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Determinants of Successful Collective Management of Forest Resources

Evidence from Kenyan Community Forest Associations

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Determinants of Successful Collective Management of Forest Resources: Evidence from Kenyan Community Forest Associations*

Boscow Okumu† **and Edwin Muchapondwa**‡

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 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

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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[1] (CPRs) (Muchara et al., 2014).

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). Hence the increased adoption of PFM in most developing countries (Wily, 2001; Agrawal, 2007).

[1] 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.

1.1 Participatory Forest Management in Kenya

Kenya's forest cover of the land area stands at 7%, far below the constitutional requirement of 10% (GOK, 2015). It is also estimated that about 80% of the Kenyan population are rural communities dependent on rain-fed subsistence agriculture, supplemented by forest resources for their livelihoods (FSK, 2006). The five major water towers[2] 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.

Between 2000 and 2010 alone, it is estimated that about 50,000 hectares were lost as a result of human-induced deforestation (UNEP, 2012). 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)[3]. Under the PFM arrangement in Kenya, the government retains ownership of the forest while forest-adjacent communities, organized in the form of Community Forest Associations (CFAs), obtain user rights. The rationale for promotion of participation of locals in resource management was based on the premise that the resource can be effectively managed when local resource users benefit from the resource and have exclusive or shared rights to make decisions in management of the resource. Communities have in turn been able to form community-based organizations known as CFAs in collaboration with the Kenya Forest Service (KFS).

1.1.1 Organization of Community Forest 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)[4]. 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

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

[3] 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.

[4] 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.

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.

1.1.2 Motivation of the Study

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 under each forest conservancy in Kenya[5], 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. 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 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.

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

In light of socio-economic and demographic pressure, the sustainability of forest management requires successful coordination and cooperation among users, hence 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. Mixed results have also been obtained on the determinants of household levels of participation in community forest management (see Baral 1993; Malla 1997; Agrawal 2000; Adhikari 2004; Fujiie et al. 2005; Maskey et al. 2006; Jumbe and Angelsen 2007; Coulibaly-Lingani et al. 2011; Jana et al. 2014; Ali et al. 2015). Moreover, most of the studies on drivers of successful collective action have been based on intensive case studies of individual CPRs (Fujiie et al., 2005). 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) represent some of the significant analysis of conditions necessary for successful collective action. More recent literature in support of these scholars includes Cox (2014), Frey and Rusch (2014), Rasch et al. (2016a), Rasch et al. (2016b) and Behnke et al. (2016). Ostrom also developed a framework for organizing variables identified as affecting the interaction patterns and observed outcomes in empirical studies of Social Ecological Systems (SESs) (see Ostrom 2009, 2010)[6].

An overview of this literature further suggests the lack of consensus on what determines the success or failure of local institutions in management of CPRs and also suggests that 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 to move beyond pilot projects and case studies that have formed the basis of most studies to date. There are also considerable differences in applied definitions, 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 the nature of collective action problems (Poteete and Ostrom, 2004), resulting in measurement error problems. For example, an index of collective action is constructed to capture community involvement in collective action. Others have also measured forest conditions using an index of respondents' rankings 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 perceptions of forest condition (see Heltberg et al., 2000; Gibson et al.,

[6] The framework has also been applied in other spheres e.g., communal livestock production (see Rasch et al. 2016a,b).

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). These approaches are rather subjective. Once communities have collectively organized, the main interest should be in objective measures of outcome of such collective action, i.e., whether there is an increase in forest cover that can guarantee efficient and sustainable provision of ecosystem services as per the government's key policy goal. Lastly, 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 these gaps by identifying the factors influencing households' level of participation in CFA activities and identifying 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 as we apply Ostrom's SESs framework.

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[7] 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. An overview of the findings reveals that CFAs tend to be more successful with higher levels of household participation, when initiated by the communities themselves, and with frequent interaction with government institutions at the national and devolved levels. We also find that communities tend to self-organize more when the forest cover is low and less when there is abundant supply of forest resources.

The rest of the paper is organized as follows: Section 2 presents a description of the study area; Section 3 outlines the methodological framework; Section 4 presents the data collection and sampling method; Section 5 presents the results and discussions and Section 6 presents conclusions and policy recommendations.

[7] 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.

2 Description of the study site

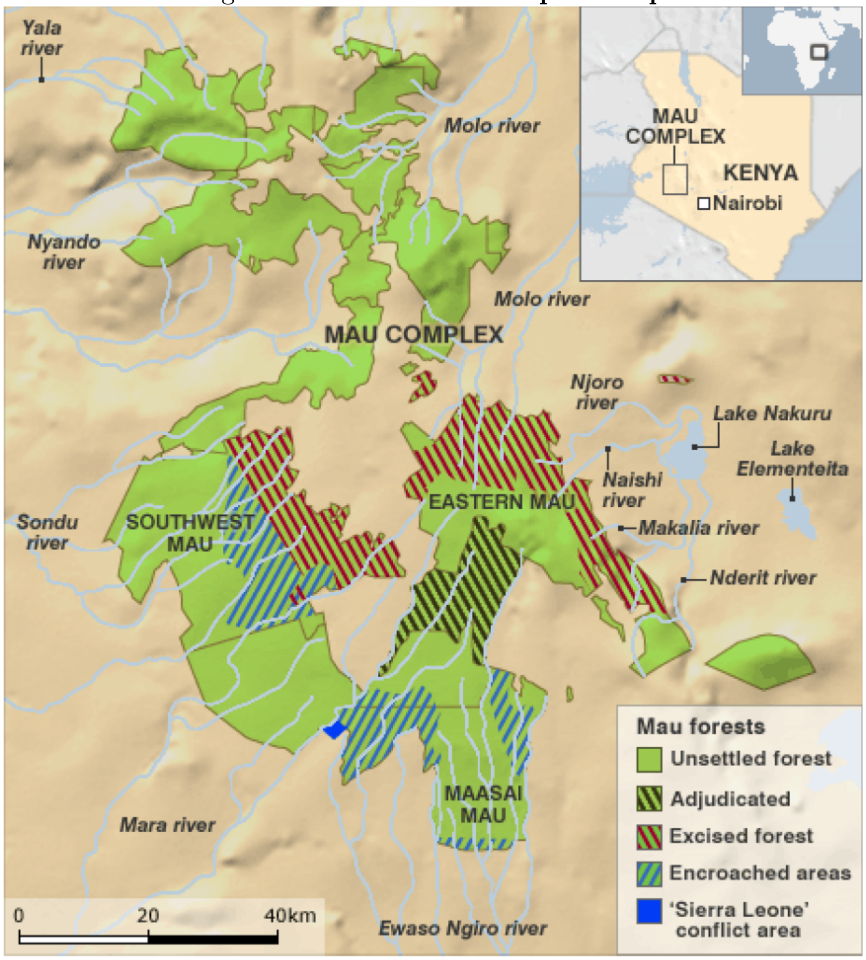
The study was conducted in the Mau forest conservancy. The Mau forest provides a range of ecosystem services and supports significant population in terms of livelihood needs. The choice of the Mau forest was based on two criteria: high susceptibility to degradation and a long history of community forestry, with the highest 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. It is also the largest closed canopy forest among the five major Water Towers in Kenya and has lost over a quarter of its forest resources in the last decade (Force, 2009). The forest is located 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 conservancy is made up of 22 forest blocks[8], of which 21 are gazetted forests managed by KFS. The remainder is Mau Trust Land Forest (46, 278 ha), which is managed by the Narok County Council (NEMA, 2013). A picture of the Mau forest complex is presented in Figure 1.

The Mau ecosystem is also the upper catchment of many major rivers[9], as depicted in Figure 1. These rivers feed into various lakes, e.g., Nakuru, Baringo, Natron, Naivasha, Turkana and Victoria. The lakes and rivers also provide much-needed water for 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 hydro-power potential of the Mau forest is estimated to be about 535 MW, which equals about 47% of the total installed electric power generation capacity in Kenya (UNEP, 2008). Apart from provision of local public goods such as food, herbs, and wood-fuel, the forest also supplies global public goods and services e.g., wildlife habitat, carbon sequestration and biodiversity conservation. The upper catchment of the forest also hosts the last groups of hunter-gatherer communities in Kenya, such as the Ogiek (Force, 2009).

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

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

Figure 1: **Mau Forest Complex Map**



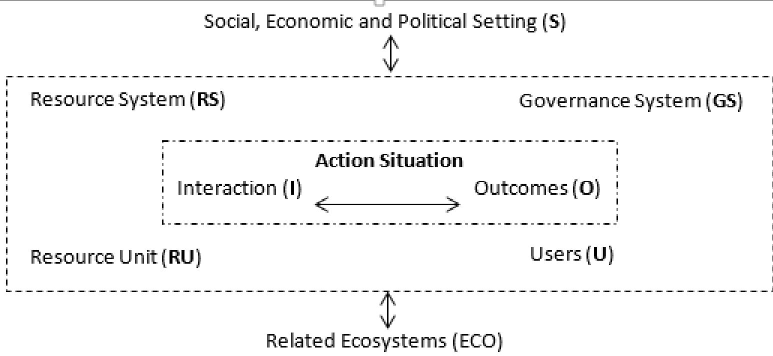
3 Methodology

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

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 2: **A Framework for Analyzing a Social-Ecological System**



Adapted from Elinor Ostrom (2009)

Figure 2 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 2 can be decomposed into several tiers depending on the research problem. A detailed exposition of the second-tier variables in Figure 2, 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 1. The table presents the grouping of the variables we employed in the empirical models. A clear description of these variables, how they are measured and the expected signs is presented in Table 2.

Table 1: **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[10]; 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 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.

[10]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 (Ostrom, 1993).

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.

3.2.1 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[11]. 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[12] 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

$$\mathbf{Y_j} = \beta_0 + \beta_1 CFAPartHt_{ij} + \beta_2 X_{ij} + \beta_3 Z_j + \varepsilon_{ij} \tag{1}$$

where Y_j is a vector of two dependent variables, namely percentage forest cover and reported cases of vandalism in CFA j, $\mathrm{CFAPartHt_{ij}}$ 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 2.

[11] We acknowledge that the percentage change in forest cover would be an ideal measure of success as opposed to the aggregate 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 aggregate 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 aggregate 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.

[12] 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 2: **Description of variables included in the econometric analysis and expected signs**

		Expected signs	
variable	**Definition**	**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. 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, re-seeding, weeding, silviculture activities, thinning and watering. Household participation in each collective action activity is recorded as one and non-participation 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 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[13]. 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 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[14]. 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 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

[13] 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.

[14] 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

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 1 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[15], 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)[16].

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 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. The expected signs and description of variables employed in this study are shown in Table 2.

5 Results and Discussion

5.1 Descriptive statistics

The summary statistics of variables used in the econometric models are presented in Table 4 in the appendix. 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. 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,

[15] 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.

[16] Households were then classified as active (i.e., active or interactive) and inactive (i.e., nominal or passive).

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 6 to 12 in the appendix.

5.2 Logistic regression Results

The logistic regression results are presented in Table 3. 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 hence 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[17]. 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 fall-back 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.

[17]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 3: **Results for Logistic Regression for Probability of Active Participation in CFA Activities**

	(1)	(2)
VARIABLES	CFAParticipation	Marginal Effects
MaritSta	0.452	0.0897
	(0.322)	(0.0646)
MedAge	-0.00942	-0.00187
	(0.00990)	(0.00193)
hhsize	0.0805	0.0160
	(0.0622)	(0.0119)
Education	0.517***	0.102***
	(0.144)	(0.0274)
EmploymentStat	-0.902***	-0.179***
	(0.237)	(0.0420)
Woodlots	0.847***	0.168***
	(0.303)	(0.0573)
Hlandsize	-0.000104	-2.06e-05
	(0.0206)	(0.00409)
DistForest	0.103	0.0204
	(0.0718)	(0.0140)
DistMroad	0.113*	0.0224*
	(0.0617)	(0.0123)
DistMarket	-0.0815**	-0.0162**
	(0.0338)	(0.00670)
ResidStatus	-0.390	-0.0774
	(0.279)	(0.0546)
IncentIndex	0.0527	0.0105
	(0.107)	(0.0213)
Precipitation	0.00229***	0.000455***
	(0.000690)	(0.000140)
Constant	-3.430***	
	(0.987)	
Observations	518	518

Clustered robust 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 hence 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; hence, 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.

5.3 Regression Model Results

Empirical results for the multiple regression models are presented in Table 5 in the appendix. 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[18]. To correct for heteroscedasticity in the models, we estimated the three models with clustered robust standard errors[19]. The IV estimates were obtained using the ivreg2h stata command (Baum et al., 2015).

We first tested for endogeneity using the Durbin-Wu-Hausman tests for endogeneity under the null hypothesis that the variables are exogenous (see Table 14 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 15). 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).

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

[19] 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.

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).

5.3.1 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 hence 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[20]. This suggests that face-to-face 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.

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

5.3.2 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[21].

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, 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

[21] 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.

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[22].

5.3.3 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[23]. 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).

5.3.4 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 six 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 six, 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

[22] We opted to use data on the proportion of immigrants because we could not get data on in and out migration at CFA level.

[23] Other variables such as competition, social interaction, group structure, improvement index and initiation of the CFA were dropped from the model due to multicollinearity

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.

5.3.5 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, 1994). Further, the Kaiser-Meyer-Olkin (KMO)[24] 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 13. 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

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

successful collective action using the PC score[25]. The results are presented in Column (5) of Table 5. 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.

6 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

[25] 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.

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.

References

Adhikari, B. (2004). Community forestry in Nepal: Management rules and distribution of benefits. *Policy Brief, South Asian Network for Development and Environmental Economics (SANDEE)*, (1-04).

Agrawal, A. (2000). Small is beautiful, but is larger better? Forest-management institutions in the Kumaon Himalaya, India. *People and forests: Communities, institutions, and governance*, pages 57–86.

Agrawal, A. (2001). Common property institutions and sustainable governance of resources. *World Development*, 29(10):1649–1672.

Agrawal, A. (2007). Forests, governance, and sustainability: Common property theory and its contributions. *International Journal of the Commons*, 1(1):111–136.

Agrawal, A. and Chhatre, A. (2006). Explaining success on the commons: Community forest governance in the Indian Himalaya. *World Development*, 34(1):149–166.

Agrawal, A. and Gibson, C. C. (1999). Enchantment and disenchantment: The role of community in natural resource conservation. *World Development*, 27(4):629–649.

Agrawal, A. and Goyal, S. (2001). Group size and collective action third-party monitoring in common-pool resources. *Comparative Political Studies*, 34(1):63–93.

Agrawal, A. and Gupta, K. (2005). Decentralization and participation: The governance of common pool resources in Nepal's Terai. *World Development*, 33(7):1101–1114.

Akamani, K. and Hall, T. E. (2015). Determinants of the process and outcomes of household participation in collaborative forest management in Ghana: A quantitative test of a community resilience model. *Journal of Environmental Management*, 147:1–11.

Ali, A., Behera, B., et al. (2015). Household participation and effects of community forest management on income and poverty levels: Empirical evidence from Bhutan. *Forest Policy and Economics*, 61:20–29.

Alló, M. and Loureiro, M. L. (2016). Evaluating the fulfillment of the principles of collective action in practice: A case study from Galicia (NW Spain). *Forest Policy and Economics*, 73:1–9.

Andersson, K. and Agrawal, A. (2011). Inequalities, institutions, and forest commons. *Global Environmental Change*, 21(3):866–875.

Angelsen, A. and Wunder, S. (2003). Exploring the forest–poverty link: Key concepts, issues and research implications. Technical report, CIFOR, Bogor, Indonesia.

Araral, E. (2009). What explains collective action in the commons? theory and evidence from the philippines. *World development*, 37(3):687–697.

Baland, J.-M. and Platteau, J.-P. (1996). *Halting degradation of natural resources: Is there a role for rural communities?* Food and Agriculture Organization.

Baral, N. (1993). Where is our community forestry? *Banko Janakari: A Journal of Forestry Information for Nepal*, 4(1):12–15.

Bardhan, P. (1993). Analytics of the institutions of informal cooperation in rural development. *World Development*, 21(4):633–639.

Bardhan, P. (2000). Irrigation and cooperation: An empirical analysis of 48 irrigation communities in South India. *Economic Development and Cultural Change*, 48(4):847–865.

Baum, C. F., Schaffer, M. E., et al. (2015). Ivreg2h: Stata module to perform instrumental variables estimation using heteroskedasticity-based instruments. *Statistical Software Components*.

Behera, B. (2009). Explaining the performance of state-community joint forest management in India. *Ecological Economics*, 69(1):177–185.

Behnke, R., Robinson, S., and Milner-Gulland, E. (2016). Governing open access: Livestock distributions and institutional control in the Karakum Desert of Turkmenistan. *Land Use Policy*, 52:103–119.

Coleman, E. A. and Fleischman, F. D. (2012). Comparing forest decentralization and local institutional change in Bolivia, Kenya, Mexico, and Uganda. *World Development*, 40(4):836–849.

Coulibaly-Lingani, P., Savadogo, P., Tigabu, M., and Oden, P.-C. (2011). Factors influencing people's participation in the forest management program in Burkina Faso, West Africa. *Forest Policy and Economics*, 13(4):292–302.

Cox, M. (2014). Understanding large social-ecological systems: introducing the sesmad project. *International Journal of the Commons*, 8(2).

Darnell, A. C. (1994). A dictionary of econometrics. Technical report, Edward Elgar Publishing.

Dash, M. and Behera, B. (2012). Management of similipal biosphere reserve forest: Issues and challenges. *Advances in Forestry Letter (AFL)*, 1(1):7–15.

Dash, M. and Behera, B. (2015). Local institutions, collective action and forest conservation: The case of Similipal Tiger Reserve in India. *Journal of Forest Economics*, 21(4):167–184.

Dietz, T., Ostrom, E., and Stern, P. C. (2003). The struggle to govern the commons. *Science*, 302(5652):1907–1912.

Force, P. M. T. (2009). Report of the Prime Ministers Task Force on the conservation of the Mau Forests Complex. *Nairobi, Kenya*.

Frey, U. J. and Rusch, H. (2014). Modeling ecological success of common pool resource systems using large datasets. *World Development*, 59:93–103.

FSK (2006). Kenya forestry in the new millennium and the challenges facing a forester under the Forestry Act No 7 of 2005. *Forest Society of Kenya*.

Fujiie, M., Hayami, Y., and Kikuchi, M. (2005). The conditions of collective action for local commons management: the case of irrigation in the Philippines. *Agricultural Economics*, 33(2):179–189.

Gautam, A. P. and Shivakoti, G. P. (2005). Conditions for successful local collective action in forestry: some evidence from the hills of Nepal. *Society and Natural Resources*, 18(2):153–171.

Gebremedhin, B., Pender, J., and Tesfay, G. (2004). Collective action for grazing land management in crop-livestock mixed systems in the highlands of northern Ethiopia. *Agricultural Systems*, 82(3):273–290.

Gibson, C. C., Williams, J. T., and Ostrom, E. (2005). Local enforcement and better forests. *World Development*, 33(2):273–284.

Godoy, R., O'neill, K., Groff, S., Kostishack, P., Cubas, A., Demmer, J., McSweeney, K., Overman, J., Wilkie, D., Brokaw, N., et al. (1997). Household determinants of deforestation by Amerindians in Honduras. *World Development*, 25(6):977–987.

GOK (2015). Economic survey. Technical report, Kenya National Bureau of Statistics.

Gopalakrishnan, S. (2005). *Collective Action in the Management of Common-Pool Resources: Is There an Alternative to the Rational Choice Model?* PhD thesis, Citeseer.

Hardin, G. (1968). The tragedy of the commons. *Science*, 162(3859):1243–1248.

Hayes, T. and Ostrom, E. (2005). Conserving the world's forests: Are protected areas the only way? *Indiana Law Review*, 38:595.

Heltberg, R. (2001). Determinants and impact of local institutions for common resource management. *Environment and Development Economics*, 6(02):183–208.

Heltberg, R., Arndt, T. C., and Sekhar, N. U. (2000). Fuelwood consumption and forest degradation: A household model for domestic energy substitution in rural India. *Land Economics*, pages 213–232.

Horrace, W. C. and Oaxaca, R. L. (2006). Results on the bias and inconsistency of ordinary least squares for the linear probability model. *Economics Letters*, 90(3):321–327.

Hyde, W. F. (2016). Whereabouts devolution and collective forest management? *Forest Policy and Economics*, 72:85–91.

Jana, S. K., Lise, W., and Ahmed, M. (2014). Factors affecting participation in joint forest management in the West Bengal state of India. *Journal of Forest Economics*, 20(4):317–332.

Johnson, K. A. and Nelson, K. C. (2004). Common property and conservation: The potential for effective communal forest management within a national park in Mexico. *Human Ecology*, 32(6):703–733.

Jumbe, C. B. and Angelsen, A. (2007). Forest dependence and participation in CPR management: Empirical evidence from forest co-management in Malawi. *Ecological Economics*, 62(3):661–672.

Lewbel, A. (2012). Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models. *Journal of Business & Economic Statistics*, 30(1):67–80.

Lise, W. (2005). A game model of people's participation in forest management in northern India. *Environment and Development Economics*, 10(02):217–240.

Liu, P. and Ravenscroft, N. (2016). Collective action in China's recent collective forestry property rights reform. *Land Use Policy*, 59:402–411.

Malla, Y. (1997). Sustainable use of communal forests in Nepal. *Journal of World Forest Resource Management*, 8(1):51–74.

Maskey, V., Gebremedhin, T. G., and Dalton, T. J. (2006). Social and cultural determinants of collective management of community forest in Nepal. *Journal of Forest Economics*, 11(4):261–274.

Measham, T. G. and Lumbasi, J. A. (2013). Success factors for community-based natural resource management (CBNRM): Lessons from Kenya and Australia. *Environmental Management*, 52(3):649–659.

Meinzen-Dick, R., Raju, K. V., and Gulati, A. (2002). What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India. *World Development*, 30(4):649–666.

MENR (2005). The Kenya Forests Act, 2005. *Ministry of Environment and Natural Resources.*

MENR (2016). The Kenya Forest Act, 2016. *Ministry of Environment and Natural Resources.*

Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., and Mwangi, E. (2012). Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. *Conservation and Society*, 10(2):182.

Muchara, B., Ortmann, G., Wale, E., and Mudhara, M. (2014). Collective action and participation in irrigation water management: A case study of Mooi River irrigation scheme in KwaZulu-Natal Province, South Africa. *Water SA*, 40(4):699–708.

Nagendra, H. et al. (2011). Heterogeneity and collective action for forest management. Technical report, Human Development Report Office (HDRO), United Nations Development Programme (UNDP).

NEMA (2013). Mau complex at a glance. *Nairobi, Kenya.*

Olson, M. (1965). *The logic of collective action: Public goods and the theory of group*. Harvard University Press, Cambridge.

Ongugo, P. O., Mogoi, J., Obonyo, E., and Oeba, V. (2008). Examining the roles of community forest associations (CFAs) in the decentralization process of Kenyan forests. In *Conference Paper Presented at the IASC Conference in England.*

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Ostrom, E. (1993). Design principles in long-enduring irrigation institutions. *Water Resources Research*, 29(7):1907–1912.

Ostrom, E. (2000). Reformulating the commons. *Swiss Political Science Review*, 6(1):29–52.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, 325(5939):419–422.

Ostrom, E. (2010). Analyzing collective action. *Agricultural Economics*, 41(s1):155–166.

Ostrom, E. and Gardner, R. (1993). Coping with asymmetries in the commons: Self-governing irrigation systems can work. *The Journal of Economic Perspectives*, 7(4):93–112.

Ostrom, E., Gardner, R., and Walker, J. (1994). *Rules, games, and common-pool resources*. University of Michigan Press.

Ostrom, E. and Nagendra, H. (2006). Insights on linking forests, trees, and people from the air, on the ground, and in the laboratory. *Proceedings of the National Academy of Sciences*, 103(51):19224–19231.

Pagdee, A., Kim, Y.-s., and Daugherty, P. J. (2006). What makes community forest management successful: A meta-study from community forests throughout the world. *Society and Natural Resources*, 19(1):33–52.

Parente, P. M. and Silva, J. S. (2012). A cautionary note on tests of overidentifying restrictions. *Economics Letters*, 115(2):314–317.

Poteete, A. R. and Ostrom, E. (2004). Heterogeneity, group size and collective action: The role of institutions in forest management. *Development and Change*, 35(3):435–461.

Rasch, S., Heckelei, T., Oomen, R., and Naumann, C. (2016a). Cooperation and collapse in a communal livestock production ses model: A case from South Africa. *Environmental Modelling & Software*, 75:402–413.

Rasch, S., Heckelei, T., and Oomen, R. J. (2016b). Reorganizing resource use in a communal livestock production socio-ecological system in South Africa. *Land Use Policy*, 52:221–231.

Shackleton, C. M., Shackleton, S. E., Buiten, E., and Bird, N. (2007). The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics*, 9(5):558–577.

Szell, A., Hallett IV, L., et al. (2013). Attitudes and perceptions of local residents and tourists toward the protected area of Retezat National Park, Romania. *International Journal of Humanities and Social Science*, 3(3):45–61.

Tang, S. Y. (1992). *Institutions and collective action: Self-governance in irrigation*. ICS Press.

Tesfaye, Y., Roos, A., Campbell, B. J., and Bohlin, F. (2012). Factors associated with the performance of user groups in a participatory forest management around Dodola forest in the Bale mountains, Southern Ethiopia. *The Journal of Development Studies*, 48(11):1665–1682.

Thondhlana, G. and Shackleton, S. (2015). Cultural values of natural resources among the San people neighbouring Kgalagadi Transfrontier Park, South Africa. *Local Environment*, 20(1):18–33.

UNEP (2008). CDM/JI Pipeline Analysis and Database, March 1st 2008. *RISCOE, Roskilde Denmark*.

UNEP (2012). Kenya. Economy-wide impact technical report. *Unpublished report.*

Wade, R. (1988). *Village republics*. Number 40. Cambridge University Press.

Wily, L. A. (2001). *Forest management and democracy in East and Southern Africa: Lessons from Tanzania*. International Institute for Environment and Development.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

Appendix

Table 4: **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

Table 5: **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)
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)	
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)
Other Controls					
Climate & Geographic Variables	Yes	Yes	Yes	Yes	Yes
Asset Holdings	Yes	Yes	Yes	Yes	Yes
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

Table 6: **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 7: **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 8: **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 9: **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 10: **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 11: **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 12: **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 13: **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 14: **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 15: 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