and protocols on environment and natural resources. Some of these include:

- The Convention to Combat Desertification (Article 5 (d));
- The Convention on Biological Diversity (Article 13);
- The Cartagena Protocol on Biosafety (Article 21);
- The Nagoya Protocol on access and benefit sharing to the CBD (Article 23);
- The United Nations Framework Convention on Climate Change (UNFCCC) (Article 4).

The 1992 Rio Declaration on Environment and Development included elements that offer guidance on public participation. Principle 10 states that "environmental issues are best handled with participation of all concerned citizens, at the relevant level." The content and elements of the concept of public participation are: the opportunity to participate in decision and policy making processes; right of access to environmental information; obligation on states to undertake public awareness; and access to judicial and administrative review mechanisms. Therefore, participation of the public in natural resources management is well articulated as an instrumental mechanism in international treaties. Nonetheless, the elements do not provide a succinct normative content to expound on the key legal elements that would facilitate application of public participation in law, policy and practical implementation mechanisms for citizens. Thus, Kenya like other countries has ratified diverse international agreements and a plethora of sector specific legislations that govern the environmental sector in general and forests in particular to meet their own needs.

2.5 National Policy and Legal Framework for Public Participation

Globally, many countries have decentralized natural resource management in an effort to increase parity in benefit sharing and decision-making. The concept of decentralizing is widely believed to increase both efficiency and equity (Ribot, 2005; Mogoi *et al.,* 2012). Decentralization refers to any act by which a central government cedes rights of decision-making in management of natural resources to stakeholders and institutions at lower levels in a politico-administrative and territorial hierarchy (Larson, 2005). Various institutional changes have been made to Kenya's forest law to increase the participation of local populations in forest management and to contribute to socio-economic development. The main legal framework that guides the forest sector is summarized in the Constitution of Kenya (2010), Environmental Management and Coordination (Amendment) Act (2015), Draft Forest Policy (2014) and Forest Conservation and Management Act (2016).

2.5.1 The Constitution of Kenya, 2010

The Constitution of Kenya, 2010 was a landmark yardstick and an outstanding model for environmental management. It should be noted that forest management and access to forest resources have political ramifications. In Kenya, it has been noted that different political situations influence forest policy and practice and in the way forestry is organized. The political atmosphere during the colonial period and after independence is superficially different, the forest governance systems and structures are not very different, and the pressures on forestry development are similar. However, the new constitutional dispensation in Kenya provides a window of change and PFM may thrive (Mogoi *et al*., 2012; Kabugi, 2014; Ongugo *et al*., 2014).

This is due to the fact that it enshrines specific measures for environmental management, which can be concretely used to augment PFM. In addition, it entrenches bold and purposive environmental principles, rights and obligations, which signal unwavering commitment to ensure sustainable use of natural resources including forests. The rationale for including public participation in environmental management in the Constitution needs not to be gainsaid.

The Constitution sets out certain obligations contingent on the Government of Kenya relating to environmental management. These obligations compel the Government and all persons to ensure sustainable exploitation, utilization, management and conservation of the environment and natural

resources, and ensure the equitable sharing of accruing benefits in Article 69 (1 (a). It is useful to highlight that these obligations represent some of the legislative and other measures set out as part of realization of the right to a clean and healthy environment in Article 42. The Constitution therefore creates a sound basis for subsequent review of sectoral statutes with competence over natural resources to ascribe by these obligations. Equitable sharing of accruing benefits necessitates ensuring local and indigenous communities adjacent to forest resources are part and parcel of its management and prosperity. The other implicit obligations that would indirectly require the State and its apparatus to ensure involvement of local communities and relevant stakeholders to execute include: -

a) Achieve and maintain a tree cover of at least 10% of the land area of Kenya. There is need to harness the synergy created by cooperation among the concerned public, local communities, stakeholders and KFS to achieve a tree cover of at least ten percent of the land area of Kenya.

b) Protect and enhance intellectual property in, and indigenous knowledge of, biodiversity and the genetic resources of the communities. EMCA, 2015 has taken traditional interests of local communities with provisions that collectively envision the active participation and involvement of local and indigenous communities in the management of forests.

2.5.2 The Environmental Management and Coordination (Amendment) Act, 2015

The Environmental Management and Coordination (Amendment) Act (EMCA, 2015) is the framework law for environmental management in Kenya. It requires inclusion of environmental considerations during decision making; confers a statutory right to a clean and healthy environment; and extends legal standing to any person to bring a claim to the High Court if that right is breached. More importantly, EMCA directs that public participation is a core principle to guide the High Court when enforcing the right to a clean and healthy environment; and mandates National Environmental Management Authority (NEMA) to undertake environmental education and public awareness.

2.5.3 The Forest Conservation and Management Act, 2016

The pre-independence laws governing the management of all the major forests entailed the enforcement, through policing and punitive actions, of laws to prevent illegal activities. These continued even after Kenya's independence. Such management led to widespread conflicts

between the people and the Forest Department as more forest reserves were being created amidst the rising population. To alleviate the rising discontent and conflict, the government had to introduce changes in the forestry sector. In 1994, the government initiated the Kenya Forestry Master Plan, which spelt out the need for reform in forest policy and legislation as well as the importance of involving communities in forest management (KFMP, 1994; Anyonge, 2011; Ongugo *et al*., 2014). Subsequently, Kenya enacted the Forests Act, 2005 whose aspirations are advanced by its successor, Forest Conservation and Management Act, 2016.

The Act states that the community, through a legally formed entity referred to as the community forest association (CFA) shall enter into an agreement with the KFS to assist in the safeguarding of forest resources through protection and conservation activities. In exchange, they are expected to benefit from timber and non-timber forest products as well as revenue from community-based industries, ecotourism and recreation, scientific and educational activities. In some instances, some forests have aspects of community forest management, as demonstrated by the sacred/cultural forests such as the Kayas, Ramogi, and Loita forests, where communities have more power and rights over management although the KFS remains the overall manager (Ongugo *et al*., 2008; Matiku *et al*., 2013). The inclusion of communities is expected to enhance biodiversity conservation, the equitable distribution of benefits, conflict resolution, poverty reduction, and sustainable use (Tesfaye, 2017).

2.5.4 The Wildlife Conservation and Management Act, 2013

Similarly, the Wildlife and Conservation Act, 2013 also recognizes public participation, particularly community participation in wildlife conservation pursuant to the Constitution Of Kenya 2010. For example Article 4 (b) stipulates that "Conservation and management of wildlife shall entail effective public participation. Further, to enhance stakeholder participation, the Act created County Wildlife Conservation and Compensation Committee under Article 18 and 19 where one of the functions stipulated in 19 (d) is "bring together all relevant stakeholders within the county to actively harness their participation in the planning and implementation of projects and programmes related to the protection, conservation and management of wildlife resources in the county."

2.5.5 The Water Act, 2016

The Water Act, 2016 equally upholds public participation in management of water resources. Article 10 (1) and Article 67 (10) calls for public participation during formulation of a National Water Resource Strategy and a Water Services Strategy respectfully. The Act operationalizes community participation through establishment and of water resource users' associations under Article 29 (1). Their responsibilities include collaborative management of water resources and resolution of conflicts concerning the use of water resources under Article 29 (2).

2.6 Importance of Valuing Ecosystem Services

2.6.1 Contribution of forest ecosystems to the economy

Ecosystems and their associated services have economic value for society because people derive utility from their actual or potential use and also value services for reasons not connected with use (i.e. non-use values) such as altruistic, bequest and stewardship motivations (Holling, 2001; Kenter *et al*., 2015; Kretsch & Kelemen, 2016). Economic valuation attempts to elicit public preferences for changes in the state of the environment in monetary terms and can therefore provide evidence that is appropriate for use in a cost-benefit analysis. Valuing ecosystem services serves a number of purposes. Valuing the benefits – both current and future – from the natural environment illustrates its significant contribution to wellbeing and the high dependency of society on its ecological base. In one sense, the natural environment is of infinite value since it underpins and supports all human activity (DEFRA, 2007; de Groot *et al*., 2010; TEEB, 2010). Therefore, valuation, which may be defined as "the act of assessing, appraising or measuring value, as value attribution, or as framing valuation is critical for sustainable forest management (Dendoncker *et al.*, 2013).

Valuing ecosystem services serves a number of purposes. Valuing the benefits – both current and future – from the natural environment illustrates its significant contribution to wellbeing and the high dependency of society on its ecological base. In one sense, the natural environment is of infinite value since it underpins and supports all human activity. However, valuing ecosystem services presents two main challenges; First, it is the difficulty faced in deciding on what should be valued – the ecosystem processes or the services (TEEB, 2010). Second, ecosystem services do not always show a one-to-one correspondence. Many times, a service is the product of two or more

processes whereas in other situations, one process contributes to more than one service (de Groot *et al*., 2002).

The forests in Kenya are particularly important in terms of their contribution to the local and national economy in their provision of important ecological and environmental services. These forests are important sources of food (plant and animal), employment, traditional medicines and many indirect benefits. An estimated over 3 million people depend on forests to meet one or more of their household needs (Wass, 1995) The Kenyan economy being mainly agrarian; it is supported by forest ecosystems as well as other natural resource based economic production activities. Forest resources therefore, largely influence social, cultural, economic and political development of a vast majority of local communities (World Bank, 2004b).

The natural wood vegetation of Kenya consists of closed canopy indigenous forest, wood lands, bush lands and wooded grasslands all covering an estimated area of about 7% (KFS, 2013) of the total land area. The vegetation types are defined by climate, soil, biotic factors and occurrences of fires. Despite the proportionately small area covered by closed canopy forest compared to the overall country's surface area, forests continue to play a significant role by providing a wide variety of resources for human development (Salafsky *et al*., 2002). They provide utility products such as timber for construction industry, transmission poles for the energy and communication sector, paper for education and print media sector, fuel wood for the tea industry and also for subsistence utilization by the community. Forests also provide a variety of non-wood products. They are important in conservation of biological diversity, regulation of water supplies, carbon dioxide sequestration and are major habitat for wildlife (Beentje, 1990; KFS, 2010).

In spite of the products and functions served by forests, they are not reflected as a contribution to country's Gross Domestic Product (GDP) (Emerton, 2001; Manyindo, 2003). Further, the values of locally important species have not been incorporated in official statistics, which implies that these species could be under or over-valued in a market situation. This under-values the landscapes in which they are found (IIED, 1997). Valuation of natural environment is central to decision making for sustainable development. It is evident that zero priced resources are over-used in economic terms (Emerton & Mogaka, 1996; CBD, 2001; María *et al*., 2010).

Although the contribution of Kenya's forests is not fully reflected in the national statistical abstracts, various studies and reports estimated that forest products and services contributed about 7 billion Kenya shillings to the economy and the sector directly employed 50,000 people and another 30,000 indirectly (KFMP, 1994, IUCN, 1996; Emerton & Karanja, 2001). According to available data the forest industry contributed about 320 million Kenya shillings to the GDP and the timber industry alone had investments of over Kenya Shillings (KES) 44 billion. The value of indigenous forests as water catchment was estimated at KES 2,050 per hectare per year (IUCN, 1996). At the national level, it is estimated that the value of unaccounted forest resources is KES 9,226.2 million per annum (Mogaka, 2002). Forests are also valued for religious and cultural practices and some are important habitats for plant and animal species (Verschuuren, 2006). The forests in Kenya are also rich in species diversity. Some estimates in the recent past revealed that Kenya harbours 6,000 species of higher plants, 875 and 1,097 different butterflies and birds respectively (KWS, 2003; KFS, 2010). On this account, the importance of forest resources in Kenya in promoting economic and social development need not be emphasized.

2.6.2 National accounts and depreciation of forest values

Incorporating natural capital calculations into national accounts was launched as an idea in the 1980's in response to environmental concerns. It was observed that, in the absence of such calculations, the destruction of important habitats through logging or mining appear as wholly beneficial due to its positive contribution to Gross National Domestic Product (GNP) (Sjaastad *et al.*, 2003; Gundimeda & Sukdev, 2008; WAVES, 2012; Kubiszewski *et al*., 2013; Costanza *et al*., 2014b). It was recognized that standard measures of economic growth like GNP, and NNP do not reflect changes in either environmental quality or changes in natural capital. The standard existing System of National Accounts (SNA) is therefore inadequate in measuring the contribution of, and impact on the environment (Mogaka, *et al.*, 2001; Sjaastad *et al.,* 2003; van Kerkhoff & Lebel, 2006; Kubiszewski *et al*., 2013). When SNA is used, the costs of environmental degradation and natural resource depletion and non-market amenities are not included. In addition, defensive expenditures designed to offset pollutions are counted as additions to GNP/NNP (de Groot, 2006).

2.6.3 Valuation of forest goods and services

Many studies have identified under-estimation of the economic importance of forest by many planners, policy-makers and resource managers as a key driver in forest ecosystem degradation

(Becker, 1999; de Groot, 2006; 2010; Bunse *et al*., 2015; Kelemen *et al*., 2016b; Kenter, 2017). One of the reasons for the apparently low value of forests being that most official statistics (and many less formal markets and balance sheets) consider only the commercial or industrial use of wood products (Emerton, 2001; Daily *et al.*, 2009; Holding *et al*., 2011). This situation is clearly inequitable with other sectors and sends confusing economic signals about the worth of forest ecosystems. This gives people few incentives to conserve forests; limit their consumption of forest resources to sustainable levels; halt forest clearance for seemingly more profitable land uses, or implement developments in ways that do not harm forests (Knight *et al*., 2006; TEEB, 2010; Langat *et al.,* 2016; Rita *et al.,* 2017).

Economic instruments offer incentives and finance that form vital ingredient for natural resource conservation. Conservation would only succeed if the regional, national and local disincentives that encourage natural resource degradation are revised and replaced with positive incentives for conservation (Karanja *et al.,* 2001; de Groot *et al.,* 2010; Engida & Mengistu, 2013). An essential means of achieving this is to align private costs with social costs in a way that externalities become part of decision-making (Mogaka, 2000; de Groot, 2006). It is apparent that inadequate policies and local economic activities, notably agricultural land uses and subsistence natural resources exploitation form the main direct and underlying causes of natural resource degradation (Sjaastad *et al.*, 2003; Obati, 2007; TEEB, 2010; Langat *et al*., 2015). Understanding these forces, in the context of forest conservation and using economic policies, tools and measures to address them is fundamental to sustainable forest management (Dendoncker *et al*., 2013).

The high rate of deforestation globally which was estimated at 13×10^6 ha per year (FAO 2007) and the increasing international concern about deforestation (TEEB, 2010) illustrate that economic valuation of forest ecosystem services has an important role to play. The importance or ‘‘value’’ of ecosystems and their services can be expressed in three value domains ecological, socio-cultural and economic (MEA, 2003; Kubiszewski *et al.,* 2013; Costanza *et al*., 2014a). The ecological value encompasses the health state of a system, measured through ecological indicators such as diversity and integrity, while socio-cultural values include the importance people give to, for example, the cultural identity and the degree to which that is related to ecosystem services. The primary role of economic analysis is to assist decision-making (Tietenberg, 1996; Daily *et al*., 2009). In this context, following some of the relevant references of ecosystem services valuation

the broader understanding of value is applied where it is not restricted to monetary value (de Groot *et al.,* 2002, 2010; Costanza 2014b).

Economic literature identifies two broad categories of values: use values and non-use values (Pearce, 2001; TEEB, 2010). This taxonomy defines the different sources of values that people attribute to the different services provided by ecosystems. It should be noted that this taxonomy depends on whether ecosystem services gratify human needs directly or indirectly. Hence, economic value is a measure of the degree of satisfaction provided by these services (Boyd & Banzhaf, 2007; Ruijs *et al.,* 2013). These values constitute TEV which generally includes direct use, indirect use, option, and non-use. The first three categories generally constitute the use values whilst values such as bequest and existence values aggregate into the non-use values. Use values encompass direct use values which are services that are used directly mainly encompassing provisioning services such as the value of timber, fish and cultural services like recreation and aesthetic appreciation (Fisher & Turner, 2008; TEEB, 2010; Fish *et al*., 2011).

Indirect use values relate to the benefits derived from regulating services such as climate regulation, air- and water-purification, erosion prevention and pollination of crops (Burke *et al.,* 2015). Non-use value is the importance attributed to an aspect of the environment, in addition to, or irrespective of its use values. These are almost entirely associated with cultural services and they are divided into bequest and existence values. In essence, it can be understood as the value attributed to the simple existence of the good or service sometimes also referred to as ‘‘insurance’’ or ‘‘glue’’ value (Becker, 1999; de Groot, 2006; Fisher & Turner, 2008). On one hand, bequest values represent the value that an individual consigns to an ecosystem or species due to its significance to the well-being of future generations. Existence value, on the other hand, represents the value that an individual attributes to an ecosystem or species due to its importance at the present time. Option values encompass all values (both use and non-use) that are expected to be enjoyed in the future like provision of genetic resources, maintenance of a gene pool for bioprospecting, cultural heritage, either within the individual’s life time, or for future generations (Hein *et al.,* 2006; Kipkoech *et al*., 2011; Biedenweg, 2012; Edwards *et al*., 2016; Fish *et al*., 2016).

According to Gómez-Baggethun *et al*. (2014), the importance (value) of ecosystems and their services can be expressed in three different value domains which are ecological, socio-cultural and

economic values. The ecological value encompasses the health state of the ecosystem, measured with ecological indicators such as diversity and integrity, whilst socio-cultural values include the importance people attribute to the ecosystem, for example, the cultural identity and the degree to which culture is interrelated to ecosystem services (de Groot *et al.*, 2002; Costanza, 2008; Fish *et al*., 2011, de Groot *et al.,* 2016). Nonetheless, they all agree that the sum of the total use and non-use values related to resources or an aspect of the environment can be summed up as TEV (Fisher & Turner, 2008; Daily *et al.,* 2009; TEEB, 2010; Gómez-Baggethun *et al.*, 2014; Kenter, 2017) as shown in Figure 2.1.

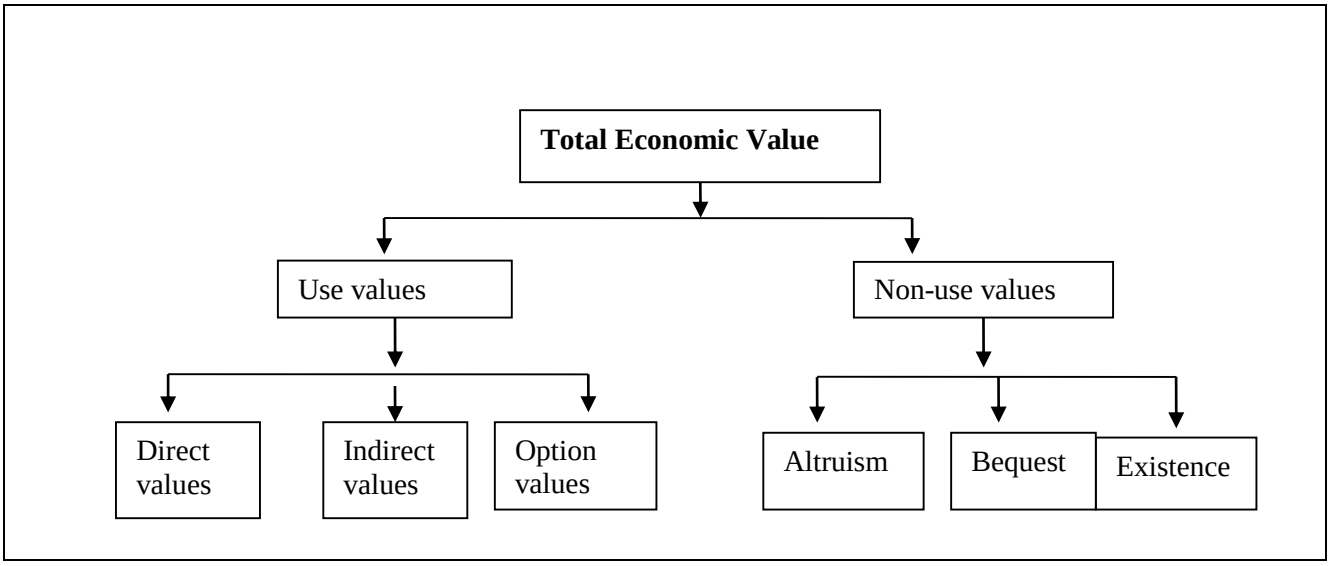

Figure 2.1: Total Economic Value framework

Adapted from CBD (2001), DEFRA (2007) and TEEB (2010)

2.6.4 Valuation techniques and approaches for ecosystem services

The main reason for valuation of ecosystems is that, failure to value these services makes the economic systems to remain predisposed towards ecosystem degradation and over-exploitation. It is important to understand what and how much people value forest ecosystems within their socio-economic and cultural context (Berlyn & Ashton, 1996; Daily *et al*., 2009; Chan *et al*., 2012a). As observed by Bunse *et al*. (2015) and Fraser *et al*. (2016) resource values not expressed in prices are at a comparative disadvantage in a market economy since the ecosystems supporting them can be undervalued and also overused. It should also be noted that sustainable development cannot be achieved in the absence of sustainable resource utilization at the household level.

The stability of the local and national economy largely depends on the production capability of rural households, which in turn are determined by the natural resource base (Adhikari *et al*., 2004; Fisher, 2004; Bennett *et al.*, 2009; Musyoki *et al*., 2014). As elucidated by Fraser *et al.* (2016) and Kretsch and Kelemen (2016), value can be measured by the size of the well-being improvement provided to humans through the provision of good(s). Essentially, valuation methods and techniques put a 'price-tag' on services that nature provides based on the underlying premise that with or without markets, the flow of ecosystem services affects human well-being in many ways (Daily *et al*., 2009; Costanza *et al*., 2014a; Gómez-Baggethun *et al*., 2014).

The measurement unit for economic benefits is predominantly money, however, it is crucial to realize that economic monetary value essentially reveals only part of the true worth or TEV of a forest ecosystem (Groot *et al.*, 2010; Orchard-Webb *et al.*, 2016). This is because people derive diverse goods and services from ecosystems. Therefore, the total value should encompass ecological and socio-cultural values of an ecosystem service (Holling, 2001; de Groot, 2006; Daily *et al*., 2009; Kenter *et al*., 2011; Chan *et al*., 2012b). There are number of ways to capture the various ecosystem services and translate the ecological and socio-cultural importance of ecosystem services into monetary values. These are classified broadly into non-economic or non-monetary and economic or financial valuation methods. These terms have specific meanings in the economist's parlance as explained by Kukkala and Moilanen (2013), Gómez-Baggethun *et al.* (2014) and Kelemen *et al.* (2016b).

Value in economics is always associated with trade-offs, thus, something only has economic value if one is willing to give up something to get or enjoy it (Daily *et al*., 2009; Gómez-Baggethun *et al*., 2014). The (gross) economic value of a good or service is the total value an individual is willing to pay for a good or service. Economic or financial values refer to the value of goods and services to individuals as reflected by the price they fetch in market transactions (de Groot *et al*., 2010; Chan *et al*., 2012a; Kelemen *et al*., 2016b). Non-economic values on the other hand, seek to measure the total benefits of the good or service, whether traded in the market or not (TEEB, 2010; Balvanera *et al*., 2014).The non-monetary approaches (Kelemen *et al.*, 2016a) examine the importance, preferences, needs or demands expressed by people towards nature, and articulate plural values through different qualitative and quantitative measures other than money (Chan *et al.*, 2012a). This facilitates grasping the multi-dimensional nature of human well-being with monetary value being just one aspect of importance as it comprises symbolic, cultural, ecological

and spiritual. Following the rationale of Martín-López *et al*. (2012) and Balvanera *et al*. (2014), a combination of economic and non-economic valuation approaches enables a more holistic picture of the value of the forest ecosystem.

(a) Economic (Monetary) valuation

Environmental economists have developed a broad range of techniques to derive both economic and non-economic values of ecosystem services. Some valuation methods are more appropriate for capturing some specific values within particular ecosystem services than others. Within the TEV framework, the available techniques used for valuation of ecosystem services are commonly categorized into three, namely; (a) revealed preference approaches (b) stated preferences approaches and (c) benefit transfer approaches (DEFRA, 2007; TEEB, 2010; Fisher *et al*., 2011b; Gómez-Baggethun *et al*., 2014; Kenter, 2017).

The RP approaches employ various methods such as market prices (market price method) derived from direct market transactions and in their absence, price information is based on proxies derived from parallel market transactions that are associated indirectly with the good to be valued (hedonic pricing method), or on observed consumer behavior (travel cost methods) (TEEB, 2010; Fisher *et al*., 2011b; Gómez-Baggethun *et al*., 2014; de Groot *et al.,* 2016). The SP approach relies on expected consumer behavior in hypothetical markets simulated through surveys using contingent valuation (CVM) and choice modelling methods (Vatn & Bromley, 1994; Landell-Mills & Porras, 2002; Muradian & Rival, 2012; Gómez-Baggethun *et al*., 2014; Kelemen *et al*., 2016b; Kenter, 2017).

In CVM, respondents directly state their value or preference in the context of a constructed market. Valuations are "contingent" on a hypothetical market scenario presented to respondents in a survey (Whittington, 2004). This is in contrast to revealed preference techniques where values are inferred from actual choices made by respondents. Whittington (1998) observed that it is easier to do high-quality contingent valuation surveys in developing countries than in industrialized countries. This is because response rates are high and respondents are quite receptive and consider prudently the questions posed. Additionally, costs of administering surveys are usually lower than in developed nations, allowing researchers to use larger sample sizes and undertake more elaborate experimental designs. Further, other methods as elucidated by Kumar and Kumar (2008), TEEB (2010) and

Fisher *et al*. 2011a), ecosystem values from original valuation study sites can be applied to other similar sites/situations through benefit transfer approach.

(b) Non-economic (Non-monetary) valuation

Economic valuation is not the only approach to assigning a value to nature, nor is it necessarily the best approach (Wilson & Howarth, 2002; TEEB, 2010; Martín-López *et al*., 2013). As Nelson *et al*. (2009) and Kareiva and Marvier (2012) pointed out, it is important to emphasize that an economic valuation does not substitute or disregard the intrinsic value of nature, nor does it decrease the moral authority to conserve nature. Non-monetary valuation, which is sometimes used synonymously to non-economic valuation is therefore important (Nelson *et al*., 2009; TEEB, 2010; Martín-Lopez *et al*., 2012). However, it is important to note that notion of "economic" is challenged. Some schools of thought think of the 'economic' as defined by orthodox neoclassical economics whilst other schools (feminist, institutional, ecological, etc.) demand for a delimitation of the term 'economic'. In the latter case, market relations are a subset of the sphere of the economy.

In the last decade, international initiatives like the Millennium Environmental Assessment (MEA) and TEEB have acknowledged various methods (Table 2.3) including the role of non-monetary valuation (NMV) in ecosystem services (ES) valuation (MEA, 2003, 2005a; TEEB, 2010; Kelemen *et al*., 2016a). Non-monetary approaches can be applied in various stages of ecosystem planning and management (Kelemen *et al*., 2016a). They examine the importance, preferences, needs or demands expressed by people towards nature, and articulate plural values through diverse qualitative and quantitative measures other than money (De Groot *et al.,* 2010; Chan *et al*., 2012b). Moreover, non-monetary valuation offers options and solutions to some of the methodological difficulties and constraints of monetary valuation (Chan *et al*., 2012a; Nieto-Romero *et al*., 2014).

According to TEEB (2010) and Christie *et al*. (2012), the choice among NMV methods should be determined by several factors: 1) the capabilities and the socio-cultural context of the communities involved, 2) the institutions and the value-systems held by stakeholders, 3) the needs of the decision-makers, 4) the capacity of the researchers and practitioners who carry out the valuation process and 5) the fundamental characteristics of the decision making process. Since the nature of biophysical assessments and economic and socio-cultural valuation is interconnected, non-monetary methods can reveal how stakeholders attach social and cultural values to species,

ecosystems and other biophysical components of the environment (Kumar & Kumar, 2008; TEEB, 2010; Kelemen *et al*., 2016a).

Table 2.3: Matching ecosystem services to valuation methods related to TEV framework

Ecosystem Services	Ecosystem services	TEV framework	Valuation methods
Provisioning	Food; fibre fuel, biochemicals, natural medicines, fresh water supply, pharmaceuticals	Direct use	-Market prices -Hedonic pricing
		Option use	-Random utility -Contingent valuation -Choice modeling -Benefit transfer method
Regulating	Air-quality regulation; climate regulation; water regulation; natural hazard regulation	Indirect use	-Market prices -Hedonic pricing
		Option use	-Production function approach -Contingent valuation -Choice modeling -Benefit transfer method
Cultural	Cultural heritage; recreation and tourism; aesthetic values	Direct use	-Market prices -Hedonic pricing
		Option use	-Travel cost method -Random utility
		Non use	-Contingent valuation -Choice modeling -Benefit transfer method
Supporting	Primary production; nutrient cycling; soil formation	Supporting services are valued with the other categories of ecosystem services	

Adapted from CBD (2001), TEEB (2010) and Fish *et al*. (2011)

2.7 Valuation Techniques Applied in this Study

2.7.1 Economic valuation

In assessing ecosystem services available to the local communities in this study, insights from economic analysis and sociological investigations were integrated (Chan *et al*., 2012b; Kelemen *et al*., 2016a; Rita *et al.,* 2017). Different methods were applied to impute the two types of value, economic and non-monetary. These methods were used in this study to combine qualitative data with quantitative index of socio-cultural value to evaluate total value of ecosystem services (Fraser *et al*., 2016). As explained by Kretsch and. Kelemen (2016), value can be measured by the size of the well-being improvement provided to humans through the provision of good(s). Following the logic of Balvanera *et al*. (2016) and Christie *et al*. (2012), this research combined economic and other valuation approaches to provide a more holistic picture of the value of the forest ecosystem.

The different approaches were used to investigate the differences in values of forest resources across individuals, and what was causing variation. The focus of this study was to assess the annual economic and non-economic value of forest ecosystem services to forest adjacent households. The National Park was under protection FMA whilst the National Reserve was under conservation FMA which meant different ranges of goods and services and therefore utility derived by local households.

Economic value of the ecosystem services was obtained using both revealed preference (RP) and stated preference (SP) methods. The RP was based on market price for provisioning services that had local market prices and were widely traded either formally or informally such as firewood, timber, poles and honey.

(a) Revealed preference (RP) method

The RP employs market price to estimate the economic value of ecosystem products or services that are bought and sold in commercial markets. The market price method can be used to value changes in either the quantity or quality of a good or service (Daily *et al*., 2009; Muradian & Rival, 2012; Gómez-Baggethun *et al*., 2014). It uses standard economic techniques for measuring the economic benefits from marketed goods, based on the quantity people purchase at different prices, and the quantity supplied at different prices. The market price method in this study used prevailing prices for goods and services such as firewood, charcoal and timber that are sold locally or traded in markets.

According to Nelson *et al*. (2009) and Obst and Vardon (2014) market price method has on one hand various advantages such as reflecting an individual's willingness to pay for costs and benefits of goods that are traded in markets, such as fish, timber, or fuel wood and prices. Quantities and costs are comparatively easy to obtain from established markets, use of observed data of actual consumer preferences and application of standard, accepted economic techniques. On the other hand, the method has limitations like the market data being available for only a limited number of goods and services derived from an ecological resource, thus may not reveal the value of all productive uses of a resource; the true economic value of goods or services may not be fully reflected in market transactions; the seasonal variations and other effects cause wide market prices fluctuations due to market imperfections and/or policy failures. In addition, the method is

inappropriate for measuring the value of large scale changes that influence the supply or demand for an ecosystem good or service; and it also does not consider the market value of other resources used to bring ecosystem products to market hence, may overstate benefits.

The prices of forest products were established at the household level as reported by respondents. The prices were expected to vary with distance from forest/producers, type of product, level of processing and state of development of the market. The total value of forest product marketed was estimated using the own reported values and use of the market price less transaction costs, i.e.

$$Tv = Qm\ (Pm) - C$$

Where;

Tv = total values of forest products marketed;
Qm = quantity of good extracted;
Pm = the forest gate price of good; and
C = transaction costs.

The mean quantities of own reported values (Qm) for extractable products from each household per period are converted to annual values. This was done by multiplying quantities extracted (Qm) by market price of the product (Pm) less transaction costs as shown in the equation above. The total value of the product(s) was the aggregate of the total number of households surveyed and extrapolated for the total population adjacent to the forest.

Surrogate market prices were used for the products with undeveloped markets such as thatching grass, wild fruits, and forest grazing were valued using market prices of substitute or proxy products for example iron sheets, locally available fruits and renting of land in relation to Tropical Livestock Unit (TLU) respectively (CIFOR, 1997; Mogaka, 2000; de Groot *et al*., 2016). Grazing of livestock (mainly sheep and cattle) in the forest was found to be an important livelihood activity especially to local communities adjacent to forest reserves. To estimate the value of grazing, a number of factors were taken into consideration. Firstly, it was necessary to classify all the livestock types into comparable units. The Tropical Livestock Unit (TLU) was used to determine the level of savings made by households by herding livestock in the forest. It is estimated that one TLU is equivalent to 250 kg live weight (CIFOR, 1997). For local breeds, one head of livestock is estimated at 0.65 TLU while goats are estimated as 0.1TLU (Emerton, 1996; Mogaka, 2000). By

estimating the number of cattle and goats herded in the forest by the surveyed households and from the records in the forest station, was possible to estimate the total value of forest grazing.

Secondly, it was important to estimate the annual livestock requirements equivalent to one TLU. Land hiring was assumed to be the alternative to forest grazing. Thus, the estimates of TLU provided an indication of how much extra land households require to maintain the same number of livestock. Given the local rates of hiring land at an average of KES 2000/ha/yr and opportunity cost of labor which was value at KES 250/day, the net economic worth of the forest for livestock herding was calculated. Similarly, the value of land hiring was used to obtain the economic worth of the area under cultivation in the forest under PELIS. The total value of the products was the aggregate for all households surveyed and extrapolated for the total number of households living in forest adjacent sub-locations around Aberdare forest ecosystem.

To obtain net value of forest conservation, it was necessary to determine the cost of procuring, processing and/or marketing various products. The indirect opportunity cost of time was used to determine the cost of labour (this was found to be the major input). The prevailing level of daily wage rate in the area at that time was KES 250/day (US$ 2.5/day) was applied as the indirect cost of time. Therefore, the net value of resource procurement is a factor of market price (P), quantities of products extracted (Q) and the indirect opportunity cost of time (C).

On the basis of market or surrogate market prices, the annual net present economic value of provisioning services from the forest ecosystem was estimated based on Equation 1.

$$NV = \Sigma_{i=1} Q_i (P_i - C_i) \qquad \text{(Equation 1)}$$

Where

NV = net value of forest products procured from forest by households for domestic use or for sale

Q_i = the quantity of the i^{th} product extracted

P_i = the forest gate price or market price of the i^{th} product

Ci = the cost of extraction (mainly labour or opportunity cost of time) of the i^{th} product

i = 1, 2, 3 …n

(b) Stated Preference (SP) method

People derive utility from the services provided by ecosystems. Economic value estimates and measures are based on people's preferences. People express their preferences through the choices and trade-offs they make to improve their welfare. The SP method used in this study was contingent valuation method (CVM). The CVM is used to estimate economic values for all kinds

of ecosystem services. It is able to estimate both use and non-use values, and it is the most widely used method for estimating non-use values (Diamond & Hausman, 1994; Whittington, 1998; 2002; DEFRA, 2007: de Groot *et al*., 2010). The contingent valuation method is a "stated preference" (SP) method, because it asks people to directly state their values, rather than inferring values from actual choices, as the "revealed preference" methods do (TEEB, 2010; Fish *et al*., 2011).

The CVM is the only way to assign monetary values to non-use values of the environment—values that do not involve market purchases and may not involve direct participation (DEFRA, 2007; María *et al.*, 2015). These values are sometimes referred to as "passive use" values which include everything from the basic life support functions associated with ecosystem health or biodiversity, to the enjoyment of a scenic vista or a wilderness experience; appreciating the option to fish or bird watch in the future; or the right to bequest those options to future generations. It also consists of the value people place on simply knowing that unique plant or animal species like white rhinos or whales exist. In this study, SP method was used to elicit value of the ecosystem to the local community for both regulating and cultural services.

CVM employs constructed market approaches which involve undertaking a survey and directly asking people either their WTP or WTA to give up a specific ecosystem services (Hanley *et al.*, 1997; Boyle, 2003; Whittington, 2004; de Groot *et al*., 2010). This is used as a tool for eliciting the economic wealth of environmental goods and services that have no related or surrogate markets. The WTP approach was used in this study as WTA was found inappropriate as it involves creating a hypothetical forest absence scenario, thus, respondents could give values for all potential benefits lost not only those being investigated. Further, the question on WTA raises respondents' expectations of monetary benefits (Wilson & Howarth, 2002; TEEB, 2010; Christie *et al*., 2012). Therefore, although WTP-derived values are more conservative than WTA-derived values, they are more useful in planning and policy formulation.

The advantages of CVM according to various studies (Hanley *et al*., 1997; Whittington, 2004; de Groot, 2006; Fisher *et al*., 2009) include being flexible in that it can be applied in estimating the economic value of essentially anything. It is the most widely accepted method for estimating TEV or all types of non-use, passive use values and use values. Additionally, the nature of contingent valuation studies and results are not challenging to analyze and describe. However, CVM has

various limitations such as the fact that it requires a competent survey analysts to achieve consistent estimates. For example, in a WTP question, the respondent may inadvertently be answering a different question than the surveyor intended by assuming that one or more related improvements are included; respondents may make associations among environmental goods that the researcher had not intended; strategic bias can arise when the respondent provides a biased answer in order to influence a particular outcome; and information bias may arise whenever respondents are forced to value attributes which they have little or no experience (Whittington, 2004; TEEB, 2010; Christie *et al*., 2012).

Contingent valuation was particularly important in this study because it can estimate values where: (i) markets do not exist (ii) market data cannot be applied; (iii) there are major limitations of market price valuation methods (Whittington 1998; 2002; Bhatnagar, 2008; Ellis & Ramankutty, 2008). Whittington (1998) observed that it is easier to do high-quality contingent valuation surveys in developing countries than in industrialized countries. This is because response rates are high and respondents are quite receptive and consider judiciously the questions posed. Additionally costs of administering surveys are lower than in developed nations, allowing researchers to use larger sample sizes and conduct more elaborate experimental designs. CVM was applied in this study based on WTP to measure use values, existence values, option values, and indirect use values which constituted the regulating and cultural ecosystem services deemed as most important to the community.

The measures of change in welfare are reflected in people's WTP or WTA compensation for changes in ecosystem goods and services (DEFRA, 2007; de Groot *et al*., 2016). WTP provides a measure of how much purchasing power people are willing to give up to get a particular (or set of) regulating services. This is used when beneficiaries of ecosystem services do not own the resource or when service levels are being increased. Conversely, WTA is appropriate when beneficiaries own the resource providing the service (Whittington, 2004; MEA, 2005a; de Groot *et al*., 2016). Therefore, this study employed WTP as Aberdare forest ecosystem is largely a state forest and people derive some benefits from farmlands. Further, WTP was utilized in this study as WTA was found inappropriate as it involves creating a hypothetical forest absence scenario, thus, respondents could provide values for all potential benefits lost not just the indirect and existence values. Further, the question on WTA could raise respondents' expectations of monetary benefits. To elicit WTP values of ecosystem services, primary data collected using the detailed

questionnaire explained above was used. The respondents were requested to indicate their WTP to continue receiving the preferred goods and services. The amount they were willing to pay per month was used to compute the annual WTP values.

(c) Benefit Transfer Approach (BTA)

Benefits transfer is a process which estimates economic values by transferring existing benefit estimates from studies already generated in a similar site and applies them in another location (2006; DEFRA, 2007; de Groot *et al*., 2010). Application of the benefit transfer method involves four steps. Firstly, identification of existing studies or values that can be transferred. Secondly, evaluation of the existing values to determine whether they are appropriately transferable by considering factors such as similarity of the ecosystem and relevant population. Thirdly, evaluation of the objectives and quality of studies to be transferred as high quality studies yield more accurate and useful value estimates. Fourthly, adjusting the estimated values to reflect the values for the site under consideration, using the relevant site specific information available. This may necessitate collection of supplementary data from a survey of key informants or collect some primary data at the study site to apply in making adjustments (de Groot *et al*., 2010; TEEB, 2010).

Due to the almost complete absence of estimates for ecosystem services in the study area, benefit transfer method was applied to estimate the values particularly regulating, supporting and cultural services. This therefore involved adjusting estimates from original studies mainly drawn from tropical forests, based on site specific characteristics, number of affected people, economic factors as well as target area of the ecosystem. BTA has various advantages as illustrated by some studies (de Groot *et al*., 2010; TEEB, 2010; Bunse *et al*., 2015) for instance the fact that it is faster and more economical than conducting an original valuation study; economic benefits can be estimated more quickly; it can be used as a screening technique to determine if a more detailed, original valuation study should be conducted; and it can be applied for making gross estimates of comparable sites with ease as the more similar the sites, the fewer the biases of the estimates. The limitations of BTA include inaccuracy, mostly being useful for estimating gross values except for very similar sites; appropriate studies for the policy or issue in question may be difficult or may be unavailable; and accuracy of benefit transfers being dependent on the precision of primary study (DEFRA, 2007; de Groot *et al*., 2010; Hauck *et al.*, 2016).

In this study, extensive literature review was carried out to find appropriate valuation studies that could be applied to the study area. Application of benefit transfer was found important as it reduced the need for primary valuation studies for each cost-benefit especially when dealing with multiple non-market goods and services. In this study, values of regulatory and cultural services based on BTA were predominantly established from tropical forests where no appropriate information was available locally that could be applied to meaningfully estimate many of the services.

2.7.2 Non-economic valuation

Aberdare forest ecosystem also provided values which were deemed important by forest adjacent communities. Non-economic valuation, also referred to as non-monetary valuation (NMV) was applied. NMV has emerged and proliferated at a time when the literature on ecosystem services' valuation has been dominated by monetary valuation. In this context NMV offers an alternative to equating the valuation of Ecosystem Services with their monetization and reflects upon the plurality of values attached to ecosystem services (Orchard-Webb *et al*., 2016; Kenter, 2017).

Similar to monetary methods, different non-monetary methods are capable of capturing value plurality and heterogeneity to different extents of ecosystem services (Bunse *et al*., 2015; Kelemen *et al*., 2016a). NMV methods include quantitative and qualitative research techniques such as surveys and interviews (Milcu *et al*., 2013; Edwards *et al.*, 2016); participatory and deliberative tools like focus groups, citizens juries, participatory or rapid rural appraisal (PRA/RRA), Delphi panels (Balvanera *et al.*, 2014; Kenter *et al*., 2015); as well as methods expressing preferences in non-monetary but quantifiable terms for example preference assessment, time use studies, Q-methodology (Christie *et al*., 2012). These methods define the subject of valuation and the meaning of value along different perspectives, and they can be used to value diverse ecosystem services and aspects therein.

In this study, participatory (deliberative) environmental valuation (PEV) was applied. This is a non-economic valuation method that tends to explore how values obtained or opinions are formed or preferences expressed in units other than money (Bhatnagar, 2008; Bunse *et al*., 2015; Kenter, 2016; 2017). It has been noted that while economic valuation is the most widespread method used to compare people's perspectives on benefits, there is growing interest in non-monetary techniques (Kenter *et al*., 2011; Orchard-Webb *et al*., 2016). Participatory methods apply more of a qualitative approach rather than focusing solely on assigning economic values (Christie *et al*., 2012). These

can elicit values often by asking people to explain or discuss why they behave in a particular way or hold a particular view. The focus can be on what people think society should do, rather than on their personal behavior (Chan *et al.*, 2012a; Kelemen *et al*., 2016b; Kenter *et al*., 2016).

This approach was applied in this study to estimate the flow of regulating and cultural ecosystem to households adjacent to Aberdare forest. Pearce (2001) stated that the economic value of the environment refers to the role of the environment in satisfying human preferences. What is measured is not the value of the environment *per se* but the human value of the environment (Bhatnagar, 2008; María *et al.,* 2015). PEV was used to estimate the value of perceived forest conservation - regulating and cultural ecosystem such as watershed protection, local climate regulation, aesthetic and cultural importance; and biodiversity conservation and source of indigenous knowledge. The values were elicited from environmental conservation groups in the area, selected to represent the views of the forest adjacent community.

PEV was used to elicit values by asking people to explain or discuss why they behave in a particular way or hold a particular view rather than focusing solely on assigning economic values. This approach used expert/stakeholder groups to represent the general public. In this study, PEV was used based on focus group discussions with six conservation groups that were interacting with the ecosystem in various ways. The approach was used to examine the importance, preferences, needs or demands expressed by people towards nature, and articulate plural values through different qualitative and quantitative measures other than money (Chan *et al*., 2012a; Kelemen *et al*., 2016b). This was to grasp the multi-dimensional nature of human well-being with monetary value being just one aspect of importance beside e.g. symbolic, cultural, ecological and spiritual. These provided the community preferences for regulatory and cultural ecosystem services. The intention was to obtain a collective view on what people think about the forest ecosystem, focusing on patterns of attitudes and shared perceptions which did not represent solely the views of individuals (DEFRA, 2007; Hanley *et al.,* 1997; Muhammed, 2006; Kenter *et al*., 2015).

PEV is employed often in combination with economic valuation studies that use stated preference methods. The combined information allows for an improved understanding of the reasons for and motivations of respondents' valuation responses (Hanley *et al.,* 1997; Wilson & Howarth, 2002; DEFRA, 2007; Orchard-Webb *et al*., 2016). Therefore, the choice is not a case of either economic

or non-economic valuation methods but of using a combination of both to gain a deeper understanding of people's preferences and the process of decision-making.

Subsequently, the services that the community held in high regard were then investigated using BTA to impute the monetary values. It was applied to estimate the monetary value of perceived forest conservation of regulatory and cultural services such as watershed protection, local climate regulation, aesthetic cultural importance; biodiversity conservation; and source of indigenous knowledge. The various methods were applied in this study because diverse studies have shown that it is important for economic valuation studies that use stated preference methods to use participatory methods (Bhatnagar, 2008; DEFRA, 2007; Langat & Cheboiwo, 2010). The combined information allows for an improved understanding of the reasons for and motivations of respondents' valuation responses (Bull *et al*., 2016; Kenter, 2017). The combination is meant to explore how opinions are formed or preferences expressed in units other than money.

2.8 Knowledge Gaps Addressed by the Study

There has been a few recent attempts to determine economic value of forest ecosystems in Kenya that have provided ample evidence that ecosystem values can be substantial (Langat & Cheboiwo, 2010; Rhino Ark, 2011; Musyoki *et al.,* 2014). However, most of the information is based on valuation of provisioning services, both wood and non-wood products to the forest adjacent community.

This study therefore sought to assess the value of all forest ecosystem services to communities living adjacent to Aberdare Forest Ecosystem. This involved valuation of the provisioning, regulating, cultural and supporting services as defined by MEA (2005a). This is because forest ecosystem uses and subsequent degradation are driven by household choices. The study therefore, estimated the value of forest ecosystems with reference to forest adjacent communities' values, perceptions, needs and priorities.

The reciprocal link also implies that improved forest management would also impact on livelihoods of adjacent communities. Thus, this link necessitates promotion of PFM so that communities can safeguard their very livelihood. This requires understanding of the existing economic values of forest ecosystems in the household economy as also observed by Musyoki *et*

al. (2013). Naturally, placing a monetary value on ecosystem services and involving communities supports conservation and avoids destructive extraction. Therefore this study set out to evaluate socioeconomic factors that could promote PFM to improve livelihoods while enhancing sustainable forest conservation.

The introduction of PFM to Kenya was reported to improve forest condition and to some extent alleviate households' poverty (Ongugo *et al.*, 2007; Ogada, 2012; Mogoi *et al.*, 2012). The limited studies like Matiku *et al.* (2013) and Tesfaye (2017) that analyze the impact of PFM on livelihood fail to trace the causal attributes that promote household involvement in PFM. Thus, there is an empirical knowledge gap on drivers of participatory forestry in Kenya. This study aimed at bridging the knowledge gap between values of ecosystem services to the adjacent communities and effect of different FMAs on these values. Assessment of the effect of management approaches, household socioeconomic attributes and their relationship and influence on community involvement in PFM was done.

2.9 Conceptual Framework

Forest valuation is a tool that can provide society and decision-makers with information to choose among alternatives or preferred combinations of possible interventions that contribute to sustainable forest management. Thus, valuation provides a means of quantifying the benefits that people obtain from forests, the costs associated with their loss, and the relative profitability of land and other resource uses which are compatible with forest conservation vis a vis those activities that contribute to their degradation. Valuation also enables prediction and better understanding of the economic motives, decisions and activities that impact on forest integrity and status (de Groot *et al.*, 2010; Bastian, 2013; Balvanera *et al*., 2014).

Forest valuation in this study was done based on the TEV framework as a basis for evaluating the economic value of ecosystem services that various stakeholders derive from forests such as the Aberdare. The ecosystem goods and services have been categorized as use and non-use values and expressed as provisioning, regulating, cultural and supporting services whose sum total is termed as total economic value. TEV provides a holistic spectrum of use and non-use values From this perspective, direct benefits (provisioning services) accruing from the forest ecosystem include timber, fuel wood, poles, medicines, bamboo, thatching materials, ropes, fodder/foliage, tourism

and ecotourism benefits. The indirect values (regulating and supporting services) such as water catchment, soil erosion control, climate regulation, carbon sequestration, biodiversity conservation and wildlife habitat. Other benefits include option values and existence values (cultural services) (Emerton, 1996: Fisher & Turner, 2008; Daily *et al.*, 2009; TEEB, 2010).

Thus, the concept of TEV can be depicted as;

$$TEV = DV + IV + OV + XV - \qquad \text{(Equation 2)}$$

Where;

TEV = Total economic value
DV = Direct values
IV = Indirect Values
OV = Option values
XV = Existence values

To enhance sustainability, the deliberate studying and understanding human interactions with ecosystems and appropriate ways to involve them in management is fundamental. As such, decentralization of forest management and public participation is widely recognized as an important process for sustainable forest management. FMAs that focus on incorporating local people into forest management need to take cognition that communities are not homogeneous and any intervention should take into account that unsustainable resource extraction is frequently the result of many decentralized decisions made daily by individuals and households regarding use of forest resources and not the consequence of collective decision-making (Hulme & Murphee, 2001; Fisher *et al*., 2009).

It is therefore essential to understand the household-level socio-economic conditions and incentives that make the resource valuable to individual members of the community (Mbairamadji, 2009; Hulme & Murphee 2001). This therefore implies there is important degrees of variation in the benefits of forest ecosystem resources and costs of forest use restrictions across households. Lutz (1994) and Gaveau *et al*. (2009) further recommended that taking into consideration the benefits and costs at the household level is crucial because this is the level where conservation management measures are undertaken. Since forest ecosystem uses and subsequent degradation are driven by household choices, this calls for thorough analysis of socio-economic factors that

influence their interaction with the forest ecosystems through their involvement in PFM to enhance conservation while improving livelihoods (Figure 2.2).

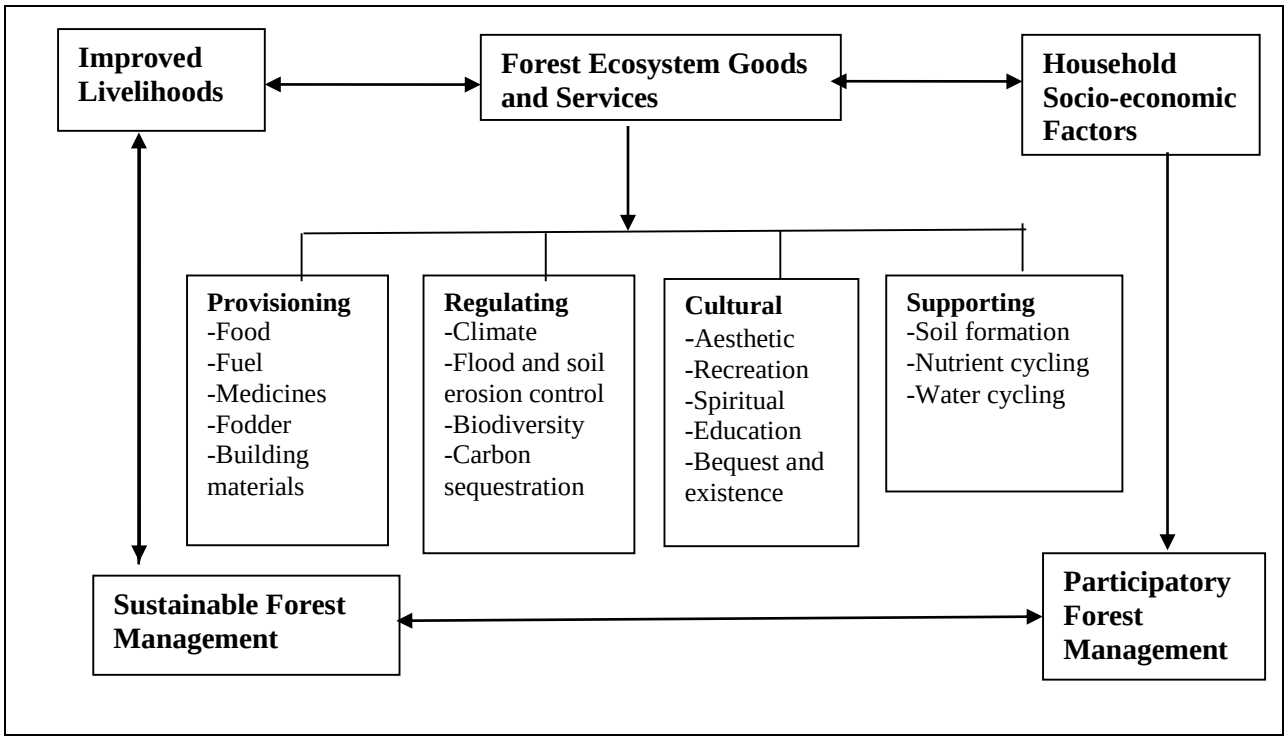

Figure 2.2: Conceptual framework used in this study

Adapted from MEA, (2005) and de Groot *et al*. (2010)

It is presumed that the reciprocal link also implies that improved forest management would also impact on livelihoods of adjacent communities. Thus, this link necessitates promotion of PFM so that communities can safeguard their very livelihood. This requires understanding of the existing economic values of forest ecosystems in the household economy as also observed by Musyoki *et al*. (2013). Naturally, placing a monetary value on ecosystem services and involving communities supports conservation and avoids destructive extraction.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 The Study Area

The study focused Aberdare Forest Ecosystem which a montane forest in Kenya. The montane forest ecosystems include the five major water towers: Mount Kenya, Aberdare Range, Mau Forest Complex, Mount Elgon and the Cherangani Hills. They represent the largest tracts of high-canopy forests that form the upper catchments for most of the main rivers, and are sources of essential wood and non-wood products. Aberdare fores ecosystem is unique, as it consists of both a Forest Reserve and a National Park, which share boundaries with adjacent farmlands (Figure 3.1). Aberdare forest is located between longitude 36^0 30'E and 36^0 55'E and latitude 0^0 05'S and 0^0 45'S. The forest ecosystem was gazetted in 1943 as a Forest Reserve. Subsequent excision and regazettement of part of the reserve into a National Park was done in 1950.

The forest ecosystem is approximately 226,522 ha, whereby the Forest Reserve covers an area of 149,822 ha and the National Park covers 76,700 ha (KFS, 2010). Aberdare forest is adjacent to four administrative counties, which are Nyandarua to the North West, Nyeri and Murang'a on the Eastern side and Kiambu to the South. The forest area is managed under two FMAs (Dunker *et al.*, 2012). The KFS manages the area gazetted as Forest Reserve using conservation (allows some sustainable use) FMA whereas KWS manages the National Park using protection (allows only conservation-related use) FMA.

The climate of the Aberdare forest is largely determined by altitude. The forest is on a series of mountainous ranges that vary in altitude ranging from 2,000m on eastern forest boundary to 4,000m at the peak of Ol Donyo Lesatima towards the northern edge of the range. The Aberdare forest is therefore sometimes referred to as the Aberdare ranges. The mean maximum temperature is 25.8^{o}C and the mean minimum temperature experienced in the months of July and August is 10.3^{o}C. The distribution of the rainfall is bimodal.

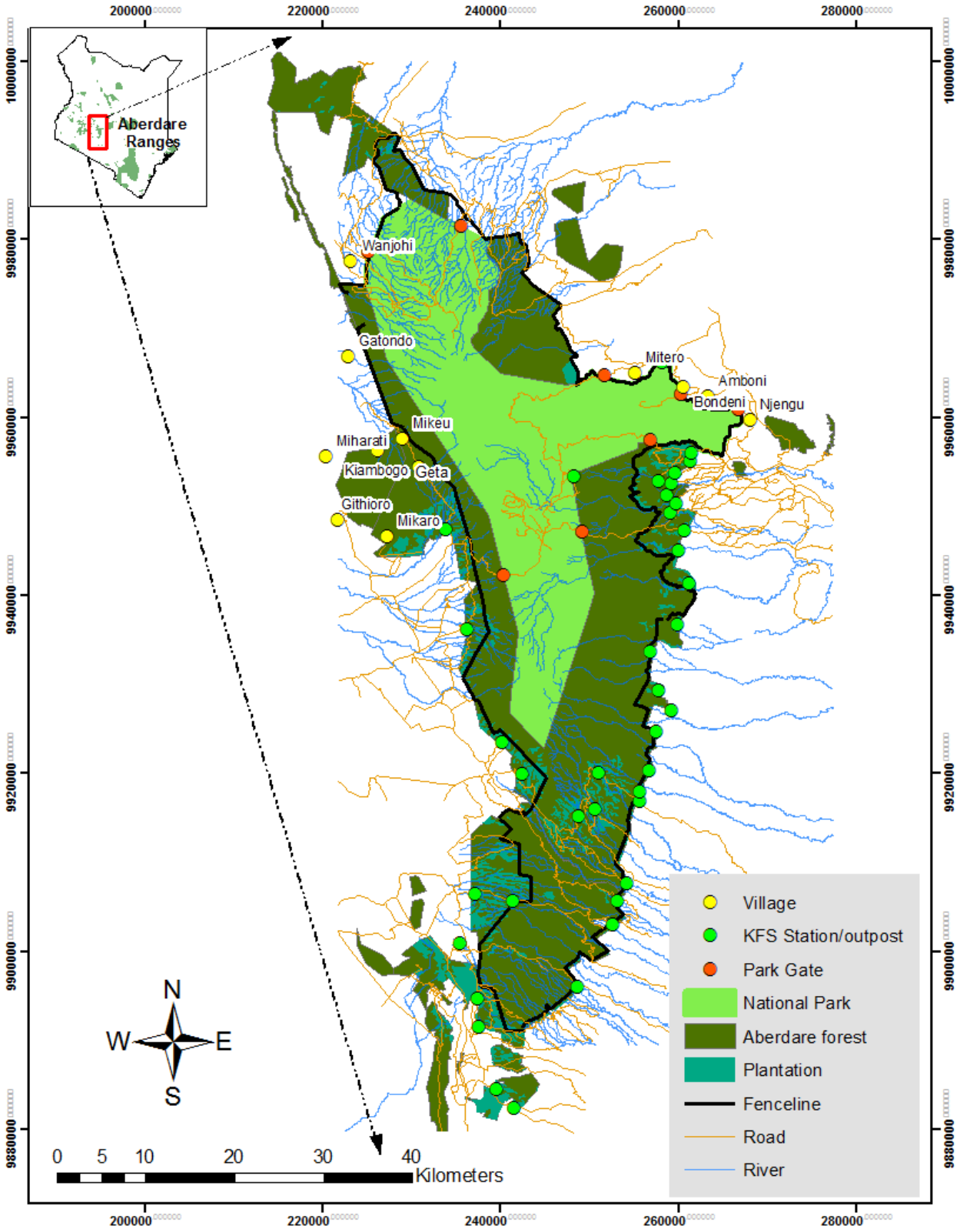

Figure 3.1: Map of Aberdare forest ecosystem showing the study sites.

The eastern side of the Aberdare forest experiences equatorial type of climate, which is wet and humid with reliable rainfall and extended wet seasons. The rainfall ranges from 1,400 to 2,200 mm per year. On the western side, rainfall decreases sharply from about 1,400 mm at the forest border to less than 700 mm per year in the Malewa River valley, which is only 50 km away from Aberdare forest (Jaetzold *et al.*, 2006).

The Aberdare Forest Ecosystem is one of the five water towers in Kenya. It provides water to feed four out of Kenya's five major drainage basins. The main rivers from the Aberdare forest are; Tana and Athi which flow into the Indian Ocean, the semi-permanent Ewaso Nyiro which drains into northern Kenya, and Malewa River that drains into Lake Naivasha. In addition numerous tributaries flow from all sides of the Aberdare and increase their water volume downstream. Higher up the moorlands and afro-alpine zones, numerous water bogs marking the source of many streams and rivers dot the slopes. The Aberdare forest, also referred to as the Aberdare ranges supplies all the water to Nairobi City through Sasumua and Ndakaini dam. It also supplies water to the major towns in the neighbouring districts. Together with the Mt. Kenya, these two catchments, provide water for the bulk of Kenyas' hydroelectric schemes along the Tana River. Many small weirs have been installed in the forest to supply water to the forest adjacent communities (KFS, 2010).

The Aberdare ranges are essentially the product of fissure volcanic eruptions. The soils on the upper eastern slopes have inherent high fertility, being of basaltic origin. They are well-drained, normally very deep, dark reddish brown, friable clays with a humid top- soil layer. Soils on the western boundary of the ranges are of medium to high inherent fertility, but are more variable and interspersed with poorer draining soils and lower fertility. The soils of the Northern Aberdare are rich in clay content (82.7%) and consist almost exclusively of kaolinite. The soils of the southern area are characterized by dark surface horizons and are rich in organic matter (Jaetzold *et al.*, 2006). Agriculture is the main economic activity for communities adjacent to the Aberdare forest ecosystem. The type of agriculture practiced and the potential of productivity depend mainly on altitude as it determines temperatures and amount of rainfall.

The fertile soils attracted agriculturists who settled in the lower slopes of the mountain. Subsequent population increase led to gradual encroachments into upper slopes and destruction of the forest. The agricultural practices are both large-scale (horticulture, floriculture and silk farming) and

small scale. Wildlife conservation (ranching and game sanctuaries) is also practiced adjacent to the forest under freehold (private ownership).

The area around the Aberdare forest ecosystem is densely populated with many areas with 565 people/km^2, particularly in the East (KNBS, 2010). The people who live adjacent to the forest depend heavily on the forest for their livelihood. Hence the forest adjacent communities view the forest as a reservoir of goods and services. Some parts of the forest have been opened up for cultivation under the Taungya system (previously called Shamba System). So far the system has been modified and renamed Plantation Establishment and Livelihood Improvement Scheme (PELIS) (KFS, 2007). There has been conflict of interest from the use of land within the forest and along the forest boundaries for cultivation. The Kenya Forest Service looks upon the cultivators as contributors to forest development while cultivators would like the forestland to continue being the source of the food crops (Musyoki *et al*., 2013; Ongugo *et al*., 2014). Hence Aberdare forest ecosystem forms a good study site for determination of: contribution of ecosystem services to livelihoods, existing and potential factors that enhance PFM under diverse FMAs.

3.2 Research Design

A cross-sectional socio-economic survey was used to collect and collate data. Cross-sectional studies (status studies) were found useful in obtaining an overall picture at the time of the study as they are designed to study a phenomenon by taking a cross-section of it at a time. A study is cross-sectional with regard to both the study population and the time of investigation (Kumar, 1999; Frankfort-Nachmias & Nachamias, 2004). Under this design, the study identifies the phenomena, situations or problems to be investigated, study population, selection of samples to obtain the information required (Babbie, 1995; Mugenda & Mugenda, 2003).

3.3 Sampling Procedure

A two level sampling procedure was employed. First, the forest adjacent communities were stratified on the basis of FMA. That is whether they were adjacent to Forest Reserve or National Park. Secondly, the area was stratified on the basis of sub-locations directly adjacent to the Aberdare forest. Sub-locations are government administrative units at local community level. They are headed by Assistant Chiefs. Through systematic random sampling, households were identified within the selected sub-locations.

3.3.1 Stratification by forest management approach

The communities bordering the forest ecosystem were stratified based on FMA of adjacent forest because the kind of forest products availability, access, control, utilization and conservation, level of community participation, threats and opportunities varied depending on management approach in place. The selected area under KWS was the only area in the ecosystem where farmlands are adjacent to the National Park. This was a dry forest and the management approach legally allowed non-extractive uses except for water. The selected area of the Forest Reserve was a high forest and management approach allowed controlled extraction of forest products. It was selected because it had an area set aside for forest cultivation under the *shamba system* which was re-introduced as Plantation Establishment for Livelihood Improvement Scheme (PELIS) (KFS, 2010).

3.3.2 Stratification by forest adjacent sub-locations

The forest adjacent sub-locations were chosen as an entry point for this survey because of the various reasons, mainly; (i) Past research has found that communities directly adjacent to forest areas depend heavily on forest resources to meet various household needs (KFMP, 1994; Mogaka, 2000; Karanja *et al.,* 2001; Langat *et al*., 2016) (ii) The community bears a large proportion of conservation costs both directly and indirectly (Shyamsunder & Kramer, 1996; Langat & Cheboiwo, 2010) (iii) The communities also play an important role in conservation of these resources either as agents of destruction or catalysts of conservation (Rhino Ark, 2011) (iv) Sub-locations are the most visible administrative units with clear boundaries which can be used to delineate the research sampling frame (KNBS, 2010).

Survey households were from 16 administrative sub-locations. These were twelve (12) adjacent to Geta Forest Station in Nyandarua County under KFS. The other four (4) were in Kieni West within, Nyeri County adjacent to the National Park under KWS. The total number of households in each sub-location was derived from government of Kenya 2009 human population census data. Kenya population 2009 census data indicated that the sub-locations adjacent to the Forest Reserve were densely populated with a total of 23,824 households. In comparison, the sub-locations adjacent to the National Park had 3,246 households (KNBS, 2010).

3.3.3 Sampling frame and unit of analysis

The study used the household as the unit of analysis whereas the total number of households in the study 16 forest adjacent sub-locations constituted the sampling frame. Decision to employ households as the unit of analysis was based on the fact that;

i. Forest ecosystem uses and subsequent degradation are driven by household choices.
ii. The household provided an important matrix, which facilitates an analysis of supply and demand of ecosystem services.
iii. The household was also an important decision making organ with the potential to influence community involvement in PFM
iv. It was the unit that can directly be affected by the impacts of conservation or degradation of forest ecosystem.

3.4 Sample Size

In this study, a sample size of 202 households at 95% confidence level was selected for administration of questionnaire (Table 3.1). The decision over the total number of respondents selected was influenced by availability of time, financial and physical resources. It was also guided by World Agroforesty Center's (ICRAF) procedural guidelines for characterization of studies at household level as described by Nyariki *et al*. (2005). These suggest that a sample size of 70 households spread over two or three communities is adequate to make inferences about a larger population. Further, on the understanding that forest adjacent populations are similar in many aspects, the survey did not require a very large sample.

Finsterbusch *et al*. (1983) recommended that samples of 40 to 80 provide useful information on populations with similar characteristics and attitudes if used carefully. In this study, the sample size was drawn through systematic random sampling proportionately allocated based on total number of households in each sub-location and partly population density. Although 202 households were interviewed, the n value in the tables sometimes varies. This is due to non-participation of households in some activities or missing variables, resulting in some households being excluded from a certain parts of the analysis.

Table 3.1: Study sites and distribution of the households surveyed

FMA	County	Locations	No. of Sub-locations	No. of households	HH Interviewed
Conservation (Forest Reserve)	Nyandarua	Wanjohi, Geta, Kipipiri, Kinangop North	12	23,824	115
Protection (National Park)	Nyeri	Mweiga, Endarasha	4	3,246	87
Total	**2**	**6**	**16**	**27,070**	**202**

Source: KNBS, 2010 and Field Survey, 2012

3.5 Data Collection Methods

3.5.1 Reconnaissance survey

A reconnaissance survey was undertaken initially both in the forest and adjacent farmlands to provide a better understanding on the diverse issues regarding goods and services from the Aberdare forest ecosystem, community structure, local resource governance institutions, marketing of forest products, community perceptions, attitudes and priorities regarding forest use and conservation, forest utilization patterns, and household economy. The preliminary findings informed the design of a semi-structured and non-scheduled-structured questionnaire and provided information about conservation groups.

3.5.2 Pre-testing of the household questionnaire

Surveys were carried out between March 2012 and February 2014. The questionnaire (Appendix 1) were pre-tested and essential adjustments made before their final administration. Locally generated resources reflecting on-the-ground situations were found more appropriate (Shyamsundar & Kramer, 1996). Pre-testing was also conducted to identify weaknesses in the presentation and comprehension of the tool by both the enumerators and respondents. The questionnaire was administered to 12 respondents including 2 conservation groups and 2 key informants who were not included in the final sample. The use of counters was also pre-tested on the respondents to assess their ability to prioritize their preferences for forest conservation for indirect and existence values. The pre-testing stage ensured that only relevant questions were asked and the whole range of forest values, services, costs and pricing was covered.

3.5.3 Design of survey instruments

The semi-structured and non-scheduled-structured questionnaire (Appendix 1) was employed to elicit quantitative and qualitative household socio-economic characteristics, forest ecosystem benefits and functions and other relevant data and information (Neuman, 1997; Frankfurt-Nachmias & Nachamias, 2004). Some of the key issues that were raised in the questionnaire included household information – household size, age, gender and educational level of respondents; duration of settlement, household members working on the farm, landholding and productivity; distance to the forest, forest uses – benefits, costs, annual consumption of forest products; market value and opportunity cost of procuring forest products and alternative sources of meeting forest based needs (Nyariki *et al.*, 2005; Langat *et al*, 2016).

The inclusion of non-scheduled-structured approach was preferred as opposed to scheduled-structured interview in which the questions, their wording and sequence are identical for respondents. This was because non-scheduled-structured interviews gave respondents an opportunity to define the situation presented to them and they were free to express their perceptions relating to the research questions (Neuman, 1997; Mugenda & Mugenda, 2003). It also allowed probing details of other relevant issues that can explain the respondent's preferences, perceptions and values of forest resources.

A group checklist was used to guide forest conservation groups during focus group discussions comprised of 10-15 members to elicit information on sources and pricing of forest resources, current level of community participation in forest management, valuation and perceptions of indirect, option and existence values. The use of counters assisted the respondents to assess and prioritize their preferences of regulatory and cultural ecosystem services. The price of the forest products was established at the household level first to obtain the mindsets and attitudes of the respondents through individual responses and afterwards through the group discussions to ascertain whether personal and group opinions were in agreement. This added to the reliability of the study (Babbie, 1995; Mugenda & Mugenda, 2003).

3.5.4 Household interviews

The study adopted household units within the selected sub-locations bordering the Forest Reserve and National Park as the sampling units. Eleven enumerators were recruited to assist in the household socio-economic survey. The enumerators were selected with assistance of the KFS and

KWS staff working in the area on the basis of their vast understanding of the adjacent forest area and community interaction with the forest ecosystem. Recruitment was on the basis of knowledge of the area adjacent to the forest and community interactions with the forest ecosystem. Thus, enumerators were drawn from the community adjacent to Aberdare forest ecosystem. The capacity of the enumerators to address the needs of the study was evaluated before recruitment. The enumerators were trained for two days to familiarize with, and administer the questionnaires.

The whole process was rigorously supervised to ensure that enumerators complied with established procedures. The study utilized systematic random sampling to select households from the sampling frame, where every eighth household on alternate side of the road was interviewed. The household heads or their representatives were interviewed. If an interview was not possible due to the absence of household members or a suitable representative, the subsequent household was selected. This ensured that each household had an equal chance of being selected. A household as used in this study was defined as a group of people who regularly shared the same "cooking pot" (Nyang, 1999).

The face-to-face approach was favored over other methods like telephone interviews and mail surveys due to the low level of literacy especially among the elderly and the limited availability of telephone facilities within the study area. Further, although face-to-face interviews are more expensive, they generally ensure a higher response rate and better responses where questions are of a technical nature and require further explanation. The method also allows use of pictorial aids for easier conceptualization of various forest uses (Emerton, 1996; Kumar, 2002; Mugenda & Mugenda, 2003). The data collected was based on people's own perceptions and reported values about household wealth and net income in their local context. Importantly respondents were assured of complete anonymity so that they could feel free to provide information. The financial information was collected in Kenya shillings, but was later converted to United States Dollar equivalents for ease of reference based on an exchange rate of 100 Kenya Shillings to the US Dollar (US$) during the survey period.

3.5.5 Focus group discussions

To obtain the appropriate conservation groups, key resource managers, mainly KFS, KWS, WRA and Agricultural officers, local administrators as well as opinion leaders and working/living in the area were used. They were requested to provide a list of stakeholder groups participating in various aspects of conservation of natural resources in the ecosystem to represent the general public. The

groups included Community Forest Association (CFA), wildlife conservation groups, water project committees and Water Resource Users Associations (WRUAs).

Non-probability purposive sampling was used to select community conservation groups to participate in focus group discussions (FGD). This was found suitable as it provides a sample of observations that are expected to yield the most comprehensive understanding of the subject that was being studied (Babbie, 1995; Kumar, 1999). This also enabled selection of a wide variety of respondents who had the required information such as diverse aspects of ecosystem services, resources, utilization, pricing, availability, accessibility and values of ecosystem services that are not based on household level such as water catchment, climate regulation, cultural values and tourism activities.

Focus group discussions were held with six selected groups using a checklist or open ended checklist which was used to guide the discussions. The open ended questionnaire was to elicit information on sources and pricing of forest resources, current level of community participation in forest management, valuation, perceptions and prioritization of indirect, option and existence values.

3.5.6 Opportunity cost of converting forest land in Aberdare forest ecosystem

Usually, local communities forego a lot of benefits such as possible agricultural and livestock production, timber and other products they could harvest while others downstream enjoy benefits of conservation without paying for them (IUCN, 1996; Bush *et al*., 2011; Fisher *et al*., 2011b). In the absence of the forest, the land occupied by natural forest, plantations and bushland could be put under human settlement and agricultural and livestock production. Therefore, the opportunity cost of maintaining this forest is the net benefits foregone from the potential agricultural and livestock production as this was the main economic activity of the adjacent community. This study applied the average annual production per household obtained from the survey. Based on the topography, geology of Aberdare forest ecosystem, the entire forest area is not arable. This study converted the area under natural forest, plantation and bushland which was approximately 64% of the total 226,522.0 ha, hence the study made use of 144,974.08 ha of arable land to derive the opportunity cost of forest conversion.

3.5.7 Forest management approaches and importance of the forest ecosystem

The study investigated the association and relationship between the FMA and the values local communities attach to the forest ecosystem. The respondents were requested to indicate - whether they value the forest ecosystem mostly for its economic (provisioning) or non-economic (regulatory and cultural) services, their sources of food and income and their annual income was calculated based on the responses on income sources and amounts from each. Based on the annual income levels, households were categorized as very poor, poor, average, rich and very rich The operationalization of these variables was as shown in Table 3.2.

Table 3.2: Descriptors of community perceptions of the importance of the ecosystem

Importance	Indicators/descriptors	Value labels	Score
Source of household food	Rented or private farm, forest cultivation (PELIS plot) and purchase from market	Forest (PELIS)	1
		Own private/rented land	2
		Market	3
Sources of income	Agricultural products, livestock and livestock products, forest, casual labor, business and remittances	Agricultural products	1
		Agriculture and Livestock	2
		Livestock	3
		Forest products	4
		Casual labour	5
		Salary/remittance	6
Household perception of the importance of forest ecosystem	Non-economic like rainfall, soil conservation, wildlife habitat (regulatory, cultural and supportive services)	Non-economic	1
	Economic – harvesting of wood and non-wood products(Provisioning services)	Economic	2
Household forest dependence	Few or none used	Very low	1
	Market	Low	2
	Own farm	Moderate	3
	Both Forest and Farm	High	4
	Forest mainly	V. High	5
Household annual income (KES)	<25,000	Very poor	1
	25,001 – 50,000	Poor	2
	50,001 – 75,000	Average	3
	75,000 – 100,000	Rich	4
	> 100,000	Very rich	5

To obtain the values local communities attach to the forest resources, variables indicating the household's main sources of forest products were redefined and weighted to calculate the indices.

It was considered for example, that those who depend mostly on the forest for various products have a higher value than those who meet their forest products needs from elsewhere.

3.5.8 Community involvement in PFM

The study used various socio-economic factors to find out their association, relationship and influence on household involvement in PFM from the 202 respondents. The attributes included type of adjacent forest, gender, age, education level, household headship, reasons for settlement in the area, duration of settlements, farm size, household size, number of household members working in the farm, distance to Forest Reserve or National Park, household land renting (in or out), main source of household food, group membership, type forest user group as well as household income and sources. These were as described in Table 3.3.

Table 3.3: Operationalization of household socio-economic factors

Variables	Descriptors
Community demographic profile	Age, Education level,
Household dwellings	Number, construction materials
FMA	Conservation, Protection
Distance to the ecosystem	Forest Reserve, National Park
Gender	Gender of respondent and household head
Settlement in the area	Settlement history, duration of settlement
Land adequacy	Farm size, land renting in or out, land tenure
Livestock keeping	Forest, own farm, type of animals, type of grazing, etc.
Household use of water	Water sources, availability, quantity
Household members	Size of household,
Household members occupation	members working in the farm or employed elsewhere
Main source of household food	Own/rented farm, PELIS, market
Household participation in groups	Group membership, duration of membership, membership to forest user group
Source of household income	Agriculture, livestock, Salary/remittance, casual labour
Household income	Total household annual income
Household sources of forest products	Farm, forest, market

3.5.9 Households' level of involvement in PFM

In addition, the detailed questionnaire had the respondents indicate their interaction with the adjacent forest and various activities were considered as different levels of involvement in PFM. Table 3.4 shows the description and measurement levels of the variables considered to be indicators of household involvement in PFM.

Table 3.4: Scores for activities in the index for household level of involvement in PFM

Activity	Scores	
	Forest Reserve	National Park
Grazing in forest	3	0
Cut and carry grass	3	0
Enter forest	1	1
Contribute to management	3	2
Harvest products	3	1
Tree planting	3	3
Forest policing	3	3
Fire fighting	3	3
Membership to forest user group (FUG)	3	3
Decide on who can enter forest	2	2
Lease forest land	1	0
Cultivate in forest (PELIS)	3	0
WTP	3	3

Using the above criteria for the definition of household level of involvement in PFM, these variables were redefined and weighted in order to calculate the indices. It was considered for example, that the more a household interacted with the forest, the higher their involvement in PFM (Table 3.5).

Table 3.5: Indices for households' level of involvement in PFM

Value labels	Range of scores
Low	0 – 5
Moderate	6 – 10
High	11 – 15
Fully involved	> 15

3.6 Data Analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS) for Windows Version 21 and MS Excel 2013. Descriptive statistical analysis was performed to generate both qualitative and quantitative data sets to provide information like frequencies, means, sum and percentages **(**Babbie, 1995; Mugenda and Mugenda, 2003). In addition, Chi Square was used to test the association between the diverse household socio-economic factors, FMA and and PFM whereas Spearman's rho correlation was used to test the strength of the relationships between these factors. The relationships that gave statistically significant Chi Square and Spearman's rho correlation results were further investigated using logistic regression analysis to ascertain the cause-effect of the socio-economic factors upon community level of involvement in PFM. The summary of

valuation methods, socio-economic factors and statistical tests carried out was as shown in Table 3.6

Table 3.6: Summary of objectives, methods of evaluation and statistical analysis

No.	Objective	Variables	Valuation method/Statistical test
1	Estimate the value of ecosystem services to communities adjacent to Aberdare forest ecosystem	Provisioning, Regulating, Cultural Supporting	Market price Willingness To Pay Participatory Economic valuation Method Benefit transfer Method
2	Evaluate the effect of FMAs on the values local communities attach to Aberdare forest ecosystem	Community perception on the importance of the ecosystem -sources of household food, -household annual income -household socio-economic status. -overall community forest resource values -PFM involvement level	Chi square Spearman's Rho correlation
3	Assess the socio-economic factors that influence community involvement in PFM	FMA, distance to FR and NP; gender of respondent and HH head, size, number of members working on the farm, settlement history, farm size, land renting, sources of food and income; group membership, importance of the forest ecosystem and household forest dependence .	Chi Square Spearman's Rho correlation Logistic regression analysis

A regression model was fitted where the coefficient of determination (R^2) was generated to provide information on the goodness of fit of the model. The higher the value of R^2 the greater the percentage of variation of the dependent variable explained by the regression plane. The general model applied was:

$$Y_i = b_o + bx_1 + bx_2 + bx_3 + \ldots\ldots bx_n \qquad \text{(Equation 3)}$$

Where;

Y_i = the i^{th} observed value of PFM
b_o = intercept
b = independent variable coefficient
x_1 to x_n are independent variables

CHAPTER FOUR

RESULTS

4.1 Socio-economic Characterization

4.1.1 Community demographic profile

Out of the whole sample size of 202 respondents who satisfactorily responded to the interview schedule, 57% were adjacent to the Forest Reserve. Among the households sampled, males comprised 61%, 78% were male headed and the mean household size was 7 members. In most (52%) of the households, 3-6 members of the family worked on the farm whereas 1-2 members were formally employed elsewhere. The average distances were 2.9 km and 1.6 km to the Forest Reserve and to the National Park respectively. The distribution of other demographic factors were as shown in Table 4.1.

Table 4.1: Community demographic profile

Demographic factors	Units	N	Minimum	Maximum	Mean
Age of respondent	Years	202	21.0	101.0	54.0
Duration of settlement	Years	202	1.0	50.0	32.0
Household size	No.	202	1.0	30.0	6.7
HH members working in the farm	No.	202	1.0	14.0	2.8
HH members formally employed	No.	44	1.0	6.0	1.5
Mobile phone	No.	202	0	13.0	2.3
TV	No.	96	1.0	4.0	1.3
Radio	No.	187	1.0	7.0	1.1
Distance to Forest Reserve	Km	129	1.0	6.0	2.9
Distance to National Park	Km	86	1.0	5.0	1.6

Majority (42%) of the respondents were in the area as a result of resettlement by the government after independence. The results also showed that 21% had purchased their land parcels. Majority (59%) of the sampled households had attained primary school education (Table 4.2). The results also indicated that most (96%) households had piped water for both domestic and livestock use Water for livestock was particularly important to those practicing zero grazing where they were the majority (60%) of farmers enhanced its availability by storing in water tanks.

Table 4.2: Households' settlement history, level of education and sources of water

Attribute	Frequency	Percent
Settlement reasons		
By birth	11	5.4
Purchased land	43	21.3
Marriage	11	5.4
Inheritance	53	26.2
Settlement by government	84	41.6
Total	**202**	**100.0**
Education level		
No formal education	10	5.0
Primary level	120	59.4
Secondary	61	30.2
Tertiary	11	5.4
Total	**202**	**100.0**
Main source of domestic water		
Piped water	125	61.9
Shared piped water	72	35.6
None	5	2.5
Total	**202**	**100.0**
No of water tanks		
1	92	45.5
2	23	11.4
>2	5	2.5
None	82	40.6
Total	**202**	**100.0**

Results from this study showed that farm sizes ranged from 0.3 to 50 acres with a mean of 3.5 acres and about 34% of the households were involved in either renting land out or in). Further, most (61%) households interviewed had small land parcels of less than 3 acres (Figure 4.1), as such the tendency of renting land in or out was common in the area (Table 4.3).

Table 4.3: Land size and land renting

Variable	N	Percent	Minimum	Maximum	Mean
Farm sizes (acres)	202	100.0	0.025	50.0	3.5
Land renting out (acres)	6	3.0	0.25	1.0	0.7
Land renting in (acres)	68	33.7	0.25	4.0	1.19
Cost of hiring land (KES)	74	36.6	1000.00	6000.0	2831

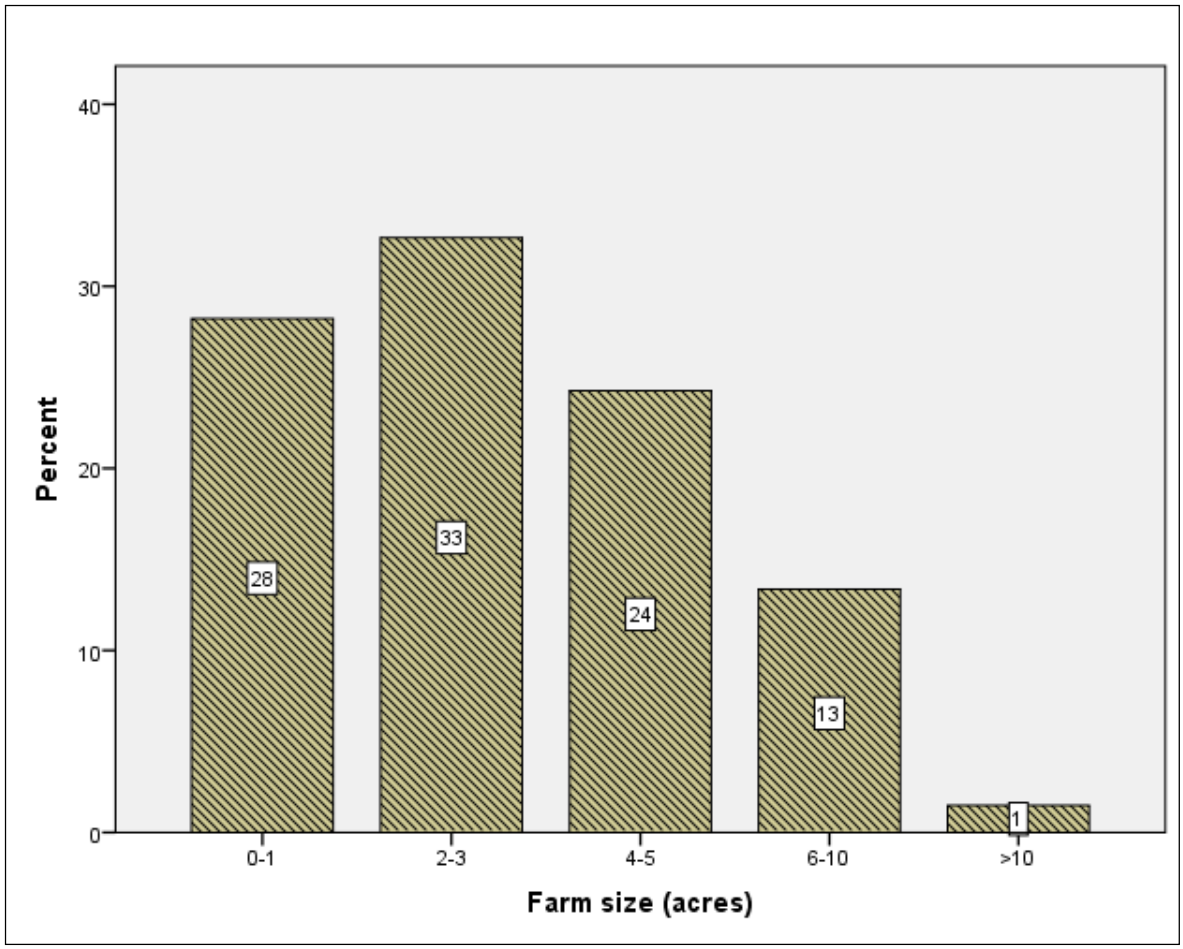

Figure 4.1: Farm size (acres) categories in the study area

The number of dwellings for the sampled households ranged from 1 to 9 with an average of 4 dwellings for each household. (Table 4.4).

Table 4.4: Wall construction materials for dwellings

No. of dwellings made of wooden walls	Frequency	Percent
1	23	11.4
2	41	20.3
3	35	17.3
4	29	14.4
5	8	4.0
6	12	5.9
7	5	2.5
8	2	1.0
9	1	.5
Sub-total	**156**	**77.2**
Other Materials	46	22.8
Grand total	**202**	**100**

On average most (77%) households had wooden structures where majority had 2 - 4 semi-permanent houses which were primarily made of timber and iron sheets. Only about 2% of the households had grass thatched roofs with mud walls.

4.1.2 Household sources of livelihoods

Majority (85%) of the surveyed households depended on food production from own or rented plots while 14% benefited from cultivation of forest land under the PELIS programme. The results also showed that 45% of the households depended on sale of agricultural crops as the most important source of income followed by 31% who relied on livestock and livestock products. The common livestock kept were mainly cattle, sheep and poultry with a few farmers rearing pigs. Since majority (61%) of the respondents had small land parcels, 23% and 16% depended on forest grazing of cattle and sheep respectively (Table 4.5).

Table 4.5: Household sources of food and income

	Frequency	Percent
Main source of household food		
Forest PELIS plot	29	14.4
Own /rented private land	171	84.6
Purchase from market	2	1.0
Total	**202**	**100.0**
Main source of household income		
Agricultural crops	91.0	45.0
Livestock and livestock products	62	30.7
Both crops and livestock	41	20.3
Forest products/ecotourism	3	1.5
Casual labour	3	1.5
Salary/remittance/others	2	1.0
Total	**202**	**100.0**
Livestock grazing		
No. of HH grazing cattle in forest	47	23.3
No. of HH grazing sheep in forest	33	16.3
No. of HH with an area of farm allocated to fodder	94	46.5
No. of HH with an area of farm allocated to pasture	105	51.9

Household annual income

Results from this study showed that the average household annual income in the area was KES 139,576 (US$ 1,396). However, a large proportion (26%) earned KES 25,000/yr (US$ 250/yr) or less (Figure 4.2).

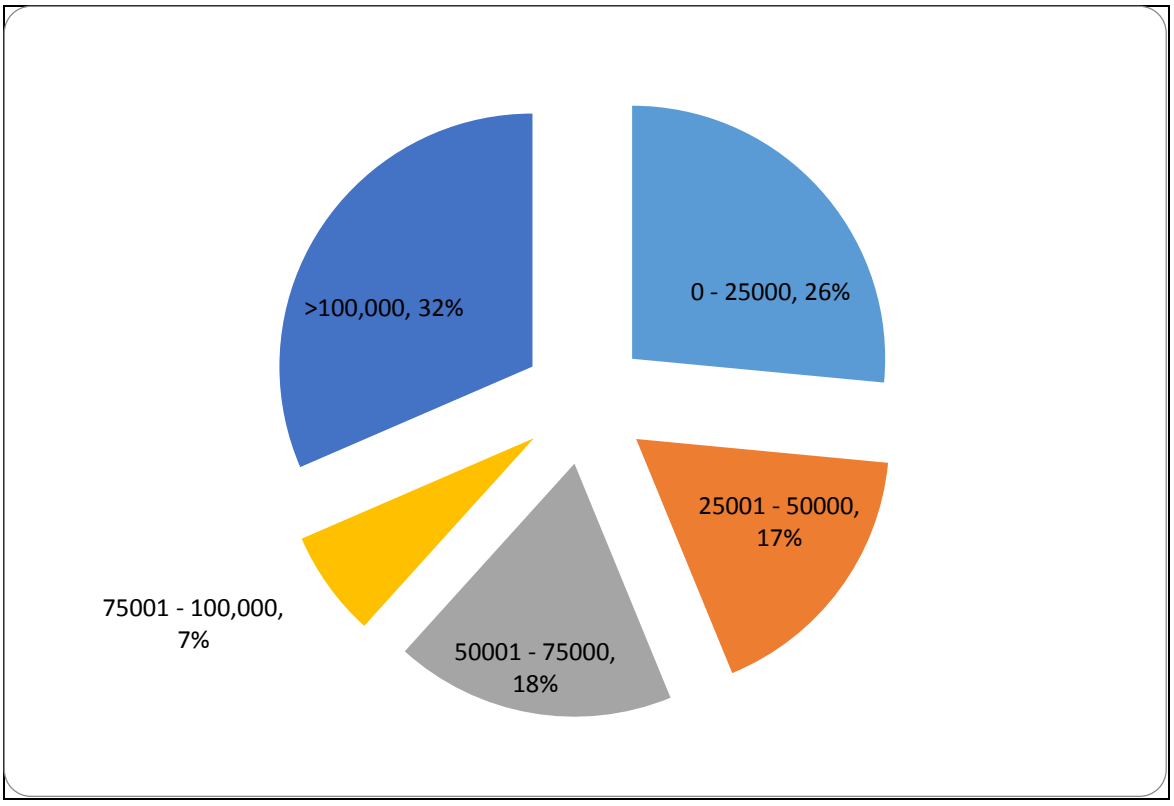

Figure 4.2: Annual household income (in KES) range

Household social stratification

Results from this study indicated that the socio-economic statuses of most (44%) households were in the very poor or poor category. That notwithstanding, there were 32% within the very rich category (Table 4.6).

Table 4.6: Household socio-economic status

Social status	Frequency	Percent
Very poor	54	26.5
Poor	35	17.3
Average	36	17.9
Rich	14	6.8
Very rich	64	31.5
Total	**202**	**100.0**

4.1.3 Household interaction with the forest ecosystem

Results from the socio-economic survey showed that the respondents utilized a wide range of forest products from the forest as well as from the farmlands. The majority (98%) of the households used the forest ecosystem as the main source of water as only 2% reported they depended largely

on stored rain water. Provision of fuelwood and grazing in the forest were viewed as the second (25%) and third (13%) most important respectively. In general, survey results indicated that many forest products utilized were essentially acquired from the farmlands except for wild game was solely obtained from the forest as shown in Table 4.7.

Table 4.7: Sources of forest products from farm and forest areas

Forest product	Total No. of HH involved	Total No of HH percent	Forest Reserve		Farm	
			No. of HH	Percent	No. of HH	Percent
Water	202	100.0	198	98	4	2
Fuelwood	142	70.3	48	34	94	66
Grazing	136	67.3	26	19	110	81
Fodder	63	31.2	17	27	46	73
Seedlings	35	17.3	1	3	34	97
Charcoal	32	15.8	1	3	31	97
Posts	30	14.9	15	50	15	50
Beehive	27	13.4	3	11	24	89
Timber	24	11.9	0	0	24	100
Poles	22	10.9	3	14	19	86
Wildlings	16	7.9	3	19	13	81
Herbs	10	5.0	4	40	6	60
Honey	8	4.0	4	50	4	50
Wild vegetables	6	3.0	0	0	6	100
Thatch	3	1.5	2	67	1	33
Wildfruits	2	1.0	0	0	2	100
Wild game	1	0.5	1	100	0	0

Although many (77%) households had used timber for house construction in the period requested under review, none of the surveyed households indicated they had obtained timber from the forest. All was from own farm, neighbour's farms or local market. To obtain timber, the respondents indicated that they purchased or sold mature standing trees to or from neighbours which were then converted into timber using simple methods like pit sawing and power saws (Plate 4.1).

Plate 4.1: On-farm tree harvesting and local processing of timber

Majority of households were involved in purchasing firewood (98%), charcoal (95%) and seedlings (95%) as the main products to meet domestic requirements whereas of those involved in production for sale, most dealt with honey (27%) and poles (17%) as shown in Table 4.8.

Table 4.8: Commercialization of forest products

Forest product	Total No. of HH involved	Purchased for domestic purpose		Produced for commercial purpose	
		No. of HH	Percent	No. of HH	Percent
Charcoal	61	58	95	3	5
Fuelwood	55	54	98	1	2
Seedlings	37	35	95	2	5
Honey	22	16	73	6	27
Timber	13	13	100	0	0
Posts	7	7	100	0	0
Poles	6	5	83	1	17
Beehive	3	3	100	0	0
Wildlings	3	3	100	0	0
Herbs	1	1	100	0	0

Nonetheless, some households were involved in small scale trade of forest products which were predominantly honey (27%) and poles (17%). All households involved in purchase of forest products such as timber, beehives, wildlings and herbs was primarily to meet domestic needs.

4.1.4 Division of labour for forest based activities

In the survey area, most of the forest based activities were predominantly carried out by men. Activities like collection of herbal medicine, fence attendants (fencing and maintenance of electric fence) and hunting of wild game were all (100%) performed by men some of them in their youth. The only activities performed by women at almost the same scale with men were collection of firewood (86%), thatching grass (79%) fodder for livestock (65%) and cultivating in the forest (45%). Youth and children were only involved to a small extent (less than 10%). Responses showing the involvement of men, women, youth and children in various forest related activities were as shown in Appendix 2.

4.1.5 Household participation in groups

The results of this study showed that the greater part (60%) of all the respondents were members of groups of which formal were 69%. Additionally, most (60%) respondents were members of forest user groups (FUG) as indicated in Table 4.9.

Table 4.9: Profile of community participation in groups

Group	Variable	Frequency	Percent
Member	Yes	140	60.0
	No	62	40.0
Group registration	Formal	91	68.9
	Informal	41	31.1
Type of group	Forest User Group	72	60.0
	Others	48	40.0
Family group member	Wife	29	32.6
	Husband	51	57.3
	Both/either	9	10.1
Duration of involvement	<1 Year	8	5.9
	1-3 years	50	36.8
	4-5 years	25	18.4
	>5 years	53	39.0
Household benefits from group	Large negative effect	1	1.1
	Small negative effect	3	3.2
	No effect	6	6.3
	Small positive effect	17	17.9
	Large positive effect	68	71.6

The respondents also indicated that most (57%) of the group activities were attended by the husbands. Results from this study showed that a high percent (90%) of the households derived benefits from group membership. The profile of different community members in terms of group participation, duration of involvement, benefits to household and household group member involvement.

4.1.6 Community perception on importance of forest ecosystem resources

Results from this study showed that respondents' utilization and hence value of the forest ecosystem mainly ranged between low (42%) to moderate (46). About 6% depended almost entirely on the forest ecosystem to me*et al*l their forest goods and/or services related needs whereas a similar number indicated no direct benefits from the forest (Table 4.10).

Table 4.10: Households' dependence on forest resources

Value level	Frequency	Percent
None	12	5.9
Low	85	42.1
Moderate	93	46.1
High	12	5.9
Total	**202**	**100.0**

4.1.7 Household involvement in PFM activities

In this study, the community narrated the different ways they were involved in PFM within the adjacent forests. There was variance in these activities depending on the type of forest (natural or plantation forest) and the management objective (protection or conservation) founded on the management approach. However, across the sites, there were some common activities undertaken by the community members aimed at contributing to improved forest management. The main activities included; creating awareness on the need to conserve the forest; participation in firefighting in collaboration with forest resource managers; establishing tree nurseries either on their farms or in the forest to raise seedling for planting in the forests, farmlands, riparian areas and in public places; rehabilitation of degraded areas in the Forest Reserve or National Park and also re-establishment of plantations through PELIS; community policing to protect the forests against illegal harvesting, charcoal production and wildlife poaching; undertaking silvicultural operations like thinning, pruning, coppice reduction, maintenance of roads and fire breaks in plantation areas.

The sampled households indicated they had been involved mainly in voluntary PFM within the adjacent forests in different ways through provision of labour for activities such as tree planting (11%), Policing (7.5%) and firefighting and prevention (8%). The results showed that while many respondents had participated in diverse activities within the forest reserve, involvement in the park area was only in a few activities. However, over 70% had visited the two types of forests for recreation purposes. The distribution of household involvement in PFM was as shown in Table 4.11.

Table 4.11: Household involvement in PFM activities

Activity		Forest Reserve		National Park	
		Frequency	Percent	Frequency	Percent
Recreation	Yes	48	75.0	37	74.0
	No	16	25.0	13	26.0
Harvest products	Yes	18	50.0	2	13.3
	No	18	50.0	13	86.7
Tree planting	Yes	15	46.9	1	9.1
	No	17	53.1	10	90.9
Participate in policing	Yes	6	25.0	0	0
	No	18	75.0	193	100.0
Participate in fire fighting	Yes	14	41.2	2	16.7
	No	20	58.8	10	83.3
Made decisions on forest management	Yes	17	50.0	1	8.3
	No	17	50.0	11	91.7
Made decisions on who can enter forest	Yes	7	29.2	1	10.0
	No	17	70.8	9	90.0
Leased forest land	Yes	1	4.8	0	0.0
	No	20	95.2	192	100.0
Grazing in forest	Always	19	20.4	0	0.0
	Dry season	5	5.4	2	2.2
	Never	41	44.1	26	28.0
Cut grass/fodder	Yes	13	12.0	4	3.7
	No	76	13.9	15	70.4

4.1.8 Household level of involvement in PFM

Among the households interviewed, most (57%) of the respondents indicated they were involved to a small extent and only 8% indicated being fully involved as shown in Figure 4.3.

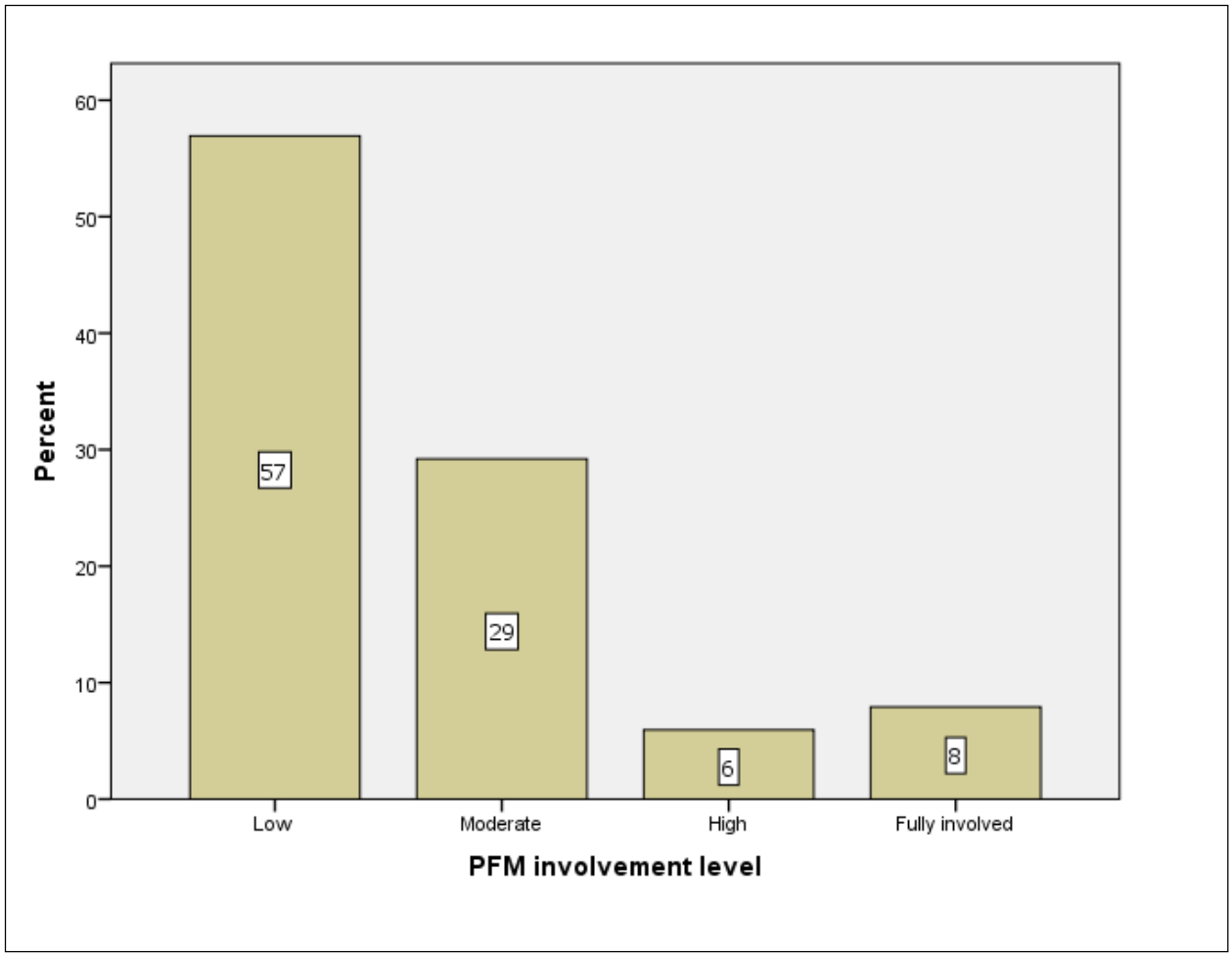

Figure 4.3: Households' level of involvement in PFM

4.2 Value of Ecosystem Services

4.2.1. Non–economic value of ecosystem services

The results from community perception of ecosystem services showed that most (83%) of the communities adjacent to both forest types valued the forest predominantly for non-economic benefits such as climate moderation, water catchment protection, flood and soil erosion control as shown in Table 4.12 and Plate 4.2.

Table 4.12: Community value of economic and non-economic services

Value of ecosystem	Frequency	Value to Community		Total
		National Park	Forest Reserve	
Economic reasons like firewood, timber, PELIS and grazing	F	1	23	24
	%	2	25	17
Non-economic values like climate moderation, soil erosion control and water regulation	F	49	71	120
	%	98	75	83
N	F	50	94	144
Total	%	100	100	100

However, more (25%) of those adjacent to the Forest Reserve indicated that the ecosystem was more important for economic benefits compared to 2% of those adjacent to the National Park.

Plate 4.2: Flood control and water catchment protection from Aberdare ecosystem

(a) Community valuation and sources of provisioning services

Survey results showed that the most important forest products derived from the ecosystem were water (98%), firewood (70%) and grazing (67%). In addition, other products like charcoal, wild game and cedar posts were illegally extracted from the ecosystem. The distribution of products was as shown in Figure 4.4.

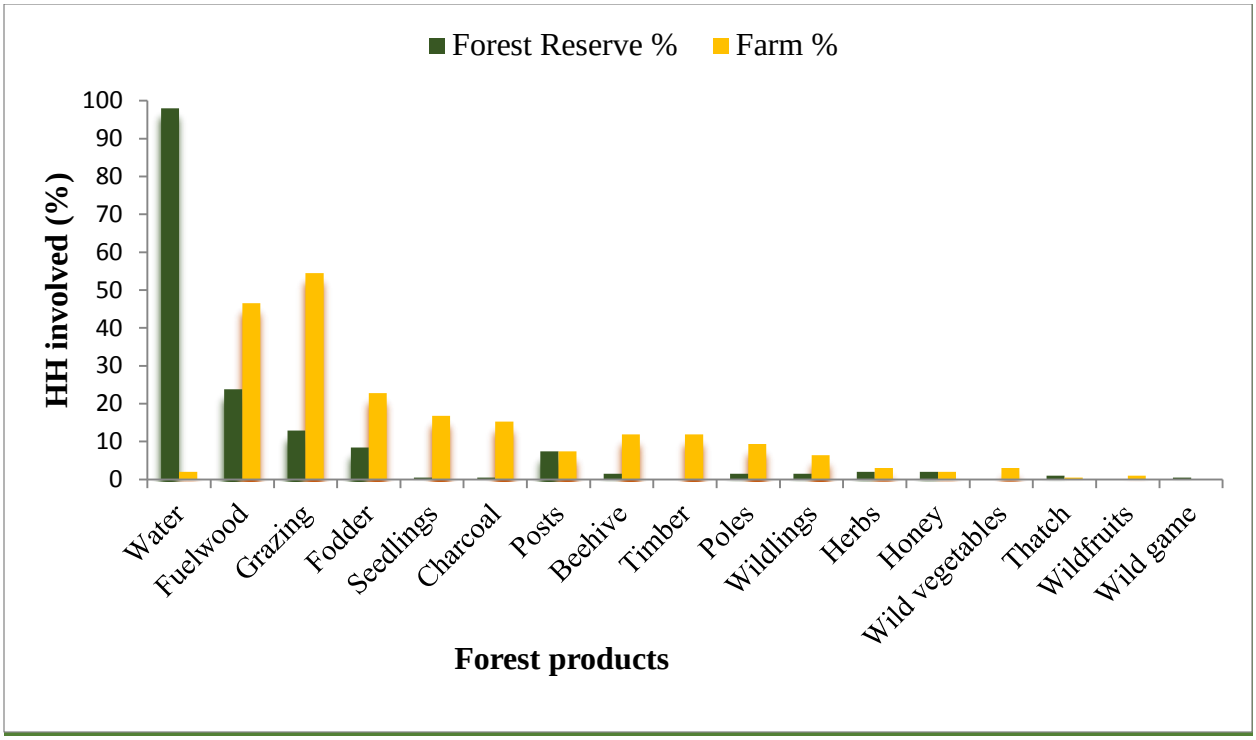

Figure 4.4: Community utilization of forest products from ecosystem and farmlands

(b) Community valuation of regulatory services

Results from this study indicated that there were five important regulatory services from the ecosystem which were; water catchment function, climate regulation, biodiversity conservation, carbon sequestration and flood/soil erosion control as ranked in Table 4.13.

Table 4.13: Community valuation of regulatory services

Ecosystem Service/group	National Park			Forest Reserve			Overall Rank
	Ruhotii	Endarasha	Njeng'u	Githai	Michukia	Cascadia	
Water catchment protection	1	1	2	1	2	1	1
Climate regulation	2	4	3	2	3	4	2
Biodiversity conservation	3	2	4	3	4	5	3
Carbon storage and sequestration	5	3	10	4	6	2	4
Flood/soil erosion control	6	5	9	6	5	3	5

(c) Community valuation of cultural services

The PEV results showed that the most important cultural services to the community were source of knowledge, tourism/aesthetic, cultural/historical, and heritage/bequest values was as shown in

Table 4.14. On one hand, Michukia and Cascadia groups ranked tourism as least important explaining that "*we hardly get any benefits, it is the government and tour operators who get all the benefits"*. On the other hand, Njeng'u group ranked tourism as most important explaining that *"tourism is better than all regulatory and cultural services because it has potential to provide a regular income."*

Table 4.14: Community valuation of cultural services

Ecosystem Service	National Park			Forest Reserve			Overall Rank
	Ruhotii	Endarasha	Njeng'u	Githai	Michukia	Cascadia	
Source of knowledge/ education	4	10	6	8	1	8	1
Recreation and Aesthetic	8	6	1	7	10	10	2
Cultural Heritage	9	7	7	5	9	6	3
Bequest and existence	10	9	5	9	8	9	4

4.2.2 Economic value of ecosystem services

(a) Value of ecosystem services based on SP method

Although the socio-economic status of the communities varied widely, majority (76%) of the respondents' WTP for ecosystem services was between KES 600 - 1200 (US$ 6 - 12) annually to conserve and protect the forest. Only 4% indicated that though they desired the forest to be better conserved and protected, they were not willing to contribute anything as they felt that it was the responsibility of the government (Figure 4.5).

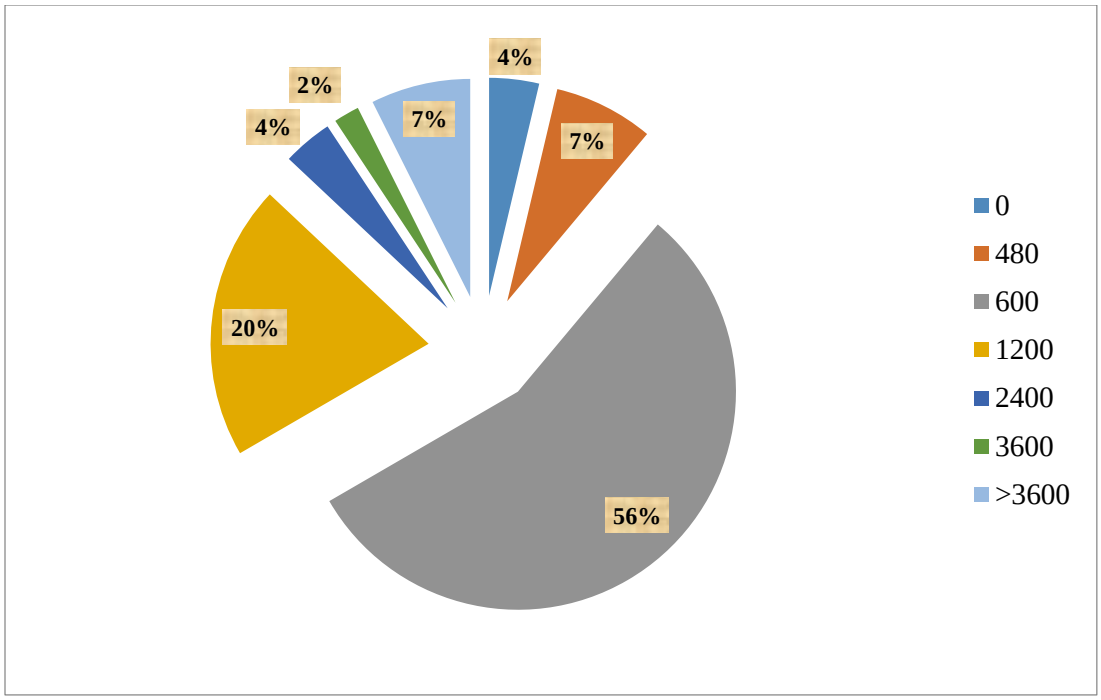

Figure 4.5: Annual WTP for ecosystem services (in KES)

Annually, the total contribution that all the forest adjacent households were willing to pay amounted to KES 19,556,990 (US$ 195,570).

(b) Value of provisioning services based on market and surrogate market prices

Survey results indicated that most of the household annual income (Appendix 3) obtained from forest ecosystem related sources was fodder which was approximately KES 211 million (US$ 2.11 million) and forest grazing KES 131 million (US$ 1.31 million) as shown in Figure 4.6.

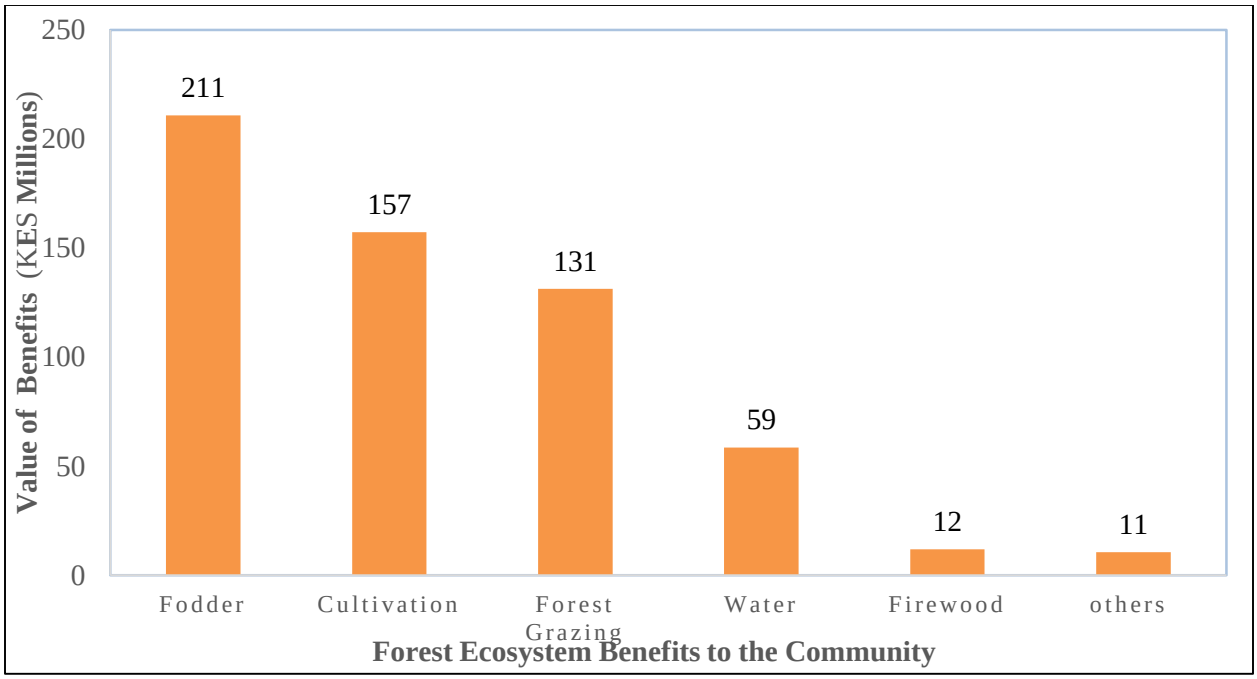

Figure 4.6: Value of provisioning services from Aberdare forest ecosystem the community

Livestock was presented as an important household livelihood enterprise in the area. Although only a few households engaged in fodder collection (27%) and grazing (19%) in the forest (Plate 4.3), the two activities had an annual net value of KES 342 (US$ 3.42) million which accounted for more than 50% of the value obtained from all other provisioning services (Appendix 3).

Plate 4.3: Grazing of cows and sheep in Geta Forest Station

Other products/services reported as important to the community for income generation were cultivation amounting to KES 157 (US$1.57) million and firewood collection KES 12 (US$ 0.12) million (Plate 4.4).

Plate 4.4: Forest cultivation under PELIS and firewood collection in Geta Forest Station

The net annual value of the provisioning services was found to be about KES 580 (US$ 5.8) million for the 25,553 households around the ecosystem resulting to an average income of KES 22,700 (US$ 227)/household/yr.

(c) Value of forest regulatory services

To estimate the value of climate regulation, this study made use of conservative values provided by Costanza *et al*. (1997a) who found that forests yield KES 45,000 (US$ 450)/ha/yr in terms of climate regulation benefits. Thus, the value for climate regulation in the area amounted to KES 10.2 (US$ 0.1) billion as shown in Table 4.15.

Table 4.15: Economic value of regulatory services

Regulatory Service	Unit	Total No. of units	Estimated value/ unit (KES)	Total estimated annual value (KES)	Total annual value (US$)	Study	Study area
Climate regulation	Ha	226,522.03	45,000	10,193,491,350	101,934,914	CBD, (2001)	Global
Water catchment protection	Ha	226522.03	2,400	543,652,872	5,436,528	Yaron (2001)	Mt. Cameroon
Flood/soil erosion control	Ha	226522.03	12,528	2,837,867,992	28,378,680	Langat and Cheboiwo, (2010)	Mau forest complex
Carbon sequestration	tCO2e	39,665,656.8	570	22,609,424,376	226,094,244	Ndichu, (2016)	Kasigau
Biodiversity conservation	Ha	226522.03	700	158,565,421	1,585,654	Reid (1999)	Costa Rica
Grand total				**36,343,002,011**	**363,430,020**		

To estimate the value of water catchment protection, the study applied the findings by Yaron (2001) for Mt. Cameroon which was based on flood protection, avoidable crop and tree losses valued at KES 2400 (US$ 24)/ha/yr since agriculture is the major livelihood activity for communities in Aberdare region. Therefore, the value obtained for water catchment protection in the study area based on 226522.03 ha amounted to KES 543.7 (US$ 5.44) million.

To obtain the value of flood/soil erosion control, this study applied the findings from Langat and Cheboiwo (2010) obtained from a local research in Mau Forest Complex in Kenya. The value they obtained for soil erosion and flood protection was KES 12,528/ha/yr. Consequently, the estimated value of this service for Aberdare ecosystem was KES 2.8 (US$ 0.28) billion.

To indicate the likely magnitude of the service offered by Aberdare forest in carbon storage and sequestration, this study applied the average amount of Carbon sequestered from various types of tropical forests which were provided by CBD (2001) which was 198tCO_2e/ha. The available area for Carbon offsets in Aberdare ecosystem is 200,331.60 ha. According to State of the Voluntary Carbon Markets (2015), the market-wide average price of voluntary carbon offsets reached a new low of KES 380 (US$ 3.8)/tCO_2e in 2015 but the average over the years was US$5.8/t$CO_2$e. A similar price of KES 570 (US$ 5.7)/tCO_2e was applied in a local Reducing Emissions from Deforestation and Forest Degradation (REDD+) Project in to compensate land users and/or owners for conserving ecosystem services Kasigau (Ndichu, 2016). Thus, this study made use of KES 570 (US$ 5.7)/tCO_2e which amounted to KES 22.6 (US$ 0.22) billion as shown in Table 4.15.

To estimate the value of biodiversity conservation, the study applied the findings of Langat and Cheboiwo (2010) in Mau forest complex where they obtained the value of biodiversity conservation as KES 700 (US$ 7)/ha/yr. Therefore, the estimated value of this service was KES 158.7 (US$ 1.59) million as shown in Table 4.15.

(d) Value of cultural services

To estimate the value of source of knowledge/education, the study applied the average values obtained from a similar study by Mogaka (2000) which amounted to KES 737 (US$ 7.37). This was applied because the dry and wet forest conditions where the values were derived from were similar to the study sites. Hence, the value obtained for source of knowledge/education in the study area amounted to KES 18.8 (US$ 0.19) million for the households adjacent to Aberdare ecosystem as shown in Table 4.16.

Table 4.16: Economic value of cultural services

Cultural Service	Unit	Total units	Value/ Unit (KES)	Estimated annual value (KES)	Estimated annual value (US$)	Study used	Study area
Source of knowledge/ education	HH	25553	737	18,832,561	188,325.61	Mogaka, (2000)	Ntugi-Kijege and Kakamega forests
Recreation and aesthetic	HH	25553	204	5,212,812	52,128.12	Mogaka, (2000)	Kakamega forests
Cultural heritage	HH	25553	687	17,554,911	175,549.11	Mogaka, (2000)	Ntugi-Kijege
Heritage/bequest	Ha	226522.03	85	19,254,373	192,543.73	Pearce (2001)	Global
Grand total				**60,854,657**	**608,546.57**		

Aberdare ecosystem experiences both local and foreign visitors pursuing recreation/tourism services. However, it is imperative to bear in mind that highest benefits accrued hardly trickled to the community as major beneficiaries were the government through KWS and tour operators. Hence, this study opted to use the conservative figure of KES 204 (US$ 2.04)/household/yr based on the study mentioned above from Kakamega Forest Reserve (Mogaka, 2000). The total value amounted to KES 5.2 (US$ 0.05) million/for the households adjacent to the ecosystem (Table 4.16).

Valuation studies undertaken in various parts of the world have shown that, though cultural and historical values are at the heart of local communities, low monetary value is placed on them. This study used the average values obtained from a similar study based in Ntugi-Kijege (Mogaka, 2000) which was KES 687 ((US$ 6.87)/household/yr. The total value amounted to KES 17.6 million (US$ .18) for the households adjacent to the ecosystem (Table 4.16).

(a) Bequest and existence

This study applied KES 500 (US$ 5)/ha from a study by Pearce (2001) based on world WTP for limited forest areas covered by debt-for-nature swaps to estimate the value of bequest and existence services. Thus, the heritage and bequest values amounted to KES 19.3 (US$ 0.19) million as shown in Table 4.16. The community expressed that they would like special sites and tree species conserved as bequest to the future generations (Plate 4.5).

Plate 4.5: A giant cedar tree in Aberdare National Park conserved as bequest for future generations

4.2.3 Human-wildlife conflicts and losses

The ecosystem is a habitat to a host of large and small animals including birds that invade adjacent farmlands leading to crops and livestock losses and sometimes injury or loss of human life. The main problem animals cited by the respondents that affected crops and livestock were diverse but monkeys (16%) porcupines (11%) and leopards (5%) were more frequent) as shown in Table 4.17.

Table 4.17: Problem animals common in Aberdare ecosystem

Wild animal	Frequency	Percent
Monkeys	32	15.9
Porcupines	21	10.5
Leopards	9	4.5
Various (Baboons, hyenas, elephants, birds, squirrels)	140	69.3
Total	**202**	**100**

The other animals mentioned were varied and they included birds, squirrels and some incidences of elephants when they broke out of the electric fence. All the respondents interviewed reported existence of human-wildlife conflicts with 34% indicating livestock and crop losses amounting to KES 555,000 (US$ 5,550) and KES 804,700 (US$ 8,047) respectively. This resulted to a total of KES 172 (US$ 1.72) million which was approximately KES 20,601 (US$ 206)/household/yr.

However, they also reported that the electric fence had reduced the problem significantly with 76% reporting a large positive effect as the losses were higher before (Figure 4.7).

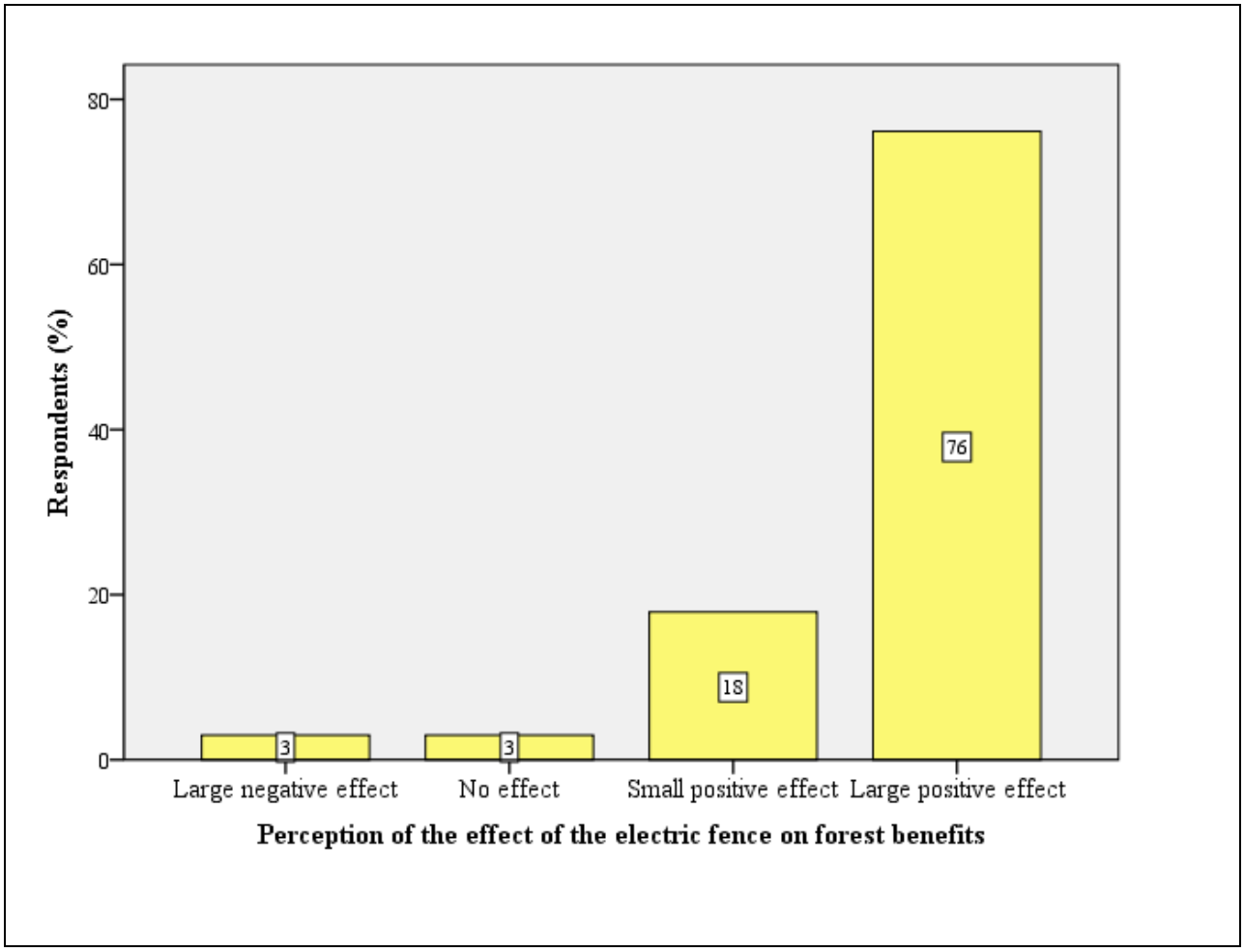

Figure 4.7: Household perception of the effect of electric fence around the forest ecosystem

4.2.4 Opportunity cost of forest land conversion

The main economic activities in the area around Aberdare forest ecosystem were small scale mixed farming of various food crops and livestock keeping. Opportunity cost of forest conservation therefore was conversion of forest land into these agricultural activities. Based on the topography, geology of Aberdare forest ecosystem, the entire forest area is not arable. Therefore, the results obtained from converting the area under natural forest, plantation and bushland was approximately 64% or 144,974.08 ha of total area. The net annual return from forest conversion for agricultural production in the area was approximately KES 28,952 (US$ 289.5)/ha. Hence, the total benefits from forest conversion amounted to KES 4,197,355,728 (US$ 41,973,557.3). As a result, the

opportunity cost of not converting forest land into agricultural production by the adjacent community was KES 32.6 (US$ 3.26) billon annually.

4.2.5 Net annual benefits of ecosystem services from Aberdare forest ecosystem

The total value of the benefits from ecosystem services derived from Aberdare forest was approximately KES 36.8 (US$ 0.37) billion annually, where regulatory services accounted for at 95% which amounted to KES 36.3 (US$ 0.36) billion. The estimation of provisioning and cultural services were as shown in Table 4.18.

Table 4.18: Net annual benefits and costs of ecosystem services from Aberdare forest

Benefit/cost	Benefits/costs/year	
	KES (millions)	US$ (millions)
Provisioning	580,601,063.60	5,806,010.64
Regulatory	36,343,002,011.00	363,430,020.00
Cultural	60,854,657.00	608,546.57
Total	**36,984,457,731.60**	**369,844,577.21**
Wildlife losses	172,002,050.00	1,720,020.50
Total net annual benefits	**36,812,455,681.60**	**368,124,556.71**

4.3 FMA and Perceived Values of the Forest Ecosystem to the Adjacent Communities

4.3.1 FMA and community perception of the importance of the ecosystem

Survey results showed that majority (83%) of respondents adjacent to the forest under both types of management approaches indicated that the forest ecosystem was important to them mainly for non-economic benefits (Table 4.19.

Table 4.19: FMA and community perception of the importance of the ecosystem

FMA	Frequency	Importance of forest ecosystem		Total
		Economic	Non-economic	
Protection	F	1	49	50
	%	4.2	40.8	34.7
Conservation	F	23	71	94
	%	95.8	59.2	65.3
Total	F	24	120	144
	%	16.7	83.3	100.0

The results also showed that most (96%) of those who high regard for economic benefits were mainly adjacent to the conservation area). There was a strong association between management

approach and community perception of the importance of the forest ($\chi^2 = 11.863$, df = 1, $\alpha = 0.05$, $p = 0.001$, n = 144).

4.3.2 FMA and sources of household food

The main source of household food for the majority (85%) of the households in the area was from their own or rented private farms. However, 14% of those adjacent to the conservation area obtained household food from forest cultivation under the PELIS (Table 4.20). There was a significant association between FMA and household source of food ($\chi^2 = 27.704$, df = 2, $\alpha = 0.05$, $p < 0.001$, n = 202)

Table 4.20: FMA and household main source of food

Main source of HH food	Frequency	Adjacent Forest type		Total
		National Park	Forest Reserve	
Forest PELIS plot	F	0	29	29
	%	0.0	14.4	14.4
Own or rented private land	F	87	84	171
	%	43.1	41.6	84.7
Purchased from Market	F	0	2	2
	%	0.0	1.0	1.0
Total	F	87	115	202
	%	43.1	56.9	100.0

4.3.3 FMA and annual household income level

The study results showed that about 27% of the households were within the low income (less than KES 25,000 annually) bracket. Among the low income households, more (23%) lived adjacent to the conservation area as only 4% were adjacent to the area under protection FMA (Table 4.21).

Table 4.21: FMA and household annual income

FMA	Frequency	HH Annual Income (KES)					Total
		0 - 25000	25001 - 50000	50001 - 75000	75001 - 100,000	>100,000	
Protection	F	6	6	12	4	28	56
	%	3.7	3.7	7.4	2.5	17.3	34.6
Conservation	F	37	22	17	7	23	106
	%	22.8	13.6	10.5	4.3	14.2	65.4
Total	F	43	28	29	11	51	162
	%	26.5	17.3	17.9	6.8	31.5	100.0

More households (17%) within the higher income category (more than KES 75,000 per year) lived adjacent to the protection area compared to 14% who lived adjacent to the conservation area. There

was a significant association between the management approach and household income (χ^2 = 20.194, df = 4, α = 0.05, p < 0.001, n = 162).

4.3.4 FMA and forest dependence

Results showed that the majority (94%) of the households derive some benefits from the ecosystem as only 6% indicated low benefits. However, the perception was dissimilar depending on FMA. More (9%) of those living adjacent to the Conservation area rated the benefits as very high compared to 2% of those living adjacent to Protection area as shown in Table 4.22. There was a significant association between FMA and forest dependence (χ^2 = 53.580, df = 3, α = 0.05, p < 0.001, n = 202).

Table 4.22: FMA and forest dependence

FMA	Frequency	Forest dependence				Total
		V. High	High	Moderate	Low	
Protection	F	2	20	62	3	87
	%	2.3	23.0	71.3	3.4	100
Conservation	F	10	73	23	9	115
	%	8.7	63.5	20	7.8	100
Total	F	12	93	85	12	202
	%	5.9	46	42.1	5.9	100.0

4.3.5 FMA and PFM involvement level

The findings of this survey indicated that fewer (1%) respondents adjacent to the protection area were involved fully compared to 7% of those adjacent to the conservation area (Table 4.23). There was a significant association between the FMA and PFM involvement level (χ^2 = 17.551, df = 3, α = 0.05, p = 0.001, n = 202).

Table 4.23: FMA and PFM involvement level

FMA	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Protection	F	56	29	0	2	87
	%	27.7	14.4	0.0	1.0	43.1
Conservation	F	59	30	12	14	115
	%	29.2	14.9	5.9	6.9	56.9
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.3.6 FMA and household social status

The results showed that about 21% of the households were within the very poor where most (18%) lived adjacent to the conservation area. Of the 46% of the households within the very rich category, where 30% of them lived adjacent to the under protection FMA whereas 16% lived adjacent to the conservation area (Table 4.24). There was a strong and significant association between the management approach and household income levels ($\chi^2 = 43.474$, df = 4, $\alpha = 0.05$, $p < 0.001$, n = 202).

Table 4.24: FMA and household social status

FMA	Frequency	Household social status					Total
		Very poor	Poor	Moderate	Rich	Very Rich	
Protection	F	6	4	8	8	61	87
	%	3.0	2.0	4.0	4.0	30.2	43.1
Conservation	F	37	22	16	8	32	115
	%	18.3	10.9	7.9	4.0	15.8	56.9
Total	F	43	26	24	16	93	202
	%	21.3	12.9	11.9	7.9	46.0	100

4.3.7 Relationship between FMA and the perceived values of forest ecosystems

The relationship between FMA and community perception on the importance of the ecosystem, sources of household food, household annual income, forest dependence, PFM involvement level and household social statuses were evaluated using Spearman's rho correlation and all found to be both strong and significant at $\alpha = 0.05$ (Table 4.25).

Table 4.25: Relationships between FMA and the perceived values of forest ecosystems

Variables	Significance ($\alpha = 0.05$)	r-value
FMA	.	1.000
Importance of forest ecosystem	0.000	-0.287
Source of HH food	0.000	-0.322
HH annual income	0.000	-0.345
Forest dependence	0.000	0.440
PFM levels	0.007	0.191
HH Social status	0.000	0-.456

The analysis revealed that on one hand, there was a negative and significant relationship between FMA and community forest dependence ($r = -0.29$, $p < 0.001$), importance of the ecosystem ($r = -0.29$, $p < 0.001$), source of household food ($r = -0.32$, $p < 0.001$) and household annual income (r

= -0.35, $p < 0.001$). On the other hand, the relationship between FMA and Community level of involvement in PFM as well as household social status was positive and significant.

4.4 Socio-economic Factors and Community Involvement in PFM

4.4.1 Type of FMA of adjacent forest and PFM involvement

Survey results showed that all the respondents were all involved in PFM, though the majority (57%) indicated being involved to a low extent. Nonetheless, about 8% were fully involved where most (7%) were those living adjacent to Forest Reserve compared to the 1% adjacent to National Park (Table 4.26). Results showed that type of FMA of adjacent forest had a strong significant association with community involvement level in PFM ($\chi^2 = 17.551$, df = 3, $\alpha = 0.05$, $p = 0.001$, n = 202).

Table 4.26: Type of FMA and PFM involvement level

Adjacent Forest type	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
National Park	F	56	29	0	2	87
	%	27.7	14.4	0.0	1.0	43.1
Forest Reserve	F	59	30	12	14	115
	%	29.2	14.9	5.9	6.9	56.9
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.2 Distance to Forest Reserve and PFM involvement

Results showed that majority (80%) of those who were mainly involved in PFM were within a distance of 5km of the forest reserve as only a few (6%) households beyond 10km indicated low involvement (Table 4.27). There was a strong and significant association between distance to the Forest Reserve from the household and PFM involvement level ($\chi^2 = 29.071$, df = 15, $\alpha = 0.05$, $p = 0.016$, n = 129).

Table 4.27: Distance to Forest Reserve and PFM involvement level

Distance to forest reserve (Km)	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
<1	F	8	10	3	7	28
	%	6.2	7.8	2.3	5.4	21.7
1-2	F	19	13	5	4	41
	%	14.7	10.1	3.9	3.1	31.8
2.1-3	F	6	6	2	0	14
	%	4.7	4.7	1.6	0.0	10.9
3.1-5	F	12	6	0	1	19
	%	9.3	4.7	0.0	0.8	14.7
5.1-10	F	10	9	0	0	19
	%	7.8	7.0	0.0	0.0	14.7
>10	F	8	0	0	0	8
	%	6.2	0.0	0.0	0.0	6.2
Total	F	63	44	10	12	129
	%	48.8	34.1	7.8	9.3	100.0

4.4.3 Distance to the National Park and PFM involvement

Similarly, level of involvement in PFM was highest for those (87%) within 2km radius to National Park (NP) on showed that majority of those who were mainly involved were. Those who were far, particularly those living beyond 3km indicated low or no involvement as shown in Table 4.28. There was a strong and significant association between distance to NP with community PFM involvement level ($\chi^2 = 27.303$, df = 8, $\alpha = 0.05$ $p = 0.001$, n = 86).

Table 4.28: Distance to the National Park and PFM involvement level

Distance to NP	Frequency	PFM involvement level			Total
		Low	Moderate	Fully involved	
<1	F	31	15	2	48
	%	36.0	17.4	2.3	55.8
1-2	F	19	7	1	27
	%	22.0	8.1	1.2	31.4
2.1-3	F	2	5	0	7
	%	2.3	5.8	0.0	8.1
3.1-5	F	1	0	2	3
	%	1.2	0.0	2.3	3.5
5.1-10	F	1	0	0	1
	%	1.2	0.0	0.0	1.2
Total	F	54	27	5	86
	%	62.8	31.4	5.8	100.0

4.4.4 Gender of respondent and PFM involvement

Survey results showed that the level of involvement in PFM of both men and women was low (57%) or moderate (29%). Nonetheless, (7%) men were fully involved in PFM compared to women (1%) (Table 4.29). There was a strong and significant association between gender of respondent and PFM involvement ($\chi^2 = 12.790$, df = 3, $\alpha = 0.05$, $p = 0.005$, n = 202).

Table 4.29: Gender of respondent and level of community involvement in PFM

Gender		PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Male	F	59	43	7	14	123
	%	29.2	21.3	3.5	6.9	60.9
Female	F	56	16	5	2	79
	%	27.7	7.9	2.5	1.0	39.1
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.5 Gender of household head and PFM involvement

Results indicated that both male-headed households and female-headed households were both involved in PFM to a low extent. Nonetheless, more (88%) of male-headed households were fully involved compared to 13% of female-headed households (Table 4.30). There was a strong and significant association between household headship and household involvement in PFM ($\chi^2 = 10.719$, df = 3, $\alpha = 0.05$, $p = 0.013$, n = 202).

Table 4.30: Gender of household head and PFM involvement level

HH Headship	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Male	F	82	52	8	14	156
	%	71.3	91.2	66.7	87.5	78.0
Female	F	33	5	4	2	44
	%	28.7	8.8	33.3	12.5	22.0
Total	F	115	57	12	16	200
	%	100.0	10.0	100.0	100	100.0

4.4.6 Household size and PFM involvement

Survey results showed that households with few family members (1-2) were involved to a low extent as none indicated being highly or fully involved in PFM. On the other hand, majority (over 63%) of those who indicated being involved fully had over 7 family members (Table 4.31). There

was a weak but significant association between household sizes with community PFM involvement level ($\chi^2 = 15.340$, df = 9, $\alpha = 0.05$, $p = 0.042$, n = 202).

Table 4.31: Household sizes and PFM involvement level

HH sizes	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
1 - 2	F	13	4	0	0	17
	%	11.3	6.8	0.0	0.0	8.4
3 - 6	F	64	32	3	6	105
	%	55.7	54.2	25.0	37.5	52.0
7 - 10	F	29	16	7	6	58
	%	25.2	27.1	58.3	37.5	28.7
>10	F	9	7	2	4	22
	%	7.8	11.9	16.7	25.0	10.9
Total	F	115	59	12	16	202
	%	100.0	100.0	100.0	100.0	100.0

4.4.7 Number of household members working on the farm and PFM involvement

Results showed that majority (63%) of those mainly involved in PFM had a large (more than 3) number of family members working on the farm. Conversely, majority (65%) of those with few (1 - 2) members working on the farm expressed low PFM involvement level (Table 4.32). There was a moderate and significant association between number of household members working on the farm and PFM involvement level ($\chi^2 = 21.277$, df = 9, $\alpha = 0.05$, $p = 0.011$, n = 202).

Table 4.32: Household members working on the farm and level of involvement in PFM

HH members working on farm	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
1 - 2	F	75	44	4	6	129
	%	65.2	74.6	33.3	37.5	63.9
3 - 5	F	36	10	6	8	60
	%	31.3	16.9	50.0	50.0	29.7
6 - 9	F	2	3	2	2	9
	%	1.7	5.1	16.7	12.5	4.5
>9	F	2	2	0	0	4
	%	1.7	3.4	0.0	0.0	2.0
Total	F	115	59	12	16	202
	%	100.0	100.0	100.0	100.0	100.0

4.4.8 Land tenure and PFM involvement

Survey results depicted that, among those who indicated being fully involved in PFM, majority (81%) were either resettled by the government or had formally inherited the land (Table 4.33). In contrast, 6% of those who had purchased land and none (0%) of those married in the area indicated being fully involved. There was a strong and significant association between household settlement history and PFM involvement level ($\chi^2 = 34.313$, df = 12, ($\alpha = 0.05$) p = 0 001, n = 202).

Table 4.33: Land tenure and level of involvement in PFM

Land tenure	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
By birth	F	7	2	0	2	11
	%	6.1	3.4	0.0	12.5	5.4
Purchased	F	19	21	2	1	43
	%	16.5	35.6	16.7	6.3	21.3
Marriage	F	9	1	1	0	11
	%	7.8	1.7	8.3	0.0	5.4
Inherited	F	19	22	5	7	53
	%	16.5	37.3	41.7	43.8	26.2
Settlement by government	F	61	13	4	6	84
	%	53.0	22.0	33.3	37.5	41.6
Total	F	115	59	12	16	202
	%	100.0	100.0	100.0	100.0	100.0

4.4.9 Farm sizes and PFM involvement

Results showed that people with large farms (> 5 acres) were less involved in PFM as there was less than 1% who indicated being highly or fully involved (Table 4.34). However, in spite of these results, the association between farm size and community involvement in PFM was not significant ($\chi^2 = 12.803$, df = 12, $\alpha = 0.05$, $p = 0.383$, n = 202).

Table 4.34: Farm sizes and level of involvement in PFM

Farm size (Acres)	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
0-1	F	29	15	4	9	57
	%	14.4	7.4	2.0	4.5	28.2
2-3	F	41	20	2	3	66
	%	20.3	9.9	1.0	1.5	32.7
4-5	F	25	16	5	3	49
	%	12.4	7.9	2.5	1.5	24.3
6-10	F	17	8	1	1	27
	%	8.4	4.0	0.5	0.5	13.4
>10	F	3	0	0	0	3
	%	1.5	0.0	0.0	0.0	1.5
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.10 Land renting and PFM involvement

Analysis of the association between renting of land and involvement in PFM indicated that more (11%) of those who were renting additional land were fully involved. (Table 4.35).

Table 4.35: Land renting and level of involvement in PFM

HH rent land in	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Yes	F	27	20	8	11	66
	%	17.4	12.9	5.2	7.1	42.6
No	F	55	28	3	3	89
	%	35.5	18.1	1.9	1.9	57.4
Total	F	82	48	11	14	155
	%	52.9	31.0	7.1	9.0	100.0

On the contrary, less than 2% of those who were not renting land indicated interest in being fully involved. There was a strong and significant association between renting land and PFM involvement level ($\chi^2 = 14.648$, df = 3, $\alpha = 0.05$, $p = 0.002$, n = 155).

4.4.11 Household source of food and PFM involvement

Results indicated that nearly all (99%) of the households depended on own food production from own farm (including rented land) or cultivation in the forest and majority (57%) indicated being involved in PFM to a low extent (Table 4.36). That notwithstanding, there was a strong and

significant association between the source of household food and PFM involvement level (χ^2 = 26.582, df = 6, α = 0.05, p < 0.001, n = 202).

Table 4.36: Household sources of food and level of involvement in PFM

Main source of HH food	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Forest PELIS land	F	11	8	7	3	29
	%	5.0	4.0	3.5	1.5	14.4
Own private/rented land	F	103	51	5	12	171
	%	51.0	25.2	2.5	5.9	84.7
Purchase	F	1	0	0	1	2
	%	0.5	0.0	0.0	0.5	1.0
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.12 Household sources of income and PFM involvement

Survey results indicated that those who were fully involved depended mostly on livestock production (7%) whereas a similar number those who relied largely on casual labour indicated low (7%) involvement in PFM (Table 4.37). The association between the sources of household income and PFM involvement level was found to be significant (χ^2 = 31.553, df = 18, α = 0.05, p = 0.025, n = 202).

Table 4.37: Household's sources of income and PFM involvement level

HH income sources	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Agricultural crops	F	46	18	3	5	72
	%	22.8	8.9	1.5	2.5	35.6
Livestock and products	F	31	18	4	9	62
	%	15.3	8.9	2.0	4.5	30.7
Both crops and livestock	F	17	18	5	1	41
	%	8.4	8.9	2.5	0.5	20.3
Forest and fruit products	F	3	0	0	0	3
	%	1.5	0.0	0.0	0.0	1.5
Casual labour	F	0	2	0	1	3
	%	0.0	1.0	0.0	0.5	1.5
Salary/remittance	F	1	1	0	0	2
	%	0.5	0.5	0.0	0.0	1.0
Others	F	17	2	0	0	19
	%	8.4	1.0	0.0	0.0	9.4
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.13 Household income level and PFM involvement

Results illustrated that 40% of those who were fully involved were within the highest income category (> KES 100,000 (US$ 1000) as shown in Table 4.38. That notwithstanding, there was a significant though weak association between annual household income and PFM involvement level ($\chi^2 = 22.571$, df = 12, $\alpha = 0.05$, $p = 0.032$, n = 202).

Table 4.38: Household income level and level of involvement in PFM

HH annual income	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
0 – 25000	F	29	9	2	3	43
	%	35.4	17.0	16.7	20.0	26.5
25001 – 50000	F	15	6	5	2	28
	%	18.3	11.3	41.7	13.3	17.3
50001 – 75000	F	15	9	1	4	29
	%	18.3	17.0	8.3	26.7	17.9
75001 – 100,000	F	7	3	1	0	11
	%	8.5	5.7	8.3	0.0	6.8
>100,000	F	16	26	3	6	51
	%	19.5	49.1	25.0	40.0	31.5
Total	F	82	53	12	15	162
	%	100.0	100.0	100.0	100.0	100.0

4.4.14 Group membership and PFM involvement

Survey results showed that majority (69%) of the respondents were group members where more (5%) indicated being fully involved in PFM compared to only 3% of the non-members (Table 4.39). There was a strong and significant association between being a group member and PFM involvement level ($\chi^2 = 21.134$, df = 3, $\alpha = 0.05$, $p < 0.001$, n = 202).

Table 4.39: Group membership and level of involvement in PFM

Group member	Frequency	PFM involvement level				Tot.al
		Low	Moderate	High	Fully involved	
Yes	F	66	51	12	11	140
	%	32.7	25.2	5.9	5.4	69.3
No	F	49	8	0	5	62
	%	24.3	4.0	0.0	2.5	30.7
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.15 Type of group and PFM involvement

Results indicated that all group members were involved but more (8%) members of FUGs indicated being fully involved compared to less than 1% of non-FUG members (Table 4.40). There was a strong and significant association between type of group and PFM involvement level (χ^2 = 14.693, df = 3, α = 0.05, p = 0.002, n = 120).

Table 4.40.: Type of group and level of involvement in PFM

Type of group	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
FUG	F	21	33	8	10	72
	%	17.5	27.5	6.7	8.3	60.0
Others	F	30	14	3	1	48
	%	25.0	11.7	2.5	0.8	40.0
Total	F	51	47	11	11	120
	%	42.5	39.2	9.2	9.2	100.0

4.4.16 Group status and PFM involvement

The study also sought to find the association between group statuses and level of involvement in PFM (Table 4.41). Results pointed that all members of formal or informal groups being involved. Nonetheless, all of those fully involved in PFM were members of formal groups as no member of an informal group indicated full involvement. Results showed there was a positive and significant association between status of group and PFM involvement level (χ^2 = 10.807, df = 3, α = 0.05, p = 0.013, n = 132).

Table 4.41: Group statuses and level of involvement in PFM

Group status	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Formal	F	34	36	10	11	91
	%	25.8	27.3	7.6	8.3	68.9
Informal	F	26	13	2	0	41
	%	19.7	9.8	1.5	0.0	31.1
Total	F	60	49	12	11	132
	%	45.5	37.1	9.1	8.3	100.0

4.4.17 Household perception of the importance of the forest ecosystem and PFM involvement

Survey results indicated that the majority (52%) of the forest adjacent community who valued the ecosystem for non-economic ecosystem services, were involved to a low extent whilst the majority

(38) of those who valued the ecosystem for economic values indicated moderate involvement as shown in Table 4.42. There was a strong and significant association between household perception on importance of forest ecosystem and PFM involvement level ($\chi^2 = 29.241$, df = 3, $\alpha = 0.05$, $p < 0.001$, n = 144).

Table 4.42: Perceptions of importance of the forest ecosystem and PFM involvement level

Importance of forest ecosystem	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Economic	F	5	9	8	2	24
	%	20.8	37.5	33.3	8.3	100
Non-economic	F	62	41	3	14	120
	%	51.7	34.2	2.5	11.7	100
Total	F	67	50	11	16	144
	%	46.5	34.7	7.6	11.1	100.0

4.4.18 Household dependence on the forest and PFM involvement

Research results showed that none of those who were in low forest dependence category indicated high or full PFM involvement. Further, more (3%) of those on very high forest resource category indicated being fully involved compared to 1% who indicated low involvement level (Table 4.43). The results on association between respondents level of involvement in PFM and forest dependence was found to be very strong and significant ($\chi^2 = 43.505$, df = 9, $\alpha = 0.05$, $p < 0.001$, n = 202).

Table 4.43: Household forest dependence and level of involvement in PFM

Forest dependence	Frequency	PFM involvement level				Total
		Low	Moderate	High	Fully involved	
Low	F	10	2	0	0	12
	%	5.0	1.0	0.0	0.0	5.9
Moderate	F	97	46	6	8	157
	%	48.0	22.8	3.0	4.0	77.7
High	F	6	7	5	3	21
	%	3.0	3.5	2.5	1.5	10.4
Very high	F	2	4	1	5	12
	%	1.0	2.0	0.5	2.5	5.9
Total	F	115	59	12	16	202
	%	56.9	29.2	5.9	7.9	100.0

4.4.19 Relationships between household socio-economic factors and PFM involvement

The relationships between various socio-economic factors and community PFM involvement level were tested using Spearman's rho correlation (Appendix 4). On one hand, the attributes that indicated positive and significant correlations included FMA of adjacent forest (r = 0.19, p = 0.007), household size (r = 0.21, p = 0.003), number of household members working on the farm (r = 0.14, p = 0.40) and household forest resource values (r = 0.39, $p < 0.001$).

On the other hand, the attributes that exhibited negative but significant relationships included distance to Forest Reserve (r = -0.35, p = 0.007), gender of respondent (r = -0.23, p = 0.001), Gender of household head (r = -0.16, p = 0.022), land tenure (r = -0.16, p = 0.024), land renting (r = -0.27, p = 0.001), group member (r = -0.27, $p < 0.001$) and type of group (r = -0.34, $p < 0.001$), Group status (r = -0.28, p = 0.001) and household perception on importance of forest ecosystem (r = -0.25, p = 0.002). Nonetheless, although the association between distance to the National Park, farm size, and household source of income, annual income and social status with was significant as shown above, they showed non-significant correlations with PFM involvement level.

4.4.20 Influence of household socio-economic factors on community PFM involvement level

Results of the multinomial logistic regression analysis showed that farm size, household size, household total income, type of adjacent forest, settlement history and economic importance of the forest to the household significantly influenced community level of involvement in PFM as shown in Table 4.44. The Cox and Snell pseudo R^2 was 0.703 showing that the regression model predicted 70% of the variance. The model was a good fit for the data ($\alpha = 0.05$, $p < 0.001$).

A strong positive relation was found between community level of involvement in PFM and household size and economic importance of the forest ecosystem to the household. A positive coefficient indicated that an increase in these attributes resulted in an increase in involvement in PFM. Therefore, as the number of family members increased, there was more labour available to participate in forest activities. The results also illustrated that families that derived more economic benefits from the forest ecosystem were more involved in PFM (Table 4.44).

Table 4.44: Influence of household socio-economic factors on level of involvement in PFM

Socio-economic factors	β	Model Fitting Criteria -2 Log Likelihood of reduced Model	Likelihood ratio Tests Chi-Square	df	p-value
Intercept	10.825	209.696	0.000	0	.
Farm size	-0.282	220.298	10.603	4	0.031
HH size	0.308	219.698	10.002	4	0.040
HH income	0.000	219.474	9.778	4	0.044
FMA	-1.386	221.109	11.413	4	0.022
HH head gender	0.64	216.506	6.810	4	0.146
Land tenure	-0.317	251.229	41.534	4	0.003
HH land renting	1.091	220.399	10.704	8	0.219
Economic importance	0.497	225.785	16.089	4	0.003
Social status	-0.216	232.253	22.558	16	0.126
HH income source	-17.163	236.539	26.843	20	0.140

$R^2 = 0.703$; $\alpha = 0.05$

A strong negative correlation was found between community level of involvement in PFM and farm size, type of adjacent forest and settlement history of the household. Thus, as expected, an increase in farm size decreased the households' need and dependence on forest ecosystem; households adjacent to the National Park were less involved in PFM as they derived low benefits. Further, those with short settlement history as well as those with insecure land tenure were less involved in PFM. Additionally the results depict that gender of the household head, renting of land, socio-economic statuses and sources of income did not significantly ($p > 0.05$) contribute to the final model. The adopted model with respect to PFM involvement was as follows;

PFM involvement level = 10.825 – 0.282 (Farm size) + 0.308 (Household size) – 1.386 (Forest type) – 0.317 (Settlement history) + 0.497 (Economic importance).

Where;

Farm size = – 0.282
Household size = 0.308
Forest type = –1.386
Settlement history = – 0.317
Economic importance = 0.497

CHAPTER FIVE

DISCUSSION

5.1 Value of Ecosystem Services to the Forest Adjacent Communities

5.1.1 Value of provisioning services

The measurement units of forest ecosystem economic benefits are primarily money, however, in this study, the communities derived both monetary and non-monetary goods and services from the ecosystem. These were use values which encompassed the direct consumptive use values such as firewood, timber, posts, herbs, fruits and honey. The direct, non-consumptive use values found in the area comprised of recreation and aesthetic appreciation. Indirect use values present included air and water purification, erosion prevention and pollination of crops. Therefore, the total value encompassed ecological and socio-cultural values of the ecosystem (Holling, 2001; de Groot, 2006; Daily *et al.*, 2009; Kenter *et al.*, 2011; Chan *et al.*, 2012b).

The importance of Aberdare forest ecosystem for provisioning services derived by the community was demonstrated through their utilization of diverse provisioning services to meet subsistence household needs. The findings of the socio-economic survey showed that the respondents utilized a wide range of forest products acquired either from the forest ecosystem or farmlands. The source depended on availability as well as ease of access. Similarly, Burgess *et al*. (2007) from their study based on Eastern Arc Mountains in Kenya and Tanzania; reported that households rely on the forest products essentially to meet basic household needs. This concurred with other studies which showed that forest products supported local economies as forest adjacent communities largely depended on them mostly for subsistence uses (Kelemen *et al.*, 2016b; Newton *et al*., 2016).

Nonetheless, contrary to a wide perception that communities value the forest mainly for extractive benefits (World Bank, 2005; Musyoki *et al*., 2013), the perceptions of these communities indicated somewhat differently. This is because majority (83%) placed a higher value for the ecosystem for non–economic benefits which were largely regulatory, supportive services and partly cultural services. This demonstrates that local communities are not ignorant of the significance of the diverse functions and services they obtain from forest ecosystems as observed by Emerton (1996) and Silvano *et al*. (2005). Further, other findings in this study indicated that 75% of the respondents adjacent to Forest Reserve who though, they had access to economic benefits, still perceived non-

economic benefits from the ecosystem as more important. Thus, the community seemed to understand that regulatory, cultural and supportive services provide a larger good as well as play a significant role in supporting their livelihood activities (Daily, 1997; Knight *et al*., 2006; Langat & Cheboiwo, 2010; Kukkala & Moilanen, 2013).

Various studies have shown that, communities overwhelmingly support forest conservation in cash or kind (Emerton, 2001; Mogaka, 2000; Musyoki *et al*., 2013; Newton *et al*., 2016). The economic value estimates and measures of goods and services they derived from the ecosystem using WTP showed that the majority (76%) of the community members were willing to make annual contributions to conserve and protect the forest. Nonetheless 4% were not willing to make any monetary contributions stating that it was solely the responsibility of the government. Similarly, Emerton (2001) in a study of valuation of East African forests including Kenya reported a small proportion of people who apparently placed low value of forests. They at best considered it a right to utilize forest goods and services for free and at worst, they actively contributed to forest degradation.

On average, the average contributions based on willing to pay from the forest adjacent households was approximately KES 767 (US$7.67)/household/year. Considering the average socio-economic status, the geographical location and the limited economic opportunities of the majority of forest adjacent households (World Bank, 2005; Musyoki *et al*., 2013), this symbolizes a great commitment. In additional to monetary contribution, the community participated in voluntary activities such as tree planting, policing, fire prevention and control. This implies the value of community contribution could is higher if these non-monetary contributions were considered. These findings are supported by Musyoki and Mbuvi (2014) in their study in Ontulili and Ngare Ndare forests where communities also indicated similar non-monetary contribution. The communities in those areas were also involved in activities such as creation of awareness among community members about forest conservation and production of seedlings for rehabilitation in the forest. Conversely, this study suggests further research and monetization of community contributions to forest ecosystem conservation as it could be higher than the monetary contributions. This would then capture the true value of community contribution to PFM and thus engage resource managers and policy makers to enhance mechanisms to promote PFM adoption (Newton *et al*., 2016).

The forest resources rated as most important in the survey area were water, firewood and grazing in that order as similarly reported by Burgess *et al*. (2007) from their study based on Eastern Arc Mountains in Kenya and Tanzania. Water was similarly ranked as important by the local community in Taita Hills (Himberg *et al*., 2009). This study showed that majority (98%) of the households' accessed water either as piped water, directly from the river, boreholes or dams whose source was the forest ecosystem. Those who had excess and reliable water sources engaged in small scale irrigation. According to TEEB (2010), water can be valued both as a provisioning service and regulatory service. Due to the proximity of the area to the forest ecosystem which is a major water catchment, most households had no water problem and consequently water was not a tradable commodity in the area. Subsequently, the community regarded water both as a good and service but not for commercial purposes.

Like the rest of Kenya's rural population, the community in the surveyed area used firewood as a main source of energy (Mwangi, 1992; Makee, 2005, Ongugo *et al*., 2014), thus provision of fuelwood from the forest was viewed as the second most important for 70% of the community members. Those bordering the forest reserve cited the forest as their preferred source of energy. They explained this preference by stating that firewood collected from the forest is dead and fallen thus saving the time to cut, split and drying. Further, the subsidized monthly fuelwood license (MFL) of KES 100 (US$ 1)/month charged by Kenya Forest Service was considered affordable to most households (KFS, 2015). Other sources of firewood that were reported on-farm or purchase of whole trees from neighbours as firewood for domestic use was scarcely sold in the local market as also reported by Langat *et al*. (2010).

Grazing in the forest was viewed as the third most important to 67% of the community members. As reported in other studies, livestock keeping is an important livelihood activity for the people living adjacent to forest ecosystems (Emerton, 1991; 1996; Langat & Cheboiwo, 2010; Langat *et al*., 2015). The types of livestock reared in the area were mainly cattle, sheep and poultry with a few farmers keeping pigs and donkeys. Since majority of the respondents owned small land parcels, little or no part of their land was set aside for grazing. Therefore many (47%) community members grazed their animals solely in the forest reserve whilst others, supplemented pasture from farmlands with forest grazing or cut and carry fodder from the forest reserve as espoused by Langat *et al*. (2016) from findings based in Mau forests.

A look at the livelihood activities in other areas adjacent to forest ecosystems, show similar trends of livelihood activities. For example, in Iveti forest the main source of livelihood was crop farming (88%), livestock rearing (70%) and poultry (44%); Nanyuki forest station was mainly crop farming (77%), livestock-milk and poultry (49%) (Mbuvi *et al.*, 2009; Thenya, 2014). This only emphasizes the common livelihood approach utilized by these communities, which implies devising appropriate intervention measures to address forest conservation and livelihood improvement in one area can widely be employed in many other areas. As reported in other studies, this explains the fact that the most preferred form of forest use by forest adjacent communities is typically skewed towards extraction of forest products (Ongugo *et al*., 2008; Thenya, 2014).

Further, this study found out that some products such as game meat, charcoal and cedar posts were accessed illegally since they were unavailable in the farmlands. These findings demonstrate that, if there are no alternative sources of products, the pressure on the ecosystem would continue unabated, efforts of ecosystem managers notwithstanding (Roux *et al.,* 2006; Putz *et al.,* 2012; Ongugo *et al*., 2014). Other products ranked as important by more than 10% of the households were fodder, seedlings, beehives, timber and poles. IIED (1997), Ellis and Ramankutty (2008) and Langat *et al*. (2016) also observed, forest products harvested were mainly used to meet diverse subsistence household needs and scarcely for commercial purposes. These findings were similar to those of Wass (1995) who estimated that approximately 3 million people depend on forests to meet one or more of their household needs and World Bank (2004b) who reported that globally, an estimated 1.6 billion people rely on forests for their livelihoods to varying degrees and about 60 million forest dwellers are virtually dependent on forests.

Similarly, another study done in Arabuko Sokoke forest by Matiku *et al*. (2013) indicated that households living adjacent to the forest depended on the forest for their daily subsistence for one product or another. This therefore underpins the importance of the forest products to household economy considering that respondents admitted they took high risks to acquire some products that were not available in the farmlands illegally. This reliance of local people on the forest signify an apparent linkage between the livelihoods of forest-adjacent households and forest ecosystems, which needs to be regulated as it could interfere with forest conservation objectives. As recommended in other studies, extraction of forest resources should be maintained at sustainable levels for sustainable human well-being (IIED, 1997; Scoones, 1998; MEA, 2005a; Silvano *et al.*, 2005; Langat *et al*., 2016).

That notwithstanding, this study further observed that, except for products and services that are not available in the farmlands, the communities preferred to use on-farm resources. This could be due to the high cost of acquisition in terms of time or high risks involved when acquired products illegally (Ellis & Ramankutty, 2008; Putz *et al.*, 2012). In Kenya, high penalties are surcharged for wildlife poaching and illegal harvesting of trees. Further, the findings also showed that even other products in high demand like firewood, though available at a subsidized fee from the forest, only 48% of the households depended on the forest. This demonstrates that communities had an inclination of utilizing forest products from farms based on economic reasons such as opportunity cost of time to travel to the forest (Fischer *et al.*, 2008; Bush *et al*., 2011). This was also corroborated by the fact that, though majority (77%) of the households largely used timber for construction, none was sourced from the forest during the period under review.

These findings were supported by a World Bank (2004a) report that explained that farmers are rational beings and they realized that the associated costs of extraction from the forest was higher than from their own or neighbours' farms. Therefore, this study suggests that there is need to promote agroforestry to provide basic household needs. This would reduce household expenditure and increase farm productivity from opportunity cost of time. Conversely, this would improve livelihoods as well as enhance forest conservation from the reduced pressure from the forest. In addition, it would leave the forest to perform its regulatory and supportive functions and thus mitigate climate change (Anthoff *et al.,* 2009; UNEP, 2012; Wambugu, 2013).

On the contrary, a similar study undertaken around Mt. Kenya region, reported that though communities acquired timber from farmlands, it was a major source of discontentment between them and ecosystem management. They felt that due to their contribution in forest establishment and protection, they should be included in sharing of tangible benefits like timber harvesting from the forest (Musyoki *et al*., 2013). This was expressed as a bone of contention as communities felt their contribution in forest planting, protection and conservation was inadequately compensated. The dissatisfaction could be as a result of shortages of timber and wood products that led to escalation of prices. This could be interpreted in the light of the enforcement of regulations and rules regarding exploitation of the resources within the forest ecosystem (Word Bank, 2005; Putz *et al.,* 2012) which need to be recognize community contribution. This could also be attributed to government moratorium on timber harvesting that was imposed in 1999 such that the low quantity

being harvested did not directly benefit local communities (KFS, 2010; Holding *et al.*, 2011; Mutune *et al*., 2015).

Based on the findings of this study, it can be concluded that the local community place positive values and preferences of the forest for provision of household energy, livestock production and water supply as a service, particularly for household sustenance and to enhance farm productivity. Therefore, to engage the community in PFM, there is need to consider their basic livelihood strategies. This study therefore recommends increased efforts to make forest products available on the farmlands through agroforestry. These findings correspond with Mutune *et al*. (2015) in a comparable study in Kenya where they found that households with more trees on their farm depended on them for the products instead of extracting from forests. Broadly, this implies that promotion of agroforestry could directly benefit households and indirectly enhance state of forest conservation by reducing pressure on the reserves.

Based on the non-economic valuation, the community rated water, firewood and grazing as most important products from the forest in that order. In contrast, using economic valuation methods fodder cultivation and forest grazing emerged as the most important. These findings could be qualified by the fact that communities in the region depended on agriculture and livestock keeping as the major livelihood activities. As such there was high demand for land for cultivation of food crops for both domestic and commercial purposes in addition to livestock fodder and grazing area. Further, due to the high population in the area, most farm families had small land parcels, thus the high demand for some parts of the forest suitable for plantation establishment for cultivation under the Plantation Establishment and Livelihood Improvement Scheme (PELIS) programme.

This dependence in agricultural activities and high interest in forest land for cultivation and grazing by the forest adjacent communities has also been reported in other studies (Ongugo *et al.*, 2008; Mogoi, *et al*., 2012; Musyoki *et al*., 2013; Mutune *et al*., 2015). Nevertheless, PELIS is also reported as unsustainable as it can only be practiced in the few areas being prepared for plantation re-establishment. In this arrangement, the Kenya Forest Service looked upon the cultivators as contributors to forest development whilst the cultivators desired that the forestland continue to be the source of food crops for subsistence and cash income (Ongugo *et al*., 2002; Thenya, 2014).

Community valuation however is not uninformed, despite the fact that only 9.4% of the population in the study area participated in forest cultivation, the monetary value of forest cultivation was

KES 157 (US$ 1.57) million. As such, the demand for forest cultivation was high though it remained largely unmet as PELIS plots were issued depending on clearfelled areas targeted for the annual plantation establishment (Musyoki *et al*., 2013). This research therefore, suggests improved farming practices and introduction of high value crops and livestock on the farms to meet the rising demand and reduce pressure on the ecosystem for cultivation purposes.

The findings of this study also showed that, although water was rated as the most important product from the forest for the majority (98%) of households, the net annual income was low compared to fodder, cultivation and forest grazing. This could be attributed to the law of demand and supply as the ecosystem, being a major water catchment, the area around has no problem of water scarcity. This was confirmed by other findings from the household survey that showed that piped water was not metered, thus amount used was not quantified and payment was highly subsidized at a fee of KES 200/month. As Marta-Pedroso *et al*. (2014) put it, "prices generated by supply and demand reflect scarcity, not value", as exemplified by the paradox of the relative prices of water and diamonds, hence, although water is essential to support life (unlike diamonds), it is cheaper than diamonds because it is largely abundant in the area under study.

Additional findings from this work showed that some community members obtained products like game meat charcoal and cedar posts from the forest ecosystem illegally. This value of these products could conceivably be higher except that some respondents could have been apprehensive of admitting illegal harvesting due to possible legal repercussions. According to the Wildlife Conservation and Management Act (2013), section 97, one who engages in hunting for subsistence purposes is liable to a fine of not less than KES 30,000 (US$ 300) or imprisonment for a term of not less than six months or both fine and imprisonment.

Further analysis from this study suggested that, the net value of the products acquired illegally could have been higher but due to the illegal nature of the operation, extraction costs accounted for almost 50% of the gross benefits. Equally, a CBD (2001) study reported that values for non-accessible forest products would be close to zero in net terms due to the costs of access and extraction. The illegal access of forest products could be attributed to poor local enforcement of the regulations by under resourced staff leading to a *de facto* open access arrangement as also reported by Bush *et al.* (2011) based on a study in Uganda and Ongugo *et al*. (2014) based on a report on Mt. Elgon. These findings contrasts reports from a study in stations adjacent to Mt. Kenya

forest ecosystem by Musyoki and Mbuvi (2014) where community members were not willing to state legal or illegal economic benefits that they derived from the ecosystem.

The net value of the provisioning services of Aberdare forest ecosystem to the 25,553 households in the area translated to KES 22,700 (US$ 227)/household/yr. This amount could be interpreted as what households would require to secure from elsewhere to obtain the products and services derived from the forest. This compared favourably with Emerton (2001) findings which indicated KES 16,500 (US$ 165)/household/year as the value of same ecosystem for the forest adjacent communities. The difference could be suggesting an appreciation in value for forest resources over time (Naidoo *et al.*, 2006; Obst & Vardon, 2014). Moreover, a similar TEV study based on Maasai Mau, Trans Mara and Eastern Mau Forest Blocks, of the Mau Forest complex supports these findings as it reported KES 23,367 (US$ 233.7)/household/yr (Kipkoech *et al.*, 2011). The minor variation could be attributed to inclusion of forest revenue collected by government institutions like KFS, KWS and WRA as well as non-point population.

5.1.2 Value of regulatory services

The findings from this research on the role of forest-based regulatory services showed that water catchment protection, climate regulation, biodiversity conservation, carbon sequestration; and flood and erosion control were services were deemed as most important to local community adjacent to Aberdare forest ecosystem. Consequently, this underscores the need to value the full range of benefits from ecosystems to prevent ecosystem managers pursuing market-based ecosystem goods and overlooking non-marketed services (Burke *et al.,* 2015; Bull *et al.,* 2016).

(i) Water catchment protection

Ecosystem services such as natural hazard regulation, water filtration, flood and soil erosion control and climate regulation have no value in the marketplace until they are degraded or destroyed (Kubiszewski *et al.,* 2013; Costanza, *et al.*, 2014a). This challenge is compounded by the inherent uncertainty related with valuation of ecological and economic benefits of ecosystem services; a situation that is further complicated by the fact that these benefits are greatly dependent on the local setting, which changes from time to time (Farley, 2012; Costanza *et al.,* 2014a; Burke *et al.,* 2015). This is for example, the degree of water filtration provided by forests depend on the specific watershed.

Water is vital for human life and biodiversity as well as foundation of the economy (Turpie *et al.*, 2005; Kumar *et al.*, 2010). Even though water resources perform several functions and are potentially very valuable, like other regulatory services, these values have been frequently disregarded, resulting in their depletion and degradation (Costanza *et al.*, 1997b; Kumar *et al.*, 2010). In recent years, there has been a debate over what the value of the environment or nature and more specifically water is, which has underscored the fact that the fundamental concept is intricate and multidimensional (Costanza, 2008; Bennett *et al.*, 2009; McDermott *et al.*, 2013). As explained by various studies, an economic perspective of water depicts it as a natural asset providing a stream of goods and services, which include physical, aesthetic, intrinsic and moral importance (DEFRA, 2007; Kumar *et al.*, 2010; Burke *et al*., 2015).

The findings of this study showed that the community understood these functions and had high regard for water catchment function as all the surveyed groups categorized water catchment protection as the most important regulatory service to the community. They elucidated that it supports their very livelihood sources which were agriculture and livestock production. This revealed that the community clearly understood that forests play an important role in water flow regulation, domestic water supply as well as in supplying water for small scale irrigation as also reported from a study undertaken in Tanzania where the community reported that irrigated areas produce higher incomes per ha than fields without irrigation (Turpie *et al.,* 2005).

As watersheds absorb and store water, they contribute to the quantity of water available to support the flow of goods and services as well as regulating the periodic flow of surface and underground water. The vegetation soaks up and stores water when abundant, discharging it slowly during the dry periods (van Wilgen *et al*., 1996; Nelson *et al.*, 2009; Kumar *et al.*, 2010; Ongugo *et al*., 2014). The main problem when including the full range of environmental services in economic preferences is that many of these water-related services have no market value (MEA, 2005c; Silvano, *et al.*, 2005; Costanza *et al,* 2014a). There is a gap between market valuation and the economic value of many water functions. In the case of many of the functions, the identification of economically relevant services is of special importance as over time those services not allocated value by the market have at times gained importance (Ruijs *et al.,* 2013 and at other times disregarding them leads to their degradation.

The low value of KES 2400 (US$ 24)/ha/yr was applied in this study, considering that water was the most important function cited by the community from the FGD. However, the low value was supported by Kumar *et al.* (2010) and Farley (2012) whose observations noted that, watershed protection values seem to be low when expressed per hectare but given that watershed areas are large, small unit values are aggregated across large areas like the case of Aberdare ecosystem. Similar values were used by Costanza *et al.* (1997b) who applied KES 1400 (US$ 14)/ha/yr for watershed regulation including water supply. In the study area, the total estimated value for water regulation for the households under consideration was lower than the findings reported by a Rhino Ark (2011) study in the same area which was KES 2,323.8 (US$ 23.2) million. This could be attributed to the fact that the Rhino Ark study included the values of water supply from the ecosystem not only to local communities but also nationally through its support to other sectors like agriculture, and tourism as well as commercial provision of water to major urban centres including Nairobi city. It also considered the hydroelectric power generation from the Tana River drainage system. The lower values in this research were however preferred also because protective functions have a 'public good' characteristic since the benefits accruing to any one person also accrue to everyone (Kumar *et al.,* 2010; Rosen, 2014) both locally and regionally especially in the case of ecosystems like Aberdare.

The findings of this study also showed that, although there was a higher benefit from commercial utilization of water in urban centres, these benefits did not impact directly on the community or ecosystem. This study therefore recommends a comprehensive estimation of water catchment protection functions in view of a possibility for Payment for Environmental Services (PES) which should accrue to the local community (Engel *et al.*, 2008; Kumar *et al.*, 2010; UNEP, 2012; McDermott *et al.,* 2013). This is moreover stipulated by EMCA (2015) and Forest Conservation and Management Act (2016).

A certain percent of the income obtained by the beneficiaries should be ploughed back to support protection of the water catchment and part should support community livelihood improvement activities as similarly reported in various studies (van Wilgen *et al.,* 1996; Wilson & Howarth, 2002; Vatn, 2010). This would contribute to reduction of increasing pressure and threats on the water and wetlands resources (Himberg *et al*., 2009). This has been occasioned by various emerging and increasing uses driven by the growing population. Some of these threats include agricultural intensification, pollution, invasive species, overuse and an inadequate institutional

framework to manage forests and wetlands. These threats have affected both the quantity and quality of water available (Bhatnarger, 2008; McDermott *et al*., 2013; Ongugo *et al*., 2014). In reality, water from this catchment area is utilized beyond the geographical coverage of the study area. This study therefore suggests that the government should introduce incentives to promote conservation efforts, as is done in different places with PES (Turpie *et al*., 2005; McDermott *et al*., 2013, UN, 2014). Such external incentive schemes could encourage the local communities to participate in sustainable conservation of the forests and sustain both national and global interests.

(ii) Climate regulation

UNEP (2012) perceives the benefits of forest-based regulatory services as reducing risks to the economy and availing a range of insurance values, especially in times when market fluctuations and/or industrial exports are challenging some economic sectors. This insurance value is critical for maintenance of economic resilience in cases of unpredictable changeability of environmental and economic circumstances and minimization of long-term economic catastrophes. Globally and even in Kenya, the recurrence of natural hazards, like floods, storms, droughts, major fires, and disease and pest outbreaks, draws attention to the importance of ecosystems in alleviating calamities and the need to restore ecosystems (Burke *et al.,* 2015; Bull *et al.,* 2016).

Climate regulation at global and regional scales as well as in the study area relates to the maintenance of a favorable climate, which has important association with health, crop productivity, recreation and other human activities (Lescuyer *et al.,* 2007; Costanza, 2008; Rosen, 2014). Forest ecosystems regulate climate by trapping moisture and cooling the earth's surface, thus regulating rainfall and temperature (CBD, 2001; DEFRA, 2007; Bull *et al.*, 2016). Manmade climate change and large-scale alteration of the landscape are affecting the planet and the ecosystem services upon which humans depend. These alterations include loss of forests that were once large carbon sinks, loss of pollination services provided by insects, and loss of ecosystem resilience in the face of natural disasters (de Groot *et al.,* 2002; Turpie *et al.,* 2005; Fisher *et al.,* 2011a; Ongugo *et al*., 2014).

Aberdare ecosystem was found to perform these functions leading to regulation of climatic conditions of the adjacent area (Turpie *et al.,* 2005, KFS, 2010). The importance of climate regulation showed that it was viewed as the second most important in this research. The community seemingly understood this clearly when they compared the rainfall patterns and reliability with

other areas further from the forest ecosystem. The community expounded that productivity decreased with increase in distance from the ecosystem. They explained that forests played an important role in drought mitigation and increasing land productivity. The community expounded that they were able to grow rainfed horticultural crops whereas areas that were 30-50 km from the forest suffered from food scarcity and a higher intensity of drought leading to recurrent food insecurity. As reported by Turpie *et al*. (2005) and Burke *et al*. (2015), the farmers felt that water catchment protection and climate regulation services enhanced agricultural productivity.

The value for climate regulation to the community in this study amounted to KES 10.2 (US$ 0.1) billion based on KES 45,000 (US$ 450)/ha/yr This was conservative compared to Lescuyer *et al*. (2007), who estimated the value of climate regulation by tropical forests in Cameroon at KES 84,200-226,500 (US$ 842-2,265)/ha/yr. However, the low values from the study were supported by Costanza, *et al*. (1997a) who obtained KES 22,300 (US$ 223)/ha/yr for global tropical forests. Though the value of climate regulation is higher than that of water catchment protection, as stated by Simpson (1998), prices should not to be confused with values, and they are not the only important values. This work consequently, like other studies advocate for the combination of valuation methods for ecosystem services through application of both monetary and non-monetary valuation methods (Kenter *et al.,* 2011; Kelemen *et al.,* 2016b).

(iii) Biodiversity conservation

Biodiversity, both within and between species populations, is typical of all ecosystems and, through natural selection, it results in evolution and adaptions of species to specific habitats. Biodiversity and natural ecosystems contributes to different elements of TEV (Harrington *et al*., 2010; TEEB, 2010; Chhetri *et al.,* 2016). All the TEV elements are an essential source of non-material well-being through their influence on mental health and their inherent cultural, medicinal, historical, bequest and existence, religious and spiritual values (MEA, 2003; TEEB, 2010; de Groot *et al*., 2016). The findings of this study illustrated that biodiversity has these diverse values in the study area.

However, similar to other findings, the community in the study area had limited direct or indirect use value for biodiversity (Emerton, 1996; Kumar *et al.,* 2010; Obst & Vardon, 2014; Fraser *et al.,* 2016) except for a few instances where some collected herbal medicines directly from the forest or propagation material in form of seeds, wildlings or cuttings to plant in their own farms. The

community reported that they used herbs to cure general maladies affecting people and livestock or control pest and diseases in crops. Diversity has been shown as important for a wide range of services, such as atmospheric regulation, pollination, pests and disease control, including timber production.

Therefore, diversity is a critical precondition for all the other values derived from the forest, ranging from tourism to timber and non-timber products as well as the information flows (DEFRA, 2007; Bastian, 2013; Balvanera *et al.*, 2016; de Groot *et al.*, 2016). Though biodiversity was only used on a small scale, the community ranked it as third most important explaining that it was an important resource which should be conserved for its bequest and existence values too. These findings were consistent with Krieger (2001) and Kumar *et al*. (2010), who explained that the genetic material is important for its option values. As observed by Martín-López *et al*. (2013), the essence of biodiversity is that the existing stocks safeguard the entire array of goods and services provided by the diverse system.

There has been an on-going debate as to whether biodiversity is an ecosystem service (Nelson *et al.*, 2009; Dinerstein *et al*., 2014; Jax & Heink, 2015) or is the underlying concept providing services. The latter concept suggests that the link between biodiversity and ecosystem services is a matter of both biophysical relations and also related to social dimensions, hence, the need for different emphasis of conservation strategies (McDermott *et al.*, 2013; Jax & Heink, 2015). This multifunctional value of diversity was evidently and plainly articulated by the community during the FGD when they stated that biodiversity contributed to all other benefits including tourism "*without the different animals and plants, the tourists will not come.*" This perception is an important finding in this study and can be used to create awareness to curb illegal tree harvesting and wildlife poaching.

Nonetheless, these multiple functions has made valuation of biodiversity fairly complex as estimates are made from valuing different attributes of the diversity. For example, the estimates that were applied in this study by Langat and Cheboiwo (2010) derived from Mau Complex estimated the forest biodiversity for future industrial use and the carbon sequestration value. This is comparable with Kipkoech *et al*. (2011) who used KES 1,000 (US$ 10)/ha/yr for the rich flora and fauna for some forest blocks in Mau complex.

On the other hand, Reid (1999) indicated a value of KES 100 (US$ 1)/ha/yr based on a case of a banana plantation in Costa Rica which was the amount paid to an adjacent forested conservation area annually to provide natural pest control as well as pollination services. These varying attributes of biodiversity have made its economic value the subject of a fast growing literature but one that remains largely inadequate in providing values for diverse forest types (Ruijs, 2013; Marta-Pedroso *et al.*, 2014; Chhetri *et al.,* 2016). The situation is compounded by the fact that there lies confusion between the value of biological resources and the value of biodiversity. According to CBD (2001) and Bull *et al.* (2016), many studies relate to the former and few to the latter, though they do not report the variance.

Further, the unsatisfactory nature of current research lies in the fact that 'true' value of the forests is ascribed to the role they play as the repository of biological diversity and that the economic value of this diversity has yet to comprehensively understood and measured (Daily *et al.*, 2009; TEEB, 2010; de Groot *et al.,* 2016). The diversity embodies billions of years of information and resilience to environmental change. The latter protect the former but also protects all the other functions of forests - use and non-use values alike (TEEB, 2010; Chhetri *et al.,* 2016). Hence the economic value of any tract of forest must be equal to its informational value plus its insurance value (Nelson *et al.,* 2009; Keune *et al*., 2015; de Groot *et al.*, 2016).

Various studies (Mbuvi *et al*., 2009; Nelson *et al.,* 2009; Jax & Heink, 2015) explain the basis of the proposition that biodiversity protects all ecosystem goods and services. They state that the real economic value of diversity is the insurance premium that the world should be willing to pay to evade the value of losing ecosystem services. If a market existed, the actuarially fair premium for this insurance, is the likelihood of the loss taking place multiplied by the value of all the losses that would arise.

This study also notes that another major drawback in the valuation and conservation of biological diversity is that several species and their properties remain unknown, thus valuation is constructed on the potential uses of these resources (Bastian, 2013; Chhetri *et al.,* 2016). This diversity therefore, as expounded by Pearce (2001), is valued for the options that it denotes. Option value reflects the readiness of a risk-averse society to pay a premium, on top of the use value itself, for securing access to a resource of unknown future supply.

In the study commissioned by Rhino Ark (2011), biodiversity in Aberdare Conservation area was valued at KES 20 (US$ 0.2) billion. The conservative biodiversity values used in this study were preferred because as elucidated in the case of Costa Rica study, such costs have not actually been incurred. These estimates represent only the cost of replacing the regulating services and not the true value of these services. Further, the value provided by Rhino Ark (2011) was higher as the report included the regional and national community and much less of this trickled to the forest adjacent community.

(iv) Carbon storage and sequestration

Forests are the only major terrestrial ecosystems where the amount of carbon stored in biomass of the plants exceeds that in the soil and deforestation therefore also impacts on climate regulation (TEEB, 2010; Gren & Carlsson, 2013). The forest ecosystems absorb and release both natural and fossil CO_2 through the global carbon cycle (IPCC, 2005). The global carbon cycle is strongly buffered, in that much of the CO_2 discharged by human activities into the atmosphere is absorbed by forest ecosystems (Janzen, 2004; Tavoni & Sohngen, 2007). As CBD (2001) explains, it is essential to differentiate between carbon stored in a standing forest and carbon sequestered in a growing forest. Aberdare forest ecosystem provides (i) carbon stored in the standing forest (carbon balance); and (ii) carbon sequestered in a growing forest. The carbon stored in the standing forests would be lost if the trees are harvested. However, in this study like many other studies (Haugan & Joos, 2004; IPCC, 2005; Kipkoech *et al*., 2011; Dinerstein *et al*., 2014; Rubin *et al.,* 2015), the community could not distinguish between carbon storage and sequestration and viewed these functions as one and ranked it as an important regulatory service to them. Similar perceptions were obtained from a study in Peru that also showed farmers could not segregate the two but they were not indifferent to the benefits they derive from forests in carbon sequestration (Tavoni & Sohngen, 2007; Gren & Carlsson, 2013).

Kenya is one of the few countries in Africa which are benefiting from the carbon markets with at least five carbon projects being implemented under the Clean Development Mechanism facility, though only one is under the sector of afforestation and reforestation (SOVCM, 2015). Kenya was also the first country to win a validation for REDD credits under Voluntary Carbon Standard (Ndichu, 2016). It has been argued that carbon projects offer major potential to raise funds for environmental conservation; target existing funds and in additionally, secure environmental benefits

that can develop initiatives targeting community livelihoods (Brink *et al*., 2011). According to the REDD plus findings from Kasigau in Kenya, the project has contributed to increased household income and has received support from communities and stakeholders in the area. Ndichu (2016) highlighted that the communities in the project area were involved in decision making and particularly on how and where to invest their part of the proceeds amounting to KES 586,300 (US$ 0.59) million based on US$5.7 (KES 570)/t$CO_2$e. Thus, this study made use of the same rate amounting to a total of KES 22.6 billion based on the prevailing price of carbon in Kenya.

Kipkoech *et al*. (2011) in the forest blocks in Mau complex made use of almost similar estimates of KES 1200 (US$ 12) per tC/ha/yr. The conservative figure was preferred in this study because of two reasons. One, the forest ecosystem has diverse vegetation including low-carbon density areas (Dinerstein *et al.*, 2014), excluding forest plantations as they may be harvested after some time resulting in CO_2 emission (IPCC, 2005; Rubin *et al.*, 2013). Two, this benefit accrues not only to the local community but also to the regional and global community. These findings are reinforced by Norton *et al.* (1995) who reported that governments heavily subsidize conservation because most of the benefits, although substantial, accrue to regional and global community and adjacent communities have no way of arrogating the values. It is important to note that ecosystem services like carbon storage and sequestration are global benefits whereas the local communities bear the costs of maintaining these forests (TEEB, 2010; Dinerstein *et al*., 2014), as such this study recommends that appropriate mechanisms such as development of carbon markets to compensate local communities (Kipkoech *et al*., 2011; Gren & Carlsson, 2013; Rubin *et al*., 2015).

Many uncertainties are related with this regulatory service, particularly due to; (1) extended interval in the responses between changes in ecosystem processes and the atmosphere and (2) the rate of emissions gradually exceeding absorption capacity (Dinerstein *et al*., 2014; Ing-Marie, 2015). Additionally, this capacity is further reduced by anthropogenic damage to ecosystems like conversion of forests to agriculture. Agricultural ecosystems have low soil carbon stores owing to intensive production methods, and there are challenges in enhancing those stores. The complex interactions and long-time lags make it very challenging to forecast ultimate outcomes of, if and when significant thresholds will be surpassed (Ing-Marie, 2015; Rubin *et al.*, 2015).

There few estimates for this regulatory service different types of forests (Gren & Carlsson, 2013; Rosen, 2014; Rubin *et al.*, 2015). Like in Peru, it was reported that if a compensation scheme was

devised, local farmers were willing to accept a lower compensation of KES 10,000 (US$ 100)/ha for agroforestry practice. However, they would only accept KES 20,000 (US$ 200)/ha if the preferred conservation option was to be absolute conservation (Gren & Carlsson, 2013).

A review of the literature suggests that the value of forests as carbon stock should be in the range of KES 3400-5000 (US$ 34-50)tC (Clarkson 2000; Tol *et al.,* 2000; CBD; 2001). However, many studies argue that the real guide to the value of carbon should be the price at which it is traded in the carbon market (CBD 2001, Tavoni & Sohngen, 2007; SOVCM, 2015). According to Zhang (2000), when an open market exists for carbon trading, carbon credits exchange would be at about KES 1000 (US$ 10)/tCO_2e). Nonetheless, other authors argue that the climate impact of CO_2 from an imperfect storage will vary over time, so will the prices (Haugan & Joos, 2004; Ing-Marie, 2015).

Since poor public participation in addition to little or no benefits from conservation work has contributed to the increasing deforestation and forest degradation, adoption of compensation to land users/owners at the national level, could lead to reduced rate of forest degradation and deforestation. In the REDD+ project in Kasigau, through the committees formed at the local level, communities living in the area invested in social amenities and paid school bursaries for their children. It was noted that this created ownership of the natural resource (forests) and positive attachment of economic values to the forest ecosystem (Ndichu, 2016).

(v) Flood and soil erosion control

Soil erosion and the subsequent siltation and sedimentation is predisposed to many complex relations such as intensity and periodicity of rain, soil type, slope, type of vegetation and the agricultural practices prevalent within a given area (Bruijnzeel, 2004; Kipkoech *et al*., 2011; Dinerstein *et al.,* 2014). The area around Aberdare ranges is characterized by steep slopes, moderate to high rainfall and it is under intensive agricultural activities. Since the topography is characterized by steep slopes, cases of flooding are rarely experienced except for low lying farmlands. However, there frequent incidences of land and mud slides. As such, the community indicated the forest was important as it contributed to flood reduction mostly in other areas along the Tana basin. Accordingly, they did not have clear ways of valuing flood control primarily due to the non-point nature of impact (Pearce, 2001; DEFRA, 2007; Dinerstein *et al.,* 2014).

However, due to the steep slopes, high rainfall and intense agricultural practices, the area was prone to soil erosion whose extent varied from one area to another because of the variation in these contributory factors around the whole ecosystem. The community was able to identify themselves with the problem of soil erosion and the costs allied with it. These costs are associated with mitigation of loss of soil productivity for agriculture, damage to roads and other infrastructure, filling up of ditches and reservoirs; and flooding on the farmlands (Krieger, 2001; Pearce, 2001; Ing-Marie, 2015).

Flooding is a problem that occur in a wide range of ecosystems which include steep deforested catchments, flat silty plains and urban ecosystems with constrained water flows (TEEB, 2010; Fish *et al*., 2011). Thus, forest ecosystems play various roles in soil conservation which include control of erosion, flooding, siltation and sedimentation including soil formation and nutrient cycling (TEEB, 2010; Rhino Ark, 2011). The plant cover protects soil from the force of rain by intercepting rainfall whereas roots support and maintain the soil structure (Kumar *et al.*, 2010). Wind breaks from woodlots or from the use of natural forest features are a traditional means of protecting crops and habitations against both violent storms and strong winds (TEEB, 2010). In the study area, farmlands are dotted with woodlots, boundary planting and planting of trees around homesteads. These not only provide timber and other wood products as shown in this study but also act as wind breaks and control soil erosion.

The importance of vegetation cover in preventing soil erosion was illustrated by the classic historical American dust bowl of the 1930s, where lack of vegetation cover combined with prolonged drought caused unprecedented wind erosion, destroying farmland and livelihoods (Cooke *et al.*, 1936). Further, landslide frequency seems to be increasing as a result of land-use changes, particularly deforestation. In the areas on steep terrain in the area, forests provided protection against landslides by modifying the soil structure and moisture regime (Sidle *et al.*, 2006). In all these circumstances the role of forests or vegetation is structural, and the part played by forest is normally indirect as it in controls the stability and resilience of the system.

Soil formation and nutrient cycling functions are other aspects of this regulating service (de Groot *et al.*, 2002; TEEB, 2010). This is through a slow processes that have significant implications for maintenance of farm productivity (Bruijnzeel, 2004; Pimentel, 2008; Dinerstein *et al.*, 2014). The process of soil formation is governed by the parent materials, biological processes, topography and

climate. The progressive accumulation of organic materials depends on the activity of a wide range of microbes, plants and associated organisms (Carr *et al*., 2006; Brussaard *et al*., 2007; Nelson *et al*., 2009). Nutrient cycling reinforced soil quality, which occurs in all ecosystems and is strongly linked to productivity (Janzen, 2004; Brussaard *et al*., 2007). Nitrogen fixation by organisms accounts for around half of all nitrogen fixation worldwide, and sustainable agricultural systems rely and will increasingly have to rely on this process in future (de Groot *et al*., 2002; Carr *et al.*, 2006; TEEB, 2010). Agricultural practices, especially expansion into new areas often occupy terrains that are unsuitable for agriculture, and soil fertility declines quickly as crops effectively mine the soil nutrients (Carr *et al*., 2006). As a result, this ecosystem service is important to communities around the ecosystem who lived on steep slopes and largely depended on agricultural production.

Several studies have shown that in many areas, loss of forest cover in watersheds is certainly a principal factor in accelerating soil loss (Bruijnzeel, 2004; Brussaard *et al.*, 2007; Dinerstein *et al.*, 2014). In this study, the estimated value of this service applied KES 12,528 (US$ 125.3)/ha/yr from based on a local study by Langat and Cheboiwo (2010) in a study based on Mau forest ecosystem. This was higher than a similar study that used KES 5,680 (US$ 56.8)/ha/yr by Kipkoech *et al*. (2011). This higher value was applied for various reasons. Firstly, the consideration that the ecosystem protects sedimentation of many water intakes serving the community. Secondly, the non-point control of sedimentation of the hydropower dams as Aberdare ecosystem water which accounts for 40% of the national hydropower production in Kenya (KFS, 2010; Rhino Ark, 2011; Ongugo *et al.*, 2014).

These findings contrast the estimates from other existing research which suggests that likely savings to the water treatment industry from reduced erosion are a relatively minor benefits (Lutz, 1994; Bruijnzeel, 2004). Their low estimates could also be attributed to the fact that they represent one-off or periodic costs avoided and they did not approximate annual losses (CBD, 2001; DEFRA, 2007) as done in this study. Nonetheless, these estimates are also supported by the findings of Ing-Marie (2015) who observed that if there is complementarity in the provisioning of these services, the calculated value can be raised since increases in the soil conservation provides a simultaneous improvement in provision of other services like carbon sink, biodiversity, agricultural yields and recreation.

These findings illustrated that farmers were not indifferent to the diverse non-cash benefits they secure from forests. These findings were reinforced by Smith *et al*. (1997) from the Peruvian Amazon where farmers indicated their WTA compensation to forego the existing slash-and-burn land use in favour of either agroforestry or forest conservation. The farmers on average stated a WTA of KES 24,600 (US$ 246)/ha to leave the forest in a conserved state and KES 15,300 (US$ 153)/ha for agroforestry. The lower value for compensation for agroforestry reflected the fact that small scale farmers were aware they would secure some benefits from crop yields in addition to forest products within an agroforestry system. This illustrates that farmers are aware of the economic benefits they secure from forests, and according to the Peruvian study, if a scheme of compensation could be devised; they were willing to accept payments to be involved in conservation.

5.1.3 Value of cultural services

Forest ecosystems have clear and important cultural values for people living in or near the forests as well as in towns. Since people experience cultural services almost individually, they barely agree explicitly on what is most important. As a consequence, the assessment and valuation of cultural services requires wider stakeholder involvement as observed by Bunse *et al*. (2015), Edwards *et al*. (2016) and Kenter (2017). This enables "making sense" (Jordan & Russel, 2014) of differing viewpoints in the course of intersubjective and inclusive deliberation as observed from the members of the community during the FGD in this study. The wider involvement of stakeholders in the analysis is essential to obtain both priority benefits and also "buy in' (Burke *et al.*, 2015) which provides additional weight for use in decision making (Jordan & Russel, 2014; Bull *et al*., 2016). Therefore in this study, the rankings by the different groups surveyed were quite dissimilar and each of them had compelling reasons to support their decisions. Although, the various groups could hardly agree on the rating of the ecosystem cultural services, they were able to rank source of knowledge/education, tourism/aesthetic, historical/cultural and bequest as most important in that order.

(i) Source of knowledge and education

Although source of knowledge and education is an important cultural service, there is little quantitative data on its value in Kenya and even globally (Nasi, *et al.*, 2002; MEA, 2005c; Chan *et al*., 2012a; Milcu, 2013; Kelemen *et al*., 2016a). The community in the area, after much

deliberation, considered source of knowledge as the most important service to them. Further probing on the reasons of this ranking, Michukia group that ranked source of knowledge most highly compared to other cultural services explained that "*we need to get more knowledge on the ecosystem and from that knowledge we can improve the management and all other benefits will flow*." Similarly, various studies provided diverse perspectives of ecosystems as a source of education and knowledge (Wilson & Howarth, 2002; Chan *et al.*, 2012a; Kelemen *et al*., 2016b).

This study therefore opted to make use of the average values obtained from local forests with similar characteristics (Mogaka, 2000). The conservative value obtained for source of knowledge/education in this study amounted to KES 735.7 (US$ 7.4)/household/yr for the households adjacent to Aberdare ecosystem. The shortage of information is a paradox because, thus far many researchers have not found it worthwhile to isolate and undertake substantive valuation studies, yet according to the community, source of knowledge and education is the paramount cultural service.

This could have been an oversight that could be explained by what Nasi *et al*. (2002) and Milcu *et al.* (2013) refer to as lack of distinction between local, national, regional and global values which depended on who captures the benefits. Nasi *et al.* (2002) notes that though in an operational sense they are not necessarily mutually exclusive, the distinction is important to understand the incentives for conserving these values at the various levels. Additionally, TEEB (2010) states that although all societies value the cultural services that ecosystems provide, these may have different significance in affluent, stable and democratic societies. The problem could have also been compounded by the labelling of cultural ecosystem services as "residual" ecosystem services category, to encompass everything that does not fit in the more utilitarian classes of ecosystem services (Chan *et al*., 2012b, Daniel *et al*., 2012). This study therefore recommends more studies to obtain quantitative data on cultural services, particularly source of knowledge.

(ii) Recreation and aesthetic value

Recreation is one of the ecosystem services recognized by the MEA (2005b) and in recent decades the world has witnessed an increasing demand for outdoor recreation opportunities (MEA, 2005a; de Groot *et al*., 2010; Kenter *et al*., 2011; Chan *et al.*, 2012b; Clough, 2013). Recreation and tourism is a growing activity and constitutes a potentially valuable non-extractive use of tropical forest ecosystems including Aberdare (Nasi *et al.*, 2002; Milcu *et al.*, 2013). Forests hold a wide

range of recreational opportunities comprising a major part of non-consumptive recreational activities such as hiking, bird watching, wildlife viewing and other such pursuits (Edwards *et al.*, 2012). The major activities are those centered on gratifying 'inner-directed' needs for activity, exploration and appreciation of the natural environment and covers the 'free services' of natural capital in providing opportunities for recreational expeditions (de Groot *et al.,* 2010; Kenter *et al.*, 2011; Milcu *et al.*, 2013).

In this research, these findings on increased interest in recreation were illustrated by the fact that over 70% of the respondents indicated they had visited either or both the Forest Reserve and National Park for this purpose. Clough (2013) and Milcu *et al*. (2013) attributes demand for recreation to a combination of interrelated factors which consist of increasing incomes; increasing leisure time and holiday habits; improved mobility through rising car ownership; improved road networks; and higher educational achievement which has resulted to increased environmental appreciation and its potential for recreation. Other aspects are associated with the various indirect benefits including improved physical health, the regenerative qualities related to being outside (cognitive benefits) and benefits related to support of local economic growth (Edwards *et al.*, 2012; Cooper *et al.*, 2016).

In this study, the values attached to recreation and tourism were apparently influenced by the locality of the group as the order was inconsistent across all the groups. Although recreation and tourism was on average the second most important cultural service, the conservation groups surveyed had mixed reactions regarding its significance in the area. On one extreme, Njeng'u group neighbouring the tourist lodges in the National Park ranked it as the most important. On being probed further, they stated that tourists and accruing benefits stream throughout the year unlike other regulatory service benefits which were largely intangible and intermittent.

On the other extreme, Cascadia and Michukia groups which were adjacent to the Forest Reserve rated the service as the lowest. On further probing, the members explained that, though tourism is important to Kenya as a foreign exchange earner, the benefits scarcely trickled to the local community in their area. This is supported by Nasi *et al*. (2002) and Cooper *et al*. (2016) who revealed that the total benefits from recreation that accrue at the local forest level tend to be small or non-existent.

Various studies have shown that recreation and tourism values of forested areas vary widely depending on various parameters such as proximity to major urban areas, accessibility and uniqueness of the forest ecosystem (Krieger, 2001; Butler & Oluoch-Kosura, 2006; Naidoo & Ricketts, 2006; Kipkoech *et al.*, 2011). Therefore, some ecotourism sites attract an enormous number of visitors and consequently have very high values per hectare (Krieger, 2001; Nasi *et al*., 2002; Cooper *et al.*, 2016). The Aberdare National Park is an important tourism destination in Kenya driven by the diversity of wildlife, attractive sites, accessibility and wilderness experience (Rhino Ark, 2011; de Groot *e al.,* 2016). Further, as observed by Edwards *et al*. (2012) and Clough (2013) recreational opportunities and interests vary between social groups such as socio-economic status, demographic background and age; requiring long-term and targeted planning based on preferences.

This study was largely interested with perceptions and net gains to forest users or/and forest adjacent communities. In the area, the community viewed recreation services in two dimensions – tourism and aesthetic appreciation as explained by MEA (2005b) and Clough (2013). The reason being that the community did not directly obtain monetary benefits from tourism as they reported in the FGD. Nevertheless, they all admitted that they enjoyed the aesthetic values as most of them had a panoramic view of different parts of the scenic landscape from whichever locality. Some studies provide some evidence that living near to forests offers some benefit in terms of amenity (Nasi *et al*., 2002; TEEB, 2010; Cooper *et al.*, 2016). As reported by de Groot *e al.* (2016) people enjoy areas that contain a visually pleasing combination of features, visual contrasts or dramatic elements such as wildlife and scenic landscapes which are generally present in Aberdare ecosystem.

Some of these studies have shown that the presence of a forest or woodland within or near housing estates increases house prices (TEEB, 2010; Chan *et al*., 2012a; Edwards *et al*., 2012; Cooper *et al.*, 2016). Fuller *et al*. (2007) and Lee *et al*. (2009) espoused that the psychological benefits of green space increase had a strong positive effect on economic productivity as a green view from a window was found to improve job satisfaction and ease job stress. Despite the existence of these diverse factors, the tourism potential in the Aberdare seemed not to have been fully exploited by both the local and external markets.

Tourism is among the leading sectors in the Kenyan economy, accounting for 12% of the GDP and 9% of the wage employment (Kipkoech *et al.*, 2011). Findings from a study in Costa Rica valued recreation at KES 16,000 (US$ 160)/ha (Tobias & Mendelsohn, 1991) whereas Maille and Mendelsohn (1991) findings in Madagascar were KES 36,000-46,800 (US$ 360-468)/ha. Both studies used travel cost method; however, the former study used local visitors only and the latter used foreign visitors only. Noting that Aberdare ecosystem experiences both types of visitors and bearing in mind that highest benefits accrued did not trickle to the community, this study therefore opted to use the conservative figure of KES 204 (US$ 2)/household (Mogaka, 2000) for the households adjacent to the ecosystem. This followed guidance from Diamond and Hausman (1994); CBD (2001) and Kenter *et al*. (2016) who observed that in valuation of recreation and tourism of forested areas, caution need to be taken as the benefits can flow to beneficiaries who reside far from the forest area and may even be non-nationals. This was confirmed by the communities who appropriately explained that "*though tourism is important to Kenya as a foreign exchange earner, it had the least impact to the local households in their area*."

The precaution is also advocated by other studies (Nasi *et al*., 2002; Kumar *et al*., 2010; Chan *et al*., 2012b; Rita *et al.,* 2017) who report that recreation and amenity are forest ecosystem services that accrue to the recipients as public goods. They are enjoyed by any number of people without affecting other people's enjoyment. They explain that the problem with public goods is that, although people value them, individuals have no incentive to pay or maintain the good. These observations however, are not supported by a local study by Kipkoech *et al*. (2011), from their findings based on Forest Blocks of Mau Forest complex where they obtained KES 127,120 (US$ 1,271.2)/household/yr. Their higher estimates could be attributed to the presence of the Mara National Reserve and the adjacent Serengeti National Park in Tanzania which have more earnings from a high number of foreign visitors.

In the study area as well as other parts of the world, despite the rapid increase in recreational demand, there are key challenges about meeting this demand as landscapes change. As observed by Milcu *et al*. (2013), the limited governmental budgets may not keep pace with the maintenance and development of adequate recreational and green infrastructure. Therefore, this study recommends the involvement of stakeholders especially local communities in conservation, protection and development of these areas. As such, governments should come up with policies to

enlist support from the adjacent communities in ways that remunerate them adequately for their conservation efforts.

(iii) Cultural heritage

Aberdare forest has both biophysical and historical features that the people who live within its vicinity have a high cultural regard (KFS, 2010). The ecosystem has numerous instances where particular types of forests, particular plant and animal species were strongly associated with cultural identities, place attachments, social practices, and images (KFS, 2010; Kumar *et al*., 2010). As explained by Verschuuren (2006), different cultures may have different heritage associations with the same ecosystem features; thus, understanding cultural heritage as an ecosystem service requires simultaneous consideration of both the ecological and cultural contexts.

Natural features of the environment are usually related with the identity of individuals, a specific group, community or society (Krieger, 2001; de Groot *et al*., 2010). They offer experiences, including spiritual and religious values, which are shared from one generation to another in addition to providing settings for communal interactions for important social practices. The early human societies viewed trees as having souls and spirits and believed trees possessed natural powers, including a wide range of natural forces such as bringing the rainfall and sunshine; ensuring abundant harvests; helping flocks and herds to multiply; ensuring the fertility of women and easing childbirth (Nasi *et al.*, 2002; Daniel *et al.*, 2012). The MEA (2003) acknowledged that many societies place high value on the maintenance of either historically important landscapes termed as'cultural landscapes' or culturally significant species. According to TEEB (2010) and Milcu *et al*. (2013) historical and socio-cultural values are some of the ecosystem services considered essential to a people's very identity and existence.

Aberdare ecosystem provides important sites in terms of historical, spiritual and religious significance which the community felt they were important in maintaining their identity. Traditionally, the community used various giant *Ficus spp* trees as shrines for worship and these have been conserved and revered to date (KFS, 2010). The findings of the survey showed that some of those areas regarded as sacred are still visited by some community members for religious activities. Further, the forest was used as a camping site for runaway Italian prisoners during the World War II and thereafter it was used as hideout place for Mau Mau freedom fighters during the struggle for independence in Kenya (KFS, 2010).

Many of the caves used by the freedom fighters dot the forest ecosystem, where some are currently used as ecotourism sites. The communities around the ecosystem were alive to these historical and cultural values and they explained that this informed its ranking as an important benefit necessitating conservation of Aberdare forest. As reported by Daniel *et al*. (2012), cultural heritage is intricately linked with historical relationships between human societies and ecosystems. As elucidated in other studies, cultural landscapes are vessels of historical values that contribute to the uniqueness of communities (Stephenson, 2008; Daniel *et al.,* 2012; Milcu *et al.*, 2013).

There are many existing and potential cultural ecosystem benefits to the general public and specific communities associated with history, heritage and identity in relation to the forest ecosystems as noted by Daily *et al*. (2009) and Jobstvogta *et al*. (2014). Nonetheless, markets primarily indicate monetary values for only some cultural heritage services, like those marketed to tourists, of which their valuations are incomplete in many instances (Milcu *et al*., 2013). This is has been demonstrated through valuation studies undertaken in various parts of the world which show that although, cultural and historical values are at the heart of local communities, low monetary value has been placed on them (Butler & Oluoch-Kosura, 2006; Daily *et al.,* 2009; Kipkoech *et al.*, 2011). For example, in a study carried out in Amazonian forests, Torras (2000) suggested that 1% of the TEV of the forest can be used.

This study applied a conservative value of KES 431 (US$ 4.31)/household/yr based on the average values obtained from a similar local study (Mogaka, 2000). Use of low values is further expounded by other studies that point out that some cultural services like spiritual and religious services do not generalize well both across communities and among individual community members (Daniel *et al.,* 2012; Norton *et al.,* 2012). Further, valuations of some aspects, such as regional identity or sense of place remain elusive, hence, they are difficult to value in economic or monetary terms (Butler & Oluoch-Kosura, 2006; de Groot, 2006; Daily *et al.*, 2009; Daniel *et al.,* 2012). The situation is further compounded by the fact that ecosystem services that contribute to cultural heritage are often public goods that are shared rather than owned (Nasi *et al.*, 2002; DEFRA, 2007; Kipkoech *et al.*, 2011; Daniel *et al.*, 2012; Milcu *et al.*, 2013; Jobstvogta *et al.*, 2014).

That notwithstanding, nature conservation specialists recognize various ways in which spiritual and religious values support biodiversity conservation (Posey, 1999; Sponsel, 2001; Kumar *et al.*, 2010). In addition, diverse religious groups and conservationists promote strengthening of the

relationship between religion and environmental conservation, supporting the concept of "environmental stewardship" (Sponsel, 2001*;* Dudley *et al.*, 2005*;* Wild *et al.*, 2008). In some cultures, their early ancestors were largely dependent on natural resources like trees, animals and rivers for food, protection, healing shelter, and other forms of sustenance leading them to hold a deep cognizance of the environment (Nasi *et al.*, 2002; TEEB, 2010, Milcu *et al*., 2013).

This resulted in both respect and reverence for sacred forests or tree species, which were often protected from cutting or dismemberment unless for a worthy cause. The trees were respected not only for their practical material value but also for their importance in the community's spiritual life. Therefore, this study recommends the evaluation of cultural heritage including spiritual and religious benefits, the possibility of undervaluing the complexities of lived experiences of spirituality and religiosity notwithstanding.

(iv) Bequest and existence values

Due to the association of Aberdare ecosystem with Kenya's independence and the pivotal role it played through the Mau Mau freedom fighters, the community in the area ranked bequest as an important ecosystem service that they desired to conserve and bequeath it to the future generations. Non-use values are divided into bequest and existence values, and predominantly exemplify the non-consumptive cultural services (Milcu *et al*., 2013). Bequest values to the community represented the value derived from their desire to conserve the ecosystem and some species intact for the welfare of future generations, giving them the option to use the ecosystem in accordance with their own preferences as expressed by TEEB (2010), Chan *et al.* (2012a) and de Groot *et al.* (2016). Existence value was the satisfaction the community derived from knowing that the species or ecosystem existed, even if they did not use it directly.

As expounded by TEEB (2010), functioning ecosystems produce multiple services which interact in complex ways resulting in diverse services being bundled together, influencing each other negatively or positively. Cultural ecosystem services are largely dependent on intermediate ecosystem services (Fisher *et al.,* 2009; Milcu *et al*., 2013), and cultural benefits are derived from final cultural ecosystem services (Chan *et al.,* 2012b; Costanza *et al*., 2014b). Hence, the ecological significance of ecosystem services like Aberdare originates from; (i) specific ecosystem services which fulfill essential physiological human needs and (ii) ensuring the maintenance of other ecosystem services that are necessary for satisfying other vital human needs, such as

affection, local identity, recreation, religious and environmental knowledge (Daily *et al.,* 2009; Chan *et al.*, 2012b; Marta-Pedroso *et al.*, 2014; de Groot *et al.*, 2016).

Despite the divergent views in prioritizing cultural ecosystem services, the findings from the FGD showed that community evidently understood that ecosystem services were closely intertwined and each of them was important to societal wellbeing in general. Therefore, their conclusion was "*if the ecosystem is well protected and conserved when pursuing one service, the other services will inherently flow"* said a member from Endarasha group. This study upholds the view which is supported by Chan *et al*. (2012b) who analyzed provisioning, cultural, and income generation services within indigenous communities in Suriname and found that members of the local communities viewed these services as co-occurring.

In another study in Tanzania, Sjaastad *et al*. (2003) found that fishing, a provisioning service, was not only material but also termed as beautiful. Both women and men were fishing in groups where they enjoyed gendered communication among peers and the exchange of stories and gossip, which were perceived as socially valuable. This viewpoint though supported by the MEA (2003) definition of cultural ecosystem services has been criticized (Boyd & Banzhaf 2007, Wallace, 2007; Chan *et al.,* 2012a) because it does not clearly make a distinction between the above concepts of services, benefits, and values, based on their connectedness to the welfare of human beneficiaries.

As with other environmental goods and services, bequest and existence values can be substantial in contexts where the forests in question are themselves unique or contain some highly revered biodiversity (Krieger, 2001; Daniel *et al.,* 2012). Some studies recommend use of higher values for unique forests for example Adger *et al*. (1995) who applied KES 1200 (US$ 12)/ha/yr for conserving Mexican forests. Loomis and Ekstrand (1998) proposed KES 440,000 (US$ 4400)/ha/yr for conserving a habitat of the highly prized Mexican spotted owl. Additionally, Krieger (2001) proposed between KES 1000 (US$ 10) and KES 1400 (US$ 14)/ha/yr as the amount people were willing to pay for a forest quality programme to maintain high forest densities in Colorado.

Pearce (2001) made use of KES 200 (US$ 2)/ha based on world WTP for option, bequest and existence values through the Global Environmental Facility. Nonetheless, this study applied KES 500 (US$ 5)/ha/yr based on world WTP for limited forest areas covered by debt-for-nature swaps

(CBD, 2001). The modest value was applied as recommended by Marta-Pedroso *et al*. (2014) due to the presence of unique wildlife species like the rare bongo and black rhino. The ecosystem is also listed as an Important Bird Area (KWS, 2003). The higher values were not applied since only part of Aberdare ecosystem has bequest and heritage values. This is because special attributes that provide for existence and bequest values were absent in some areas due to competing land uses. The low value was also used to make provision for other option and existence values that are important to communities. Moreover, the use of KES 500 (US$ 5)/ha/yr for option values coincide with Bush *et al*. (2011) who suggested that the values are a small fraction relative to use values. This is because option value can be taken as a measure of risk aversion, i.e. an aversion of not having the good in question available in future.

5.1.4 Human-wildlife conflicts

Estimating the economic value of ecosystem services faces several challenges, and regardless of the objective of the economic valuation, it is also important to take into consideration the costs that forest adjacent communities incur from invasion by wild animals (Emerton & Mogaka, 1996; Fischer *et al*., 2008; Rhino Ark, 2011). Though the forest ecosystem provides benefits to local communities, 94% of the respondents interviewed reported the continued existence of wildlife destruction. A study carried out by Butynski (1999) identified a physical barrier as a necessity for the Aberdare forest ecosystem to among other objectives prevent wildlife from moving out of the ecosystem, therefore reducing human-wildlife conflicts (KFS and KWS, 2010).

The community reported that though the electric fence had reduced the problem significantly, there were some incidences of elephant's damage when they break out of the electric fence current fence. Further, the existing fence was inadequately designed to prevent some animals like monkeys, porcupines, baboons and leopards as well as birds and squirrels. The wildlife related losses in this study ware approximated at KES 172 (US$ 1.72) million which was estimated as KES 20,601 (US$ 206)/household/yr. In 1998, FAO estimated that crops worth KES 40 (US$ 0.4) million were destroyed annually by wildlife around the entire perimeter of Aberdare ecosystem. This loss in farm production is a potential disincentive to forest conservation that is hardly accounted for in forest planning and management as also observed by Rhino Ark (2011). Therefore, there is need for re-designing the fence to minimize the human wildlife conflicts as it works against other poverty alleviation strategies.

5.1.5 Summary of the value Aberdare ecosystem services

The findings of this study showed that the annual benefit to the forest adjacent community for regulating services was approximately KES 36.3 (US$ 0.36) billion, provisioning was KES 580.6 (US$ 5.81) million and cultural services was KES 60.9 (US$ 0.61) million. Thus, since there were wildlife related losses estimated at KES 172 (US$ 1.7) million, the net annual benefit of various ecosystem services obtained in this study was approximated at KES 36.8 (US$ 0.37) billion. Thus, if only provisioning services are considered, the net benefit of conservation is negative suggesting that the forest in its current state was not accruing benefits and the government is heavily subsidizing conservation (Langat and Cheboiwo, 2010).

These findings are comparable to KES 17 (US$ 0.17) billion obtained in Mau forest blocks (Kipkoech *et al.,* 2011). The differences mainly emanating from the total forest area under consideration as well as variation of the regulatory services available. Despite these findings, as observed by Farber *et al*. (2002), Chan *et al*. (2012a) and Marta-Pedroso *et al*. (2014), the value of forests to a community whose social system is intimately dependent on them is more than the sum of the independent individual values. Thus, this value is conservative, at best it generally indicates the kinds of value that could materialize if markets were created. However, it should be noted that market creation assumes that specific features of the forest are present (Stephenson, 2008). For instance, unlike carbon values, tourism values are not relevant for remote and inaccessible forests. In addition, it should be noted that since some uses are competitive, they cannot be added simplistically (DEFRA, 2007, TEEB, 2010; Gómez-Baggethun *et al*., 2014).

As demonstrated in other studies however, it should be noted that there are some critical ecosystem services required to sustain human and non-human life, irrespective of where they may be ranked in valuations based on subjective preferences from any community (Mogaka, 2002; de Groot, *et al.*, 2010: Martín-López *et al.,* 2012). Furthermore, people may underestimate ecosystem services because they not be willing (or able) to pay for them but that does not make them less important. For instance, maintaining the vital services like air purification or water regulation for which technological substitutions are not feasible or are economically unaffordable (TEEB, 2010; Gómez-Baggethun *et al*., 2014).

Although considerable progress has been made in valuation of forest ecosystems, the major challenge is to scale up the inclusion of the value of ecosystem services in the multitude of

decisions that affect or depend on them. The values are still intangible to many of the public decision-makers, private landholders and resource users whose actions have the potential to influence forest conservation activities (Farley, 2012; Martín-López *et al.*, 2012; Ongugo *et al*, 2014). Until these values are reflected in conservation and development planning, policies and management practices and subsequently captured in the costs and profits facing forest users, forest ecosystems, a vital source of economic life and human wellbeing, will continue to be degraded and lost (Mbuvi *et al*, 2009; Jordan & Russel, 2014; Everard *et al*., 2016). There is also a dire need to create awareness to people and society about the valuable benefits ecosystems provide, creating incentives for their sustainable management and developing mechanisms to reward investment in restoring and managing ecosystems.

5.1.6 Opportunity cost of conversion of forest land

Forests ecosystems provide multiple benefits to society with the whole range of benefits depending on the type of the forest and the prevailing management strategies (Duncker *et al.*, 2012; Marta-Pedroso *et al.*, 2014). The cost-benefit outcomes of forest ecosystems are determined by factors such as the nature and actual location of forest; and possible alternative land uses (Langat & Cheboiwo, 2010; Fisher *et al*., 2011b). This understanding is a prominent feature of the contemporary literature and is commonly associated with the conservation of multifunctional forests (Naidoo *et al.*, 2006; Putz *et al.*, 2012; Newton *et al*., 2016). This study contributes by estimating the costs of forgone forest access, or incentives to pursue alternative land use activities (opportunity costs), to adjacent households. This is to address concerns about the efficacy of conservation management approaches to create incentives to mitigate the problems of forest land conversion, illegal and unsustainable use (Fisher *et al*., 2008; Bush *et al*., 2011). This was done through estimation of opportunity costs which Naidoo *et al*. (2006) defines as costs of foregone opportunities from the alternative best use of a resource if not for the existing use.

As observed by Marta-Pedroso *et al*. (2014), forest land conversion is not a forest value. Nevertheless the converted use constitutes an estimation of the value of the forest land. In the study area, like other forest adjacent areas, gazettement of protected areas denied the local community land for agricultural and livestock production as this was found to be the most predominant livelihood strategy. Thus farmers in the area, *ceteris paribus*, if the objective is financial gain were likely to select crop farming and livestock keeping as a priority farming enterprise given any extra

land to utilize. As discussed by IIED (1997); Langat and Cheboiwo (2010); Musyoki *et al*., 2013 and Newton *et al*. (2016) the community obtained forest products to meet primarily subsistence needs. This dependency on the forest provides an opportunity to save the meager household income. The savings are thereafter used to meet other felt household needs.

In this study, forest land conversion was presumed to reflect the predominant livelihood activities of the adjacent community. In the study area, converting forest land to agricultural production through crop farming and livestock keeping was in high demand to support household food production and income generation. However, Pagiola and Bosquet (2009) and Dixon and Challies (2015) cautions that there is spatial variation of opportunity costs based on factors such as terrain, accessibility and distance to markets. Thus, based on the 64% of the land that could be converted to agricultural production, this was found to be approximately KES 4.2 (US$ 0.04) billion. In comparison to the approximately KES 36.8 (US$ 0.36) billion net annual benefit from the ecosystem services, the benefits of forest conservation was positive. Therefore, conserving the forest in its current state accrues about KES 32.6 (US$ 0.33) billion more than the opportunity cost of forest conversion. These findings underpin the importance of this study.

As stated by CBD (2001) and Marta-Pedroso *et al*. (2014), if economic values of converted forest land exceed the economic values of conserved forest or sustainable forest use, economic forces lead to forest conversion. Other studies in Kenya present comparable opportunity cost values based on agriculture as an alternative land use. This is for instance, Emerton (1996) who obtained 7.2 (US$ 0.72) billion/yr from Mt. Kenya forest; Emerton (2001) who found KES 30.7 (US$ 0.31) billion/yr of agriculture foregone from all forests in Kenya; Langat and Cheboiwo (2010) who reported KES 237 (US$ 2.37) million/yr from Tinderet forest; and Kipkoech *et al*. (2011) who obtained KES 4.2 (US$ 0.42) billion/yr from three blocks in Mau forest complex. The slight variations emanating from differences in forest hectarage or agricultural productivity of the area. That notwithstanding, all these studies except for the last one reported the net benefit from forest conservation as negative.

Therefore, the findings of this study showed that the net annual benefit from the ecosystem services being approximately KES 36.3 (US$ 0.36) billion was positive. Thus, conserving the forest would accrue a net benefit of about KES 32.6 (US$ 0.33) billion from forest conservation compared to forest conversion. The findings of this study were reinforced by various studies on cost-benefit

analysis of forest conversion (Wunder, 2005; Kipkoech *et al*., 2011; Newton *et al*., 2016). The notable uses of converted land included cash crop plantations of palm oil cocoa and tea; cattle ranching; slash and burn agriculture and permanent agriculture. All these studies showed that when regulatory services like watershed, biodiversity and carbon values in addition to cultural services are excluded, there is a net loss arising from conservation as opportunity cost is higher. Therefore, in view of the difficulties of competing land uses, there is need to lay emphasis on the significance of encashing all the benefits of forests, particularly the regulatory and cultural services (DEFRA, 2007, de Groot *et al*.,2010; TEEB, 2010).

Similarly, the study by Rhino Ark (2011) on environmental, social and economic assessment of the fencing of the Aberdare Conservation Area showed that at 5% discount rate, the Net Present Value (NPV) was KES 22.3 (US$ 0.22) billion without biodiversity value, but inclusion of biodiversity increased the NPV to KES 263 (US$ 2.63) billion. The findings of this study as well as the Rhino Ark (2011) thus demonstrate that regulatory and cultural services are of great importance to the adjacent community.

Generally, sustainable forest management may not pay well in commercial terms, which suggests finding ways to convert noncommercial value to cash flows to compensate land users for forgoing a more lucrative land use (Bush *et al*., 2011; Marta-Pedroso *et al.*, 2014; Newton *et al*., 2016). Early literature further suggest sustainable commercial uses of forest land portend considerable difficulty competing with alternative commercial uses such as conventional logging, agri-business and agriculture (CBD, 2001; Newton *et al*., 2016). These have been the findings of many studies even in Kenya which dwell on the value of provisioning ecosystem services only. For example, Langat and Cheboiwo (2010) from Mau forest, Emerton and Mogaka (1996) from a study in Aberdare forest as well as Emerton (1996) from a study from Mt. Kenya forest. Their conclusions were that the benefits from this forest were inadequate to offset the opportunity cost of leaving the forest in its conserved state.

5.2 FMA and Community Value of the Forest Ecosystem

5.2.1 FMA and community perception on the importance of the ecosystem

Forest resources are important components of livelihoods and development opportunities in Africa (Cavendish, 1999; Springate *et al*., 2003). According to Bush *et al*. (2011) and Mogoi *et al*. (2012), institutional factors are an important determinants of socio-economic values of forest ecosystems to local communities. In this study, among the 202 respondents interviewed, 57% lived adjacent to the Conservation area (Forest Reserve) whilst the other 43% were adjacent to the protection area (National Park). Contrary to a wide perception that local communities value forest ecosystems predominantly for extractive benefits (de Groot *et al*., 2010; Dendoncker *et al*., 2013), communities adjacent to Aberdare forest ecosystem showed that majority (83%) of them under both FMAs valued the forest ecosystem mainly for non-economic benefits. These were primarily regulatory, cultural and supportive services. Thus, even those with access to provisioning services were not oblivious of the complete bundle of services provided by the ecosystem. That notwithstanding, majority (96%) of those who indicated the forest ecosystem was important to them for economic reasons were adjacent to the Forest Reserve.

Additionally, the study showed that the association between FMA and community perception on the value of the ecosystem was strong and significant. Comparable observations were made by Kipkoech *et al*. (2011) based in their study on total economic valuation of Mau forests in Kenya and Dinerstein *et al*. (2014) based on their study conservation of tropical forests. The relationship between FMA and perception on the importance of the ecosystem though was negative and significant. This could be attributed to the fact that there were high value on importance for those who derived more benefits from the conservation area relative to those adjacent to protection area. These findings demonstrated that forest economic benefits are important to forest adjacent communities and those adjacent to forests under protection FMA expressed discontentment for not deriving full benefits.

The lack of economic benefits especially near the park created simmering discontent among community members in the study area as explained by Mzee Kagondu "…. *We value the ecosystem more for non-economic reasons because …….* (*pause) after all, where are those economic goods? We don't get them!"* Therefore, the 83% who value the ecosystem for non-economic services were effectively reporting the services they obtain, thus the low interest in PFM involvement compared

to those who valued and accessed economic services. Broadly, households whose forest dependence was low also indicated low PFM involvement level. As observed in other studies, FMAs and the kinds of benefits local communities derive from forest resources influence the way they perceive the forest ecosystem (Mbairamadji, 2009; Costa *et al.*, 2017). Similar sentiments were obtained from Focus Group Discussions where community members' claimed the use of forest ecosystem products theirs by *de facto* and they felt they should not be denied as also reported by Ongugo *et al*. (2014) and Musyoki *et al*. (2013). Similar observations were made by Mutune *et al*. (2015) in a related study based on Sururu and Eburu forests where KFS remained in control of the forest resources such as licensing forest products and decision making while in practice the CFA were involved as labour providers for forest rehabilitation and policing. Therefore, sustainable FMAs should contemplate on both the variety of local uses of forests and resources and also the diverse views assigned locally to forest ecosystems. Evidence from several studies indicate that issues determining use of resources in protected forests are often related to FMAs and thus are area specific (Godoy *et al*., 1995; Cavendish, 1999; Vedeld *et al*., 2004).

5.2.2 FMA and household sources of livelihood

Forest-adjacent communities operate behind a background of limited economic opportunities. Farmers are faced with multiple problems: scarcity of land, food, fodder, fuelwood, biomass and increased land degradation. As stated by Kumar (2002), World Bank (2005) and Mbairamadji (2009) most rural population maintain diversified livelihood strategies because they cannot obtain sufficient income from any single strategy and also to distribute risks. In the area around Aberdare forest ecosystem, over 90% of the farmers engaged in agricultural production – growing of food and horticultural crops as well as livestock keeping as their main economic activity as a source of both sustenance and income as also reported by (Emerton & Mogaka, 1996; Rhino Ark, 2011). Similar findings were reported by Kipkoech *et al*. (2011) and Langat and Cheboiwo (2010) based on communities adjacent to some forests in Mau forest complex as well as to Musyoki *et al*. (2013) for forest reserves within Mt. Kenya forest ecosystem. Most of the households depended entirely on small scale mixed farming as their main economic activity.

In the Aberdare region, the farming activities were mainly rain-fed, the seasonal calendar being dictated by the amount of rainfall. However, where there was high rainfall or water for irrigation, horticultural production was more predominant and took place throughout the year. The

agricultural activities were to meet household food requirements as well as to raise income. Over 70% of the households depended on food production from own or rented plots whilst about 14% depended on food from cultivation of forest land under the PELIS programme as reported in Mau forests (Langat & Cheboiwo, 2010; Mutune *et al.*, 2015). The major crops grown in the area for both food and cash income were mainly potatoes, cabbages, peas, carrots, maize and onions. The area adjacent to National Park had low amounts of rainfall and wheat was grown as a cash crop in addition to the various food crops being grown seasonally. The survey findings indicated that only a small proportion of the population engaged in forest product extraction for commercial purposes as also reported by Langat *et al*. (2016) in Mau.

The local community involvement in forest related activities for cash income was also found to be relatively low except for sale of horticultural crops from PELIS plots. The reasons for this could be; firstly, many products in high demand could be acquired legally, and hence, households acquired them directly from the forest (Thenya, 2014). Secondly, products that were in demand but could not be obtained legally, only a small proportion of the community especially the youth were procuring them for sale to the few people who could afford. The findings also indicated that posts, charcoal, poles, firewood and timber were procured from the forest, at times illegally for cash income. As reported in other studies in rural areas, firewood and charcoal drive the local hotel industry as well as sustain the urban dwellers (Mwangi, 1992; Makee, 2005).

Charcoal from indigenous tree species also fetched a high price of KES 600-800 (US$ 6-8)/bag compared to charcoal made from exotic trees that was costing KES 350 (US$ 3.5)/bag. The charcoal from indigenous trees was deemed to have a higher calorific value compared to charcoal made from exotic trees like eucalypts and wattle in the farmlands. This was directly threatening forest conservation as on-farm planting was essentially with exotic tree species (Emerton, 1991; Ellis, 2000). Cedar posts were fetching a high price of KES 250-300 (US$ 2.5-3)/piece compared to KES 50 (US$ 0.5)/piece from exotic tree species. The community explained the high preference for cedar emanated from the fact that cedar is durable, resistant to termites and could withstand prolonged water logging that was common in some areas.

Due to the high population and small land parcels, some households looked upon the forest ecosystem as an alternative source of food and fodder (Mogaka, 2000; Thenya, 2014). The findings showed that the association between FMA with household source of livelihood was strong and

significant. Based on these findings, this study therefore suggests that the government should promote sustainable agricultural practices through for example irrigation, zero grazing and introduction of high value crops as demand for land for agricultural expansion has been variously cited as a major cause of the increasing pressure on forest ecosystems and their subsequent degradation (Emerton, 2001; Vedeld *et al*., 2004; Mbairamadji, 2009). The household sources of livelihood was negatively and significantly correlated with FMA due to the community over dependence on the ecosystem. Thus, the need to reduce pressure on forest ecosystem through improved farming practices, as espoused by the "green revolution" in agriculture, technological development can increase productivity on intensively managed land, thereby releasing other land from agricultural production (Waggoner, 1994; Fischer *et al*., 2008; Costanza *et al*., 2014a).

Several studies show that there is no restriction in increasing income from conservation areas as long as one follows the laid down regulations like applying and paying for licenses and permits (Mbuvi *et al.,* 2009; Thenya, 2014; Mutune *et al*., 2015). However, the poor were found not to benefit as the process is expensive, thus, the middle and high income or outsiders were obtaining most benefits (Mogoi *et al*., 2012; Musyoki *et al*., 2013; Ongugo *et al.,* 2014). Similarly, this study showed that majority (51%) of the households in the very poor and poor categories lived adjacent to the conservation area. These findings concur with various studies (Vedeld *et al.,* 2004; Ellis & Ramankutty, 2008; Musyoki *et al*., 2013) that poor people live in remote, forested and fragile areas. In many studies, poverty is linked to increased pressure on forests which leads to forest degradation and destruction (World Bank, 2005; Kenter *et al*., 2015; Bull *et al*., 2016; de Groot *et al*., 2016). This was found to be happening in the study area and thus, it necessitated erection of the electric fence around the ecosystem (Rhino Ark, 2011) to curb forest destruction as well as human wildlife conflict.

According to the results of this survey, majority of the forest adjacent community were in the lower income group category where almost half (44%) of the population earned below KES 50,000 per year. Although the average household annual income in the area was found to be about KES 139, 000, the greater part (68%) earned less than KES 100,000/ year which translates to less than KES 10,000/month with 26% earning less than KES 2,000/month which further translates to less than a dollar/day. Similar findings were also obtained from communities living in various PFM sites in Kenya like Iveti, Museve, Nthangu and Makongo (Musyoki *et al*., 2013; Thenya, 2014).

As shown by the results of this survey respondents were overwhelmingly poor that is, per capita income less than the ES 200 (US$ 2)/day as per capita global poverty measure. In addition survey households were highly dependent on natural resources as the basis of their livelihood. Majority (62%) of the households in the area were either in average or poor socio-economic categories. The similar socio-economic profile could be attribute to the fat that the majority (86%) of the households depended on agricultural activities for income and subsistence. Comparable findings were observed by Mogaka (2000) and Matiku *et al*. (2013) in relation to forest adjacent dwellers. Those classified as rich or very rich in the area had large pieces of land, had reliable water for irrigation or more livestock. Subsequently, less than 3% of the sampled households recorded sources of income other than agriculture, livestock or protected area related activities. Similar findings were reported by Bush *et al*. (2011) where only 2% of the forest adjacent dwellers reported other sources of livelihoods such as casual labour, remittances from extended family or small business activities.

In the same way, a study on households adjacent to Sururu and Eburu forests found that community members were engaged in diverse livelihood strategies with crop, livestock, forest and casual labour being the major sources of household incomes which they sought to extend into the adjacent forest (Mutune *et al.,* 2014). This calls for attention on addressing poverty reduction, a major factor cited variously as key driver of forest destruction (CIFOR, 1997; Fischer *et al*., 2008; Ongugo *et al.,* 2008; Bush *et al*., 2011). An important finding was that social (non-market) values related with forest income was higher for low income households than for high income households. This possibly reflects the difference between household dependence for low income households who have few alternatives to forest income versus use as a livelihood alternative for high income households.

5.2.3 FMA and PFM involvement level

Forest ecosystems provide a wide spectrum of goods and services that contribute to the socio-economic development of forest dependent communities. Chakraborty (1995) and Pearce (2001) observed that there are two opposite perspectives to the cause of deforestation. Firstly, increased demand for fuelwood, timber, land for agricultural expansion and settlements leads to deforestation. Proponents pinpoint growth in population and the resultant forest dependence and poverty as the main causes. Secondly, the popular perception is that drivers of deforestation lie in

the failure of the forest bureaucracy to adequately involve stakeholders in the management and governance of the forest resources, especially the forest adjacent communities (Webler, 2001; Armitage *et al.*, 2008; KEFRI, 2009; Musyoki *et al*., 2013).

The second perception has been gaining popularity and ten to twelve per cent of the world's natural forests are officially being managed using some degree of community participation. In sub-Saharan African, at least 21 countries have embraced various participatory approaches to natural resources management (Lise, 2000; Mogoi *et al.*, 2012). In some of these cases, the devolution of forest management appear to facilitate improved forest conservation (Lund & Treue, 2008; Mwangi *et al*., 2011), though the picture seems uncertain with respect to livelihood impacts (Daniel *et al*., 2012; Lund & Treue, 2008; Larson, 2005; Mogoi *et al*., 2012; Matiku *et al.*, 2013). In tropical countries, the diversity of stakeholders depending on forests with different interests make sustainable forest management difficult to achieve. The concept of sustainable forest management (SFM) was therefore developed and expanded so that forest management integrates the ecological, economical and sociological issues (Salleh, 1997; FAO, 2006; Mbairamadji, 2009; Rita *et al.*, 2017).

The concept of sustainable forest management also advocates for stakeholder participation, particularly the adjacent communities, in forest management and decision-making (Salleh, 1997; Newton *et al*., 2016). This is a tendency that has occupied a significant place in development thinking and practice in the recent years (Kumar, 2002; Ellis & Ramankutty, 2008; Mbairamadji, 2009; Kenter *et al*., 2015). Governments, funding agencies, civil society and multi-lateral agencies seem to all agree that development can be sustainable only if people's participation is made central to the development process (Hein *et al*., 2006; Ellis & Ramankutty, 2008). Putting these considerations into account reduces conflicts among stakeholders with respect to access to and use of forest resources as well as guiding the allocation of forest space amongst stakeholders for different purposes (Salam *et al*., 2005; Lund & Treue, 2008).

Consequently, it is critical to obtain quantitative information on the socio-economic value of protected forests to local communities as a means to develop practical solutions that effectively mitigate the conservation and development conflicts that forest managers are faced with. This calls for identification and quantification of the main social and economic parameters that drive local people to make unsustainable or illegal use of protected areas (Ellis & Ramankutty, 2008;

Mbairamadji, 2009). In particular, there is a need to recognize the role that the natural resources play in poverty alleviation and in the overall economic development of forest adjacent communities. This is mostly vital in defining realistic expectations about what can be achieved from PFM.

Though these studies advocate for decentralization of forest management and public participation as important processes for SFM, this has not been achieved in many forests and level of participation differ even within same forests depending on management approach. In the study area, there was generally a high interest by the communities under both FMAs to be involved in PFM. Although the proposition that natural resources need protection from the destructive actions of people is widely accepted, this study showed that communities in the past and increasingly today collaborate with resource managers for long-term resource management as also supported by other findings (Thenya *et al.,* 2007; Reed, 2009; Engida & Mengistu, 2013; Matiku *et al*., 2013 and Musyoki *et al.,* 2013). The findings of this study showed that the community adjacent to Aberdare forest ecosystem were involved in PFM, albeit to various extents.

Nevertheless, the level of participation was higher for those adjacent to the conservation area as more (7%) adjacent to Forest Reserve were fully involved compared to only 1% adjacent to National Park. Further, the findings showed that the association between FMA and level of community involvement in PFM was strong and significant ($\chi^2 = 17.551$, df = 3, $p = 0.001$, n = 202). This can be explained by the fact that communities adjacent to the National Park were essentially benefiting from environmental services and few extractive products like water (Bush *et al*., 2011) as FMA is predominantly preservationist. As observed by Duncker, *et al*. (2012) and Mogoi *et al*. (2012), access to forest resources is influenced by, and dependent on FMA.

This therefore suggests that the high interest in participating in forest management could be driven by some anticipated benefits as has been observed in other studies (Lise, 2000; Ongugo *et al*., 2008; Bush *et al*., 2011; Musyoki *et al*., 2013). The findings of this study agree with their observations as further illustrated by the relationship between FMA and level of community involvement in PFM which was a positive and significant ($r = 0.19$, $p = 0.007$). These findings disagree with Bush *et al.* (2011) who found lower respondents' WTA from community adjacent to National Parks in Uganda. The anomaly of their findings was however attributed to *de facto* access of forest resources from the national park. Like in Kenya, due to the strict national park

protectionist management approach, the regulations prohibit any use by local communities, but poor enforcement of the regulations by under resourced park management meant that a *de facto* open access arrangement existed. In the case where regulations are strictly enforced, the WTA is higher due to the foregone benefits.

Similarly, in Kenya, there is little community involvement in management of natural resources in the parks except for a few cases of revenue sharing in some national parks and consultation over government planned initiatives (Mogoi *et al*., 2012; Ongugo *et al.,* 2014). Nevertheless, the findings of this study demonstrate that communities can collaborate with resource managers for long-term resource management if given an opportunity. Following these findings, there is need to empower communities to overcome obstacles that may interfere with their efficiency, dynamism, openness and active participation in planning and decision making as observed by Ghai (1994). This will make communities get a sense of ownership of the forest resources and partner with resource managers to enhance sustainable management of forest ecosystems.

However, while there is virtual unanimity about the need for people's participation, the concept of participation in forest management and conservation and the ways of achieving it under different FMAs needs to be clearly defined. This is because PFM and associated investments enhance local peoples' socio-economic development. This study therefore, advocates for substantial financial investment for capacity-building (Ogada, 2012; Coulibaly-Lingani, 2011), joint management, income generating activities (Fisher, 2004), and adequate awareness creation, for forest resource managers to increase household support for forest conservation through alternative household livelihood improvement options (Kenter *et al*., 2015; Costa *et al.,* 2017). The great interest in PFM involvement as shown by the community requires a strategy for harnessing to sustain it and have it contribute to sustainable forest management.

5.2.4 FMA and forest dependence

Many rural households depend on natural resources for their livelihoods. Therefore, their impacts on natural resource management in areas within and adjacent to forest ecosystems require a clear plan of how conservation goals can be balanced with their economic wellbeing (Cavendish, 1999; Pearce, 2001; Mbairamadji, 2009). Since its early stages, the goals of PFM were manifold; to contribute to the socio-economic development of forest dependent communities (Agarwa, 2009); reduce environmental degradation (Tesfaye, 2017) and alleviate poverty in developing countries

(Lise, 2000; Engida & Mengistu, 2013). PFM was necessitated by the high degradation of natural resources caused by high discount rates of the local communities at the household level and a lack of clear policies that could enable participatory management approaches (Costanza *et al*., 1997a; Pearce, 2001; Gaveau *et al*., 2009). Therefore, the main challenge in achieving sustainable forest management consist of finding a sound balance between the increasing pressure on forest resources from divergent community interests and sustainable forest conservation. Such a balance requires that an equilibrium be attained between the forest ecosystem, uses and users of forest resources as well as key institutional regulations taking into account all the ecological and socio-economic constraints as observed by Gaveau *et al*. (2009) and Fisher *et al*. (2011).

In the study area, forests contributed significantly towards the diversification of livelihoods of adjacent communities like reported in other studies (MEA, 2005a; DEFRA, 2007; Himberg *et al.*, 2009; Yemiru, 2011; Mogoi *et al*., 2012; Kenter *et al*., 2015). The findings of this study showed that households benefited from a wide range of forest products from the forest ecosystem which were acquired either legally or illegally, irrespective of the FMA. The source of the products was subject to availability as well as ease of access. As discussed earlier, the products that were viewed as most important were water (98%), fuelwood (25%) and grazing (13%). Although the benefits from the forest varied between the two management approaches in the study area, the majority (86%) of all the households derived or perceived the forest as beneficial to them as only 6% indicated no benefits. This is an important finding as when ecosystems do not make substantial contributions to livelihood, this lowers the resource values placed on them (Engida & Mengistu, 2013; Mutune *et al*., 2015). Hence, the community admitted that the forest contribution to household economy and welfare could not be ignored.

However, a higher percentage of those adjacent to the conservation area had access to both more and diverse forest products and services compared to those adjacent the National Park. The findings of this study showed that 88% of the community derived moderate (78%) to high (10%) benefits from the forest ecosystem. The association between FMA and forest resource values findings was strong and significant as those who obtained more benefits indicated higher values. Further, the FMA was positively and significantly correlated with the community forest dependence. The value of the ecosystem among communities adjacent to protection area was low as the FMA did not allow resource exploitation. This is because the National Park was being managed for high biodiversity value and water catchment functions among other regulatory and

supportive functions. The FMA applied does not legally allow extractive utilization of ecosystem resources (KFS, 2010; Wildlife Act, 2013). To enforce this, strict regulations coupled with heavy fines are implemented by KWS. Therefore, there were minimal opportunities for communities to benefit from provisioning services under the protection FMA to supplement their food or income sources, hence the lower resource values assigned. Similar reports were made by Bush *et al*. (2011) from their study based in Uganda on impacts of FMAs. As also observed by Pearce, 2001 and Maingi, 2014, it is evident from this study that forests played a critical role in rural livelihoods, yet given the rising competition over forestland for agriculture, such information suggest there is an urgent need to make forest ecosystems economically more meaningful to the local people so that they can appreciate the importance of forest conservation.

The lower resource values assigned by park adjacent communities could also be explained based on the costs incurred by local people due to the existence of forests. Similarly, related studies report that local population incur high costs from the damage they suffer from forest dwelling-animals as well as risks associated with forest poachers and robbers who use forests as hideouts (Emerton, 1996; Hulme & Murphee, 2001; Fischer *et al*., 2008). Nonetheless, 76% reported that the electric fence had reduced the problem considerably. This was an important finding from this study that can be used to enhance community involvement in forest conservation, particularly maintenance of the electric fence.

These findings are collaborated by previous studies showing that in the area around the Aberdare forest, an estimated 36% of adjacent households lost crops to wildlife in 1991, and 61% suffered damage to fences and farm buildings (Emerton & Mogaka, 1996). In Mount Kenya Reserve, households on the south-western side frequently suffered crop damage from wildlife, and lost between 50% and 83% of their yields in 1993 (Mbuvi *et al.,* 2009). In Shimba Hills National Reserve, which contains about 700 hectares of indigenous forest, communities claimed a total of KES 4.5 (US$ 0.05) million in 1987-1988 as compensation for the damage caused to their crops by wildlife (Ndichu, 2016).

The value local people attach to forest conservation and their support for forest conservation objectives is largely dependent on the balance between costs and benefits. A study done by Matiku *et al*. (2013) showed that supporting school fees for poor households adjacent to Arabuko Sokoke forest was considered a higher benefit than individual benefit. This helped improve household

attitudes towards the forest and enhanced forest protection to improve resources available for their own access and use.

This was further elucidated by the fact that though the community valued the forest ecosystem mainly for its non-monetary reasons, where a management approach did not allow provisioning benefits, there was a negative bearing on households' perception of economic benefits from forest ecosystems (Kipkoech *et al*., 2011; Costa *et al.*, 2017). This demonstrates that local communities are not ignorant of the various ecosystem services obtained from the forest and where some are not available they place lower values on the ecosystem. The findings of this study are supported by various studies that showed that many forest adjacent communities who derived forest resources to supplement household subsistence uses (Mogaka, 2002; World Bank, 2003; Langat & Cheboiwo, 2010; Kenter *et al*., 2015) contributed more in their conservation.

This calls for stakeholders including the government and development partners to support livelihood improvement schemes in the farmlands for the community to value and support conservation in the ecosystem as also highlighted by Emerton (2001) and Rhino Ark (2011). Therefore, Kenya Forest Service and Kenya Wildlife Service should explore and exploit the full potential to provide more benefits to the community. Benefits to these communities could be improved by initiating income generating activities in the farmlands as well as supporting the community to participate in non-extractive activities.

Like recommended by Rhino Ark (2011) and Matiku *et al*. (2013), non-extractive uses can be enhanced like promoting the area as a tourism destination so that revenues from recreation can offset the high costs of maintaining the forest. Other avenues like payment for environment services should be explored to compensate Kenya and the communities for maintaining the forests because various non-use values accrue to global community and Kenya bears the costs of conservation (UN, 2014; EMCA, 2015; Forest Act, 2016). Kipkoech *et al*. (2011) and Kenter *et al*. (2015) also suggest payment for environmental services and access to direct use of forest products and services as an opportunity that the government and other agencies can use to motivate community participation in forest conservation.

This research also espouses the need for awareness creation about the non-monetary economic values derived from forest ecosystems as they support all the livelihood activities undertaken by the community. The study therefore recommends awareness creation on contribution of forest

ecosystems to the rural economies especially the regulatory and supportive services as also observed by Mbairamadji (2009) and Maingi (2014). Nonetheless, for people to make the choice to conserve the forest, conservation measures should be accompanied by livelihood improvement initiatives. This study concurs with Kipkoech *et al*. (2011) who explained that since the main drivers of degradation of forest ecosystems are the local people, there is need for some package of incentives that support their sustenance and motivate them to participate in forest resource conservation and management. A broad supposition in all cases is that the supported communities may be less inclined to unsustainably or illegally use forest ecosystem resources when rural poverty and development needs have been addressed (Hulme & Murphee 2001; Vedeld *et al*., 2004; Mbuvi *et al*., 2009; Rita *et al.*, 2017).

5.3 Community Involvement in Participatory Forest Management

5.3.1 Proximity of forest ecosystem and community involvement in PFM

Participation in forest management was technically open to all households; however as also noted by Himberg *et al*. (2009) in Taita hills and Mutune *et al*. (2015) in Mau, not all individuals in the vicinity of the forest are involved. As also explained by Ogada (2012) and Engida and Mengistu (2013), households that are far from the forest are affected by longer time to travel to the forests, information asymmetry and have lower access to benefits from the forest compared to nearer households. Thus, since many households join community forest association to benefit from extraction of forest products, distant households have lower incentives to fully participate in forest conservation activities. This study showed that majority (over 70%) of the community members who interacted mostly with the forest ecosystem lived within 0-5km for FR with few members living beyond 5km from the forest edge being fully involved in PFM.

The findings revealed that the association between the level of community involvement in PFM activities and distance to both the FR was significant. Further, the correlation between the distances to the ecosystem and PFM involvement level were significant but negative. The high interest in involvement in PFM for those adjacent to the boundary can be elucidated by the fact that farmers are rational beings and they look at the cost effectiveness of their activities (World Bank, 2005; Maingi, 2014). Those living far would incur higher costs in terms of travelling time and transportation of goods compared to those households in the vicinity. Further, those adjacent to the NP boundary bore the blunt of wildlife damage to human, crops and livestock. Therefore, they were more willing to participate in activities that reduced the human-wildlife conflict compared to those who lived beyond 5km as the wildlife were controlled before they reached them. These findings were consistent with Makee (2005) and Musyoki *et al*. (2013) in their study on PFM implementation experiences in Kenya. Similarly, Mutune *et al*. (2015), also found that as the distance from forest increased by an hour, the probability of households participating declined by 30%. Therefore, this research, recommends that efforts to promote PFM should mainly target the community living within a radius of 5km of the forest ecosystem boundary.

5.3.2 Gender of respondent and household head and community involvement in PFM

Recent approaches to management of natural resources in many developing countries have tended towards greater community involvement by devolving powers to local communities. Despite this

disposition, increasingly evidence suggests that women have remained marginalized in the processes of decision making and in the distribution of the benefits of forest resources, in spite of the fact that they have been found to depend largely on forest resources (Lise, 2000; Mwangi *et al*., 2011; Engida & Mengistu, 2013). There is therefore a need to understand and remedy the continued inadequate involvement of women in forest management (Banana *et al*., 2012). Moreover, Lise (2000) found that greater involvement of women in the community stimulated participation in conservation of resources across different types of forests in India.

In view of the fact that forest adjacent communities engage in forest activities as a livelihood strategy, women and female-headed households appeared to be disadvantaged in this study. The low participation of women, particularly, those in female-headed households could be attributed to the fact that they rank among the poorest of the poor households (Lise, 2000; Banana *et al*., 2012). In this research, the poor were reported not to afford subscription fees and levies required to obtain forest products as well as adequate time to attend PFM activities. As observed by Agarwal (2009) and Musyoki *et al*. (2013), in order to ensure that PFM is efficiently implemented by practitioners on the ground, there is need to provide a balanced, impartial and gender-sensitive approach.

The low participation was also observed in Ethiopia by Engida and Mengistu (2013) who suggested that women's productive and reproductive tasks restrain their participation due to multiple burdens such as childcare, fetching water, cooking food, travelling to long distance markets and farming. Similarly, Musyoki *et al* (2013), reported that there is a highly significant relation between gender and participation in forest conservation in Kenya, explaining that women were disadvantaged due to their social and household tasks. Therefore, their multiple roles hindered them from participating actively in conservation activities related to forest management activities. This also agrees with Coulibaly-Lingani *et al*. (2011) from their study based in in Burkina Faso where they observed that there is a highly significant relation between gender roles and participation in forest conservation

Nonetheless, this research attributes this to the fact that most forest activities are male-dominated as per the division of labour by gender in most communities in Africa (Kabutha & Humbly, 1996; Agarwal, 2009; Coulibaly-Lingani, 2009; Mwangi *et al*., 2011). In line with many African traditions, the key forest activities which include logging, charcoal production, grazing,

employment as fence attendants, hunting, pruning and thinning plantations; firefighting and transportation are primarily performed by men (Kabutha & Humbly, 1996; Wambugu, 1999; Banana *et al*., 2012). Similarly, in Kenya, male and female community members experience different circumstances that impact on their participation in forest conservation activities such as firefighting and forest patrol.

The main activities done by women in the study area were predominantly collection of firewood, wild fruits, wild vegetables and water for domestic purposes in addition to cultivation under PELIS programme. These trends showed that the cultural division of labour in the farm is extended to forest based activities (Wambugu, 1999; Coulibaly-Lingani, 2009; Mwangi *et al*., 2011) and there is need to develop all-inclusive and appropriate community involvement strategies. That notwithstanding, divergent findings were obtained from a survey of Sururu and Eburu forests where women participated more in almost all activities (Mutune *et al.*, 2015). This study therefore calls for exploration of gender-sensitive approaches to PFM so that both male and female-headed households not only benefit but contribute to forest conservation.

Other studies in Kenya show that women have been disadvantaged as the major product exploited and marketed from forest has been wood products (Thenya *et al.,* 2007;), yet forests are a source of many other products and services. The introduction of PFM has led to the exploitation of products that were considered minor though currently, some surpass timber in value in some forests (Mbuvi *et al.*, 2009). In Arabuko Sokoke forest, for example, the adjacent communities and the Kenya Government obtain more benefits from the forest through butterfly farming and honey production than what used to be obtained from the sale of wood products (Mbuvi *et al.,* 2009; Matiku *et al*., 2013).

Various studies have shown that women's participation can be increased where they take part in the exploitation of diverse natural resources such as ecotourism, payment for environmental services (PES), bird watching, fish farming, beekeeping, tree nurseries and mushroom farming (Mbuvi *et al*., 2009; Matiku *et al.,* 2013; Wambugu, 2013; Mutune *et al.,* 2014; Langat *et al.,* 2016). Therefore this study recommended that local leaders need capacity building to promote the adoption of forest management activities that support knowledge acquisition, skills development and governance structures that advance the course of women's participation.

5.3.3 Household size and community involvement in PFM

As observed by Engida and Mengistu (2013) and Tesfaye (2017), local communities living adjacent to forest ecosystems including Aberdare area are not homogeneous units that can be isolated and recognized by a collective objective or interest. Consequently local forest resource management institutions need to take these disparities into consideration to ensure sustainable forest conservation and livelihood improvement. In the study area, household size was found to be an important determinant of level of participation in forest conservation activities. The findings showed that PFM attracted high interest particularly from larger households as they were more involved in PFM activities. Further, both the association and relationship between number of household members working on the farm and PFM involvement level was significant. This suggests that labour to undertake activities in the forest for paid or unpaid employment was generally available.

Apparently, this is a general characteristic of communities in high population areas adjacent to forest ecosystem as similar findings were reported by Mogaka (2000) and Makee (2005) from similar studies based on Kakamega forest. Correspondingly, Engida and Mengistu (2013) in Ethiopia and Mutune *et al*. (2013) in Kenya found that the correlation between household sizes on the level of participation was positive and significantly increased PFM involvement level. Most likely, this was due to their high dependence on forest resources to diversify livelihoods, as large households may have challenges in accessing alternative sources of sustenance as reported by Coulibaly-Lingani (2011) in Burkina Faso. Mutune *et al*. (2015) reported the same for communities adjacent to Sururu and Eburu forest in relation to availability of farm labour.

In the study area, a plausible explanation is that most households depended on agricultural activities, which were largely influenced by availability of family labour. Hence, households with fewer family members had less labour available to be deployed in PFM activities which are typically labour intensive. This was further illustrated by the very high number (97%) of households with few (5 or less) family members working on the farm were only involved in PFM activities to a low extent. These findings agree with Ogada (2012) who explained that households with large family size have adequate labour time to allocate to both agricultural and PFM activities.

5.3.4 Land tenure, farm size and community involvement in PFM

The main type of land tenure in the study area was privately owned land, a resultant of government resettlement scheme after independence in a former gazetted forest area with some people renting in or out depending on farm size and family labour. Consequently, majority (42%) of the respondents were resettled by the government having been squatters or as compensation after compulsory acquisition of their land. There were some (21%) incidences of land owners who had acquired through purchase. Those who were resettled by the government or inherited the land expressed a higher PFM involvement. This could be have been influence by security of land tenure and the long history of interaction with the pristine forest before it was cleared for agriculture and settlement.

According to Gaveau *et al*. (2009) and Fisher *et al*. (2011) access to agricultural land is an important determinant in household involvement in forest conservation activities. In the study area, majority (61%) of the households had small land parcels of about 3 acres or less (Figure 1). Due to the decreasing farm sizes in the area, farm families rented land to supplement their small pieces. Therefore, as generally expected, the findings of this study showed that people with large farms were less involved in PFM The findings of this study indicated that less than 1% of households with large farms were fully involved in PFM. This showed that land size had a negative influence on PFM involvement level as it increased with the decreasing land sizes. Musyoki and Mbuvi (2014) also found that cultivating in the forest under PELIS in Mt. Kenya area drew more interest from those with small and unproductive land compared to those who had adequate land. Those with small farms required the forest for cultivation and collecting wood and non-wood products that were insufficient in their farms as also observed by studies from various forest adjacent communities (Mbuvi *et al.,* 2009; Thenya *et al*., 2007; Himberg *et al*., 2009; Engida & Mengistu, 2013). This implies that PFM is a livelihood strategy for resource challenged families and ways to enhance PFM involvement would enhance livelihood improvement for the resource poor as also observed by Mbairamadji, (2009) and Bush *et al*. (2011).

However, those who had not been formally bequeathed their inheritance as well as women married in the area felt insecure and they reported low involvement. Various studies reveal that land tenure and security significantly influences tree planting, conservation and other PFM activities (World Bank, 2005; Musyoki *et al*., 2013; Mutune *et al*., 2015). Dolisca *et al*. (2006) also observed that

lack of secure land rights contributed to farmer's low participation in conservation programmes in Haiti. This illustrates that, although PFM envisages near total community participation, not all community members adjacent to the forest are involved hence there is need to address land tenure and security for inclusivity to be adequately achieved.

In contrast to findings by Fisher (2004) in Malawi and Mutune *et al*. (2015) from forest reserves in Mau forest complex, the association and correlation between farm size and community involvement in PFM was not significant in this study. This research suggests that farm sizes were insignificant in the study area because wealthier households were equally using the forests because they could, whilst poorer households were using the resources because they had fewer alternatives.

5.3.5 Household sources of livelihood and community involvement in PFM

With regard to link between level of involvement in forest conservation activities and economic benefits from forest, previous studies (Putman, 1993; Gibson *et al*., 2005; Agrawal & Chhatre 2006; and Mutune *et al*., 2015; Newton *et al.,* 2016) found that higher economic benefits from forests encourage the community to participate in the management of forest resources. Concurrently, in this survey, the association between the sources of household food, sources of household income and annual household income level with PFM involvement level were significant. Hence, as also reported by Engida and Mengistu (2013) and Mutune *et al*. (2015), households that derived more benefits from forest had a higher level of participation in forest conservation activities. Similarly, the relation between household source of food and PFM involvement level was negative and significant (r = -0.17, p = 0.014).

Nevertheless, sources of household income and annual household income level had positive but non-significant correlations with the level of involvement in PFM in this study. This was attributed to the fact that even people who were not benefiting directly from activities such as forest cultivation and grazing were involved in other diverse PFM activities. This is an important finding as there has been a prevalent misconception that PELIS is the most important PFM activity and has been projected as one of the most successful form of PFM involvement that make meaningful change in household income and food security (Thenya *et al.,* 2007; Mbuvi *et al.,* 2009; KFS, 2010). Some of the CFAs such as in Gathiuru Forest station heavily rely on crops harvested from areas under PELIS have been quoted severally as a case study. The major shortcoming of dependence on PELIS being the fact that it is only practiced where forest plantations need to be

re-established (KFS, 2010) and hence sustainability cannot be guaranteed. This study therefore illustrates that community involvement can be promoted in many forest types including those where PELIS is not a viable option.

In recent years, there has been an increasing interest in the contribution that forests make as a source of local rural and urban employment and as a source of income. In the study area, forests products are not a major source of income; this could be attributed to the fact that households depended on forests mainly for subsistence uses. Additionally, this could be as a result of increased policing from both resource managers and, the electric fence. Nonetheless, as reported in other studies (Ongugo *et al.*, 2002; Mutune *et al.*, 2015), the community through the CFAs were anticipating that KFS would share some of the proceeds from sale of forest products. However, the Forest Conservation and Management Act, 2016 and the subsequent management agreements between KFS and CFAs are silent on benefit sharing yet this is an important aspect of rural livelihoods. The development of cost-benefit sharing mechanisms has been recommended in many studies and the recourse managing institutions should consider is to find equitable mechanism to share benefits to sustain the community interest in PFM involvement (Kumar, 2002; Bush *et al*., 2011; Engida & Mengistu, 2013).

Consequently, there are many emerging lessons, especially of a socio-institutional nature that are pointing out that PFM can be effective when considering community and their livelihood sources as a factor of influence (Yemiru, 2011; Newton *et al*., 2016). Therefore, community-based efforts need to be encompassed in a strong local-level institutional framework that is sociospatially inclusive. This calls for "community" to be more readily defined variously on the basis of adjacency, culture, socio-economic activities and its historical relationship with the resource (Lise, 2000; Gibson *et al*., 2005; Engida & Mengistu, 2013).

These observations need to draw attention to the government, researchers and PFM proponents as one of the key objectives of PFM is livelihood improvement especially for the rural poor. The fact that the forest adjacent community members in this study were largely in the poor well-being category calls for pro-poor methods of PFM implementation. This agrees with Kamugisha *et al*. (1997) and World Bank (2004b) who observed that a large share of people suffering from extreme poverty live and exert substantial pressure on fragile lands which include forest ecosystems, steep slopes, poor soils and arid zones. Coulibaly-Lingani *et al*. (2011) in Burkina Faso and Mogoi *et*

al. (2012) in Kenya recommended a review of user rights and empowerment of forest users by allowing direct involvement of vulnerable and marginalized groups like women and migrants, who happen to constitute majority of the poor in forest management activities and thus guarantee their access to forest products.

5.3.6 Group membership and community involvement in PFM

The inclusion of communities in the management of state-owned forest resources has become increasingly common in the past few decades (Kallert *et al*., 2000; Yemshaw, 2007; Mogoi *et al*., 2012). Schreckenberg *et al*. (2006) pointed out that many countries in Africa and Asia are promoting involvement of rural communities in the management and utilization of different types of forests through some form of PFM. In Kenya, Forest Conservation and Management Act, 2016 dictate that the community form FUGs which should thereafter register as a legal entity known as Community Forest Associations (CFAs). This is a prerequisite for entering into a forest management agreement with KFS under the PFM. The role of the FUGs is to assist in safeguarding forest resources through protection and conservation activities (GoK 2014). In return, they are expected to benefit from wood and non-wood forest products revenue from community-based industries, dairy farming, fish farming, establishment of tree nurseries; bee keeping, seeds and wildlings collection, ecotourism and recreation, as well as scientific and educational activities (Mogoi *et al*., 2012; Musyoki *et al*., 2013).

Majority of these groups are informal as they are still in the primary stages of formation (Ongugo *et al.*, 2008), however their level of involvement in PFM was found to be high in this study. The findings showed that the greater part (60%) of the respondents belonged to FUGs. The findings also indicated that most of these households had been participating in groups for some time as only 6% had joined FUGs for a period of less than a year. The study observed that households derived benefits from participating in groups as 72% reported large positive effect. Similar findings were reported in Mau and Mt. Kenya forests (Musyoki *et al.*, 2013; Mutune *et al.*, 2015). Therefore, PFM being a livelihood strategy, the potential of forest ecosystems to provide various goods and services sustainably should be promoted through formation and formalization of the CFAs.

The findings further established that, although all the community members participated in various forest conservation activities regardless of whether they were group members or not, it was observed that more of those who were group members compared to non-members participated in

forest conservation activities. Further, the association between group membership and level of participation in forest conservation activities was strong and significant. Similarly, Mutune *et al*. (2015) reported that membership to environmental groups increased involvement in PFM activities by 18% in communities adjacent to Mau forest ecosystem. Moreover, there was a significant and inverse relationship between group membership (formal or informal) and participation in conservation activities. This concurs with Ongugo *et al*. (2008) and Reed (2009) who found that there was more involvement of group members than non-members.

Additionally, Dolisca *et al.* (2006) in Haiti, observed that respondents who were members to local groups were positive towards social, environmental, and economic participation inside the Forest Reserve. In Kenya, Musyoki *et al*. (2013) made comparable observations concerning CFA membership in Ontulili and Ngare Ndare forests within Mt. Kenya forest ecosystem. It is plausible that local non-group members depicted low participation due to not to being informed about forestry programmes as suggested by Biendenweg (2012) and Engida and Mengistu (2013). Biendenweg (2012) further explains that group membership enhances information sharing and knowledge acquisition in issues that are important to the community.

These findings further illustrate that the tendency for community members to join and work in groups can be used to implement legal requirements governing conservation of natural resources like forests, water and wildlife which require communities to form associations to engage, collaborate and get support from government for natural resource conservation. This is concurs with the observations made by Lise (2000) and Pretty and Smith (2004) that social capital is important for shaping individual's behavior in pursuing shared objectives like participation in conservation of natural resources. Therefore, community members should be encouraged to form common interest groups participating in various livelihood activities that are linked to the ecosystem to enhance ecosystem conservation while addressing livelihood improvement.

5.3.7 Importance of the forest ecosystem and community involvement in PFM

In many parts of the world, forest adjacent dwellers depend on forest goods as services to supplement their livelihood activities (Agarwal, 2009; Yemiru, 2011; Rita *et al.*, 2017; Tesfaye, 2017). In this study, 85% of those who valued the ecosystem highly, they were more involved in PFM. Conversely, none of those who indicated low resource value was highly or fully involved in PFM. The association between household perception on importance of forest ecosystem and PFM

involvement level was a positive and highly significant. Adhikari *et al*. (2004) made comparable observations in Nepal that households which collected more fuel wood were more involved in various activities related to forest conservation. This was attributed to the information acquired through various community meetings concerning availability of forest products. With regard to the relationship between community perceptions of the importance of the forest ecosystem with their level of involvement in PFM, it was negative and significant. Thus, level of involvement decreased depending on the perception as those who valued the ecosystem for non-economic reasons indicated lower participation in conservation activities.

Additionally, these findings showed that products that were predominantly unavailable in the farmlands such as game meat, charcoal, cedar posts and grazing in the park were accessed illegally. Therefore to attain sustainable forest management, communities should be provided with clear and recognized but structured access rights to the forest resources. This also calls for multi-stakeholder agreements on increased but sustainable use of existing products from the forest, particularly non-extractive products. As stated in various PFM discourses, there is a gradual realization that with adequate awareness of the contribution of the forest resources to rural livelihood strategies, the forest adjacent communities would contribute more positively to the long term forest conservation and management goals (Musyoki *et al*., 2013; Langat *et al*., 2016; Tesfaye, 2017).

Based on these findings, determination of how the forest may be used sustainably becomes a managerial decision and one with which local or more distant users need to negotiate as proposed by Engida and Mengistu (2013) and Musyoki *et al*. (2013). In the Aberdare region economic issues are playing a clearer role in determining support for local-level involvement, thus it can be termed as "resource" participation (Armitage *et al.*, 2008). Thus, generally, the move towards community involvement in management will require more to be done to increase forest resources for the vast majority of the rural people. Nonetheless, it should be noted that the benefits that accrue from protected areas are not all obvious and may not be divided equitably among the different stakeholders.

In view of the association between economic benefits and community involvement in PFM, the implementation of PFM especially for those adjacent to the National Park may therefore not be smooth. This is because many issues remain unresolved, such as the transfer or sharing of power and resources between the official traditional bureaucracy to community institutions, and the

sharing of costs and benefits between KWS and communities. This study hence recommends negotiations and capacity building of local communities so that PFM can position them less as client-users to be appeased but as stakeholders who have both interests and rights over resources in the ecosystem, and thus, have a stake in safeguarding their future.

5.3.8 Influence of socio-economic factors on community involvement in PFM

This study went beyond the descriptive use of forest resources and explored the relationships between the levels of forest use and other socio-economic factors in an attempt to better understand forest dependence. Likewise, other studies for instance, Cavendish (1999) evaluated the diverse ways environmental goods interacted with households' other production activities to illustrate the poverty-environment interactions in Zimbabwe. Similarly, Godoy *et al.* (1995) assessed income effects on extraction of forest products as determinants of forest use in Nicaragua. In Kenya, Langat *et al*. (2015) investigated forest use and dependence by forest adjacent households on East Mau forest ecosystem whilst Mutune *et al*. (2015) analyzed the benefits communities derived from Eburu and Sururu forests. Analogous to this research, the aforesaid studies demonstrate that environmental demands as well as environmental supplies are predisposed to diverse household factors, consequently, simplistic conceptions of the relation between rural households and the environment would undoubtedly be wrong. As observed by Bush *et al*. (2011), the fundamental message from these studies is that understanding the issue of dependency is crucial in designing equitable and effective forest management policies.

In order for community to be adequately involved in PFM, household socio-economic characteristics played an important role both in the resource usage and in the preceding decision making process. Understanding the factors that influence community participation in natural resource management activities is crucial to forest resource managers and policy makers. This has led to various studies analyzing household characteristics and their influence on community participation in forest Management (Adhikari, *et al.*, 2004; Agrawal & Gupta, 2005; Dolisca *et al*., 2006; Engida & Mengistu, 2013; Langat *et al.*, 2015; Tesfaye, 2017). Many of these studies indicate that participation of rural communities in management of protected forests may vary according to socio-economic and demographic backgrounds of the individuals. Further, an individual's characteristics may influence decision making on whether or not to participate in PFM (Mogoi *et al*., 2012; Mutune *et al*., 2015).

In this study, farm size had an inverse influence as the probability for high level participation increased with decreasing farm sizes as also observed by Engida and Mengistu (2013) in Ethiopia,. This could be attributed to the fact that the surveyed sub-locations were densely populated and thus land hunger was intense. The average farm sizes in the area were relatively small where over 60% had 3 acres or less. This prompted the households with small land parcels to increase dependence on the forest and hence the increased involvement in PFM. They also have a bearing on Repetto's (1988) claim that some of the proximate causes of forest degradation within the tropical regions are population pressure leading to land hungry small-scale farmers facing an ever increasing demand for food, fodder and fuelwood. The land ownership and tenure also had a negative influence on PFM involvement where those who had purchased land, married or born in the area but had not yet been bequeathed land exhibited the lowest interest in PFM involvement. On the contrary, households that had been resettled by the government or inherited land referred to the forest as "our forest" implying they had a feeling of ownership to the forest rather feeling it belonged to the government (Makee, 2005). Thus, they were ready to protect and maintain it as provided for in PFM arrangement. The findings on the apathy of those born in the area and not bequeathed land could be elucidated by the importance of land tenure and security (Wambugu, 1999; Emerton, 2001; Temesgen *et al.*, 2007; Engida & Mengistu, 2013).

The FMA of the adjacent forest had an inverse relationship with PFM as the households adjacent to the National Park had fewer opportunities for participation. This could be attributed to the protection management approach which calls for strict law enforcement by KWS leading to low opportunities for economic benefits streaming to households. Similar findings were reported by Makee (2005) on the reduced firewood collected from areas managed by KWS in Kakamega forest. With regards to level of economic benefit from forest, a higher level of economic benefits from forests encourage the community to participate in the management of forest resources. Concurrently, the findings of a related study by Mutune *et al*. (2015) showed that as the level of economic benefit increased, the probability of households' level of participation increased by 12%. Similarly, Bush *et al*. (2011) in their study in Uganda observed that a higher level of forest dependence gave the people a higher stake in its management, leading to a higher level of participation.

In this study, as explained above family farm labour was an important determinant of household level of participation in PFM. Regression analysis showed that the influence of family size on the

level of participation was positive and significantly increased PFM involvement level. This could further be attributed to the households' dependency on forest based livelihoods which is closely associated with large households and high population (World Bank, 2005; Coulibaly-Lingani *et al*., 2011; Thenya, 2014; Rita *et al.*, 2017). Hence, as can be expected, large families have a greater demand for forest products such as firewood, food and fodder and thus depend on forest resources to diversify household livelihoods. This is in line with related studies by Dolisca *et al*. (2006) in Haiti; Coulibaly-Lingani *et al*. (2009) in Burkina Faso and Musyoki *et al*. (2013) in Mt. Kenya forest ecosystem

The positive and significant link between wealth as shown by household annual income revealed that, though the participatory process was intended to help the vulnerable groups in society, it had more benefit and support from wealthy classes. Thus, contrary to the common believe that poor households participate more in forest conservation activities (World Bank, 2005, Ongugo, *et al*., 2014), fewer (20%) of low income households were fully involved compared to 40% of the higher income category. These findings also agree with a study conducted in Tanzania which showed that while overall revenues from community based forest management (CBFM) had increased dramatically, poorer members of the community who had been highly dependent on open-access harvesting turned to be wage labourers (Lund & Treue, 2008).

Similarly, though the costs of participatory management may be more or less the same across the income groups, the accrued benefits are higher among the rich. Thus, paradoxically the financial benefits of local forest resources was much higher for high income households than low income households. The findings of this study therefore contradict the popular proposition that poverty is a driving factor behind forest dependence, where it is assumed that improving incomes will reduce forest use (Fisher, 2004; Lund & Treue, 2008). According to Mutune *et al*. (2015) based on Mau forests, of the household categorized as poor, 55% cited lack of direct livelihood benefits in PFM activities, 22% lack of information and 23% cited lack of money to pay for subscription fees and levies as reasons for not participating in CFA. Other reasons could be the unclear benefit sharing mechanisms especially tangible benefits (Lise, 2000; Dolisca *et al*., 2006). These findings therefore suggest the opposite, increasing household incomes for local communities at best *ceteris paribus* may have no significant variation on local use of the protected area or at worst may intensify the off take of goods from the forest ecosystems.

The positive and significant influence of economic importance of the forest ecosystem on PFM involvement level was aptly elucidated by Maingi (2014). He observed that forest stakeholders including forest adjacent communities are economic agents who spend the much needed resources in forest management expecting returns from their invested outlays. Most of them look at PFM as an investment arrangement where after participating in a series of outlays expect a comparable series of returns. As elucidated by Himberg *et al*. (2009), these are critical issues when thinking about efforts to pursue community based approaches to forest management. Any conservation activities planned within and around protection areas require to be designed compensating both the local welfare loss and financial loss to maintain household participation.

Therefore, the government should support development and implementation of appropriate income generating activities (IGAs) not to lose the interest ("bubble bursts") of the majority of community members (Vedeld *et al*., 2004; Mutune *et al*., 2015). In Kenya, the obligations in the Constitution of Kenya (2010) compel the government and all persons involved in natural resources management to ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of accruing benefits in Article 69 (1)(a). This study, underscores the importance of development and implementation of benefit-cost sharing mechanisms to ensure that both the government and citizens meet their constitutional obligations.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Value of forest ecosystems

Forest ecosystems are important to our ecological, economic and social wellbeing. The ways in which forests are used and valued depends largely on people's economic needs and priorities in a particular place at a particular time. This is balanced against the relative abundance or scarcity of forest resources. However, over recent years, a complex range of social, economic and political variations have transformed human demands on forests. These changing demands have had devastating impacts on forest status and integrity. A classic example of an "economic problem" (Plummer & Armitage, 2007) in relation to forest ecosystems has been how to meet people's unlimited demands from a scarce resource base, in a way which is efficient, equitable and sustainable (Kubiszewski *et al*., 2013). Therefore, it has become clear that there is need to (1) measure all forest values in quantitative economic terms for the full range of social, economic and ecological trade-offs implied by alternative forest land use; (2) review the management options to be accurately compared; and (3) involve stakeholders, particularly local communities whose livelihoods are closely intertwined with the forest ecosystems.

This findings showed that the communities derived various provisioning goods and services. Water, firewood and grazing were ranked as the three most important benefits for more than 60% of the households based on the non-economic valuation methods. However, using economic valuation methods, fodder, cultivation and forest grazing emerged as the three most important benefits. These findings underpin the importance of using various methods as prices should not be confused with values, and to local communities, prices are not the only values that are important.

Further, this study found out that the communities predominantly preferred on-farm sources of forest products. However products that were unavailable in the farmlands, were accessed illegally from the ecosystem. These findings demonstrate that, on one hand, if there are no alternative sources of products, the pressure on the ecosystem would persist, efforts of ecosystem managers aside. On the other hand, promotion of agroforestry to avail forest products in the farmlands would reduce pressure on the ecosystem. Conversely, this would improve livelihoods through increased

farm productivity from opportunity cost of time and leave the forest to perform its regulatory and supportive functions. That notwithstanding, this signifies an apparent linkage between the livelihoods of forest-adjacent households and forest ecosystems. This needs to be regulated as it could violate forest conservation objectives. Extraction of forest resources should be maintained at sustainable levels for sustainable human well-being.

The findings of this study showed that the annual benefit to the forest adjacent community for regulating services was approximately KES 36.3 (US$ 0.36) billion, provisioning was KES 580.6 (US$ 5.81) million and cultural services was KES 60.9 (US$ 0.61) million. Thus, since there were wildlife related losses estimated at KES 172 (US$ 1.7) million, the net annual benefit of various ecosystem services obtained in this study was approximated at KES 36.8 (US$ 0.37) billion. The important finding of this study was that the net benefit of forest conservation was positive, when all ecosystem services are accounted for but negative if only provisioning services are considered. In view of the difficulties of competing land uses, the significance of encashing all the benefits of forests is underscored.

Despite the divergent views in prioritizing regulatory and cultural ecosystem services, the findings from the FGD in this study showed that community clearly understood that ecosystem services are closely intertwined and important to the societal wellbeing in general. Therefore, the conclusion of this study as aptly stated by the community was "*if the ecosystem is well protected and conserved when pursuing one service, the other services will inherently flow*." This is because functioning ecosystems produce multiple services which interact in complex ways, diverse services being intertwined, affecting each other negatively or positively as one service changes.

In this study, forest land conversion was presumed to reflect the predominant livelihood activities of the adjacent community which were agricultural production through crop farming and livestock production. Thus, based on the 64% of the land that could be converted to agricultural production, the opportunity cost was found to be approximately KES 4.2 (US$ 0.04) billion. This can be compared to the net annual benefit from the ecosystem services which was approximately KES 36.3 (US$ 0.36) billion. Therefore, conserving the forest in its current state accrues about KES 32.6 (US$ 0.33) billion more than the opportunity cost of forest conversion. These findings underpin the importance of this study.

6.1.2 Influence of FMAs on PFM involvement

The findings from this study showed that access to forest good and services was characterized by, and dependent on FMA. The diversity of intrinsic, economic, cultural and aesthetic values from forest ecosystems has led to a wide range of users, particularly the forest adjacent community, who rely on forests to meet diverse subsistence and income needs. Therefore, a change management approach leads to a change not only in supply of goods but also for the complete bundle of services provided by the ecosystem.

Contrary to a common perception that local communities value forest ecosystems predominantly for extractive benefits, the findings in this study showed that the majority (83%) of the community members valued the forest ecosystem mainly for non-economic benefits irrespective of FMA. Nonetheless, the study showed that those who derived more economic placed higher values on the ecosystem. These findings demonstrated that forest economic benefits are important to forest adjacent communities and those adjacent to protection area felt discontented for not deriving full benefits. Thus, to reduce pressure on forest ecosystem, it is imperative to broaden the benefits derived from the ecosystem to include various non-extractive benefits so that those adjacent to protection area would have opportunities for some economic benefis.

The findings of this study revealed that of those communities who were fully involve in PFM, more were adjacent to Forest Reserve. This therefore suggests that the high interest in participating in forest management could be driven by the anticipated benefits. It is evident from this study that forest benefits played a critical role in shaping the community perception of the forest ecosystem, yet given the rising competition over forestland for agriculture, such information suggest there is a dire need to make forest ecosystems economically more meaningful to the local people so that they can appreciate the importance of forest conservation.

6.1.3 Factors that influence community involvement in PFM

Local communities in many instances have been considered as enemies and the destroyers of forest resources. This stance, which is based on the perception that local communities are uninformed of what constitutes a well-managed forest, has persisted for a long time. The findings of this study illustrated that PFM has huge potential to correct this notion and make communities contribute towards the objective of sustainable forest management and livelihood improvement.

The investigations on the determinants of community participation in forest management in this study revealed that the level of involvement differed amongst households, thus resource management institutions need to take into account these variations in order to strike a balance between improving the livelihoods and forest conservation. Further, the findings indicated that the most important determinants of local people's participation in forest management programmes in Aberdare region were the factors related to economic benefits.

In view of the association between economic benefits and community involvement in PFM, the implementation of PFM especially for those adjacent to the National Park may therefore not be smooth. This is because many issues remain unresolved, such as the transfer or sharing of power and resources between the official traditional bureaucracy to community institutions, and the sharing of costs and benefits between KWS and communities. Thus, the move towards PFM will require more to be done to increase access to benefits for the vast majority of the rural people. The findings illustrated that any arrangement that does not adequately meet this expectation cannot translate into sustainable natural resources management. These findings suggest that, in the event of forest returns imbalances, participating stakeholders will attempt to cover their short falls by whichever means whether legal or not leading to forest degradation and deforestation.

Additionally, group membership was associated and correlated significantly with more participation in forest conservation activities. Therefore, CFA membership would encourage community participation in forest conservation activities in the protected areas. Thus, this study advocates that the government through resource managers and other stakeholders mobilize and facilitate community members living adjacent to forests to form such institutions to enhance participation in forest management in line with Wildlife conservation and management Act, 2013, Forest conservation and Management Act, 2016 and Water Act, 2016 among others.

6.2 Recommendations for Forest Conservation and Management

In view of the findings from Aberdare forest ecosystems exhibiting enormous value of all ecosystem services to local communities and the need to enhance the level and outcome of PFM; the following strategies are made to foster sustainable forest management locally, nationally and regionally:

(i) Review of policies related to natural resources management to encompass application of the valuation results to real-world natural resources development planning, conservation and management practices and subsequently capture all the costs and profits facing forest users and forest ecosystems.

(ii) Creation of awareness to the community and all stakeholders to appreciate the benefits of all ecosystem services, beyond the provisioning services. This can be through provision of incentives such as identification of viable non-extractive income generating activities.

(iii) Promotion of policies that engender pro-nature behaviors of institutions managing the ecosystems and incorporate effective benefit sharing, provide guidelines in costing activities pursuant to the legislation related to management and conservation of natural resources which should be reviewed periodically.

(iv) Enhancing the economic performance of adjacent communities by broadening the range of benefits appropriate to each FMA which is a prerequisite for sustainable ecosystem management.

(v) Government should mobilize the adjacent community members to form and actively participate in conservation groups to increase participation in forest management.

(vi) Promotion of agroforestry to make forest products available on the farmlands to reduce pressure on the forest ecosystem. This could be done by operationalizing the forest conservation fund to support on-farm tree planting as well as nature based economic activities.

6.4 Suggestions for Further Research

Since this research was not conclusive on valuation on ecosystem services as envisioned by various natural resources policies and legislation, this study recommends further research on the following:

(i) Valuation of forest ecosystem for PES, such as hydrological services, carbon sequestration and climate change mitigation and translate this into benefits for Kenya and the adjacent communities

(ii) Research on the full range of benefits of forest ecosystems and costs associated with community participation in forest conservation activities to inform development of a

proportionate benefit-cost sharing in line with stakeholders' contributions and subsequent expectations by the participants.

(iii) A deliberate appraisal and monetization of community contributions to forest ecosystem conservation as it could be higher than the monetary contributions. This should provide for a proportionate benefit-cost sharing in line with contributions and subsequent expectations by the participants based on FMA.

(iv) Thorough analysis of households' interaction with the forest ecosystems including the processing, marketing and value addition of forest products to be supported by the government and other stakeholders

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APPENDICES

Appendix 1: Household Socio-economic Questionnaire

1. (a) General household information

Date of Interview		**Name of interviewer**				**Questionnaire No.**	
GPS Readings	**Elevation**		**M asl**	**37H**		**UTH**	
Site/village		**Location**		**Sub-location**		**District**	

Name of respondent						
Male	**Female**		**Year Born**		**Educational Level**	

Year of settlement		**Place of Origin**		**Gender of Household Head**	

Reasons for moving here

Farm size (acres)		**Land adequacy**	

Household size		**Adults**		**Children 0-18**		**Others**	

No. of dwellings		**Walls**	**Mud**	**Wood**	**Stone**	**Other**
		Roof	**Thatch**	**Mabati**	**Tiles**	**Other**

No. of HH members working in the farm	
No. of HH members in employment in the area	
No. of HH members in employment elsewhere	

(b) Household assets

Item	No. of units owned by household	Remarks
Car/truck		
Tractor		
Bicycle		
Motorcycle		
Mobile phone		
TV		
Radio		
Electricity/solar		
Piped water		
Water tanks		

(c) Distance from each forest

Forest type	**Time to reach forest**		**Remarks**
Distance	Minutes	Kms	
1. Forest Reserve			
2.National Park			
3.Private/on-farm forest			

2. (a) Farming systems and land holdings

1. Does the household rent land out?			Yes/No
(i) If yes, how much land is currently rented out?			Acres
(ii) What is the cost of hiring land out?	KES		acres/yr
3. Does the household rent land in?			Yes/No
(i) If yes, how much land is currently rented in?			acres
(ii) What is the cost of hiring land?	KES		acre/yr
4. Does the household cultivate land in the forest?			Yes/No
(i) If yes, how much forest land is currently being cultivated by household?			Acres
(ii) What is the cost of hiring forest land**?**	KES		acres/yr

5. What is your main source of food for your household?
1. Forest PELIS plot
2. Own private land
3. Buy
4. Others (specify)----------

IF PELIS FARMER, PLEASE COMPLETE THE SET OF QUESTIONS AT THE BACK OF THIS QUESTIONNAIRE AFTER YOU ARE THROUGH WITH THIS ONE

(b) Farm Utilization (year 2010)

Category	**First season**			**Second season**			
	Area (acres)	**Harvest**	**Income**	**Area**	**Harvest**	**Income**	**Remarks**
Food crops							
Cash crops							
Livestock							
Pasture/ fodder							
Fruits							
Agroforestry							
Woodlot							
Silvipasture							
Fallow							
Other							
Total							

(c) Grazing

Type of grazing	Zero grazing		Farm pasture		Forest	Roadside/ communal land	

Area (ha) of farm allocated to:	Fodder		Pasture	

How often do you graze in forest?	Always	Dry season	Never

How many heads do you take to the forest?	Livestock	No.	Cost/animal
	Cattle		
	Goats		
	Donkeys		
	Never/free		

Do you cut and carry grass/fodder from the forest?		
	Never	
	No. of times	
	Bags/head loads	
	Mode of transport	
	Season	

Yes/No	

Do you water livestock in the forest?	Never		
	No. of times		Per week
	Distance		Minutes
	Season		
What is the alternative source of water that is there?	Distance		Minutes

	Specify e.g name of river

Where does your household obtain water for domestic purposes?

Source		
Amount/day		Jerry cans
Distance		Minutes

3. (a) Sources of Household Income and Ranking

	Income Source	***Examples***	**Rank**
	Sale of agricultural crops from private farm		
	Sale of food crops from PELIS plot		
	Unprocessed F. products	*Fuel wood; timber; wild fruits; game hunted in forest etc.*	
	Processed forest products	*Charcoal; furniture; Purified honey etc.*	
	Local agricultural wage labor		
	Local non-agricultural wage labor		
	Migratory agriculture	*or forestry wage labour*	
	Service with government	*or private within village*	
	Support from government	*Other support not waged labour*	
	Pension	*Fish from the rivers or ponds*	
	Wild areas not forests	*e.g. wetlands, grasslands. Thatching grass; wild foods; game*	
	Own business	*Small shop; transportation business (specify).*	
	Livestock	*Sale of animals; birth of new animals etc.*	
	Livestock products	*Milk; eggs; butter; hides; dung etc.*	
	Payment for forest services	*Carbon sequestration; watershed management etc.*	
	Casual labour	*On- or off-farm*	
	Remittances and gifts	*Cash from relatives; financial support from NGOs etc.*	
	Other (*specify*)		

(b) Household income levels

Activity	**Income per month? (KES)**	**Income in last 12 months (KES)**	**Remarks**
Others (specify)			
Total			

4. In the past 12 months have you done any of the following?

Forest Rights	Forest Reserve	National park	Private/On-farm forest	Remarks
Entered the forest				
Harvested products from the forest				
Contributed to managing forest				
Participated in tree planting				
Participated in tree policing				
Entered for cultivation				
Participated in fire fighting				
Made decisions about managing the forest				
Decided who can and cannot enter the forest				
Sold or leased forest land				

5.(a) What is the nearest market centre for timber, poles and other wood products used by household?

Market centre	Products obtained	Distance (Km)	Remarks

(b) Sources and utilization of forest products per month (only those used by household in year 2010)

Forest product	Units		Forest	Farm	Bought	Price (KES)	Other (specify)	Total /yr	Remarks
Fuel wood	Head loads	Domestic							
		Sale							
Timber	Running ft	Domestic							
		Sale							
Charcoal	Sacks	Domestic							
		Sale							
Poles	Pieces	Domestic							
		Sale							
Posts	Pieces	Domestic							
		Sale							
Thatch	Head loads	Domestic							
		Sale							
Beehives	Nos	Domestic							
		Sale							
Honey	Kgs	Domestic							
		Sale							

Forest product	**Units**		**Forest**	**Farm**	**Bought**	**Price (KES)**	**Other (specify)**	**Total /yr**	**Remarks**
Wildlings	Nos	Domestic							
		Sale							
Seedlings	Nos	Domestic							
		Sale							
Cultivation	Bags	Domestic							
		Sale							
Wild game	Kgs	Domestic							
		Sale							
Wild fruits	Kgs	Domestic							
		Sale							
Herbs	Kgs	Domestic							
		Sale							
Other		Domestic							
		Sale							

(c) Pricing and source of forest products for trade (buy and/or sell)

Product	Unit	Source	Buying price	Processing	Duration (hrs)	Selling Price (KES)		
						Minimum	Maximum	Average
Firewood	Headloads							
Timber	Running ft							
Poles	Nos							
Posts	Nos							
Rafters	Nos							
Charcoal	Bags							

(d) Time spent on acquiring forest goods

Forest product	Unit	Time spent (hrs)				Total time spent (hrs)	Estimated value (KES)
		Collecting	Processing	Marketing	Other costs		

(e) Other costs related to forest extraction and marketing *(only for those who trade in forest products)*

Type of forest product	Unit	Type of cost	Unit	Unit cost/ month	Annual estimated value (KES)	Remarks
		Labour	M/days			
		Transport	KES			
		Buying price	KES			
		Licences	KES			
		House rent	KES/mth			
		Storage	KES			
		Others				

6. Participation in Organizations

(a) Do you or someone in your household belong to a group?

1. Name of Group	2.Type of group (Forest User Group (FUG) or other (specify)	3.Organization group is affiliated to (KFS, GBM, WRMA, etc)	4. Household member name	5. Position (Official or member)	6. Group formal or informal	7.Years of involvement

codes: 1=wife; 2=husband; 3=both; 4=children; 5=other HH member

If respondent belongs to a Forest User Group, ***answer the section b on FUG members.***

(b) Forest User Group Members (FUG MEMBERS)

1. In your household, who normally attends group meetings and participates in group activities? *Codes: 1=only the wife; 2=both, but mainly the wife; 3=both participate about equally; 4=both, but mainly the husband; 5=only the husband; 9=other arrangements*		
2. How many person days (= full working days) did household's member spend on group activities (meetings, policing, joint work, etc) over the past 12 months? *Female----(days) Males ----(days)*		*(1-0)*
3. Does your household make any cash payments/contributions to the group? *If 'no', go to 9.*		
5. **If 'yes':** how much did you pay in the past 12 months? *(KES)*		
6. Did your household receive any cash payments from the group (e.g., share of sales) in the past 12 months? *If 'no', go to 11.*		*(1-0)*
7. **If 'yes':** how much did you receive in the past 12 months? *(KES)*		
8. What are your reasons for joining the group? *Please rank the most important reasons, max 3.*	**Reason**	**Rank 1-3**
	1. Increased access to forest products	
	2. Better forest management and more benefits in future	
	3. Access to other benefits, e.g., government support donor programmes	
	4.My duty to protect the forest for the community and the future	
	5. Being respected and regarded as a responsible person in village	
	6. Social aspect (meeting people, working together, fear of exclusion, etc.)	
	7.Forced by Government/chiefs/neighbors	
	8. Other, specify:	
9. Overall, how would you say the existence of the FUG has affected the benefits that the households involved get from the forest? *Codes: 1=large negative effect; 2=small negative effect; 3=no effect; 4=small positive effect; 5=large positive effect.*		

(c) Forest activities/benefits undertaken by gender

Activity	**1. Men**	**2. Women**	**3. Youth**	**4. Children**	**Remarks**
Tree nursery					
Tree planting					
Firewood collection					
Charcoal production					
Logging					
Honey harvesting					
Grazing					
Cultivation					

Activity	1. Men	2. Women	3. Youth	4. Children	Remarks
Eco-tourism					
Wild foods/fruits					
Herbal medicine					
Fence attendants					
Posts/Rafters					
Wild game					
Thatch					
Grass					
Transportation					
Other *(specify)*					

7.(a). Which of the following two statements do you agree with the most?

_____ 1 ***"Improvements in the condition of local forests are necessary for economic reasons such as their contribution of fodder, fuel wood, and timber".***

_____2 ***"Improvements in the condition of local forests are necessary for non-economic benefits such as cleaner air, soil conservation, and water retention".***

(b) What are the problems that your village is facing in protecting forests?

_____

_____

_____

(c) What suggestions would you make for improving the governance and management of forest resources in your village?

_____

_____

_____

Appendix 2: Responses on Division of Labour for Forest Based Activities

Activity	Gender	Responses	Percent
Tree nursery	Men	107	83.6
	Women	12	9.4
	Youth	9	7.0
Tree planting	Men	137	81.5
	Women	27	16.1
	Youth	3	1.8
	Children	1	.6
Fire wood collection	Men	20	11.8
	Women	146	86.4
	Youth	2	1.2
	Children	1	.6
Charcoal production	Men	93	92.1
	Women	6	5.9
	Youth	2	2.0
Honey harvesting	Men	102	96.2
	Women	2	1.9
	Youth	2	1.9
Logging	Men	69	89.6
	Women	2	2.6
	Youth	6	7.8
Grazing in the forest	Men	129	78.2
	Women	22	13.3
	Youth	11	6.7
	Children	3	1.8
Cultivation in the forest	Men	74	54.0
	Women	62	45.3
	Youth	1	0.7
Eco-tourism	Men	37	80.4
	Women	5	10.9
	Youth	1	2.2
	Children	3	6.5
Wild food/fruit	Men	22	68.8
	Women	1	3.1
	Youth	6	18.8
	Children	3	9.4
Herbal medicine	Men	92	100.0
Fence attendants	Men	127	97.7
	Youth	3	2.3
Posts/rafters	Men	62	100.0
Wild game	Men	28	84.8
	Youth	2	6.1

Activity	Gender	Responses	Percent
	Children	3	9.1
Thatch	Men	11	20.8
	Women	42	79.2
Grass/fodder from	Men	33	33.0
forest	Women	65	65.0
	Youth	2	2.0
Transportation	Men	67	94.4
	Women	1	1.4
	Youth	2	2.8
	Children	1	1.4

Appendix 3: Estimation of the Net Annual Benefits from Provisioning Services

Step 1: From the sample households, obtain the No. of households (%) benefiting from the good or service

Step 2: Obtain the quantity utilized per household and the price per unit

Step 3: Calculate the gross benefits (B) from good or service

Step 4: Calculate the total cost of extraction © which was largely in terms of labour whereby, the cost of one man day in the area was KES 250 (USD$ 2.5). In some products surrogate prices were applied like the case of grazing, TLU a livestock unit (250Kg) requires a minimum quantity of fodder for maintenance of between 5.0-7.5 kg/ day was used, price of iron sheets KES 250 (USD$ 2.5) was used for thatching grass and price of meat (KES 250 US$2.5)/kg was used for game meat

Step 5: Calculate the net annual benefits (B - C)

Forest product	Unit	HH involved (%)	Price/ unit (KES)	Total units/HH/yr	Gross benefits (B) (KES)	Total cost © labour (KES)	Net annual benefits (B - C) (KES)
Fodder	Bags	8.4	50	4636336.3	231816816	20863513	210953302.6
Cultivation	Acres	9.4	500	31706.6	158530812	1268246.5	157262565.5
Forest Grazing	TLU	12.9	950	138446.2	131523846	124601.5	131399244.8
Water	No.	98	5	12020131	60100656	1502516.4	58598139.6
Firewood	Hdload	23.8	11.9	1364714.2	16220881	4367085.4	11853795.5
Seedlings	Nos	17.3	10	707660.7	7077933.1	1061491	6016442.1
Poles	Nos	1.5	11.5	159466.1	1833491.6	478398.2	1355093.5
Thatch	Hdload	1	171.9	6132.72	1054214.6	33730	1020484.6
Charcoal	Portions	1.5	132	6117.4	807372.59	21410.9	785961.7
Wildlings	Nos	2	1.1	1557710.9	1790038.8	1246168.7	543870.1
Herbs	Portions	2	12.3	61327.2	751258.2	398626.8	352631.4
Beehive	Nos	1.5	33.1	12418.8	410968.9	124187.6	286781.3
Posts	Nos	0.5	4.3	31123.6	134549.32	62247.1	72302.2
Wildfruits	Batches	1	13.3	3833	51106	2683.1	48422.9
Honey	Kg	2	4.7	62860.4	292990.7	251441.5	41549.2
Wild game	Kg	0.5	10.4	3066.4	31941.25	21464.5	10476.7
Total					**612428876.2**	**31827813**	**580,601,063.6**

Appendix 4: Relationship Between Household Socio-economic factors and Community PFM Involvement Level

HH socio-economic factors		PFM level	FMA	Dist. to FR	Dist. to NP	Gender	HHHH	HH size	HH No. on farm	HH Settle history	Farm size	HH rent land	HH food source	HH income source	Group member	Type of grp	Grp status	Imp. of forest	Dependence	HH social status	HH Total income
PFM level	r	1.000																			
	Sig	.																			
FMA	r	.191**	1.000																		
	Sig	.007	.																		
Distance to FR	r	**-.345****	-.204*	1.000																	
	Sig	**.000**	.020	.																	
Distance NP	r	.109	.276*	-.552**	1.000																
	Sig	.319	.010	.000	.																
Gender	r	**-.227****	.001	.082	-.257*	1.000															
	Sig	**.001**	.994	.354	.017	.															
HH Head	r	**-.162***	-.124	.026	-.254*	.646**	1.000														
	Sig	**.022**	.081	.772	.019	.000	.														
HH size	r	.209**	.458**	-.214*	-.002	-.052	-.108	1.000													
	Sig	.003	.000	.015	.988	.464	.126	.													
HH No. on farm	r	.144*	.297**	-.143	.099	-.167*	-.213**	.535**	1.000												
	Sig	.040	.000	.105	.364	.017	.002	.000	.												
Land tenure	r	**-.158***	-.092	-.179*	-.071	-.002	.077	-.047	.273**	1.000											
	Sig	**.024**	.193	.042	.518	.975	.277	.507	.000	.											
Farm size	r	-.112	-.178*	.084	-.147	.062	.069	-.096	.172*	.240**	1.000										
	Sig	.114	.011	.347	.176	.382	.334	.175	.015	.001	.										

HH socio-economic factors		PFM level	FMA	Dist. to FR	Dist. to NP	Gender	HHHH	HH size	HH No. on farm	HH Settle history	Farm size	HH rent land	HH food source	HH income source	Group member	Type of grp	Grp status	Imp. of forest	Dependence	HH social status	HH Total income
HH rent land	r	**-.265****	-.367**	.180	-.143	.037	.064	-.295**	-.318**	.119	.298**	1.000									
	Sig	**.001**	.000	.059	.249	.645	.430	.000	.000	.141	.000	.									
HH food Source	r	**-.173***	-.322**	.028	-.043	.070	.094	-.166*	-.111	.147*	-.026	.149	1.000								
	Sig	**.014**	.000	.750	.694	.319	.183	.019	.116	.036	.715	.065	.								
HH income source	r	.013	.107	.205*	-.349**	.144*	.040	.100	-.093	-.090	-.073	.069	.040	1.000							
	Sig	.852	.131	.020	.001	.041	.571	.157	.189	.202	.303	.396	.568	.							
Grp member	r	**-.273****	-.115	.053	-.330**	.105	.088	-.091	-.177*	.046	-.065	.061	.217**	.192**	1.000						
	Sig	**.000**	.104	.548	.002	.139	.217	.198	.012	.517	.356	.454	.002	.006	.						
Grp Type	r	**-.342****	.243**	.114	-.245	.155	.002	.042	.061	-.025	-.153	-.021	-.057	.120	-.106	1.000					
	Sig	**.000**	.008	.292	.104	.090	.981	.645	.506	.786	.096	.833	.537	.192	.248	.					
Grp status	r	**-.278****	-.433**	.034	-.139	.116	.128	-.223*	-.172*	.243**	.176*	.157	.282**	-.053	.296**	.084	1.000				
	Sig	**.001**	.000	.753	.322	.184	.148	.010	.049	.005	.043	.099	.001	.547	.001	.376	.				
Imp. of forest	r	**-.252****	-.287**	.264**	.120	-.026	-.053	-.219**	-.297**	-.134	-.091	.246**	.259**	-.137	.210*	.061	.150	1.000			
	Sig	**.002**	.000	.005	.391	.756	.528	.008	.000	.109	.276	.008	.002	.101	.012	.546	.120	.			
FR value	r	.387**	.440**	-.212*	.118	-.129	-.106	.245**	.202**	.076	-.108	-.267**	-.349**	-.135	-.250**	.061	-.168	-.229**	1.000		
	Sig	.000	.000	.016	.279	.067	.135	.000	.004	.284	.124	.001	.000	.055	.000	.506	.054	.006	.		
HH social status	r	.069	-.456**	.076	-.264*	-.099	-.070	-.232**	-.179*	-.063	.089	.224**	.050	.126	.133	-.267**	.181*	.121	-.267**	1.000	
	Sig	.329	.000	.390	.014	.161	.328	.001	.011	.371	.206	.005	.481	.074	.059	.003	.038	.150	.000	.	
HH annual income	r	.090	-.490**	.046	-.085	-.106	-.059	-.234**	-.209**	-.122	.130	.231**	.066	.090	.100	-.286**	.181*	.162	-.309**	.946**	1.000
	Sig	.205	.000	.603	.437	.134	.408	.001	.003	.085	.065	.004	.353	.205	.155	.002	.038	.053	.000	.000	.

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Review

Socioeconomic Factors that determine community participation in forest management and conservation of adjacent ecosystems: A case of Aberdare forest, Kenya

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Forest ecosystems are important to ecological, economic and social wellbeing, particularly for the adjacent communities who depend on it. Understanding the socioeconomic dynamics that make households choice to be involved in forest conservation is crucial for sustainable management of natural resources. This study therefore examined the socioeconomic factors that influenced households' participation in forest management. Multistage probability sampling technique was used to select 202 respondents from households adjacent to Aberdare forest ecosystem. Data collected was analysed using Chi-square test, Spearman's rho correlation and multinomial logistic regression. The factors that influenced participatory forest management included forest management approach (χ^2 = 17.551, p < 0.001), distance to the forest reserve (χ^2 = 29.071, p < 0.001), distance to the national park (χ^2 = 27.303, p = 0.008), gender of household head (χ^2 = 10.719, p = 0.002), land tenure (χ^2 = 34.313, p < 0.001), sources of income (χ^2 = 31.353, p < 0.001) and importance of the forest ecosystem (χ^2 = 29.241, p < 0.001). The factors that significantly influenced the regression model were farm size, household size, annual income, forest management approaches (FMA), land tenure, and importance of the forest ecosystem where R^2 was 0.703. The study established that, although the proposition that natural resources need protection from anthropogenic destruction is widely accepted, communities are interested in collaborating with resource managers for long-term resource conservation. This study therefore recommends strategies for harnessing this high interest through broadening the economic benefits base on spur community involvement in conservation, a prerequisite for sustainable forest conservation. These include promotion of agroforestry practices, supporting non-extractive benefits and formation and capacity building of community associations to enhance participation in forest ecosystem management.

Key words: Benefit-cost sharing, economic and non-economic benefits, forest ecosystem, forest management approach, forest reserve, national park, livelihoods.

NTRODUCTION

Forests ecosystems contribute significantly towards the diversification of livelihoods of adjacent communities

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Full Length Research Paper

Effect of forest management approach on household economy and community participation in conservation: A case of Aberdare Forest Ecosystem, Kenya

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Forest ecosystems are important for ecological and socio-economic wellbeing, particularly for diversification of the livelihoods of adjacent communities. The forest management approach applied in an ecosystem influences availability, access and utilisation of forest products, and community participation in conservation. This study examined the effect of forest management approach on households' economy and participation in forest management. **A random sample of 202 households adjacent to Aberdare forest ecosystem was selected for characterisation and interviews using semi-structured questionnaires. Data collected were analysed using Chi-**square test, Spearman's rho **correlation and multinomial logistic regression. Although the benefits varied with management approach, the majority of the households indicated the forest was beneficial as only 6% reported no benefits. There was a significant association between forest management approach and** households' **sources of food (χ^2 = 27.704, $p < 0.001$), socio-economic status (χ^2 = 20.194, $p < 0.001$) importance of forest (χ^2 = 11.863, $p < 0.001$),** forest dependence **(χ^2 = 53.580, $p < 0.001$) and participation in forest management (χ^2 = 17.551, $p < 0.001$) at α = 0.05. The factors that significantly influenced the regression model included households' dependence on the forest, socio-economic status and participation in forest management where R^2 was 0.797. These findings depicted that when ecosystems made no substantial contributions to livelihoods, their value and the level of community participation in conservation was lower.**

Key words: Conservation management approach, economic importance, forest dependence, household economy, participatory forest management, protection management approach.

INTRODUCTION

Forests are multi-functional ecosystems which provide diverse goods and services, including intrinsic, economic, cultural and aesthetic values essential for socio-economic well-being, particularly to the forest adjacent community (de Groot et al., 2016; Costa et al., 2017). Although forest contribute significantly towards the diversification of