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Research

Leadership accountability in community-based forest management: experimental evidence in support of governmental oversight

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ABSTRACT. Evidence of the impact of community-based forest management (CBFM) on conservation outcomes is mixed. Local governance is a key moderating factor, but what constitutes good governance is still up for debate. Desirable institutional features typically arise endogenously, which complicates the analysis of causality. We use an experimental design to analyze the impact on environmental outcomes of adding an externally implemented monitoring regime to an existing CBFM initiative in Ethiopia. We distinguish between bottom-up and top-down monitoring to improve the accountability of local leaders. We find that enhanced bottom-up monitoring by community members does not affect forest outcomes, but top-down monitoring promotes forest conservation. We also identify a mechanism linking top-down monitoring to conservation: leaders work harder to protect the forest, which “crowds in” effort by community members. Our results are not about reducing the role of communities in forest management, they are a plea for oversight by the relevant authority to help communities overcome local power asymmetries.

Key Words: *community-based forestry; field experiment; government oversight; monitoring; social forestry*

INTRODUCTION

Many governments in low-income countries have promoted community-based approaches to forest management and embarked on forest devolution programs to promote forest conservation and improve local livelihoods (Faguet 2014). Forests play an important role in climate change mitigation, protection of biodiversity, and improved livelihoods of nearby communities (FAO 2020). There is increasing international attention toward forests with major initiatives across the world on forest protection and reforestation. For example, the Africa Forest and Landscape Restoration Initiative (AFR100) aims to reforest more than 100 million hectares of land in 31 African countries by 2030. Given the common-pool resource nature of most forests, the eventual success of such initiatives depends on whether there are effective and inclusive collective action institutions at the local level. Devolving use rights and management responsibilities to local communities is expected to create a sense of ownership that incentivizes sustainable exploitation by motivating forest users to respect extraction rules and monitor and sanction transgressions (Ostrom and Nagendra 2006, Faguet 2014). About one-third of forests in low-income countries are now managed by local communities (Blackman et al. 2017). However, the impacts of community-based resource management are ill understood, which suggests a need for improved learning about the design, implementation, and governance of community-based forest management (CBFM) programs. Most CBFM programs are implemented by external actors, such as the government or non-governmental organizations, often with the participation of local communities in their design or implementation. Although these programs come with intensive community mobilization, training, and capacity-building components at the beginning, these support mechanisms eventually disappear as the project funding ends, leaving local communities vulnerable to governance challenges.

Developing evidence on the causal link between different governance structures and outcomes of interest is crucial to understand how to best support CBFM and to institutionalize accountability. Local governance is a key factor in addressing collective action challenges and determining community-level outcomes in the management of commons (e.g., Ostrom 1990, 2009). But what exactly constitutes “good local governance” is still a topic of debate (Agrawal 2001, Dietz et al. 2003, Ostrom et al. 2007, Saunders 2014, Baggio et al. 2016, Young et al. 2018). Institutional features typically mentioned as principles of good governance range from community participation in decision making and rule setting, to adequate monitoring and sanctioning of transgressions (Hardin 1978, Ostrom 1990, Agrawal 2003, Ostrom et al. 2007). The main challenge for sustainability science is isolating the impact of alternative governance designs on desirable outcomes. Institutional features typically arise endogenously and over a long time span in “properly functioning” communities, making the analysis of causality difficult. Without exogenous variation in community’s governance structures (i.e., more or less random occurrence of good governance across a sample of communities), one cannot judge the impact of these governance features on outcomes relevant to the community. Furthermore, desirable institutional features typically are observed in bundles, making it hard to isolate the specific effects of each one of them for analytical purposes (Slough et al. 2021a).

We used an experimental design to analyze how adding alternative versions of externally implemented monitoring to an existing CBFM affects environmental outcomes in Ethiopia. To reverse trends of deforestation and forest degradation, the Ethiopian government initiated a CBFM program in the late 1990s. So-called “forest user groups” (FUGs) received exclusive use rights for clearly demarcated forest blocks, enabling members to extract forest resources for consumption or sale. In return, they were expected to manage forest resources in a sustainable manner, restrict further settlement and agricultural expansion, and pay an annual rent (Ameha et al. 2014b). Our study area concerns the Adaba and Dodola districts in which 132 FUGs were created (maximum 30 members, blocks of 360 hectares). Many groups in charge of managing their forest block do not have properly

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functioning monitoring institutions (Kahsay and Bulte 2019). In our study area, all FUGs are governed by an executive committee consisting of five members: the chairperson, vice-chairperson, secretary, cashier, and representative member, typically populated by members of the local elite (Kahsay and Bulte 2021). Although the power structure within the executive committee varies across FUGs, the chairperson is often the most powerful person and leader. There is also a general assembly, consisting of all group members, in which strategic issues are discussed and agreed upon. A common problem in CBFM programs in developing countries is that group leadership may be unaccountable, and elite capture is widely perceived as a big problem (e.g., Agrawal and Gupta 2005, Kahsay and Bulte 2021). Elite capture refers to circumstances in which local elites (individuals with higher socio-political status) control decision-making processes and misappropriate or "grab" a disproportionately large share of forest benefits (Fritzen 2007, Lund and Saito-Jensen 2013). Tesfaye et al. (2015) and Kahsay and Bulte (2021) documented such cases in our study area. One mechanism may be side selling of forest resources, and another may be diversion of group income. Testing alternative designs of an externally motivated monitoring program on top of an existing CBFM to increase the accountability of community leaders is therefore of high practical and scientific relevance.

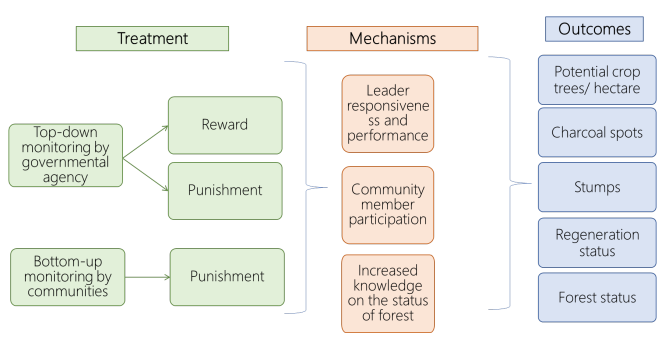
Our study focuses on the challenge of ensuring accountability of FUG leaders, a central element of local governance. We distinguish between bottom-up and top-down monitoring regimes to improve the accountability of the local leader, thereby assisting FUGs to improve their own governance. Bottom-up monitoring involves supporting local communities to enhance their capacity to monitor and track forest use and management, as well as hold their leader accountable. Top-down monitoring is done by local governments responsible for forest management (Gupta and Koontz 2019). We randomly assigned FUGs to one of the three intervention groups (top-down monitoring + punishment for worst-performing leaders, top-down monitoring + reward for best-performing leaders, bottom-up monitoring + punishment for badly performing leaders) and a control group. In the bottom-up monitoring group, FUG members were encouraged and trained to engage in (increased) forest management and to use monitoring as well in evaluating their leader's performance. Underperforming leaders could be removed from their positions after a democratic, anonymous voting process (but user rights would remain at the community level and not revert to the state). In the top-down monitoring groups, governmental officials engaged in intensified monitoring, and either rewarded good leadership or punished a failing group leader. Rewards take the form of a material gift, namely a solar panel with market value of US$60. Punishment implies the group leader is removed from the position of authority by the regulating agency (the Oromia Forest and Wildlife Enterprise, OFWE), which is well within the terms of agreement between OFWE and FUGs. Afterward, group members elect a new group leader, and user rights remain at the community level. The three interventions are implemented in addition to an existing CBFM, in which communities manage their forest resources. The purpose of these interventions is to improve the governance of FUGs and the effectiveness of CBFM programs in promoting livelihood and conservation outcomes.

Initially, we hypothesized that both top-down and bottom-up monitoring treatments led to greater forest conservation than the control group (or business-as-usual CBFM). A broader literature on community involvement in development interventions (i.e., beyond natural resource management) suggests that increased monitoring of both types can potentially discipline leaders and result in improved development outcomes. For example, Olken (2007) found that top-down monitoring reduced missing expenditures in infrastructure interventions in Indonesia, and Björkman and Svensson (2009) documented a positive impact of bottom-up monitoring on health outcomes in Uganda (a finding that was subsequently contested by Raffler et al. 2019).

Conditional on moderating conditions, our three treatments are expected to operate through the same three mechanisms: improved leader responsiveness and performance, increased community member participation, and, ultimately, increased information to guide decision making. Figure 1 shows our theory of change. A key feature of our experiment is that differences in the treatments do not lead to consequential variation. Following Ferraro and Agrawal (2021:6), a "treatment variation is consequential if different versions of the treatment create variations in mechanism effects." Having no consequential variation in our treatments increases the internal validity of comparing them to each other. To this end, all our treatments affect our outcome variables through the same mechanisms. Forest inventory data across the FUGs are one of the unique features of our study. As proxies for conservation success, we used an increase in the number of potential crop trees per hectare (PCT/ha: trees of marketable species with a minimum diameter at breast height), as well as reductions in the number of charcoal spots and stumped trees per ha, and also the forest experts' rating of forest regeneration and overall forest status. We recognize that trees alone do not capture the spectrum of forest biodiversity (Spicer et al. 2020).

Monitoring interventions are likely to affect leader's effort and behavior through the threat of sanctioning (removal from power in the interventions with punishment) or the prospect of a reward (in one of the top-down monitoring versions). This is consistent

Fig. 1. Theory of change. The figure shows the mechanisms (orange boxes) through which the three variations of the monitoring program are hypothesized to affect our outcome variables, namely PCT/ha (+), charcoal spots (-), tree stumps (-), regeneration status (+), and forest status (+; blue boxes). Our experimental design is captured by the green boxes.



with Kahsay and Bulte (2021), and with results of Grossman and Hanlon (2014). In addition, presentation of monitoring reports to the general assembly meeting of FUGs may imply possible informal sanctions (social pressure). Thus, the FUG leader is more likely to behave in accordance with group interests, i.e., increase the effort in forest patrolling, reduce side selling of forest products, and involve group members in group decisions. Second, group members are expected to increase their involvement in group activities including forest patrolling because (1) they follow the leader's example of increased engagement in forest patrolling and other group activities (e.g., meeting and joint works); and/or (2) group members are more likely to believe that their (collective) actions will succeed in the face of the monitoring interventions and are more likely to engage in group activities (see also Hermalin 1998, Dionne et al. 2010). The combined leaders' and members' forest patrolling efforts as well as the engagement of group members in other group activities (meetings and joint works) and decision making are likely to reduce illegal forest extraction by the leader, group members, and outsiders. We are fully aware that, ultimately, the final impact of monitoring on improved leader responsiveness and member participation will depend on moderating site-specific factors, for example, potential information asymmetries, the level of group empowerment vis-à-vis the leader, the possibility of collusion between leaders and monitors, the group's ability to overcome social dilemmas, and incentives for voluntary monitoring by members. It's hard to produce exogenous variation in these factors, and they therefore remain outside of the scope this work. Most importantly, our randomization efforts should ensure no systematic bias in the degree to which these factors are present in our communities.

Evidence of the impact of CBFM on conservation and livelihood outcomes is mixed and heterogeneous (see e.g., Porter-Bolland et al. 2012, Buntaine et al. 2015, and Blackman et al. 2017 for conservation outcomes, and Sikor and Nguyen 2007, Coleman and Fleischman 2012, and Ameha et al. 2014b for social and economic outcomes). Kahsay and Bulte (2021) compared the impact of top-down and bottom-up monitoring on livelihood outcomes among FUGs in our study area and found that only top-down monitoring improved income of FUG members. A recent Proceedings of the National Academy of Sciences (PNAS) special issue presented causal evidence on the impact of externally implemented community monitoring on common pool resources (CPR) using preregistered and harmonized randomized control trials (RCTs) across heterogeneous contexts (forest and water resources in six sites located in four continents). In a meta-analysis of these experimental studies, Slough et al. (2021a) found that the community monitoring intervention was widely adopted in five of the six sites with a modest effect on CPR extraction and status. These effects are mediated primarily through increased accountability (Ferraro and Agrawal 2021). However, results are heterogeneous across study sites. For instance, Christensen et al. (2021) and Eisenbarth et al. (2021) found no effects of community-based forest monitoring on deforestation in, respectively, Liberia and Uganda. Eisenbarth et al. (2021) found an increase in forest loss in non-monitored forest areas in treatment groups, suggesting a negative spillover effect of the monitoring intervention. In contrast, Slough et al. (2021b) found that community-based monitoring reduces forest cover loss among Indigenous communities in the Peruvian Amazon.

Our study context differs from these PNAS studies. With the exception of Bernedo Del Carpio et al. (2021), who studied community monitoring in community-based water management organizations in Costa Rica, none of these studies involved formally established resource user groups. Similar to Kahsay and Bulte (2021), our context focuses on CBFM in which local communities are formally organized into FUGs and enter into agreement with a government, detailing their rights and responsibilities. Our study expands on the previous literature in two ways. First, we compared the forest conservation impact of bottom-up monitoring to an approach involving top-down scrutiny by the government. Second, although our bottom-up intervention involved similar activities to earlier studies (e.g., community workshops, recruiting and training local monitors, disseminating the monitoring report with group members), it added a unique feature by facilitating the punishment of underperforming leaders; our intervention has teeth. Our rich dataset also allows us to shed light on the mechanisms linking interventions to forest conservation. Details about the data, context, treatments, and variables used are available in Appendix 1 (supplementary information section).

BACKGROUND AND CONTEXT

In Ethiopia, forest cover declined from 40% in the late 19th century to approximately 4% in recent years (Dessie and Christiansson 2008). To reverse this trend of deforestation and forest degradation, the Ethiopian Government initiated a large community-based forestry program in the late 1990s. The key principle was that forest user groups (FUGs) received exclusive use rights for clearly demarcated forest blocks, enabling them to extract forest resources for consumption or sale. The program is particularly widespread in the Oromia Regional State, with about 900 established FUGs overall. One of the earliest CBFM programs was implemented in the Adaba-Dodola forest (our study area) by the Ethiopian Government in collaboration with the German Society for International Cooperation (GIZ). The Adaba-Dodola forest has an estimated forest cover of 73,600 ha (WBISPP 2001) and is located on the northern slopes of the Bale Mountains, some 320 km from Addis Ababa. The program was implemented with the participation of the local community. There were a series of information and awareness meetings with village residents, who later set-up a committee responsible for identifying a list of membership criteria. Village residents subsequently approved, with a majority vote, three main membership eligibility criteria: settlement proximity to the forest area, permanent residence in a village, and traditional and customary use rights (Ameha et al. 2014b). Eligible village members voluntarily joined FUGs with a maximum group size of 30 households. With an average 12 ha per member, groups manage forest blocks up to 360 ha (Amente 2005, Ameha et al. 2014a). Each FUG draws up a bylaw stipulating rights and responsibilities of leaders and members, so some level of bottom-up scrutiny is part of all FUGs, but the extent to which ordinary members dare to stand up to their leaders varies across FUGs. Currently, there are 132 FUGs in the Adaba-Dodola CBFM program, with each village having multiple FUGs, each with access to its own forest area. The livelihood of group members includes subsistence agriculture, livestock production, and forest utilization. On average, group members derive one quarter of their income from forest resources, highlighting the importance of the forest stock for their livelihoods.

Rights and duties of groups are written in a contract signed by the FUG and the responsible branch of the government. Part of the agreement is that group members are allowed to extract forest products. In return, they should sustainably manage the forest, restrict settlement and agricultural expansion, protect the forest from incursions by others, and pay an annual rent (Kosfeld and Rustagi 2015, Ameha et al. 2014b). The agreement between FUGs and the government remains valid indefinitely, or until harvesting exceeds the allowable cut by more than 10%. In that case, the agreement is terminated and use rights revert to the government. An important part of the management responsibility concerns protecting forests from illegal harvesting by outsiders (and sometimes group members). This involves extensive patrolling of the forest, an activity planned and overseen by group leaders, and in which leaders participate themselves. When a transgression or theft is detected, the punishment is likely severe and includes confiscation of materials and payment of fines, and for group members, this may also include extra work assignment and reduced sharing in benefits from the forest. All FUG members are required to engage in forest patrolling. About 91% of the FUGs in our study have rules on forest patrolling. However, forest patrolling is a public good and there are concerns about free riding. The FUG leaders should play a role in mitigating free riding problems by enforcing forest patrolling rules.

Although leaders in our context are not directly paid by FUG members for their service, they get indirect benefits. First, leaders often receive labor contributions from members, e.g., during crop planting and harvesting seasons. Second, leaders represent group members in meetings and trainings organized by the government or NGOs, and this often involves payments for participation and opportunities for external networking. Finally, leadership positions are associated with status and networking in the local community. Nearly 70% of the FUGs in our sample do not have an internal monitoring committee to keep track of leader activities and performance. When one is in place, the scope of monitoring and their mandate is much narrower than what we implement in the context of our interventions (Kahsay and Bulte 2019). Some 50% of the groups have so far changed their leaders at least once, but leader turnover is slower than may be expected based on FUG bylaws (Kahsay and Medhin 2020).

The selection of the Adaba-Dodola CBFM program as our study site was motivated by four main reasons. First, CBFM program is widely practiced in the area with about 132 established FUGs, which guarantees us a large sample of FUGs for our study. Second, unlike in other areas, the Adaba-Dodola CBFM program kept a baseline and follow-up forest inventory data for each FUG. Without this data, it would not have been possible to estimate the impact of our monitoring interventions. Although data from satellite imagery is another option, it would have been difficult to detect significant differences between the experimental groups given the relatively short treatment period. Third, FUGs in our sample have a manageable size of 30 households unlike in some areas, where group size can reach up to several thousand households. This made it easier to understand the forest governance in detail. Finally, the area borders the important Bale Mountain National Park, which is home to various endangered and critically endangered species.

MATERIALS AND METHODS

Experimental design

We partnered with Oromia Forest and Wildlife Enterprise (OFWE), which is the branch of government responsible for forest management in the study region, and used an RCT design to randomly assign the 132 forest user groups to 4 experimental groups: a control group (with business-as-usual monitoring and governance) and 3 treatment groups. In one treatment group, we intensify monitoring by group members, and in the two others, this responsibility was assumed by the government, represented by officials from the OFWE. The interventions are described in detail below (see Figure 1 for theory of change). Additional details of the treatment groups can be found in Kahsay and Bulte (2021).

Bottom-up monitoring with punishment

We facilitated the creation of group-level monitoring committees (one per FUG). Creating such a committee is an obvious choice for intervening organizations that seek to promote engagement of group members in scrutinizing group leadership. All elected committee members accepted the responsibility, were trained, and provided with stationary materials and score cards to facilitate monitoring. A monitoring protocol was developed by OFWE experts with the participation of FUG representatives and was subsequently given to committee members. The main function of the committee was to monitor forest use and management, including inspection of forest blocks, books and records, and organization of group discussions and interviews with anonymous group members and non-members. Six months into the program, the monitoring committee presented a summary report of its findings to the group's general assembly. This report was "benchmarked" by OFWE, providing members with information about how their leaders performed compared to other leaders in the program. Finally, FUG members anonymously voted whether the leader should be (1) complimented for his efforts, (2) reprimanded for poor performance, or (3) dismissed. In case of severe underperformance and leader dismissal, OFWE facilitated an election process of new leaders, again involving anonymous majority voting. Removal from power implies a loss of indirect benefits and possibly social stigma. It is important to emphasize that our intervention is likely different from the type of bottom-up monitoring that has grown organically within successful groups.

Top-down monitoring with punishment or reward

The study involved two types of top-down monitoring by OFWE expert, using similar assessment criteria, approaches, and tools provided to the committee members in the bottom-up monitoring group. In both top-down monitoring groups, OFWE experts visited the forest, checked the books, and organized conversations with forest users. In one group, monitoring was combined with punishment. Oromia Forest and Wildlife Enterprise would present its draft report to the FUG's general assembly to validate its findings and collect additional information. The final monitoring report was used by OFWE management to compliment, reprimand, or dismiss group leaders. In the case of dismissal, OFWE assisted FUGs to elect a new leader. The other top-down monitoring group combined top-down scrutiny with a reward for top performing leaders. This treatment group was based on the same procedures, but now OFWE management selected the three best leaders and awarded them a solar panel (with market value of 60$US or 197$US in PPP terms). Rewards were provided in a workshop attended by all FUG leaders from this treatment group.

The monitoring experts sent by OFWE may have previous engagements with the groups. To mitigate potential collusion between the OFWE experts and group leaders, OFWE experts were randomly assigned to each group for each meeting (so an expert assigned to one group may not visit the same group in the next engagement). Furthermore, the decision of whether to punish leaders or not (and reward leaders or not) is done by OFWE management, not by the experts.

Table 1 gives the allocation of groups across the treatment groups. The experiment included the entire population of FUGs. The ex-ante power analysis suggests a minimum detectable effect below previous findings in the literature. See Appendix 1 and Table A1.1 for details of power analysis.

Table 1. Number of forest user groups (FUG) per treatment and leader turnover.

	Number of FUGs per treatment	Leader turnover during study period
Control group	34	1
Top-down + punish	33	9
Top-down + reward	32	2
Bottom-up	33	6

The timeline of the experiment was as follows. We collected baseline survey data in March and April 2017. Interventions started in May 2017 with group-level start-up meetings. Follow-up visits to FUGs took place in July 2017 and general assembly meetings were organized in December 2017 and January 2018, more than 18 months after starting the program. Finally, the current analysis is based on forest inventory data collected in the period between September and December 2019. Our forest data were therefore collected nearly 2.5 years after the start of the interventions. Although the duration of our interventions follows previous randomized controlled trials in the forest domain (e.g., Jayachandran et al. 2017, Christensen et al. 2021), this is a relatively short interval to observe significant changes in standing forests. We therefore also consider "flow variables" that capture the intensity of on-going extraction such as number of charcoal spots and stumps as well as the status of the forest and its regeneration.

Data and identification strategy

Most of our data are from OFWE's database, which includes administrative information on group characteristics, such as year of establishment, group size, composition and location of groups, and size of the forest block they manage. Oromia Forest and Wildlife Enterprise also provides three waves of data on forest conservation, based on extensive inventories. This involves (1) systematic sampling of circular plots with a radius of 25 m at 100 m intervals between individual plots and between straight lines (approximately one plot per hectare, in total about 48,000 plots were measured), and (2) counting the number of potential crop trees (PCTs) and mature trees (MTs) for each tree species. Trees are recorded on a recording sheet. The PCTs are young and healthy trees that are over 2 m in height with a diameter at breast height (DBH) of up to 40 cm for group 1 species (*Podocarpus falcatus*, *Juniperus procera*, *Hagenia abyssinica*, *Olea europaea* ssp. *cuspidata*, *Ekebergia capensis*, *Gymnosporia arbutifolia* subsp. *arbutifolia*, and *Schefflera abyssinica*) and up to 25 cm for group 2 species (mostly *Pittosporum abyssinicus*, *Hypericum lanceolatum, Erica arborea*, and *Rapanea melanophloeos* but also other species not listed in group 1). Mature trees are trees with DBH exceeding 40 cm for group 1 tree species and exceeding 25 cm for group 2 species. Data were collected by trained forest experts.

Two waves of collecting forest inventory data took place before the start of our experiment. The first inventory was conducted in 2004, before the establishment of most FUGs. This baseline inventory is available for 117 forest blocks, managed by 117 FUGs. The second inventory was conducted in 2012, for only 49 forest blocks. Data from the first and second inventory were used in previous studies (Rustagi et al. 2010, Kosfeld and Rustagi 2015, Ameha et al. 2016, Kahsay and Bulte 2019, Kahsay and Medhin 2020). Part of the PCT/ha variable collected in 2019 (third inventory) was used in Kahsay et al. (2021) to study the association between gender balance in FUG management and forest outcomes. The first forest inventory data were included in our regression models to control for baseline differences in forest condition (see Appendix 1, Tables A1.3, A1.5, and A1.6). The second inventory data were used to show that groups assigned to the treatment groups have, on average, the same number of PCT/ha (see Appendix 1, Table A1.3).

Our dependent variables are collected during the third inventory, which took place in 2019. Forest data are available for 120 forest blocks. Following Rustagi et al. (2010), Kosfeld and Rustagi (2015), and Kahsay and Medhin (2020), we used the density of potential crop trees (PCT/ha) as our main performance indicator. Mature trees are less informative for our purposes because these large trees are unlikely to be extracted due to lack of access to suitable machinery. The main advantage of our PCT/ha variable is that it can respond quickly to changes in local forest management, which is important in light of the relatively short duration of the research intervention. Trees slowly enter the class of PCTs as they mature and graduate to the class of MTs as they age further, but PCT densities can change rapidly in response to changes in extraction. Although our study period is presumably too short to pick up the effect of increased regeneration efforts, it is sufficiently long to capture changes in thinning and extraction intensity. In this light, it is important to mention that PCTs are the type of trees that local community members use for their own consumption and sale in the form of firewood and charcoal, and for construction purposes.

Potential crop tree counts are not a perfect proxy of forest quality. For example, PCT densities are uninformative about the tree species composition and distribution, or the conservation status of specific tree species. Obviously, it is silent about biodiversity more generally, beyond trees, as well. Unfortunately, we do not have access to data to include these dimensions in our analysis. However, we do have access to four additional performance indicators collected during the third forest inventory. These are (1) the total number of charcoal burning spots per hectare; (2) the total number of stumped trees per hectare; (3) the share of the sample plots whose regeneration status was rated as "good" or "very good" by OFWE forest experts; and (5) the share of sample plots whose overall status was rated as "good" or "very good." Selling charcoal is one of the most common sources of forest income for forest users in our study area because it is the main source of energy to urban residents in Ethiopia. Previous studies have shown charcoal production is one of the main drivers of forest degradation (Sedano et al. 2016). We do not have data on the total amount of charcoal produced, but we believe that the number of charcoal burning spots may proxy for charcoal production. Similarly, counts of tree stumps have previously been used as a measure of forest degradation (Williams-Linera 2002). We aggregate individual variables in one index of forest conservation, following the approach by Kling et al. (2007). We define the summary index as the equally weighted average of z-scores of the components. The z-scores are calculated by subtracting the control group mean and dividing by the control group standard deviation.

We also implemented two survey waves among randomly selected FUG members, before and after implementing the monitoring interventions. On average, we surveyed one-third of the members from each group, as well as all group leaders (1222 members at baseline) and collected information on socio-demographic characteristics, political affiliation, and forest governance. We aggregated these co-variates at group level, and group-level baseline averages are used as co-variates in some models. We summarize dependent variables and co-variates in Appendix 1, Table A1.2.

Because of the randomized nature of our intervention, our statistical strategy can be simple. Various factors that affect conservation outcomes of FUGs such as local settings and circumstances, geographic characteristics (e.g., distance to market), level of income and poverty, alternative income generating activities (e.g., off-farm income activities), and climatic factors such as drought are, on average, the same across the experimental groups. This enables us to focus only on one source of exogenous variation, the monitoring intervention. Table A1.3 in Appendix 1 shows that treatment and control groups have, on average, the same characteristics and forest resources at baseline. Hence, randomization "worked" in terms of balancing baseline group characteristics. For 12 groups in our sample, we did not have access to forest conservation data (an attrition rate of 9%). Appendix 1, Table A1.4 shows that groups included in the analysis have, on average, the same characteristics as groups without forest data. This suggests that attrition is not systematic. Our identification strategy rests on regressing end-line forest outcome variables for group g, F_g, on group-level treatment dummies T_{jg} (j = 1, 2, 3), baseline co-variates (X_g), and *kebelle* fixed effects. Kebelles are a low level of government administration in Ethiopia. The average kebelle population is about 6500 people in our region. Our 120 FUGs are located in 13 kebelles, and the fixed effects capture local differences in geo-physical and climatic conditions, market development, and village-level governance.

$$F_g = \beta_0 + \sum_{j=1}^{3} \beta_{1j} * \boldsymbol{T}_{jg} + \beta_2 \boldsymbol{X}_g + \alpha_k + \varepsilon_g \qquad (1)$$

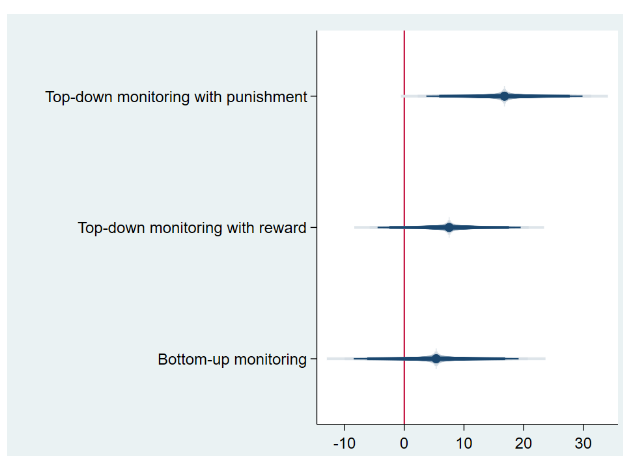
In Equation (1), ε_g captures unobserved time-varying factors causing variation in forest outcomes. Vector β_{1j} contains our parameters of interest, which captures the causal effect of treatment j on forest outcome F. Vector X_g includes the following baseline variables: average age of FUG members, share of literate members, average livestock holding, average land holding, distance to daily market, year of FUG establishment, group size, share of female members, and size of the forest block. These co-variates are chosen based on the collective action literature and previous studies in the study area. Expanding the set of co-variates by including political affiliation of members does not affect the estimated results (see Appendix 1, Table A1.8). Our ANCOVA model also controls for the number of potential crop trees per hectare in 2004 and kebelle fixed effects; the latter are included to capture village level characteristics that may explain the forest outcome such as geo-physical factors and quality of local administration. We will also estimate variants of (1) in which we explain variation in our measures of group governance and member participation. These auxiliary models are intended to shed light on the mechanisms linking the interventions to conservation results.

RESULTS

Compared to the mean value of PCT for the control group at endline, top-down monitoring with punishment increases PCT/ha by about 53% (about 17 PCT/ha). Figure 2 summarizes the estimated coefficients for our main outcome variable, the number of potential crop trees per hectare (PCTs/ha) for both 95% and 90% confidence intervals. These estimated coefficients are based on ANCOVA models and include the number of potential crop trees per hectare in 2004 and kebelle fixed effects as explanatory variables (see column 3 in Table A1.5 in Appendix 1). Although all three interventions increased the number of PCTs/ha, only the intervention involving top-down monitoring with punishment of underperforming leaders is statistically significant.

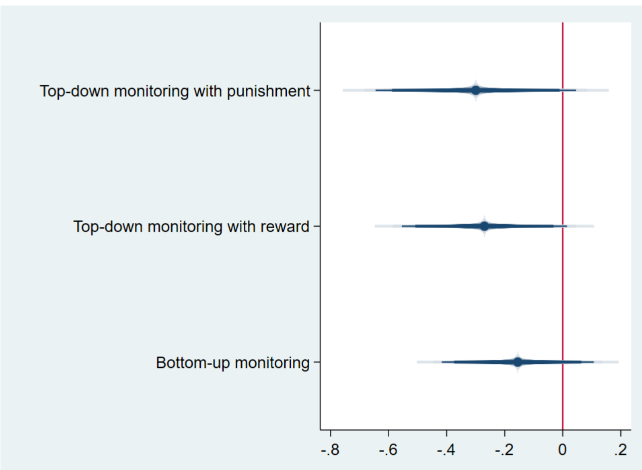
Our results remain the same when using our alternative outcome variable, the forest conservation index, instead of PCTs/ha. Figure 3 summarizes the estimated coefficients for our forest conservation index for both 95% and 90% confidence intervals.

Fig. 2. Estimated effect (ATE) on number of PCT/ha. Dots are mean estimates taken from column 3 in Appendix 1, Table A1.5. Thick (thin) lines are 90% (95%) confidence intervals for a two-tailed hypothesis.



Again, this is based on ANCOVA models, and we again control for kebelle fixed effects (see column 3 in Table A1.6 in Appendix 1). Estimation results for individual variables of the forest conservation index are presented in Appendix 1, Table A1.7. We aggregated the variables such that lower scores are associated with greater conservation. The estimated coefficients for both top-down monitoring treatments is significantly different from zero ($p < 0.1$), providing robust evidence that top-down monitoring of local leaders contributes to conservation in the context of CBFM.

Fig. 3. Estimated effect (ATE) on averaged z-score index. Dots are mean estimates taken from column 3 in Appendix 1, Table A1.6. Thick (thin) lines are 90% (95%) confidence intervals for a two-tailed hypothesis.



We used the survey data to explore the mechanisms (highlighted in Figure 1) through which forest outcomes are affected by the three variations of monitoring. All interventions are designed to incentivize leaders to allocate more effort to their job, i.e., organizing, overviewing, and participating in patrols of the forest block to prevent incursions and resource theft by outsiders (or group members). We consider the (self-reported) number of days that FUG leaders spent in the forest for patrolling and monitoring purposes, and distinguish between the group leader and the full executive committee. The variable captures the number of days that group leadership is to some extent involved in monitoring and does not necessarily measure the number of "full days." Results are summarized in Table 2.

Leaders exposed to top-down monitoring with the risk of punishment spent more days patrolling the forest than their peers in the control group. The same is true for leaders in the top-down monitoring with reward group, but this difference is much smaller and not significant. Leaders in the bottom-up monitoring seem to spend slightly fewer days patrolling than their counterparts in the control group, but this difference is also insignificant (Table 2, column 1). We also found that executive committee members in both of the top-down monitoring groups spent more days patrolling than their peers in the control group, which implies that the group leader is able to incentivize or force his fellow group leaders to supply greater effort. In contrast, there was no significant difference in patrolling effort between executive members from the bottom-up monitoring group and the control group (Table 2, column 2).

Table 2. Monitoring and forest patrolling efforts.

	Group leader	Executive committee members	Ordinary members
Control	54.364	46.886	47.796
Top-down + punish	70.666**	76.142***	65.82***
Top-down + reward	59.68	58.371***	60.61***
Bottom-up	51.648	52.348	55.28***

Notes: Number of days spent by different FUG stakeholders patrolling and monitoring their forest. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, where we test the null hypotheses that effort for the treatment is identical to effort in the control group.

Although all the monitoring interventions increased patrolling effort by group members compared to the control group, this increase is significantly greater in the top-down monitoring groups than in the bottom-up monitoring group ($p < 0.1$). If leaders spend more time in the forest, this may reduce opportunities for theft by outsiders and group members thereby promoting conservation. The presence of leaders may also "crowd in" effort by other members, who may wish to signal their commitment to the group or copy the behavior of high-stratus individuals. It is also possible that leaders can more credibly demand that other group members work harder to patrol the forest when they do so themselves. These channels are consistent with the literature on leading by example in general (e.g., Hermalin 1998, Dionne et al. 2010) and the influence of local leaders on conservation outcomes in particular (e.g., Kosfeld and Rustagi 2015, Kolinjivadi et al. 2019, Duong and De Groot 2020). Column 3 in Table 2 supports the idea that group members also spent more days patrolling in the forest.

The increase in effort by group members in the bottom-up group likely reflects a response of members to the encouragement and support of OFWE staff (instead of a response to more effort by group leaders). But, as evident from Figures 2 and 3, this extra member effort does not translate into significant conservation success, thus behavioral change of FUG leadership is essential to promote conservation. Perhaps ordinary group members are unlikely to punish transgressions, especially when encountering side-selling or theft by high-status individuals. Anecdotal evidence suggests that punishment by leaders is tougher than punishment by ordinary members. If elite capture is a problem, and elites are powerful relative to other group members, then top-down monitoring by relevant authorities is required to hold leaders accountable. Empowering ordinary group members to hold their leaders accountable fails to produce the desired results. Indeed, we do observe that fewer leaders are removed from their position in the bottom-up group than in the top-down group with punishment (respectively, six leaders and nine leaders were dismissed), even if leader performance in the bottom-up group is markedly worse in terms of livelihood outcomes (Kahsay and Bulte 2021) and conservation outcomes.

DISCUSSION

Community-based forest management has decreased deforestation in developing countries in some cases (e.g., Porter-Bolland et al. 2012, Blackman et al. 2017, Baragwanath and Bayi 2020) and fails to decrease deforestation in other cases (e.g., Buntaine et al. 2015, BenYishay et al. 2017, Kraus et al. 2021). Community-based forest management is supposed to incentivize local communities to sustainably manage forest resources, particularly compared to government-managed forests, which are often de facto open access resources. Design, implementation, and governance issues have played a role in the heterogeneous conservation outcomes of CBFM (Agrawal and Gupta 2005, Ostrom 2009).

We show that in the context of our study, externally enhancing accountability through top-down monitoring by a government organization increases the number of potential crop trees and improves the overall state of forest conservation as assessed by forestry experts. We did not find that externally initiated bottom-up monitoring affected leader behavior in the context of CBFM in our study site. Consistent with earlier evidence, from other contexts and sectors, we found that local communities may struggle to hold their own leaders accountable (Olken 2007, Tesfaye et al. 2015, Casey 2018, Raffler et al. 2019, Kahsay and Bulte 2021). Kahsay and Bulte (2021) found that ordinary members did not benefit from our bottom-up monitoring intervention in terms of increased income. The current study documents that, compared to the control group, forest conservation does not improve either. This may reflect persistent information asymmetries, i.e., if group members are less efficient and effective in monitoring than government experts, or if power asymmetries prevent group members to follow-up on their findings.

Our results suggest that forest outcomes can be improved by strengthening the capacity of FUGs to monitor their forest use and management, and hold their leaders accountable. In our context, top-down monitoring by governmental officials delivered a significant improvement in forest outcomes. We believe it does so by providing FUGs with an assurance that evidence will be heard, a watchdog against abuse of power by local elites, and a platform to discuss governance challenges without fear of repercussions. As a result, we see increased effort in forest patrolling by group leaders, members of the executive committee, and ordinary members. Our results do not rule out the possibility of combining top-down and bottom-up monitoring as recently suggested (Casey 2018, Gupta and Koontz 2019, Raffler et al. 2019). Rigorous evidence has yet to come to support this.

Several caveats to our main results should be mentioned. The first caveat is conceptual in nature. It’s important to emphasize that our interventions are implemented in addition to existing CBFM and represent an addition or extension of a pre-existing local community regime. Top-down monitoring in this study is neither a replacement for CBFM, nor a substitution for monitoring efforts by local communities. When assisting FUGs with top-down monitoring by a governmental authority, special care should be taken not to exacerbate existing power asymmetries and/or concentrate decision-making power in the hands of an “enforcers” because this will effectively undermine the whole purpose of CBFM. Similarly, the use of monitoring by governments should be carefully designed to avoid eroding the community’s motivation for engaging in natural resource management in general and monitoring in particular. This type of crowding out has been documented in previous research (e.g., Cardenas et al. 2000) and should be avoided.

Another conceptual caveat concerns the nature of our bottom-up monitoring intervention. On average, the impact of fostering bottom-up monitoring produces disappointing results, but this should not be misconstrued as an argument against bottom-up monitoring per se. Our study focuses on an externally initiated intervention, which may be different from endogenously evolving community-initiated monitoring regimes. Although our study speaks to whether outside agencies can readily promote community engagement with monitoring, it is silent on the usefulness of homegrown monitoring in successful groups. However, heterogeneity at the group level is likely important. Kahsay and Bulte (2021) documented that bottom-up monitoring fails to improve average livelihood outcomes of group members, however the intervention’s impact varied depending on the extent to which groups were able to earn an income based on their forest resources prior to the intervention. The impact of outside interventions can leverage or crowd-out pre-existing endogenous institutions. For example, auxiliary empirical analyses (not shown) suggest that the positive conservation impact of the top-down monitoring intervention studied is driven by outcomes in FUGs when prior to the intervention forest-based income of group members was low, thereby where community-based monitoring did not work well. In contrast, top-down monitoring did not meaningfully promote forest conservation for the subsample of FUGs in which group members earned high forest-based incomes at baseline. Apparently pre-existing community-level institutions worked there.

Second, future studies can improve upon our measures of forest conservation. Our main variable captures the density of potential crop trees, which leaves out many important aspects of forest conservation. Our index of forest conservation is also primarily tree based. Moreover, our intervention period was only 2.5 years, which is admittedly short to pick up many relevant changes in the domain of forest conservation. We encourage future studies that consider a longer time frame.

Third, an issue related to design choices warrants attention. To preserve statistical power, we could not implement a factorial (i.e., 2 × 2) design and had to drop the treatment arm combining bottom-up monitoring with a reward for good leadership. It is an open question about how this combination would have fared.

Finally, care should be taken to transplant findings from this case study to other contexts. Forest user groups in our study area are, on average, 12 years old, and were established and supported by the Ethiopian Government in collaboration with GIZ. Local conditions regarding FUG formation and capacity will be quite different elsewhere, as will be ecological conditions and power asymmetries between local parties.

CONCLUSION

This study documents the impact of adding bottom-up and top-down monitoring to CBFM on several measures of forest conservation using a field experiment and contributes to the debate about the design of effective and transparent institutions for community-based forest conservation. We document that adding top-down monitoring to CBFM promotes forest conservation in the context that we study. This suggests that external scrutiny by outsiders matters for leader behavior. We found that enhanced bottom-up monitoring by group members themselves does not improve forest outcomes, which is consistent with recent experimental findings by Christensen et al. (2021; in Liberia) and Eisenbarth et al. (2021; in Uganda), and contrasts with Slough et al. (2021b), who find evidence of reduced forest cover loss due to community-based monitoring in the Peruvian Amazon. Our results suggest that adding top-down, governmental monitoring to an existing CBFM improves conservation by inducing leaders to exert more effort, which crowds in effort by other group members. Whether similar effects are obtained in other contexts should be explored in future studies.

Our results are not about reducing the role of communities in forest management, reducing the involvement of community members in forest patrolling, or monitoring of their leaders. Our results are a plea for outside oversight by the relevant authority to help communities overcome local power asymmetries. Community management appears to promote conservation, and in most settings, it is hard to imagine how forests can be sustainably managed without engaging local communities. But within the sample of CBFM forest blocks, conservation success can be (further) improved by keeping the governmental organization responsible for forest management involved in the monitoring of group leadership.

Author Contributions:

G. A. K. conceived the idea and designed the survey; G. A. K., E. B., and L. G. H. designed the field experiment; G. A. K. and H. M. coordinated the data collection and facilitated the implementation of the field experiment; G. A. K., E. B., and F. A. conducted the data analysis and wrote the manuscript; and H. M. and L. G. H. provided feedback on the manuscript.

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Data Availability:

Data/code available on request because of privacy/ethical restrictions.

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Appendix 1: Supplementary Information

Study area

The livelihood of group members in the Adaba-Dodola CBFM includes subsistence agriculture, livestock production and forest utilization. While farming land accounts only for about 1.5% of total area inside forest blocks, 21% of the forest dwellers reported to have agricultural plots just outside the forest (Schmitt 2002). The main sources of forest income for FUGs are sale of unprocessed and processed forest products, fees collected from permits and penalties, sale of grass, and trophy hunting. On average, group members derive a quarter of their income from forest resources, highlighting the importance of the forest stock for their livelihoods. However, OFWE suspected that the flow of forest-based benefits for group members could increase further if FUG governance would improve. A forest inventory was conducted before use rights were transferred to FUGs.

The program implementing agency, the Oromia Forest and Wildlife Enterprise (OFWE), provided FUGs with guidelines on their organizational structure, but groups can modify these rules depending on their needs. Each FUG has a general assembly, comprising of all members, and an executive committee of five members. Many FUGs also have other committees, such as for forest product marketing, forest development, or monitoring. Leaders and members of the executive body and other committees are elected 'democratically' by the members, but this selection process is rather opaque for most groups. Group leadership is typically in the hands of local elites—relatively wealthy and educated individuals holding positions of authority (Kahsay and Bulte, 2021).

At the beginning of the Adaba-Dodola CBFM program, there was substantial capacity building support. These support mechanisms gradually declined and have disappeared after the phase out the GIZ program. OFWE rarely inspects groups and during our preparatory field visits, some of the groups informed us that it has been many years since OFWE experts visited them.

Consistent with evidence from other countries, non-experimental impact evaluation studies suggest that community-based forestry contributes very little to the livelihood of local communities (e.g., Gelo and Koch 2014; Ameha et al. 2014b), but effects on conservation outcomes are positive (Ameha et al. 2016). Compared to non-CBFM areas, deforestation rates in forest areas managed by communities are typically lower. In non-CBFM areas, the average deforestation rate after 1990 is approximately 3% per annum, while deforestation has almost come to a stop in CBFM areas (Kahsay and Bulte 2021). However, a close look into the groups suggests substantial heterogeneity—some groups succeed while others failed. These differences in outcomes are affected by several factors, including the details of local bylaws and group-level organization, the share of conditional cooperators in the group (Rustagi et al. 2010), the quality of FUG leadership (Kosfeld and Rustagi 2015; Kahsay and Bulte 2021), and the two-way interaction between group-level social capital and formal rules and bylaws (Kahsay and Bulte 2019). Issues of elite capture and free riding have been documented (e.g., Tesfaye et al. 2015). Our own preparatory field visits to major PFM areas in Oromia (Bale, Arsi, Hararghe and Jimma), which involved a series of key informant interviews and focus group discussions with zonal and district OFWE leaders and experts, and FUG leaders and members as well as OFWE's own reports find evidence of accountability and benefit distribution challenges.

OFWE proposed to introduce monitoring mechanisms to curb these problems, but it was not clear which type of monitoring (external, internal, joint) would be preferred and how to use the outcomes of the monitoring report: to punish the group leader or the entire group, to reward leader or the entire group. Our key informant interviews and focus-group discussions during the preparatory field visits suggest the idea of punishing or rewarding leaders instead of the entire group members, but it was not clear which of the monitoring types are preferred. We therefore tested the effectiveness of alternative monitoring paradigms combined with a punishment or reward to the leader. However, one important point that emerged out of these visits was that FUGs in our study area typically do not have group/level resources to pay or reward leaders. Only forest cooperatives, established by FUGs to facilitate joint marketing of forest products, have group revenues. So, it was not feasible for most FUGs to reward their leaders. Moreover, from interviews and focus-group discussions we learned there was no appetite for community rewarding of leaders. Kahsay and Bulte (2021) explore how improved top-down monitoring and bottom-up monitoring affect group governance and members' livelihoods (consumption and forest-based income). This paper extends the analysis by considering the effect of monitoring on forest conservation outcomes, rather than members' income or livelihoods.

Ethical considerations

Oromia Forest and Wildlife Enterprise was planning to introduce some sort of monitoring intervention as documented in its 2012 assessment of the PFM program (Tesfay et al. 2015). OFWE reviewed and officially approved our proposal for delivering the treatments in a randomized experimental way. OFWE subsequently designed and implemented the actual treatments. Our role was to provide inputs regarding the literature on community-based monitoring, and the technicalities of group randomization.

Importantly, all FUGs are part of a project implemented by OFWE. As such, OFWE has the mandate of removing non-performing FUG leaders, after consulting FUG members, and IRTB approval was not required as per OFWE regulations. Importantly, OFWE asked for a signed consent of forest user group members before implementing any of the proposed interventions and data collection. OFWE ensured gender, religion, and minority representation in its training and workshops. Finally, the involved researchers followed the ethical procedures and responsible research conduct of their corresponding institutions as well as the EU General Data Protection Regulation (EU GDPR) rule in relation to data collection, handling and sharing.

Power analysis

Our study is based on a census of all 132 FUGs in the study area, so it was not possible to increase the sample size. We present the summary of an ex-ante statistical power analysis in Table A1.1. We use baseline forest inventory data, which include counts of potential crop trees per hectare (PCTs/ha; the main outcome), collected from 117 FUGs in 2004 and 49 FUGs in 2012 by OFWE. The power analysis conducts two-sided tests with a power level of 0.8 and a significance level of 0.05. We compare the calculated minimum detectable effect sizes (MDE) with a threshold value of 25% of the value of PCT/ha of the control group. This assumed threshold value is consistent with previous studies on top-down and bottom-up monitoring (Olken 2007; Bjorkman and Svensson 2009; Slough et al. 2021). For instance, Slough et al. (2021) find a 37% reduction in tree loss in the Peruvian Amazon due to community monitoring. However, we also consider more conservative threshold values of 20% and 15% of the value of PCT/ha of the control group.

The power analysis suggests that we have sufficient power to detect a meaningful treatment effect. The calculated MDEs are lower than the assumed threshold values, except for bottom-up monitoring under the conservative 15% threshold value.

Table A1.1: Power calculation

Ex-ante power calculation: Minimum Detectable Effect (MDE), power of 0.80, significance level of 0.05 and ICC=0.05	

Top-down with punishment (MDE)	9.08
Top down with reward (MDE)	9.24
Bottom-up (MDE)	8.52
Sample mean of the control group	62
Critical effect = 0.25*sample mean of the control group	15.5
Critical effect = 0.20*sample mean of the control group	12.4
Critical effect = 0.15*sample mean of the control group	9.3

Note: The statistical power was calculated using STATA power command.

Tables in support of the main text

Table A1.2: Descriptive statistics of the forest user groups in our sample

	N	Mean	Std. Dev.	min	max
Endline forest outcomes (2019)					
PCT/ha	120	41.45	37.04	0.23	189.4
Charcoal spots	116	16.80	30.44	0	183
Stumps	113	0.53	0.72	0.055	3.92
Regeneration status	113	25.50	24.11	0	100
Forest status	116	15.87	17.58	0	75
Forest inventory (2012)					
PCTs/ha	45	54.385	37.714	8.54	168.58
Forest inventory (2004)					
PCTs/ha	111	44.33	29.865	1.1	147.63
Baseline FUG characteristics					
Average age	122	48.035	6.192	34.7	60.636
Average education	122	0.497	0.228	0	1
Average livestock holding	121	21.925	7.312	10.7	58.25
Average land holding	122	9.126	7.311	0.814	59.627
Group characteristics					
Distance to market	122	2.666	3.551	0.433	30.775
Altitude	122	2.246	0.659	1	3
Year of establishment	122	2005.549	3.49	1999	2011
Group size	122	27.336	4.545	11	30
Share of female members	122	0.207	0.12	0	0.727
Forest area (ha)	119	391.395	245.024	102	1813
Governance indicators					
Satisfaction with chairperson	120	3.552	0.632	1.875	4.702
Satisfaction with executive committee	120	3.549	0.605	2.17	4.75
Satisfaction with fellow members' behavior	120	3.777	0.578	2.28	4.834
Members' participation and influence	120	4.05	0.383	2.929	4.823
Member of a political party/movement	122	0.017	0.049	0	0.30

Note: PCT/ha refers to the number of potential crop trees (young trees) per hectare.

Table A1.3: Balance of covariates across treatments at baseline

	Control	Top-down + punish			Top-down + reward			Bottom-up		
	Mean	Mean	Diff	*p*-val	Mean	Diff	*p*-val	Mean	Diff	*p*-val
PCTs/ha (2004)	59.80	55.39	4.41	0.82	56.67	3.13	0.87	47.37	12.43	0.42
PCTs/ha (2012)	42.66	39.57	3.09	0.68	50.05	-7.39	0.36	43.90	-1.25	0.87
Average age	48.71	49.47	-0.76	0.64	46.98	1.73	0.30	47.33	1.38	0.32

Average education	0.46	0.54	-0.09	0.14	0.54	-0.09	0.14	0.46	-0.001	0.99
Average livestock holding	23.09	22.33	0.77	0.70	20.81	2.28	0.19	21.56	1.53	0.48
Average land holding	10.21	9.97	0.23	0.92	9.06	1.14	0.59	7.50	2.71	0.17
Distance to market	2.29	3.27	-0.98	0.36	1.97	0.32	0.29	3.25	-0.96	0.22
Altitude	2.28	2.24	0.04	0.83	2.22	0.063	0.71	2.24	0.04	0.81
Year of establishment	2005.6	2005.2	0.47	0.60	2005.6	0	1	2005.7	-0.07	0.93
Group size	27.44	27.56	-0.12	0.92	27.06	0.38	0.75	27.33	0.10	0.93
Share of female members	0.20	0.20	0.003	0.92	0.21	-0.01	0.81	0.21	-0.005	0.87
Forest area (ha)	445.81	405.79	40.02	0.62	369.03	76.78	0.27	350.3	95.56	0.095
Member of a political party/movement	0.01	0.04	-0.03	0.08	0.02	-0.01	0.54	0.01	-0.001	0.95

Note: PCT/ha refers to the number of potential crop trees (young trees) per hectare.

Table A1.4: Balance of covariates across groups with and without the 2019 forest data

	Forest data available	Groups Forest data not available		
	Mean	Mean	dif	*p*-value
PCTs/ha (2004)	54.385	62.523	-8.138	0.676
PCTs/ha (2012)	44.933	43.709	1.224	0.905
Average age	47.952	46.7	1.252	0.541
Share of literate members	0.501	0.497	0.004	0.961
Average livestock holding	21.791	22.707	-0.916	0.698
Average land holding	9.073	9.643	-0.569	0.812
Distance to market	2.683	2.049	0.635	0.578
Altitude	2.25	2	0.25	0.255
Year of establishment	2005.525	2006.6	-1.075	0.351
Group size	27.317	26.5	0.817	0.582
Share of female members	0.207	0.19	0.017	0.674
Forest area (ha)	392.103	276.5	115.603	0.144

Note: PCT/ha refers to the number of potential crop trees (young trees) per hectare.

Full estimation results

In Tables A1.5 and A1.6, Column (1) presents results for a parsimonious model without baseline controls, baseline forest stock and *kebele* fixed effects. In column (2) we include baseline group controls, and in column (3) we estimate an ANCOVA model and include the number of potential crop trees per hectare in 2004 and *kebele* fixed effects. Differences in the number of observations across columns are due to missing observations for specific variables.

Table A1.5: The impact of monitoring on forest management (PCT/ha), full estimation results

	(1)	(2)	(3)
Top-down + punish	14.951*	14.240**	16.781**
	(8.715)	(6.998)	(6.574)
Top-down + reward	21.457**	20.067**	7.514
	(9.843)	(8.287)	(6.026)
Bottom-up	4.482	7.884	5.342

	(7.815)	(7.972)	(6.944)
Average age		-0.232	0.080
		(0.543)	(0.537)
Share of literate members		16.910	13.759
		(14.940)	(15.203)
Average livestock holding		-0.374	-0.205
		(0.366)	(0.350)
Average land holding		0.246	0.139
		(0.279)	(0.317)
Distance to market		-1.575***	-1.422*
		(0.565)	(0.838)
Altitude		19.628***	41.558*
		(4.382)	(22.218)
Year of establishment		-4.245***	1.373
		(0.926)	(1.796)
Group size		0.250	0.184
		(0.575)	(0.571)
Share of female members		-38.935*	-21.277
		(21.606)	(26.448)
Size of forest block		0.020*	-0.008
		(0.011)	(0.016)
PCTs/ha (2004)			0.803***
			(0.156)
Kebelle fixed effects	No	No	Yes
Constant	31.594***	8507.812***	-2856.045
	(5.233)	(1867.445)	(3638.121)
R^2	0.054	0.451	0.676
Mean of control group at endline	31.594	31.594	31.594
Observations	120	116	105

*Notes: The dependent variable in columns (1)-(3) is PCT/ha, which refers to the number of potential crop trees (young trees) per hectare. The estimates compare PCT/ha between each treatment arm and the control arm. * p < 0.10, ** p < 0.05, *** p < 0.01.*

The regression results in Table A1.5 above are generally stable across specifications, and demonstrate that FUGs in the top-down monitoring arms have more potential crop trees than FUGs in the control group. Both top-down monitoring arms (significantly) positively affect PCT/ha, though the result of the top-down plus reward treatment is not robust to including baseline forest controls. The estimated effects for top-down monitoring with punishment and top-down monitoring with reward are significantly different from each other in all columns (p<0.1, according to a Wald test).

When we re-estimate the model in column (3) for the same subsample of 105 FUGs included in column (4), we find that both top-down treatment arms enter significantly (at the 5% level). In other words, the result that top-down + reward does not enter significantly in column (4) is not due to the change in the sample of FUGs included in the regression. Based on the ANCOVA model in column (3) and considering the mean value of PCT for the control group at endline, PCT/ha increases by about 53% for the treatment arm where top-down scrutiny is combined with punishment. The average increase in PCT/ha for groups assigned to the bottom-up monitoring intervention is never significantly different from zero in all models (columns 1-3).

Table A1.6 estimation results for the index of forest conservation. The results provide robust evidence that top-down monitoring contributes to conservation. For both top-down monitoring treatments, the overall quality of the forest increases.

Table A1.6: Alternative monitoring regimes and forest conservation

	(1)	(2)	(3)
Top-down + punish	-0.311*	-0.346**	-0.300*
	(0.168)	(0.165)	(0.173)
Top-down + reward	-0.434***	-0.431**	-0.270*
	(0.163)	(0.177)	(0.143)
Bottom-up	-0.137	-0.086	-0.155
	(0.119)	(0.136)	(0.131)
Average age		0.018	0.002
		(0.011)	(0.012)
Share of literate members		0.054	0.107
		(0.255)	(0.266)
Average livestock holding		-0.008	0.003
		(0.008)	(0.011)
Average land holding		0.012**	0.001
		(0.005)	(0.007)
Distance to market		0.008	0.028
		(0.016)	(0.032)
Altitude		-0.032	-0.234
		(0.094)	(0.781)
Year of establishment		0.015	-0.016
		(0.014)	(0.034)
Group size		0.001	0.008
		(0.011)	(0.009)
Share of female members		0.656	1.008*
		(0.403)	(0.515)
Size of forest block		-0.000	-0.000
		(0.000)	(0.000)
PCTs/ha (2004)			-0.010***
			(0.003)
Kebelle fixed effects	No	No	Yes
Constant	-0.011	-30.276	32.340
	(0.081)	(28.704)	(70.020)
R^2	0.078	0.164	0.432
Observations	110	109	99

*Note: The dependent variable in columns (1)-(3) is the averaged z-score index of a vector of variables measuring forest conservation (potential crop trees, charcoal spots, stumps, regeneration status, forest status). The estimates compare averaged z-score index between each treatment arm and the control arm. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Table A1.7 below presents estimation results for individual variables of the forest conservation index, controlling for baseline co-variates and *kebele* fixed effects. While not all coefficients are significant, the patterns in these data are broadly consistent with the findings of Tables A1.5 and A1.6. Again, the bottom-up intervention has no significant effect on any forest outcome.

Table A1.7: Alternative monitoring regimes and individual measures of forest management

	Charcoal spots	*Stumps*	*Regeneration*	*Forest status*
	(1)	(2)	(3)	(4)
Top-down + punish	-0.017	0.017	-1.308	2.979*
	(0.018)	(0.094)	(6.139)	(1.699)
Top-down + reward	-0.031**	-0.013	7.686	1.699
	(0.012)	(0.084)	(5.856)	(1.145)
Bottom-up	-0.002	-0.086	6.358	0.897
	(0.017)	(0.135)	(5.809)	(0.820)
FUG baseline controls	Yes	Yes	Yes	Yes
Kebelle fixed effects	Yes	Yes	Yes	Yes

Constant	5.131	225.648***	2409.303	196.503
	(3.736)	(54.270)	(1451.344)	(171.582)
R^2	0.319	0.326	0.143	0.120
Mean of control group at endline	.052	.612	18.444	12.079
Observations	112	112	109	112

*Notes: The dependent variable is number of charcoal spots/ha (column (1)), number of stumped trees/ha (column (2)), the share of the forest inventory sample plots whose regeneration status was rated as "good" or "very good" (column (3)), and the share of the forest inventory sample plots whose overall status was rated as "good" or "very good" (column (4)). The estimates compare averaged z-score index between each treatment arm and the control arm. Included controls: average age, share of literate members, average livestock holding, average land holding, distance to daily market, year of FUG establishment, group size, share of female members and size of the forest block. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Table A1.8: The impact of monitoring on forest management (PCT/ha), full estimation results

	Number of PCT/ha	Averaged z-score index
	(1)	(2)
Top-down + punish	13.336**	-0.343**
	(6.441)	(0.157)
Top-down + reward	14.124*	-0.385**
	(7.424)	(0.184)
Bottom-up	4.135	-0.081
	(8.132)	(0.155)
Average age	-0.077	0.017
	(0.536)	(0.012)
Share of literate members	3.816	0.094
	(16.754)	(0.289)
Average livestock holding	-0.225	-0.009
	(0.402)	(0.008)
Average land holding	-0.379	0.018***
	(0.362)	(0.005)
Distance to market	-0.636	0.001
	(0.470)	(0.016)
Altitude	11.979***	0.070
	(4.198)	(0.085)
Year of establishment	-0.990	-0.028
	(1.179)	(0.021)
Group size	0.153	-0.002
	(0.636)	(0.011)
Share of female members	-37.230	0.482
	(24.842)	(0.376)
Size of forest block	0.010	-0.000
	(0.011)	(0.000)
Member of a political party/movement	52.030	-0.633
	(44.158)	(1.009)
PCTs/ha (2004)	0.663***	-0.007**
	(0.133)	(0.003)
Constant	1973.581	54.746
	(2376.606)	(42.763)
R^2	0.559	0.219
Observations	105	99

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