Economic Analysis of Participatory Forest Management in Kenya

by

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*__Declaration__

I declare that this thesis is my original work. Where other people's work is used, acknowledgements have been made. I declare that it has not been previously submitted for the award of a degree at any university.

Signed

Candidate Signed by candidate **Date***:* 16th October, 2017

Dedication

This work is dedicated to my late father Josiah Okumu, late mother Pamela Okumu, late Grandmother, my wife Lilian Otieno and my kids Rhoda, Darrelle, Shannelle and Salmah.

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Abstract

The failure of the centralized top down approach to management of common pool resources such as forests led policy makers and donors to conclude that devolution of forest management to local communities can be the only solution to such failures. Developing countries have thus resorted to devolution of forest management to forest adjacent communities through approaches such as joint forest management (JFM) and participatory forest management (PFM). PFM is part of the initiative towards devolution of power of management and decision making from government to local communities. Communities therefore self-organize into community forest associations (CFAs) or forest user groups to manage forest resources. In Kenya for instance, the recent and ongoing forest sector reforms as envisaged in the Forest Act (2005) and the Forest Act (2016) led to devolution of forest management through CFAs and provision of incentives such as plantation establishment and livelihood improvement scheme (PELIS), eco-tourism, harvesting of forest products among others. These efforts were aimed at deepening community participation in forest management and improving welfare of forest adjacent communities.

However, despite the numerous efforts aimed at empowering communities to sustainably manage forest resources through PFM and provision of various incentives, the success of PFM in terms of efficiency, equity, accountability and environmental outcomes have been mixed. In this thesis, we contribute empirically to the understanding of how PFM can be successfully implemented and make suggestion for more inclusive, equitable and sustainable forest management in Kenya from a micro perspective using household and community level data collected from 22 CFAs in the Mau forest conservancy. We take into account the values and preferences attached to salient forest ecosystem services by local communities and how this can be used to design incentive schemes like PES to incentivize local communities and also influence devolution of forest management. We

also assess the impact of existing incentives specifically PELIS on welfare of forest adjacent communities as well as the environment and the heterogeneous impact of the scheme on household welfare. We then look at the context specific factors influencing the varying levels of success among the CFAs. The thesis therefore, comprises of three separate, but related analysis chapters.

The second chapter seeks to determine the economic value of salient forest ecosystem services in Mau forest conservancy in Kenya and assess whether they are sufficient to incentivize local communities to engage in forest conservation through PES schemes and the implication on devolution of forest management to local communities through PFM. The choice experiment approach using the Bayesian efficient design was thus employed to estimate the welfare associated with the selected forest ecosystem attributes based on data collected from 321 randomly selected households in the Mau forest conservancy. We applied discrete choice econometric techniques namely the conditional logit, random parameter logit model and the random parameter logit model with interactions to enable consideration of preference heterogeneity. We also estimate the welfare impacts of various conservation policies.

In the third chapter, we evaluate the welfare and environmental impact of incentive based conservation focusing on a unique incentive in Kenya known as PELIS. Using data collected from 406 randomly selected households from the 22 CFAs, we employ Propensity Score Matching (PSM) to measure the mean impact of the scheme on forest cover and welfare of forest adjacent communities. We further employed the endogenous quantile treatment effects model to assess the heterogeneous impact of the scheme on household welfare while accounting for heterogeneity, selection bias and potential endogeneity. We also identify the determinants of household decision to participate in PELIS.

In the fourth chapter, we employ Ostrom's Social Ecological Systems framework for analyzing complex ecological systems to identify the determinants of household level of participation in CFA activities and assess the determinants of successful collective management of forest resources as well as the link between level of participation and success of collective action. Using data collected from 518 randomly selected households from the 22 CFAs in the Mau, we estimated a logit model to identify the determinants of household level of participation and obtained the predicted probabilities of active household participation for use in the second stage regression. In the second stage, we employed OLS models and instrumental variable estimation using Lewbel (2012) heteroscedasticity based instruments with the predicted probabilities from the logit model as one of the explanatory variables. For robustness checks, using Principal Component Analysis, we constructed a third outcome variable, an indicator of successful collective management showing level of cooperation using forest management activities that CFAs participate in to assess the consistency of our estimates and any significant variation in the effect of the variables on outcome of successful collective action.

Results from the second chapter revealed that, forest adjacent communities have higher willingness to pay for improvement in forest cover/forests structure, reduction of flood risk, and water purification and storage in that order but would experience loss in welfare for choosing an alternative with medium wildlife population. One significant finding from the study is the altruistic nature of forest adjacent communities as revealed by their high willingness to pay for flood mitigation showing that they are not just concerned with the private benefits accruing to them but also the welfare of the society. There is also considerable preference heterogeneity which to a large extent was determined by employment status of household head, ownership of PELIS plot, household size, and distance to the nearest edge of the forest. In terms of welfare, respondents

revealed that forest conservation policy and a combination of flood mitigation and forest conservation policy would have high welfare impacts on livelihoods of locals.

Results from the third chapter revealed that on average, PELIS has significant and positive impact on overall household welfare and on the environment. However, in terms of welfare, the scheme cannot be defended on equity grounds as it has inequitable distributional impacts on household welfare. The scheme raises welfare of the least poor than the poorest and marginalizes sections of the community through elite capture and lack of market linkages. Determinants of household decision to participate in PELIS are also identified.

In the fourth chapter, the empirical results suggest that success of collective action is associated with the level of household participation in CFA activities, distance to the forest resource, institutional quality, group size, and salience of the resource, among other factors. We also found that collective action is more successful when CFAs are formed through users' self-motivation with frequent interaction with government institutions, provision of alternative lands through PELIS and when the forest cover is low. Factors influencing the level of household participation are also identified.

A number of policy recommendations can be highlighted from the various chapters. First, policy makers need to understand local communities' attitudes, values and preferences for various forest ecosystem services in deciding how to devolve forest management. The information on willingness to pay thus forms the basis for design of PES schemes and roll out, design and implementation of PFM. However, more research on the demand and supply side is needed as well as consideration of issues as to what private partners may consider worth involving in PES schemes. A demonstration of the significance of ecosystem services as input in the production process can also play a role in increasing environmental awareness and motivating forest adjacent communities to

conserve forest resources through PFM. This can also encourage shifts from socially unacceptable land management activities towards ecosystem oriented approaches. Second, policy makers need to ensure equity in access and management of forest resources and existing incentives to avoid further marginalization of any income group in order to ensure sustainability of the scheme. This can be achieved through exploring ways of improving market linkages for agricultural harvest from PELIS farms either through formation of forest user cooperatives or collaboration with relevant stakeholders. The design and implementation of the scheme should also be given due consideration if it is not to discriminate the very group that it is meant to benefit.

Finally the study findings point to the need for: a robust diagnostic approach in devolution of forest management to local communities, considering diverse socio-economic and ecological settings; government intervention in reviving and re-institutionalizing existing and infant CFAs in an effort to promote PFM within the Mau forest and other parts of the country; and intense effort towards design of a mix of incentive schemes to encourage active and equal household participation in CFA activities. KFS should also consider increasing proportion of collected revenues (user-fees) that goes to CFAs and forest user groups to support the CFAs financially.

List of Acronyms

ASC: Alternative Specific Constant

ATT: Average Treatment effect on the Treated

CBO: Community Based Organization

CBNRM: Community Based Natural Resource Management

CE: Choice Experiment

CFA: Community Forest Association

CIA: Conditional Independence Assumption

CL: Conditional Logit

CPR: Common Pool Resources

CVM: Contingent Valuation Method

FGDs: Focus Group Discussion

FUG: Forest User Group

IIA: Independence of Irrelevant Alternatives

IV: Instrumental Variable

JFM: Joint Forest management

KEFRI: Kenya Forestry Research Institute

KFS: Kenya Forest Service

KWS: Kenya Wildlife Service

LR: Likelihood Ratio

MNL: Multinomial Logit

MWTP: Marginal Willingness to Pay

NACOFA: National Alliance for Community Forests Associations

NEMA: National Environment Management Authority

NGO: Non-Governmental Organization

OLS: Ordinary Least Square

PCA: Principal Component Analysis

PELIS: Plantation Establishment and Livelihood Improvement Scheme

PES: Payment for Ecosystem Services

PEV: Participatory Environmental Valuation

PFM: Participatory Forest Management

PSM: Propensity Score Matching

QTE: Quantile Treatment Effects

RPL: Random Parameter Logit

SESs: Social- Ecological Systems

SQ: Status Quo

TEV: Total Economic Value

UNEP: United Nations Environment Programme

WTP: Willingness to Pay

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Chapter One

General Introduction

1.1 Background

Forest[1] resources are critical natural endowment for humanity providing a range of ecosystem services. According to MEA (2005), these services are classified into four classes namely: Provisioning services[2]; Support services[3]; regulating services[4] and cultural services[5]. Forest-adjacent communities[6] therefore significantly depend on these services for their livelihoods, provision of basic needs, cash resources and safety nets in times of crisis (Shackleton et al., 2007). The benefits from these services also accrue at various levels both global, national and local. However, the ability of these forests to provide these services for present and future generations has been hampered by the increasing demand for various ecosystem services and rising population coupled with increasing demand for agricultural land hence the increased cases of environmental degradation as people strive to earn a living. Other causes of environmental degradation especially

[1] In Kenya, forest is defined as any land area of more than 0.5 hectares with a tree higher than 5 meters and canopy cover more than 10 percent or trees able to reach these thresholds insitu. However, this excludes land and urban and agricultural use (FAO, 2015).

[2] Are products people obtain from the ecosystem they include; timber, food, fruits, fresh water, firewood, medicine and herbs, grass for thatching etc.

[3] Are services necessary for production of all other ecosystem services i.e. nutrient cycling, soil formation, primary production and production of oxygen among others.

[4] Are benefits people obtain from the regulation of ecosystem process e.g. water purification, climate regulation, erosion control, flood control, carbon sequestration etc.

[5] Refers to non-material benefits people obtain from ecosystems through spiritual enrichment, recreation, aesthetic experiences, reflection, cognitive experiences etc.

[6] Forest-adjacent communities are defined as communities living closer to the forest and directly or indirectly rely on the forest in some way for their daily livelihood. These communities are also eligible to join any forest user group or community forest association.

in developing countries include; market failure[7], policy failure[8], institutional failure[9], poverty, agricultural market integration, agricultural technological advancement and agricultural subsidies (Angelsen and Kaimowitz, 1999).

Since most forests in developing countries are often surrounded by poor households reliant on agriculture where land is the key input for production, conversion of this forests for agricultural activity has become the norm rather than exception. Even though agriculture is often considered the employer of last resort, the benefits from agriculture may be exaggerated as the externalities arising from forestry are not accounted for. It therefore implies that forest conversion decision does not reflect the socially optimal land use allocation between agriculture and forestry. Therefore, degradation and deforestation[10] of these forests would eventually lead to welfare losses and reduction in the supply of these products and services thus having a negative effect on economic growth and also limit the insurance value that these forests provide to various key sectors of the economy.

The significance of forest resources in reduction of welfare losses and provision of various ecosystem goods and services, led to the search for solutions that could mitigate or reverse the decline in forest cover and simultaneously improve the livelihood of locals. Initial efforts aimed at management of forest resources were based on the centralized approach in which the state assumed full responsibility of natural forests resulting in *de-facto* open access forestry. This approach was however, characterized by high information, monitoring and enforcement costs as well as imperfect

[7] Market failures refers to when markets fail to yield economically efficient investment in natural resource management mainly due to ill-defined and poorly enforced property rights (A property right is an enforceable authority to undertake particular actions in specific domains (Ostrom and Hess, 2007)), imperfect competition, externalities and public goods. In response to market failure, governments often implement policies aimed at regulating production or creating markets e.g. user fees, fines and penalties to discourage poor practices a possible problem from these actions could be low pricing or low levels of user fees.

[8] Sources of policy failures could be other policies not related to forest conservation that could have detrimental impacts on management of forests as well as conflict of national regulations.

[9] Institutional failures occur when there are laws and regulations aimed at managing forest resources e.g. forest act supporting various aspects of sustainable forest management but nothing happens on the ground it can also be considered as an extension of government failure (Ljungman et al., 1999).

[10] To a lay man, it is defined as the loss in stock and quality of forest cover. While to economists, it is defined the difference between land use and forest use allocation.

incentives (Adhikari, 2005). Communities thus considered state managed forests as *de-facto* open access and therefore more incentive for forest-adjacent communities to over exploit the forest resources. However, the failure of this top down approach to arrest irretrievable losses of biodiversity led to the interest in alternative policy instruments. This gave rise to the concepts of Community Based Natural Resource Management (CBNRM). The intention of CBNRM was to address economic, environmental and social goals all in one package. CBNRM emphasizes forest users' ability to effectively manage collectively owned natural resources through informal and semi-formal institutional arrangements (Wade, 1988; Ostrom, 1990; Baland and Platteau, 1996).

The invention of CBNRM brought forth concepts such as Joint Forest Management (JFM) and Participatory Forest Management (PFM). Different forms of PFM have thus arisen as depicted by the global increase in areas under community forest management (Agrawal, 2007). However, according to Sterner (2003), the choice of a given policy instrument should be based on the extent to which each could be defended in terms of equity, efficiency and effectiveness of the policy instrument.

1.1.1 Forest Conservation and Management in Kenya

Kenya has a total land area of 582,646 km squared. Although the economy is predominantly agriculture based, about 73% of these land area is arid or semi-arid (Matiru, 2002). The country is also characterized by a wide diversity of ecosystem, flora and fauna thus support a wide diversity of wildlife and most of the country's protected areas. In terms of property rights, there are mainly three types of land tenure system namely; trust (78.5%), private (1.5%) and government (20%) tenures (Central Bureau of Statistics 1996 cited in Matiru (2002)). The country is also covered with different forest resources and land use types namely, indigenous forests, plantation, woodland, bush-land, wooded grassland, mangrove, grassland, desert, farmland and urban development

owned under the three stated types of ownership (Matiru, 2002). According to GOK (2015), the country's forest cover is estimated to be about 7% of the total land area up from 5.95% in 2000. Approximately 80% of the Kenyan population reside in rural areas of which about 3 million live next to the forest and relies either directly or indirectly on benefit derived from these forests and on rain-fed subsistence agriculture for their livelihoods (WorldBank, 2000; FSK, 2006). The five major water towers[11]remain of significant importance to the economy because they supply a range of ecosystem services. In most parts of the country, the sustainability of these services is threatened or declining with the rising demand for ecosystem services.

In Kenya, these forests are not only considered of economic and ecological value as previously stated but also of political value. Political value involves illegal acquisition of land by well-connected individuals and irregular allocation of public land to politically connected rural households especially as election period approaches[12]. This has played a major role in loss of forests. Between 2000 and 2010 alone, it is estimated that about 50,000 hectares were lost as a result of human-induced deforestation (UNEP, 2012a). However, in recognition of the role of local forest-adjacent communities in reduction of forest destruction and degradation, the Kenyan government introduced the concept of PFM (MENR, 2005, 2016). This was first entrenched by the enactment of the Forest Act (2005) and the subsequent National Forest Act (2016)[13] that sought to engage forest-adjacent communities through arrangement such as PFM for sustainable forest management.

[11] Mau forest complex, Mt Elgon, Cherengani hills, Mt Kenya, and Abardares Ranges.

[12] Due to ethnic heterogeneity in the Mau forest, the success of PFM efforts is really compromised by trust issues. Most communities are from different political leanings hence every election year, ethnic conflicts and displacements are common as people who claim to be natives fight to reclaim back their lost land. Moreover, during the survey the little intel we gathered was complaints from few members about selective settlement of certain ethnic communities who are perceived to be pro the ruling government. Therefore, even if the communities are well organized there is the trust element that could compromise the success of such initiatives.

[13] Some of the key features of the Forest Act (2016) are mainstreaming of forest conservation and management into national land use systems; devolution of community forest conservation and management; deepening community participation in forest management by strengthening CFAs; implementation of national forest policies and strategies; introduction of benefit sharing arrangements such as Plantation Establishment and Livelihood Improvement Schemes (PELIS); and adoption of an ecosystem approach to management of forests.

Participatory Forest Management in Kenya

In Kenya, the concept of PFM is being implemented through devolution of forest management to forest-adjacent communities (MENR, 2005, 2016). According to the forest Act (2005) and forest Act (2016), PFM is part of an initiative towards devolution of power of management and decision making from government to local communities, or private sector/Non-Governmental organizations (NGOs) in gazetted forest reserves. Communities have therefore been able to self-organize to form community based organizations known as CFAs[14] in collaboration with the Kenya Forest Service (KFS). In the Act, CFAs are recognized as partners in forest management. In return communities are entitled to a range of user rights such as collecting firewood, timber, herbal medicine, grass for roof thatching, fodder and grazing animals, bee keeping, fish farming, eco-tourism, recreational activities, scientific and educational activities among others[15]. As part of benefit sharing arrangements, Plantation Establishment and Livelihood Improvement Scheme (PELIS)[16] was reintroduced in 2007 after several past failures to promote the livelihood of locals while ensuring sustainable management and conservation of forest. This is a departure from prior practice where the government assumed full responsibility of gazetted forest reserves.

However, devolution of forest management to forest-adjacent communities in Kenya has had its fair share of problems ranging from, conflicting interests of communities and government, overwhelming interests in groups by a large population, unpredictable evolution of groups over time e.g., forest user groups, over reliance on forest resources by even larger population and lack of adequate incentives to self-organize. Other issues have been the constant displacement of

[14] Households are required to pay a one-off registration fees and annual subscription fees which varies by CFAs.

[15] For members to enjoy these benefits they are required to pay a specific amount of which a proportion goes to Kenya Forest Service some to CFAs and the affiliated forest user group. This forms part of the financing mechanism for CFAs and user groups. Members are also free to join any user group within a CFA based on their interest in the forest. For instance, some CFAs have bee keeping, grazing, firewood collection or farming (PELIS) user groups.

[16] PELIS is an incentive scheme where landless forest-adjacent communities are allowed to grow both plantation trees and food crops on small plots (half an acre) during the early stages of reforestation tending the trees and harvesting crops for 3-4 years until tree canopy closes. It was aimed at improving forest cover and improving livelihoods of local communities.

communities during election periods due to clashes among communities or government executive orders, rent seeking behavior of foresters as they collude with loggers to harvest more than the licensed amount of trees and in some instances harvesting even indigenous trees that are meant to be protected. The situation is further worsened by collusion of foresters with CFA officials especially in allocation of PELIS plots and other incentives hence hardworking deserving members are often left out. In addition, distribution of benefits is often skewed towards the elite member of the society in some CFAs. There is also the conflict of community objective and the industry objective as well as few instances of some dictatorial tendencies of elected officials in some CFAs. Some communities also felt dissatisfied that even though they get agricultural produce from the farms, they invest a lot of their time, effort and resources on plantation forests through PELIS but the government benefits more since revenues from timber products are higher and not even a small proportion is given back to the community in any form e.g. building schools heath centres etc.

Despite these challenges, the enactment of the Forests Act (2005) and the subsequent Forest

Act (2016) has admittedly tried to revitalize the sector by giving local communities a stake in the management of state and local authority forests even though there are still instances of forest degradation in some CFAs. The myriad of challenges show that devolution of forest management need to be context specific, focus on institutional diversity and not uniformly implemented like the Kenyan case and other developing countries. However, there is still an ongoing debate on forest management cantered on how to conserve forest while simultaneously giving local people the opportunity to utilize forest resources through resource access (Casse, 2012).

1.2 Motivation

In recent decades, most developing countries have responded to market, institutional and policy failures associated with state controls by devolving the management of natural resources to local communities through initiatives such as JFM and PFM. Under these arrangements, exclusion and alienation rights remain with the state whereas withdrawal and management rights are bestowed on other forest user groups. The adoption of PFM by most developing countries is based on the premise that well defined and properly enforced property rights is one possible policy instrument towards addressing failures associated with state controls. This is either through community or private ownership although this may have significant distributional impacts. According to (Sterner, 2003; Ostrom and Nagendra, 2006) common property rights have the advantage of reduced monitoring and enforcement costs as well as better distributional consequences. Community conservation also has higher likelihood of local acceptance and achieving both welfare and conservation outcomes much easily than the state (Ostrom and Nagendra, 2006). It is also important to note that property rights vary in terms of scope of the exercising groups that is state or open access, private or common. The rights also differ in terms of access, management, withdrawal, exclusion and alienation rights (Ostrom and Hess, 2007). However, the debate on the advantage of private property and common property in terms of efficiency, equity and sustainability of natural resource use patterns is still crowded with a lot of confusion especially within the economics and legal literature (Ostrom and Hess, 2007).

Much of the literature support the notion that through semi-formal and informal institutional arrangements, communities can effectively self-organize and sustainably manage collectively owned natural resources (see Wade 1988; Ostrom 1990; Baland and Platteau 1996; Varughese and Ostrom 2001; Pretty 2003; Pagdee et al. 2006; Ostrom and Nagendra 2006). More recent studies

have also shown that local communities can self-organize to manage common pool resources through collective action and lead to better environmental outcomes (see Blom et al. 2010; Coulibaly-Lingani et al. 2011; Corbera et al. 2011; Stevens et al. 2014; Sunderlin et al. 2014). Empowering local communities could also ensure efficiency, accountability, equity and or better outcomes (Andersson et al., 2004; Tacconi, 2007). However, some studies have claimed that devolution of natural resource management to local communities may not have the potential of ensuring equity and better environmental outcomes and that it may be a means of devolving management costs by governments, reducing conflict in resource use and management and may also trigger elite and institutional capture issues (Songorwa, 1999; Campbell et al., 2001; Hyde, 2016). For instance, experiences in Kenya reveals that CFAs are responsible for various management activities in forest preservation, whereas the actual access to decision making process, allocation of benefits and control over natural resources are entrusted to KFS or other actors (Ongugo, 2007; Mogoi et al., 2012). This brings the question of the coherence between the official intention with the decentralization process and actual practice comprising devolution. According to Hajjar et al. (2012) successful community forestry requires a good amount of decentralization of authority without reaching extreme of complete decentralization. Even though much of the literature support devolution of forest management, a lot of caution needs to be taken pertaining to universal applicability of community forest management (Yin, 2016). On the other hand, according to Stevens et al. (2014), the objectives of devolution can only be realized under favourable conditions in the political, biophysical and socioeconomic realms. A significant observation from most of these studies is the failure to take into account context specific factors when devolving management of common pool resources (CPRs) and failure to account for local indigenous communities' attitudes and preferences as well as the values they attach to these forests which is crucial when considering how to incentivize them and roll out devolution of forest management.

Few studies also consider empirically the impact of existing incentives on success of PFM especially in terms of welfare and environmental outcomes that is, is there possibility of a "win win" situation? Is there possibility of local elites capturing more benefits making the poor worse off leading to further degradation of the resource?

As the human population continues to grow, the demand for forest ecosystem services also rises but these services are public goods[17] not often traded in the market. The existence of market and institutional failure in provision and regulation of these ecosystem services thus implies that the depletion of forest resources is often greater than socially optimal while the production of these services is less than socially optimal. Accounting for such market failure therefore requires economic valuation of these ecosystem services. Moreover, without an understanding of the values and preferences for these forests ecosystem services, peasant forest-adjacent communities reliant on subsistence agriculture are unlikely to take necessary steps to conserve these forests for provision of socially optimal levels of these services. Thus, community ownership may not account for such externalities. In addition, to complement PFM efforts most developing countries have always introduced incentives to deepen community participation. In Kenya one unique incentive is the Plantation Establishment and Livelihood Improvement Scheme (PELIS). PELIS was aimed at rehabilitation of degraded forests and reducing pressure on natural forests while at the same time improving welfare of forest-adjacent communities.

However, despite the recent and ongoing forest sector reforms that has led to increased community participation through devolution of forest management and provision of incentives, results from devolution of forest management has not been encouraging. Even though the number of CFAs has increased, mixed results have been reported in terms of environmental and welfare outcomes. Empirical evidence on the effects of such efforts in terms of efficiency and equity are also quite

[17] They are non-excludable and non-rival.

scant. The values and preferences attached to these resources by forest-adjacent communities are also unknown hence most developing countries are implementing devolution of forest management with due disregard to the values and preferences of forest-adjacent communities. Little attention is also given to the drivers of success of such devolution efforts. On the other hand, there is a dearth of literature on whether the existing incentives such as PELIS have the intended impact on the environment and welfare of locals. The question that comes to our mind is thus whether devolution of forest management to forest-adjacent communities can be implemented as a one size fits all solution to forest degradation and poverty alleviation? Is there any guarantee that PFM can overcome the social dilemma problems? It is also important to note that the success of PFM tend to be more context specific what works in Africa may or may not work in Asia or in other countries within Africa too hence the need for adequate consideration in devolving forest management. Differences in the literature in terms of the applied definition, methodological approach, socio-economic and ecological context thus warrants a context specific study. This also calls for additional research to improve on our understanding, provide focus areas and give recommendations on how to successfully implement PFM from a developing country perspective. Above all the study contributes to the academic and policy debate focusing on three key aspects.

First, there are relatively few studies that have tried to value forest ecosystem services within context of local indigenous communities reliant on subsistent agriculture in developing countries. We contribute to this literature by employing a state of the art choice experiment valuation method using the Bayesian D-efficient design. Further, we assess whether the values attached to these ecosystem services are sufficient for design of appropriate PES [18] schemes to incentivize communities to conserve them and further inform devolution of forest management through PFM

[18] PES is a voluntary transaction where a well-defined ecosystem service is bought from the ecosystem services provider by a buyer and assures service provision for those who are willing to pay for the service (Wunder, 2005).

to support ecosystem service provision. There is also the potential to transfer the estimates from this valuation exercise to other policy contexts.

Second, it is worth noting that, PELIS may enhance efficiency in forest resource use but there may be inequitable distribution of the benefits across the income groups hence a recipe for tragedy. We extend the scant impact evaluation literature within Africa (see Jumbe and Angelsen 2006; Kabubo-Mariara 2013; Gelo and Koch 2014; Mazunda and Shively 2015; Gelo et al. 2016) by not only assessing the average impact of the scheme on forest cover and household welfare but also assessing the heterogeneous impact of the scheme to determine whether the scheme can help poor household rise up the income ladder while simultaneously leading to improvement in forest cover. Policy makers also need to understand the drivers of adoption of PELIS by households within CFAs to help understand possible causes of past failures in the scheme and how to roll out the scheme through CFAs.

Thirdly, given the different models of PFM, we contribute to the literature on collective action empirically by employing Ostrom's Social Ecological Systems (SESs) framework to assess the socioeconomic and ecological factors influencing success of collective action in management of forest resource as well as the link between level of household participation and success of collective action using a range of econometric techniques. We extend this literature by employing objective measures of success of collective action. In addition, new case studies especially from developing countries are also necessary to test the strengths and weaknesses of governance of forests by forest-adjacent communities.

1.3 Objectives of the study

This dissertation is motivated by the identified gaps in the literature. The thesis is organized under three themes that each represent a chapter. The global objective of this study is to contribute to the

understanding of how PFM can be successfully implemented and make suggestion for more inclusive, equitable and sustainable forest management in Kenya using Mau forest conservancy as a case study. This study is guided by three general objectives namely:

(i) To determine the economic value of forest ecosystem services to local communities and the implication for design of PES and implementation of PFM

(ii) To determine the welfare and environmental impact of incentive based conservation in Kenya

(iii) To identify the determinants of successful collective management of forest resources

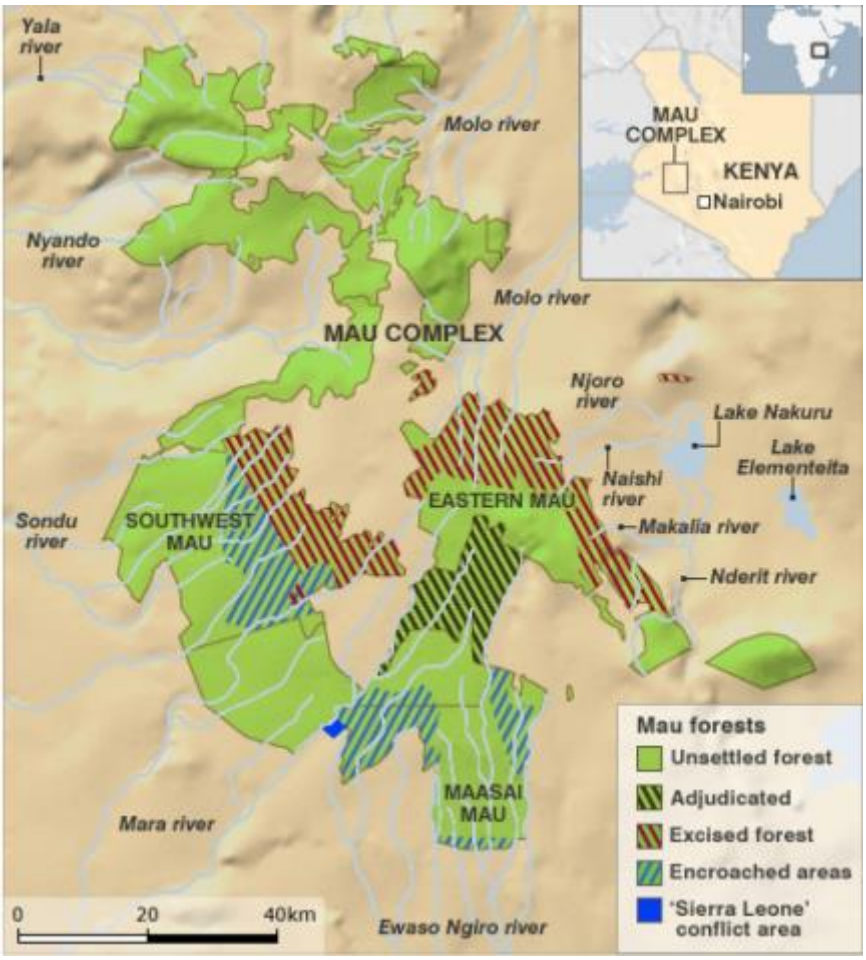
1.4 Description of the Study area

The study was conducted in the Mau forest conservancy. The choice of Mau forest was based on the following criteria: high susceptibility to degradation; long history of community forestry and participation in PELIS, largest number of CFAs of any forest in Kenya, i.e., 35. The 35 CFAs are evenly spread across the entire Mau forest complex, each with different levels of forest cover and with high levels of biodiversity. Thus, the site may provide key lessons and best practices for promotion of participatory forest management across the country. The Mau forest is one of the forests that has often attracted a lot of political interest especially through constant displacement of persons due to ethnic conflicts or government intervention through executive orders. The forest also presents a good case given the heterogeneity in terms of communities living adjacent to the forest. Mau forest is the largest closed canopy forest among the five major Water Towers[19] in Kenya that has lost over a quarter of its forest resources in the last decade (Force, 2009). It is situated at 0°30' South, 35°20' East within the Rift Valley Province. It originally covered 452,007 ha but after the 2001 forest excisions the current estimated size is about 416, 542 ha. The Mau comprise of 22

[19] Mount Kenya, the Abardares ranges, the Mau forest complex, Cherengani Hills and Mount Elgon.

forest blocks[20], 21 of which are gazetted and managed by Kenya Forest Service (KFS) the other is Mau Trust land Forest (46, 278 ha) managed by the Narok County Council (NEMA, 2013). A picture of the Mau forest complex is presented in Figure 1.

Figure 1: Mau Forest Complex Map



Mau Forest Complex supplies water to over 4 million people residing in 578 locations in Kenya and some parts of Northern Tanzania therefore supporting livelihoods and economic development of the region. The Mau ecosystem is also upper catchment of numerous rivers[21]as depicted in Figure

[20] South Molo, Transmara, Eastern Mau, Mt. Londiani, Ol Pusimoru, Maasai Mau, Mau Narok, Western Mau, South West Mau, Eburu and Molo. In the northern section are the forests of Tinderet, Timboroa, Northern Tinderet, Kilombe Hill, Nabkoi, Metkei, Lembus, Maji Mazuri, and Chemorogok.

[21] Including the Yala, Nzoia, Nyando, Mara, Sondu, Kerio, Ewaso Ngiro, Molo,Njoro, Nderit, Naishi and Makalia rivers.

1. These rivers feed into various lakes e.g., Nakuru, Baringo, Natron, Naivasha, Turkana, and Victoria among others. The rivers and lakes also provide much-needed water by pastoral communities and agricultural activity and supply essential ecosystem services such as micro climate regulation, water purification, water storage and flood mitigation. In addition, the estimated potential hydro power generation in the Mau forest catchment is approximately 535 MW which equals about 47 percent of the total installed electricity generation capacity in Kenya (UNEP, 2008). Apart from provision of local public goods such as food, herbs, wood-fuel, fodder and building materials among others, the forest also supplies global public goods and services such as wildlife habitat[22], carbon sequestration, and biodiversity conservation (Kipkoech et al., 2011). The upper catchment of the forest also hosts the last group of indigenous hunter gatherer communities like the Ogiek[23] (Force, 2009).

1.5 Thesis Outline

The thesis consists of five chapters. The first chapter presents the general introduction, motivation, the study objectives and description of the study area. The other sections of this dissertation provide a more detailed description of each of the preceding discussion points. In chapter two, a choice experiment approach is used to estimate the welfare associated with a range of forest ecosystem services and their implication for design of incentive schemes such as PES and devolution of forest management is considered. Chapter three presents an examination of the environmental and welfare impact of incentive based conservation specifically focusing on the PELIS scheme. The fourth

[22] Mau forest hosts over 450 recorded bird species, six key mammals of international concern namely; yellow backed duiker, giant forest hog, Bongo, golden cat, African elephant and leopards (Force, 2009). It also hosts numerous monkey and baboon species.

[23] The Ogiek community are hunter gatherer community that have lived for centuries deep inside the Mau forest. Majority grow vegetables and keep livestock. They used to hunt wild animals such as antelopes and wild pigs but this is now illegal. Due to the influx of illegal settlers that led to serious degradation of the Mau forest, the Kenyan government tried to evict everyone including the Ogiek from the forest. However, the Ogiek recently won their land case against the government.

chapter presents the determinants of successful collective action. Finally, Chapter five presents the general conclusion and policy implication of the thesis.

Chapter Two

Economic Valuation of Forest Ecosystem Services in Kenya: Implication for Design of PES Schemes and Participatory Forest Management[24]

Abstract

Forest ecosystem services are critical for human wellbeing as well as functioning and growth of economies. However, despite the growing demand for these services, they are hardly given due consideration in public policy formulation. The values attached to these services by local communities are also generally unknown in developing countries. Using a case study of the Mau forest conservancy in Kenya the study applied a choice experiment technique employing the efficient design criteria to value salient forest ecosystem services among forest-adjacent communities. The values attached to various ecosystem services were estimated using the conditional logit, random parameter logit model and random parameter logit model with interactions. The results revealed high level of preference heterogeneity across households and that communities would prefer conservation programs that would guarantee them improved forest cover, reduced flood risk and high water quality and quantity for drinking but would experience a loss in welfare for choosing an alternative with medium wildlife population. One significant finding from the study is the altruistic nature of forest-adjacent communities as revealed by the high willingness to pay for flood mitigation showing that they are not just concerned with the private benefits accruing to them but also the welfare of the society. Overall, we found that there is much appreciation for the role of forest ecosystem services and that forest-adjacent communities are more pro conservation mainly motivated by the direct use and non-use values. In terms of policy, the information forms a basis for the design of market based incentives such as PES and the roll out, design and implementation of participatory forest management. Policy makers also need to focus on policy options with higher mean welfare impacts to deepen community involvement in forest conservation while taking into account the heterogeneity in preferences to ensure equity.

Key words: Choice experiment, Ecosystem services, Incentives, PES

JEL Classification: Q23, Q28, Q51, Q57

[24] A version of this chapter has been disseminated as ERSA Working Paper 693.

2.1 Introduction

Forest ecosystem services are critical for the functioning and growth of world economies (Ferraro et al., 2011). These services play a significant role in contributing to human well-being and have been of significant value to rural households of developing countries that have often been faced with problem of little physical capital (Costanza et al., 1997). These services are often, although not exclusively, public goods that are enjoyed by populations free of charge since they are not traded in the market, and their benefits may materialize at different levels from local to global. The optimization of ecosystem service provision and protection between the beneficiaries of the ecosystem service and those who affects its provision have however been hampered with ill-defined property rights, information asymmetry and externalities (see Ferraro and Kiss, 2002) as well as market and policy failure. The existence of market and policy failures in provision and regulation of ecosystem services thus implies that environmental depletion is often more than the socially optimal level, while the provision of ecosystem services is below the socially optimum level (Ferraro and Kiss, 2002). In Kenya, just like the rest of the world, market and policy failures are some impediments to protection and conservation of important global forest ecosystem (Müller and Mburu, 2009). To secure standard levels of forest and environmental quality, there is need to increase revenue of benefit providers and improving management from society's perspective. For this to be achieved, policy tools such as Payment for Ecosystem Services (PES) and allocation of user rights to communities through Participatory Forest Management (PFM) are essential for identification of form of marketing. Therefore, valuation of these ecosystem services is an essential step towards the design of such policy tools (MEA, 2005).

2.2 Value of Forest Ecosystem Services in Kenya

The five major water towers in Kenya form the upper catchment of all major rivers in Kenya except the Tsavo which originates from Mount Kilimanjaro. These forests are surrounded by mostly densely populated areas since they provide sufficient water for intensive agriculture and urban settlement (Akotsi et al., 2006). They also provide ecological goods and services including: river flow regulation; water storage; water purification[25]; flood mitigation; recharge of groundwater; micro climate regulation; promoting biodiversity; nutrient cycling and soil formation; reduced soil erosion and siltation; and timber and non-timber forest products thus providing insurance value to other key sectors of the economy and consequently having significant impact on economic resilience of the country (UNEP, 2012a). These forests therefore sustain many natural habitats in the lower areas of the catchments therefore producing direct economic value to its citizens.

However, the ability of these forests to supply the various ecosystem services has been hampered by increased degradation resulting from human activities, rent seeking behavior of government officials[26] as well as intrusion by other communities and local politicians in an effort to grab forest land for agriculture purposes. According to UNEP (2012a), deforestation in Kenya's water towers between 2000 and 2010 amounted to 50,000 hectares (equivalent to 5000 hectares per year) yielding timber and fuel-wood volume of 250m^3/ha with estimated cash value of USD 13.62 million (equivalent to USD 2720/ha per year) in 2010 hence the incentive for rampant deforestation. Despite the revenue streams, the cost to the economy is quite high especially through losses of regulating services (UNEP, 2012a). It is estimated that the cost to the economy as a result of

[25] Water yield in the Mau is approximately 15,800 million cubic meters per year accounting for more than 75% of renewable surface water resources of Kenya (UNEP, 2012b)

[26] During the survey, we were informed by some community members that their conservation effort would be in vain given the fact that some foresters colluded with loggers to harvest more than the licensed number of trees and even indigenous trees that are meant to be protected.

reduction in the provision of regulating services from the effects of degradation was USD 36.52 million per year more than 2.8 times the revenues from such deforestation activities[27]. "Due to the interdependence of various sectors, the decrease in regulating services due to deforestation caused a total impact of USD 0.058 billion in 2010 implying that the cost of limiting regulating ecosystem services as a production factor for the economy was all in all 4.2 times higher than the actual cash revenue of USD 0.013 billion" (UNEP, 2012a).

Due to the significance and importance of forest ecosystem services (MEA, 2005), as many other countries, Kenya has strengthened measures towards conservation of forests through various initiatives. Efforts have been made by the government to integrate forest conservation and rural development to incorporate social concerns. Some of these efforts includes enactment of the Forest Act (2005) and the subsequent Forest Act (2016) aimed at devolution of forest management to forest-adjacent communities with a myriad of incentives aimed at deepening community participation (MENR, 2005, 2016). However, despite these efforts, there are still increased cases of degradation within CFAs. The values attached to various ecosystem services by forest-adjacent communities as well as the extent of the benefits of these forest ecosystem services are also unknown. Moreover, even though the benefits to local communities is substantial, the prices of these services are non-existent. It is therefore evident that the forestry sector's contribution to the economy[28] is based on formal market transactions since the value of most non-marketed forest products is unaccounted for[29]. According to the UNEP the challenge for developing countries facing natural resource degradation like Kenya is institutionalization of incentives to internalize the

[27] The effects were namely; reduced agricultural output by USD 22.62 million in 2010, reduced hydro power generation by USD 0.12 million (which has reasonable multiplier effect on the other sectors of the economy), decline in inland fishing catches by USD 0.86 million due to siltation of rivers and lakes and lastly increased cost of water treatment by USD 1.92 million (UNEP, 2012b). In addition, the forgone above ground carbon storage value from deforestation in 2010 was estimated at USD 3.41 million, and malaria incidences was estimated to have cost the government USD 3.95 million hence additional health cost to the government through loss of productivity (UNEP, 2012b).

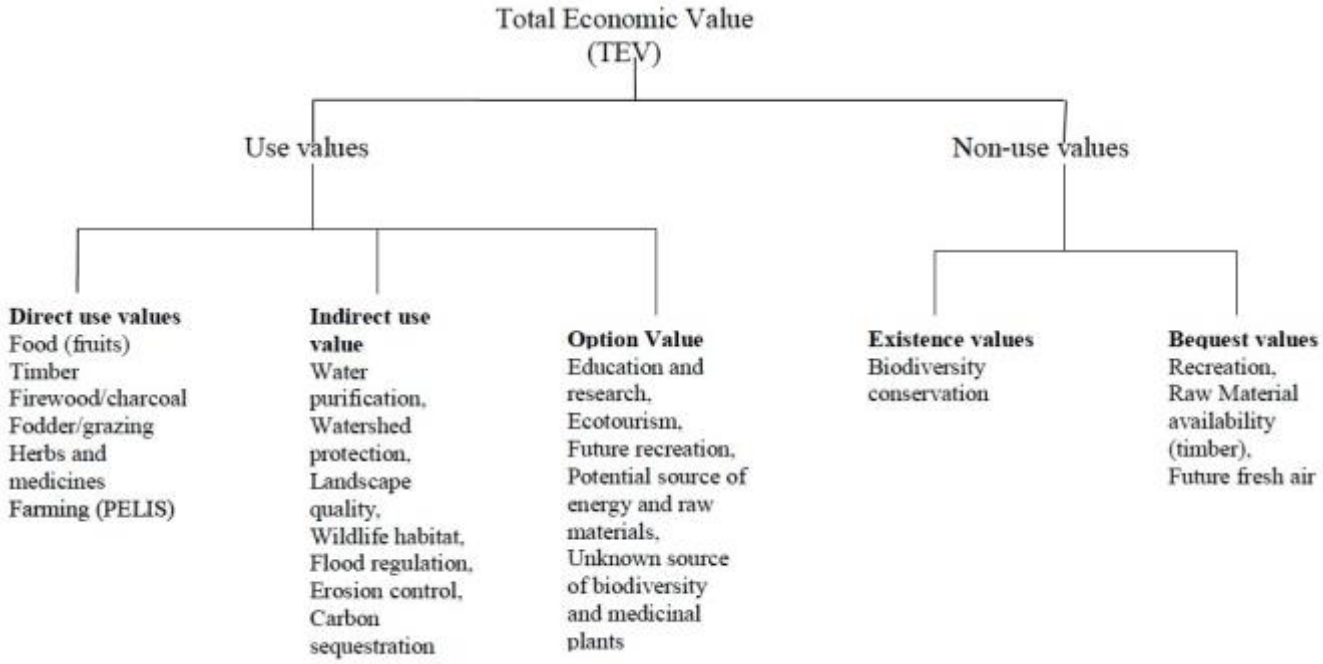
[28] The contribution of primary forests is estimated to be about 1.2% of the GDP (0.7% in the monetary sector and 0.5% is non-monetary sector) (GOK, 2015)

[29] This implies that the forestry sector contribution to the Gross Domestic Product is undervalued.

positive externalities from sustainable forest management. To protect natural resources like Kenya's water towers, "appropriate and well-funded policies, policy instruments and response strategies" are crucial (UNEP, 2012a). This is based on the premise that when provision of ecosystem services is not rewarded through suitable mechanism forest-adjacent communities will hardly include them in their management objectives unless constrained by command and control policies. This implies forest management will rarely achieve the social optimum.

It is also important to note that all these services have some economic value, but this depends on benefits humans derive from them. However, identifying and valuing the various ecosystem services requires a coherent analytical framework to ensure comprehensive consideration without double counting. This also ensures we arrive at estimates consistent and comparable within and across countries (Croitoru, 2007). The Total economic value (TEV) framework provides a consistent framework of analysis as it decomposes values into a number of categories. According to the TEV framework, these values are classified into use and nonuse values (Pearce and Pretty, 1993). Use values include direct use, indirect use and option values whereas the non-use value includes bequest and existence values. Figure 2 presents the TEV categories from which we identify policy relevant attributes for this study.

Figure 2: The total economic value framework of forest ecosystems



Adapted from Croitoru (2007)

It is evident from Figure 2 that we have all along valued the forest for products like timber and wood products that have tangible monetary worth (direct and indirect use values) but what about the values of forest ecosystem services that are priceless or hard to measure (i.e., the non-use and option values)? The question of concern is thus how can we attach a value on flood mitigation, wildlife habitat, clean water, air and climate? What is the scenic value of a pristine grove of pine? These services are worth paying for especially since the costs and responsibilities of conserving them are not in the public domain. How can providers of the ecosystem service[30] be compensated by the users? To obtain public support for conservation programs through PFM, an understanding of the values, attitudes and preferences towards various environmental services as well as the TEV

[30] Mau forest is a reserve forest under the management of KFS in collaboration with forest-adjacent communities through CFAs. Communities are therefore charged with the responsibility of conserving the forest and also deriving benefits from it. It is important to note that they do not reside inside the reserve forests.

of the forest reserve is necessary. The Ecosystem services trade-offs have also received limited attention in terms of management of ecosystems. For policy makers to incorporate public values and preferences into forest management and conservation policies, an understanding of the social benefits and tradeoffs is critical. Humans are also less likely to take necessary steps to protect ecosystem services if they do not understand or appreciate the values these ecosystem services have on their quality of life. The goals of devolution of forest management may therefore never be realized. Valuation of these services is also expected to help raise awareness of their importance and stimulate support for appropriate conservation measures, furthering policy design and development of incentive schemes such as PES to incentivize local communities. This is also critical for engaging their participation in behavioural change and encouraging adoption of ecosystem oriented management practices and therefore informing devolution of forest management through PFM.

Moreover, literature on valuation of local indigenous communities' preference for ecosystem services within developing country context specifically Kenya are anecdotal and scant hence the need to contribute to the debate. The most common valuation approach in the available empirical studies has been Contigent Valuation Method (CVM) and Participatory Environmental Valuation (PEV) (see Carson and Mitchell 1989; Emerton 1996; Emerton and Mogaka 1996), with very few using the choice experiment approach (see Diafas et al., 2017) and mostly in other fields. The advantage of the Choice Experiment (CE) approach is that it is able to elicit trade-offs between different policies and also avoids biases associated with CVM and PEV approaches. Much of the CVM literature generally focus on a single attribute of community forest (Carlsson et al., 2003). It is therefore difficult to assess preference heterogeneity in the case of valuation of just a single attribute like in most CVM studies. Most of the studies on valuation of ecosystem services have also been in developed countries (see García-Llorente et al. 2012; Gatto et al. 2013; Shoyama et al.

2013; Smith and Sullivan 2014; Yao et al. 2014) with very few in developing countries (see Gelo and Koch 2012; Dikgang and Muchapondwa 2014, 2016; Diafas et al. 2017).

In addition, most studies that have used the choice experiment approach have often relied on the orthogonal design (see Dikgang and Muchapondwa 2012; Shoyama et al. 2013; Pienaar et al. 2014) rather than the efficient design (see Gatto et al. 2013; Czajkowski et al. 2014). The efficient design has the advantage of producing more reliable and efficient estimates at smaller sample sizes. Due to the significant variation in terms of preferences and values attached to various ecosystem services, methodological approaches as well as the context specific factors, a context specific analysis is therefore critical. Moreover, attempts to estimate different forest ecosystem services especially the non-use values and their trade-offs are still rather scarce on regional scale and especially within the African context. This study therefore, seeks to fill these gaps and contribute to the debate on valuation of ecosystem services by determining the economic value of a range of salient forest ecosystem services in Mau forest conservancy in Kenya and assess whether they are sufficient to incentivize local communities to engage in forest conservation through PES schemes and the implication on devolution of forest management to local communities through PFM. There is also the potential to transfer the estimates from this valuation exercise to other policy contexts.

The rest of the chapter is structured as follow. Section 2.3 presents a review of some of the related literature, section 2.4 presents the methodological approach, including survey design and data collection, experimental design and the theoretical framework. Section 2.5 presents the estimation results and discussion. The conclusions and policy implications are presented in section 2.6.

2.3 Related Literature

The use of CE in environmental economics dates back to the works of (Adamowicz, 1995; Boxall et al., 1996). The method is now considered more preferable and superior to other approaches like

the CVM and PEV. Unlike CVM and PEV, the CE allows inclusion of multiple attributes and allows estimation of the value of each attribute hence can elicit trade-offs between different policies. It also avoids biases associated with other methods like CVM. The CE also has some few limitations e.g., observed preference may not reflect actual behaviour, respondents may also lie due to lack of incentives and there is also incentive for respondents to behave strategically (Garrod et al., 1999). However, the advantages of CE outweigh its limitations.

There is growing literature on the use of CE to value ecosystem services in various contexts. The values of ecosystem services therefore vary across countries based on what the society values most. Studies have therefore yielded different results for example, Gatto et al. (2013) found that respondents had high preference for recreation and carbon sequestration but no other ecosystem services. Whereas Qin et al. (2009) in investigating farmers' preferences for property rights attributes found that the major concern of farmers is type of right a contract provides. Dikgang and Muchapondwa (2014) also assessed using CE the potential for ecosystem services to improve livelihood of Khomani-San through PES and found that visitors preferred more pristine recreational opportunities but disapproved granting more access inside the Kgalagadi. They also assessed the supply side and found that locals would prefer, collection of bush food and increased grazing opportunities (Dikgang and Muchapondwa, 2016).

García-Llorente et al. (2012) also examined preferences for a range of land use management options using Multinomial logit model and the random parameter logit (RPL) model to account for preference heterogeneity. They found that respondents would support management plans, focusing on river quality and traditional farming. However, Birol et al. (2009) had different findings with respondents deriving significant welfare improvement from flood risk reduction over welfare improvements from both river accessibility for recreation and conserving high biodiversity level. In New Zealand, Yao et al. (2014) estimated the non-market values for a program aimed at

enhancement of biodiversity using a two-stage modelling process by first estimating individual specific WTP values and then exploring their spatial and socioeconomic determinants. Using RPL model in the first stage they found higher WTP for increased quantities of native birds than for non-bird species. In the second stage, they found WTP for biodiversity enhancement was mainly influenced by distance from large planted forests and other socioeconomic characteristics such as attitude towards the program. Similarly, Shoyama et al. (2013) found that the public strongly preferred biodiversity conservation over climate change mitigation in the form of carbon sequestration through increasing area of forest managed. Studies have also shown that farmers place high values on ecosystem services, although they consider them moderately manageable since they consider the economic costs of maintaining ecosystem service provision as a threat (Smith and Sullivan, 2014).

Communities have also shown that private and quasi development interventions can sufficiently incentivize them to engage in anti-poaching enforcement, re-vegetation of wildlife habitat and wildlife monitoring (Pienaar et al., 2014). However, most of these CE studies have been biased towards developed countries where preference for various forest ecosystem services are significantly different given the levels of economic development and variation in social and cultural contexts hence the mixed results. Literature on valuation of forest ecosystem services in the Eastern Africa and specifically Kenya are quite scant, past studies have used mainly CVM and PEV (see Carson and Mitchell 1989; Emerton 1996; Emerton and Mogaka 1996) with few employing the CE approach (see Diafas et al., 2017). Most recently Kipkoech et al. (2011) estimated total economic value of a section of the Mau forest at approximately KES 17 billion (USD 0.17 billion).

It is also important to note that most of these past choice experiment studies have relied on orthogonal designs (see Dikgang and Muchapondwa 2012; Shoyama et al. 2013; Pienaar et al. 2014) mainly because it is easy to construct and understand. In orthogonal experimental designs,

statistical independence of the attributes is achieved by forcing them to be orthogonal (Louviere et al., 2000). However, while orthogonality could be an important criterion for determining independent effects in linear model, the orthogonality property may run counter to some desirable properties of econometric models employed in analyzing stated choice data especially since discrete choice models are nonlinear (Petrin and Train, 2003).

Over time studies have revealed that efficient experimental designs can produce more efficient data and that we can still get reliable parameter estimates even with a lower or equal sample size (Bliemer and Rose, 2010). However, the use of efficient designs has been mostly applied in transport economics and market research while quite scant in environmental or resource economics (see Gatto et al. 2013; Czajkowski et al. 2014). Domínguez-Torreiro (2014) compared two experimental designs i.e. Optimal Orthogonal in the differences design and the D-efficient design and found that OOD design based on no prior knowledge is not inferior in terms of estimation efficiency to the efficient designs. He however, noted that the contradiction might have been as a result of sufficiently large sample that outweighed the expected loss of efficiency based on zero prior estimates.

An overview of the CE literature also reveals significant differences in applied definition, contextual factors and methodological approaches making comparison difficult. Moreover, attempts to estimate different forest ecosystem services and their trade-offs are still rather scarce on regional scale and especially within the African context. The application of efficient designs in CE is also mainly in developing countries with hardly any in Africa and specifically Kenya. As a departure from most studies, this study takes a different approach by employing a state of the art CE valuation method using the Bayesian D-efficient design.

2.4 Methodology

2.4.1 Survey design and data collection

Attributes and attribute Level of ecosystem services

This exercise involved a series of design and testing. Beginning with a qualitative review of literature on valuation of forest ecosystem services from both developed and developing countries. We then selected attributes that could be relevant and easily understood by local communities and sought expert opinions from foresters to identify and define the policy relevant attributes. The choice of attributes was therefore based on what the local communities could easily understand and what they interacted with most. Forest structure was deemed significant by respondents since over 78% of the forest-adjacent communities relied on fuel wood as a source of energy, they also relied on the forest for grazing hence a degraded forest would be considered to imply limited supply of these services. The cover also by extension could easily depict the aesthetic (scenic) and cultural values since some communities preserved certain sections of the forest for cultural activities e.g. Mt Blacket which Kalenjins have preserved for cultural practices[31].

These forests also act as habitat for various wildlife animals such as elephant, monkeys, leopards' bongo, buffaloes etc. About 99% of the respondents agreed to be aware of the various types of wild animals in the forest and could name several. However, due to stringent rules by the Kenya Wildlife Service (KWS), about 90% claimed not to be involved in trapping the wild animals. Communities also complained of rampant human wildlife conflict. Wildlife population was therefore included as an attribute to gauge their preference and perception towards wildlife conservation and whether they would consider conserving the forest for other benefits and cope with the increasing wildlife

[31] It is important to note that we did not consider the diversity in tree species.

population. This would also show their attitude towards biodiversity conservation and preservation of wildlife for future generations i.e., bequest values. We therefore identified elephants since they interacted more frequently with the elephants in the farms.

Most forest-adjacent communities rely on water from the forest (73% of the respondents said they relied on water from the forest). Therefore, degradation of these forest would mean a reduction in quality and quantity of water for drinking and irrigation as well as siltation of dams responsible for provision of various services to downstream users. In addition, forests play a significant role in flood mitigation and erosion reduction. This attribute was thus selected based on the fact that the continuous degradation would mean high social and economic costs of flooding episodes borne by locals, downstream settlers and nearby towns and urban centres. This attribute was therefore included to gauge the behavioural aspects of forest-adjacent communities that is, whether they are altruist or self-centered. Based on these considerations, we settled on the following attributes of forest based ecosystem services: forest structure/cover, wildlife population, water purification and supply, flood risk and cost to the household.

The attribute levels were developed based on the current average forest cover, risk of flooding, water quality and quantity and wildlife population as presented to us by the head of Mau forest conservancy and other key stakeholders. We then projected the future condition of the forest in the next five years and how the various attributes selected would be affected with the proposed policy. The levels of the selected attribute were further refined using the additional information collected, observations from the Focus Group Discussions (FGDs) and expert judgment. Following past studies (see Pearce 1994; Fitzgibbon et al. 1995; Adamowicz et al. 1998; Gatto et al. 2013), and expert opinions, the projected levels of each attribute used in the pilot and final survey are shown in Table 1.

Table 1: Attributes used in final and Pilot DCE design

Type of Attribute	Attribute Definition	Attribute Levels
Wildlife	Wildlife population (biodiversity)	753, 1103, 1203
Forest Structure	Tree population/forest cover	56.25%, 82.5%, 95%
Water purification	Water Purification and supply (Level of water Quality and quantity)	11850, 17380, 19960
Flood	Risk of flooding: regulating services	Low, Medium, high
Cost	One off payment (ksh) per year for three years	0,1744, 2683, 2951

The survey questionnaire was divided into three parts, part one collecting information on general attitudes and perceptions towards forest ecosystem services, part two involved the choice modelling scenario and last part collecting information on socio-economic characteristics and institutional variables.

The choice experiment approach involved households being presented with three different alternatives. Option C is the status quo, this option described "as at today" i.e., no change in forest conservation and management. This option does not involve any policy intervention and no cost to the household meaning the respondents are comfortable with current condition (status quo/low) of the forest regardless of the future condition of the forest without any intervention. Option A and B involves a combination of new policy interventions that may affect future condition of the forest catchment. The impact of the new policy interventions in 5 years' time are predicted and described by the attributes considered to have direct influence on well-being of forest-adjacent communities as presented in Table 1.

Respondents were informed that any policy intervention aimed at forest management would have higher cost implication[32]. However, the cost would be shared by all people living around the forest as a three-year levy on government rates during the year but paid annually for three years. The size of the levy also depends on the management option chosen either A or B.

Households were informed that the levy would be channelled into a special conservation fund set up to fund conservation and management of the forest catchment. They were further informed that the fund will be managed by officials selected by CFA members and that an independent auditor will ensure the money is spent wisely. Due to the subjective nature of valuation of forest ecosystem services, a verbal description can be interpreted differently based on variations in education levels or individual experiences. Each attribute level was therefore visualized by digital manipulation of a "control" picture depicting more or less of the attribute. This approach ensured changes in attribute levels are easily identifiable holding other factors of the forest ecosystem service constant. However, the status quo alternative was just represented as "As today" instead of pictorially. Although without any policy intervention, it is expected that provision of forest ecosystem services will be lower, we cannot quantify/predict the exact future condition of the forest.

Previously, before the government intervention through provision of incentives and devolution of forest management, the Mau forest was almost completely degraded through human interference and the adverse effects were felt across the rift valley, western regions and other parts of the country[33]. Communities were therefore well aware of the outcome if there is no policy intervention. Based on past history, respondents were informed that without any policy intervention the forest may be degraded even farther hence the provision of these ecosystem services may be low as

[32] We used the estimated cost of rehabilitation of the Mau forest complex as per the project implemented by the Kenyan government and UNEP through the European Union funding. We then divided the cost with total population around the Mau forest conservancy. Due to the poor nature of forest-adjacent communities, the amount was distributed into a three-year levy.

[33] Some of the adverse effects were, drying of rivers dams and lakes, power outages, crop failure due to inadequate rainfall and decline in wildlife population among others.

pictorially presented in other policy presentations or even lower than in the year 2000 when the forest was almost completely run down. Respondents were therefore told to imagine the condition of the forest in the next five years if they continue with current practices without any intervention although it may not have any cost implication on them at the current period[34].

Sampling and data collection

To ensure understanding and scenario acceptance by respondents, the accompanying text in the structured questionnaire and images were tested in FGDs and a pilot to test the validity and construct of the survey instrument. The pilot questionnaire was presented to a random sample of 44 households in Londiani CFA of Kericho county in October 2015. In the pilot 15 choice tasks were generated and respondents were presented with 5 choice tasks. From the pilot exercise, we estimated Multinomial logit model betas which were used as priors in the final statistical design. The survey was conducted in the months of November and December 2015. In the final survey, we used a two stage sampling procedure in data collection. In the first stage a sample of 22 out of 35 CFAs were purposively identified to reflect the entire Mau forest. This was conducted with the help of head of Mau forest conservancy[35]. The CFAs covered five counties of Bomet, Narok, Kericho, Nakuru and Uasin Gishu. The CFAs were a representation of the entire Mau forest therefore fully representative. The CFA level data were collected through focus group discussions with CFA officials and other members at their offices in the forest station. In the second stage, a sample of 321 households from the 22 CFAs were identified through simple random sampling, in which every third household was interviewed, and snowballing was used in instances where the third household

[34] This is one of the limitation of the study since respondents may not have a clear picture of how the provision of ecosystem services may be in five years' time even if the current state is low hence may influence their judgment and also bias the result to some extent. However, we believe that we can still get better estimates of the respondents' preferences.

[35] Although it is possible that the head of conservancy may have referred us to CFAs that were doing well, we can confirm that this was not the case since we also got to visit some CFAs that were in total mess. The choice of CFA was based on total representation of the entire forest and ease of accessibility since some areas are very difficult to access due to terrain and lack of motorable roads.

was not a CFA member[36]. This was conducted using individual household-level survey administered questionnaire to household heads.

2.4.2 Experimental Design

To generate different choice tasks, we employed the Bayesian D-efficient design. This was chosen due to the uncertainty on the nature of the parameter estimates for each of the attributes. The efficient designs are also less restricted and easy to find than the orthogonal and often allows much smaller number of choice sets (Greiner et al., 2014). We used the D-error criterion to optimize the efficiency of the experimental design. However, to generate an efficient design priors are needed. Since using zero priors would be same as using the orthogonal design we used a method proposed by Bliemer and Rose in Ngene forums when we have no knowledge of the priors but have an idea of the expected signs of the parameters.

We assumed a uniform distribution of the parameters as the priors to be used to generate a Bayesian D-efficient design using Ngene[37]. The efficient statistical design for the pilot was thus built using Ngene 1.1.2[38]. We then conducted a pilot/pre-test so as to validate the design in principle. Data from the pre-test was then analyzed using multinomial logit (MNL) in Stata 13 and resulting parameter estimates used as priors for development of a refined and more efficient design for the final survey. Due to complexity of running an efficient design using RPL we opted for the MNL despite its weaknesses[39]. Although these weaknesses may significantly influence the statistical

[36] In some instances, we interviewed CFA members at the farms in the forest or when there were collective activities such as tree planting or transportation of tree seedlings

[37] The uniform distribution was employed because it gives equal weight to all possible prior parameter values and because we may not be certain about the exact distribution.

[38] Choice Metrics, "Ngene 1.1. 2 User Manual & Reference Guide", Sydney, Australia: Choice Metrics (2014).

[39] First it does not easily accommodate the presence of preference heterogeneity within choice data; secondly it does not allow for the fact that with SC data, each decision maker typically responds to multiple choice tasks; and lastly the MNL imposes some constant error variance assumptions across all alternatives across the model (Bliemer and Rose, 2010).

properties of the design especially with inclusion of sociodemographic factors in the estimation model, the design still performs much better than the orthogonal or other designs.

The choice sets for the full survey were developed based on priors from the pilot. In both pilot and full survey, we checked for presence of dominant alternatives, finding limited dominance in the estimated design, and a similar distribution in the choice frequencies. The design was generated without accounting for covariates. For the final survey, we generated a design with thirty choice tasks. To reduce the answering load, each respondent would answer five choice tasks picked randomly from the thirty choice tasks generated in Ngene. A sample of the choice card used in the final survey is shown in Figure 2[40].

Figure 3: Sample choice card used in the final survey

SCENARIO 12

Attribute	OPTION A	OPTION B	OPTION C (SQ)
Wildlife			As today
Forest Cover			As today
Water purification and supply			As today
Flood Risk			As today
COST	1744	2951	0
Tick Your Choice			

[40] The pictorial presentation was further described to the respondents to avoid any mix up especially to respondents who had trouble identifying the differences to avoid any confusion. This was however done only in the first choice since after one illustration the respondent easily picked up in the other choice tasks.

2.4.3 Theoretical Framework

Empirical Model

The choice experiment approach has its roots in two theories namely, the Lancaster's economic theory of value (Lancaster, 1966) and the random utility theory (McFadden, 1974). The random utility theory posits that an individual (household head) n, chooses an alternative j, from the choice set, s=1,2.....S, if the indirect utility of j is greater than that of any other choice i. That is

$$U_{nsj} > U_{nsi} \Longrightarrow V_{nsj} + \varepsilon_{nsj} > V_{nsi} + \varepsilon_{nsi} \forall j \neq i; i, j \epsilon s \quad (1)$$

Thus

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} \quad (2)$$

Where S is the set of all possible alternatives and systematic component, V_{nsj} is the deterministic component, it is a vector of observable individual and alternative specific attributes. ε_{nsj} is the unobserved component it includes all unobservable impact and factors affecting the choice (Louviere et al., 2000). Assuming the observed component is a linear function of the observed attributes levels of each alternative X, and their weights (parameters) β where $\beta^0 s$ are unknown parameters to be estimated then we have,

$$V_{nsj} = \sum_{k=1}^{K} \beta_k x_{nsjk} \quad (3)$$

In our case, β_k appears in the utility function of multiple alternatives j. It is therefore generic over these alternatives. Assuming the unobserved components is independent and identically distributed (IID), the probability P_{nsj} that respondent n selects alternative j from a choice situation S is given by the Multinomial logit model (McFadden, 1974).

$$P_{nsj} = \frac{\exp V_{nsj}}{\sum_{j \epsilon J_{ns}} \exp V_{nsi}} \tag{4}$$

In the first step, equation 4 was estimated by means of conditional logit (CL) regression following Hensher and Greene (2003), which assumes that choices are consistent with the Independence of Irrelevant Alternatives (IIA) property. Implying that the relative probabilities of the two alternatives being selected are not affected by removal or introduction of other alternatives (Luce, 2005). The model therefore assumes that respondents' preferences are homogeneous. Given this limitation we applied other flexible approaches. The study used the Random Parameter Logit (RPL) model which is more flexible, allows for random preference variations between respondents, incorporates correlation in the utility between choices, and accounts for heterogeneity among individuals (McFadden and Train, 2000). Following Colombo et al. (2009) the RPL model is described in equation 5.

$$U_{nsj} = \beta X_{nsj} + \varphi_n X_{nsj} + \varepsilon_{nsj} \tag{5}$$

The utility function U_{nsj} is split into three parts: X_{nsj} is a vector of observable attributes for the good in question; β is the vector of coefficients of the observed attributes; φ_n is a vector of deviation parameters (they represent the individual's taste. Individual tastes are assumed constant across choices made but not across the entire sample); and ε_{nsj} is a random term and is IID. With the RPL

model, we do not have to assume that the IIA property holds. In this model, preference heterogeneity is incorporated into the random parameters directly since each respondent has his own vector of deviation parameters (Ju and Yoo, 2014). The probability of respondent n's observed sequence of choices is given by the integral in equation 6 assuming homogeneous tastes across all choice situation.

$$P_{n[y_1,y_2,\ldots,y_S]} = \int \cdots \int \prod_{s}^{S} \left[\frac{e^{X_{nsj}\beta_n}}{\sum_{i=1}^{J} e^{X_{nsi}\beta_n}} \right] f(\beta) d\beta \tag{6}$$

Integral (6) is estimated by simulation since it has no analytical solution (Colombo et al., 2009). The simulated probability $\hat{P}_n$ is given in equation 7.

$$\hat{P}_n = \frac{1}{R} \sum_{r=1}^{R} \left(\prod_{s}^{S} \left[\frac{e^{X_{nsj}\beta_{nr}}}{\sum_{i=1}^{J} e^{X_{nsi}\beta_{nr}}} \right] f(\beta) d\beta \right) \tag{7}$$

$\hat{P}_n$ is unbiased estimate of P_n whose efficiency increases as R increases (Train, 2003). The index *nr* on β implies that for each respondent, the probability is calculated using R different sets of β vectors (Ju and Yoo, 2014). However, the RPL does not show the sources of heterogeneity. To account for sources of heterogeneity, the RPL was estimated with interaction (i.e. interacting the attributes with socioeconomic variables). In addition, although the RPL is better than the CL models in terms of welfare estimates and overall fit Dikgang and Muchapondwa (2014), the RPL model has some restrictive assumptions based on assumed distribution of the coefficient vector mostly uniform, triangular, log-normal and normal distribution. If the distribution is miss-specified the estimated

results could be biased (Carlsson et al., 2003). Since most of our attributes were dummy coded the uniform distribution was best suited (Hensher and Greene, 2002).

To determine the best model in terms of overall fit, the study employed the LR test following (Hensher et al., 2005).

$$-2(LL_{Base} - LL_{Estimated}) \tag{8}$$

which is ~ X^2(difference in the number of estimated parameters between the two models).

Estimating Marginal WTP

The marginal WTP measures is given by the ratio of two parameters[41] as presented in equation 9 (Hensher et al., 2005).

$$WTP = -\left(\frac{\beta_{attribute}}{\beta_{price}}\right) \tag{9}$$

Beyond the marginal WTPs for each attribute, we also estimated welfare change or compensating surplus in five hypothetical scenarios created using information compiled from the questionnaire. The new policy scenarios were projected as follows: Scenario 1: Forest conservation: Wildlife population-SQ; Forest Structure-high; Water Quality-High; Flood Risk-medium. Scenario 2: Flood mitigation and forest conservation: Wildlife Population-SQ; Forest Structure-High; Water quality-SQ; Flood Risk-Low. Scenario 3: Water conservation and Flood mitigation: Wildlife Population-medium; Forest Structure-medium; Water Quality-high; Flood Risk-low. Scenario 4: Water conservation and forest conservation: Wildlife Population-medium; Forest Structure-high; Water Quality-high; Flood Risk-medium. Scenario 5: Water conservation and wildlife conservation:

[41] Both parameters must be statistically significant

Wildlife Population-medium; Forest Structure-medium; Water Quality high; Flood Risk-medium. We estimated the cost of each conservation policy option through comparison of the utility of each policy intervention to the status quo. Following Bennett and Blamey (2001) and Bergmann et al. (2008).

$$Welfare\ change = -\frac{1}{\beta_{cost}}(V_0 - V_1) \tag{10}$$

Where V_0 is the utility of the status quo option, V_1 is the utility of the alternative option and β_{cost} is the estimated coefficient of the cost.

2.5 Results and Discussion

2.5.1 Descriptive statistics

A total of 321 households were interviewed. Other than the Choice experiment questions, socioeconomic and demographic profiles of the respondents and their households were also collected to gain more insight on factors affecting people's perception about the various forest ecosystem services. This information forms a basis for investigating heterogeneity in personal preferences. Summary statistics of the profiles of respondents interviewed is shown in Table A.1 in the appendix. The results show that whereas all respondents considered the forest to be of significant value, approximately 73% of the respondents visited the forest to fetch water and 78% visited to collect firewood. The summary statistics also show that approximately 61% of the respondents own PELIS plots in the forest. About 88% of the respondents are also married and only 29% employed in off-farm jobs. The average households size is also approximately six members

and the average distance from the nearest edge of the forest is about 1.4 kilometres. On the other hand the average household monthly income was found to be about Ksh.13,492.

2.5.2 Model estimation results

NLOGIT 4.0 and Stata 13 econometric software were used to estimate the models. For each of the attributes except the cost, for the ease of analysis and interpretation[42], we coded them low, medium and high levels. Where low is the status quo i.e., choosing no management option. For the wildlife population low represented 753 elephants, medium 1103 elephants and high 1203 elephants[43]. Whereas for the forest structure, low represented 56.25%, medium 82.5% and high 95% forest cover. The water purification and supply attributes was reflected in million cubic meters with low being 11850, medium 17380 and high being 19960[44]. Being that quantifying risk of flooding required more technical expertise, this was just reflected by low medium and high risk flooding[45]. A description of the attributes levels after coding is presented in Table 2.

Table 2: Description of attribute levels used in the study

Variables	Description of variable
Wild_L	Low wildlife population
Wild_M	Medium wildlife population
Wild_H	High wildlife population
Tree_L	Low forest cover
Tree_M	Medium Forest cover
Tree_H	High forest cover

[42] This also for the ease of coding and choice designing in Ngene.

[43] Although elephants may be associated with a lot of damages to crops and therefore some negative attitude towards them, we chose elephants because they are the wildlife animals that most community interacted with frequently. In some communities, they are also a source of tourist attraction.

[44] Because the differences in levels of the attribute may not be large enough, we made it easier for respondents to understand the variation through a pictorial presentation of these levels. To avoid confusing the respondents in terms of quality of the water, the pictorial presentation also detailed clean and more water to reflect high level of this attribute.

[45] The risk of flooding was expressed in terms of water levels. High risk implying high above ground water level and low risk implying low above ground water levels as a result of flooding.

Water_L	Low quality and quantity water
Water_H	High quality and quantity water
Flood_L	Low risk of flooding
Flood_M	Medium risk of flooding
Flood_H	High risk of flooding

The last was the monetary attribute that is additional annual cost per household in the form of annual levy. The attributes were then effect coded as this provides estimates that are uncorrelated to the model intercept (Louviere et al., 2000; Hensher et al., 2005). Effect coding implies one level of attributes is dropped as the base category. However, for the water attribute we merged the low and medium level and classified it as low since it made more economic and logical sense for a respondent to just pay for clean water since both medium and low quality and quantity would have same health implications in some way unless treated[46]. The water attribute therefore had just one level high and the reference category. The estimated coefficient for each of the remaining levels show the respondent's preference for change from the reference (omitted) level to greater utility level (Bergmann et al., 2006). Each of the attributes levels were therefore denoted as Low (L) i.e., the base category, Medium(M) and High(H) levels as shown in Table 2. We also included a dummy equal to one for the status quo (SQ) and zero for the other options. This controls for the very important difference between SQ and non-SQ alternatives. It also measures some propensity to choose 0-cost option, or protest behavior[47]. This information is also more useful for policy purposes. Testing for status quo bias is therefore necessary. Table 3 show the frequency with which each alternative was chosen (out of 321*3*5 choice sets = 4815 across all respondents). The status

[46] By choosing medium or low quality and quantity water, it may also imply that they do not attach any value to water.

[47] Its inclusion is also important since it reflects some hidden characteristics that the respondent do not see in the choice task. The status quo inclusion means respondents are free to select status quo for all attributes hence failing to make any trade-offs.
Therefore, information on trade-off is lost for every choice of the status quo.

quo bias is significantly small (2.55%) implying that forest-adjacent communities within CFAs prefer conservation of forests for efficient provision of forest ecosystem services.

Table 3: Choice Frequency for Mau forest conservancy households

Choice	Frequency	Percent
Option A	762	47.48
Option B	803	49.97
Option C (Status Quo)	41	2.55
Total	1605	100

Conditional Logit (CL) model

Column (1) of Table 4 presents the results of the CL model. The overall fit of the model as measured by McFadden's ρ^2 is 0.47 which is within the conventional standards[48]. The coefficients are highly significant at 5% and below except for the high level of wildlife biodiversity and population. All the attributes have the expected sign. The significance of the attribute and the sign shows that *ceteris peribus*, low and medium flood risk (i.e., low and medium water levels as a result of flooding), higher levels of Water quality, and high and medium forest cover increases the likelihood of selecting a given management scenario. While medium wildlife population[49] decreases the probability of selecting a given management option. The negative and significant coefficient of the

[48] The value of ρ^2that is within the range of 0.2 and 0.4 are considered good fit (Hensher and Johnson, 1981)

[49] During the survey, we noted that most households were not concerned about the destructive nature of wildlife animals such as monkeys or elephants. They said in case of damage it was often shared since most farms in the forest are in one area. The main worry was if the population increases then human wildlife conflict would arise hence tension with Kenya Wildlife officials. However, the main concern was with leopards that often attacked their sheep at night yet no compensation from relevant authorities.

alternative specific constant (ASC) shows that people want a **change** from the SQ i.e., they want a conservation program aimed at improving forest condition.

Table 4: Conditional logit, Random Parameter logit model and Random Parameter logit model with interactions

(1) CL Model N = 1605 Log-Likelihood= -671.1730		(2) RPL model N =1605 Log-Likelihood=-664.0608			(3) RPL Model with interaction N=1605 Log-Likelihood=-624.6797		
Variable	Coeff .(s.e)	Variable	Coeff(s.e)	Coe .Std (s.e)	Variable	Coeff. (s.e)	Coeff .Std (s.e)
ASC	-1.5073***	**Random Parameters**			**Random Parameters**		
	(0.5746)	Wild_H	0.2398	1.1652**	Wild_H	0.1561	1.1071*
Wild_M	-0.3665**		(0.2112)	(0.6053)		(0.4318)	(0.5741)
	(0 .1616)	Tree_M	1.7923***	0.9655**	Tree_M	3.7825***	0.8919*
Wild_H	0.1067		(0.2171)	(0.4654)		(0.5757)	(0.4878)
	(0.1697)	Tree_H	4.0959***	0.9655**	Tree_H	6.3764***	0.8919*
Tree_M	1.5041***		(0.3811)	(0.4654)		(0.8157)	(0.4878)
	(0.1563)	Water_H	0.7877***	0.1636	Water_H	0.6486***	0.1612
Tree_H	3.5216***		(0.1530)	(0.7013)		(0.1709)	(0.6210)
	(0 .2708)	Flood_M	1.4927***	1.6582***	Flood_M	1.2260***	1.6612***
Water_H	0.6411***		(0.1797)	(0.3619)		(0.2324)	(0.3723)
	(0 .1170)	Flood_L	2.6174***	1.6582***	Flood_L	1.8427***	1.6612***
Flood_M	1.2429***		(0.2537)	(0.3619)		(0.2386)	(0.3723)
	(0.1101)	**Non-Random Parameters**			**Non-Random Parameters**		
Flood_L	2.1300***	ASC	-1.1761*		ASC	-1.6057**	
	(0.1503)		(0.7008)			(0.7246)	
Cost	-.00061***	Wild_M	-0.3783**		Wild_M	-0.4764**	
	(0.0002)		(0.1933)			(0.2002)	
		Cost	-0.0006***		Cost	-0.0008***	
			(0.0002)			(0.0002)	
					WildH*PELIS	-0.4933*	
						(0.2773)	
					WildH*Dist	-0.2313**	
						(0.1056)	
					WildH*HHsize	0.1057**	
						(0.0520)	
					TreeM*Dist	-0.2912**	
						(0.1236)	
					TreeM*HHsize	-0.2750***	
						(0.0626)	
					TreeM*Empl	1.0030**	
						(0.4331)	
					TreeH*Dist	-0.4311***	
						(0.1648)	
					TreeH*HHsize	-0.2931***	
						(0.0814)	
					TreeH*Empl	2.0138***	
						(0.6321)	
					WaterH*Empl	0.7974**	
						(0.3166)	
					FloodM*PELIS	0.6420**	
						(0.2673)	
					FloodH*PELIS	0.8020**	
						(0.3223)	
					FloodH*Dist	0.3535***	
						(0.1258)	
$\rho 2$	0.4733		0.6234			0.6457	
Standard errors in Parentheses *** p<0.01, ** p<0.05, * p<0.1							

The results therefore indicate that forest-adjacent communities would prefer forest management options which would guarantee low levels of wildlife population and diversity, clean and abundant

water, low or medium flood risk and higher or medium forest cover as indicated by the significant coefficients. We also found considerable consistency with economic theory. Specifically, that the cost of a conservation program reduce demand for a given conservation program. Our results therefore suggest the existence of significant values and preferences for the stated forest ecosystem attributes. However, if the IIA assumption does not hold then CL model would yield biased estimates. We employed the Hausman and McFadden test under the null hypothesis of no violation to test the IIA assumption (Hausman and McFadden, 1984). The results are shown in Table 5. Violation of IIA assumption is thus evident from the results. Hence the CL model is not appropriate model. This test has however been contested for giving inconsistent results (see Vijverberg, 2011).

Table 5: IIA/IID Hausman Test

Alternative dropped	Chi Square	Degrees of freedom	Comment
A	14.35	8	Violation at 10%
B	5.66	8	No violation
C (Status Quo)	-0.758	8	No violation

Due to violation of the IIA property, we considered alternative models namely the Random Parameter Logit (RPL) model and RPL model with interactions to identify the sources of heterogeneity.

Random Parameter Logit Model

Despite the violation of the IIA assumption, the CL model further assumes homogeneity across individual preferences. Since preferences are heterogeneous, we need to account for this heterogeneity in order to obtain unbiased estimates of individual preferences. In addition, for

prescription of policies that takes into account equity concerns, accounting for preference heterogeneity is critical (Birol et al., 2006). We therefore used the RPL model by Train (1998). According to Hoyos (2010) three considerations need to be made in implementing an RPL model that is: which coefficients are assumed random; type of distribution for the random parameters; and the economic interpretation for those coefficients. To determine which variables are actually random, we used the Lagrange Multiplier test by McFadden and Train (2000) to test the presence of random components[50].

Based on this test, Wild_H, Tree_M, Tree_H, Water_H and Flood_M were found to be random parameters. Some studies that have used this test are (Brey et al., 2007; Liljenstolpe, 2008; Hoyos et al., 2009). But according to Brownstone (2001), the test is not good for identification of random factors for inclusion in a general RPL specification. For robustness checks, we employed the t-test on the standard deviations assuming all parameters are random to test if they give same results. The test showed that Tree_M, Tree_H, Flood_M and Flood_L are random based on the significant t-values of the standard deviations. This test has been applied by (Carlsson et al., 2003; Colombo et al., 2005; Wang et al., 2007). Based on these two tests we decided to treat all attributes as random except Wild_M and cost since both tests showed Wild_M to be non-random. The cost attribute was treated as fixed so that distribution of marginal WTP is just the distribution of the attribute coefficient. This also places a non-positive restriction on the cost variable.

[50] The test works as follows; we first compute the artificial variable z_{tnj} given by

$$z_{tnj} = \frac{1}{2}(x_{tnj} - x_{tnC})^2, \text{ with } x_{tnC} = \sum_{k \epsilon C} x_{tnk} P_{nk}$$

where t denotes the component of x_{nj} suspected to be random, C is the set of alternatives being offered and P_{nk} is the CL choice probability. The CL model is then re-estimated including these artificial variables z_{tnj}, and the null hypothesis of non-random coefficient of attribute x is rejected if the coefficients of the artificial variables are significantly different from zero (McFadden and Train, 2000).

In terms of the distributional functions, since the random parameters were all dummies, we settled for the uniform distribution as suggested by Hensher and Greene (2002). The results for the random parameter logit model based on 500 Halton draws are presented in Column (2) of Table 4.

The model is statistically significant (chi square value of 2198.424 with 7 degrees of freedom). The overall model fit as shown by the pseudo R squared is 0.62339, which is statistically acceptable for this class of models. The RPL estimates in column 2 reveals significant and large derived standard deviation for Wild_H, Tree_M, Tree_H, Flood_M and Flood_L an indication that our data supports choice specific unobserved heterogeneity for these attributes. The null hypothesis of equality of the regression parameters is rejected at 5% based on the LR test ($-2\Delta l = -2(-671.1730 + 664.0608) = 14.224 > \chi^2_{6,0.05} = 12.592$) where l refers to the estimated log likelihood function. There is also a structural advantage in RPL over the CL as shown by the significant standard deviations of the random parameters. However, according to Boxall and Adamowicz (2002), the RPL model does not show the sources of heterogeneity. To identify the sources of heterogeneity, we used an RPL model with interactions.

Random Parameter Logit Model with Interactions

To estimate the RPL model with interaction, we included interactions of individual specific socio-demographic and attitudinal characteristics with attributes in the utility function. The interaction terms obtained by interacting random parameters with other socio-demographic characteristics decomposes any heterogeneity observed with the random parameters therefore showing sources of heterogeneity (Hensher et al., 2005).

Based on literature and economic theory, we tested various interactions of the various forest ecosystem services attributes with respondents socioeconomic and demographic characteristics collected during the survey. We found, household size, employment status of household head,

distance to nearest edge of the forest and whether a household owns a PELIS plot or not fits the data best. Column (3) of Table 4 presents these results. The model is statistically significant (chi square 2277.19 with 26 degrees of freedom). The overall model fit shown by the pseudo R squared is ρ^2=0.6457 a better fit than the RPL model without interaction. The null hypothesis of equality between regression parameters for RPL model and RPL model with interactions is further rejected at 0.5% significance level using the LR test

$$(-2\Delta l = -2(-664.0608 + 624.6797) = 78.7622 > \chi^2_{19,0.005} = 38.582).$$

This implies that the inclusion of demographic and socio-economic characteristics as interaction improves the model fit. We then fixed out interaction terms that had insignificant heterogeneity around the mean parameter estimates following Hensher et al. (2005). This does not however affect the results in any way but just reduces the number of variables by eliminating the insignificant interactions (treating them as fixed). The significant interaction terms are of the expected sign except for the interaction between household size and high wildlife population attribute. However, all the random parameters except Water_H had high and significant standard deviations.

The RPL model with interactions therefore decomposes any observed heterogeneity within the random parameters hence providing an explanation for existence of any heterogeneity. For instance, the interaction between ownership of PELIS plot in the forest and attribute of high wildlife population is negative and significant showing that those who own PELIS plots are less likely to choose alternative with high population of wildlife. This is expected since high population of wildlife would mean higher likelihood of destruction of crops in the PELIS plots. For local communities' dependent on subsistent agriculture, wildlife is not always a priority since they are more concerned with immediate gains. Moreover, the benefits from wildlife conservation may not trickle back directly to these communities and neither are they compensated in case of any crop destruction. This is a major observation especially among developing countries in Africa. Similarly,

those who own PELIS plots are also more likely to select alternatives that have low or medium risk of flooding. This shows that differences in marginal utilities for low/medium flood risk and high wildlife population may in part be explained by whether a household owns a PELIS plot or not in the forest. Household size was also found to partly explain differences in marginal utilities for high wildlife population and high/medium forest cover. The results suggest that the higher the household size the less likely the household is to select an alternative with high/medium forest cover. This is expected since most populated households may consider forest as occupying alternative land that they could use for agriculture purposes. There are also chances of these households choosing low forest cover, with the hope that they will get plots through PELIS in an effort to reclaim the forest. This is also supported by the fact that the more the scarcity of the resource the higher the incentive for collective action and vice versa[51]. However, the results suggest that the higher the household size, the more likely a household is to choose an alternative with high wildlife population. This is unexpected given that high wildlife population could mean destruction of food crops that the household depends on and constant human wildlife conflict. A possible explanation for this choice could be just the love for wildlife or more wildlife would mean more food if they are hunters or just "warm glow" associated with being pro wildlife.

Finally, the results revealed that the employment status of household head could also partially explain differences in marginal utilities for high quality and quantity water attribute and high/medium forest cover. The results indicate that household heads who are employed in off farm jobs are more likely to select alternative with high/medium forest cover and high quantity and quality water for drinking. Moreover, the higher the distance a household is from the nearest edge of the forest, the less likely the household is to choose alternative with medium/high forest cover

[51] It is important to note that, this may not hold for members involved in other forest user groups activities like bee keeping which need more forest cover.

or high wildlife population. This is expected given that households further away from the forest may find it costly to enjoy forest resources directly and may not view the forest cover to be of significance. This shows that opportunity cost with respect to distance matters.

2.5.3 Estimation of Willingness to Pay

There is ongoing debate regarding the appropriateness of calculating WTP estimates from RPL models of CE data. Key concern is the RPL assumption regarding distribution of cost variable. By specifying the cost variable as fixed as in our case, the assumption is that all respondents have same preference for cost which is quite unreasonable. It may also be equally unreasonable to assume that the distribution of preferences for cost is normally distributed. However, no "gold standard" has been established. Since the cost is not modelled as random, we do not require non-parametric bootstrapping.

The Marginal WTP was estimated by computation of the marginal rate of substitution between change in forest ecosystem service attribute and the marginal utility of income represented by coefficient of the cost attribute. The WTP estimates are computed per household and are to be paid as annual levy for three years. The WTP estimates for CL, RPL and RPL with interactions estimated using the Wald (Delta method) procedure in NLOGIT 4.0 are presented in Table 6.

Table 6: Marginal WTP for forest Ecosystem Services Attributes (Ksh/respondent (1 US$=Ksh.100)) and 95% C.I

Attributes	CL Model		RPL Model		RPL Model Interactions	
	WTP	C.I.	WTP	C.I.	WTP	C.I.
Wild_M	-604.76	(-589.67 - -619.85)	-627.92	(-612.25 - -643.59)	-601.61	(-586.59 - -616.62)
Tree_M	2481.99	(2420.04 - 2543.93)	2974.55	(2900.32 - 3048.78)	4776.73	(4657.50 - 4895.96)
Tree_H	5811.19	(5666.13 - 5956.25)	6797.80	(6628.12 - 6967.48)	8052.41	(7851.42 - 8253.39)
Water_H	1057.94	(1031.53 - 1084.34)	1307.37	(1274.74 - 1340.01)	819.13	(798.68 - 839.57)
Flood_M	2051.04	(1999.84 - 2102.24)	2477.44	(2415.61 - 2539.27)	1548.24	(1509.59 - 1586.89)
Flood_L	3514.77	(3427.03 - 3602.51)	4343.99	(4235.58 - 4452.41)	2326.98	(2268.90 - 2385.07)

The t-test of WTP estimates from the three models differ significantly at alpha=0.05 significance level or less. Positive (negative) marginal values for an attribute is an indication that the average respondent would experience an improvement in welfare with an increase (decrease) in the level of the attribute and would therefore choose an intervention that maximizes his/her utility. The positive WTP values for both high and medium forest cover and high water quality and quantity may depict use values whereas the positive WTP estimates for medium and low flood risk may depict both use and non-use values. However, the negative WTP values for wildlife indicate that individuals would experience a loss in welfare for choosing an intervention with medium population of wildlife (approximately ksh 605 (USD 6.05) loss in welfare). The negative WTP suggests that people do not have positive preference for this attribute but in absolute terms they would be willing to accept the amount as compensation to accept the policy that would guarantee them medium wildlife population[52].

During the survey communities expressed a lot of concern especially with destruction of crops and killing of their sheep by wild animals. Elephants, baboons, Warthogs, wild pigs and leopards were the most notorious as reported by most CFAs[53]. This explains why communities would develop negative attitude towards wildlife animals. The high wildlife population was however insignificant although we expected that the high wildlife population would lead to even a larger loss in welfare than medium wildlife population. These results suggest that devolution of forest management through PFM to CFAs will be more successful where human-wildlife conflict is lesser.

[52] People would not be willing to choose an intervention with this attribute due to the destructive nature of wildlife and this is further supported by the fact that most forest-adjacent communities are farmers some even own plots right inside the forest under the PELIS scheme hence prone to attacks by wild animals.

[53] During the pilot in Londiani we found the community having a meeting with Kenya Wildlife Service, Kenya Forest Service and other government department over an attack on over 50 herds of sheep by rogue leopards the previous night.

Our results are in tandem with findings from various studies on valuation of ecosystem services including those conducted in developed world. For example, García-Llorente et al. (2012) found that people had higher WTP for river quality which essentially implies water quality and quantity. Our results are also consistent with Hanley et al. (2006) who found positive and significant effect of river ecology attribute on river improvement project. Gatto et al. (2013) also found that respondents had no significant WTP for biodiversity conservation similar to our findings that increased wildlife population leads to loss in welfare. However, our results differ from findings by Carlsson et al. (2003), Shoyama et al. (2013) and Yao et al. (2014) who found high preference for biodiversity conservation. The results are also consistent with Birol et al. (2009) who found significant preference for flood reduction relative to use and non-use values from recreation or biodiversity.

2.5.4 Welfare Estimates

The marginal WTP estimates show that in general the average respondent in the Mau forest conservancy is willing to pay for forest conservation. However, they do not provide welfare estimates for alternative policy scenarios. From policy perspective, welfare estimate derivation is the most useful aspect of the CE exercise especially for assessment of cost benefit analysis. We therefore need to compare utility between status quo and a series of alternatives or policy interventions each described by attribute levels employed in the experiment. The utility is then transformed into impacts that different policy interventions have on respondent's welfare. The welfare measure for each household is then given by the overall WTP for a change from the status quo based on RPL model with interactions estimates.

The welfare estimates for the various policy scenarios are presented in Table A.2 in the appendix. The compensating surplus for a change from the status quo to the alternative policy scenarios

increases with improved social, ecological and economic conditions as expected. The mean WTP for the forest conservation policy of USD 104.19 is highest followed by flood mitigation and forest conservation policy. This means that an average household would be willing to make an annual payment of USD 104.19 for the next three years to avoid any environmental damage as described by the forest conservation policy scenario1. This also implies that forest conservation policy and a combination of forest conservation policy and flood mitigation policy are perceived to provide higher welfare gains to the households.

Implication for design of PES schemes and Participatory Forest Management

The Mau forest conservancy, is one of the reserve forests managed through PFM. Under the PFM arrangement, the government retains ownership of the forest while forest-adjacent communities, organized in the form of Community Forest Associations (CFAs), obtain user rights. Communities are also provided with incentives such as PELIS where they grow appropriate crops during early stages of reforestation as they protect and conserve the trees up to a certain stage when tree canopy forms. It is important to note that forest-adjacent communities are mainly poor with no alternative land and almost fully reliant on these forests for their livelihoods[54] and are the same people charged with conserving these forests through CFAs in collaboration with KFS[55]. This implies local communities are more of demanders of these services than suppliers of these services to some extent mainly because they also pay user fees through the CFAs to enjoy the various forest resources. Although willingness to accept (WTA) would also be an ideal measure for the supply side, given the socio-economic status of forest-adjacent communities, we may not get reliable estimates on their values and preferences since their preferences may only be driven by the

[54] The forests provide firewood, grazing land, drinking water, and food crops, grass for thatching as well as herbs and medicines. enjoy any of the resources, they pay user-fees a percentage of which goes to KFS and a percentage to CFA and associated forest user group (FUG).

[55] However, the major beneficiaries of these forests are the tea factories, energy, and water companies as well as the tourism industries among other companies downstream.

compensation from a given policy scenario. Moreover, since the forest is a reserve forest where they only have limited user rights through CFAs (members only), estimating WTA becomes a challenge. We therefore preferred to assess their WTP for the various ecosystem services to determine how the forest-adjacent communities can be incentivized to sustainably manage these forest resources through CFAs. Our estimates therefore provide a good entry point for informing the designing of incentive schemes such as PES.

However, PFM and PELIS alone is not adequate to incentivize communities to conserve these forests. If public and private partners can come together, policy instruments like PES can ensure socially optimal supply of ecosystem services through improving resource management, creating income and sustainable livelihoods for rural and urban populations. For example, the commercial value of water is relatively easy to calculate compared to protection of key wildlife habitat or protection of soil type or flood mitigation which does not easily translate to cash value. The Kenya Power and Lighting Company that relies on Sondu river that has its origins in the Mau forest for hydro power, Rift Valley water services board which supplies water to major towns in the Rift Valley and water companies such as Keringet mineral water company in Molo as well as the Coca cola company which need pure drinking water could therefore work in partnership with KFS and CFAs to explore the possibility of using a water fund as a possible financing mechanism. This could be funded by the public through increased water fees aimed at protection of the quality and quantity of water to surrounding towns and municipalities. Surrounding counties could also come up to establish voluntary conservation funds for biodiversity conservation and related ecosystem services making use of the estimated marginal WTP values.

Finally, given that forest-adjacent communities consider forest to be of significant value to them, there should be more effort towards devolution of forest management to forest-adjacent communities especially in areas where communities have been reluctant in taking up PFM.

Incentive schemes like PES can therefore incentivize communities to conserve forest resources through CFAs. However, an assessment of the contextual factors, historical and expected trends in demand and supply is vital especially if we are to target payments to those CFAs that can actually deliver the desired service.

2.6 Conclusion and Policy Implications

The main aim of the study was to determine the economic value of forest ecosystem services to forest-adjacent communities and its implication for design of PES schemes and PFM. The study found that there are positive and significant benefits associated with the various forest ecosystem services within the Mau forest conservancy that need to be considered when designing PFM programs and PES schemes with the aim of maximizing social welfare and raising acceptance within communities. There is also considerable preference heterogeneity which to a large extent was determined by employment status of household head, ownership of PELIS plot, household size, and distance to the nearest edge of the forest.

Specifically, we found high WTP values for improvement in forest structure (between USD47.76 and USD80.52)[56], flood risk reduction (between USD15.48 and USD23.26) and high water quality and quantity (at USD 8.19) respectively. The results thus show that there is much appreciation by the average respondent for the role of forest ecosystem services and that forest-adjacent communities are more pro conservation mainly motivated by the direct and few indirect benefits they derive from these forest ecosystems. Forest-adjacent communities are also more concerned with use values but also some non-use values contrary to findings from previous studies in developed countries (see Carlsson et al. 2003; Gatto et al. 2013; Shoyama et al. 2013; Yao et al. 2014). In terms of welfare,

[56] This was supported by finding from the local interactions with the locals. Most said they would pay more for the forest conservation, they compared the highest cost shown of USD30, with what they pay monthly per cow or sheep to graze in the forest and the number of cows and sheep they had and considered that as a very small amount to them.

respondents revealed that forest conservation policy and a combination of flood mitigation and forest conservation policy would have high welfare impacts on livelihoods of locals.

We also found considerable consistency with economic theory. Specifically, the cost of a conservation program reduces demand for a given conservation program. Whereas increase in forest cover, water quality and reduction of flood risk increases demand for a given conservation program. Contrary to findings from developed countries, we found that respondents would experience a loss in welfare for choosing an alternative with medium wildlife population as opposed to one with low wildlife population. A significant finding from the study was the high WTP values for reduction in flood risk, showing that forest-adjacent communities were more concerned with reduction in flood risk as a result of forest destruction. This indicates that respondents are more altruist and not only concerned with direct use values but also non-use values for the welfare of other members of the society. This aspect of the society thus motivates the design of an incentive schemes such as PES and roll out of PFM programmes.

A number of policy recommendations can be highlighted from the study. First, the WTP estimates lays foundation for the design of market based instrument such as PES which can significantly incentivize communities and enhance the roll out, design and implementation of PFM. However, more research on the demand and supply side is needed as well as consideration of issues as to what private partners may consider worth involving in PES schemes. Bundling different ecosystem services together may also help in diminishing transaction costs. A cost benefit analysis and assessment of political climate in cases where communities have strong attachment to their forests either for cultural values or other ecosystem services may also be important in designing the PES schemes.

In addition, a demonstration of the significance of ecosystem services attributes as input in the production process can play a role in increasing environmental awareness and motivating forest-

adjacent communities to conserve forest resources through PFM. This can also encourage shifts from socially unacceptable land management activities towards ecosystem oriented approaches. Incentive schemes like PELIS may also play a significant role in promoting PFM as revealed by the fact that PELIS plot owners have more willingness to pay for improvement in forest cover[57]. The government should therefore increase roll out and incentivize communities that have been hesitant at adopting PFM to adopt the programme taking into account the heterogeneity in preferences to address equity concerns as well.

Lastly, policy makers need to focus on policy options with higher mean welfare impacts to increase community involvement in forest conservation through PFM. A comparison of the different marginal WTP for the various forest ecosystem attributes may also help policy makers in understanding the values attached to these services by respondents and how to devolve forest management through PFM. Policy makers could also make use of the WTP and welfare estimates for estimation of the TEV of the Mau forest conservancy. There is also potential for benefit transfer of the estimates to other policy contexts. In summary, the study provides an entry point for designing future forest management policies in Kenya and provides valuable comparison for studies in other countries.

[57] It is important to note that communities felt that despite benefiting significantly from PELIS, the government benefited a lot from the revenue from timber sales hence there was need to dedicate a proportion of this revenues to CFAs as managers of the forests for the communities fully own the scheme. Some felt a proportion of revenue from PELIS could be channeled to construction of social amenities within the society e.g. school and health facilities.

Chapter Three

Welfare and Environmental Impact of Incentive Based Conservation:

Evidence from Kenyan Community Forest Associations[58]

Abstract

This paper focuses on whether the provision of landless forest-adjacent communities with options to grow appropriate food crops inside forest reserves during early stages of reforestation programmes enable vertical transition of low income households and conserves forests. We consider the welfare and environmental impact of a unique incentive scheme known as the Plantation Establishment and Livelihood Improvement Scheme (PELIS) in Kenya. PELIS was aimed at deepening community participation in forestry, and improving the economic livelihoods of adjacent communities. Using data collected from 22 Community Forest Associations and 406 households, we evaluated the mean impact of the scheme on forest cover and household welfare using matching methods and further assessed the heterogeneous impact of the scheme on household welfare using the endogenous quantile treatment effects model. The study revealed that on average, PELIS had a significant and positive impact on overall household welfare (estimated between 15.09% and 28.14%) and on the environment (between 5.53% and 7.94%). However, in terms of welfare, the scheme cannot be defended on equity grounds as it has inequitable distributional impacts on household welfare. The scheme raises welfare of the least poor than the poorest and marginalizes sections of the community through elite capture and lack of market linkages. In terms of policy implications, the scheme should be redesigned to ensure equitable distribution of the benefits to avoid further marginalization of some income groups in order to ensure sustainability of the scheme. There is also need to explore ways of improving market linkages for non-timber harvests to address the ensuing market failures and for greater impact on welfare of low income households and the environment.

Key words: Household Welfare. Heterogeneity, Selection, Matching, QTE JEL Classification: D02, Q23, Q28

[58] A version of this chapter has been disseminated as ERSA Working Paper 706.

3.1 Introduction

Conservation manifests itself today in various forms in different parts of the world. From state controlled such as reserve forests and exclusionary parks to community forests managed by local communities. Initial conservation efforts involved indigenous resource management based on subsistence necessity, spiritual beliefs, experience and traditions (Gbadegesin and Ayileka, 2000). Until the early 80s conservation efforts by governments in developing countries were mainly based on the protectionist approach also referred to as the classic approach to conservation (Blaikie and Jeanrenaud, 1997).

In developing countries, these forms of conservation have not yielded the best results in terms of conservation outcomes and welfare of local forest-adjacent communities. This is because in developing countries, natural forests are most often surrounded by high population of the poor basically reliant on extraction of natural resources for their daily subsistence. Forest-adjacent communities are also often the poor without access to other sources of income such as land, human and physical capital hence depend on income derived from the forests either directly or indirectly. Such dependence coupled with their high rate of time preference often leads to degradation of the resource thus contributing to further impoverishment of the dependent forest users. Therefore, the poor are considered to be agents and victims of environmental degradation as well (Wunder, 2001; Fisher, 2004).

The failure of the classic approach in many countries led policymakers and donors to conclude that the only solution is devolution of natural forest management to forest-adjacent communities through arrangements such as PFM and provision of incentives in order to enhance community support, conserve forest and offer positive welfare benefits among the forest poor. Incentive based conservation has therefore been considered as a remedy to failures associated with state control of

natural resources such as, information asymmetry, incentive incompatibility or imperfect incentives, high monitoring and enforcement costs among others (Sterner, 2003; Adhikari, 2005).

However, incentive based conservation has been marred with uncertainties since PFM places significant restrictions on extraction of forest resources. For example, in certain instances communities are required to pay user fees to access certain resources e.g., grazing, firewood collection etc. (Jumbe and Angelsen, 2006). Certain benefits are also restricted to membership to CFAs. These practices have previously contributed to forest degradation in a way. The approach has also not realized their full potential due to the design, implementation and management problems (Songorwa, 1999; Hutton and Leader-Williams, 2003). A number of countries have experimented with different programs that include the participation of locals with the main policy objective of power decentralization and have yielded mixed results (Bull and White, 2002; Gilmour et al., 2004). Results on the potential of CPRs to have positive impacts on very poor and marginalized sections of the communities have also been mixed (Campbell et al., 2001). Distributional problems have also been experienced with structured attempts at management of CPRs (Kumar, 2002). In addition, as much as forests play a critical role in prevention or reduction of poverty through provision of safety nets, over reliance on forest may also perpetuate poverty (Pattanayak and Sills, 2001).

Attempts have therefore been made in support of incentive based conservation in a number of developing countries in recent years. In Kenya, these attempts have focused on deepening community participation in forest management to aid in conservation of forest and improvement of welfare of forest-adjacent communities through CFAs and incentive schemes. This is based on the premise that other than devolution of forest management to local communities, provision of alternative incentive to landless forest-adjacent communities may help them to avoid activities that may offer short term gains in favor of activities with long term payoffs. We consider one unique

incentive in Kenya known as Plantation Establishment and Livelihood Improvement Scheme (PELIS) under the realm of PFM. PELIS is a unique incentive scheme since it provides local landless communities with alternative forest land for their livelihoods as they take care of trees up to a given stage when they move to other areas targeted for reforestation. It is also one of the schemes that has been in force for long but has been faced with a lot of challenges leading to occasional government bans over the years.

PELIS was first introduced in Kenya in 1910 by the colonial government as non-residential cultivation to promote livelihood of locals economically while ensuring sustainable management and conservation of forests through provision of raw materials for expanding timber industry and reduce pressure on natural forests (Kagombe and Gitonga, 2005). Since forests in Kenya are surrounded by mostly poor households' dependent on agriculture but constrained by inadequate agricultural land and alternative sources of income, these scheme presents an opportunity for locals to derive livelihood by planting appropriate food crops. The dominant food crops are normally peas, potatoes, vegetables, beans and maize among other short-term crops[59]. Depending on the amount of harvest, this produce can be sold to other members of the communities at the market centres hence a source of income to the households. Income from the sale of agricultural produce could be used to meet their daily household demands leading to improved welfare. There is also the nutritional value from consumption of these produce and therefore higher productivity due to improved health. This provides PELIS beneficiary members with incentive to conserve the forest reserve[60] hence the double dividend. Under the system farmers are allowed to grow both plantation

[59] Although there is no restriction on crops to grow, since most households are poor, they mostly resort to growing crops that are ready for harvest within 2-4 months so that they can make quick cash too and maximize within the given period. However, growing of long term crops such as tea, coffee or sugarcane is not allowed. The focus is mostly on crops than cannot interfere with younger tree seedlings in anyway.

[60] Once one becomes a participant in PELIS, the benefits will depend on, one's hard work and the kind of crops grown as well as, how well they market their produce to fetch better prices.

trees[61] and food crops on small plots (half an acre) tending the trees and harvesting crops for 3-4 years until tree canopy closes then they move to another degraded area as identified by the forester for reforestation an arrangement where both parties benefit. It was later banned after several attempts in 1986, 1994, and 2003 due to failure and mismanagement. The scheme was however reintroduced in 2007 with enactment of Forest Act (2005) through CFAs. Members are required to pay between Ksh. 400(4USD) and Ksh.750(7.5USD) per half an acre. The rules of allocation of plots also varies, with almost all CFAs purporting to use balloting. But this is just on paper as the process is marred with a lot of irregularities[62]. However, in some organized CFAs, first preference is given to disadvantaged groups, mostly the elderly and physically challenged.

PELIS was first rolled out in 24 forest stations in Mau, North Rift, Eastern and Central conservancies. According to the Kenya Forest Research Institute (KEFRI) the area under PELIS increased from 2933 ha in 2010/2011 financial year to 9939 ha in 2012/2013. The reintroduction of PELIS was meant to deepen community participation through CFAs in conservation as they improve their livelihoods. Despite the existence of this incentive and its increased adoption, degradation and deforestation has even increased under some CFAs and there is continuous loss of indigenous forests that were meant to be protected. As communities tends to their crops in the forest they are expected to monitor any illegal activities hence instances of forests infractions should be minimal. It is also important to note that devolution of forest management to local communities and the roll out of PELIS has had its fair share of challenges especially due to the rent seeking behavior of foresters who should be the government overseer at the devolved level coupled with a lot of political interest due to the fertile nature of forest lands. Some foresters also collude with

[61] Farmers are usually provided with tree seedlings by the KFS and each is tasked with nurturing the trees planted in their plots. In case any tree gets destroyed one is answerable to the CFA officials and the forester. In certain instances, a penalty is applied. In addition, CFAs may also construct their own nurseries in the forest and sell tree seedlings to members for setting up their private woodlots.

[62] During the survey, we noted that some CFA officials and members had more than one plot in the forest while some deserving members had none. Some rich established non-members also acquired plots in the forest by bribing the foresters or CFA officials. Some members therefore felt short changed because only the well-connected members or elites tend to get the plots. Hence an incentive for them to just sit back and watch as the forest gets destroyed.

loggers to harvest more than the licensed number of plantation trees and at times harvest even the indigenous trees that should be protected thus negating community conservation efforts. In some instances, the foresters influence decisions on who should receive the PELIS plots. Communities therefore most often feel their efforts are in vain. Communities also felt shortchanged since the revenues from timber product are too much and none is invested back to the community by the government for development purposes. As noted by Ostrom (1990) the problem of incentive based approach is the inequitable distribution of benefits hence a recipe for the tragedy of the commons. However, the debate on forest management centred on how to conserve forest while simultaneously giving local people the opportunity to utilize forest resources through resource access is still ongoing (Casse, 2012).

However, even though PELIS may enhance efficiency in forest resource use, there may be inequitable distribution of the benefits across the income groups and therefore a recipe for tragedy. It is therefore inherent to gauge PELIS impact not just with reference to its efficiency and effectiveness but also by sustainability of the benefits in promoting equity and improvement of environment. There is also limited understanding of the drivers of adoption of the scheme by households within CFAs which could shed light on reasons for past failures in the scheme and identify possible factors to consider in rolling out the scheme. In addition, since the opportunity cost of restriction of forest access and use is higher among the poor, there is uncertainty whether participation in PELIS can enable poor households to move up the income ladder. There is also high likelihood of those high up the ladder capturing the scheme therefore having a disproportionate impact on the distribution of program benefits. Empirical evidence on the impact of PELIS on environmental conservation and welfare implication is also not clear despite its significance for sustainability of PFM.

Moreover, studies that have analyzed various forms of forest management activities are more biased towards Asia mostly Nepal and India. There are relatively few studies in Africa (see Jumbe and Angelsen 2006; Kabubo-Mariara 2013; Gelo and Koch 2014; Mazunda and Shively 2015; Gelo et al. 2016). Empirical studies that have tried to evaluate the welfare effects of various incentives have mainly been focused on mean impacts assuming constant treatment effects across the income distribution (see Gelo and Koch, 2014; Ali et al., 2015; Mazunda and Shively, 2015), with very few on the heterogeneous impacts of such schemes (see Adhikari, 2005; Jumbe and Angelsen, 2006; Cooper, 2007, 2008; Moktan et al., 2016; Gelo et al., 2016). For the few that have estimated the impact of various incentive schemes in other countries, the methodological approaches have been varied ranging from treatment effects models, PSM to instrumental variable approach among others and have yielded mixed results and inconclusive evidence thus making comparison difficult. On the other hand, the measurement of outcomes employed in these studies are also significantly different and prone to measurement errors. For instance, some studies use household income which is prone to under reporting especially among poor rural communities. As a departure from past studies that have always classified households in terms of low, middle and high income households, and given the fact that measures of mean impact may not provide a clear picture of the impact of the scheme, we estimate the heterogeneous impact across the entire income distribution.

The overall impact on forest cover and household welfare and the heterogeneous impact of the scheme on household welfare therefore, motivates this study. The study therefore, seeks to fill these gaps by addressing the following research questions: What determines households' decision to participate in PELIS? What is the joint overall impact of PELIS on forest cover and household welfare? What is the distributional impact of PELIS on welfare of locals?

This study contributes to the growing body of literature on impact evaluation of environmental policies by providing a comprehensive empirical evidence from a micro perspective of the

distributional impact of PELIS on household welfare and its simultaneous overall effect on the environment and household welfare. From a policy perspective, an understanding of the overall and distributional impact of the scheme across the income distribution has the potential to inform design, implementation and roll out of PELIS to other CFAs. Lessons from this scheme can also be used to inform formulation of other market based incentives that can help in optimizing welfare gains and improving environmental conditions.

The rest of the chapter is organized as follows: Section 3.2 presents a review of related literature; section 3.3 outlines the methodological framework; section 3.4 presents the survey design and data collection; section 3.5 gives a description of the data; section 3.6 presents the results and discussions; and the conclusion and policy recommendation are presented in section 3.7.

3.2 Related Literature

3.2.1 Determinants of households' participation in incentive schemes

Households participation in various incentive schemes such as joint forest management has been found to be mostly influenced by household socio-economic profile and contextual factors (Adhikari, 2005; Kabubo-Mariara, 2013). In Kenya Kabubo-Mariara (2013) found that both poor and rich households rely on forest resources and that their participation in forest user group activities is based on monetary values rather than asset income. On the other hand, according to Adhikari et al. (2004) reliance on forest resources by forest-adjacent households is mainly influenced by households' socio-economic profiles specifically, education of family members, land and livestock holdings, caste, and household economic status. However, Agrawal and Gupta (2005) noted that the likelihood of household participation in communal activities increases when they are economically and socially better off and when they have access to government offices that deals

with devolution of the CPR management. He however, found education and household level of participation to have a negative correlation. The educated, young and wealthier households are also more likely to participate in community forest management (Ali et al., 2015).

The effect of education on household participation has however been inconclusive for example, Uberhuaga et al. (2012) and Angelsen and Wunder (2003) found that the more educated are less dependent on forest due to increased opportunity cost of labor hence less likely to participate in incentive schemes whereas Adhikari (2005) found that more education may increase capacity to over exploit environmental resources. In Malawi, Jumbe and Angelsen (2007) found that higher levels of dependence on forests increases rates of participation whereas in areas with more heterogeneous social context and more commercial forest uses, the incentive for participation decreases with increase in level of dependence. Ownership of private woodlots is also an indication of personal interest in forest conservation hence a motivation for household participation in incentive schemes (Jumbe and Angelsen, 2007). According to Lise (2000), social indicators is the first consideration followed by economic indicators and that voluntary household participation is enhanced by good forest quality and high dependence on the forest resource. Overall, it is clear that most factors influencing household participation in incentive programmes are context specific hence vary significantly by location.

3.2.2 Impact of incentives on welfare and environment

Most CPR literature support the notion that due to over dependence on natural resources coupled with their high rate of time preference, poor people tend to harvest more resources from the commons while optimally ignoring the future environmental effects of current resource uses (Adhikari, 2005; Kabubo-Mariara, 2013). A number of studies have found that most incentives towards forest management have led to worse welfare outcomes for the poor. For example, Cooper

(2007), using CGE found welfare losses for all segments of the population but worse outcomes for the poor. However, Cooper (2008) found increases in welfare but greater inequality supporting findings by Jumbe and Angelsen (2006) who found contrasting welfare outcomes in Malawi but worse outcomes for the poor. Adhikari (2005) also posit that in absolute terms, poor households derive lesser benefit than less poor households from community forestry. According to Adhikari (2005), poor households may seek to minimize risks by using forest resources for consumption smoothing whereas the less poor may be driven by selfish interest of accumulating wealth by selling forest resources especially when there are greater market opportunities. These results are in tandem with Gelo et al. (2016) who found the impact of joint forest management with market linkages in Ethiopia to be biased upwards in favour of the upper end households in the income distribution. Moktan et al. (2016) also found worse welfare outcomes for poor households.

On the overall program impact studies such as Gelo and Koch (2014) using the inverse probability weighting approach to evaluate impact of the common property forestry program in Ethiopia found significant economic effects at household level but reduced livestock holdings. Ali et al. (2015) also found that on average participation in community forest management raises household welfare whereas, Mazunda and Shively (2015) found that participation in Malawi's Forest Co-management program had significant positive impact on conservation and household welfare. Blomley et al. (2007); Thoms (2008) and Takahashi and Todo (2012) have also shown that PFM arrangements contribute more to forest conservation.

A general overview of these studies reveals significant differences in applied definition, contextual factors and methodological approaches hence making comparison difficult. Although a reasonable body of literature has shown that community involvement in forest conservation has the potential of improving forest condition and welfare of forest-adjacent households (e.g. Mazunda and Shively 2015), there is limited evidence on whether the effect is as a result of existing incentives or just as

a result of level of organization and management at the community level. Similarly, the measurement of outcomes employed in these studies are also significantly different hence prone to measurement errors for instance some use household income which is prone to under reporting. Empirical evidence on the impact of PELIS on environmental conservation and welfare implication is also not clear despite its significance for sustainability of PFM. We therefore contribute to this literature by assessing the mean and heterogeneous impact of PELIS from a developing country perspective using Kenya as a case study. We take a different approach by first assessing the mean impact of the scheme on forest cover and welfare then assessing the impact of the scheme across the entire income distribution to assess the sustainability of the scheme in terms of equity from a micro perspective using household and community level data.

3.3 Theoretical framework

The framework is grounded in Roy (1951) occupational choice model. We assume that households decide whether to participate in PELIS or not based on option that maximizes their utility. If households expect to benefit from participating in the scheme, then we assume they will join the scheme. Treatment assignment is therefore non-random. In particular, we define V_{ij} the utility of household i =1...N in treatment regime j ={0,1}, with 1 representing participation in PELIS and 0 otherwise. Therefore, D_i=1 if $V_{i1} > V_{i0}$. Similarly define $\mathbf{Y_{ij}}$ as a vector of potential outcome variable. Where $\mathbf{Y_{i1}}$ is per capita expenditure and percentage forest cover for PELIS beneficiary households and CFAs respectively and $\mathbf{Y_{i0}}$ is per capita expenditure and percentage forest cover for non PELIS beneficiaries. The difference between $\mathbf{Y_{i1}}$and $\mathbf{Y_{i0}}$ can therefore be used to measure the differential impact on forest cover and household welfare.

In this study, we measure success in terms of household outcome and community level outcome that is per capita expenditure and forest cover (We define forest cover as the percentage of forested

area both plantation and indigenous of the total forest area under each CFA jurisdiction) respectively and measurement depends on counterfactual. According to Rubin (1973), we define program impact as the difference between the observed and the counterfactual outcome. The challenge is that the counterfactual is not observable and an individual or CFA cannot be in both states at the same time. To identify the counterfactual, we apply a quasi-experimental approach given that participation in PELIS is non-random. It is therefore essential to control for participation decision to identify the impact of the scheme. To examine the impact of this incentive, the study takes account of the fact that differences in per capita expenditure or forest cover for participant households or CFAs and non-participants could be due to unobserved heterogeneity. Failure to distinguish between the causal effects of participation in PELIS and effect of unobserved heterogeneity may therefore lead to misleading conclusion and policy implication.

PELIS has two possible levels of selection. In one level, households are deemed to be eligible only if they are members of CFAs and actively involved in CFA activities[63]. In another level eligible households are left to decide whether they want to participate in PELIS[64] by participating in a balloting exercise or first come first serve basis in some instances. Households are likely to participate if they expect the potential gains to exceed the costs. In addition, Poor households may be eligible but unable to raise the fee whereas richer households may capture the scheme and obtain more plots at the expense of active eligible but poor households. On the other hand, richer households may find the opportunity costs of participating in the scheme to be higher hence may consider other alternatives. Participation in PELIS is also potentially endogenous to per capita monthly expenditure. Some unobservable characteristics that influence the participation in PELIS could also influence per capita monthly expenditure e.g. household income or access to

[63] In some CFAs, there are also non-members who have PELIS plots we consider these as contamination and avoid them in the study.

[64] However, based on their interest, they can decide to join other forest user groups for example bee keeping, tree nursery, grazing or firewood collection groups.

information. Therefore, neglecting these selectivity effects is likely to give a false picture of the relative per capita monthly expenditure for beneficiaries and non-beneficiaries of PELIS. Hence the estimated causal effect may reflect not only the treatment effect but also differences generated by the selection process.

On the other hand, the decision as to which CFAs get to benefit from PELIS is solely at the discretion of KFS. The study therefore adopts a combination of econometric methods namely; the PSM and ordinary least square regression to determine the average treatment effect of participation in PELIS on per capita monthly expenditure and forest cover. However, OLS and PSM would yield biased estimates if there are unobservable determinants of participation. Control function methods or Instrumental Variable methods becomes essential in such instances (see Wooldridge, 2010). In addition, since PSM and OLS models focuses more on the mean outcomes, we employed the QTE model under endogenous assumption following Abadie et al. (2002) to implicitly explore the distributional impact of the scheme on household welfare while addressing the potential endogeneity to assess the sustainability of the scheme.

3.3.1 Propensity Score Matching

Theoretical and analytical framework.

The theoretical foundations follow Roy (1951) and Rubin (1974). Accordingly, households' or CFAs' decision to participate in PELIS is assumed to depend on expected benefits, as measured by per capita expenditure and forest cover (The better the forest cover the more the benefits) in adjacent forest resource, associated with either participating in the scheme or maintaining the status quo. The main interest is the average treatment effect on the treated (ATT). That is how benefiting from PELIS affect conservation and welfare of forest-adjacent communities. Since it is not possible

to observe what the results would have been in the absence of the incentive. To handle the missing data on counterfactual, we identified households, which are non-beneficiaries of the incentives and used them as counterfactual. Similarly, for forest cover we identified CFAs that were non-beneficiaries of PELIS and used them as counterfactual. Since assignment to PELIS is non-random there is high possibility of selection bias. To address these issues, we first employed the PSM technique to measure the mean impact on both forest cover and household welfare.

Identification strategy

Assuming a set of observable covariates X, which are unaffected by the treatment (Participation in PELIS), potential outcomes are independent of treatment assignment i.e., Conditional Independence Assumption (CIA)[65]. A further requirement is a sizable common support or overlap condition[66]. This condition ensures that households with the same X values have positive probability of being both participants and non-participants (Heckman et al., 1999).

If the CIA holds and there is sizable overlap (Heckman et al., 1999), then the next step is to find the PSM estimator. PSM was undertaken in two steps. The first step was generation of propensity scores from probit model using the household socio-economic and demographic characteristics, community level characteristics and other controls. The score indicates the probabilities of respective households/CFAs participating in the scheme. From the scores, we constructed a control group by matching the beneficiaries to non-beneficiaries according to their propensity scores by comparing various methods of matching. The second stage involved computation of the ATT of

[65] This assumption is rather strong and needs to be justified by the data quality at hand.

[66] This rule out the phenomenon of perfect predictability of T given X: (*Overlap*): $0 < P(T = 1|X) < 1$

households and CFAs benefiting from incentives on household welfare and forest cover respectively using the matched observations.

Model specification

The PSM estimator for the ATT is specified as the mean difference in Y (per capita household expenditure and forest cover as a percentage of total forest area under each CFA) over common support, weighting the comparison units by the propensity score distribution of participants. The cross-section estimator is specified as:

$$\tau_{PSM}^{ATT} = E(P(X)|T = 1)\ \{E\ [Y\ (1)\ |T = 1,\ P(X)] - E\ [Y\ (0)\ |T = 0,\ P(X)]\} \quad (11)$$

Where Y (1) and Y (0) represents per capita household expenditure and forest cover for beneficiary and non-beneficiary households/CFAs respectively. T=1 indicates treated/beneficiary households or CFAs while T=0 indicates control/non-beneficiary households or CFAs. The PSM estimator is thus given by the mean difference in outcomes over the common support weighted by the propensity score distribution of participants[67] (Caliendo and Kopeinig, 2008). To determine the heterogeneous effect of the scheme on household welfare, and due to the restrictive identification condition, selection issues and potential endogeneity, the study also employed the use of the conditional QTE model under endogenous assumption described in the next section.

3.3.2 Quantile Treatment Effects Model

Measures of mean impact may not provide the true picture of the effect of the scheme, it is therefore essential to determine the heterogeneous impact of the scheme to assess the sustainability of the

[67] According to Caliendo and Kopeinig (2008), inclusion of non-significant variables cannot lead to inconsistent or biased results. We thus used all the variables in the PSM probit in the outcome analysis.

scheme in providing the double dividend[68]. To determine the distributional impact of the scheme on household welfare, the study employed the parametric conditional QTE model under endogenous assumption following Abadie et al. (2002) and Chernozhukov and Hansen (2008).

Analytical Framework

Given a continuous outcome variable Y, we consider the effect of a binary treatment variable D (participation in PELIS or not). Let $Y_i^1$and Y_i^0 be the potential outcomes of household i that is per capita monthly expenditure. Hence, Y_i^1would be realized if household i participated in PELIS and Y_i^0would be realized otherwise. Define Y_i as the observed outcome, which is $Y_i = Y_i^1 D_i + Y_i^0(1-D_i)$. We estimate the entire distribution functions of Y^1 and Y^0 (Frölich and Melly, 2010).

We then define QTE conditionally on covariates as we deal with the endogenous treatment choice since in our case, selection is unobservable meaning that treatment assignment is non-ignorable. Participation in PELIS is also potentially endogenous to per capita expenditure[69]. The traditional quantile regression may therefore be biased hence the need for an instrumental variable (IV) to recover the true effects. Key concerns with respect to instrumental variables are, weak instruments and over identification[70]. In addition, if the instruments affect participants in different ways interpreting the resulting treatment effects may be complicated that is treatment effects heterogeneity (Frölich and Melly, 2010). The exclusion restriction is however difficult to test as in all IV applications.

[68] That is, improving household welfare and forest cover.

[69] Participation in PELIS is mostly influenced by household income which also directly influences per capita expenditure for both participants and non-participants. This implies that, systematic differences in the distribution of per capita expenditure between participants and non-participants may reflect both differences generated by the selection process and the effect of treatment.

[70] A 2SLS that contains weak instruments is not identified hence instruments treatment effect not valid (Stock and Yogo, 2005).

Assuming we observe a binary instrument Z, we define two potential treatments denoted Dz. We then make use of several assumptions[71] underlying the potential outcome framework for IV with probability one as in Abadie et al. (2002). In addition to these assumptions, "individuals with $D_1 > D_0$ are referred to as compliers. Treatment can be identified only for this group, since the always and never participants cannot be induced to change treatment status by hypothetical movement of the instrument" (Frölich and Melly, 2010). Following Abadie et al. (2002), the conditional QTE δ^{τ} for the compliers is estimated by the weighted quantile regression:

$$(\hat{\beta}^{\tau}{}_{IV}, \hat{\delta}^{\tau}{}_{IV}) = \underset{\beta,\delta}{argmin} \sum W_i^{AAI} . \rho_{\tau}(Y_i - X_i\beta - D_i\delta)$$
$$W_i^{AAI} = 1 - \frac{D_i(1-Z_i)}{1-Pr(Z=1|X_i)} - \frac{(1-D_i)Z_i}{Pr(Z=1|X_i)} \quad (12)$$

To implement the estimator, we first need to estimate $\Pr(Z=1|X_i)$. $\rho_{\tau}(u)$ is the check function, where $\rho_{\tau}(u) = u \times \{\tau - 1(u < 0)\}$. This is estimated using the ivqte command in stata since it produces analytical standard errors that are consistent even in case of heteroscedasticity (Frölich and Melly, 2010). Given that some weights may be negative or positive, the ivqte stata command uses the local logit estimator and implements the AAI estimator with positive weights. An alternative provided by Abadie et al. (2002) shows that the following weights can be used as an alternative to W_i^{AAI}. Where $W_i^{AAI+} = E[W^{AAI}|Y_i, Di, X_i]$. Which are always positive. ivqte uses the local linear regression to estimate W_i^{AAI}.

[71] Namely, (i) Independence: Y^0, Y^1, D_0, D_1 is jointly independent of Z given X: implies that conditioned on a set of covariates, the instrumental variable should not affect the outcome of individual except through the treatment channel, (ii) Exclusion: $Pr(Y^1 = Y^0|X) = 1$, (iii) Non Trivial Assignment: $0 < Pr(Z = 1|X) < 1$: Requires existence of propensity score of the instrument, (iv) First Stage: and $E[D_1|X] \neq E[D_0|X]$ and (v) Monotonicity: $Pr(D_1 \geq D_0|X) = 1$: Requires that the treatment variable D either weakly increases or decreases with the instrument Z for all i(Abadie et al., 2002).

Identification Strategy

To determine QTE in equation 3, we used one binary variable as an instrument that is, being born in the village or not. This is used to show the households intention to participate in PELIS or not. Being born in a given village is assumed to determine participation in PELIS but cannot affect household per capita expenditure directly except through participation in PELIS. The motivation for the choice of instruments is based on Maslow's "self-actualization" theory (see Maslow, 1943). According to Maslow (1943), once an individual's psychological needs[72] are satisfied, their safety needs takes precedence and dominates behavior. Therefore, in the absence of economic security, due to say, economic crisis, and lack of job opportunities, these safety needs manifests themselves in the form of preference for job security. Therefore, we posit that when one is born in a given village, with the urge for a sense of belonging and acceptance by their peers, desire for respect (i.e., need for self-esteem and self-respect) and to be valued by others, people tend to venture into different professions or hobbies to gain recognition. Such activities give people a sense of contribution and value in a society. Individuals therefore, tend to achieve the "self-actualization" in attaining some higher goals outside one-self in altruism and spiritually (Maslow, 1991). In that endeavor, they are less likely to participate in schemes such as PELIS. Moreover, at community level when one is born in a given place, the routine often becomes monotonous (you have been born and bred around the forest you therefore see nothing new in it. Rarely will you appreciate the resource compared to someone who was not born in that community), you have always grazed in the forest, fetch firewood etc. The urge to do better in society pushes people to venture into new fields outside the normal activities within the community hence will often rarely participate in forest conservation activities like PELIS[73]. Farming may also be considered low life by peers and

[72] These needs are the physical requirements for human survival e.g., air, water, food etc.

[73] A similar argument can be based on the fact that unless constrained by say inadequate income, one would rarely want to attend a high school next to his home if he has been born and has attended say primary education in the same village. People would tend to go to areas far away from

hence a drive to seek their own identity and stand out in society. Incentives such as PELIS may therefore be unattractive hence indirectly affects household welfare.

The Mau forest area is very agriculturally productive and surrounded by different ethnic communities consisting of natives and immigrants hence often a hot spot of post-election violence as the real natives' clash with the non-natives whom they feel have encroached into their ancestral lands in case the election results are not in favor of the natives. There are also squatters from other areas who live in the market centers around the forest with the aim of joining the CFAs so that they can get access to agricultural land in the forest, most of them normally have no alternative homes elsewhere. However, it is important to note that, within the African setting, one may have been born in a given village but is actually an immigrant from another province based on where their parents or great grand parents came from[74]. Therefore, one born within the Mau forest area who has always enjoyed the benefit from the forest will not see any difference compared to a person born in a different area where they had no productive agricultural land but the presence of the forest provides a better source of livelihood. A Potential criticism of the instrument could also be due to unobservables. To minimize the bias, we considered conditioning this instrumental variable on distance to the nearest edge of the forest[75] and other set of covariates[76] to authenticate the validity of the instrument. We also conditioned the instrumental variable on household income due to the fact that one may be born in a given village, but the household income may or may not enable them to participate in PELIS therefore influencing their per capita expenditure this also enables the

where they were born for a change because they may not appreciate the school neighboring them or would just prefer a change to attract some admiration from the society as a show of achievement.

[74] Within the African context, natives are considered those whose ancestors were the original occupants and were buried in that area. Therefore, they cannot marry from the same clan since they are considered one family because they are from the same ancestral descendant. They can however marry immigrants from other areas who have settled in their villages but not the natives of that area. There are also natives who have intermarried with immigrants. For female headed households, if never married we noted the residential status and whether was born in the area or not. However, if a widow we noted the residential status as well as place of birth of the spouse.

[75] It is important to note that, one may be born or not in a given village but the cost of extraction of the resource may be higher for households far away from nearest edge of the forest than closer households hence this may influence their participation in PELIS as well as per capita expenditure and household income.

[76] Distance to main road, distance to nearest market, years of education household land size, household size, household wealth, number of children, household income, age and sex of household head, employment status of household head, residential status, membership to other environmental organizations and institutional variables like level of participation in CFA activities.

authentication of the instrument's validity. Due to the fact that few households would be willing to provide their exact household income, we gave a range of incomes to select from after which we computed the median monthly household income.

3.4 The Survey Design and Data Collection

A pilot study involving 44 households was first conducted in October 2015 in Londiani CFA of Kericho County. Information gathered was used to refine the instrument that was eventually used in the final survey. The survey was conducted in the months of November and December 2015. In the final survey, we used a two-stage sampling procedure in data collection. In the first stage a sample of 22 out of 35 CFAs were purposively identified to reflect the entire Mau forest and also to identify CFAs that do not participate in PELIS. This was conducted with the help of head of Mau forest conservancy[77]. The CFAs covered five counties of Bomet, Narok, Kericho, Nakuru and Uasin Gishu. The CFAs were a representation of the entire Mau forest. They also provide the variation by regions especially in terms of geographical and climatic variables.

All the CFAs sampled were well established, and the duration of existence varied thus giving a better understanding of the impact of this incentive. The 22 CFAs covers about 164,645 hectares of the Mau forest. The CFAs are constituted of CBOs or FUGs with membership drawn from residents of forest-adjacent communities (own survey from pilot). Table B.5 in the appendix shows the distribution of PELIS adopters and non-adopters. From Table B.5 it is clear that some CFAs had as low as four or five households sampled this was attributed to lack of cooperation from CFA officials and inaccessibility of some areas due to the terrain and bad weather conditions. However, some CFAs do not totally participate in PELIS e.g., Likia, Sururu, Nyangores, Baraget, Nairotia

[77] Although it is possible that the head of conservancy may have referred us to CFAs that were doing well, we can confirm that this was not the case since we also got to visit some CFAs that were in total mess. The choice of CFA was based on total representation of the entire forest and ease of accessibility since some areas are very difficult to access due to terrain and lack of motorable roads.

Olenguruone and Manengai this was basically due to their reluctance to adopt the scheme and dominance of pastoral activities in areas such as Likia and Nairotia that were mainly inhabited by the Maasai community. Some do not benefit from the scheme because they are not part of the KFS plan for PELIS roll out. The CFA level data were collected through focus group discussion with CFA officials and other members at their offices in the forest station.

Second step, was to select a sample of households within the selected CFAs. Since we were only interested in CFA members, this exercise was conducted using simple random sampling where every third household was interviewed and in cases where the membership was small snow balling approach was adopted especially where the third household was a non-member. Trained enumerators were guided by village elders or representatives selected by the CFA officials during the focus group discussion. Each group was prepared in advance.

3.5 Data

A total of 406 households were sampled (178 non-PELIS beneficiary households and 228 PELIS beneficiary households)[78]. Household heads provided information on household socioeconomic characteristics, such as income, age, gender, consumption expenditure, education, size of households, household land size, distance to nearest, market, road and edge of forest etc. At the CFA level, additional information relating to forest cover under each CFA, geographic and climate variables, participation and attendance of CFA meetings and other CFA level variables were also gathered through focus group discussion with CFA officials at the CFA offices based at each forest station. Forest cover is secondary data available in each forest station and regularly updated by the

[78] To identify the impact of the scheme at the household level, we considered households that had benefited from the scheme for at least two years and above. We considered the fact that two years was enough for the incentive to make a change in household welfare and forest cover as well.

foresters. It is important to note however, that this is measured at CFA level and not household level.

To assess the impact of PELIS on forest cover, we identified CFAs that did not totally participate in PELIS as controls of which seven were identified namely, Likia, Sururu, Nyangores, Nairotia, Baraget Olenguruone and Manengai constituting a sample of 130 households. We also identified CFAs that were beneficiaries of PELIS as our treatment. We considered CFAs in our sample that had fifteen households and above as beneficiaries. Six CFAs were further identified namely, Bahati, Koibatek, Esageri, Malagat, Kericho and Makutano constituting a sample of 137 households (where 128 households benefited from PELIS and 9 did not). We posit that the more PELIS beneficiaries a CFA has the higher the likelihood of improved forest cover hence the motivation for selecting CFAs with more beneficiaries of the scheme in our sample[79].

Households that participate in PELIS get to sell their agricultural produce in the local markets therefore earning income. With a rise in income the household expenditure is expected to rise due to increased purchasing power. We therefore expect an improvement in welfare with an increase in per capita expenditure. We therefore measured household welfare using per capita monthly expenditure to proxy for household monthly income. We acknowledge the fact that PELIS only influence revenues from harvested agricultural produce apart from other indirect effects like increase in livestock values. Some studies have used income from non-timber forest products (e.g. Adhikari 2005; Jumbe and Angelsen 2006; Kabubo-Mariara 2013) as opposed to per capita expenditure as a measure of household welfare. Since forest-adjacent communities are often poor (some without alternative agricultural land) and almost fully reliant on forest for their livelihood either directly or indirectly, use of per capita expenditure would still provide a good proxy for their

[79] Some CFAs did not have higher numbers in PELIS due to low uptake or differences in preferences. Most households joined user groups that they felt they would benefit most e.g., firewood, bee keeping, grazing etc. Hence in swampy areas, even if the CFA has PELIS, few households would hope for the scheme since it involves a lot of work reclaiming the land.

welfare[80]. Therefore, using per capita expenditure would still provide a better picture on the impact of the scheme than just considering income from forest harvests alone[81].

The choice of consumption expenditure is also based on the fact that households are prone to under reporting their monthly income. Secondly, per capita expenditure is also easily interpreted and widely used (see Skoufias and Katayama 2011; Gelo and Koch 2014; Gelo et al. 2016). Consumption expenditure also provides information over the consumption bundle that fits within the household's budget although this may be affected by different micro finance institutions that are enabling easy access to credit facilities among village households or even smaller women groups "chamas". We aggregated household expenditure on food supplies, education, farming and livestock, clothing and apparels, medical and other miscellaneous expenses incurred by the household. This was reported on annual basis since some expenses like education[82] were paid on annual basis. A total of the expenses was used to calculate the per capita monthly expenditure (Monthly expenditure was preferred due to ease of recall of most monthly expenses by respondents). Annual average rainfall and temperature values for the various forests were collected from the website (http://en.climate-data.org/country/124/). This data was available for most forest stations and for the ones that had no data we used the nearest weather station recorded climate data. We considered the climate variables due to the fact that the CFAs are large in sizes hence the climate variables vary significantly. A description of the variables is presented in Table 7.

[80] Moreover, in some instances even if a household does or does not benefit from PELIS, they could still be employed as casual laborers by the wealthier households that own plots in the forest to tend to their farms for some wages which they can expend on other requirements.

[81] During the survey, we noted that some very rich households, owning big shops at the shopping centres also had plots in the forest yet they were not registered members, but just used their influence to buy their way into the forest. We did not consider such cases as beneficiaries. The study only focused on registered CFA members. There are also CFA members who lease out their plots to non-members who are willing to pay higher amounts to farm in the forest. We avoided such beneficiaries in the study.

[82] We included expenses on items like education because during the survey most households attributed the benefit of PELIS as for them having been able to educate their children with ease using the income from sale of agricultural produce from PELIS plots.

Table 7: Description of Variables

Variable	Definition
Dependent variables	
PCMonthlyExp	Per capita Monthly Expenditure
Forestcover	Forest Cover expressed as a percentage of total forest size under each CFA
Explanatory variables	
HHWealth	Total value of household asserts (land, farm animals, agricultural implements, farm produce etc)
PELIS	Dummy=1 if household owns a PELIS plot and 0 otherwise
HHsex	Dummy=1 if Male and 0 if female
Numbchild	Number of children
BornVil	Dummy=1 if born in the village, 0 otherwise
MedAge	Age of the household head (Median age calculated from the categorical variables)
hhsize	Number of people in the household including household head
MaritSta	Dummy=1 if married, 0 not married
Education	Dummy=1 if household head has post primary education and 0 if household head has up to primary education
ResidStatus	Dummy=1 if household head is a native, 0 if household head is an immigrant/settler
HHEducyrs	Years of education
Multilingual	Dummy=1 if speaks more than two languages, 0 if speak two or less languages
Employment Status	Dummy=1 if employed in off farm, 0 if self-employed i.e farming
LandTitle	Dummy=1 if Own title for household land, 0 otherwise
MedIncome	Median monthly income for the household in the last month
Woodlots	Dummy=1 If the household owns a woodlot, 0 otherwise
CFAMeeting	Dummy=1 If father represents the household in CFA meetings, 0 if Mother represents the Household
CFAParticipation	Dummy=1 If the household is active in participation in CFA activities, 0 if passive
Hsepartic	Dummy=1 if household participates in CFA activities, 0 otherwise
Hlandsize	Size of household land
Hownership	Dummy=1 if the household head owns the house, 0 otherwise
DistMroad	Distance from household to the nearest motorable road in km
DistMarket	Distance from household to the nearest market using in km
DistForest	Distance from household to the nearest edge of the forest in km
Membership	Dummy=1 if a member of other environmental organizations (e.g. CBOs), 0 otherwise
Temperature	Annual average temperature in degrees Celsius
Precipitation	Average Annual precipitation (mm)
Elevation	Level of Elevation in each forest (meters)

3.6 Results and Discussion

This section present results from the different empirical approaches employed in the study. The first section presents the descriptive statistics of the household and CFA level variables employed

in the study. The next sections present the results of the ordinary least squares, PSM technique and the QTE model respectively.

3.6.1 Descriptive Statistics

The summary statistics are presented in Table 8. From Table 8, as expected, mean monthly per capita expenditure for PELIS beneficiaries was higher than non-beneficiaries. The percentage forest cover under CFAs with PELIS beneficiary household was also found to be higher than the non PELIS beneficiaries. The summary statistics of other variables used in the study are also presented.

Table 8: Summary Statistics

	Total Sample			PELIS Beneficiaries			Non PELIS Beneficiaries		
variable	**N**	**Mean**	**sd**	**N**	**Mean**	**sd**	**N**	**Mean**	**sd**
Dependent									
PCMonthlyExp	406	2186	1615	228	2405	1939	178	1905	1003
Forestcover	267	77.64	14.23	137	79.54	10.47	130	75.64	17.15
Explanatory									
HHWealth	406	1.269e+06	1.759e+06	228	1.257e+06	2.043e+06	178	1.284e+06	1.311e+06
HHsex	405	0.780	0.415	227	0.767	0.424	178	0.798	0.403
Numbchild	406	4.865	2.701	228	5.171	2.729	178	4.472	2.619
BornVil	405	0.585	0.493	228	0.531	0.500	177	0.655	0.477
MedAge	406	48.14	13.73	228	49.29	12.70	178	46.67	14.85
hhsize	406	5.798	2.631	228	6.110	2.729	178	5.399	2.450
MaritSta	406	0.869	0.337	228	0.895	0.308	178	0.837	0.370
Education	406	0.360	0.480	228	0.351	0.478	178	0.371	0.484
ResidStatus	406	0.574	0.495	228	0.570	0.496	178	0.579	0.495
Hsepartic	406	0.904	0.295	228	0.908	0.290	178	0.899	0.302
Employment	406	0.241	0.428	228	0.167	0.373	178	0.337	0.474
LandTitle	406	0.522	0.500	228	0.513	0.501	178	0.534	0.500
MedIncome	406	15788	20503	228	17862	25993	178	13132	9097
HHEducyrs	406	8.404	3.639	228	8.329	3.556	178	8.500	3.751
Woodlots	406	0.850	0.358	228	0.912	0.284	178	0.770	0.422
CFAParticipation	406	0.623	0.485	228	0.697	0.460	178	0.528	0.501
Hownership	406	0.904	0.295	228	0.917	0.277	178	0.888	0.317
DistMroad	406	1.926	2.696	228	2.485	2.983	178	1.211	2.073
DistMarket	406	3.368	3.537	228	3.885	3.504	178	2.707	3.478

DistForest	406	1.481	1.478	228	1.406	1.408	178	1.578	1.561
Hlandsize	406	2.519	5.682	228	2.473	7.020	178	2.578	3.263
Membership	406	0.0690	0.254	228	0.0702	0.256	178	0.0674	0.251
Temperature	406	15.05	1.776	228	15.51	1.726	178	14.46	1.667
Precipitation	406	1164	181.4	228	1197	183.2	178	1122	170.7
Elevation1	406	2444	233.4	228	2402	254.8	178	2499	189.9

3.6.2 OLS Estimation Results

Before we proceeded to estimate the PSM and QTE models, we considered a simple approach to tease out the impact of adoption of PELIS on household welfare and forest cover using the OLS model of per capita monthly household expenditure and forest cover that includes PELIS as a dummy variable equal to 1 if household or CFA participated in PELIS and 0 otherwise. The OLS regression results are presented in Table 9 Columns (1) and (2) for per capita monthly expenditure and forest cover respectively. We can conclude from the results that participation in PELIS increases per capita monthly household expenditure by approximately ksh. 555.30 (USD5.553) and forest cover by approximately 9.4% for beneficiary CFAs all factors constant (the coefficient of PELIS dummy is significant at 1%).

Table 9: OLS Estimation Results of Impact of PELIS on Forest Cover and Per Capita Expenditure

	(1)		(2)	
VARIABLES	PCMonthlyEXP	s.e	Forestcover	s.e
PELIS	555.3***	(151.8)	9.380***	(1.937)
HHsex	165.0	(205.4)	2.448	(2.494)
MedAge	35.22	(31.46)	-0.245	(0.368)
MedAgesq	-0.348	(0.281)	0.00195	(0.00323)
hhsize	-270.1***	(33.55)	0.549	(0.404)
MaritSta	-573.2**	(257.9)	-4.193	(3.044)
Education	711.6***	(151.0)	-1.230	(2.126)
ResidStatus	-263.0*	(146.8)	-5.119***	(1.770)
EmploymentStat	-295.9	(180.1)	5.532***	(2.027)
Numbchild	30.80	(37.30)	0.420	(0.452)
Woodlots	-128.1	(207.4)	1.932	(2.632)
Hownership	-85.75	(254.9)	2.395	(3.125)
Membership	349.8	(278.1)	0.126	(2.935)
DistMarket	-16.12	(24.64)	-0.126	(0.300)

DistForest	-137.1***	(48.57)	-1.718***	(0.616)
DistMroad	84.53**	(33.87)	-0.195	(0.429)
Hsepartic	-213.9	(239.9)	-2.315	(3.468)
Multilingual			2.331	(2.109)
Temperature			-3.033***	(0.627)
Precipitation			0.00500	(0.00537)
Constant	3,255***	(803.4)	119.4***	(12.24)
Observations	405		267	
R-squared	0.292		0.236	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

However, participation in PELIS is voluntary and may be based on self-selection. CFAs or households that participate in PELIS may also have systematically different characteristics from non-participants since their participation may be based on anticipated benefits. Unobservable characteristics of households or CFAs may also affect both participation decision and household per capita monthly expenditure and forest cover under CFA. Ignoring all these factors may result in biased and inconsistent estimates of the impact of the incentive[83]. Since participation in PELIS was not purely random, we considered the PSM technique to estimate the mean impact on forest cover and household welfare and the endogenous QTE model to assess the distributional impact of the scheme on household welfare as we address the selectivity and endogeneity issues.

3.6.3 Propensity Score Matching Estimation Results

For PSM the key assumption of unconfoundedness and overlap must be met hence the need for an initial balance test. Our descriptive statistics in Table B.1 suggests wide differences between participants and non-participants of PELIS. To match and balance the data we estimated a probit regression of participation or non-participation in PELIS. There is no consensus in published literature whether to include the significant variables or all prior variables as predictors of

[83] Another major drawback of OLS is that, it does not account for potential structural differences between the per capita monthly expenditure and forest cover for households and CFAs that participated in PELIS and those that did not.

propensity scores[84] (Rubin, 1979; Austin et al., 2007). The propensity score estimates at the household level and CFA levels are presented in Table 10[85].

Table 10: Propensity Score Estimates of PELIS adoption

	Household Level				CFA Level			
VARIABLES	Coefficients	s.e	Marginal Effects	s.e	Coefficients	s.e	Marginal Effects	s.e
MaritSta	0.152	(0.219)	0.0469	(0.0673)	0.207	(0.306)	0.0526	(0.0776)
Numbchild	-0.00508	(0.0292)	-0.00156	(0.00899)	-0.0260	(0.0417)	-0.00660	(0.0106)
BornVil	-0.610***	(0.152)	-0.188***	(0.0442)	-0.701***	(0.205)	-0.178***	(0.0491)
hhsize	0.0178	(0.0313)	0.00550	(0.00964)	-0.00366	(0.0439)	-0.000929	(0.0111)
EmploymentStat	-0.622***	(0.182)	-0.192***	(0.0534)	-0.880***	(0.256)	-0.223***	(0.0604)
MedIncome	1.85e-05***	(6.29e-06)	5.68e-06***	(1.88e-06)	3.46e-05***	(1.11e-05)	8.77e-06***	(2.67e-06)
Woodlots	0.450**	(0.206)	0.138**	(0.0625)	0.364	(0.337)	0.0923	(0.0850)
CFAParticipation	0.209	(0.151)	0.0643	(0.0462)	0.207	(0.207)	0.0524	(0.0524)
DistMroad	0.109***	(0.0367)	0.0337***	(0.0110)	0.257***	(0.0591)	0.0653***	(0.0136)
DistMarket	0.0126	(0.0271)	0.00388	(0.00833)	-0.00228	(0.0382)	-0.000578	(0.00970)
DistForest	-0.0722	(0.0478)	-0.0222	(0.0146)	-0.0671	(0.0696)	-0.0170	(0.0176)
Temperature	0.151***	(0.0578)	0.0464***	(0.0174)	0.210**	(0.105)	0.0533**	(0.0260)
Elevation1	-0.000720*	(0.000422)	-0.000222*	(0.000128)	-0.00232***	(0.000864)	-0.000588***	(0.000210)
Precipitation	0.00106**	(0.000460)	0.000326**	(0.000140)				
Constant	-2.164	(1.729)			1.698	(3.437)		
Observations	405		405		266		266	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The probit estimation results at household and CFA levels show that holding other factors constant, those born in a given village are less likely to participate in PELIS and that household heads employed in off farm jobs are also less likely to participate in PELIS given that with alternative sources of income protecting them from fluctuations in agricultural productivity, households may be less dependent on forests hence, less likely to participate in PELIS. However, the higher the

[84] However, we identified appropriate covariates from the collected socioeconomic and institutional variables taking into account economic theory and the condition that covariates should influence the household decision to adopt PELIS and the outcome variables simultaneously but at the same time unaffected by the treatment (see Heckman et al. 1998).

[85] At the household level, we consider all the 406 households but one household was dropped due to incomplete observation on Bornvil variable hence the sample of 405 households. At the CFA level, we considered 7 CFAs that did not benefit from PELIS (the controls) that is Menengai, Likia, Sururu, Nyangores, Nairotia, Baraget and Olenguruone constituting 130 households and 6 CFAs that benefited from PELIS (the treated) and had fifteen or more households benefiting they are namely; Bahati, Koibatek, Esageri, Malagat, Kericho and Makutano constituting 137 households. The household that had missing information on BornVil variable from Likia was also dropped from the analysis hence leading to a total sample of 266 households (138 controls and 128 treated).

income the more likely a household is to participate in PELIS supporting findings by Agrawal and Gupta (2005). In addition, the farther the distance from the main road the household is, the higher the likelihood of participation in PELIS. This suggests that opportunity cost associated with distance matters. Thus, contradicting findings by Agrawal and Gupta (2005) that household likelihood of participation increases if households can easily access government offices concerned with the CPR. In terms of climate and geographical variables, a rise in average temperature increases the likelihood of participation in PELIS whereas the higher the elevation the lower the likelihood of participation in the scheme. The negative influence of elevation could be due to inaccessibility of most forest areas. However, at household level, the higher the precipitation the higher the likelihood of participation in the scheme. This is due to the fact that with higher precipitation, the anticipated benefits from farming are also higher. The results also suggest that at the household level, those who own private woodlots are more likely to participate in the scheme supporting findings by Jumbe and Angelsen (2007) that participation of most households owning woodlots is motivated by personal interests. Precipitation was however not included at the CFA level due to lack of convergence[86]. These results also correlate to the mean differences reported in Table B.1. We therefore need to correct for these characteristics. These factors therefore significantly influence household decision to participate in the scheme. From the p scores, the estimated probability of participating in the scheme was estimated to be 55.9%.

Performance of Matching Estimators

We considered a range of matches namely the nearest neighbor matching, radius matching, and kernel matching[87]. However, we selected the matches that resulted in highest number of balanced covariates and large sample size within the common support as presented in Table B.2. The kernel

[86] We tried to tease out the determinants of households' participation in PELIS at both CFA and household levels to assess the robustness of our household level determinants which was the main interest.

[87] It is important to note that, the choice of matching algorithm often involves a trade-off in terms of bias and efficiency.

density showing the common support before and after matching is shown in Figure B.1 in the appendix. The figure shows a considerable magnitude of overlap after matching. Table B.2 presents the quality and performance of the matches selected out of the different matches used. The Columns of interest are labelled (1) & (2) and (6) & (7). Fourteen and thirteen explanatory variables were used at the household level and CFA level analysis respectively[88].

Matching Based treatment effects on PELIS beneficiaries

We present the estimated ATT in Table 11. The ATT were estimated for household welfare and CFA forest cover using psmatch2 command in stata (Leuven et al., 2015). The Columns of interest are labelled ATT and t-stat.

Table 11: Matching based Treatment Effects on PELIS beneficiaries

Per Capita Monthly Expenditure				**Forest cover**		
Estimator	ATT	S.Dev	t-stat	ATT	S.Dev	t-stat
NN (4)	597.02	192.32	3.10***	5.71	3.33	1.71*
NN (5)	589.65	197.55	2.98***	5.53	3.31	1.67*
Radius (0.0025)	363.48	204.68	1.78*	7.73	4.10	1.88*
Radius (0.005)	678.36	211.28	3.21***	7.94	3.30	2.40**
***<0.01, **<0.05, *<0.1						

The results show that PELIS has significant (both economically and statistically) positive impact on household welfare and forest cover. The average impact of the scheme on PELIS beneficiaries' per capita monthly expenditure was estimated at between ksh. 363 (USD 3.63) and ksh. 678 (USD

[88] A balance test of fourteen and thirteen variables in Column (1) and (6) suggests complete balance in matching. Whereas, the pseudo R squared in Column (2) and (7) shows the explanatory power for the re-estimated propensity score model after matching. From literature, a number of criteria have been suggested to gauge the performance of matching estimators. The criteria include: checking if after matching the significant mean difference across covariates remains. An alternative involves re-estimating the probit regression using the matched sample (see Sianesi, 2004). There should be no systematic differences between the covariates after matching hence the pseudo R squared should be low (Caliendo and Kopeinig, 2008). A likelihood ratio test of joint significance should also be rejected before matching but not after.

6.78). Based on the average per capita monthly expenditure for households benefiting from PELIS which is Ksh. 2,409 (USD 24.09), this accounts for between 15.09% and 28.14%. The impact of the scheme on forest cover was estimated at between 5.53% and 7.94%. However, since we included even the covariates that remained significantly different even after matching (i.e., distance to market, precipitation and temperature) in the outcome analysis, to assess the robustness of the PSM estimates, we also run a matched regression with controls (We find impact on per capita expenditure to be between Ksh. 436 (USD 4.36) and Ksh. 525 (USD 5.25) whereas, on forest cover it was estimated between 4.67% and 7.27%)[89]. It is also important to note that, matching is based on the unconfoundedness assumption which is not testable. We therefore conducted a sensitivity analysis of the matching estimates.

Sensitivity Analysis of the Matching Estimates

PSM is based on the assumption that the researcher should be able to observe all variables simultaneously influencing decision to participate in PELIS and the outcome variable (unconfoundedness or the conditional independence assumption) otherwise, the matching estimators may not be robust due to the hidden bias (Rosenbaum, 2002). Estimating the extent of selection bias is quite complex especially due to the fact that we used non-experimental data. We therefore employed Rosenbaum (2005) bounding approach to test for robustness of the matching estimates to unobserved variables. Following Rosenbaum (2005) bounding method we examined the sensitivity of the match based treatment effects estimates with respect to potential deviations from conditional independence. The sensitivity analysis results are presented in Table B.3[90].

[89] We find that the results for the matched regression and the PSM are not any different. These results are however not presented in this paper since they were used to assess the robustness of our PSM estimates.

[90] The first column contains the log odds of differential assignment due to unobserved heterogeneity, the second to fifth columns, contains the upper and lower bound significance levels respectively for the key outcome variables namely per capita monthly expenditure and percentage forest cover. The second to fifth columns examines the match based treatment effect for each measure of unobservable potential selection bias. The lower bounds are of no interests since they hold under the assumption that the true ATT is underestimated but our ATT estimates are positive (Becker and Caliendo, 2007).

Looking at our sensitivity analysis results in Table B.3, for per capita expenditure, at Γ=1.2 and 1.3 the results will not be significant at 1% and at Γ=1.4 the result is also not significant at 10% with p-value of 0.150. Whereas for forest cover, at Γ=1.1 the result will not be significant at 10% with a p-value of 0.158. This suggests that unobserved covariates would cause the odds ratio of treatment assignment to differ between the participants and nonparticipants once we reach a specific Γ level. From these results, we can infer that the results to some extent reveals some levels of selectivity bias[91].

Due to possibility of selection bias, to ascertain the robustness of our PSM estimates, we also employed instrumental variables estimation technique following Lewbel's heteroscedasticity-based instrumental variable technique (see Lewbel (2012)) to test and address the potential endogeneity of participation in PELIS on per capita household expenditure and forest cover[92]. Based on this approach, our results in Table B.6 revealed that, PELIS has significant positive impact on household per capita monthly expenditure estimated at Ksh. 1270 (USD 12.70) hence raising welfare for the average household by about 58%. On the other hand, the estimated impact of PELIS on forest cover was approximately 4.23% holding other factors constant[93]. These findings therefore resonate well with the results from our PSM estimates although the impact on household welfare was found to be slightly higher compared to the PSM estimates[94].

[91] According to Becker and Caliendo (2007), the critical of say Γ= 1.4 for per capita expenditure and 1.1 for forest cover is not an indication that unobserved heterogeneity exists and that there is no effect of the treatment on the outcome variable. The unconfoundedness assumption therefore cannot be justified using this test hence we cannot state whether the CIA assumption holds or not. The result just indicates that if any unobserved variable caused the odds ratio of treatment assignment to differ between treatment and comparison groups by say Γ=1.4 for per capita expenditure, then the confidence interval for the treatment effect would include zero (see Becker and Caliendo 2007).

[92] The main advantage of this approach is that, it provides options for generating instruments and allows the identification of structural parameters in models with endogeneity or mis-measured regressors when we do not have external instruments. The approach is also capable of supplementing weak instruments. Identification is consequently achieved by having explanatory variables that are uncorrelated with the product of heteroscedastic errors (see Lewbel (2012)).

[93] In the two models, we first tested for endogeneity using the Durbin-Wu-Hausman tests for endogeneity and control function approach under the null hypothesis that the variables are exogenous. The test rejects the null hypothesis of exogeneity at 1% significance level for the two models. We also carried out performance statistics for the IV models. We tested for, underidentifcation based on Kleibergen-Paap rk Lm statistics, weak identification using the Donald Wald F statistics, and the Hansen J statistics under the null hypothesis that the instruments are valid. The models passed all the tests hence proving that the heteroskedasticity-based IV estimates would yield reliable estimates.

[94] It is also important to note that we also arrive at similar conclusion when we used the endogenous switching regression model.

3.6.4 Quantile Treatment Effects Model

To examine the impact of the scheme across the income distribution, the study adopted the endogenous QTE model. Since participation in PELIS is potentially endogenous to per capita expenditure, we first tested for endogeneity of participation in PELIS (our treatment variable). The control function approach was used to test for endogeneity. The approach is conducted in two stages. In the first stage, the endogenous variable which in our case is PELIS was regressed on the instrumental variable BornVil (i.e a dummy variable whether the household head is born in a given village or not) and other explanatory variables and the predicted residuals saved[95]. In the second step, the outcome variable (per capita expenditure) was regressed on the endogenous variable, other explanatory variables and the residuals[96](Wooldridge, 2010). Using this test, the null hypothesis of exogeneity is rejected with a pvalue of 0.055[97]. In light of evidence of endogeneity of participation in PELIS, we proceeded to estimate an endogenous QTE model to handle selection bias and solve the endogeneity problems. The results of the endogenous QTE model following Abadie et al. (2002) are presented in Table 12.

[95] We computed the proportion of the predicted probabilities outside the unit interval. Finding only 6.4% fell outside the unit interval we chose the LPM over the probit or logit model since the LPM would still produce unbiased and consistent estimates (?). The F value for the LPM model was also found to be 11.15 with a p value of 0.000 showing the significance of the LPM model.

[96] The approach is same as the 2SLS approach but the only difference is that it allows for testing for endogeneity of PELIS participation. It however hinges on assumption of exogeneity of the instrument.

[97] The null hypothesis of exogeneity is also rejected when we use the Durbin-Wu-Hausman test of endogeneity at 1% significance level.

Table 12: Endogenous Quantile Treatment Effects Model Estimation Results

VARIABLES	QT_1	QT_2	QT_3	QT_4	QT_5	QT_6	QT_7	QT_8	QT_9
PELIS	-75.21	167.2	410.6	497.6*	532.8**	565.7**	842.7***	1,227***	2,155***
	(194.2)	(382.0)	(328.1)	(288.5)	(246.8)	(258.9)	(269.8)	(411.2)	(787.1)
DistForest	-105.3**	0.379	-68.29	-78.10*	-44.18	-48.76	-176.6***	-278.4***	-256.2***
	(44.52)	(53.86)	(51.67)	(43.28)	(36.85)	(52.45)	(41.57)	(54.36)	(81.45)
DistMroad	44.76	-37.09	-46.65	39.06	71.89**	60.14	-30.60	-74.81	-109.9
	(40.70)	(33.26)	(43.54)	(41.68)	(31.16)	(49.19)	(41.81)	(55.22)	(201.7)
DistMarket	-96.78***	-32.88	-24.18	-60.19***	-44.54***	-44.82***	-24.29	-28.87	-13.12
	(17.33)	(20.12)	(19.77)	(12.21)	(12.27)	(15.03)	(20.85)	(24.27)	(34.17)
HHEducyrs	-18.78	-7.228	-24.11**	-17.48*	-11.81	-7.174	-3.824	1.239	-11.10
	(12.23)	(12.31)	(10.18)	(9.067)	(7.749)	(10.88)	(9.992)	(12.23)	(24.31)
Hlandsize	40.53	54.70***	44.86*	-2.354	-22.62*	-38.10***	-50.85***	-59.33***	-65.26
	(32.85)	(19.62)	(24.00)	(17.38)	(12.21)	(13.01)	(14.53)	(15.60)	(43.60)
hhsize	-234.7***	-182.9***	-146.0***	-177.7***	-190.8***	-188.7***	-205.6***	-238.5***	-176.3***
	(22.71)	(41.35)	(40.11)	(26.38)	(25.00)	(34.31)	(29.02)	(42.79)	(67.18)
HHWealth	0.000139	0.000206	0.000296*	0.000523***	0.000549***	0.000566***	0.000562***	0.000698***	0.000560***
	(0.000247)	(0.000142)	(0.000169)	(8.65e-05)	(6.84e-05)	(6.59e-05)	(7.17e-05)	(7.39e-05)	(0.000160)
Numbchild	-20.56	-8.951	-56.16***	-37.01***	-21.85	-7.822	39.44	-31.97	-7.319
	(24.37)	(16.36)	(13.27)	(14.22)	(15.07)	(30.68)	(37.93)	(41.56)	(110.5)
MedAge	45.19***	29.17	1.164	-27.36	-64.09***	-55.01*	-58.92*	7.636	-58.54
	(17.36)	(27.95)	(35.95)	(28.08)	(20.01)	(28.24)	(32.84)	(52.46)	(77.39)
MedAgesq	-0.305*	-0.186	0.0919	0.466	0.742***	0.650**	0.469	-0.0834	0.517
	(0.181)	(0.305)	(0.364)	(0.288)	(0.201)	(0.292)	(0.335)	(0.556)	(0.813)
MedIncome	0.0156***	0.0151***	0.0134***	0.0111***	0.0110***	0.0200	0.0225***	0.0257**	0.0416
	(0.00462)	(0.00358)	(0.00447)	(0.00350)	(0.00425)	(0.0198)	(0.00606)	(0.0112)	(0.0465)
Temperature	72.20***	58.22***	-2.278	-8.517	-24.80	25.56	34.19	35.31	43.11
	(24.37)	(13.73)	(17.73)	(15.73)	(16.62)	(55.72)	(38.63)	(35.60)	(115.6)
Precipitation	-1.084***	-1.142***	-1.217***	-1.270***	-1.248***	-1.773***	-1.780***	-2.663***	-2.560***
	(0.241)	(0.167)	(0.133)	(0.139)	(0.139)	(0.289)	(0.240)	(0.381)	(0.714)
HHsex	578.2**	443.8***	331.5*	494.8***	325.2	-81.67	-327.6	-694.6*	-1,029*
	(274.7)	(170.5)	(191.5)	(160.9)	(201.7)	(265.1)	(310.8)	(388.3)	(530.3)
EmploymentStat	-178.5***	203.6**	58.19	171.7*	86.88	-147.0	-395.8***	-364.4**	-385.8**
	(64.71)	(85.42)	(92.32)	(88.03)	(88.08)	(188.7)	(117.0)	(171.6)	(156.5)
LandTitle	-291.0	-378.4***	-285.1**	-315.1***	-279.8***	-187.5*	159.5	608.8***	893.4***
	(190.1)	(137.0)	(115.3)	(68.39)	(58.40)	(103.6)	(111.2)	(172.6)	(270.0)
Woodlots	132.2	8.014	65.88	164.9***	136.1**	16.68	114.8	138.3	372.9
	(199.8)	(110.4)	(102.2)	(54.66)	(63.22)	(124.2)	(108.0)	(144.3)	(544.7)
Membership	94.31	10.91	-100.3	-273.2	-156.5	-59.05	-356.1*	-325.6	-233.0
	(132.4)	(150.5)	(183.4)	(177.6)	(156.1)	(189.1)	(204.3)	(220.6)	(280.5)
ResidStatus	-195.7**	-223.7**	35.68	154.4*	140.0*	-4.487	-34.03	-358.2***	-396.1
	(97.44)	(103.8)	(112.4)	(84.54)	(81.65)	(143.8)	(140.9)	(104.5)	(320.6)
CFAParticipation	224.0**	312.6***	375.5***	606.7***	453.3***	593.6***	364.5***	392.9***	507.4***
	(92.38)	(68.11)	(81.77)	(79.54)	(90.47)	(190.3)	(137.6)	(147.4)	(145.5)
Hsepartic	435.2***	345.6***	433.1***	409.6***	477.1***	398.9*	257.1*	411.1**	278.4
	(86.66)	(55.30)	(76.57)	(69.12)	(66.35)	(239.9)	(135.3)	(185.7)	(554.3)
Constant	325.3	678.1	2,553***	2,783***	4,269***	4,456***	5,686***	5,777***	7,085***
	(457.2)	(604.1)	(790.3)	(497.4)	(410.5)	(640.2)	(809.7)	(1,308)	(1,609)
Observations	404	404	404	404	404	404	404	404	404

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results show that holding other factors constant, for some quantiles, the further a household is from the nearest edge of the forest and nearest market the lower the per capita expenditure. Households may be less active in CFA activities if they find the forest to be too far from them hence

may not derive direct benefits from the forest. The opportunity cost of participating in PELIS is also higher when households are far from the forest. Whereas the further a household is from the nearest market the lower the likelihood of selling their produce or participating in any trading activities aimed at raising their welfare. This implies opportunity costs with respect to distance matters. Households that actively participate in CFA activities were also found to have higher per capita expenditure. This can be attributed to the fact that to derive benefits (e.g. getting a PELIS plot) from the forest a key requirement is to be actively involved in CFA activities. We also found that households that participate in CFA activities (regardless of the level of participation) tend to have higher per capita monthly expenditure compared to non-participants. This implies that if access to benefits from the forest is pegged on participation then the existing incentives can be effective if implemented through CFAs hence the level of institutional cooperation or organization also matters. Household wealth and income were also found to be positively related to per capita expenditure as highly expected. As expected, the higher the household size and the higher the number of children the lower the per capita expenditure.

The results also show that native of a given area tend to have lower per capita expenditure compared to settlers or immigrants. This could be attributed to the fact that most immigrants tend be driven by the motive to benefit from the forest resource hence will often maximize given any slight opportunity compared to natives who feel they will always have the resource at their disposal. At the village level within African settings immigrants often tend to be hardworking than the natives. In addition, the study results suggest that the higher the precipitation levels the lower the per capita expenditure, although we expected higher agricultural productivity with higher rainfall hence improved welfare, it could be that higher rainfall hinder activities such as transportation of goods aimed at generating income e.g. selling agricultural harvest or interfering with preservation of agricultural produce or even transporting farm inputs. In terms of property rights, we found that

households that own land titles tend to have lower per capita expenditure. This can be attributed to the fact with land ownership people tend to be lazy, while those who do not have land title tends to work hard to maximize from the farming activities for fear that they can be displaced anytime or for them to accumulate enough to get land elsewhere. Contrary to our expectation, the results suggest that for most quantiles, those employed in off farm jobs tend to have lower per capita expenditure. This may be partly explained by the kind of off-farm job. For instance, if you are a government employed teacher in rural areas, the remuneration package often tend to be lower especially allowances due to the low cost of living in rural areas compared to urban areas. Agricultural activities may therefore be more profitable hence the negative influence of being employed in off farm jobs on per capita expenditure. Agriculture also requires a lot of hard labor which some may not be ready for hence opt for employment. The results also suggest that male headed households tend to have higher per capita expenditure compared to female headed households. This is expected given that males tend to have more physical energy for income generating activities such as farming and construction works among others.

On the heterogeneous impact of the scheme, we found that conditioned on a set of covariates[98], the endogenous QTE model revealed that the scheme had significant positive impact on household welfare from the fourth to the ninth quantiles only showing the distributional inequity of the scheme[99]. A major observation during the survey was the fact that, most forest-adjacent households participating in PELIS were mainly involved in growing the same kind of crops i.e., peas, cabbages or potatoes which they complained that since they all harvested at almost the same time, this

[98] Namely, level of households' participation in CFA activities, ownership of land titles, employment status, sex of household head and whether the household head is a native or not, climate and geographical variables and distance to the nearest; market, main road, and the nearest edge of the forest, among other factors.

[99] To assess the consistency and robustness of our estimates, we re-estimated the model by omitting some variables like household income membership and CFA participation which could also be potentially endogenous (although we tested for their endogeneity and found them to be exogenous). We found that even with omission of these variables from the model we still arrive at the same conclusion just that the scheme tends to benefit households from the sixth quantile and above the results are shown in table B.7. We therefore, limit our discussion to our model with all these variables since we included them to authenticate the validity of our instrument.

resulted in excess supply hence lower prices coupled with lack of market for the agricultural produce. Moreover, most forest-adjacent communities are poor hence have very limited alternatives in terms of exploring market opportunities for their produce, and even if the harvest is good, very few can afford to transport their produce to other areas to fetch better prices for their produce. Another possible reason could be due to elite capture issues where richer elite households take over the scheme and other CFA activities in general and therefore set to benefit more than the poor households. On the other hand, the initial conditions of households at the time of adopting the scheme and duration of participation in PELIS may also have an implication on the impact of the scheme. These factors could therefore explain the inequitable distributional nature of the scheme.

We therefore reject the null hypothesis of constant impact of the scheme on household welfare because the benefits are more skewed towards the middle and upper quantile households. However, according to the Kenya Integrated Household Budget Survey (2005), the per capita monthly expenditure for rural households in the Rift valley province in which the Mau forest is located is approximately Ksh 2251(USD 22.51). Comparing this with our average per capita monthly expenditure for the sampled households which is about Ksh. 2185(USD 21.85), we find that the study population is on average slightly below the poverty line. This shows that most households living around the Mau forest are relatively poor as has been shown by most studies that, the rural poor are the most forest dependent. However, the poverty datum line lies between the sixth (average of Ksh 2082.26(USD20.82)) and 7th (average of ksh 2375.71(USD23.76)) quantiles see Table B.4. Those below the poverty datum line are thus considered poor i.e. first to sixth quantile. It is therefore, evident that the scheme raised welfare of the poor but the least poor (fourth to sixth quantile households) and the richer quantile households benefit more from the scheme than the poorest.

3.7 Conclusion and Policy Recommendations

The study aimed at identifying the determinants of household decision to participate in/adopt PELIS, and to determine the overall and distributional impact of PELIS on welfare of forestadjacent households as well as the mean impact on forest cover. The PSM method estimated the impact of PELIS on household per capita monthly expenditure at between ksh. 363 (USD 3.63) and ksh. 678 (USD 6.78) hence raising welfare by between 15.09% and 28.14% whereas the overall impact of the scheme on forest cover was estimated at between 5.53% and 7.94% slightly lower than the OLS estimate of 9.45%. We can thus conclude that on average PELIS meets the dual objective of raising household welfare and improving forest cover. This shows that devolution of forest management and provision of incentives to well organized communities can lead to better welfare and environmental outcomes on average. On the other hand, in terms of welfare, the QTE model under endogenous assumption, revealed that the scheme had positive impact on household welfare from the fourth quantile households and above only. We can therefore, infer that there is some distributional inequity on the impact of the scheme that needs to be addressed for the sustainability and success of the scheme and for it to be able to make low income household rise up the income ladder and also lead to improvement in forest cover at the same time.

However, we cannot conclude that the scheme is less pro poor since the scheme raises welfare of the least poor as well even though the poorest and marginalized sections of the community are left out. These results support findings by Angelsen and Wunder (2003), Sunderlin et al. (2005), Mazunda and Shively (2015), and Ali et al. (2015). Our findings also lend support to findings by Malla et al. (2000), Jumbe and Angelsen (2006) and Cooper (2008) (Gelo and Koch, 2014; Gelo et al., 2016) and Moktan et al. (2016) who found joint forest programs to improve welfare of the high income households more than poor households. On the determinants of households' adoption of or

participation in PELIS, we found that, being born in a village or not, employment status of household head (i.e. employed in off farm jobs or not), household income, owning woodlots or not, distance to nearest motorable road in kilometres, precipitation, temperature and elevation levels of nearest forest are the major factors influencing household decision to participate in the scheme. These results support some findings by (Lise, 2000; Adhikari et al., 2004; Adhikari, 2005; Agrawal and Gupta, 2005; Jumbe and Angelsen, 2007; Kabubo-Mariara, 2013). These factors therefore, needs adequate consideration in allocation of PELIS plots to forest-adjacent communities.

A number of policy implications may be drawn from the study. First, the findings call for a balanced and all-inclusive approach (involving the participation of all members regardless of economic status) to forest management to ensure equitable distribution of PELIS plots and benefits across the income groups. To avoid further marginalization of any income group, policy makers need to give much consideration to equity in access and management of the resource especially with respect to forest resources and existing incentives. The design and implementation of the scheme with much emphasis on method of plots distribution should also be given due consideration if it is not to discriminate the very group that it is meant to benefit and to ensure sustainability of the scheme.

Secondly, a mix of market based incentives and regulated command and control mechanisms based on policy makers understanding of the drivers of household participation in PELIS and by extension CFA activities may also create more positive impact on forest cover and household welfare. For the scheme to have significant impact on forest conservation, there is also need for increased awareness and roll out of the incentive to other CFAs that have been reluctant to adopt the scheme taking cognizant of the views and expectations of local communities especially low income households. Lastly, since the main concern is normally fetching better prices from farm produce in PELIS plots, there is need to explore ways of training forest-adjacent communities on modern farming techniques, product diversification and improving market opportunities and linkages for

various non-timber harvests from the PELIS farms by households in order to address the ensuing market failures. This objective can only be achieved through collaboration with relevant government bodies and non-governmental organizations or through formation of forest user cooperatives to provide market linkages.

Chapter Four

Determinants of Successful Collective Management of Forest Resources: Evidence from Kenyan Community Forest Associations[100]

Abstract

Participation of local communities in management and utilization of forest resources through collective action has become widely accepted as a possible solution to failure of centralized, top-down approaches to forest conservation. Developing countries have thus resorted to devolution of forest management through initiatives such as Participatory Forest Management (PFM) and Joint

[100] A version of this chapter has been disseminated as ERSA Working Paper 698.

Forest Management (JFM). In Kenya, under such initiatives, communities have been able to self-organize into community forest associations (CFAs). However, despite these efforts and an increased number of CFAs, the results in terms of ecological outcomes have been mixed, with some CFAs failing and others thriving. Little is known about the factors influencing success of these initiatives. Using household-level data from 518 households and community-level data from 22 CFAs from the Mau forest conservancy, the study employed logistic regression, OLS and heteroscedasticity-based instrumental variable techniques to analyze factors influencing household participation levels in CFA activities and to further identify the determinants of successful collective management of forest resources, as well as the link between participation level and the success of collective action. The results show that the success of collective action is associated with the level of household participation in CFA activities, distance to the forest resource, institutional quality, group size, and salience of the resource, among other factors. We also found that collective action is more successful when CFAs are formed through users' self-motivation with frequent interaction with government institutions and when the forest cover is low. Factors influencing the level of household participation are also identified. The study findings point to the need for: a robust diagnostic approach in devolution of forest management to local communities, considering diverse socio-economic and ecological settings; government intervention in reviving and re-institutionalizing existing and infant CFAs in an effort to promote PFM within the Mau forest and other parts of the country; and intense effort towards design of a mix of incentive schemes to encourage active and equal household participation in CFA activities.

Key words: PFM, collective action, participation, CFAs

JEL Classification: D02, Q23, Q28

4.1 Introduction

Forests resources are critical for the provision of ecosystem and environmental services, such as biodiversity conservation, provisioning of fresh air, carbon sequestration, maintenance of hydrological flows, and renewal of soil fertility (Nagendra et al., 2011). Rural communities around the world therefore rely on forests, as they significantly contribute to their livelihoods (Shackleton et al., 2007). Over the years, there has been an alarming decline in forest cover in many developing countries due to advances in technology, rising human population, poverty, and other social hardships, leading to over-reliance on forest resources, coupled with increased demand for forest ecosystem services. This situation fueled the search for new strategies to stem the trend and place remaining forests under secure and effective management.

Initial efforts aimed at taming the rising degradation of natural resources involved centralized administration of common pool natural resources such as forests through restrictions on levels of resource extraction. These efforts were mainly characterized by distrust of locals' ability to manage forest resources on which they depend; hence, governments almost fully assumed the role of managing the forests (Heltberg, 2001). However, high information, enforcement and monitoring costs reduced the effectiveness of such administrative structures. It is such policy, market and institutional failures in management of natural resources that led to a policy shift focusing on how local communities can self-organize and manage natural resources (Gopalakrishnan, 2005). However, there is still no consensus on the ability of local communities to self-organize (Ostrom, 2009). Neoclassical theory maintains that communities can only self-organize in the presence of coercion or external force. The gloomy prediction of Hardin (1968) that, unless there is government intervention or privatization, all commonly managed resources would inevitably end in tragedy fueled trends encouraging privatization and discouraging collaborative resource management and had disastrous consequences on welfare and ecological outcomes. Hardin's prediction also led to an increase in interest in cooperation as a means to manage the commons (Wade, 1988; Ostrom, 1990; Tang, 1992). Over time, evidence from case studies in Asian countries have shown that communities can self-organize and develop robust natural resource management institutions adapted to local conditions. This motivated scholars to challenge neoclassical economics and Hardin's tragedy of the commons theory e.g., Ostrom (2010) through the theory of collective action. The theory is based on the premise that participants have a stake in the final outcome. Therefore, agreed norms and customary rules in rural communities are a recipe for successful

collective action that can lead to well preserved and utilized Common Pool Resources[101] (CPRs) (Muchara et al., 2014).

According to Ostrom and Nagendra (2006), community conservation when effective has a better likelihood of being more locally accepted, providing greater social and economic benefits to communities and achieving conservation goals easily than the strict government approaches that are economically costly and fraught with social conflict. Therefore, local community participation in utilization and management of forest resources through collective action has become widely accepted as a possible solution to the failure of the centralized, top-down approaches to forest conservation (Wade, 1988; Ostrom, 1990). Due to the shortcomings of the traditional top down approaches to arrest losses of biodiversity, developing countries are increasingly devolving forest management to local communities through approaches such as PFM (Wily, 2001; Agrawal, 2007). The main aim of PFM is to promote active involvement of locals in management of forest resources, while addressing environmental and socio-economic goals all in one package. PFM emphasizes on user communities' ability to effectively manage common pool resources through informal and semi-formal institutional arrangements (Wade, 1988; Kiss, 1990; Ostrom, 1990; Baland and Platteau, 1996). It also involves inclusion, equity and democratic governance of forest resources (Agrawal and Gupta, 2005). In Kenya, under PFM, communities have been able to self organize into community-based organizations known as CFAs in collaboration with the Kenya Forest Service (KFS).

[101] According to Ostrom et al. (1994), a CPR is a defined as a resource from which it is relatively costly to exclude others but the use of the resource is rivalrous or subtractable in consumption.

4.1.1 Organization of Community Forests Associations

The Forest Act requires forest-adjacent-community members to enter into partnership with KFS through registered CFAs. The partnership applies both to forests owned by local authorities and those owned by the state (i.e. gazetted, forests). CFAs are registered based on approval by KFS. Local communities may apply for certain rights in utilization and management of forest resources through the CFAs so long as the rights are not in conflict with forest conservation objectives (Mogoi et al., 2012). In the Act, CFAs are recognized as partners in management of forests and are formed by several Community Based Organizations (CBOs) or Forest User Groups (FUGs)[102]. To supplement efforts, commercial plantations are also open to lease arrangements. In return, communities are entitled to a range of user rights, such as collecting firewood, grass for roof thatching and grazing animals, herbal medicine, timber and scientific and educational activities, as well as recreational activities. This is a departure from prior practice, where gazetted forest reserves were fully managed by the government. As part of benefit sharing arrangements, PELIS was reintroduced in 2007 through CFAs to promote the livelihood of locals while ensuring sustainable management and conservation of forests. However, community members are required to pay some user fees in order to benefit from these resources. A percentage of these fees goes to the FUGs and CFA, while a bigger percentage goes to KFS. Paid up members are given a receipt to show they have user rights. Violators may be prosecuted, depending on the magnitude of the offense; otherwise, smaller offenses are handled at the CFA level.

As of 2009, there was at least one forest association in each forest in Kenya. The number has increased and by 2011 there was a total of 325 CFAs countrywide, with Mau having 35 CFAs. The governing structures are the KFS board at the national level and a Forest Conservation Committee

[102] A FUG is a group of people with shared rights and duties to access and use products from the forest. FUG members register with different groups based on their interest, e.g., PELIS, bee-keeping, grazing etc.

under each forest conservancy in Kenya[103], which represents CFAs at the national level, the county forest board at the county level, and lastly the CFA executive committee or general representative body. The National Alliance for Community Forests Associations (NACOFA) also represents the rights of CFAs at the national level.

However, these CFAs have had their fair share of challenges, e.g., mismanagement, disintegration, varying interests and heterogeneity among members causing more conflicts (Ongugo et al., 2008). In addition to these challenges, the Mau forest attracts a lot of political interest and is very prone to ethnic tensions, hence the CFAs may often be destabilized during election periods. During the fieldwork for this study, a number of CFA officials complained of the rent-seeking behavior of most foresters. The main complaint was that the foresters who should be the representative of the government at the devolved level were the main agents of forest degradation, as they colluded with loggers or CFA officials to harvest more than the licensed number of trees or even indigenous trees that are to be preserved, despite intense efforts by CFAs to conserve the forest resource. This implies that in certain instances the CFA may be well organized but unsuccessful in forest conservation due to the forester's activities. In some instances, the foresters collude with CFA officials to over harvest the forest resource for selfish gains hence worse environmental outcomes as the resource degenerates in to an open access once members feel disgruntled. Most counties are therefore pushing for complete devolution of forest management to local communities to make CFAs have greater say in forest management.

Moreover, forest degradation has continued despite the existing incentives aimed at deepening community participation and conserving forests and despite the increased number of CFAs countrywide. Most of the CFAs have also remained disorganized and some are driven by selfish

[103] The forest conservancies in Kenya are Central Highlands, Nairobi, Eastern, North Eastern, Ewaso North, Coast, Mau, North Rift, Western, and Nyanza.

interests without conservation objectives (Ongugo et al., 2008). The existing CFAs have also yielded varying levels of success in terms of ecological outcomes. The mixed levels of success from the CFAs is a clear indication that PFM cannot be assumed as a blueprint for successful collective action or be treated as a one size fits all solution. A point of concern is why some CFAs succeed while others fail. There could be other context-specific factors influencing people's participation levels that are worth considering in analyzing the success or failure of collective action in managing CPRs. There is also little understanding of the factors behind the varying levels of success of these CFAs. In addition, policy makers need to understand how to incentivize household participation and roll out devolution of forest management to local communities.

In light of socio-economic and demographic pressure, the sustainability of forest management requires successful coordination and cooperation among users, thus requiring an understanding of the determinants of successful collective action (Poteete and Ostrom, 2004). For instance, what factors influence households' level of participation in CFA activities? Does the level of household participation in CFA activities matter for the success of collective action? To the best of our knowledge, no empirical study has tried to determine the drivers of successful collective action within the Mau forest, especially within the context of indigenous communities reliant on agriculture and with a history of constant displacement from their land due to ethnic conflicts and government actions. In light of the constant displacement of communities the level of cooperation in collective action is generally expected to be lower given the mistrust of the true intention of government in an effort towards devolution of forest management. Moreover, studies that have tried to identify the drivers of successful collective action in other countries have mainly used measures of wealth, no of wildlife, reduction in land degradation/soil erosion, investment in forest and forest experts or individual perception of the forest cover as measures of success (see Gibson et al., 2005; Hayes and Ostrom, 2005; Ostrom and Nagendra, 2006; Andersson and Agrawal, 2011;

Coleman and Fleischman, 2012). This approach is subjective and may not yield efficient results for policy formulation. The different methodological approaches applied in these studies also make comparison of results difficult. A common practice in these studies is the small sample size problem, especially at the institutional level. The different models of PFM also warrant a context specific study. This study therefore seeks to fill this gaps by identifying the factors influencing household level of participation in CFA activities and also to identify the determinants of successful collective management of forest resources by CFAs as we examine the link between successful collective action and level of household participation in CFA activities using the Mau forest conservancy in Kenya as a case study.

The study contributes to literature on collective action and the ongoing debate on the universal applicability of devolution of forest management as a solution to environmental degradation under different socio-economic, cultural and ecological settings, through empirical validation of the theoretical views in the commons literature. We contribute to this literature in a number of ways: first, we do not rely on subjective assessment of forest condition as a measure of outcomes of collective action, as employed by most studies, but instead use two objective outcome measures namely, percentage forest cover within each CFA and reported cases of vandalism[104] within each CFA in a year. Second, we conduct analysis at the CFA level but factor in all households sampled in these CFAs to handle the potential sample size problem. Third, we include potential intervening institutional and household-level variables that have not been employed in other studies as we try to tease out the drivers of successful collective action. To assess the consistency of our estimates and ascertain the reliability of our results, we compare the results with a composite index of collective action that has been employed in past studies. With the rising trend in devolution of

[104] We define forest vandalism as any illegal activity that is aimed at destroying existing forest resources e.g., fires, illegal logging and logging of indigenous trees that should be protected, illegal harvesting of firewood, etc.

management of natural resources thus affecting livelihoods of millions of people as well as the natural resource itself, identifying factors that incentivize household participation is critical for efficient policy formulation and devolution policy implementation. Policy makers also need to understand the factors necessary for success of PFM and how to roll out devolution of forest management under different socio-economic, cultural and ecological contexts.

The rest of the chapter is organized as follows: Section 4.2 we present a review of related literature; section 4.3 outlines the methodological framework; section 4.4 presents data collection and sampling method; section 4.5 presents the results and discussions; and the conclusion and policy recommendations are presented in section 4.6.

4.2 Related Literature

4.2.1 Factors influencing households' level of participation in CFA activities

PFM entails equity, inclusion and democratic governance of forest resources as well as involvement of locals in the management and conservation of forests (Agrawal, 1999; Agrawal and Gupta, 2005). Communities therefore have greater say and increased participation in decision making (Andersson et al., 2004). However, most studies that have assessed factors influencing households' participation in community forest management activities have largely shown that, socio-economic profile, derived benefits, property rights and collective action determine household participation in community forest management (Malla, 1997; Maskey et al., 2006; Coulibaly-Lingani et al., 2011). The economic status of households has also been shown to have a negative influence on household participation in collective action. For example, Bhattarai and Ojha (2001) and Adhikari (2004) found that richer households are the greatest beneficiaries of community forestry programs relative to poor households mainly due to the fact that product distribution decisions are made by elite and influential groups in the community. Moreover, poor households are often thought to have higher

opportunity cost of participation hence often express disinterest in participating in collective action activities and may also not have the family size or resources to utilize the forest products (Agrawal, 2000; Bhattarai and Ojha, 2001). All members of a community thus need to be actively and equally involved in management and decision making in order for the economically disadvantaged groups to enjoy the benefits (Knox et al., 2000).

In terms of education levels, Agrawal and Gupta (2005) found that household participation levels in collective action activities are negatively correlated with the education levels. These findings were also supported by Ali et al. (2015) who concluded that young, richer and educated households tend to participate more in community forestry. Distance to the nearest market has also been found to have an influence in household participation in collective action activities although there is no consensus on the direction of effect. Fujiie et al. (2005), posit that markets access often decreases interdependence thus may allow some members to opt out hence reducing likelihood of active participation in collective action. The cost of integrating with government for say registration of an association and airing out their demands also decreases the closer the proximity to markets. However, the limited the exposure to urban activities the higher the incentive for members to cooperate since with limited market access members are expected to interact indefinitely (Fujiie et al., 2005).

According to Jana et al. (2014), other factors influencing household participation levels include; frequency of committee meetings, household size, household religion, and household's willingness to pay for protection and size of land holding. On the other hand, Jumbe and Angelsen (2007) found that the higher the rate of dependence on forest resources the higher the rates of participation, and that with more heterogeneous social context, more commercial forest uses and higher levels of forest dependence, the incentive to participate reduces. Baral (1993) also highlights that political ideology, ethnic composition, and cultural factors within communities could also create problem at

the user group level. Therefore, the level of participation and decision making should be equal for successful institutions otherwise if there is a significant number of free riders whose values for the resource conflicts the community's values for the resource then collective action is doomed to fail (Hyde, 2016). On the other hand, when communities have strong attachment to the environment, the high level of ownership proves effective in managing resources thus surviving many challenges faced by other institutions (Measham and Lumbasi, 2013).

4.2.2 Determinants of successful collective action

In the last few decades, a number of theoretical and empirical literature pointing out the link between sustainable management of natural resources and successful collective action have emerged (Ostrom, 1990; Bardhan, 1993; Maloney et al., 1994; Baland and Platteau, 1996). These scholars have used various methods to identify and examine determinants of collective action. Some studies have been based on socio-anthropological case studies (e.g. Wade, 1988; Ostrom, 1990; Ostrom et al., 1994). While some have employed game theory models (see Baland and Platteau 1996; Lise 2005). Based on a number of case studies, Wade (1988), Ostrom (1990), Baland and Platteau (1996), Agrawal (2001) and Gautam and Shivakoti (2005) works are some of the significant analysis that develop conditions necessary for successful collective action. More recent literature in support of these scholars include Cox (2014), Frey and Rusch (2014), Rasch et al. (2016a), Rasch et al. (2016b) and Behnke et al. (2016). Ostrom's works are some of the significant analysis that have investigated how communities succeed or fail in managing CPRs such as forest and developed a framework for organizing variables identified as affecting the interaction patterns and observed outcomes in empirical studies of Social Ecological Systems (SESs). The framework analyzes how resource attributes, resource system, users of the system and system of governance jointly affect and are affected indirectly by resulting outcomes and interactions achieved at a

particular time and place (Ostrom, 2009, 2010). The framework has also been applied in other spheres e.g. communal livestock production (see Rasch et al. 2016a,b).

However, studies analyzing the determinants of successful collective action are mostly based on intensive case studies of individual CPRs (Fujiie et al., 2005). Hyde (2016) conducted a review of past studies on determinants of successful collective management of natural resources. Three key factors were identified i.e., participants have shared value of the resource, limited incentive for free riding and where the cost of adding new participant to the group decision makers diminishes. Using a case study of 35 villages in India, Dash and Behera (2015) found a positive association between forest growth with a function of local management institution, distance to the forest department and nearest market, and caste homogeneity. Some studies have also found that better conservation outcomes are associated with better institutional cooperation (see Baland and Platteau 1996; Heltberg et al. 2000; Heltberg 2001; Alló and Loureiro 2016). According to Morrow and Hull (1996) and Agrawal (2001) the level of market integration can also have adverse effect on collective action when distant resource systems are linked with their users, other users and markets. On the other hand, Akamani and Hall (2015) found that community location, past connection with institutions, and past bonding social capital were the strongest predictors of outcome of community forest management. Whereas, Pagdee et al. (2006) found that successful community forest management is associated with effective enforcement, strong leadership, monitoring and experience or skill of members.

Literature on effect of group size on collective action suggests that difficulty of collective action increases with group size although there is no agreement on what is large or small group size. According to Olson (1965), rational individuals will rarely act to achieve group or common interest without some form of force or coercion. This is based on the premise that as the group size increases, their marginal contribution will not affect the likelihood of provision of the good and

would therefore not make any contribution. Tang (1992), Fujiie et al. (2005) and Hyde (2016) also posit that collective action is hardly successful with large groups. On the other hand, Agrawal and Goyal (2001) takes a middle ground that compared to large or small groups, medium size groups are more likely to be successful by providing third party monitoring. In other works, Agrawal and Gibson (1999) found that the prospects for development of trust among participants are more likely to be affected by group size and group heterogeneity hence lowering the likelihood of success of collective action since it affects on divergent interests. Ostrom et al. (1993) also asserts that the size of regime, level of dependence on forest resources and an understanding of the resource value by the users are critical for successful collective action. Some of these past findings have also been confirmed by Tesfaye et al. (2012) who found level of dependence on the forest, heterogeneity, and geographical variables such as distance to town and altitude may greatly affect performance of user groups.

Moreover, if institutions have higher proportion of college graduates and influential persons in leadership positions, the likelihood of success of collective action is higher since they have more influence in lobbying and also have outside connection critical for joint interaction (Meinzen-Dick et al., 2002). Gebremedhin et al. (2004) has also shown that compared to organizations initiated by government agencies, self-organized associations have higher likelihood of successful collective action due to the stronger sense of ownership hence higher likelihood of cooperation among households. Effective interactions and higher level of engagement between local communities and the government also increases likelihood of successful collective action (Liu and Ravenscroft, 2016).

Some studies such as Szell et al. (2013) have also shown that incentives increase social support for conservation. However, the effectiveness of incentives such as PES may be different under different policy scenarios and may therefore be unsustainable due to uncertainties in human response to

policies and dynamic human nature interactions (Chen et al., 2014). Moreover, provision of direct incentives may not distribute benefits equitably within communities and poor marginalized households may lose out hence tragedy of the commons (Ostrom, 1990; Spiteri and Nepalz, 2006). Harnessing participatory approaches thus requires improving on factors associated with success or failure of these institutions (Hutton et al., 2005).

An overview of these literature suggests that there is still no consensus on what determines the success or failure of local institutions in management of CPRs and there is no universal set of conditions. For instance, Agrawal (2001) using Indian case studies identified 35 such criteria. However, identifying the determinants of successful collective action needs a move beyond pilot projects and case studies that have formed the basis of most studies on determinants of successful collective action to date. There are also considerable differences in applied definition especially considering the variation in variables employed and their measurement, contextual factors and methodological approaches hence making comparison difficult. These studies have also been more biased towards Asian case studies. Most of these studies also tend to incorrectly specify nature of collective action problems (Poteete and Ostrom, 2004) hence measurement error problems, for example an index of collective action is constructed to capture community involvement in collective action. Others have also measured forest condition using an index of respondents ranking of the forest condition or subjective assessment by foresters or experts and local communities whereas others use number of wildlife, reduction in land degradation, time to collect firewood, measures of wealth, investment in forest and perception of forest condition (see Heltberg et al., 2000; Gibson et al., 2005; Hayes and Ostrom, 2005; Agrawal and Chhatre, 2006; Ostrom and Nagendra, 2006; Behera, 2009; Andersson and Agrawal, 2011; Coleman and Fleischman, 2012; Dash and Behera, 2012). This approach is rather subjective. Once communities have collectively organized so what?

The main interest is outcome of such collective action i.e. increase in forest cover that can guarantee efficient and sustainable provision of ecosystem services as per the government key policy goal.

As a departure from most studies on collective action and motivated by the fact that success of collective action is gauged on the ecological or environmental outcomes, the study used two objective measures of outcome of collective action that is frequency of vandalism (number of vandalism cases reported in a year or forest infractions reported per year), and percentage forest cover per hectare under each CFA while also comparing the results with a composite index of collective action that has been employed in the past to assess the consistency of our estimates and ascertain reliability of our results. We further condition factors in terms of socio-economic, physical and policy environment how they affect level of participation and collective action which in turn affects outcome of collective action. This is based on the fact that the environment can either constrain or facilitate organization and also create incentive or disincentives for people to work together. In recognition of the roles played by various actors' such as resource user groups and local authorities, this study focuses on various CFAs within the Mau forest but facing different social, economic and ecological environments and how they interact with various governance structures as it applies Ostrom's framework for analyzing Social Ecological Systems (SESs).

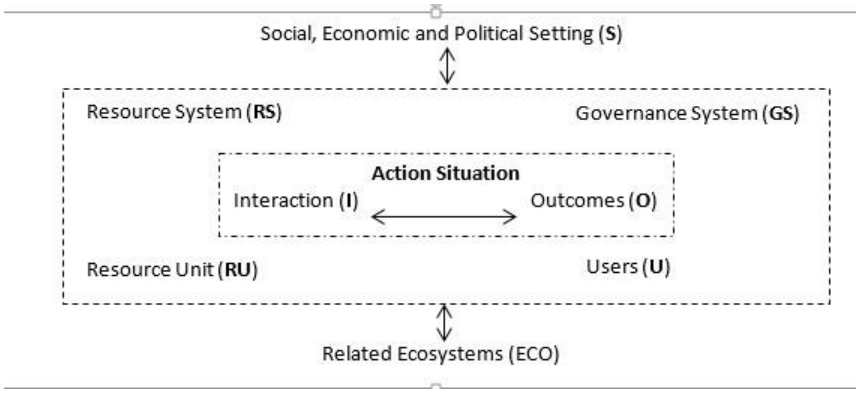
4.3 Methodology

This section highlights the conceptual framework of the study, definitions and measurement of variables, the analytical framework and the estimation model.

4.3.1 Conceptual framework

In this study, we employ the framework of Ostrom (2009) for analyzing Social-Ecological Systems (SESs), depicted in Figure 2. In the framework, eight broad variables that affect the sustainability of SES and ability to self-organize are identified. The framework analyses how attributes of resource units, the resource system, users of the system and the governance system jointly affect and are indirectly affected by interactions and resulting outcomes achieved at a particular time and place. We also make use of structural variables that may affect the likelihood of collective action as identified in Ostrom (2010).

Figure 4: A Framework for Analyzing a Social-Ecological System



Adapted from Elinor Ostrom (2009)

Figure 4 shows the relationship among the first four level of core subsystems of a SES, which affect each other and the linked economic, political and social systems and related ecosystems. The four core subsystems consist of the resource system (specified forest reserve), resource unit (trees, plants and shrubs, in the forest), governance system (KFS, CFAs, county and other NGOs) and users (individual households or communities who use the forest). Our task is therefore to empirically explore which factors are important for successful collective action in forest management. The SES

framework is also decomposable, i.e., each of the highest tier conceptual variables in Figure 4 can be decomposed into several tiers depending on the research problem. A detailed exposition of the second-tier variables in Figure 4, as per Ostrom's framework, is found in Ostrom (2009). From the literature, including the SES framework, a long list of potential determinants of successful collective action have been suggested by different authors (see Wade 1988; Ostrom 1990; Baland and Platteau 1996; Agrawal 2001; Tesfaye et al. 2012; Akamani and Hall 2015; Hyde 2016). However, due to sample size and insufficient variation across CFAs, we cannot include all the variables in the regression. We therefore concentrate on some of the key variables whose significance has been highlighted in most recent theoretical and empirical literature, as well as some intervening variables at household and community level. The second-tire variables from the SES framework employed in the study are presented in Table 13. The table presents the grouping of the variables we employed in the empirical models.

Table 13: Second Tier variables used in the study

Resource System	Governance System
RS1: Sector-Forest sector RS2: Defined boundary RS3: Finite size RS4: Salience of the resource (Dependence)	GS1: Government organization-KFS (custodian) GS2: Mau forest conservancy GS3: County forest conservation committee GS4: Community forest association GS5: Institutional design: Rules, Ostrom's design principles GS6: Group structure GS7: Financial budget
Resource Units	**Users**
RU1: Forest improvement RU2: Existing incentives RU3: Distance from forest resource	U1: Forest user Groups U2: Forest-adjacent communities U3: Level of household participation U4: Leadership U5: Socioeconomic attributes of households
Interaction	**Outcome**
I1: Horizontal interaction I2: Vertical interaction I3: Social interaction I4: Competition	O1: Forest cover O2: Reported cases of vandalism
External Environment: Climate and Geographic Variables	
EE1: Precipitation EE2: Temperature EE3: Elevation	

In addition to some of the variables identified in the literature, we factored in an index of institutional quality, capturing the level of implementation of Ostrom's design principles[105]; because the design principles are orthogonal to each other, a simple summation is sufficient to generate a sufficient index of institutional quality. Other indices captured are an incentive index capturing the number of incentives from which CFAs benefit, an index of dependence on the forest and an index of forest improvement, capturing the level of forest maintenance activities or collective action activities. Because face-to-face bargaining between communities and the regional or national government is important for the success of collective action, we considered factors such

[105] The design principles are namely: Clearly and well defined boundaries and membership; proportional equivalence between benefits and costs i.e., appropriation rules for availability of resources; collective choice arrangements i.e. those affected by the operational rules are included in the group and can modify these rules; monitoring and enforcement mechanisms; scale of graduated sanctions i.e., those who violate rules receive graduated sanctions; conflict resolution mechanisms; minimal recognition of rights to organize i.e., the rights of users are not challenged by external authorities; and organization in the form of nested enterprises (?).

the number of meetings between CFA and county/local authorities, to capture horizontal interaction, and number of meetings between CFA and KFS headquarters, for vertical interaction.

4.3.2 Analytical framework

Econometric modelling techniques are applied to investigate factors influencing households' level of participation in CFA activities and the determinants of successful collective management of forest resources. Two estimation models are used. In the first stage, we estimate a standard logit model (see Wooldridge, 2010) for the level of participation (active participation=1 and 0 otherwise) to identify factors influencing households' level of participation in CFA activities. We then compute the predicted probability of active participation and denote this by CFAPartHt, for use in the second stage regressions as one of the explanatory variables in identifying the determinants of successful collective action.

Determinants of successful collective management of forest resources

In the second stage, we employed multiple OLS regression models to estimate the determinants of successful collective action, factoring in the predicted probability of active participation in CFA activities (CFAPartHt). We measure success of collective action within each CFA using percentage forest cover and annual number of reported cases of vandalism. The study is based on the premise that the expected percentage forest cover and reported cases of vandalism under each CFA can be associated with household characteristics and CFA level characteristics (including the resource characteristics, system of governance, group characteristics and interactions, etc.). For the reported cases of vandalism, despite the count nature of the data, we used the OLS regression instead of the Tobit model because the Tobit model may not yield small standard errors compared to the OLS

model with robust standard errors. The Tobit model[106] is also more vulnerable to violation of the assumptions of the error distribution, and, hence, may produce seriously biased coefficients (Madigan (2007) cited in Araral (2009)). We define the OLS regression model as

$$\mathbf{Y_j} = \beta_0 + \beta_1 CFAPartHt_{ij} + \beta_2 X_{ij} + \beta_3 Z_j + \varepsilon_{ij} \quad (13)$$

where Y_j is a vector of two dependent variables, namely percentage forest cover and reported cases of vandalism in CFA j, CFAPartHtij is the predicted probability of a household i actively participating in CFA j activities, X_{ij} is a vector of household i in CFA j characteristics, Z_j is a vector of CFA j characteristics and $\varepsilon_{ij}$is a random disturbance term. A description of the CFA and household-level variables and the expected signs are as shown in Table 14.

[106] Some studies have also used the Poisson regression or the negative binomial regression in cases of count data like the reported cases of vandalism. We do not apply these methods because there is no serious problem of over-dispersion.

Table 14: Description of variables included in the econometric analysis and expected signs

variable	Definition	Expected signs	
		Forest cover	Vandalism
Numbhsehlds	Number of households in CFA jurisdiction (Group Size)	-	+
CFAParticipation	Dummy equal 1 if household active in CFA and 0 otherwise	+	-
GrpStructure	Dummy equal 1 if the group structure is same as it was constituted and 0 otherwise	+	-
Natives	Percentage of CFA members who are locals/natives	+/-	+/-
FBudget	Total CFA financial budget per year	+	-
ECMale	No of males in the executive committee or general representative body in the CFA	+/-	+/-
VertInt	Number of Meetings between CFA members and KFS national office	+	-
HorInt	Number of meetings between CFA and regional government i.e. county/local authority	+	-
GradChair	Dummy=1 if chair of CFA has post-secondary education(graduate) 0 otherwise	+	-
Competition1	Dummy=1 if there has been competition for any position and 0 otherwise	+	-
SocInt	Household density per hectare of the CFA jurisdiction-proxy for social interaction	+	-
MaritSta	Dummy =1 if household head is married and 0 otherwise		
MedAge	Age of household head	+/-	+/-
Education	dummy =1 if household head has post primary education and 0 otherwise		
hhsize	Household size	+/-	+/-
LivesVal	Total value of household livestock	-	+
Employment	Dummy =1 if household head is employed in off-farm jobs and 0 otherwise		
Woodlots	dummy=1 if household owns private woodlot and zero otherwise		
Hlandsize	Household land size in acres		
LandTitle	Dummy=1 If household owns land title for the land it occupies and 0 otherwise	+	-
DistForest	Distance in kilometres from household to the nearest edge of the forest	-	+
DistMroad	Distance in kilometres from household to the nearest main road		
DistMarket	Distance in kilometres from household to the nearest market/urban centre		
ResidStatus	Dummy =1 if household head is a native and 0 if immigrant/settler	+	-
MedIncome	Household income from all sources	+/-	+/-
IncentIndex	Index of incentives household benefit from within CFA (ranging from 0 to 11)		
InstIndex	Index of level of implementation of Ostrom design principles (ranging from 0 to 10)	+	-
ImprIndex	Index of forest improvement activities (e.g., silviculture, pruning etc) (0-6)	+	+/-
DepIndex	Index of level of dependence on forest resources within CFA	-	+
Precipitation	Average annual precipitation (mm)	+	+/-
Temperature	Annual average temperature in degrees celsius	-	+
Elevation1	Level of elevation in each forest (metres)	-	+

However, although we do not expect our data to exhibit endogeneity, we posit that the quality of institutions, as measured by the level of implementation of Ostrom design principles, could be

potentially endogenous to our two measures of success of collective action, i.e., percentage forest cover and reported cases of vandalism. There is some reverse causality, with the possibility that, the more CFAs become organized, i.e., as the index of institutional quality increases, the higher the forest cover and the fewer cases of vandalism; conversely, as the forest cover increases and there are fewer reported cases of vandalism, there is less incentive for enforcing the design principles due to the abundant supply of the resource. This is also supported by the theory that resource scarcity translates into more self-organization of institutions (Ostrom, 1990). We therefore proceed by first estimating an OLS model, assuming absence of endogeneity, then enrich the empirical analysis by employing instrumental variables estimation with heteroscedasticity-based instruments following Lewbel (2012) to test and address the potential endogeneity (See appendix C1 for the model framework). The main advantage of this approach is that it provides options for generating instruments and allows the identification of structural parameters in models with endogeneity or mis-measured regressors when we do not have external instruments. The approach is also capable of supplementing weak instruments. Identification is consequently achieved by having explanatory variables that are uncorrelated with the product of heteroscedastic errors (see Lewbel (2012)).

For robustness checks, we used Principal Component Analysis (PCA) to construct a composite index of success or failure in organizing collective action. The PC score was constructed using one dominant collective action activity reported by CFAs: forest management/improvement activities. The activities under forest management/improvement involved pruning, enrichment planting, reseeding, weeding, silviculture activities, thinning and watering. Household participation in each collective action activity is recorded as one and nonparticipation as zero. The PC score was then employed in an OLS regression model to assess the robustness of our results for the determinants of successful collective management of forest resources under OLS and IV estimation models. The

use of the PC score also helps us determine whether there is any variation (i.e., in terms of statistical significance and consistency of effects in both models) when we use measures of outcome or just a measure of collective action, as in past studies.

4.4 Data collection and sampling method

The survey was conducted in two phases. First, a pilot survey was conducted in Londiani CFA of Kericho county to test the validity and construction of the survey instrument. The survey instrument was then modified based on preliminary findings. In the final survey, a two-stage sampling procedure was employed in data collection. In the first stage, a sample of 22 out of 35 CFAs were purposively identified to reflect the entire Mau forest, with the help of the head of the Mau forest conservancy[107]. The CFAs were a representation of the entire Mau forest and covering five counties of Bomet, Narok, Kericho, Nakuru and Uasin Gishu. They also provide variation by regions, especially in terms of geographical and climatic variables. It is also important to note that the CFAs are very different in several aspects and have different levels of performance in terms of forest conservation, with some having as low as 2% forest cover and the highest having 98% forest cover.

The CFA level data were collected through focus group discussions with CFA officials and other members at their offices in the forest station. In the second stage, a sample of 518 households were identified through simple random sampling, in which every third household was interviewed, and snowballing was used in instances where the third household was not a CFA member[108]. This was conducted using individual household-level survey administered questionnaire to household heads. The CFA-level focus group provided CFA-level data such as years of existence of the CFA, gender

[107] One observation raised by a reviewer was that the head of the conservancy could have identified CFAs that performed well, hence raising issues about the generalizability of the results. However, we can confirm that this was not the case since we visited CFAs that were in poor condition. The main factor considered by the head was accessibility of these CFAs and representation of all counties in the Mau forest. The results can therefore be generalized for the entire Mau forest.

[108] In some instances, we interviewed CFA members at the farms in the forest or when there were collective activities such as tree planting or transportation of tree seedlings

composition of the CFA executive committee, number of households within the CFA, number of immigrants etc. The household-level data provided information such as household size, household level of participation in CFA activities (whether active or not), household head education level, residential status, and distance to the nearest edge of the forest, main road and market. Due to the nature of the terrain and inaccessibility of certain areas, coupled with negative attitudes of some CFA members as a result of mismanagement of CFAs by officials, the households sampled were unevenly distributed across the CFAs, with as few as four households sampled in some cases. Because of the variation in climatic and geographical conditions and the vastness in the sizes of the CFAs, we also collected data on annual average rainfall and temperature values for the various forests. This data was available from the website (http://en.climate-data.org/country/124/). Most of the explanatory variables were based on the decomposed second-tier variables in Table 13 from Ostrom (2009), Ostrom (2010) and Agrawal (2001).

To gauge the household head's level of participation in CFA activities, respondents were assessed based on the last meeting they attended[109], that is, whether they were just present during decision making (nominal), merely attended, were present when a decision was made and were informed but did not speak (passive), expressed an opinion whether sought or not (active), or felt she influenced the decision (interactive)[110].

In this study, two measures of outcomes of collective action were used: reported cases of vandalism in a year and forest cover as a percentage of total forest area within each CFA. The choice of these measures is based on the premise that, if CFAs are well organized, with formal or informal rules of forest management, which are in use and properly implemented, then there should be behavior

[109] We used participation in the last meeting attended as a proxy for their participation level because it is difficult for anyone to say he did not actively participate. However, we cannot rule out possibility of bias, in that some members may talk more in meetings but not work very much.

[110] Households were then classified as active (i.e., active or interactive) and inactive (i.e., nominal or passive). We constructed a dummy equal to one for active and zero for inactive.

change; hence, we expect changes in forest condition and patterns of forest use. Moreover, the better a CFA is organized, the higher the likelihood of active participation of households in CFA activities, with an expected outcome of improvement in forest cover and fewer cases of vandalism. The reported cases of vandalism and percentage forest cover are based on secondary data available at the forest station, which is regularly updated by the forester at each forest station. We acknowledge that the rate of change in forest cover would be an ideal measure of success especially in the short term for new CFAs as opposed to the absolute percentage forest cover as employed in this study. However, due to lack of baseline information on forest cover at the start of devolution of forest management for most CFAs, we opted to use the absolute measure of forest cover but also assess the reliability and consistency of the estimates using the reported cases of vandalism per year. It is also important to note that, before devolution of forest management to CFAs, the Mau forest had been highly degraded. Therefore, the absolute percentage forest cover can still be attributed to the actions of forest-adjacent communities through CFAs. This implies that the aggregate forest cover can still provide meaningful insights on the determinants of successful collective action.

4.5 Results and Discussions

4.5.1 Descriptive statistics

The summary statistics of variables used in the econometric models are presented in Table 15. The table reveals significant variation in percentage forest cover, ranging from 2% to 98%, and reported cases of vandalism ranging from 0 to 120 per year. About 63% of the sampled households were reportedly active in CFA activities. There was also significant variation in the number of households among the 22 CFAs sampled, ranging from 100 to 100,000 households in some CFAs. The reported mean number of households was estimated at about 10,081 households.

Table 15: Summary statistics of variables used

variable	N	mean	sd	min	max
ForestCover	518	76.85	19.15	2	97.97
Vandalism	518	22.63	25.57	0	120
CFAPartici n	518	0.625	0.484	0	1
Numbhsehlds	518	10081	19667	100	100000
GrpStructure	518	0.492	0.500	0	1
Natives	518	74.64	27.64	0	100
FBudget	518	299305	404142	0	1.500e+06
ECMale	518	6.836	3.880	2	18
VertInt	518	2.826	2.903	0	15
HorInt	518	4.396	6.834	0	22
GradChair	518	0.309	0.462	0	1
Competition1	518	0.759	0.428	0	1
SocInt	518	13.66	52.47	0.0350	251.0
MaritSta	518	0.863	0.344	0	1
MedAge	518	47.43	13.60	22	85
MedAgesq	518	2434	1460	484	7225
hhsize	518	5.678	2.579	1	16
Education	518	0.371	0.483	0	1
LivesVal	518	134294	343074	0	5.600e+06
Employment t	518	0.253	0.435	0	1
Woodlots	518	0.847	0.360	0	1
Hlandsize	518	2.334	5.148	0	90
LandTitle	518	0.523	0.500	0	1
DistForest	518	1.443	1.526	0	10
DistMroad	518	2.034	2.789	0	20
DistMarket	518	3.580	3.605	0	20
ResidStatus	518	0.546	0.498	0	1
MedIncome	518	15328	19238	2500	130000
IncentIndex	518	7.176	1.524	4	10
InstIndex	518	5.927	2.112	2	10
ImprIndex	518	3.678	1.532	0	6
DepIndex	518	16.35	2.617	9	21
Precipitat n	518	1170	181.2	937	1735
Temperature	518	15.04	1.726	12.20	18.20
Elevation1	518	2473	240.4	1858	2861

In terms of organizational structure, about 49% of the CFAs reported having had the same leadership structure from inception to date. The mean annual budget of CFAs is approximately USD 3000, with the maximum about USD 0.015 million. The summary statistics of other variables employed in the study are also shown. Further summary statistics of other variables within CFAs are presented in tables C.1 to C.7 in the appendix.

From table C.1 we can conclude that the main source of income for most households in the various CFAs is farming (61%) followed by livestock keeping (31%). However, the single most important and reliable source of funding for all CFAs was noted to be membership fees for all CFAs (i.e. 100%) followed by aid from external NGOs (33%) as shown in Table C.2. The main mode of communication to CFA members as shown in table C.3 was also found to be through mobile phones (85%) followed by word of mouth (71%). In terms of resource dependence levels, Table C.4 shows that most CFAs significantly depend on the forest for grazing (96%), water (87%), wood fuel (72%) and farming (64%) hence the need for alternatives aimed at reducing forest dependence. Table C.5 presents a summary of the various rules. The table shows that only rules regarding punishment (45%) and role of traditional leaders (36%) are not well instituted in most CFAs an indication of proper organization in most CFAs. On the other hand, we found that most CFAs participate in various forest improvement activities as shown in table C.6. Watering and thinning are least done by various CFAs. Finally, regarding incentives towards deepening community participation, fetching water, PELIS, Grazing, Fodder collection, Fuel wood collection and herbs collection dominated the list of incentives that most CFAs benefit from as depicted in table C.7.

4.5.2 Logistic regression Results

The logistic regression results are presented in Table 16. Finding no evidence of misspecification or omitted variable bias, the estimated coefficients in the logistic regression have the expected signs. The results show that, all factors constant, households where the head has post-primary education tend to have higher likelihood of actively participating in CFA activities. This is unexpected given that education results in out-migration and increased opportunity cost of labour (Godoy et al., 1997). However, this could be explained by the fact that the educated often tend to be informed and recognize and appreciate the value of environmental conservation. They are also

more likely to inform decision making in CFAs because they are the most respected and are listened to by community members.

Household heads employed in off-farm jobs are less likely to be active in CFA activities. This could be due to availability of exit options from farm work and other informal jobs. Participation in CFA could also be a last resort for the unemployed because their returns on labour efforts could be lower (Angelsen and Wunder, 2003). These results support findings by (Fujiie et al., 2005; Bardhan, 2000). Households owning private woodlots were found to have a significantly higher likelihood of being actively involved in CFA activities. The ownership of private woodlots would imply interest in environmental conservation activities or a search for options other than farming, say, in the forest, after engaging private land in developing private forests[111]. The results also show that a one-kilometre increase in distance from the nearest main road increases the likelihood of being actively involved in CFA activities by approximately 2.2%, holding other factors constant. In this case, distance measures the level of infrastructure integration; therefore, households would opt for being active in CFA activities to enjoy the benefits as CFA members, given that accessing other areas and markets could be costly; hence participation in CFA activities offers a fallback option. These findings also lend support to the work of Fujiie et al. (2005), who found that, when communities are less exposed to urban centres, there is higher incentive for cooperation and hence active participation.

[111] During the survey, households mentioned that tree growing offered a lot of income compared to private farming, hence some households would consider engaging in planting of trees on their farms for income generation and opt to be active in CFA activities to derive other benefits. e.g. PELIS.

Table 16: Results for logistic regression for probability of active participation in CFA activities

	(1)	(2)
VARIABLES	**CFAParticipation**	**Marginal Effects**
MaritSta	0.452	0.0897
	(0.293)	(0.0575)
MedAge	-0.00942	-0.00187
	(0.00746)	(0.00147)
hhsize	0.0805*	0.0160*
	(0.0429)	(0.00842)
Education	0.517**	0.102**
	(0.214)	(0.0417)
EmploymentStat	-0.902***	-0.179***
	(0.236)	(0.0444)
Woodlots	0.847***	0.168***
	(0.268)	(0.0513)
Hlandsize	-0.000104	-2.06e-05
	(0.0195)	(0.00386)
DistForest	0.103	0.0204
	(0.0699)	(0.0138)
DistMroad	0.113**	0.0224**
	(0.0499)	(0.00975)
DistMarket	-0.0815**	-0.0162**
	(0.0374)	(0.00731)
ResidStatus	-0.390*	-0.0774*
	(0.210)	(0.0412)
IncentIndex	0.0527	0.0105
	(0.0681)	(0.0135)
Precipitation	0.00229***	0.000455***
	(0.000663)	(0.000126)
Constant	-3.430***	
	(1.112)	
Observations	518	518

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

On the other hand, one unexpected result is that of distance to the nearest market. The results show that a one-kilometre increase in distance from the household to the nearest market reduces the likelihood of active participation in CFA activities by about 1.6%, holding other factors constant. This contradicts findings by Fujiie et al. (2005), who found that market access often reduces interdependence within a local community and thus may allow exit of some members, which might lower the likelihood of participation in collective action. Our findings also contradict Bardhan

(1993) and Ostrom and Gardner (1993), who found that anonymity among actors increases the closer households are to markets, which loosens up traditional ties, lessens mutual dependencies and lowers inter-linkages for punishment in case of violation of rules resulting in reduced prospects for active involvement and cooperation. However, a possible reason for this finding is that, when households are closer to market centres, it means they are closer to forest authorities and therefore more likely to be active; we were informed that foresters are normally keen to notice those who have been active in CFAs, for instance, during transportation of seedlings to the forest and would often ensure they get PELIS plots as a reward for being active. Lastly, more rainfall prospects increases the likelihood of households actively participating in CFA activities. This could be because more rainfall would mean more anticipated agricultural harvest; therefore, more members will tend to be active in CFA activities to access PELIS plots or derive other non-timber forest products such as firewood for cooking and keeping warm during the rainy season.

4.5.3 Determinants of successful collective management of forest resources

Empirical results for the multiple regression models are presented in Table 17. We first present the OLS regression estimates assuming absence of endogeneity, then present the instrumental variable estimation with heteroscedasticity-based instruments to address the potential endogeneity issues. Columns 1 and 2 present the OLS model of forest cover and reported cases of vandalism respectively, assuming absence of endogeneity. Columns (3) and (4) present the IV estimation with heteroscedasticity-based instruments to address the endogeneity concerns. The last column, Column (5), presents the OLS estimates for the PC score. We tested for multicollinearity for all the regression models and found all variables to have a variance inflation factor (VIF) below 10, with a mean VIF of between 5.99 and 6.63[112]. To correct for heteroscedasticity in the models, we

[112] Other variables such as age of CFA were dropped due to multicollinearity issues.

estimated the three models with clustered robust standard errors[113]. The IV estimates were obtained using the ivreg2h stata command (Baum et al., 2015).

Table 17: OLS regression results

VARIABLES	(1) ForestCover	(2) Vandalism	(3) IVforestcover	(4) IVVandalism	(5) PCA1
InstIndex	2.048*	-0.460	1.949***	0.984***	0.0968***
	(1.014)	(1.364)	(0.259)	(0.309)	(0.0264)
FBudget	1.73e-05**	-2.13e-05**	1.48e-05***	-5.09e-06*	4.26e-08
	(7.29e-06)	(9.03e-06)	(2.17e-06)	(2.85e-06)	(2.42e-07)
MedAge	-0.262**	0.370**	-0.298***	0.394***	0.00224
	(0.113)	(0.140)	(0.111)	(0.122)	(0.00254)
MedAgesq	0.00206**	-0.00269**	0.00238**	-0.00312***	-2.41e-05
	(0.000937)	(0.00109)	(0.00105)	(0.00115)	(2.00e-05)
Natives	0.000743	-0.819***	-0.0366	-0.710***	-0.00247
	(0.0739)	(0.115)	(0.0282)	(0.0458)	(0.00231)
Numbhsehlds	-0.000394**	0.000222	-0.000527***	0.000457***	-1.00e-05*
	(0.000142)	(0.000164)	(5.66e-05)	(7.32e-05)	(5.29e-06)
DepIndex	-2.405***	2.545***	-2.231***	3.738***	-0.0157
	(0.698)	(0.650)	(0.360)	(0.268)	(0.0370)
ECMale	1.166	0.122	1.178***	1.710***	-0.0161
	(0.692)	(0.961)	(0.282)	(0.383)	(0.0228)
CFAPart_Ht	3.559**	-4.966**	3.377*	-3.441*	0.139
	(1.519)	(2.027)	(1.796)	(1.873)	(0.0844)
MedIncome	-2.65e-05	-4.40e-06	-2.98e-05***	3.26e-05**	5.98e-07
	(1.96e-05)	(2.20e-05)	(1.06e-05)	(1.64e-05)	(6.42e-07)
GradChair	-7.735	-13.73*	-11.04***	1.351	-0.462***
	(4.721)	(7.931)	(1.711)	(3.130)	(0.102)
DistForest	-0.529*	0.639**	-0.494***	0.501***	-0.0108
	(0.269)	(0.251)	(0.157)	(0.183)	(0.00662)
Precipitation	-0.0698***	0.141***	-0.0599***	0.120***	1.92e-05
	(0.0143)	(0.0288)	(0.00584)	(0.00760)	(0.000324)
Temperature	-5.883***	14.23***	-5.262***	14.98***	-0.0216
	(1.288)	(2.633)	(0.679)	(0.644)	(0.0346)
Elevation1	-0.00995	0.117***	-0.00753*	0.127***	0.000751***
	(0.0103)	(0.0165)	(0.00406)	(0.00424)	(0.000185)
Init_NGO	10.77	4.046	10.83***	10.19***	
	(6.804)	(11.47)	(1.647)	(3.572)	
Init_RegGov	-14.17**	49.71***	-13.88***	57.97***	
	(6.386)	(7.353)	(2.120)	(2.282)	
Init_NatGov	-19.53***	14.37	-19.23***	3.253	
	(6.735)	(8.992)	(1.883)	(2.392)	
GrpStructure	13.14**	-49.36***	11.24***	-46.92***	
	(5.845)	(9.063)	(2.119)	(2.104)	
Competition1	3.327	-21.01**	4.570***	-31.33***	
	(4.525)	(8.035)	(1.317)	(2.170)	
SocInt	0.206***	-0.327***	0.176***	-0.269***	
	(0.0291)	(0.0597)	(0.0167)	(0.0179)	

[113] It is important to note that, because reported cases of vandalism are count data, other models such as negative binomial and Poisson regression could be explored. Though the results are not presented here, we found that the Poisson regression was less appropriate than the negative binomial regression. However, the negative binomial regression results produced results almost identical to results to the IV model with heteroscedasticity-based instruments. Hence, we settled on the IV model with heteroscedasticity-based instruments because it addresses the endogeneity problem.

LandTitle	2.147**	-1.875**	2.242***	-1.845***	
	(0.816)	(0.694)	(0.575)	(0.682)	
ImprIndex	3.855**	-24.69***	2.133**	-18.71***	
	(1.815)	(2.604)	(0.929)	(1.278)	
VertInt			1.057*	-1.365***	0.0953*
			(0.592)	(0.523)	(0.0504)
HorInt			0.254**	-1.921***	0.0486***
			(0.111)	(0.211)	(0.0154)
ForestCover					-0.0130***
					(0.00405)
PELIS					0.526**
					(0.206)
Constant	279.1***	-504.6***	259.3***	-579.5***	-0.795
	(50.44)	(94.61)	(28.19)	(28.50)	(1.391)
Observations	518	518	518	518	518
R-squared	0.895	0.907	0.897	0.923	0.830

Clustered robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

We first tested for endogeneity using the Durbin-Wu-Hausman tests for endogeneity under the null hypothesis that the variables are exogenous (see Table C.9 in the appendix). The test rejects the null hypothesis of exogeneity at the 1% significance level for the second IV model of reported cases of vandalism but not the first IV model where the dependent variable is forest cover. This suggests that OLS estimates yield better results in model one of forest cover (Column (1)), while the IV method with heteroscedasticity-based instruments yield better results in the second model, where the dependent variable is reported cases of vandalism (Column (4)). We further carried out performance statistics for the IV models (see Table C.10). First, we tested for under-identification (i.e., whether the excluded instruments are correlated with the endogenous regressors). Based on the Kleibergen-Paap rk LM statistic, we reject the null hypothesis that the equations are under-identified in the two IV models, at the 1% significance level. Secondly, we tested for weak identification because, if excluded instruments are weakly correlated with the endogenous regressors, then the instrument may lead to poor estimates. Using the Craig-Donald Wald F statistic, we reject the null hypothesis of weak identification, as shown by the large F statistic.

Lastly, we carried out a test of over-identification using the Hansen J statistic under the null hypothesis that the instruments are valid (i.e., that the instruments are uncorrelated with the error

term and the excluded instruments are correctly excluded from the estimated equation). Based on this test, we reject the null hypothesis that the instruments are valid. This result raises questions about the validity of the IV estimates. It is important to note, however, that the Hansen J statistic checks the validity of the over-identifying restriction. Our results imply that the validity of over-identifying restrictions provides limited information on the ability of the instruments to identify the parameter of interest. This is, however, not a finite sample limitation of the test but just one of the intrinsic characteristics (Parente and Silva, 2012). According to Parente and Silva (2012), the outcome of the test of over-identifying restriction does not rely on having a reasonable number of valid instruments but rather the test checks the coherence of the instrument and not the validity of the instrument. Therefore, we can still make inferences based on the instrumental variable estimates of the second IV model. Recall that the Durbin-Wu-Hausman test of endogeneity revealed that the OLS model for forest cover (reported in Column (1)) provides better estimates than the IV model for forest cover, while the IV estimates for the reported cases of vandalism (reported in Column (4)) were superior to the OLS model for reported cases of vandalism. Our discussion will henceforth be focused on the results in Columns (1) and (4) along the various subsystems in Ostrom's SES framework.

Institutional organization and governance system

Using the level of implementation of Ostrom's design principles to assess institutional quality or level of organization, our results suggest that, holding all factors constant, as the index of institutional quality increases from zero to ten, there is a higher likelihood of successful collective action, as depicted by the increase in percentage forest cover. This supports findings by most studies (e.g., Ostrom 1990; Baland and Platteau 1996; Heltberg et al. 2000; Heltberg 2001; Johnson and Nelson 2004; Gautam and Shivakoti 2005; Pagdee et al. 2006; Dash and Behera 2015). However, the positive association of the institutional index and reported cases of vandalism suggest

otherwise. This finding is hard to explain given that it is highly significant, contradicting findings by Alló and Loureiro (2016) and other past studies. However, according to Alló and Loureiro (2016), it is important to understand the social aspects of the community to explain the possible positive association, because some vandalism may be intentional within certain communities, especially where communities are not satisfied with actions of their officials.

Consistent with theory, we found that organizations initiated by NGOs and national or regional governments are less likely to lead to successful collective action. Our findings suggest that CFAs initiated by local communities themselves tend to be successful in collective action. This also reveals that communities generally mistrust the government and are less to likely self-organize in respect to directives from government, due to fear of the government's intentions. This finding could also be attributed to foresters' rent-seeking behavior and their wanton interference in the affairs of CFAs. These results are consistent with findings by Gebremedhin et al. (2004) and (Measham and Lumbasi, 2013).

When it comes to the composition of the CFA executive committee, the results indicate that the higher the percentage of male executives, the lower the likelihood of successful collective action, as shown by the increase in cases of vandalism. These results are consistent with Agrawal and Chhatre (2006), who found that having more women in power leads to better forest outcomes. We also considered the frequency of interaction between the CFAs and local/regional government (horizontal interaction) and national government offices (vertical interaction) with the CFAs and how this affects the success of collective action. The results show that, the greater the interaction between CFA members and the national or regional governments, the greater the success of collective action, as depicted by the reduced cases of vandalism[114]. This suggests that face-to-face

[114] We did not include the frequency of interaction in the two OLS models of forest cover due to multicollinearity.

bargaining/interaction and frequent contact with CFA members encourage communities to work collectively in managing and conserving the natural resources adjacent to them, apparently by increasing trust between forest-adjacent communities and the state. This also implies that frequent government and community interactions can improve the success of collective action. These results lend support to findings by Ostrom (2000) and Liu and Ravenscroft (2016).

The study results suggest that financial empowerment of CFAs is an incentive for successful collective action, as depicted by the growth in forest cover and a decline in reported cases of vandalism. This is expected given that, with more funding, CFAs can offer compensation to incentivize some members of the community to guard the forests, or can even hire forest guards. From the survey, we observed that CFAs with limited financial resources faced problems of forest degradation. However, we also noted that some CFAs with high income generating activities, such as eco-tourism, experienced mismanagement of funds and hence degradation of forests by disgruntled members who felt the CFA officials were mismanaging their resources. This implies that, as much as financial resources may increase the success of collective action, it may have an opposite effect if not properly managed, or if there is inequitable distribution.

In terms of the organizational structure, we asked respondents during the focus group discussion whether the structure of the organization was still the same as when it was first constituted, in terms of the officials. This was used to assess the effect of trust and group structure on the success of collective action. Our results show that organizations that had not changed their group structure or where the structure does not change regularly were more successful in collective action. That is, in organizations where group members trust and have faith in the group structure in terms of its officials, then collective action is more likely to be successful. Similarly, to assess the level of democracy in the group and its effect on the success of collective action, CFA members and officials were asked during the focus group discussions whether the positions in the CFA are

normally competed for in an election. The study results revealed that democracy leads to successful collective action. This is expected, given that communities will only have faith in working together if they perceive the organization to be democratic and they have a say in who leads the group; otherwise, they might opt to sabotage the group by participating in illegal activities.

Household/User Characteristics

Looking at the regression results in Columns (1) and (4), the results show that, holding all else constant, the higher the likelihood of active household participation in CFA activities, the greater the success in collective action. This is expected, given that, with active involvement in CFA activities, communities are more likely to work collectively towards forest conservation, leading to better ecological outcomes. When we look at the effect of income heterogeneity, the results indicate that greater income inequality is detrimental to the success of collective action, in tandem with findings by Agrawal and Gibson (1999), Andersson and Agrawal (2011) and Tesfaye et al. (2012). On the other hand, we found that, for sustainability of forest conservation, allocation of property rights, especially land titles or allotment letters, is critical for successful collective action[115].

As expected, the study results suggest that the success of collective action increases with people's age. The relationship between forest cover and age is U shaped, while it is an inverted U shape for age and reported cases of vandalism. These results suggest that forest cover decreases and reported cases of vandalism increase up to a certain age, when forest cover begins to rise and reported cases of vandalism begin to decrease. This is because, as people get older, they have less physical energy to engage in intense economic activities such as forest clearing for farming or illegal logging activities. Similarly, as people get old, children move away in search of new opportunities and start their own households; there is less available labour but also fewer mouths to feed, and, therefore,

[115] Giving forest-adjacent communities a sense of belonging encourages them to conserve forest resources, unlike the case when they know they can be displaced by the government at any time.

less dependence on forests as a source of livelihood. These results support findings by Godoy et al. (1997), although differing with Thondhlana and Shackleton (2015), who argued that the old often have more ecological knowledge regarding maximal harvest of certain resources like medicinal plants and wild game.

The study also examined how group size affects the success of collective action, using number of households within the CFA jurisdiction. Our results suggest that the higher the number of households within the CFA, the lower the success of collective action, as indicated by the increased cases of vandalism. This can be due to the fact that the marginal private gains to an individual are more than the marginal social cost of defection of an individual. More households also mean greater demand and competition for forest products. The study findings are in accord with expectations in group theory (Olson, 1965; Tang, 1992; Bardhan, 1993; Fujiie et al., 2005; Hyde, 2016) but contradicts findings by Agrawal and Goyal (2001) and Meinzen-Dick et al. (2002), who argued that, as the group size increases, the transaction costs of organizing within a group may also increase; however, the payoff in terms of lower transaction costs between government and groups also increases as the size increases. On the other hand, using density of household population as a proxy for intensity of social interaction, our findings revealed that the higher the household density, the higher the incentive for successful community wide-collective action, as shown by the positive effect on forest cover and reduced cases of vandalism as expected. This is because, where people live closely in a common neighborhood or social circles, enforcing rules is much easier and there is a lower marginal cost of coming together in collective action. These results are in tandem with findings by Fujiie et al. (2005) and Akamani and Hall (2015).

Our results also revealed that CFAs with a higher proportion of natives tend to be more successful in collective action, as revealed by the decline in reported cases of vandalism. This can be explained by the fact that immigrants may be driven by the motive of extracting forest resources for their

short-term gains rather than conserving the forest, because they have their own homes to go back to, in the event the resource gets depleted. In general, there is a good deal of ethnic tension between natives and immigrants within the Mau forest[116].

Resource Characteristics

Using distance from the household in kilometres to the nearest edge of the forest to proxy for resource scarcity, the results suggest that the farther a household is from the nearest edge of the forest, the lower the success of collective action, as depicted by the decrease in forest cover and increased cases of vandalism. These results are as expected, given that the farther households are from the forest, the higher the opportunity costs of participating in CFA activities, hence the lower likelihood of successful collective action. It is also difficult to monitor forests when households are far away from the forest, hence the increased cases of reported vandalism.

In the PCA model, we included forest cover to capture forest condition and existence of PELIS within a CFA to capture the effect of incentives on collective action[117]. The results suggest that greater forest cover reduces the likelihood of successful collective action. This is as expected because, when the forest cover or condition is good, there is an abundant supply of forest ecosystem services and hence no incentive for communities to self-organize and conserve the forest. Moreover, when the forest cover is good, people may consider returns from such collective action activities as low. On the other hand, if the forest condition is bad, there is more incentive to self-organize and restore the degraded forest due to resource scarcity. Similarly, the existence of incentives such as PELIS increases the ability of CFAs to self-organize, supporting findings by Szell et al. (2013).

[116] We opted to use data on the proportion of immigrants because we could not get data on in and out migration at CFA level. [117]Other variables such as competition, social interaction, group structure, improvement index and initiation of the CFA were dropped from the model due to multicollinearity

Interaction of the resource with the users

To study the interaction of the resource with forest users, we constructed an additive improvement index ranging from zero to seven to measure the level of improvement activities undertaken by CFAs; this could also measure cooperation in CFA activities. The study results show that, as the level of forest improvement activities increases from zero to seven, there is significant increase in forest cover as well as significant decrease in reported cases of vandalism. This means that the more locals carry out forest improvement activities, such as pruning, the greater the success of collective action, as depicted by both improvement in forest cover and reduced cases of vandalism. This is attributed to the fact that forest improvement activities increase forest growth and that locals also monitor the forest during such activities, thereby reducing cases of vandalism.

To assess the effect of the salience of the resource, we constructed an index of resource dependence, where the index was coded from 0 to 3 with the score ranging from 9 (low dependence) to 21 (very high dependence). Although studies such as Dietz et al. (2003) and Wade (1988) found that the level of dependence on a resource is key in facilitating the success of collective action, our results contradict these studies. We found that the higher the level of dependence on the resource for livelihood by forest-adjacent communities, the lower the success of collective action, indicated by the decreased forest cover and increased vandalism. The negative effect on forest cover and positive effect on reported cases of vandalism can be partly attributed to over-reliance on common pool resources by forest-adjacent communities' due to lack of alternative sources of livelihood.

Climate and Geographic Variables

In terms of climate and geographic variables, the results suggest that an increase in precipitation leads to a decline in forest cover and increased reported cases of vandalism. This suggests that an increase in precipitation reduces the likelihood of successful collective action hence the negative effect on forest conservation and positive influence on reported cases of vandalism. Although we

expected precipitation to have a positive effect on forest cover. The unexpected results may be attributed to the fact that when it is rainy people tend to over exploit or take advantage to engage illegal activities such as illegal logging or cutting trees for cooking and keeping warm taking advantage of limited security during rainy seasons as depicted by the increased cases of vandalism. This can also be explained by increased demand for charcoal during rainy season. On the other hand, during period of high rainfall people may tend to engage in their private farms given that the opportunity cost of participating in CFA activities may be higher and therefore less monitoring activities. Similarly, the results show that an increase in temperature leads to a decline in forest cover but increase in reported cases of vandalism per year. This show that higher temperature lowers success of collective action hence the negative impact. This can be attributed to the fact that during hot or dry seasons, cases of wildfires are rampant and higher temperatures also lowers the productivity of members of communities thus very few may be active in collective activities. As expected, the results suggest that the higher the altitude/elevation, the lower the forest cover and the higher the reported cases of vandalism implying that the success of collective action reduces with the increase in altitude in tandem with findings of Tesfaye et al. (2012) but contradicting findings by Agrawal and Chhatre (2006). This can be attributed to the inaccessibility of certain sections of the forest hence illegal activities are more likely.

4.5.4 Robustness Checks

For robustness checks, we considered use of PCA to construct an index of collective action (considering collective action activities under forest management and improvement) to assess how our results would vary when we use a measure of collective action as opposed to the outcome of collective action. Because the seven types of collective action activities under forest management and improvement may be orthogonal to each other, we used PCA instead of an additive index

because it produces a more effective measure (Darnell et al., 1994). Further, the Kaiser-Meyer-Olkin (KMO)[117] measure of sampling adequacy revealed that about five out of the seven variables had a KMO measure above 0.5, with an overall KMO of 0.49, which justifies the use of PCA. For each collective action activity, households' participation in a given CFA is recorded as one and non-participation as zero. In our sample of 22 CFAs, 75%, 87%, 78%, 81%, 72%, 33% and 29% of them successfully organized collective pruning, enrichment planting, reseeding, weeding, silviculture operations, thinning and watering, respectively.

The PCA results revealed that the first of three components that had eigen values more than one dominates in terms of eigen values and proportion of variation; see Table C.8. Moreover, the first component also makes more sense economically because none of the coefficients is negative, unlike the other components. The first component vector contains positive weights for all collective action variables, which is evidence of aggregate variation as a result of varying degrees of cooperation (Fujiie et al., 2005). However, this approach does not guarantee that the first component gives the index of cooperation but just that it is consistent with economic theory (Fujiie et al., 2005). Following Fujiie et al. (2005), we used the first component as a measure of successful collective action. We classified CFAs with PC scores greater than zero as successful and those with scores less than zero as unsuccessful. We then conducted an OLS regression using the constructed measure of successful collective action using the PC score[118]. The results are presented in Column (5) of Table 17. The results do not depict much difference in terms of signs (except for the few insignificant variables) when we compare with our results using the measures of outcome of collective action.

[117] The KMO measure tests for sampling adequacy for each variable in the model and for the complete model.

[118] We used Linear Probability Model (LPM) with robust standard errors rather than a logit or probit model on the dummy variable for success of collective action. Due to unboundedness of the predicted probabilities that may lead to inconsistent and biased estimates, we followed the approach of Horrace and Oaxaca (2006) by estimating and assessing the predicted probabilities outside the unit interval. We found that the predicted probabilities outside the unit interval were less than 30%, hence the LPM would still provide reliable estimates in this case.

4.5 Conclusion and Policy Recommendations

In this study, we have attempted to analyze factors influencing households' level of participation in CFA activities and the determinants of success of collective action in community forest management, as well as the link between households' participation levels and the success of collective action. Using the SES framework for analyzing complex ecological systems, several conclusions can be made about factors influencing households' participation levels in community forest management. The empirical results suggest that employment status, educational level, ownership of private woodlots, precipitation, and distance to nearest main road and nearest market influence the household level of participation in community forestry, lending support to the works of (Malla, 1997; Adhikari, 2004; Agrawal and Gupta, 2005; Maskey et al., 2006; Coulibaly-Lingani et al., 2011). These factors therefore need adequate consideration in devolving forest management to local communities in the Mau forest.

The study further revealed that, for the success of collective action, other than just handing over management of CPR resources to communities, it is important to consider factors such as the average age of household heads, distance of households from the nearest edge of the forest, the institutional quality (i.e., level of institutional organization in terms of implementation of Ostrom's design principles), salience of the resource (level of dependence on the resource), number of households within a CFA jurisdiction (group size), proportion of males on the executive committee, level of interaction with the various government departments in terms of frequency of meetings, intensity of social interaction, structure of the group and whether officials are selected competitively/democratically. In terms of the link, we found that the higher the probability of households actively participating in CFA activities, the higher the likelihood of success in collective action activities. The results also suggest that CFAs are more likely to be successful in

collective action if they are initiated by the communities themselves, with frequent interactions with government departments. Our PCA results also revealed that, in addition to the factors identified earlier, communities are more likely to self-organize in the presence of incentives such as PELIS and when the forest cover is low or when there is scarcity in the supply of forest ecosystem services. One evident point is the significantly large effect of institutional quality variables on measures of outcome of collective action. This shows that the principle of collective action within the Mau is key for better ecological outcomes. We also noted that, whether we use the outcome of collective action or just a measure of collective action activity or cooperation, we would still arrive at very similar conclusions.

A number of policy recommendations can be made from the study. First, although devolution of forest management has the potential to increase efficiency and equity, it may not be an end in itself in terms of achieving sustainability of CFAs as well as conservation of forests. Foresters therefore need to understand the needs of households under their CFAs to effectively promote the objectives of PFM. A more robust diagnostic approach in devolution of forest management to local communities, considering diverse socio-economic and ecological settings, is therefore necessary. Secondly, there is a need to revive and re-institutionalize existing CFAs in an effort to promote PFM within the Mau forest and other parts of the country. Policy makers also need to promote PFM in areas where, despite low forest cover, communities have been reluctant to adopt the approach and explore other incentives and alternatives that can reduce over-reliance on forest resources. Thirdly, intense efforts should be geared towards design of a mix of incentive schemes to encourage active and equal household participation in CFA activities. In addition, public-private partnerships could also play a role in strengthening and nurturing existing and infant CFAs and creating awareness among locals. Lastly, to incentivize communities, the government should explore ways of allocating land rights to forest-adjacent communities. In addition, KFS should consider

increasing the proportion of collected revenues that goes to CFAs and forest user groups to support the local communities and CFAs financially as they find a way of handling wayward foresters through constant interaction with community members.

Chapter Five

5.1 General Conclusion

The main objective of devolution of forest management to forest adjacent communities has been to sustainably manage forest resources through increasing community participation in forest management, improving welfare of locals and addressing market, institutional and policy failures associated with ill-defined property rights, externalities and market imperfections. Literature also supports the claim that in terms of efficiency and equity, common property rights seems more superior. Efficiency increases due to the fact that more local input result in well targeted policies and lower transaction costs especially to the government. However, the equity and democratic benefits accrue mostly to the local communities. Agrawal and Ostrom (2001); Larson and Ribot (2004); Sikor (2006); Bluffstone et al. (2008) are some of the recent literature on co-management of forests between the state and forest adjacent communities that has been seen as effective policy instruments in conservation of forests. However, empirical works supporting the theoretical predictions are quite scant and inconclusive due to the varying socio-economic and ecological contexts and the methodological approaches. It is this scant literature that motivated our study to contribute to the academic and policy debates on this matter. Specifically, using advanced econometric techniques, we sought to: first, determine the economic values of forest ecosystem services to local indigenous communities in Kenya and assessed their implication for design of incentive schemes such as PES and on PFM; second, evaluate the welfare and environmental impact of incentive based conservation focusing on one unique incentive scheme known as the PELIS; and lastly, identify the determinants of successful collective management of forests in Kenya. The findings from the study broadens and deepens conclusions from past studies and

informs both academic and policy debates on community forest conservation and management policy in developing countries.

This thesis contributes to the body of knowledge in the following aspects. First, we contribute to the Choice experiment literature using the Bayesian efficient design from a developing country perspective, our analysis also helps identify peasant farmers' preferences for various salient forest ecosystem attributes that can help design widely accepted conservation programs through PFM and also inform the design of PES schemes to incentivize forest adjacent communities. We also extend this literature through application of state of the art discrete choice econometric models to test for preference heterogeneity and sources of these heterogeneity.

Second, the thesis contributes to the rigorous literature on impact evaluation of government policies and programs by specifically looking at one unique incentive scheme known as PELIS. Most literature on impact evaluation assume constant treatment effect across the population. To identify the true welfare impact, it is important to assess the heterogeneous impact of the scheme on household welfare. This also assists in assessing the sustainability of the scheme in terms of forest conservation. We therefore contribute to this literature by employing a mix of PSM and instrumental variable method specifically the endogenous QTE model to identify the heterogeneous impact of the program as we address selection issues and potential endogeneity. This empirical approach therefore extends previous literature by identifying the correct program impact for policy and academic debates especially on how incentives can sustainably promote livelihoods of forest adjacent communities while simultaneously conserving the forests. The main interest of policy makers would be on the scheme's equity and whether the program can help the poor rise up the income ladder. Identifying the heterogeneous impact of the scheme on household welfare, would thus supply policy makers with the requisite information for policy formulation specifically with the design, implementation and roll out of incentives like PELIS to other CFAs.

Lastly, the empirical results contribute to the debate on whether devolution of forest management can be taken as blue print for successful collective management of forest resources under different socio-economic, cultural and ecological settings through empirical validation of the theoretical views in the commons literature. We also extend this literature empirically by identifying context specific factors that incentivize households to actively participate in collective management of forest resources. Policy makers also need to understand the contextual factors influencing successful collective management for design and implementation of PFM.

A number of findings emerged from the research. Results from chapter two revealed that the average respondent has high WTP for improvement in forest structure, flood risk reduction and high water quality and quantity but would experience a loss in welfare for choosing an intervention with medium wildlife population. The results thus show that there is much appreciation by the average respondent for the role of forest ecosystem services and that forest-adjacent communities are more pro conservation mainly motivated by the direct and few indirect benefits they derive from these forest ecosystems. These results also point to the context specific variations in terms of values and preferences for ecosystem services within developed and developing countries. A significant finding from the study was the high WTP values for reduction in flood risk, thus revealing the altruistic nature of forest adjacent communities that they are not only concerned with direct use values but also non-use values for the welfare of other members of the society. This aspect of the society thus motivates the design of incentive schemes such as PES. We also found considerable preference heterogeneity which to a large extent was determined by employment status of household head, ownership of PELIS plot, household size, and distance to the nearest edge of the forest. In terms of welfare, respondents revealed that forest conservation policy and a combination of flood mitigation and forest conservation policy would have high welfare impacts on livelihoods of locals. A number of policy recommendations can be highlighted from the

valuation exercise. First, the WTP estimates lays foundation for the design of market based instrument such as PES which can significantly incentivize communities and enhance the roll out, design and implementation of PFM. However, more research on the demand and supply side is needed as well as consideration of issues as to what private partners may consider worth involving in PES schemes. Bundling different ecosystem services together may also help in diminishing transaction costs. A cost benefit analysis and assessment of political climate in cases where communities have strong attachment to their forests either for cultural values or other ecosystem services may also be important in designing the PES schemes.

In addition, a demonstration of the value of ecosystem services as input in the production process can play a role in increasing environmental awareness and motivating forest adjacent communities to conserve forest resources through PFM. This can also encourage shifts from socially unacceptable land management activities towards ecosystem oriented approaches. Lastly, policy makers need to focus on policy options with higher mean welfare impacts to increase community involvement in forest conservation. A comparison of the different marginal willingness to pay for the various forest ecosystem attributes may also contribute to the understanding of the relative importance that respondents hold for them as well as the computation of TEV of the forest reserve. In effect, the study provides policy makers with reliable input for maximizing social welfare which has always been shown to be determined by non-market forest externalities. The study also presents recommendation to policy makers and business communities at the national, international, regional and local levels on how to take proper account of the value of ecosystem services in decision making. It is thus evident that communities consider the forest of significant values hence the need to consider more roll out of PFM to forest adjacent communities that have been hesitant to self-organize into CFAs.

In the third chapter, we found that on average PELIS meets the dual objective of improving household welfare and improving forest cover. However, the QTE model under endogenous assumption, revealed that the scheme had positive impact on household welfare from the fourth quantile households and above only. We can therefore, infer that there is some distributional inequity on the impact of the scheme that needs to be addressed for the sustainability and success of the scheme and for it to be able to make low income household rise up the income ladder and lead to improvement in forest cover at the same time. We also found that the scheme is less pro poor since the scheme raises welfare of the least poor as well even though the poorest and marginalized sections of the community are left out. The results show that on average PELIS leads to improvement in forest cover and generates income thereby reducing poverty for the rural poor who have always been thought to be the most dependent and agents of environmental degradation. Its sustainability is however compromised by the distributional inequity. The determinants of households' level of participation that are essential for consideration in allocation of PELIS plots to forest-adjacent communities were also identified.

In terms of policy implications, there is need for a balanced and all-inclusive approach (involving the participation of all members regardless of economic status) to forest management to ensure equitable distribution of PELIS plots and other incentives across the income groups. Attention to equity in resource management and access should therefore be given prime consideration particularly with respect to forest resources and existing incentives to avoid further marginalization of any income group. The design and implementation of the scheme with much emphasis on method of plots distribution should also be given due consideration if it is not to discriminate the very group that it is meant to benefit and to ensure sustainability of the scheme. Failure to address the equity concerns could lead to increased degradation and worsened welfare outcome for lowest income groups with the rising population since the short-term gains from illegal logging may not

be sustainable following a decline in forest cover and reduced soil fertility[119]. Secondly, there is need to explore ways of training forest adjacent communities on modern farming techniques and product diversification and improving market opportunities and linkages for various non-timber harvests from the PELIS farms by households either through formation of forest user cooperatives or partnership with other relevant organizations.

Finally, in the fourth chapter, factors affecting households level of participation in community forest management as well as the determinants of successful collective management of forest resources are identified. We found that for the success of collective action, other than just handing over management of CPR resources to communities, it is important to consider factors such as; age of household heads, distance an household is from the nearest edge of the forest, the level of institutional organization in terms of implementation of Ostrom design principles, salience of the resource (level of dependence on the resource), level of interaction with the various government departments in terms of frequency of meetings, among other factor. In terms of the link we found that, the higher the probability of a household actively participating in CFA activities the higher the likelihood of successful collective action. The results also revealed that CFAs are more likely to be successful in collective action if they are initiated by the communities themselves with frequent interaction with government departments. The PCA results also confirmed that in addition to the identified factors, communities are more likely to self-organize hence in effect successful in collective action in presence of incentives such as PELIS and when the forest cover is low or when there is scarcity in supply of forest ecosystem services. Our findings therefore, show how the contribution of these factors to the success of collective action significantly vary with and within country context. Overall, we found that better welfare and ecological outcomes are realized not

[119] This is mainly attributed to the fact that poorest sections of the community are often attracted by short term gains than the long-term costs which the key concern of policy makers.

only through incentives but also as a result of higher levels of organization, cooperation and participation among communities.

A number of policy implications can be drawn from these results. First, foresters within the various CFAs need to understand the households needs under their CFAs to effectively promote the objectives of PFM. A more robust diagnostic approach in devolution of forest management to local communities considering diverse socio-economic and ecological settings is therefore necessary. Second, there is need for revival and re-institutionalizing existing CFAs in an effort to promote PFM within the Mau forest and other parts of the country. Policy makers also need to promote PFM in areas where communities have been reluctant to adopt the approach. Third, intense efforts should be geared towards design of a mix of incentive schemes to encourage active household participation in CFA activities. It is important to note however, that participation is broad based and achievements of objectives of PFM may be a challenge equal participation is therefore necessary. In addition, public private partnership through NGOs could also play a role in strengthening and nurturing existing and upcoming CFAs and creating awareness among locals. Finally, to reduce pressure on forest resources, there is need to explore alternative sources of income and employment opportunities for local communities.

The study findings reveal that collective action can be successful under careful policy design and targeted interventions and incentives schemes based on context specific understanding of household and community level profiles and preferences. Incorporation of local community values and preferences for various forest ecosystem services could also enhance participation and ownership hence increasing sustainability of devolution efforts. Overall the study provide support to further PFM as alternative policy instrument to improve forest-adjacent communities' welfare and conserve the forests as well. The welfare gains can be maximized with well-designed programs that take into account attributes that communities value most and accounting for preference

heterogeneity in program implementation. Our study also show that PFM should not be implemented as a one size fits all approach given the contextual variation. The study therefore provides an entry point for understanding how to build capacity of rural poor towards poverty reduction and environmental conservation. Given the positive impact of incentive schemes such as PELIS, forest adjacent communities can therefore be positively influenced through incentives such as PES and PELIS to accept and participate in PFM related activities.

The study suggest that future research should focus on; first, valuation of forest ecosystem services from the demand and supply side to inform the design of efficient and effective PES schemes. Second, we focused on the impact of PELIS on household welfare, however, considering that farm produce like potatoes, peas among others are sold to traders and consumers in other areas, within a given CFA, county or to other counties or CFAs, there may be other indirect impacts e.g. health wise in terms of nutritional supplies and spillover effects not specific to CFA members only. Further, we suggest an evaluation of whether duration of household participation in PELIS may have varying welfare impact across households. Due to the cross-sectional nature of the data, controlling for other political economy factors like election years was not possible hence panel data may be more appropriate for impact assessment. In addition, an exploration of the impact of other incentives that can be more pro poor could help in designing a mix of incentives with high impact. Lastly due to the variation in values, preferences ecological and socio-economic profiles within the country, a comparative analysis would provide a better understanding of the determinants of successful collective management of forest resources.

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Appendix A: Appendix for Chapter Two

Table A. 1: Summary statistics of the respondents

Variable	N	mean	sd
Waterforest: dummy=1 if household collect water from the forest and 0otherwise	321	0.732	0.443
MedIncome: Household monthly income	321	13492	10660
Fetch Firewood: Dummy=1 if respondent fetch firewood from forest, 0 otherwise	321	0.776	0.224
ForestValue: Dummy =1 if respondent consider forest as of value, 0 otherwise	321	1	0
DistForest:: Distance from household to the nearest edge of the forest in km	321	1.445	1.408
hhsize: Number of people in the household including household head	321	5.994	2.541
MaritSta: Dummy=1 if married, 0 not married	321	0.882	0.323
Education:Dummy=1 if household head has post primary education 0 otherwise	321	0.361	0.480
Employment: Dummy=1 if employed in off farm, 0 if self employed i.e. farming	321	0.293	0.455
PELIS: Dummy=1 if household owns a PELIS plot and 0 otherwise	321	0.607	0.488
HHWealth: Total value of household asserts	321	1.160e+06	1.346e+06

Table A. 2: Welfare change from hypothetical future scenarios

Attributes	Hypothetical future scenarios				
	Forest conservation policy	Flood mitigation and Forest conservation policy	Water conservation and Flood mitigation policy	Water conservation and Forest conservation policy	Water conservation and Wildlife conservation policy
Wildlife	SQ	SQ	Medium	Medium	Medium
Forest structure	High	High	Medium	High	Medium
Water	High	SQ	High	High	High
Flood risk	Medium	Low	Low	Medium	Medium
Welfare change	Ksh. 10419 (USD104.19)	Ksh.10379 (USD(103.79)	Ksh. 7321(USD73.21)	ksh.9818 (USD98.18)	ksh. 6542(USD(65.42)

Appendix B: Appendix for Chapter Three

Table B. 1: Descriptive Statistics

Variable	PELIS Beneficiaries		Non PELIS Beneficiaries		Mean Difference	
	mean	s.e	mean	s.e	Mean	s.e
PCMonthlyExp	2404.52***	(128.42)	1905.33***	(75.14)	499.19**	(159.82)
Forestcover	79.72***	(0.95)	75.73***	(1.41)	3.99***	(1.72)
HHWealth	1.256e+06	(135333)	1.283e+06	(98298)	27294.18	(176098)
HHsex	0.767***	(0.028)	0.798***	(0.030)	-0.031	(0.042)
Numbchild	5.171***	(0.181)	4.472***	(0.196)	0.699**	(0.268)
BornVil	0.531***	(0.033)	0.655***	(0.036)	-0.125**	(0.049)
MedAge	49.285***	(0.841)	46.67***	(1.112)	2.611*	(1.369)
hhsize	6.109***	(0.181)	5.399***	(0.184)	0.711***	(0.261)
MaritSta	0.895***	(0.020)	0.837***	(0.028)	0.058*	(0.034)
Education	0.351***	(0.032)	0.371***	(0.036)	-0.019	(0.048)
ResidStatus	0.570***	(0.033)	0.578***	(0.037)	0.008	(0.050)
Hsepartic	0.907***	(0.019)	0.899***	(0.023)	0.009	(0.030)
Multilingual	0.491***	(0.033)	0.438***	(0.037)	0.053	(0.050)
Employment Status	0.167***	(0.025)	0.337***	(0.035)	-0.170***	(0.042)
LandTitle	0.513***	(0.033)	0.533***	(0.037)	-0.021	(0.050)
MedIncome	17862***	(1721.409)	13132***	(681.868)	4729.798**	(2039.709)
HHEducyrs	8.328***	(0.235)	8.500***	(0.281)	-0.171	(0.364)
Woodlots	0.912***	(0.019)	0.770***	(0.032)	0.143***	(0.035)
CFAParticipation	0.697***	(0.030)	0.528***	(0.038)	0.169***	(0.048)
Hownership	0.917***	(0.018)	0.888***	(0.024)	0.029	(0.030)
DistMroad	2.485***	(0.198)	1.211***	(0.155)	1.274***	(0.262)
DistMarket	3.885***	(0.232)	2.707***	(0.261)	1.177***	(0.349)
DistForest	1.406***	(0.093)	1.578***	(0.117)	-0.173	(0.148)
Hlandsize	2.473***	(0.465)	2.578***	(0.245)	-0.104	(0.569)
Membership	0.0702***	(0.017)	0.0674***	(0.019)	0.003	(0.025)
Temperature	15.51***	(0.114)	14.46***	(0.125)	1.044***	(0.170)
Precipitation	1197***	(12.134)	1122***	(12.792)	74.437***	(17.787)
Elevation	2401***	(16.875)	2498***	(14.233)	-97.059***	(22.869)

Table of mean differences and test of significance. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B. 2: Performance of Matching estimator

	Household Level					CFA level				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Matching estimator	Bal test*	Ps R2	LR chi^2	P>ch^2	Matched n	Bal test*	Ps R2	LR chi^2	P>ch^2	Matched n
NN (4)	11	0.048	24.44	0.041	362	11	0.055	10.50	0.653	207
NN (5)	11	0.047	24.08	0.045	362	12	0.047	9.07	0.768	207
Radius (=0.0025)	14	0.033	9.89	0.770	284	13	0.073	6.26	0.936	169
Radius (=0.005)	11	0.046	19.46	0.148	331	13	0.036	5.07	0.974	189

* covariates with insignificant mean difference between beneficiaries and non-beneficiaries after matching

Table B. 3: Sensitivity Analysis of Matching Estimates

	PCMonthlyExp		Forest Cover	
Gamma	**sig+**	**sig-**	**sig+**	**sig-**
1	0.00141	0.00141	0.0956	0.0956
1.100	0.00759	0.000191	0.167	0.0493
1.200	0.0273	2.30e-05	0.256	0.0244
1.300	0.0720	2.50e-06	0.356	0.0117
1.400	0.150	2.50e-07	0.457	0.00549
1.500	0.261	2.40e-08	0.554	0.00252
1.600	0.393	2.20e-09	0.643	0.00114
1.700	0.529	1.90e-10	0.719	0.000506
1.800	0.655	0	0.784	0.000223
1.900	0.761	0	0.836	9.70e-05
2	0.842	0	0.877	4.20e-05

*gamma: Log odds of differential assignment due to unobserved factors
sig+ : Upper bound significance level
sig-: Lower bound significance level

Table B. 4: Per Capita Monthly Expenditure across the quantiles

Quantile	Mean PCMonthly Exp	No of Households
1st Quantile	695.19	46
2nd Quantile	1111.58	47
3rd Quantile	1370.93	43
4th Quantile	1596.29	45
5th Quantile	1847.10	45
6th Quantile	2082.26	45
7th Quantile	2375.71	45
8th Quantile	3019.14	46

9th Quantile	5673.27	44
All households	2185	406

Figure B. 1: Kernel density before and after matching

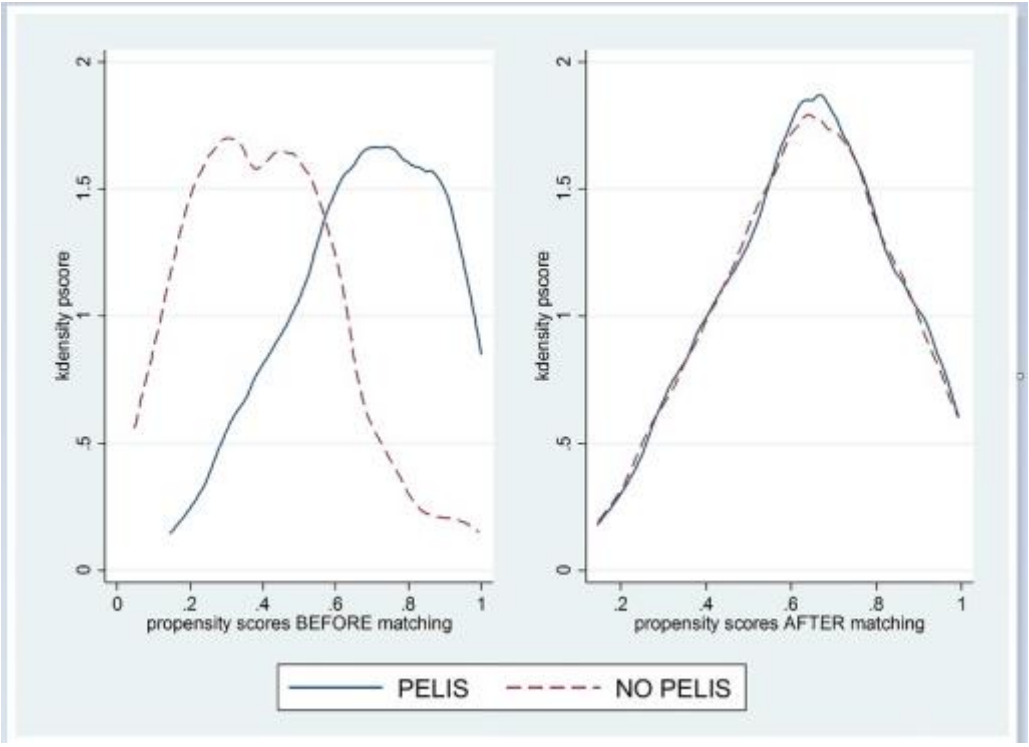

Table B. 5: Distribution of adopters and non-adopters of PELIS by CFAs

No	CFA	No PELIS	PELIS	Total
1	Bahati	1	26	27
2	Dondori	9	12	21
3	Menengai	4	0	4
4	Koibatek	0	24	24
5	Molo	3	9	12
6	Sorget	10	9	19
7	Longman	3	9	12
8	Likia	56	0	56
9	Tendeno	1	13	14
10	Kerisoi	3	13	16
11	Baraget	5	0	5
12	Saino	1	12	13
13	Sururu	25	0	25
14	Esageri	0	24	24
15	Malagat	0	16	16
16	Kericho	6	15	21
17	Makutano	1	24	25
18	Kiptunga	7	11	18
19	Nyangores	10	0	10
20	Nairotia	20	0	20
21	Olenguruone	10	0	10
22	Chepalungu	3	11	14
	Total	178	228	406

Table B. 6: Heteroscedasticity Based Instrumental Variable Estimation Results

	(1)	(2)
VARIABLES	**PCMonthlyExp**	**Forestcover**
PELIS	1,270**	4.229**
	(635.6)	(2.051)
HHsex	-184.0	0.439
	(191.7)	(1.366)
EmploymentStat	-236.4	-0.261
	(185.9)	(1.427)
LandTitle	285.3**	0.767
	(139.8)	(1.135)
Woodlots	-162.4	0.225
	(247.1)	(1.644)
ResidStatus	-260.1	-0.0392
	(233.8)	(2.297)
CFAParticipation	151.9	2.244*
	(155.6)	(1.253)
Hsepartic	-522.2*	4.153***
	(302.2)	(1.504)
DistForest	-98.40**	-0.981***
	(44.75)	(0.349)
DistMroad	43.32	-0.126
	(42.18)	(0.305)
DistMarket	13.10	0.699***
	(25.45)	(0.238)
HHEducyrs	85.65***	-0.0167
	(23.36)	(0.165)
Hlandsize	4.909	-0.208**
	(19.86)	(0.0953)
hhsize	-292.4***	0.0641
	(36.34)	(0.269)
HHWealth	0.000127	6.00e-07
	(9.53e-05)	(4.43e-07)
Numbchild	41.08	0.246
	(38.94)	(0.295)
MedAge	4.254	-0.481**
	(41.05)	(0.239)
MedAgesq	-0.0577	0.00374*
	(0.351)	(0.00207)
MedIncome	0.0126*	1.64e-05
	(0.00745)	(1.95e-05)
Temperature	-191.3***	-3.827***
	(58.40)	(0.463)
BornVil	58.28	-5.203**
	(263.5)	(2.286)
Precipitation	0.0920	-0.0748***
	(0.427)	(0.00665)
Membership	175.3	0.637
	(315.4)	(1.683)
Other Controls Institutional variables	No	Yes

Constant	5,279***	212.7***
	(1,322)	(13.60)
Observations	404	404
R-squared	0.351	0.721

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B. 7: Re-estimated Endogenous Quantile Treatment Effects Model Estimation Results

VARIABLES	QT_1	QT_2	QT_3	QT_4	QT_5	QT_6	QT_7	QT_8	QT_9
PELIS	162.1	370.8	482.7	655.2	624.1	803.3*	1,064*	1,219***	2,170***
	(170.5)	(477.9)	(436.2)	(441.7)	(410.8)	(483.1)	(578.5)	(384.4)	(671.7)
DistForest	-135.4***	-53.25	-64.62	-118.1	-136.4*	-152.2	-191.5*	-339.3***	-469.3***
	(27.08)	(92.87)	(77.47)	(75.95)	(77.39)	(101.8)	(99.99)	(59.45)	(89.86)
DistMroad	74.14	13.32	3.623	-8.944	28.83	12.06	3.815	24.38	2.863
	(45.11)	(53.89)	(40.36)	(66.98)	(51.88)	(53.02)	(60.72)	(45.31)	(66.27)
DistMarket	-76.14***	-75.65**	-40.77	-10.60	-29.04	-20.71	-54.91	-86.38***	-117.3**
	(21.18)	(30.79)	(39.29)	(26.09)	(29.14)	(31.68)	(47.15)	(30.47)	(50.33)
HHEducyrs	43.99***	22.59*	25.01**	15.45	17.72	37.46**	11.72	3.230	57.65***
	(14.05)	(12.60)	(12.35)	(15.20)	(13.89)	(18.33)	(26.36)	(12.30)	(22.14)
Hlandsize	49.49***	66.17*	53.28**	12.21	-3.604	-9.359	-5.548	-71.82***	-50.73**
	(17.18)	(36.62)	(23.54)	(30.98)	(20.65)	(23.33)	(24.48)	(15.63)	(20.46)
hhsize	-165.2***	-201.2***	-170.0***	-160.0***	-188.1***	-230.4***	-193.9***	-270.5***	-313.4***
	(22.03)	(73.41)	(57.94)	(56.51)	(55.50)	(53.58)	(43.55)	(45.19)	(70.70)
HHWealth	0.000109***	0.000128	0.000163	0.000433**	0.000491***	0.000505***	0.000617***	0.000874***	0.000737***
	(1.55e-05)	(0.000229)	(0.000163)	(0.000182)	(0.000126)	(0.000117)	(0.000110)	(6.85e-05)	(0.000122)
Numbchild	14.54	-0.451	1.115	9.959	-11.70	-5.098	-63.05	-66.23	-149.2**
	(19.95)	(31.36)	(31.06)	(47.17)	(39.37)	(44.04)	(55.18)	(52.16)	(60.47)
MedAge	47.52**	10.59	5.439	-17.79	26.46	18.49	-10.40	35.84	45.94
	(23.73)	(36.31)	(40.97)	(47.78)	(47.00)	(45.99)	(46.00)	(34.89)	(108.6)
MedAgesq	-0.410*	-0.121	-0.0859	0.181	-0.184	-0.171	0.0926	-0.519	-0.507
	(0.235)	(0.388)	(0.424)	(0.506)	(0.455)	(0.432)	(0.420)	(0.336)	(1.159)
Temperature	4.961	11.30	-1.874	-42.89	-67.50*	-44.73	-11.07	17.60	-10.96
	(25.79)	(29.02)	(33.16)	(43.54)	(37.41)	(49.41)	(41.78)	(51.57)	(69.94)
Precipitation	-0.190	-0.130	-0.651**	-0.922***	-1.036***	-1.470***	-1.438***	-2.229***	-2.475***
	(0.190)	(0.237)	(0.319)	(0.343)	(0.295)	(0.373)	(0.379)	(0.394)	(0.652)
HHsex	255.7	-22.71	65.84	81.11	-299.7	-312.3	-480.0	-201.7	-636.9
	(310.1)	(381.5)	(313.1)	(318.0)	(323.9)	(269.7)	(350.8)	(258.2)	(436.5)
EmploymentStat	-111.1	123.2	173.4	226.9	335.3*	155.6	41.66	-778.8***	-662.5
	(86.45)	(160.4)	(166.3)	(231.4)	(175.8)	(181.5)	(205.8)	(174.0)	(416.2)
LandTitle	-106.4	-149.9	-233.6	-180.9	-89.41	3.083	277.8	804.0***	1,724***
	(118.9)	(173.3)	(188.0)	(214.7)	(164.0)	(199.1)	(287.1)	(220.6)	(288.9)
Woodlots	150.3**	182.1	210.4*	224.5	405.0**	397.4**	388.4**	207.0	375.6*
	(71.49)	(130.6)	(115.7)	(192.4)	(178.4)	(175.0)	(195.8)	(145.9)	(206.0)
ResidStatus	-236.5**	-121.8	-172.8	-231.8	-174.6	-297.6	-424.0**	-353.3**	-726.4***
	(110.8)	(118.7)	(183.4)	(183.3)	(156.6)	(204.7)	(183.7)	(154.6)	(157.5)
Hsepartic	463.5***	344.9**	528.5***	563.8***	439.2***	386.4*	203.7	710.5***	-325.8
	(105.5)	(145.7)	(104.5)	(119.3)	(134.1)	(225.8)	(282.8)	(133.2)	(299.3)
Constant	-152.4	1,528*	2,113**	3,377***	3,250***	4,053***	5,091***	5,419***	7,472***
	(732.3)	(855.3)	(1,036)	(905.7)	(871.0)	(971.1)	(1,077)	(935.8)	(2,614)
Observations	404	404	404	404	404	404	404	404	404

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix C: Appendix for Chapter Four

Table C. 1: Major sources of Income within CFAs

Source of Income	Percent	Cumulative
Farming	60.81	60.81
Livestock Keeping	30.50	91.31
Bee Keeping	3.86	95.17
Tree Nursery	4.83	100.00

Table C. 2: Major sources of finance for the CFA

Sources of Finance	N	mean	sd	min	max
Voluntary Contribution	518	0.286	0.452	0	1
Membership Fee	518	1	0	1	1
Payments for labour input	518	0	0	0	0
Fines	518	0.0888	0.285	0	1
Development agency	518	0.129	0.336	0	1
National/Regional govt	518	0.0483	0.215	0	1
Forest product sales	518	0.317	0.466	0	1
Own taxes	518	0	0	0	0
Special levies	518	0.0483	0.215	0	1
Aid from External NGO	518	0.330	0.471	0	1
Aid from Indigenous NGO	518	0.0637	0.244	0	1
Aid from Foreign govt	518	0	0	0	0

Table C. 3: Mode of communication to CFA members

Mode	N	mean	sd	min	max
Letters	518	0.290	0.454	0	1
Schools	518	0.141	0.348	0	1
Vilhead	518	0.403	0.491	0	1
Cellphone	518	0.847	0.360	0	1
Mouth	518	0.707	0.456	0	1

Table C. 4: Scale of dependence on forest resources

	Scale of Dependence (%)			
Resource	**Not dependent**	**Slightly dependent**	**Moderately dependent**	**Very dependent**
Wood fuel	4.83	0	22.78	72.39
Timber	95.17	4.83	0	0
Bee keeping	8.69	31.47	33.78	26.06
Herbs	5.02	41.12	30.89	22.97
Thatching	46.14	21.24	25.87	6.76
Fish farming	0	79.15	10.04	10.81
Water	3.09	4.83	5.02	87.07
Grazing	0	3.86	0	96.14

Poles harvesting	63.51	18.15	18.34	0
PELIS	23.36	4.83	8.11	63.71
Tree Nursery	92.28	2.90	0	4.83
Quarrying	92.28	7.72	0	0
Cultural activties	87.07	2.90	0	10.04

Table C. 5: Existence of rules

Rules regarding	N	mean	sd	min	max
Forest access	518	0.759	0.428	0	1
Fire Management	518	0.938	0.241	0	1
Logging/charcoal burning	518	0.900	0.301	0	1
Punishment	518	0.448	0.498	0	1
Conflict Resolution	518	0.562	0.497	0	1
Role of EC/GR	518	0.965	0.183	0	1
Sharing benefits	518	0.550	0.498	0	1
Role of traditional	518	0.355	0.479	0	1
Conservation areas	518	0.961	0.193	0	1

Table C. 6: Summary of forest improvement activities

Activity	N	mean	sd	min	max
Pruning	518	0.745	0.436	0	1
Enrichment planting	518	0.871	0.336	0	1
Reseed	518	0.780	0.415	0	1
Weeding	518	0.813	0.390	0	1
Silviculture	518	0.720	0.449	0	1
Thinning	518	0.330	0.471	0	1
Water	518	0.290	0.454	0	1

Table C. 7: Existing incentives within CFAs

Incentive	N	mean	sd	min	max
PELIS	518	0.766	0.424	0	1
Grazing	518	0.932	0.251	0	1
Herbs	518	0.830	0.376	0	1
Fuel wood	518	0.952	0.215	0	1
Bee Keeping	518	0.909	0.288	0	1
Milling	518	0.143	0.350	0	1
Fodder	518	0.749	0.434	0	1
Thatching	518	0.459	0.499	0	1
Eco-tourism	518	0.309	0.462	0	1
Fish farming	518	0.156	0.364	0	1
Fetching Water	518	0.969	0.173	0	1

Table C. 8: Principal Components of Collective Action by CFAs

	Comp 1	Comp 2	Comp 3
Eigen Value	2.227	1.571	1.147
Proportion of total variance	31.8	22.5	16.4
PC Vector			
Pruning	0.403	0.428	-0.224
Enrichment planting	0.177	0.041	0.723
Reseeding	0.464	-0.294	0.292
Weeding	0.431	0.275	0.310
Silviculture	0.461	-0.417	-0.279
Thinning	0.432	-0.047	-0.398
Water	0.073	0.690	-0.099

Table C. 9: Durbin-Wu-Hausman test for endogeneity

ForestCover		Vandalism	
InstIndex_res1	0	InstIndex_res2	0
F (1,491)	0.80	F (1,491)	78.77
Prob > F	0.3792	Prob > F	0.000

Table C. 10: Performance statistics of IV models

Test	Forestcover	Vandalism
Under-identification test (Kleibergen-Paap rk LM statistic	182.080	182.080
Chi-sq(25) p-val	0.0000	0.0000
Weak identification test (Cragg-Donald Wald F statistic)	2084.697	2084.697
Hansen J statistic (over-identification test of all instruments)	161.272	200.273
Chi-sq(24) p-val	0.0000	0.0000

Appendix C1: Chapter Four Model Frameworks

Framework for the IV model with heteroscedasticity based instrument

In the presence of endogeneity, the standard approach most often applied is the standard IV estimation method. However, the main challenge with this approach is identifying a plausible instrument that satisfies the three standard conditions namely: (i) The instrument Z must be highly correlated with the endogenous variable (X); (ii) The orthogonality condition i.e. the instrument is uncorrelated with the error term i.e. $E(UZ) = 0$ and (iii) Exclusion restriction. That the effect of the instrument on the outcome variable should be only through the endogenous variable (X).

Finding an instrument that satisfies the three conditions is often a challenge hence the biggest obstacle in standard IV estimation. The most recent approach that has gained cognizant is the Lewbel (2012) heteroscedasticity based instrumental variable approach. The method serves to identify structural parameters in regression models with endogenous or mis-measured regressors in the absence of plausible external instruments. It can also be used to supplement existing instruments to improve efficiency of the IV estimates.

Lewbel's Approach

In this approach, identification is achieved by having regressors that are uncorrelated with the product of heteroscedastic errors. Consider Y_1, Y_2 as observed endogenous variables, X a vector of observed exogenous regressors and $\varepsilon = (\varepsilon_1, \varepsilon_2)$ as unobserved error process. Given a structural model of the form:

$$Y_1 = X + Y_2\gamma_1 + \varepsilon_1$$

(20)

$$Y_2 = X\beta_2 + Y1\gamma_2 + \varepsilon_2$$

The system is triangular when $\gamma_2 = 0$ (or with renumbering when $\gamma_1 = 0$). Otherwise it is fully simultaneous. The errors ε_1, ε_2 may be correlated with each other. If the exogeneity assumption, $E(\varepsilon X) = 0$ holds, the reduced form is identified, but in the absence of identifying restrictions, the structural parameters are not identified. These restrictions involve setting certain elements of β_1 or β_2 to zero, which makes instruments available. The third assumption is however difficult to establish.

In Lewbel's approach, identification is achieved by restricting correlation of $\varepsilon\varepsilon'$ with X. This approach is likely to be less reliable than identification based on coefficient zero restriction since it relies on higher moments. But in the absence of plausible instruments it is the only plausible approach.

However, under the assumption of homoscedasticity i.e. $E(\varepsilon\varepsilon'|X)$ is a matrix of constants, the structural model remains unidentified therefore identification can only be attained in the presence of heteroscedasticity related to some elements of X. In a fully simultaneous system, assuming that $cov(X, \varepsilon_j^2) \neq 0$ j=1,2 and $cov(Z, \varepsilon_1\varepsilon_2) = 0$ for observed Z will identify the structural parameters. Z may be a subset of X, hence no information outside the model specified is required. The key assumption that $cov(Z, \varepsilon_1\varepsilon_2) = 0$ will automatically be satisfied if the mean zero error process are conditionally independent: $\varepsilon_1 \perp \varepsilon_2|Z = 0$. This condition is however not strictly necessary.

Source: *Adopted from Lewbel (2012)*

Appendix D: Community Forest Association and Household Questionnaires

No.

UNIVERSITY OF CAPE TOWN

COMMUNITY FOREST ASSOCIATION QUESTIONNAIRE

This questionnaire is part of research being conducted by Mr. Okumu from the University of Cape Town. The research has been approved by the Commerce Faculty Ethics in Research Committee. Relevant authorization has also been obtained from the National Council for Science and technology in Kenya and the Kenya Forest Service.

The student is carrying out a survey to examine how communities' self-organize to manage forests adjacent to them under Participatory Forest Management arrangements. The values and preferences local communities attach to these forests and the existing incentives towards forest management and how it impacts on the livelihoods of locals as well as the environment are examined. Please be assured that your answers are anonymous and all information collected is confidential. The questionnaire will take approximately 20 minutes of your time. Your participation in this research is voluntary and you can withdraw from the research at any time. Should you have any question regarding the research please feel free to ask.

Name of enumerator _____Date: _____
Time started: _____Time Ended: _____CFA Name_____
Forest Name _____ County_____
District _____Ward _____
Village _____ CFA code_____

Point	**Longitude**	**Latitude**
Forest location (CFA office)		
Nearest Main Road		
Nearest Market		
Nearest entrance to the forest		

Elevation in meters	

A: HISTORY OF THE ASSOCIATION

A1: What year was the CFA formed_____?

A2: Who initiated the initial formation of the CFA?

- ▫ Local community members
- ▫ Non-governmental program (local/international)
- ▫ Local/regional government program
- ▫ National government program
- ▫ International government program

A3: Is the group's present structure the same as it was in the beginning?

- ▫ Yes
- ▫ No

A4: How many years has this CFA had its present structure?_____years

B: RESOURCE CHARACTERISTICS

B1: What is the size of the forest under this CFA _____acres

B2: Is the boundary or jurisdiction of the CFA well defined?

- ▫ Yes
- ▫ No

B3: Is it possible to exclude non-members from using or accessing the forest? ▫ Yes

- ▫ No

B4: In your view, what is the current condition of the forest compared to when you first formed the association?

- ▫ Worse
- ▫ Good
- ▫ Better/improved condition ▫ Very good condition

B5: What is the extent to which one person's use of the resource limits the other person's use of the resource (e.g. grazing in the forest/grass for thatching) tick one.

Code	**Activity**
1	Does not Affect at all
2	Limits to some extent
3	Affects the usage
4	Affects very much
5	Extreme limitation

B6: What is the **CURRENT FOREST COVER** as a percentage of forest area under the CFA's? _____ jurisdiction

B61: What is the forest cover under the CFA in hectares. _____

B7: Which of the se activities are carried out by CFA members to improve forest condition? (Tick the ones carried out).

	Activity
1	Pruning
2	Enrichment planting
3	Reseeding
4	Weeding
5	Silviculture operations
6	Thinning
7	Watering

B8: What is the average number of reported cases of vandalism/ (e.g. fire, illegal logging, and other unauthorized activities) within the CFA in the periods specified?

Period	**No of cases**
Weekly	
Monthly	
Quarterly	
Semi annually	
Annually	

B9: What are the available species of trees in the forest within the CFA area (*if information available).*

Tree Species	**No of Trees**

C: GROUP CHARACTERISTICS

C1: How many households are within the CFA area (both members and nonmembers)? _____

C2: How many households are members of this forest association?

_____

C3: What is the number of members of this association (list in terms of gender)?

Gender	**Number of individuals**
Males	
Females	
Total	

C4: What is the average age of CFA members? _____

C5: What is the distribution of CFA members in terms of locals and immigrants?

Distribution	**Percentage**
Locals/Natives	
Immigrants/settlers	
Total	

C6: What is the employment status of CFA members?

Employment status	**Percentage**
Unemployed	
Employed (permanent/casual)	
Self Employed	
Retired	

C7: Name ethnic groups in the forest association and the number of individuals within each ethnic group

Ethnic group	**Percentage**

C8: Which is the dominant ethnic group in the area? _____

C9: Name the religious groups in the association and percentage of individuals within each religious group.

Religious group	**Percentage**
Catholic	
Protestants	
Muslims	
Other sects	

C10: Can CFA members buy/sell land to non-forest adjacent communities?

- ▫ Yes
- ▫ No

C11: If No in C10 is it entrenched as a rule or just a norm?

- ▫ Written rule

- ▫ Norm

C12: Are forest benefits shared equally among members?

- ▫ Yes ▫ No

C13: What are the existing incentives to encourage community participation in forest conservation?

Incentives	**Tick those that apply**
PELIS (cultivation in forest)	
Pure grazing	
Herbs/medicine collection	
Fuel wood collection	
Bee Keeping (Honey)	
Full time saw millers	
Fodder collection	
Collection of grass for thatching	
Use of revenues accrued through ecotourism	
Fish farming	
Water	

C14: Do all the CFA members benefit from PELIS?

- ▫ Yes
- ▫ No

C15: What criterion is used to determine beneficiaries of PELIS?

Criteria	**Tick appropriately**
Balloting	
First come first serve	
Rotation	
Others (Specify)	

C16: If CFA members benefit from PELIS, which year was PELIS first introduced within this _____ CFA?

C17: How many members are beneficiaries of PELIS? _____

C18: Since the first initiation of PELIS has it been suspended by the government at any one particular time?

- ▫ Yes ▫ No

C19: If yes in C18, how many times has it been suspended? Indicate the years and reason

Year	Reason

C20: What are some of the challenges you face with adoption and implementation of PELIS?

_____

_____

C21: Are members of the CFAs allowed to cultivate their plots using tractors or other machineries?

- ▫ Yes ▫ No

C22: In the last five years how many members of the CFA have migrated to other areas? _____

C23: In the last five years how many members of the CFA have left the group (but still around)? _____

C24: What do members of the group depend most on in the forest on a scale of 0-3 ? (0=not dependent, 1=slightly dependent, 2=moderately dependent, 3=very dependent)

Forest product	**Scale**
Wood fuel	
Timber/saw milling	
Bee keeping	
Medicine/herbs	
Thatching Grass	
Fish farming	
Water	
Grazing/forage/fodder	
Harvesting poles	
Farming (PELIS)	
Others (specify)	

C25: What is the **MAJOR** source of income for CFA members?

- ▫ Farming
- ▫ Livestock keeping
- ▫ Bee keeping
- ▫ Fish Farming
- ▫ Selling forest resources
- ▫ Ecotourism

- ▫ Others specify_____

C26: What are the **other** sources of income for CFA members (Tick the ones mentioned)?

- ▫ Farming
- ▫ Livestock keeping
- ▫ Bee keeping
- ▫ Fish farming
- ▫ Selling forest resources
- ▫ Ecotourism
- ▫ Others specify_____

C27: How many households within the CFA own title for the land they occupy?

_____

C28: What is the **dominant** roofing material used in the CFA area?

- ▫ 1= Thatch
- ▫ 2=Wooden boards
- ▫ 3=Iron or other metal sheets
- ▫ 4=Tiles
- ▫ 5=Other (Specify)

C29: Are majority of the households connected to electricity in the area?

- ▫ Yes
- ▫ No

C30: What is the **MOST** popular fuel for cooking in CFA households?

- ▫ Electricity or gas
- ▫ Oil
- ▫ Wood
- ▫ Charcoal
- ▫ Small sticks or scrap wood
- ▫ Weeds, leaves, dungs
- ▫ Others (specify)

C31: What is the **MOST** popular source of lighting in CFA households?

- ▫ Electricity or gas
- ▫ Oil
- ▫ Wood
- ▫ Charcoal
- ▫ Small sticks or scrap wood
- ▫ Weeds, leaves, dungs
- ▫ Others (specify)

C32: What are some economic activities in the CFA area? (Tick all that apply)

- ▫ Pure agriculture
- ▫ Livestock farming/Pure grazing of animals
- ▫ Charcoal burning
- ▫ Fuel wood collection for selling
- ▫ Herbs collection for selling
- ▫ Fish farming
- ▫ Bee keeping (Honey)

- Full time saw millers

D: ACTIVITIES CARRIED OUT BY THE ASSOCIATION

D1: If members of the association graze livestock in the forest, are there periods when there is shortage of pasture?

- Yes
- No

D2: Are there alternative grazing areas outside the forest?

- Yes
- No

D3: During the year, have individuals in this association adopted any of the following technologies that reduce their needs for the forest products?

Technology	Tick appropriately
More efficient wood burning stoves	
Gas cookers	
Pressure cookers	
Solar panels	
Use of D-light	
Others specify	

D4: How many members of the forest association know about the rules that govern the forest association?

- None
- A few people
- Half the people
- Almost everyone
- Everyone

D5: Are members of the association made familiar with these rules at the time of joining?

- Yes
- No

E: INSTITUTIONAL ARRANGEMENTS

EXECUTIVE COMMITTEE OR GENERAL REPRESENTATIVE BODY

E1: Does the association have a constitution or by laws?

- Yes
- No

E2: How easy are the rules to understand?

- ▫ Very easy
- ▫ Average
- ▫ Difficult
- ▫ Very difficult

E3: Does this association have an executive committee or general representative body?

- ▫ Executive committee
- ▫ General representative body

E4: How many members comprise this general representative body or executive Committee?

Gender	**Number**
Males	
Female	
Total	

E5: Has a woman ever been the **CHAIRPERSON** of the executive committee or general representative body of the association?

- ▫ Yes
- ▫ No

E6: How are most of the members of the executive committee or general representative
body of the association selected?

- ▫ Elected by members
- ▫ Inherited e.g. from father to son or mother to daughter)
- ▫ Appointed

E7: IF some members are appointed in E6 above who appoints?

- ▫ Local village head/chief or village elders
- ▫ Appointed by national or county government

E8: If members elect the EC or GR officials, how are the elections conducted?

- ▫ Secret ballot
- ▫ Acclamation
- ▫ Queuing (Mlolongo)

E9: How often does the EC or GR body of the association meet?

- ▫ Once a week
- ▫ Twice a month
- ▫ Once a month
- ▫ Quarterly

E10: How long a period can the EC or GR body of the association serve?

Official	(1) Life	(2) Fixed period elected	(3) Fixed period, not elected	(4) Variable, subject to vote
Chair				
Vice Chair				
Secretary				
Treasurer				
Most members of the EC or GR				

E11: If the president of the association serves association for a fixed term. Please record number of. _____ years

E12: How many chairpersons have led the association since its inception?

_____

E13: In the past decade has there been any competition for any position on the executive committee or general representative body

- ▫ Yes, always
- ▫ Yes, in some elections
- ▫ No

E14: Is it possible for users to remove the members of the executive committee or general representative body?

- ▫ Yes
- ▫ No

E15: Can an external or higher-level authority remove the members of the executive committee or general representative body?

- ▫ Yes
- ▫ No

E16: If yes in E15, under what circumstances?

_____

E17: Are members of the executive committee remunerated or paid for their services?

- ▫ Yes
- ▫ No

E18: If yes in E17, how are they remunerated?

- ▫ Funds from the general budget of the association
- ▫ Allocated extra shares of the forest products
- ▫ Obligations to forest association are reduced
- ▫ Funds from external or local government ▫ Funds from a development agency

E19: What is the highest level of education for members of executive committee or general representative body?

Position	**Education level**
Chair	
Vice Chair	
Secretary	
Treasurer	
Most members of the EC or GR	

E20: Do any members of the executive committee or general representative body hold

leading positions in other collective or government bodies?

- ▫ Yes ▫ No

E21: If yes in E20 state position held by the members of the executive committee or general representative body in different bodies

Position in CFA	**Position in other (state the body)**

F: INSTITUTIONAL ARRANGEMENTS, MEETINGS AND GENERAL MEMBERSHIP OF THE FOREST ASSOCIATION

F1: How many members have left the association since its inception? _____

F2: Are meetings held in which all members of the assosciation are eligible to participate?

- ▫ Yes
- ▫ No

F3: How frequently are meetings organized?

- ▫ Once a week
- ▫ Twice a month
- ▫ Quarterly
- ▫ Half Yearly ▫ Once a year
- ▫ Irregular intervals

F4: What is the attendance of these meetings?

- ▫ Almost all members attend
- ▫ About half the members attend ▫ Few members attend

F5: How many meetings have been held between the association members and the local/county/regional government in the last one year_____

F6: How many meetings have been held between the CFA members/executive with the national officials i.e NACOFA, KFS national representative per year? _____

F7: Can members of the association call a general meeting when they want to discuss a special problem (such as lack of rainfall or the breaking of association rules by members of executive committee or members of executive body)?

- ▫

- ▫ Yes
- ▫ No

F8: If yes in F7, has a special meeting been called during the last one year

- ▫ Yes
- ▫ No

F9: Has the rules of the association been changed as a result of suggestions made by members of the forest association?

- ▫ Yes
  No

F10: If yes in F9, describe an example of such a change in rules _____

_____

_

F11: level of implementation of Ostrom design principle

Ostrom Principle	**Tick appropriately**
Clearly defined boundaries (physical boundaries of the CFA)	
Well defined membership (rules as to who can join the association)	
Free entry or exit of members	
~~Rules regarding the appropriation~~ Appropriation rules match availability of resource	
~~Collective choice arrangements~~ Effective monitoring by community members	
~~A scale of graduated sanctions~~ Mechanism of conflict resolution that are cheap	
Self-determination of the community (no external influence)	
~~Organization in the form of nested enterprises~~	

F12: How does the CFA rank the condition of this forest?

- ▫ Very sparse
- ▫ Somewhat sparse
- ▫ About normal for this ecological region
- ▫ Somewhat abundant ▫ Very abundant

F13: To what extent does community enjoy user rights?

	Extent
1	No user rights
2	Limited user right
3	Full user rights

F14: Existence of rules and regulation _____

Rule	Tick appropriately
Rules regarding access to forest	
Rules regarding fire management	
Illegal logging/charcoal burning	
Punishment	
Conflict resolution	
Role of Executive committee/or GR	
Sharing benefits	
Role of traditional leaders	
Forest conservation areas	

F15: Do the local or higher authorities recognize CFA rules and regulations?

- Yes
- No

F16: Which other parties apart from CFA members participate in setting the CFA rules?

- Local/county council
- County government
- KFS
- All the above

F17: Who is involved in monitoring forest resource use?

- Local communities
- Employed forest rangers
- Executive committee or general representative body
- County council
- County government
- Kenya Police service
- All the above

F18: Is there punishment/penalty for members of the community who deviates?

- Yes
- No

F19: Are the penalties commensurate (fair or equal to) to the crime committed

- Yes
- No

F20: Are the penalties increased if you are a second/frequent rule breaker?

- Yes
- No

F21: Is there a committee to administer justice for rule breakage and grievances?

-

- ▫ Yes ▫ No

F22: How long does it take to initiate and complete a disciplinary action or process for an errant member (Indicate) ? _____ days/weeks/months

F23: How costly is the group justice system in terms of money paid to access it?

- ▫ Costless
- ▫ Affordable
- ▫ Very Expensive
- ▫ Unaffordable

F24: Do you think the group justice system is effective in deterring potential offenders within the group?

- ▫ Yes
- ▫ No

F25: To what extent are penalties complied with

- ▫ No one complies with penalties imposed on them
- ▫ Few members comply with the penalties imposed
- ▫ About half the members comply with penalties imposed
  Most users comply with penalties imposed on them

- Penalties are fully complied with when imposed

F26: During the last two years have individuals in this group faced any issues that have engendered conflict within the association

- Yes
- No

F27: During the last one year would you say the level of conflict in the group has?

- Increased
- Remained same
- Decreased

F29: Do CFA members undergo training related to forest management activities?

- Yes - No

F30: What is the mode of communication to CFA members?

Communication	**Tick**
Word of mouth	
Cell phone	
Village heads	
Schools	
Letters	

G: CLIMATE AND GEOGRAPHIC VARIABLES

G1: What is the average rainfall and temperature in the Forest area during this seasons?

Season	**Rainfall**	**Temperature**
Yearly Average		

G2: What is the soil type in the CFA forest area?

Soil type	**Tick**

H: OFFICE MANAGEMENT

H1: What is the registration and annual renewal fee for members to join the forest association?

	Amount
Registration	

▫

Annual renewal	

H2: Has the association employed anyone?

- ▫ Yes
- ▫ No

H3: How are guards selected to watch over the forest?

- ▫ By election
- ▫ By appointment
  Volunteer
- ▫ By lots

H4: On average how many forest guards are on duty on a daily basis_____

H5: What were the major financial sources for this association during the most recent year?

1. Voluntary contribution of funds
2. Membership fees
3. Payments that substitute for labor inputs
4. Fines
5. Development agency
6. National or regional government
7. Sales of forest products from the forest
8. Own taxes(taxes raised by a general purpose government
9. Special levies
10. Aid from external NGOs
11. Aid from Indigenous NGOs
12. Aid Foreign government 13. Others Specify

H6: From the above sources of funding, what was the single most impo of
finance for the forest association? _____

H7: What is the total financial budget per year of this CFA (specif year for which data
is available)? _____

H8: What is the average annual amount spent on security enforcement_____

H9: If the association did not receive any funds from external agenc ies and had to on contribution from members or its user groups, or other funds raised rely it
support all its expenditure?

- ▫ Yes

- ▫
- ▫ No

H10: What is the largest item on which the association spends its income? Mark one

- ▫ Salaries to official
- ▫ Salaries to hired personnel
- ▫ Court cases
- ▫ Account keeping
- ▫ Fees paid to specialized staff or contractor
- ▫ Expenses of the community
- ▫ Monitoring the forest resource
- ▫ Guarding the forest resource
- ▫ Maintaining the forest resource
- ▫ Improving the forest resource
- ▫ Travel and entertainment of CFA officials

H11: Is any of the association's income supposed to be used for specific purposes?

Yes
No

H12: If yes in H11, specify the income source and purpose_____

H13: Does any other organization determine how the forest association spends or earns
income?

- ▫ Yes
- ▫ No

H14: Are the rules of this forest association based on a set of rules provided by a government
agency?

- ▫ No
- ▫ Yes

H15: Can the association be sued or sue?

- ▫ Yes
- ▫ No

H16: Do internal conflict exists?

- ▫ Yes
- ▫ No

H17: Are there internal conflict resolution mechanisms?

- ▫ Yes
- ▫ No

H18: How does internal conflicts get resolved?

_____
_
_____
_

H19: Have there been any problems in selecting officials for the association?

- ▫

- ▫
- ▫ Yes
- ▫ No

H20: How have the rules created by the association been reinforced? Are they enforced by?

- ▫ Members of the user group
- ▫ External officials appointed by the government
- ▫ Officials appointed by the forest association
- ▫ Other ways (specify)

H21: How does the association perceive itself, in terms of relating to other forest governing structures?

- ▫ Non-cooperating
- ▫ Cooperating, but independent of other organization's rules and regulations ▫ Cooperating jointly in determining rules/regulations

Thank you very much once more for your cooperation

No.

UNIVERSITY OF CAPE TOWN

HOUSEHOLD QUESTIONNAIRE

This questionnaire is part of research being conducted by Mr. Okumu from the University of Cape Town. The research has been approved by the Commerce Faculty Ethics in Research Committee. Relevant authorization has also been obtained from the National Council for Science and technology in Kenya and the Kenya Forest Service.

The student is carrying out a survey to examine how communities' self-organize to manage forests adjacent to them under Participatory Forest Management arrangements. The values and preferences local communities attach to these forests and the existing incentives towards forest management and how it impacts on the livelihoods of locals as well as the environment are examined. Please be assured that your answers are anonymous and all information collected is confidential. The questionnaire will take approximately 20 minutes of your time. Your participation in this research is voluntary and you can withdraw from the research at any time. Should you have any question regarding the research please feel free to ask. Please be assured that your answers are anonymous and all information collected is confidential

Name of enumerator _____Date: _____

Time started: _____Time Ended: _____

Forest Name _____County_____District _____ Ward _____Village _____Household No_____

	Longitude	Latitude
Household location		
Nearest Main Road		
Nearest Market		
Nearest entrance to the forest		
Elevation in meters		

HOUSEHOLD PHYSICAL LOCATION Point

HA: KNOWLEDGE OF THE FOREST CATCHMENT AREA

HA1: Have you visited the forest in the last 3 months?

- ▫ Not visited
- ▫ Visited between one and 5 times
- ▫ Visited more than five times
- ▫ I live permanently in the forest catchment

HA1-1: How many times do you think you have visited the forest in the last 12 months?

- ▫ Below 10 times
- ▫ 10 times
- ▫ 11-30 times
- ▫ Always in the forest every day

HA2: If you visited the forest in the last three months, what was the reason for the visit?

Activity	Tick all that apply
Farming (PELIS	
Fetched Firewood/charcoal	
Fetched timber/other wood	
Fetched medicine/herbs	
Grazing/Fetched fodder/forage	
Bee keeping	
Fish farming	
Fetched water	
Bird watching	
Walking	
Camping	
Taking tourists/visitors around	
Others specify	

HA3: Think about the forest cover around the forest named above, which statement do

you think best describes the current condition of the forest?

- ▫ Very bad
- ▫ Quite bad
- ▫ Neither good nor Bad
- ▫ Quite good ▫ Very good
- ▫ Don't Know

HA4: Think about the rivers and water bodies in the forest, which statement do you think best describes the current condition (**cleanliness/purity of the water**) of the rivers in this forest?

- ▫ Very dirty
- ▫ Somehow dirty
- ▫ Quite clean ▫ Very clean
- ▫ Don't Know

HA5: Think about the rivers and water bodies in the forest, which statement do you think best describes the current condition (**volume of water**) of the rivers in this forest?

- ▫ Very low
- ▫ Somehow low
- ▫ High
- ▫ Very high
- ▫ Don't know

HA6: Where do you get your water for domestic use?

Source	**Tick all that apply**
Borehole/well	
Stream river	
Spring protected	
Spring unprotected	
Pond/Dam	
Lake	
Other Specify	

HA7: Does your water come from the forest?

- ▫ Yes ▫ No

HA8: Who mainly collects water in the household?

Person	**Tick all that apply**
Children	
Female adults	
Male adults	
Domestic workers (Hired labor)	
Other Specify	

HA9: How many 20L jerry cans do you use per day in your household? _____

HA10: Do you buy water for domestic use?

- ▫ Yes
- ▫ No

HA10-1: IF you buy water how much do you pay per 20L jerry can?
Kshs _____

HA11: What type of treatment do you use to purify drinking water?

Treatment Method	**Tick all that apply**
Nothing	
Boiling	
Boiling and filtering	
Chemicals	
Other Specify	

HA12: If you fetch water from the forest, does the quantity of water change during the
year?

- ▫ Yes
- ▫ No

HA13: What is the quality of your drinking water?

- ▫ Very dirty
- ▫ Somehow dirty
- ▫ Quite clean ▫ Very clean
- ▫ Don't Know

HA14: If you fetch water from the forest, does the quality of water change during the year?

- ▫ Yes No

HA15: How would you describe the quality of water for your domestic use over the
following
periods

Time	**Quality (1 Very dirty, 2. Somehow dirty, 3. Quite clean, 4. Very clean, 5. Dont know)**
10 years ago	
5 years ago	
1 year ago	

HA16: How do you expect the water quality to change in the future?

- ▫ Improve
- ▫ Deteriorate ▫ No change
- ▫ Don't know

HA17: How far is the water source from the dwelling? (Read out options)

- ▫ Less than 100m
- ▫ Between 100 and 200m
- ▫ More than 200m but less than 500m
- ▫ More than 500m but less than 1 km
- ▫ 1km or more

HA18: Do you know the kind of wild animals that exist in this forest?

- ▫ Yes
- ▫ No

HA19: If yes above can you list some of the animals that you know exist in this forest?

_____

HA20: Do you have any problems with crop/animal raiding animals from the forest (tick the one you have problems with)

Animal	**Tick all that apply**
Elephants	
Buffaloes	
Antelopes	
Chimpanzees	
Baboons	
Hedgehogs	
Monkeys	
Porcupines	
Warthogs	
Rabbits	
Wildpigs	

HA21: Which of the animals in HA20 is most problematic?

_____

_ **HA22:** Do you ever trap some of these animals?

- ▫ Yes ▫ No

HA23: What is the main source of energy for this household?

Source	**Cooking**	**Heating**	**Lighting**
Wood			
Charcoal			
Kerosene			
LPG gas			

Solar Energy			
Electricity			
D-light			

HA24: Do you buy firewood?

- ▫ Yes
- ▫ No

HA24-1: If u don't buy firewood, how far on average do you travel each day to collect firewood?

_____kms

A24-2: How long does it take you to collect firewood from the forest? (include walking time to and from the forest)

_____

HA25: Is the firewood from the forest reserve?

- ▫ Yes ▫ No

HA26: How many hours per week do members of your household spend on collecting firewood for family use? (*Adult time should be reported; child time is 50% of adult time*)

_____

HA27: How much time do you spend on getting firewood today compared to five years ago?

- ▫ Same time
- ▫ More time
- ▫ Less time
- ▫ Don't Know

HA28: How has availability of firewood changed over the last five years?

- ▫ Declined
- ▫ About same ▫ Increased
- ▫ Don't know

HA29: If firewood has declined in HA28 above, how has your **household responded to decline in availability of firewood**?

- ▫ Use of energy saving Jiko
- ▫ Use of biogas
- ▫ Use of Kerosene stove
- ▫ Use of charcoal

- Others specify_____

HA30: Which quarters of the year do you use the forest most?

Quarter	**Reason**
January-March	
April-June	
July-September	
October-December	

HA31: How would you rank the following benefits derived from forests

Benefit	**Rank (0= not important, 1=slightly important, 2=Important, 3= very important)**
Farming (PELIS)	
Water	
Firewood	
Medicine/herbs	
Fruits/food/vegetables/mushroom	
Grazing	
Timber	
Leisure	
Fish farming	
Honey	
Wildlife	
Reduced erosion	
Carbon sequestration	

HA32: Overall do you consider this forest to be of value to you?

- Yes
- No

A33: What is the most significant value of this forest to you (list in order of importance)?

_____

CE1: CHOICE EXPERIMENT EXERCISE

In each question 1-5, we ask you to make a choice between alternative future options for managing the named forest reserve. The forest reserve and some future management actions are described in the poster.

OPTIONS

OPTION C (STATUS QUO): is the same in each question 1-5. In this option described "as at today"'. This option involves no new management actions and no cost to you. It is not represented pictorially but left to your imagination how the forest would be in the next five years if there is no any other policy intervention.

OPTION A & B involves combination of new management actions. These actions are likely to affect the future condition of the forest catchment. The impact that the new actions will have in 5 years' time are predicted and described by

- Population of wildlife animals

- Tree population/forest cover/ nature of the forest/ structure of the forest
- Water purification: availability of clean water (quantity and quality)
- Flood control/flood risk

Attribute description

Population of wildlife animals: the no of wildlife that will be available if the given alternative is chosen

Tree population/forest cover (wood fuel): the amount of wood fuel that will be available if the given alternative is chosen

Water purification and supply: the quality and quantity of water that will be available if the alternative is chosen

Flood Risk: the risk of flooding downstream if the alternative is chosen

Cost: cost to the household per year if the alternative is chosen

COSTS

Taking action to change the way the forest catchment is managed would involve higher costs. The money to pay for the management changes would come from all the people living around the forest including your household, as a one off levy on rates collected by the government during the year. The size of the levy will depend on which new management actions are proposed. The money from the levy would go into a special trust fund specifically set up to fund management and changes in forest catchment. The fund will be managed by a committee comprising of elected community members and other state and non-state actors. An independent auditor will make sure the money is spent properly.

MAKING A CHOICE

Now I will present you five different choice scenarios with three options to choose from in each choice scenario. Two of the three options are based on differences in the attributes of forest ecosystem services I have explained to you. The third option is choosing **None of the forest management options**. You are requested to choose only **ONE** of the three alternatives in each round which is most suitable for your household. There is no right or wrong answer (only your opinion matters). When deciding the option, you prefer, please consider:

- The different future outcomes that scientists have predicted
- The one off payment you would need to make to pay for the new catchment management actions
- Your available income is limited and you will have other expenses
- Other issues and other catchments in the forest reserves may also need your payments.

You are presented with five choice scenarios to choose from. Consider each question separately by referring to information on the poster for each of the choice scenarios. ***(Indicate the choice scenario presented and the option picked in each choice scenario for each round)***

Round	**Choice scenario presented**	**Option picked A, B or C (status quo)**

1		
2		
3		
4		
5		

CE1: If you have chosen, the status quo in all the choice sets. What is the main reason for this ?

_____

CE2: How certain are you about the choice you made in question 3?

(Indicate percentage certainty on the scale)

- ▫ 0%-10
- ▫ 11-20
- ▫ 21-30
- ▫ 31-40
- ▫ 41-60
- ▫ 61-80
- ▫ 81-100%

HB: DEMOGRAPHIC CHARACTERISTICS

HB1: Gender of household head

Gender	**Tick appropriately**
Male	
Female	

HB2: Age of household head

- ▫ 20-24
- ▫ 25-29
- ▫ 30-34
- ▫ 35-39
- ▫ 40-44
- ▫ 45 -49
- ▫ 50-54
- ▫ 55-59
- ▫ 60-64
- ▫ 65-69
- ▫ 70 and above

HB3: Do you have children?

- ▫ Yes
- ▫ No

HB4: If you have children, how many? _____

HB5: How many people live in your household?

People	**Number**
Adults (including respondent)	
Number of children (Below 18 years)	

HB6: Marital Status of household head

Marital Status	**Tick appropriately**
Married	
Divorced	

Single/never married	
Separated	
Widow/Widower	

HB7: What is your highest level of education?

- ▫ Never went to school
- ▫ Primary
- ▫ Secondary school
- ▫ College diploma/certificate
- ▫ University degree
- ▫ Post graduate degree
- ▫ Others (specify)

HB7-1: Specify the number of years spent in school (whatever highest level reached)
_____yrs.

HB8: Residential status of the household head

- ▫ Native
- ▫ Immigrant/settler
- ▫ On employment

HB9: Are you a member of any CFA?

- ▫ Yes
- ▫ No

HB10: If a member, specify name of CFA_____

HB10-1: IF a member of the CFA, which CBO are you affiliated to?_____

HB10-2: Do you attend CFA/CBO meetings?

- ▫ Yes
- ▫ No

HB10-3: How often do you attend CFA/CBO meetings?

- ▫ Always ▫ Rarely
- ▫ Mostly ▫ Hardly

HB11: Are you a member of any other environmental organization?

- ▫ Yes
- ▫ No

HB12: If a member, specify the environmental organization _____

HB13: Were you born in this village?

- ▫ Yes
- ▫ No

HB14: If no in HB13, how long has your household been in this village?
_____Years

HB15: What is your **mother tongue**? _____ **HB15-1:** Which other language do you speak?

Language	Tick Appropriately
English	
Kiswahili	
Kalenjin	
Luhya	
Kisii	
Luo	
kikuyu	
Turkana	

HC: SOCIOECONOMIC CHARACTERISTICS

HC1: Employment status of household head

Employment Status	Tick Appropriately
Employed (Permanent)	
Employed (Casual)	
Unemployed	
Self-employed (e.g. farming)	

HC2: What is the distance from your house/homestead to the nearest natural or managed forest that you have access to and can use? _____Kms

HC2-1: How long does it take you to walk from your house to the edge of the forest? _____

HC3: What is the distance from your house/homestead to the nearest market? _____Kms

HC3-1: How long does it take you to walk from your house to the nearest market? _____

HC4: What is the distance from your house/homestead to the nearest main road? _____Kms

HC4-1: How long does it take you to walk from your house to the nearest main road _____

HC5: Do you own the house you live in?

- ▫ No
- ▫ Yes

HC6: What is the type of house (***Make discrete observations on approach***)?

Type of house	Tick Appropriately
Permanent (stone/concrete brick wall with corrugated iron sheet roof	
Semi-permanent House (Plastered mud wall and roof of corrugated iron sheet)	
Iron sheet walled house with corrugated iron sheet roof	
Wooden walled house with roof of corrugated iron sheet	

Mud walled house with a roof of corrugated iron sheet	
Mud walled, grass thatched	

HC7: What is the size of the household land _____acres

HC8: Do you own a title deed for this piece of land?

- ▫ Yes
- ▫ No

HC9: Which of these incentives does your household benefit from?

No	Incentives	Tick all that apply
1	PELIS (cultivation in forest)	
2	Pure grazing	
3	Herbs collection	
4	Fuel wood collection	
5	Bee Keeping (Honey)	
6	Full time saw millers	
7	Fodder collection	
8	Collection of grass for thatching	
9	Use of revenues accrued through ecotourism	
10	Fetching water	
11	Fish farming	

HC10: If your household benefits from PELIS when did the household start participating in the PELIS _____ scheme?

HC11: If your household benefits from PELIS, how many acres does the household have under _____ PELIS?

HC12: If your household benefits from PELIS**,** how far is your plot in the forest from your _____kms house

HC12-1: How long does it take you to walk from your house to the plot in the? forest

_____

HC13: If you are a beneficiary of PELIS, have you ever withdrawn or stopped from

participating in PELIS?

- ▫ Yes
- ▫ No

HC13-1: If yes, what were the reasons for withdrawal?

_____

HC14: What would you say the last month's household income was?

Income Level	**Tick appropriately**
Below 5000	
5000-10000	
10001-20000	
20001-30000	
30001-40000	
40001-60000	
Above 60000	

HC15: What are the major sources of income

Source	**Tick all that apply**
Employment (Salaries and wages)	
Agriculture and Livestock sales	
Land rented out	
Compensation from mining or logging company	
Pension	
Gifts/support from friends	
Payment from CFA	

HC16: How much money did this household spend on all its expenses in the last 30 days? _____

HC 17: Please indicate the approximate amount of annual expenditure on the following items

Expenditure	**Amount**
Education (Fees, Tuition, books, uniforms)	
Food and household supplies	
Farming (livestock and Agriculture)	
Clothing and apparel	

Medical	
Other expenses	
Total Expenditure	

ASSET OWNERSHIP

HC18: Livestock Assets

Livestock	**Number**	**Value**
Cows		
Goats		
Sheep		
Pigs		
Donkeys		
Ducks		
Chicken		
Rabbits		
Guinea pigs		
Turkey		
Total value		

HC18-1: Other Assets

Item	**Tick all that apply**	**Value (current sales value of all units not purchase price)**
Household land size and value		
Tractor		
Motorcycle		
Motor vehicle		
Wheel barrow		
Ox/Donkey cart		
Posho mill		
Bicycle		
Sewing machine		
Welding machine		
Mobile phone		
TV		
Radio		
Cassette/DVD/VCD player		
Refrigerator/Freezer		

Cooking stove		
Chain saw/Power saw		
Ox/Disc plough		
Household furniture		
Water pump		
Solar panel		
Total value		

HC18-2: Household agricultural produce

Item	**Volume**	**Value**
Maize		
Beans		
Potatoes		
Peas		
Vegetables		
Milk in litres		
Others specify		
Total		

HD: HOUSEHOLD INVOLVEMENT IN COMMUNITY ACTIVITIES AND FOREST MANAGEMENT

HD1: Do you consider your village or community to be a good place to live?

- ▫ Yes
- ▫ No

HD2: Do you in general trust people in the village (community)

- ▫ No
- ▫ Partly trust some and not others
- ▫ Yes

HD3: Can you get help from other people in the village (community) if you are in need for example if you need extra money because someone in your family is sick

- ▫ No
- ▫ Can sometimes get help, but not always
- ▫ Yes

HD4: How well off is your household today compared with the situation five years ago?

- ▫ Less well off
- ▫ About the same
- ▫ Better off now

HD5: How did you learn about the CFA and its activities?

- Friends
- Village meetings/barazas
- Media
- Local chief

HD6: What was one of the greatest motivation for joining the CFA?

- The will to conserve the environment
- To be together with friends
- Participating in making forest beautiful (Aesthetic value)
- For Social prestige (class)
- For Income (from selling forest products)
- For agricultural purposes
- Employment Opportunity
- Access to forest resources (fruits, timber, wood fuel, grazing etc)

HD6-1: What **other** reasons motivated you to join the CFA?

- The will to conserve the environment
- To be together with friends
- Participating in making forest beautiful (Aesthetic value)
- For Social prestige (class)
- For Income (from selling forest products)
- For agricultural purposes
- Employment Opportunity
- Access to forest resources (fruits, timber, wood fuel, grazing etc)

HD6-2: Do you know the functions of the CFA?

- Yes
- No

HD6-3: What are some of the activities the CFA of which you are a member is involved
in?

Activity	**Tick all that apply**
Fire fighting	
Farming (PELIS)	
Prunning	
Transporting seedlings	
Monitoring	
Others specify	

HD7: How many person days (=full working days) did the household members spend in total on CFA activities in the last one year *(probe approximate number of days*)?

HD8: What is **ONE OF THE MOST** important use of the forest for your household?

Activity	Tick all that apply
Farming (PELIS)	
Water	
Firewood/charcoal	
Timber/other wood	
Medicine	
Fodder/forage	
Bee keeping	
Others specify	

HD9: Would you conserve the forest given the importance of these resources to you?

- ▫ Yes
- ▫ No

HD10: Does anyone in your household normally/regularly attend CFA meetings?

- ▫ Yes
- ▫ No

HD11: Who normally represents the household in CFA meetings?

- ▫ Mother ▫ Daughter
- ▫ Father ▫ Grand children
- ▫ Son

HD12: Does your household normally participate in CFA activities?

- ▫ Yes
- ▫ No

HD13: What is the household level of participation in CFA meetings (specifically in the last meeting attended)

1. Nominal: participant present when a decision was made; 2. Passive: member merely attended and was informed about the decision but did not speak up; 3. Active: expressed an opinion whether it was sought or not; 4. Interactive: participant felt she influenced the resolution

Participation level	Tick one that applies
Nominal	
Passive member	
Active member	
Interactive	

HD14: If your household participated which activities did the household participate in?:

_____

_

HD15: How many hours does your household contribute to monitoring and security enforcement in the forest per month? _____

HD16: Does your household make any cash payments/contribution to CFA and activities of the CFA?

- ▫ Yes
- ▫ No

HD17: If yes in HD16 how much did you pay in the last 12 months?

_____

HD18: Did the household receive any cash payment from the CFA (e.g. share of sales) in the last 12 months?

- ▫ Yes
- ▫ No

HD19: Have you ever contravened any of the rules of the CFA?

- ▫ Yes
- ▫ No

HD19-1: Have you ever been summoned for contravening the CFA's rules?

- ▫ Yes
- ▫ No

HD20: Has your household planted any woodlots or trees on farm over the past five years?

- ▫ Yes
- ▫ No

HD21: Overall, how would you say the existence of the CFA has affected the benefits that the household gets from the forest?

- ▫ Large negative effect
- ▫ Small negative effect
- ▫ No effect
- ▫ Small positive effect
- ▫ Large positive effect

Thank you very much for the cooperation; once more this information will be used purely for research purposes.