Lessons on Successful Utilization of Forest Land for Crop Agriculture: Evidence from Kenyan Community Forest Associations*

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Abstract

The broad objective of this paper is to boost the provision of landless communities in land-scarce areas with options to grow appropriate food crops and other related economic activities inside the available forest reserves during early stages of reforestation programmes. In itself, the 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. In addition, finding ways of making sure that community participation in forest conservation yields desirable results opens up options for satisfying more land needs using forest reserves in a manner which does not negatively affect their mandate. This is important as in some areas there is no alternative land to allocate to the landless communities. Using household level data from 518 households and community level data from 22 CFAs from the Mau forest conservancy, the study employed regression techniques to identify 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, provision of alternative lands through PELIS and when the forest cover is low. Policy implications are also highlighted. Our findings help inform policy programmes which seek to satisfy some of the community land needs in land-scarce countries through conservation-friendly agricultural use of areas previously demarcated for exclusive use on forests.

Key words: PFM, collective action, participation, CFAs
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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 land and other 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). Evidence from Asian case studies 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).

1.1 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 agricultural land and other 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

[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.

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

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. Communities have in turn been able to form community-based organizations known as CFAs in collaboration with the Kenya Forest Service (KFS).

To supplement these efforts, commercial plantations are also open to lease arrangements through PELIS where local landless communities are provided with opportunity to grow appropriate crops in the early stages of reforestation[4]. This is a departure from prior practice, where gazetted forest reserves were fully managed by the government. As part of benefit sharing arrangements, PELIS was reintroduced in 2007 after several past failures through CFAs to promote the livelihood of locals through provision of alternative agricultural land 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.

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. 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 land and surrounding lands are very fertile and agriculturally productive hence attracts a lot of political interest as the political class strive to allocate part of forest reserve land to their constituents. It is also very prone to ethnic tensions, hence the CFAs may often be destabilized during election periods as people get displaced from their lands. There are also other institutional challenges from the government side[5]. Therefore, 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.

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? Understanding these factors are critical for policy formulation for effective utilization of forest land by landless forest adjacet communities without compromising the environmental benefits. However, to the best of

[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]Communities are also entitled to other range of user rights, such as firewood collection, grass for roof thatching and grazing animals, herbal medicine, timber and scientific and educational activities, as well as recreational activities.

[5]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. Some foresters also allocate the PELIS plots to cronies and on an "who knows who" basis.

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 landless communities reliant on agriculture and with a history of constant displacement from their settlements 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). 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. Moreover, 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[7]. 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 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.

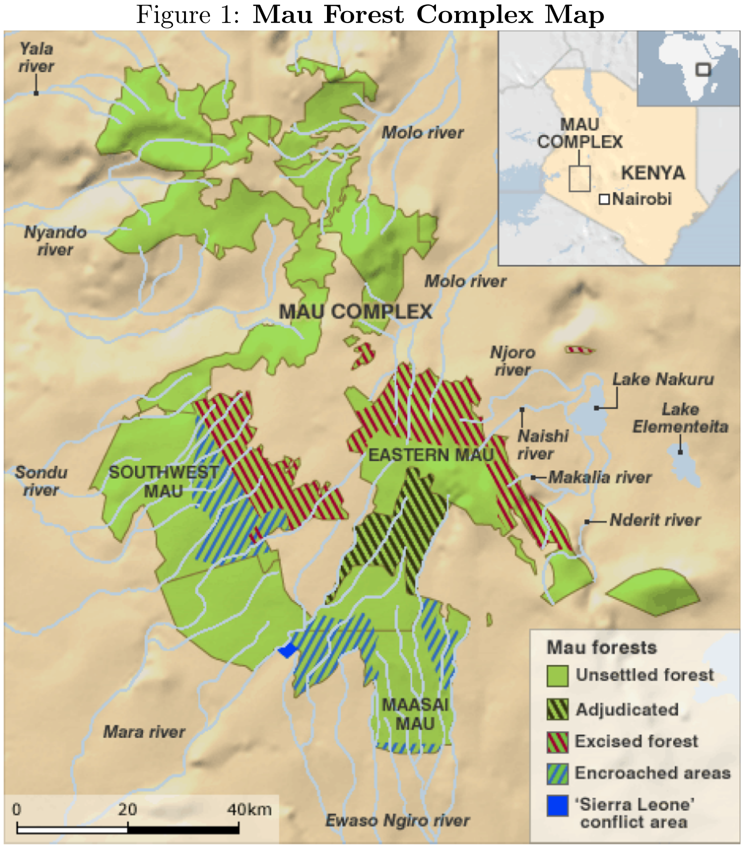
[6]The framework has also been applied in other spheres e.g., communal livestock production (see Rasch et al. 2016a,b).

[7]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., 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).

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, it is also prone to ethnic and land conflicts due to the agriculturally productive nature of the land and 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 in an effort to satisfy some community land needs. 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.

Figure 1: **Mau Forest Complex Map**



The Mau ecosystem is also the upper catchment of many major rivers[9], as depicted in Figure

[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.

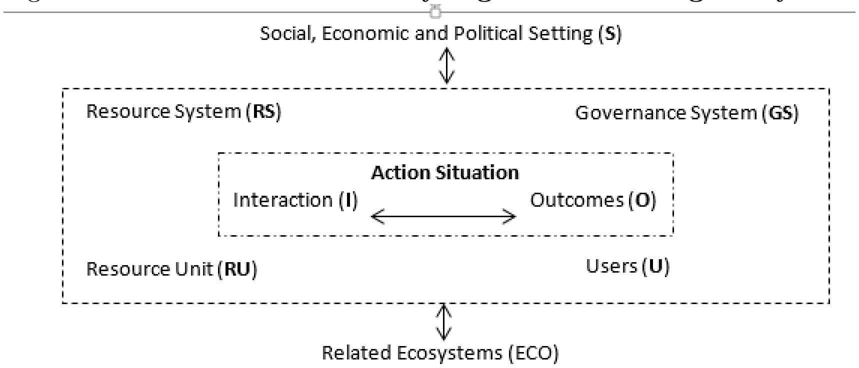
1. These rivers feed into various lakes, e.g., Nakuru, Baringo, Natron, Naivasha, Turkana and Victoria. The lakes and rivers also provide much-needed water for pastoral communities and agricultural activity and supply essential ecosystem services. The upper catchment of the forest also hosts the last groups of hunter-gatherer communities in Kenya, known as the Ogiek who have always been the occupants of the forest land (Force, 2009).

3 Methodology

3.0.1 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[10]. 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[11]. 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 (see Table 1). 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. In addition to some of the variables identified in the literature, we factored ownership of agricultural

[10] 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.

[11] 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).

land in the reserve forests through PELIS and an index of institutional quality, capturing the level of implementation of Ostrom's design principles[12]. 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. We also assessed the level of interaction between communities and the devolved and national government and how this would affect success of collective action.

3.0.2 Analytical framework

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

Determinants of Successful collective management of forest resources

In the second stage, we employed multiple OLS regression models to estimate the determinants of successful collective action, factoring in the predicted probability of active participation in CFA activities (CFAPartHt). We measure success of collective action within each CFA using percentage forest cover and annual number of reported cases of vandalism[13]. 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[14]. 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. However, because of

[12]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).

[13]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.

[14]The Tobit model (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.) 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)).

potential endogeneity of institutional variable[15], we proceeded 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[16].

For robustness checks, we used Principal Component Analysis (PCA) to construct a composite index of success or failure in organizing collective action as employed in other studies. The PC score was constructed using one dominant collective action activity reported by CFAs: forest management/improvement activities[17]. The PC score was then employed in an OLS regression model to assess the robustness of our results.

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[18]. 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[19].

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[20]. This was conducted using individual household-level survey administered questionnaire to household heads. Most of the information collected at CFA and household levels 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[21], 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

[15] 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).

[16] 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)).

[17] The activities under forest management/improvement involved pruning, enrichment planting, reseeding, weeding, silviculture activities, thinning and watering. Household participation in each collective action activity is recorded as one and non-participation as zero.

[18] 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.

[19] 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.

[20] 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

[21] 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.

the decision (interactive)[22]. 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[23]. This is secondary data available at the forest station, which is regularly updated by the forester at each forest station. We also collected data on climate and geographic variables.

5 Results and Discussion

5.1 Descriptive statistics

The summary statistics of variables used in the econometric models are presented in Table 3 in the appendix. Further detailed 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 4. 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).

Household heads employed in off-farm jobs are also 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). Households owning private woodlots were found to have a significantly higher likelihood of being actively involved in CFA activities. Other factors found to influence household level of participation include, distance to the nearest main road and market, and rainfall prospects.

5.3 Regression Model Results

Empirical results for the multiple regression models are presented in Table 5 in the appendix. 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[24]. 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 13). The test rejects the null hypothesis of exogeneity at the 1% significance level for the second IV model of reported cases of vandalism

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

[23] 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.

[24] 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. To correct for heteroscedasticity in the models, we estimated the three models with clustered robust standard errors.

but not the first IV model where the dependent variable is forest cover. This suggests that OLS estimates yield better estimates in model one of forest cover (Column (1)), while the IV method with heteroscedasticity-based instruments yield better estimates in the second model, where the dependent variable is reported cases of vandalism (Column (4))[25]. 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). 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. 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. The results also 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[26]. 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. In terms of the organizational structure, 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. We found that democracy leads to successful collective action.

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. 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.

[25] We further carried out performance statistics (i.e., under identification, weak identification and overidentification) for the IV models (see Table 14).

[26] 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.

(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[27].

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 clearing of forest land for farming or illegal logging activities. 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.

On group size, 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. The study findings are in accord with expectations in group theory (see 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). 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. This is because, the marginal cost of coming together in collective action is often lower. 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.

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. This shows that opportunity cost with respect to distance matters. The results also 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[28]. Similarly, we found that provision of alternative agriculture land to communities through 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. 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 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.

[27] 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.

[28] 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.

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. This can be partly attributed to over-reliance on common pool resources by forest-adjacent communities due to lack of alternative sources of livelihood such as land for agriculture.

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[29]. Following Fujiie et al. (2005), we used the first component as a measure of successful collective action. We classified CFAs with PC scores greater than zero as successful and those with scores less than zero as unsuccessful. We then conducted an OLS regression using the constructed measure of successful collective action using the PC score[30]. 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 conclusion, Our findings revealed that to increase level of participation of landless communities in CFA activities, factors such as employment status, educational level, ownership of private woodlots, precipitation, and distance to nearest main road and nearest market influence should be considered in devolving forest management. These findings lend support to the works of (Malla, 1997; Adhikari, 2004; Agrawal and Gupta, 2005; Maskey et al., 2006; Coulibaly-Lingani et al., 2011).

The study further revealed that, through well-managed institutions such as CFAs, local forest-adjacent communities land needs, can effectively be met through conservation-friendly agricultural use of forest reserves previously demarcated as forest reserves. We found that for successful utilization of forest land for crop production, reforestation and other activities through CFAs, 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, salience of the resource (level of dependence on the resource), number of households within a CFA jurisdiction (group size), proportion of males in 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, proportion of natives and whether officials are selected competitively/democratically. In terms of the link, we found that

[29]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.

[30]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.

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 and when households are allocated property rights through land titles or allotment letters. 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 allocation of land through PELIS and when the forest cover is low or when there is scarcity in the supply of forest ecosystem services.

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. Second, 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 to settle the thorny issue of land tenure security within the Mau.

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Appendix

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	

Table 2: **Description of variables included in the econometric analysis and expected signs**

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

Table 3: **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 4: **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

Table 5: **OLS regression results**

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ForestCover	Vandalism	IVforestcover	IVVandalism	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 activities	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: **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 14: 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