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Competition for Ecosystem Services: Theory and Evidence

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Response to Reviewers:	Please see the attached “Response to Reviewers” document for detailed, point-by-point responses to all reviewer and editor comments.

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Abstract

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Keywords: payment for ecosystem services, PES, competition mechanism, drone-based forest carbon measurement, RCT

JEL codes: Q23, Q15, Q56

Study pre-registration: The trial is registered on the AEA RCT registry (AEARCTR-0017395) at https://doi.org/10.1257/rct.17395-1.0

Proposed timeline

We plan to introduce either a Payment for Ecosystem Services (PES) scheme or a new competitive scheme, Competition for Ecosystem Services (CES), into existing community-based forest management systems in Bangladesh in March 2026. The intervention will target 60 communities, each of which manages a Village Common Forest (VCF). Both PES and CES will remain in place for approximately two years, ending in January 2028.

To measure forest carbon stocks within each VCF, we will conduct three rounds of drone-based measurements in January of 2026, 2027, and 2028. In addition, we will administer questionnaire surveys to forest management committee members and a sample of other community members before and after the intervention.

At the end of the experiment, in January 2028, payments will be disbursed to the forest management committees based on the amount of forest carbon conserved during the intervention period.

1 Introduction

Deforestation and forest degradation account for approximately 15% of global greenhouse gas emissions annually (Kumar et al., 2022), making forest conservation a critical component of climate change mitigation. Much of this forest loss is concentrated in biodiversity-rich tropical forests in developing countries, where deforestation is driven by strong economic incentives to convert forest land to alternative uses such as agriculture or timber extraction (West et al., 2025). To address this challenge, Payment for Ecosystem Services (PES) programs—which provide direct monetary compensation to communities or landowners who protect or restore forests—have emerged as a prominent policy response to this challenge. A growing body of rigorous experimental and quasi-experimental evidence documents positive effects of PES on both ecological outcomes and local livelihoods (Alix-Garcia and Wolff, 2014; Blundo-Canto et al., 2018; Jack et al., 2008). However, the literature has also highlighted an important limitation of PES: its conservation impacts are often modest on average, underscoring the need for more effective policy designs (Börner et al., 2017; Wunder et al., 2020; Wunder et al., 2018).

To enhance the effectiveness of community-based forest management in developing countries, we propose "Competition for Ecosystem Services" (CES) as a novel payment-based forest management policy. As in standard PES programs, CES rewards communities for forest conservation and restoration achievements. CES differs, however, in that payments are explicitly performance-ranked across communities: communities that achieve greater restoration success relative to others receive higher financial rewards. Insights from a broad literature suggest that intergroup competition can generally enhance productivity by motivating greater effort and coordination among group members (Backus, 2020; Holmes and Schmitz, 2010). Applying this insight to natural resource management, CES is expected to strengthen conservation incentives for individuals involved in forest management, thereby increasing conservation effort and potentially generating larger restoration outcomes than non-competitive PES schemes.

The primary objective of this study is to examine whether introducing a CES system into existing community-based forest management increases forest carbon restoration by strengthening community members' incentives to contribute labor to management activities. In addition, if competitive incentives lead to greater conservation gains, we aim to identify the mechanisms underlying this effect. We focus on two potential pathways through which competition may increase the effectiveness of community-based forest management: (1) enhanced within-community cohesion and (2) parochial altruism.

The first mechanism is enhanced within-community cohesion. Competition with external groups may strengthen bonds among community members, promoting greater cooperation and coordination and thereby improving the efficiency of forest management (Liu et al., 2014; Puurtinen and Mappes, 2009). Stronger cohesion can also mitigate concerns about free-riding in collective forest management, as individuals become more confident that others will exert effort. As a result, individual effort increases, strengthening the community's overall capacity for collective action. Under this mechanism, we would expect to observe increases in within-group prosocial behavior toward fellow community members, without necessarily reducing generosity toward other communities.

The second mechanism is parochial altruism. Competition may trigger parochial altruism—a combination of in-group favoritism (altruism toward one's own group members) and reduced generosity toward out-groups. Prior research shows that inter-group competition can generate this pattern of parochial altruism by simultaneously enhancing prosocial behavior within groups and lowering generosity or cooperativeness toward rival groups (Bauer et al., 2016; Bowles, 2008; Choi and Bowles, 2007; Lehmann and Feldman, 2008). Under this mechanism, we would expect to observe increases in within-group prosociality, accompanied by reduced generosity or more competitive behavior toward other communities.

These two mechanisms have distinct behavioral signatures. While both predict enhanced within-group cooperation, only the parochial altruism mechanism predicts lower generosity toward out-groups. By measuring both within-group prosociality and out-group generosity, we can empirically distinguish between these mechanisms and identify the processes through which competition affects forest conservation outcomes.

To evaluate these hypotheses, we will conduct a randomized controlled trial in Bangladesh. The study will be implemented in the Chittagong Hill Tracts (CHT), a mountainous region that retains some of the country's remaining forest resources. The CHT contains more than 300 Village Common Forests (VCFs), which are community-managed forests governed by forest management committees composed of approximately ten members from each community (Uddin et al., 2019). These committees are responsible for forest management and conservation activities. For our experiment, we select 60 VCFs and randomly assign them to one of three groups: a PES treatment group, a CES treatment group, or a control group with no intervention. By implementing actual PES and CES schemes in treated communities, this design allows us to causally assess the effects of competitive and non-competitive payment schemes on forest conservation outcomes and related behavioral mechanisms.

In the CES treatment, we introduce competition across communities through a deliberately moderate and non-winner-take-all design. Communities assigned to CES are ranked based on their forest carbon conservation outcomes and divided into an upper-performing group and a lower-performing group. Communities in the upper group receive payments that are 20 percent higher than the baseline payment rate used in the PES scheme, while those in the lower group receive payments that are 20 percent lower. Importantly, even lower-ranked communities receive positive payments; the lowest-ranked prize is strictly greater than zero.

This moderate prize structure is motivated by two key design considerations. First, it is intended to limit the risk that competition induces parochial altruism. The objective of this study is to examine the mechanisms through which competition enhances productivity in community-based resource management, not to generate conservation gains through reduced tolerance or generosity toward other communities. Indeed, an important contribution of this study is to provide evidence on how competition can be designed to improve conservation outcomes without triggering parochial altruism.

Existing evidence suggests that such negative social responses are arised under winner-take-all competitive designs (Abbink et al., 2012). To mitigate this risk, we adopt a competition structure in which even lower-ranked CES communities receive positive financial rewards when they achieve conservation outcomes.

Second, this design is also important for strengthening individual effort incentives. Fang et al. (2020) show that winner-take-all tournaments can reduce effort by discouraging lower-ranked participants, whereas more egalitarian prize structures—where the lowest-ranked prize remains strictly positive—sustain higher effort across participants. Consistent with this insight, the CES design applies moderate performance-based adjustments to a common payment benchmark.

A key feature of this study is that it evaluates both the impacts and mechanisms of CES by using ultra–high-resolution forest data and incentivized behavioral measures. To assess the environmental effects, we measure forest carbon stocks for each VCF using drone-based remote sensing with an approximate spatial resolution of 5 centimeters. In addition, to investigate the underlying mechanisms, we implement three incentivized behavioral games with real monetary stakes—the trust game, dictator game, and donation choice game. These games allow us to quantitatively measure prosocial behavior toward members of one's own community and generosity toward other communities within the CHT.

This study makes four primary contributions. First, this study can make a significant contribution to the literature on payment schemes for environmental conservation by examining how incentive design can enhance the effectiveness of payment based approach. PES has been widely adopted as a policy tool to improve forest conservation outcomes, and a substantial body of empirical research documents its positive effects on conservation (Alix-Garcia et al., 2015; Cisneros et al., 2022; Jack et al., 2008; Jayachandran et al., 2017). Beyond forests, payment schemes have been applied across a broad range of environmental contexts, including fisheries management (Begossi et al., 2011; Booth et al., 2023), water resource conservation (Muñoz-Piña et al., 2008; Zheng et al., 2013), and air pollution mitigation (Jack et al., 2025; Wang and Lei, 2021).

However, the literature has also highlighted an important limitation of PES, in that its conservation effects are often modest on average. Because PES relies on voluntary participation, its average environmental impact tends to be modest, raising concerns about its effectiveness when scaled up (Börner et al., 2017; Wunder et al., 2020; Wunder et al., 2018). As PES programs continue to expand in scope and coverage, there is a growing need to evaluate alternative and more efficient payment designs that can generate stronger conservation outcomes. To our knowledge, this study will be among the first to explicitly incorporate competition into payment-based resource management and to provide causal evidence on how competitive incentive schemes can strengthen conservation impacts beyond those achieved by standard PES.

Second, we advance the literature on competition and productivity by clarifying the mechanisms through which competition operates and by highlighting its potential hidden costs. A large body of research across diverse contexts—including firm productivity (Atalar, 2025; Perra et al., 2024; Schiffbauer et al., 2025), workplace performance (Olabisi et al., 2024), education (Campos and Kearns, 2024), and healthcare (Bloom et al., 2015; Gaynor et al., 2013)—documents that competitive incentives can enhance performance relative to non-competitive schemes. Importantly, these productivity gains are not limited to individual- or firm-level competition; they also arise in settings characterized by competition across groups or communities. For example, Bandiera et al. (2013) show that intergroup competition can enhance collective performance, and Olken et al. (2014) demonstrate that competition across communities in the public sector improves the efficiency of health and education service delivery.

A common explanation proposed in the literature is that intergroup competition strengthens within-group coordination and cooperation. Bornstein et al. (2002) argue that facing a shared external rival creates a “common challenge” that promotes cooperation among group members. Consistent with this mechanism, Garg et al. (2025) show that competition across villages for additional public funding in Indonesia increases coordination and cooperation within villages and reduces incidents of within-community violence.

However, an important shortcoming of the existing literature is that the mechanisms through which competition enhances coordination and cooperation remain insufficiently understood. In particular, it is unclear whether competition primarily strengthens within-group cohesion without altering attitudes toward rival groups, or whether it operates through parochial altruism, whereby productivity gains are achieved at the expense of reduced tolerance toward competitors. These alternative mechanisms have rarely been disentangled in real-world settings.

This distinction is of first-order policy relevance. Competitive incentive schemes are increasingly applied across a wide range of domains, yet little is known about whether such approaches generate hidden social costs in the form of heightened intolerance toward out-groups. Identifying competition designs that enhance coordination and cooperation without inducing such costs is therefore critical for the scalable and socially sustainable use of competitive incentives. This study contributes to this debate by examining whether competition can improve conservation outcomes without triggering parochial altruism.

Third, this study contributes methodologically by integrating ultra–high-resolution drone-based monitoring into the design and evaluation of an outcome-based PES scheme. The use of satellite imagery and remote sensing in economics dates back to the early 2000s, with seminal studies such as Foster and Rosenzweig (2003) and Burgess et al. (2012) employing satellite data to assess forest conditions. In the PES literature, commonly used satellite products typically have pixel sizes ranging from 30 to 250 meters (Alix-Garcia et al., 2015; Cisneros et al., 2022), while one of the highest-resolution applications relies on 2.4-meter multispectral imagery (Jayachandran et al., 2017). Although satellite imagery offers broad spatial coverage, its precision is fundamentally constrained by spatial resolution.

This limitation is particularly consequential in outcome-based PES settings, where measured conservation outcomes directly determine payments. Measurement error therefore translates into payment error, generating basis risk and potentially weakening the incentive compatibility of the scheme. Improving measurement precision is thus important not only for impact evaluation but also for sustaining credible conservation incentives. To address this challenge, we collect original drone-based imagery at a spatial resolution of 5 centimeters by flying drones directly over the study sites.

Beyond improving precision, drone-based monitoring has important implications for the design of outcome-based PES schemes. Low-resolution satellite imagery is widely accessible but may lack the granularity needed to monitor conservation at fine spatial scales. High-resolution commercial satellite data can be costly and subject to cloud-cover and scheduling constraints, while public forest-loss alert systems (e.g., Global Forest Watch) rely on binary disturbance indicators that do not directly measure carbon stocks. Ground audits, though precise, are often administratively infeasible in remote mountainous regions. In this context, drone deployment provides a flexible and locally implementable alternative that enables continuous, cell-level estimation of carbon stocks while remaining operationally feasible in geographically challenging environments.

To systematically evaluate the value added by high-resolution drone imagery, we will also estimate forest carbon stocks using conventional satellite products (i.e., Sentinel-1 and Sentinel-2 imagery) and compare the resulting treatment effect estimates with those obtained from drone-based measurements. This comparison allows us to assess the extent to which lower-resolution monitoring attenuates estimated treatment effects and increases basis risk in outcome-based contracts. By quantifying these differences, we provide evidence on the marginal returns to investing in higher-resolution monitoring technologies.

Finally, this study also has the potential to offer significant policy implications. While CES and PES are implemented with the same average payment level of USD 2,400 per community, conservation outcomes can be evaluated using prevailing carbon market prices. Under PES, payments correspond to conservation outcomes valued at the carbon price, whereas under CES this benchmark price is adjusted upward or downward by 20 percent based on relative performance. This comparison is policy-relevant because prior research finds that PES often yields limited livelihood benefits (Blundo-Canto et al., 2018; Liu and Kontoleon, 2018), potentially because conservation gains under PES are modest in absolute terms. If CES increases conservation effort, then even communities facing a discounted payment rate under CES may receive higher total payments than under PES when conservation outcomes are valued at carbon market price. This may offer important insights relevant for the design of conservation payment policies with implications for both conservation and livelihoods.

2 Research design

2.1 Conceptual framework

This section develops a theoretical framework to guide our empirical analysis. We compare conservation outcomes across three institutional regimes: conventional community forest management (baseline), PES, and CES. Details of the mathematical derivation of these results is provided in Appendix B; here we present the key intuitions.

The key theoretical innovation lies in modeling how competitive incentives interact with community cooperation. While standard theory predicts that monetary incentives enhance effort for conservation, behavioral economics suggests the possibility that monetary incentives crowds out social norms and, accordingly, decreases collective activities. CES introduces an additional dimension: competition may strengthen within-group cooperation while potentially affecting attitudes toward out-groups. Our framework captures these competing forces and derives conditions under which CES outperforms PES.

Basic Setup

Consider a community of N members collectively managing a shared forest. Each individual i chooses an effort $e_i \geq 0$ toward forest management, encompassing protective actions (monitoring) and productive actions (planting, watering, pruning). Total forest improvement is $E = \sum e_i$, generating ecological benefit $\alpha\gamma E$ (where $\gamma > 0$ is productivity and $\alpha > 0$ is per-unit value of forest stocks). The total benefit is shared equally among members.

Each individual in the community allocates a fixed amount of labor time ($\bar{L}_i (= \bar{L})$) between forest management activities ($l_{e,i}$) and their own economic activities ($l_{x,i}$), such as agriculture. One unit of labor input for economic activity generates one unit of income (x_i), which accrues to the individual who performed the economic activity.

$$x_i = l_{x,i}.$$

We assume that the marginal labor cost for creating an additional unit of effort for forest is increasing. The basic relationship between the time allocated to forest activities and the corresponding effort level is given by

$$e_i = \left(2\lambda l_{e,i}/c\right)^{1/2} \qquad \Leftrightarrow \qquad l_{e,i} = (c/2\lambda) \cdot e_i^2$$

where $c > 0$ is a baseline cost parameter (disutility of effort) and $\lambda \in (0, 1]$ is the degree of cooperation (cooperation parameter). This parameter captures how in-group cohesion, mutual support, peer monitoring, and social norms reduce the marginal cost of effort. Both the baseline cost and cooperation parameters are common for all community members.

In addition, we consider two dimensions of prosocial behavior: **ingroup altruism** (***h***), measuring prosociality toward one's own community, and **outgroup generosity** (***g***), measuring prosociality toward other communities. Ingroup altruism influences the effort decisions through two channels: (i) an increase in ingroup altruism enhances the degree of cooperation and, (ii) an increase in ingroup altruism enhances the effectiveness of cooperation. Outgroup generosity influences the effort decisions through two CES-specific channels: (i) a reduction in outgroup generosity strengthens the cooperative attitude within the community, and (ii) a reduction in outgroup generosity boosts the motivation to win (greater outgroup generosity weakens competitive drive) and, accordingly, enhances the effectiveness of cooperation.

Considering the first channels of both ingroup altruism and outgroup generosity, the degree of cooperation can be rewritten as: $\lambda(h, g)$, $\partial\lambda/\partial h > 0$, $\partial\lambda/\partial g < 0$. In particular, λ under each institution is written as follows: $\lambda_{base} = \lambda(h_{base}, g_0)$, $\lambda_{PES} = \lambda(h_{PES}, g_0)$, and $\lambda_{CES} = \lambda(h_{CES}, g_{CES})$, where $g_{base} = g_{PES} = g_0$.

We consider the following stages for determining the effort amounts in equilibrium. First, the degrees of ingroup altruism and outgroup generosity and, accordingly, the degree of cooperation are exogenously determined given the institution: the baseline management, PES, or CES. Second, given h, g, and λ, each individual simultaneously choose their effort level, e_i, to maximize their own utility.

Equilibrium Under Each Regime

In this section, to facilitate comparisons of equilibrium efforts across different institutional regimes, we describe equilibrium efforts for the case of an additively separable utility function (Appendix B.6). For analysis and comparisons using more general forms of utility functions, see Appendix B.1 through B.4.

Under conventional community management (baseline), communities rely solely on intrinsic benefits. Individual utility is given by

$$U_{i,base} = \left(\frac{\alpha\gamma}{N}\right) \cdot E - \left(\frac{c}{2H(h_{base}) \cdot \lambda_{base}}\right) \cdot e_i^2 + \bar{L}.$$

where $H(h)$ represents the effectiveness of cooperation, which is the second channel of the effects of ingroup altruism ($\partial H/\partial h > 0$). Utility maximization yields the equilibrium effort under the baseline management:

$$\hat{e}_{base} = (H(h_{base}) \cdot \lambda_{base}/c) \cdot (\alpha\gamma/N).$$

Under PES, communities receive payments $\beta \cdot E$ that are distributed equally to all members. Individual utility is given by:

$$U_{i,PES} = ((\alpha\gamma + \beta)/N) \cdot E - [c/(2H(h_{PES})\lambda_{PES})] \cdot e_i^2 + \bar{L}.$$

Utility maximization yields the equilibrium effort under PES:

$$\hat{e}_{PES} = (H(h_{PES}) \cdot \lambda_{PES}/c) \cdot [(\alpha\gamma + \beta)/N].$$

The monetary incentive (β) under PES gives community members an incentive to increase their efforts given the degree of cooperation.

Under CES, the basic scheme of the external payment is the same as that of PES in the sense that the reward is paid according to the effort of the community. However, the per-unit payment also depends on its relative total effort compared to the effort of another community. Let E* denote the other community's effort. The payment structure is $2\beta\pi = 2\beta E/(E + E^*)$. When the total effort of this community is the same as that of the other community ($E = E^*$), the payment rate is equal to that under PES, β. Individual utility is given by:

$$U_{i,CES} = \left(\frac{\alpha\gamma}{N}\right) \cdot E + \left(\frac{2\beta E}{N}\right) \cdot \frac{E}{E+E^*} - \left(\frac{c}{2 \cdot (H(h_{CES}) + G(g_{CES})) \cdot \lambda_{CES}}\right) \cdot e_i^2$$

where G (g) represents the effect of outgroup generosity on the effectiveness of cooperation through the motivation to win, which is the second channel of the effects of outgroup generosity ($\partial G/\partial g < 0$). For two identical communities, utility maximization yields the symmetric equilibrium effort under CES:

$$\hat{e}_{CES} = ((H(h_{CES}) + G(g_{CES})) \cdot \lambda_{CES}/c) \cdot [(\alpha\gamma + 3\beta/2)/N].$$

Comparing CES and PES

First, to compare fairly CES with PES, consider the case in which $G(g_{CES}) = 0$. Then, for any given the degree of cooperation and ingroup altruism, the effort under CES is 1.5

times that under PES, which is the essential effect of competition. The intuition is that under CES, each unit of effort has a dual effect—it increases one's own payment and decreases the rival's share. This strategic complementarity generates stronger marginal incentives under CES than under PES.

The total CES effect decomposes into: (i) the essential competition effect (1.5× amplification), (ii) the cooperation effect ($\lambda_{CES} - \lambda_{PES}$), (iii) the change in the effectiveness of cooperation ($H(h_{CES}) - H(h_{PES})$), and (iv) motivation to win ($G(g_{CES})$). The essential competition effect increases the incentive to make efforts, and strengthened ingroup altruism increases the degree of cooperation and enhances the effectiveness of cooperation. Thus, if ingroup altruism is stronger under CES than under PES, the equilibrium effort is necessarily greater under CES than under PES. Similarly, reduced outgroup generosity strengthens parochial altruism and motivation to win, and increases the degree of cooperation. Thus, if outgroup generosity is weaker under CES than under PES, the equilibrium effort is necessarily greater under CES than under PES.

Evolution of Prosocial Preferences

Ingroup altruism may evolve differently under PES and CES. External incentives rewarding collective outcomes may enhance consideration for fellow members, but monetary compensation may crowd out intrinsic prosocial motivation, as shown in prior studies (Bénabou and Tirole, 2006; Gneezy and Rustichini, 2000). CES may further strengthen ingroup altruism through shared competitive experience and group identity reinforcement.

Outgroup generosity faces opposing forces under CES: awareness of other communities may increase concern for out-group welfare, while competitive pressure may prioritize one's own community. The net effect is theoretically ambiguous—increased outgroup generosity would suggest competitive mechanisms need not generate parochial attitudes, while decreased generosity would indicate a trade-off between conservation effectiveness and broader social cohesion.

2.2 Hypotheses

Based on the theoretical framework, we establish four testable hypotheses that correspond to distinct predictions about how competition affects conservation outcomes and social behavior.

Hypothesis 1 (Payment Effect): Introducing monetary incentives for forest conservation increases conservation effort relative to conventional community forest management.

This hypothesis verifies that external payments increase conservation effort by raising the marginal returns to effort beyond those generated by intrinsic community motivations alone. In the model, both PES and CES augment individual incentives through direct monetary rewards, and may additionally influence the degree of within-community cooperation (λ) through changes in coordination, norms, or shared objectives. Prior studies document that PES schemes can increase conservation effort through such incentive channels (Alix-Garcia et al., 2015; Cisneros et al., 2022; Jayachandran et al., 2017). Confirming this relationship validates our experimental design and establishes the baseline for evaluating competition's incremental effects. Formally, we expect:

$$\hat{e}_{PES} > \hat{e}_{base} \text{ and } \hat{e}_{CES} > \hat{e}_{base}$$

Hypothesis 2 (Competition Effect): Competition-based incentives generate higher conservation effort than equivalent non-competitive payments.

This hypothesis tests whether introducing intergroup competition increases conservation effort beyond what can be achieved by monetary incentives alone. In the model, CES amplifies marginal incentives relative to PES by tying payments to relative performance, while potentially also affecting within-community cooperation through changes in coordination and group identity. Holding expected payments constant, CES generates stronger incentives for effort provision than PES due to the strategic effect of relative performance. Formally, we expect:

$$\hat{e}_{CES} > \hat{e}_{PES}$$

We posit two mechanisms through which competition may enhance conservation outcomes:

Hypothesis 3a (Social Cohesion): Competition-based incentives strengthen within-community cohesion and cooperation, without reducing generosity toward members of other communities.

Hypothesis 3b (Parochial Altruism): Competition-based incentives strengthen within-community cohesion and cooperation, with a reduction in generosity toward members of other communities.

These competing hypotheses test whether the gains in within-community cooperation induced by competition come at the expense of intergroup relations. Under Hypothesis 3a, competition functions primarily as a coordination and identity-building device within communities, without harming attitudes or prosocial behavior toward outsiders. Under Hypothesis 3b, competition activates zero-sum psychological mechanisms, leading individuals to prioritize in-group outcomes at the expense of out-group welfare.

Distinguishing between these mechanisms has important policy implications. If competition operates through parochial altruism, scaling CES programs may generate negative externalities for intergroup cooperation and broader social cohesion, even if local conservation outcomes improve.

While both hypotheses predict enhanced within-group cooperation on average, competition could also have adverse within-group effects. If some community members perceive that they bear a disproportionate share of the effort burden, competition may generate pressure or resentment rather than cohesion. This risk may be particularly pronounced in lower-performing CES communities, where repeated underperformance could undermine group morale or trigger blame attribution among members. We examine whether treatment effects on within-group prosociality differ between higher- and lower-performing VCFs in the CES arm as part of our heterogeneous effects analysis.

2.3 Study Context: Village Common Forests in the Chittagong Hill Tracts

To test the above hypotheses, we implement a randomized controlled trial that introduces CES or PES into community forests currently managed under conventional community-based forest management. As the study setting, we select Village Common Forests (VCFs) located in the Chittagong Hill Tracts of Bangladesh.

The CHT in southeastern Bangladesh span approximately 13,184 km^2 and are characterized by hilly terrain and a tropical monsoon climate, with annual rainfall between 2,200 and 3,000 mm (Uddin et al., 2019; Uddin et al., 2021). Only 3.2% of land is suitable for permanent agriculture, while approximately 77% is suitable for forest ecosystems (Uddin et al., 2019). The region is inhabited by eleven indigenous ethnic communities (e.g., Chakma, Marma, Tripura, Tanchangya, among others) whose livelihoods are historically intertwined with forests.

Agriculture in CHT is dominated by shifting cultivation, complemented by horticulture, livestock rearing, and small-scale trade (Chowdhury et al., 2018). Forest resources provide fuelwood, bamboo, timber, medicinal plants, and drinking water, and in some cases are used to finance collective expenditures, such as schools or religious buildings. Livelihood dependence on forest resources implies that forest management decisions have direct welfare implications at both household and community levels.

VCFs are community-conserved forest patches embedded within broader agricultural landscapes. They emerged as indigenous responses to forest degradation, with local communities beginning to set aside and conserve forest patches from around the 1930s (Uddin et al., 2021). In 1965, the government formally encouraged the establishment and conservation of these forests by issuing a circular to traditional Headmen, recognizing the role of communities in forest management (Chowdhury et al., 2018). VCFs are governed by Forest User Groups led by traditional Headmen and supported by local leaders. VCF committees operate under internal rules that regulate extraction, restrict commercial harvesting, impose penalties for unauthorized use, and maintain physical boundaries. Individual households may collect forest products for domestic purposes, but commercial use is prohibited.

The broader CHT landscape has experienced substantial deforestation driven by shifting cultivation, tobacco farming, illicit logging, infrastructure expansion, and population growth (Uddin et al., 2019). However, VCFs were established precisely to counteract such pressures. Within VCF boundaries, outright land conversion is institutionally discouraged, and forest use primarily takes the form of regulated extraction rather than clearing. Forest change within VCFs is therefore more likely to occur through forest degradation—most plausibly via unauthorized logging by outsiders and other unregulated extraction that reduces biomass—as well as through variation in forest management practices, including insufficient maintenance activities (e.g., pruning and thinning), rather than through widespread forest-to-nonforest transitions.

These governance arrangements imply that VCFs are not open-access forests but collectively managed conservation areas with monitoring and sanctioning capacity. Importantly, no performance-based environmental incentive schemes—such as PES, REDD+, or carbon credit programs—have previously operated within VCFs. Forest governance in this setting has relied entirely on customary collective rules rather than external financial incentives.

2.4 Primary outcomes

To test the hypotheses outlined above, we identified the primary outcomes, which are detailed in Table 1.

Forest related outcomes. Our primary conservation outcome is forest carbon stock at the cell level, which serves as the basis for testing Hypotheses 1 and 2. We will estimate carbon stocks using a DJI Mavic 3 Multispectral drone, which captures ultra–high-resolution imagery with a ground sampling distance of approximately 5 centimeters. The drone is equipped with multispectral sensors covering the Green, Red, Red Edge, and Near Infrared bands. These data enable the construction of vegetation indices such as the Normalized Difference Vegetation Index (NDVI), which provides detailed information on vegetation vigor and canopy density. To calibrate these remote-sensing measures, we will establish approximately one to two ground plots in each VCF (roughly 60–120 plots in total). Plot-level biomass will be measured through standard forestry inventory methods, including tree diameter measurements, height assessments, and application of allometric equations. These ground-based estimates will be used to develop predictive equations linking remotely sensed vegetation indices to above-ground carbon stocks.

Each VCF will be divided into a regular grid of 30 m × 30 m cells for the main empirical analysis, and carbon stock will be estimated at the cell level using the calibrated prediction equation. This spatially disaggregated approach follows PES literature (Alix-Garcia et al., 2015; Cisneros et al., 2022). Carbon stock will be measured at three time points: baseline (January 2026), and two follow-up periods (January 2027 and January

2028), corresponding to one and two years after the intervention begins. The primary outcome variable will be the change in carbon stock between baseline and endline.

A potential concern is strategic or differential measurement error if communities adjust deforestation behavior in response to drone monitoring. Several features of our design mitigate this risk. First, the ultra–high spatial resolution of the imagery (approximately 5 cm) substantially limits the scope for selectively clearing forest in ways that would systematically evade detection. Second, carbon stocks are measured at three points—baseline, midline, and endline—and payments are determined based on endline outcomes. As a result, deforestation shifted to the period following baseline or midline would be captured in the final measurement and reduce payouts, limiting incentives for strategic timing within the study period. While deforestation occurring immediately after the endline flight is possible in principle, such behavior would take place after the intervention and outcome measurement window and therefore does not threaten identification of treatment effects during the study horizon. Moreover, monitoring protocols and flight schedules are identical across treatment arms and are not disclosed to communities in advance. This limits the scope for communities to strategically adjust forest clearing behavior around the timing of drone measurements.

More broadly, how communities adjust behavior after the termination of an incentivized conservation scheme is an important question in its own right. Indeed, post-program dynamics have been examined in the PES literature (Hayes et al., 2022). While our primary focus is on treatment effects during the intervention period, understanding longer-run behavioral responses following the removal of incentives represents an important avenue for future research.

In addition, to assess whether the intervention strengthens incentives for labor allocation to forest management, we examine conservation efforts among members of the VCF management committees. Questionnaire surveys will be conducted before and after the intervention (in 2026 and 2028) to measure self-reported labor input devoted to forest management activities, captured as time spent on planting, watering, monitoring, thinning, and pruning. We include thinning and pruning as conservation efforts because these are standard silvicultural practices that promote forest health and growth by reducing competition among trees and improving stand structure (Otsuka et al., 2015; Takahashi et al., 2024).

Beyond these primary outcomes, we examine three types of secondary outcomes (Table 2). The first secondary outcome is the average carbon stock per hectare at the VCF level, which provides an aggregate measure of forest condition complementary to our primary cell-level estimates.

Second, we estimate forest carbon stock using satellite imagery. In most real-world PES implementations, high-resolution drone monitoring—as used in this study—is often financially and technically infeasible at scale. Instead, lower-cost satellite-based monitoring is typically employed. To assess the scalability and policy relevance of our findings, we therefore construct satellite-based measures of forest carbon stock using Sentinel-1 (radar) and Sentinel-2 (multispectral) imagery, both of which provide 10 m spatial resolution. To ensure comparability with the drone-based analysis, satellite-derived measures will be aggregated to the same 30 m × 30 m grid cells used in the main analysis. We use these data to estimate above-ground carbon stock within VCF boundaries and include the resulting measure as a secondary outcome.

Third, we include a measure of forest clearing as an indicator of deforestation. As discussed in the context section, outright land conversion within VCF boundaries is rare due to community enforcement, but forest loss may occur through unauthorized extraction by external actors. We therefore construct a binary, cell-level measure indicating whether a given grid cell transitions from forest to non-forest. This allows us to capture discrete clearing events, even if such transitions are relatively infrequent in this setting.

Pro-social behavioral outcomes. For the mechanisms analysis, we will measure cooperative preferences toward in-group members using incentivized behavioral games. These games will be administered to both forest management committee members and other community members at baseline and endline. Payment procedures for all behavioral games are described in Section 3.1.

To measure trust and reciprocity, we implement a simplified trust game designed to minimize respondent confusion in the field. Each participant plays both roles (i.e., sender and recipient) in turn. First, as the sender (Player A), the participant receives an endowment of 300 BDT and chooses how much to send to an anonymous member of the same community, choosing among 0, 100, or 300 BDT. The amount sent is tripled for the recipient.

Second, the participant is asked to take the role of the recipient (Player B) and indicate how much they would return to an anonymous community member under two possible contingencies: if they were to receive 300 BDT (when Player A sends 100 BDT) and if they were to receive 900 BDT (when Player A sends 300 BDT). For each contingency, participants choose one of five options—0%, 25%, 50%, 75%, or 100% of the received amount—to return to Player A. These contingent return decisions provide an incentivized measure of reciprocity and conditional cooperation toward in-group members.

In addition to trust game, we will conduct the dictator game to measure in-group prosociality or altruism toward fellow community members. Each participant is endowed with 150 BDT and asked to decide how much (0 to 150 BDT) to allocate to an anonymous community member. The recipient has no decision to make and simply receives the allocated amount. Unlike the trust game, where giving may be motivated by expectations of reciprocity, the dictator game captures prosocial behavior toward in-group members in a setting without strategic interaction.

Complementing these behavioral measures, we will also collect self-reported trust toward members of the same community as a secondary outcome through baseline and endline surveys. Participants will be asked to rate their level of trust in community members using a four-point scale.

To distinguish between the social cohesion enhancement and parochial altruism mechanisms, we measure generosity toward out-group using three incentivized tasks. First, we implement a trust game similar to the one used to measure prosociality toward in-group members. The structure of the game is identical; the only difference is that participants are matched with an anonymous individual from another community who is assigned to the same treatment status. To minimize confusion, the out-group trust game is administered in the same module as the in-group trust game. To mitigate potential order effects, the sequence of the two trust games is randomized across participants. For payment, one of the two trust games is randomly selected for payment, and payouts are determined based on the selected game.

Second, we conduct a set of dictator games in which recipients are drawn from communities other than the participant's own. In each version, the participant is endowed with 150 BDT and decides how much to allocate to an anonymous individual from another community within the CHT. We distinguish between two types of out-group recipients: (i) a recipient from a community assigned to the same treatment status as the participant, and (ii) a recipient from a community that is not participating in this study. Because the recipient has no decision to make, these tasks capture prosociality in a non-strategic setting. To avoid order effects, the sequence of the three dictator games (one in-group and two out-group) is randomized across participants. After all decisions are made, one dictator game decision is randomly selected for payment, and payouts are based on the selected choice.

Lastly, we implement a donation choice game adapted from Bursztyn et al. (2020). In this task, participants are asked whether they authorize a 150 BDT donation to be made on their behalf to a randomly selected community within the CHT that is assigned to the same treatment status. Importantly, the donation is financed entirely by the research team—participants do not incur any personal financial cost. The identity of the recipient community is anonymous to the participant, eliminating strategic considerations or specific intergroup histories that might confound the measure. The outcome is a binary choice—whether to authorize the donation—which provides an additional measure of out-group generosity.

Table 1. Description of primary outcomes

Outcomes	Source	Measurement
Forest carbon stock (cell level)	Drone-based remote sensing calibrated with ground measurements	Above-ground carbon stock estimated at the 30 m × 30 m grid cell level using calibrated prediction equations linking multispectral vegetation indices to ground-based forestry measurements.
Conservation efforts	Questionnaire survey	Self-reported labor input devoted to forest management activities, measured as time spent on planting, watering, monitoring, thinning, and pruning.
Within-group prosociality	Incentivized behavioral games and questionnaire survey	Incentivized behavioral games ○ **Trust game**: Amount sent to an anonymous member in the respondent's own community ○ **Dictator game**: Amount allocated to an anonymous member in the respondent's own community
Out-group generosity	Incentivized behavioral games	Incentivized behavioral games ○ **Trust game**: Amount sent to an anonymous person in anotoher community assigned to the same treatment status ○ **Dictator game**: Amount allocated to (i) an anonymous participant in another community assigned to the same treatment status and (ii) an anonymous person in another community assigned not participating in this study ○ **Donation choice game**: Binary indicator for authorizing a donation to a randomly selected community assigned to the same treatment status

Table 2. Description of secondary outcomes

Outcomes	Source	Measurement
Forest carbon stock (VCF level)	Drone-based remote sensing calibrated with ground measurements	Above-ground carbon stock per hectare estimated at the VCF level.
Satellite-based forest carbon stock (cell level)	Satellite imagery	Above-ground carbon stock estimated at the 30 m × 30 m grid cell level using Sentinel-1 (radar) and Sentinel-2 (multispectral) imagery.
Deforestation (cell level, binary)	Drone-based land cover classification	Indicator equal to 1 if a grid cell classified as forest at baseline is classified as non-forest at follow-up, and 0 otherwise. Forest classification is based on canopy cover and vegetation structure derived from high-resolution drone imagery.
Trust	Questionnaire survey	Self-reported trust toward individuals from different social groups: o Members of one's own community o Members of other communities within the CHT
Committee member turnover rate (VCF level)	Questionnaire survey	Proportion of baseline VCF management committee members who are no longer serving at endline, measured at the VCF level.

2.5 Basic methodological framework/identification strategy

To create exogenous variation in payment schemes for forest conservation, we will implement a cluster-randomized controlled trial with 60 VCFs in the CHT of Bangladesh. VCFs will be randomly assigned to one of three arms—Control, PES, or CES—with 20 VCFs per arm. Randomization at the VCF level ensures that all communities face identical baseline forest conditions and traditional management structures, with treatment assignment being the sole source of systematic variation in incentives. This design allows us to estimate the causal effect of introducing monetary incentives for conservation (comparing PES and CES to Control) and the incremental effect of competitive incentive structures (comparing CES to PES).

Experiment procedure. The experimental procedure is illustrated in Figure 1. During the preparation phase, communities will be informed about the study design, the payment schemes under consideration, and the possibility of receiving a conservation-based payment intervention. Informed consent for participation in the study will be obtained prior to data collection. Baseline activities include drone-based measurement of forest carbon stocks across all 60 VCFs and questionnaire survey including incentivized behavioral games.

Treatment assignment will be revealed in March 2026, at which point the intervention will begin. Communities will be informed of their assigned treatment arm, and the specific payment rules will be disclosed to PES and CES communities. Then, the intervention will be implemented over a two-year period (2026–2027). In January 2027, CES communities will receive an interim report summarizing their conservation performance and their relative ranking within the CES group (upper or lower half). We adopt a binary classification rather than finer gradations to minimize discouragement effects among lower-ranked communities (Fang et al., 2020). Endline data collection will be conducted in January 2028, replicating all baseline measurements.

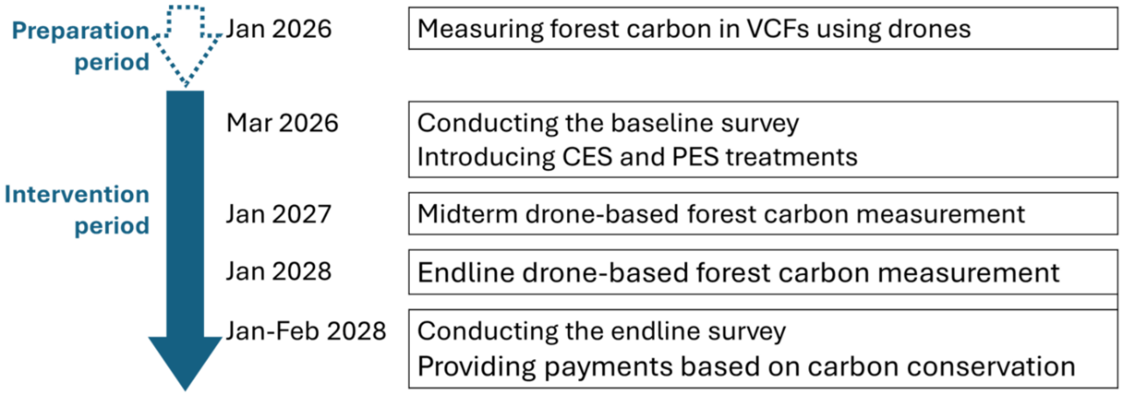

Figure 1. Experimental procedure

Identification strategy. Our identification strategy relies on the random assignment of VCFs to treatment conditions. Because VCF assignment is determined by a random number generator prior to any intervention activity, treatment status is orthogonal to all potential confounders. To assess the validity of the randomization, we will examine baseline balance across treatment arms using pre-intervention measures of forest conditions, as well as demographic characteristics and social preference measures collected in the baseline survey.

2.6 Intervention

A total of 60 VCFs and their corresponding communities will be randomly allocated to one of two treatment arms—CES or PES—or to a control group prior to the start of the intervention. The randomization will be conducted at the VCF level, with 20 VCFs assigned to each group.

Because forest management is already carried out by established VCF management committees, the introduction of CES or PES does not impose additional organizational or administrative burdens on participating communities. Moreover, there is local demand for forest conservation payment schemes in the CHT. For these reasons, we anticipate full take-up of the assigned treatment among treated VCFs. The details of each group are described below.

Control group—The 20 communities assigned to the control group will continue conventional community-based forest management without any external payment scheme. The control group provides the counterfactual benchmark against which we calculate the conservation gains achieved by PES and CES communities. Carbon stock changes in control communities also serve as the reference point for determining payment amounts in both treatment arms.

Payment for Ecosystem Services Treatment—The 20 communities assigned to the PES treatment will receive monetary rewards based on the amount of forest carbon conserved per hectare within their VCFs. Payments will be calculated relative to baseline carbon stocks measured in January 2026 and benchmarked against changes observed in the control group. Specifically, even if carbon stock per hectare in a PES community's VCF remains constant over the intervention period, the community will still receive a payment if carbon stocks per hectare in control VCFs decline. The detailed payment formula used in the experiment is described later.

Competition for Ecosystem Services Treatment—The 20 communities assigned to the CES treatment will also receive payments based on forest carbon conservation per hectare relative to the control group, using the same baseline and benchmarking approach as in the PES treatment. The critical difference is that CES introduces performance-based differentiation within this arm: communities that rank above the median in terms of conservation outcomes receive payments 20% higher than they would have received under the PES formula, whereas those below the median receive payments 20% lower than the PES benchmark.

The 20% adjustment follows Olken et al. (2014), who allocated 20% of block grants based on relative performance in their community incentive experiment in Indonesia. The median-based classification ensures that half of the participating communities receive the higher payment rate while maintaining sufficient sample size within each performance group. This binary classification also provides a transparent rule that is easily communicable to participating communities. While our design tests one specific parameterization suited to a sample of 20 CES communities, scaled implementations could adopt finer performance gradations and adjust prize spreads based on local context.

Payment Design—Because the project operates under a binding budget constraint, we calibrated the payment level. The payment schedule is structured such that the average total payment per community over the two-year intervention period is approximately USD 2,400 for both PES and CES treatment arms.

Payments are calculated using a common two-step procedure across treatments. First, we measure each community's carbon conservation outcome, defined as the change in carbon stock per hectare between baseline (January 2026) and endline (January 2028), adjusted by the average change observed in the control group. Second, payments are determined by multiplying each community's conservation outcome by a scaling factor. This factor is calibrated ex post so that the average payment across communities within each treatment arm equals the target level of USD 2,400. Importantly, in both treatment arms, communities are never subject to fines, negative transfers, or clawbacks. If a treated community experiences a decline in carbon stocks relative to the control group, its payment is simply set to zero.

While many large-scale PES programs operate under fixed per-hectare or per-ton payment rules, our design incorporates an ex-post scaling mechanism that ensures total payments within a predetermined budget constraint. Under this rule, payments are adjusted proportionally after observed conservation outcomes are realized. Although this differs from the most common fixed-rate PES contracts, budget-adjusted or relative allocation schemes are not unprecedented. For example, ecological compensation programs in China allocate funds based on the relative supply of ecosystem services across regions (Yan et al., 2024).

Importantly, the ex-post calibration in our setting preserves incentive monotonicity: payments are strictly increasing in conservation performance. Thus, while the exact per-unit payment rate is determined after outcomes are observed, the marginal return to improved conservation performance remains positive. As emphasized in the literature on relative performance incentives and budget-constrained reward schemes (Olken et al., 2014), such designs can maintain effort incentives as long as rewards are strictly increasing in performance. In this sense, our payment rule preserves incentive compatibility while allowing us to operate under a fixed total budget.

The payment level of USD 2,400 is calibrated to be reasonable relative to local opportunity costs. As emphasized by Jack et al. (2008), participation in PES programs requires payments that at least compensate participants for the opportunity costs of conservation. Because VCFs are community-conserved forests where land conversion is institutionally prohibited under existing customary rules, the relevant opportunity cost is associated with monitoring and enforcement activities rather than foregone agricultural production. Evidence from the same region indicates that the average daily wage is approximately USD 2.3 (Higashida et al., 2025). As an upper-bound estimate, assuming continuous daily involvement of one committee member in VCF monitoring throughout the year—representing maximum monitoring intensity—the annual opportunity cost would be approximately USD 840 (365 days × USD 2.3), or USD 1,680 over two years. In practice, actual labor requirements are likely substantially lower, as communities already manage their VCFs under existing institutional arrangements without continuous daily presence. Setting the average payment at USD 2,400 over two years therefore ensures a clear incentive premium above opportunity costs while remaining operationally feasible.

In addition, the payment level is substantial when compared with those used in prior PES studies. Alix-Garcia et al. (2018) and Jayachandran et al. (2017) focus on PES programs in Mexico and Uganda with payment rates of approximately USD 20 per hectare and USD 28 per hectare, respectively. Cisneros et al. (2022), examining a PES program in Brazil, adopt a payment level of USD 15 per household. In this study, the average VCF located in Rangamati District covers approximately 43 hectares. Applying per-hectare payment rates in the range of USD 20–28 implies total payments of roughly USD 1,720 to USD 2,408 over a two-year period. The calibrated payment level of USD 2,400 therefore lies well within this benchmark range, indicating that the incentives offered in our study are comparable to, and in some cases exceed, those employed in existing PES programs.

An important design choice in our payment scheme is that conservation outcomes are measured relative to changes observed in the control group, rather than solely relative to each community's own baseline. This relative-to-control approach serves a specific purpose for experimental identification: it isolates the effect of conservation effort from confounding factors such as climatic shocks, pest outbreaks, or regional trends that affect all communities similarly. Under a baseline-only rule, communities would receive payments for forest changes driven by factors beyond their control, introducing noise into the incentive structure and complicating causal inference.

We emphasize, however, that this design choice does not limit the scalability of the underlying monitoring technology. In practice, outcome-based PES programs typically operate under baseline-only rules, where payments depend on changes relative to each participant's own pre-intervention forest condition. Our drone-based measurement approach is fully compatible with such designs. The core innovation—precise, cell-level carbon stock estimation enabling credible outcome-based payments—remains applicable regardless of whether the payment formula incorporates a control-group benchmark.

Ethical consideration—The moderate prize structure adopted in CES, which contrasts with winner-take-all tournaments, reflects explicit ethical design considerations. In particular, the design is intended to limit the risk of reducing generosity through parochial altruism. In addition, we will take several measures to ensure that the intervention does not induce or exacerbate inter-community tension. We will monitor any signs of inter-community tension throughout the study period through regular field visits and informal conversations with community leaders. Should any adverse effects emerge, we will immediately adjust or suspend the relevant components of the intervention to safeguard community well-being. We will continue monitoring inter-community relations for at least six months after the final payments (through mid-2028). If concerns persist or if additional support is deemed necessary, we will organize facilitated dialogue sessions bringing together communities from different treatment arms to discuss shared challenges in forest management and to rebuild any social ties that may have been strained. We commit to transparent reporting of all findings, including any adverse effects on inter-community relations.

2.7 Sample and statistical power

We performed power calculations for the primary outcomes (i.e., forest carbonstock and prosociality measures). Because treatment is assigned at the VCF level, statistical power is primarily determined by the number of VCFs rather than the number of cell-level observations. Although our main analysis uses cell-level outcomes, the effective sample size is constrained by within-VCF correlation in carbon stocks. We therefore compute minimum detectable effects (MDEs) under alternative assumptions about the intra-cluster correlation coefficient (ICC).

To parameterize the ICCs, we use NDVI data constructed from satellite imagery and prosociality outcomes obtained from prior research. We first estimate the ICC for vegetation conditions using Landsat satellite imagery. Specifically, we calculated the

NDVI, which is the same remote-sensing indicator used in this study to derive cell-level estimates of forest carbon stocks. We overlaid these NDVI values onto the 30 m × 30 m grid cells that will serve as the primary unit of analysis and computed within- and between-VCF variation. Across all VCFs in our study area, the average number of grid cells per VCF was 505.3. Based on this spatial structure, we estimate an ICC of 0.18.

For prosociality-related outcomes, we draw on data from a prior study conducted in the CHT that implemented incentivized trust and dictator games using data from 40 households across four villages (Higashida et al., 2025). Based on these data, the estimated ICCs are 0.01 for the trust game and 0.14 for the dictator game.

Table 3. Minimum detectable effect (SD units) by assumed ICC (20 VCFs per arm)

ICC (ρ)	Forest carbon stock (m = 400)	Prosociality (m = 20)
0.1	0.20	0.24
0.2	0.28	0.31
0.3	0.34	0.36
0.4	0.40	0.41
0.5	0.44	0.45

Following these empirical estimates of cluster size and ICC, we parameterize the power calculations using assumptions aligned with the structure of our experimental design. We assume 20 VCFs per arm (CES, PES, and Control) and employ an ANCOVA specification with an assumed R^2=0.5. Although the average number of grid cells per VCF is approximately 505, we conservatively set the cluster size to m=400 grid cells when computing detectable effects. For prosociality-related outcomes, we plan to survey approximately 20 individuals per community and therefore set the cluster size to m=20.

For two-arm comparisons (e.g., CES vs. PES or each treatment arm vs. Control), we calculate standardized MDEs under a range of ICC values (ρ) from 0.1 to 0.5, while using ρ=0.2 as the primary value for interpretation. The resulting detectable effect sizes are summarized in Table 3.

As shown in Table 3, the MDEs are broadly similar for cell-level forest carbon stock outcomes and individual-level prosociality measures. For plausible ICC values in the range of 0.1 to 0.5, the MDE for a two-arm comparison with 20 VCFs per group ranges from approximately 0.20 to 0.45 standard deviations. Using our preferred ICC value of 0.2, the corresponding MDEs are 0.28 standard deviations for forest carbon stocks and 0.31 standard deviations for prosociality outcomes.

Figure 2: Minimum Detectable Effect as a Function of the Intra-Cluster Correlation

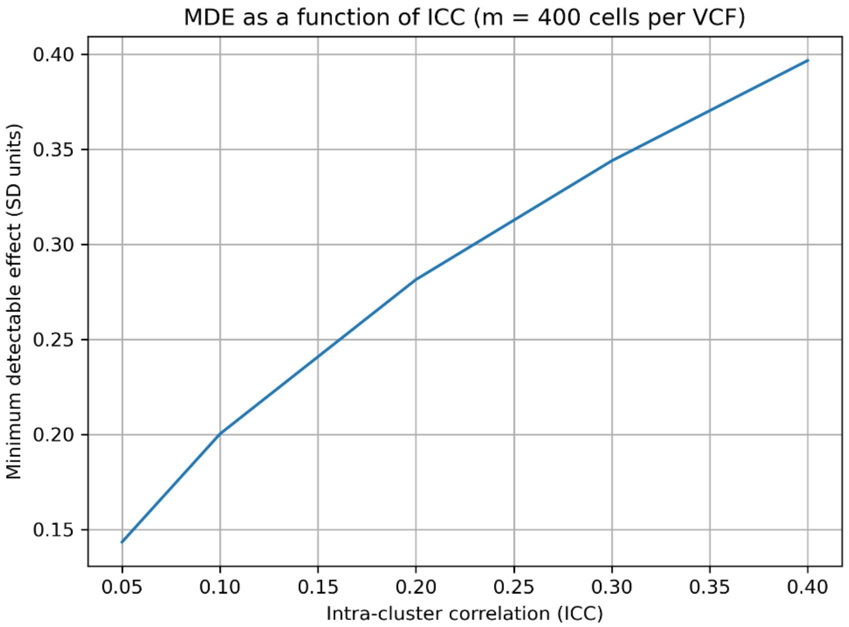

Figure 3: Minimum Detectable Effect as a Function of the Number of Cells per VCF

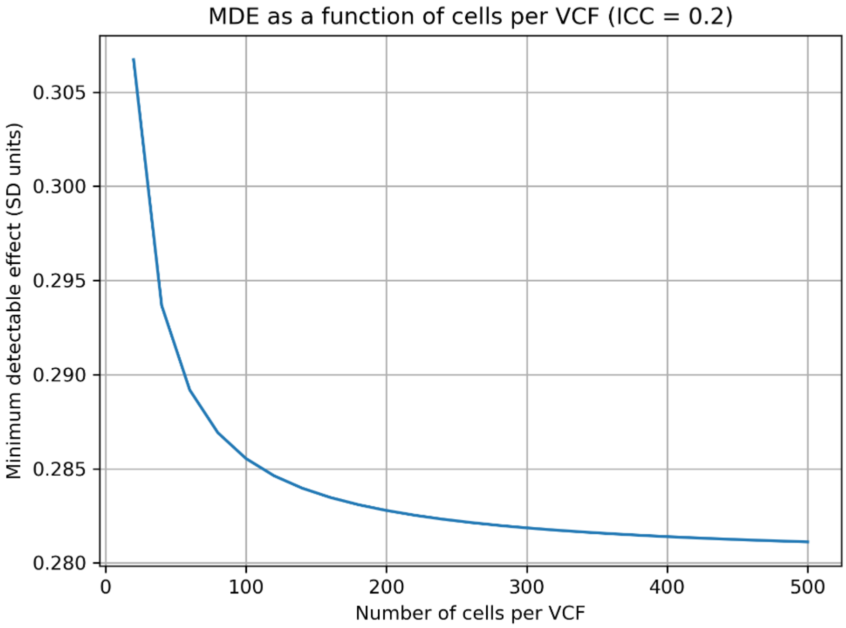

Figure 2 plots the MDE as a function of the ICC, holding the number of VCFs and the number of cells per VCF fixed, highlighting that statistical power is mainly driven by the degree of within-VCF correlation. To illustrate the limited role of additional within-cluster observations once m is large, Figure 3 plots the MDE against the number of cells per VCF for a fixed ICC of 0.2. The curve declines initially but quickly flattens, indicating that beyond a moderate number of cells per VCF, further increases in cell-level observations contribute little to power relative to the number of clusters and the ICC.

As an additional sensitivity check, we will complement the analytical MDE calculations with a non-parametric bootstrap using the baseline cell-level carbon data. Specifically, we will repeatedly resample VCFs with replacement, preserve the cluster structure of the data, and compute the sampling distribution of treatment–control differences under varying ICC assumptions.

3 Data

3.1 Data collection and processing

Forest Carbon Stock Measurement. The primary outcome variable is the amount of forest carbon conserved within each VCF. Carbon conservation is central both to the payment calculations under the PES and CES interventions and to evaluating the causal impacts of introducing competitive mechanisms into community-based forest management.

We will estimate forest carbon stocks using a DJI Mavic 3 Multispectral drone, which captures standard RGB imagery as well as Green, Red, Red Edge, and Near Infrared (NIR) spectral bands. Carbon stock data will be collected at three points in time: the pre-intervention baseline in January 2026 and the follow-up measurements in January 2027 and January 2028, corresponding to one and two years after the intervention, respectively.

The multispectral bands enable the construction of vegetation indices such as the NDVI, which provides information on vegetation vigor. However, NDVI exhibits saturation in dense canopy conditions and therefore offers only an indirect proxy for biomass. To complement these indices, we will generate canopy height estimates using Structure-from-Motion (SfM) photogrammetry from Unmanned Aerial Vehicle (UAV) derived point clouds. The combination of spectral information and canopy structure provides a more robust basis for estimating above-ground biomass.

To calibrate these remote-sensing measures, we will establish approximately one to two ground plots in each VCF (roughly 60–120 plots in total). Plot-level biomass will be measured through standard forestry inventory methods, including tree diameter measurements, height assessments, and application of allometric equations. These ground-based estimates will be used to develop predictive equations linking above-ground biomass density to UAV-derived vegetation indices and canopy height.

Carbon conservation will be calculated as the change in estimated above-ground carbon stock between the baseline and each follow-up period. Because these carbon estimates will be used as the basis for PES and CES payments, we will construct a VCF-level measure expressed as tons of carbon per hectare (tC/ha) to account for differences in VCF size.

For the main empirical analysis, each VCF will be divided into a regular grid of 30 m × 30 m cells, and carbon stock will be estimated at the cell level using the calibrated prediction equation derived from UAV-based and ground-plot data. This gridded structure allows for spatially explicit estimation and more precise identification of treatment effects across heterogeneous forest areas. The cell-level analysis leverages within-VCF variation while accounting for clustering of observations within communities through appropriate standard error adjustments.

Survey Data Collection. We will conduct questionnaire surveys in all 60 communities before and after the intervention (referred to as the baseline and endline surveys, respectively). The surveys will target two groups: all members of the forest management committee (typically around ten individuals) and a randomly selected sample of ten non-committee community members from each community. For the latter group, we randomly select ten households from a comprehensive household list obtained from each community; one adult member from each selected household will be invited to participate in the survey. This sampling strategy yields approximately 20 respondents per community, resulting in a total of 1,200 observations across the 60 communities in each survey round. Because committee members serve fixed terms of approximately three years and are periodically replaced, the surveys will generate cross-sectional—not balanced panel—data at both baseline and endline.

Across respondents, we will collect information on socioeconomic and demographic characteristics, including income, assets, education, and household composition. For committee members, we will additionally gather detailed data on labor contributions to forest management, including time spent on patrolling, tree planting, and other conservation activities.

Behavioral Game Experiments. To investigate the mechanisms through which competition affects forest conservation, we will integrate three incentivized behavioral game experiments at both baseline and endline surveys. The monetary incentives associated with each game follow parameter values established in prior experimental research (Higashida et al., 2025; Higashida et al., 2024).

First, the **dictator game** will be used to measure prosociality toward different types of recipients. As described above, we implement three versions of the game: one involving an in-group recipient, one involving an out-group recipient from another community assigned to the same treatment status, and one involving an out-group recipient from a community not participating in the study. In each version, the participant is endowed with 150 BDT and chooses how much (0–150 BDT) to allocate to the designated recipient. The recipient has no decision to make and simply receives the allocated amount. The amount given measures the participant's willingness to sacrifice their own payoff for the benefit of the respective recipient type. After all three dictator game decisions are completed, one of the participant's dictator game choices is randomly selected for payment. Earnings from the dictator game are determined based on the selected allocation decision.

Second, we conduct a trust game to measure trust and reciprocity toward both in-group and out-group partners. Each participant is endowed with 300 BDT. The participant (Player A) chooses how much to send to an anonymous recipient (Player B), selecting one of three amounts: 0, 100, or 300 BDT. The amount sent is tripled. Player B then chooses how much to return to Player A, selecting one of five options corresponding to 0%, 25%, 50%, 75%, or 100% of the tripled amount received. The amount sent by Player A measures trust, while the amount returned by Player B measures reciprocity.

We implement two versions of the game: in the in-group version, Player B is an anonymous member of the participant's own community; in the out-group version, Player

B is an anonymous member of another community assigned to the same treatment status. The game is conducted using the strategy method: each participant makes decisions both as Player A (how much to send) and as Player B (how much to return for each possible amount received). After all decisions are made, one of the participant's trust game decisions (across roles and versions) is randomly selected for payment. Final earnings from the trust game are calculated as the participant's initial endowment minus any amount sent when acting as Player A, plus any amount received based on the matched counterpart's return decision when the participant is assigned the role of Player B.

Third, we will conduct the **donation choice game**, adapted from Bursztyn et al. (2020). In this task, participants are asked whether they authorize a 150 BDT donation to be made on their behalf to a randomly selected para assigned to the same treatment status as theirs within the CHT. The donation is financed entirely by the research team; participants do not incur any personal financial cost. The identity of the recipient community is anonymized, and participants are informed that the donation will be actually implemented after the study. This decision therefore provides an incentive-compatible behavioral measure of participants' generosity toward another community within the CHT, as refusing to authorize a costless donation indicates a behavioral preference to avoid benefiting the out-group community.

3.2 Variations from the intended sample size

We anticipate a 100% take-up rate for all treatment arms. Treatment assignment occurs at the VCF level, and communities are informed of their assignment when the intervention begins in March 2026. Several factors support our expectation of universal take-up. First, forest management committees already exist in all selected VCFs and have been managing their forests under traditional community-based arrangements for years. Participation in the PES or CES schemes imposes no additional administrative burden or responsibility beyond what committees already undertake. Second, there is substantial demand for payment schemes in the CHT, where communities face limited economic opportunities and forest-dependent livelihoods remain prevalent. Prior consultations with community leaders during the site selection phase indicated strong interest in participating in conservation payment programs. Third, participation carries no financial risk or upfront costs to communities; payments are entirely contingent on conservation outcomes and involve no contribution or co-financing requirement from communities.

While take-up is expected to be universal, there is a potential risk of reduced sample size due to attrition—defined here as communities withdrawing from the intervention or refusing to participate in endline data collection. However, we consider this risk to be very low for several reasons. First, forest management committees hold formal responsibility for VCF stewardship regardless of whether this research project exists. The intervention does not impose new obligations; it merely provides additional financial incentives for activities that committees are already mandated to perform. Communities assigned to treatment arms thus face no additional burden that might motivate withdrawal. Second, even if a community's forest carbon stock declines during the intervention period—perhaps due to drought, pest outbreaks, or other factors beyond their control—there is no penalty or negative consequence, eliminating a key source of attrition risk. Third, even communities in the CES treatment that rank below the median face positive expected payments and thus have continued incentives to participate.

In the unlikely event that a community wishes to withdraw from the study, we will document the reasons for withdrawal and assess whether the community's characteristics differ systematically from those that remain. If attrition occurs and appears to be non-random, we will conduct sensitivity analyses.

4 Analysis

4.1 Model specifications

In this study, following recent PES literature that conducts spatially disaggregated analysis (Alix-Garcia et al., 2015; Charoud et al., 2023; Cisneros et al., 2022), we will conduct the estimation at the cell level rather than the VCF level. Each VCF will be divided into a grid of 30 m × 30 m cells, and forest carbon stock will be estimated for each cell using the calibrated prediction equation described earlier. These cell-level observations will serve as the primary unit of analysis. As a robustness check, we will also estimate the same regression model at the VCF level.

Because we will construct a panel dataset of cell-level forest carbon stocks, our main empirical specification will use an analysis of covariance (ANCOVA) model, following McKenzie (2012). Specifically, we will estimate the following linear regression:

$$Y_{ij} = \beta_1 CES_j + \beta_2 PES_j + Y_{ij,0} + e_{ij}$$

where Y_i is the follow-up carbon stock for cell i in VCF j. CES_j and PES_j are the dummy variables equal to one if VCF j is assigned to the CES or PES treatment arm, respectively. $Y_{ij,0}$ represents the baseline value of the outcome in the same cell. Because the intervention is assigned at the VCF level, all standard errors will be clustered at the VCF level.

In contrast, conservation efforts (i.e., labor inputs for forest management activities) and social preference measures are observed only cross-sectionally and therefore cannot be analyzed using an ANCOVA specification. Accordingly, we estimate treatment effects on these outcomes using a standard ordinary least squares (OLS) specification, excluding the baseline outcome $Y_{ij,0}$ from the ANCOVA model and conducting the analysis at the individual level. In these regressions, we will include a set of control variables reflecting respondents' demographic characteristics, such as gender and years of education, as well as behavioral traits including competitiveness and risk preferences. As a robustness check, for the subset of observations in which forest management committee membership remains unchanged over the study period, we additionally estimate treatment effects using an ANCOVA specification.

In addition, to assess the external validity of our findings for real-world PES implementation, we will also compute hypothetical payments under a baseline-only rule, in which each community's payment depends solely on the change in its own forest carbon stock relative to its pre-intervention baseline, without adjustment for control-group trends. Specifically, for each treated community, we calculate what its payment would have been under this alternative rule and compare the resulting payment distribution to that observed under the relative-to-control rule used in the experiment.

4.2 Multiple outcome and multiple hypothesis testing

To address concerns related to multiple hypothesis testing, we report Anderson's sharpened q-values alongside conventional p-values. This approach controls the false discovery rate and provides a more conservative assessment of statistical significance when testing multiple outcomes.

4.3 Exploratory heterogeneity and spillover analysis

Given the relatively small number of clusters, we treat the heterogeneous effects analysis as exploratory. These analyses are intended to provide suggestive evidence regarding mechanisms rather than definitive tests.

We will examine treatment effect heterogeneity along three dimensions that are directly relevant to both conservation outcomes and the underlying behavioral mechanisms. First, for forest carbon outcomes, we assess heterogeneity with respect to pre-intervention vegetation conditions. Using baseline drone-based measures of forest carbon and vegetation indices, we test whether treatment effects differ between VCFs with relatively higher versus lower initial forest quality.

Second, within the CES treatment arm, we examine variation by relative performance. Because CES explicitly introduces performance-based differentiation, we compare outcomes between communities that rank in the upper versus lower half of the CES performance distribution. Importantly, relative performance is a post-treatment outcome. Therefore, this comparison should not be interpreted as a causal heterogeneous treatment effect based on pre-treatment characteristics. Rather, we present this analysis as exploratory evidence aimed at shedding light on potential mechanisms. In particular, it allows us to assess whether lower-performing CES communities exhibit differential social responses—such as reduced within-group prosociality—which would be consistent with competition generating adverse social dynamics among communities that struggle to compete. Given the relatively small number of clusters, these performance-conditioned comparisons are interpreted cautiously.

Third, we examine heterogeneity with respect to baseline characteristics measured prior to the intervention. Specifically, we interact treatment indicators with pre-intervention measures of behavioral traits from incentivized games—such as trust, reciprocity, and in-group prosociality—as well as key demographic characteristics, including gender and education.

In addition to the heterogeneous analyses described above, we conduct an exploratory analysis of potential spillover effects. A common concern in PES settings is leakage, whereby conservation within monitored areas may shift degradation to adjacent areas. Because VCF boundaries are fixed ex ante and shapefiles are available, we are able to examine forest outcomes in buffer zones surrounding each VCF. Specifically, we test whether treatment assignment is associated with changes in forest carbon or deforestation indicators in areas immediately outside VCF boundaries.

Finally, we examine whether the interventions affect the composition and dynamics of VCF management committees. Performance-based payments under CES may alter incentives for participation in committee governance—for instance, by attracting more competitive or engaged individuals, or by increasing retention among existing members. We assess this along two dimensions. First, we estimate treatment effects on committee member turnover rates between baseline and endline. Second, we present descriptive comparisons of committee member characteristics—including behavioral traits measured through incentivized games—across treatment arms at endline. Because these comparisons cannot distinguish selection effects from attitudinal changes among continuing members, and given the limited number of clusters, we treat this analysis as purely exploratory.

4.4 Interpreting the results

Payment effect (Hypothesis 1). If payment schemes effectively enhance conservation, we expect positive and significant coefficients for both CES (β_1) and PES (β_2) when regressing endline carbon stocks on treatment indicators and baseline values. In addition, we expect both treatments to increase conservation efforts among VCF management committee members, reflected in higher labor inputs devoted to forest management activities. Together, these effects would confirm that monetary incentives raise conservation outcomes and the underlying management effort relative to conventional forest management. While this relationship for PES is well established in the prior literature, confirming it in our setting provides a validity check and establishes a benchmark for evaluating the incremental effect of competition.

Competition effect (Hypothesis 2). We test whether competition provides additional conservation benefits by comparing β_1 to β_2. If $\beta_1 > \beta_2$, this indicates that the performance-based differentiation in CES generates stronger incentives than uniform PES payments despite identical average compensation. The magnitude of this effect is policy-relevant: a large competition premium would suggest efficiency gains, though this must be weighed against potential negative externalities on intergroup relations. If $\beta_1 \leq \beta_2$, competition may be ineffective or may backfire by undermining intrinsic motivations.

Mechanisms (Hypotheses 3a and 3b). We examine two competing pathways through which competition may enhance the effectiveness of community-based forest management: (i) strengthened within-community cohesion and (ii) parochial altruism. Under both mechanisms, competition is expected to increase in-group cooperation, reflected in higher levels of in-group prosociality and trust. The key distinction lies in how competition affects prosocial behavior toward out-group members.

- Hypothesis 3a (Social Cohesion): Competition strengthens within-community cooperation while maintaining relations with other communities. Under this mechanism, CES is expected to increase in-group prosociality and trust relative to PES, without reducing prosociality toward out-group members and communities. Empirically, this implies no decline in generosity toward out-group members, as measured by allocations in out-group dictator games and donation authorization rates. Evidence consistent with this hypothesis would indicate that CES can be scaled without generating adverse social spillovers across communities.
- Hypothesis 3b (Parochial Altruism): Competition strengthens in-group cooperation at the expense of prosocial behavior toward out-group members. Under this mechanism, CES is expected to increase in-group prosociality and trust relative to PES, while reducing generosity toward out-group members. Empirically, this would be reflected in lower allocations in out-group dictator games and lower donation authorization rates under CES. Such a pattern would raise concerns about the scalability of CES, as local conservation gains may come at the cost of weakened intercommunity prosociality and broader social cohesion.

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Appendix A: Administrative information

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Appendix B: Theoretical Model

B.1 Model Setup and Primitives

As explained in the main text, we examine the three types of institutional regimes for the forest management by communities: conventional community forest management (baseline), PES, and CES. In particular, in this appendix, we provide the formal theoretical analysis for and comparison among these regimes in details by using general utility functions.

B.1.1 Environment

We consider a community of N members ($N \geq 2$) collectively managing a shared forest. Each individual *i* chooses an effort level $e_i \geq 0$ toward collective forest management activities. These activities encompass both protective actions (monitoring to prevent illegal logging and livestock intrusion) and productive actions (planting, watering, thinning, pruning) that enhance forest stock.

B.1.2 Production Function of the Forest Stock

The total forest stock improvement is determined by the aggregate effort:

$$E = \Sigma e_i$$

We assume a linear relationship between effort and forest stock improvement for tractability. The ecological benefit from improved forest stock is $\alpha\gamma E$, where $\gamma > 0$ represents the physical productivity of effort in enhancing forest stock (units of forest improvement per unit of effort) and $\alpha > 0$ captures the per-unit utility value of forest conservation to community members. It is assumed that each individual receives an equal share of the total benefit, that is, $(\alpha\gamma/N) \cdot E$.

B.1.3 Cost for allocating labor for forest management activities

Each individual in the community allocates a fixed amount of labor time ($\bar{L}_i (= \bar{L})$) between forest management activities ($l_{e,i}$) and their own economic activities ($l_{x,i}$), such as agriculture. Given mechanisms and efficiency of cooperation among community members, an increase in the time allocated to forest management activities reduces the time allocated to economic activities. One unit of labor input for economic activity generates one unit of income (x_i), which accrues to the individual who performed the economic activity[1].

$$x_i = l_{x,i}.$$

We assume that the marginal "created effort" by labor input is decreasing. In other words, the marginal cost for creating an additional unit of effort is increasing. The basic relationship between the time allocated to forest activities and the corresponding effort level is given by

$$e_i = \left(2\lambda l_{e,i}/c\right)^{1/2} \qquad \Leftrightarrow \qquad l_{e,i} = (c/2\lambda) \cdot e_i^2$$

where $c > 0$ is a baseline cost parameter (disutility of effort), which is common to all community members. $\lambda\,(> 0)$ is the degree of cooperation of community members (cooperation parameter), which is also common for all community members. The cooperation parameter captures the degree to which internal cohesion, mutual support, trust, peer monitoring, and social norms reduce the marginal cost of contributing effort. Higher λ implies:

- Stronger social bonds that make effort provision less burdensome
- More effective peer monitoring that reduces free-riding

[1] In the case of agriculture, it can be assumed that as the proportion of labor time allocated to agriculture increases, the area of farmland also increases. This proportional increase is particularly likely in cases such as shifting cultivation. The negative externality of this increase in farmland area on forest conditions will be discussed in Section B.5.

- Shared norms that internalize the social cost of shirking
- Better coordination that makes effort more efficient

Thus, an increase in the degree of cooperation (λ) can be considered to decrease the cost of effort. We consider that institutional changes (baseline, PES, and CES) influence λ, the degree of cooperation.

B.1.4 Ingroup altruism and outgroup generosity

We consider two types of altruism of community members that influence the effort decisions: ingroup altruism, $h \in [0, \infty)$, and outgroup generosity, $g \in [0, \infty)$. The former measures prosocial behavior toward their own community which could manifest as:

- Willingness to share forest management knowledge with members of the same community
- Cooperation on within-community problems
- Implementation of more efficient monitoring systems
- Cooperation in adjusting tree species for planting to regenerate primary forests.

By contrast, the latter measures prosocial behavior toward members of other communities, which could manifest as:

- Willingness to share forest management knowledge with members of other communities
- Cooperation on inter-community problems (e.g., forest corridors, watershed management)
- Consent to researcher-provided donations to out-group communities
- Transfers to out-group members.

The larger h (g), the greater the degree of ingroup altruism (outgroup generosity).

Ingroup altruism (h) influences the effort decisions for forest management through two channels. First, it changes the degree of cooperation (λ) under both PES and CES as compared with the baseline forest management. Second, ingroup altruism improves coordination technology among community members and accumulate social capital such as trust and reciprocity norms, which increases the marginal effect of an increase in λ on the effectiveness of efforts. We denote the degrees of ingroup altruism under the baseline management, PES, and CES as h_{base}, h_{PES}, h_{CES}, respectively.

Similarly, outgroup generosity (g) influences the effort decisions through two channels only under CES, because under the baseline management or PES, the gains of a community are not affected by the forest management activities in other communities. Therefore, with regard to the forest management issue currently under consideration, outgroup generosity does not affect the effort decisions under the baseline management or PES. First, it changes the degree of cooperation (λ) under CES as compared with the baseline forest management and PES. Second, competition with another community may improve coordination technology among community members through the motivation to win the competition. This effect increases the marginal effect of an increase in λ on the effectiveness of efforts. How the second factor is incorporated into the utility function will be described in the subsection for CES (B.2.3). We denote the degree of outgroup generosity under the baseline management, PES, and CES as g_{base}, g_{PES}, and g_{CES}, respectively. Because outgroup generosity changes only under CES, we assume that $g_{base} = g_{PES} = g_0$ holds.[2]

B.1.5 Cooperation Across Regimes

From the definition of ingroup altruism and outgroup generosity, the degree of cooperation can be written as $\lambda(h, g)$. In particular, λ under each institution can be written as follows:

$$\lambda_{base} = \lambda(h_{base}, g_0)$$

$$\lambda_{PES} = \lambda(h_{PES}, g_0),$$

$$\lambda_{CES} = \lambda(h_{CES}, g_{CES}).$$

For the following analysis, we set up the following assumptions.

Assumption 1. $\partial\lambda/\partial h > 0, \;\; \partial\lambda/\partial g < 0.$

[2] We consider the evolution of ingroup altruism and outgroup generosity in Section B.4.

The first inequality is intuitive. An increase in ingroup altruism strengthens the cohesion of the community. Then, members collaborate to build more effective schemes for productive and protective activities. By contrast, in general, the effect of outgroup generosity on the degree of cooperation may be negative or positive. First, in many cases in the real world, an increase in parochial altruism and a decrease in outgroup generosity are two sides of the same coin. In such a case, a decrease in outgroup generosity strengthens the social cohesion of the community, and $\partial\lambda/\partial g < 0$ holds. Second, an increase in outgroup generosity gives the community members an incentive to consider the other communities' forest stock management. Because the restoration of forest resources in this community may generate positive externalities for forest resources in other communities, an increase in outgroup generosity may lead to more effective productive and protective activities. In such a case, $\partial\lambda/\partial g > 0$ holds. The second inequality in Assumption 1 implies that the former effect dominates the latter effect.

Assumption 2: $\lambda_{base} > 0,\ \lambda_{PES} > 0,\ \lambda_{CES} > 0$

These inequalities are also reasonable assumptions that do not compromise generality, because the relative magnitude of the degree of cooperation under the three institutions is crucial for the following analysis.

B.1.6 Timing and Information

Stage 1 (Cooperation Formation): The degree of cooperation level (λ) is determined. This stage is influenced by the following exogenous factors:

- The institutional regime (base, PES, or CES)
- Basic community characteristics (baseline social capital, leadership quality)
- Changes in ingroup altruism and outgroup generosity

Note that we do not consider a two-stage game in which communities choose their degree of cooperation collectively to maximize their community's welfare. Instead, we assume that ingroup altruism and outgroup generosity are determined exogenously depending on the institution, the baseline management, PES, or CES. Then, the degree of cooperation is determined exogenously by both ingroup altruism and outgroup generosity.[3]

Stage 2 (Effort Choice): Given h amd g, each individual simultaneously choose their effort level, e_i, to maximize their own utility.

The remainder of Appendix B is organized as follows. Section B.2 derives equilibrium efforts in Stage 2 for a given h and g, and Section B.3 compares the equilibrium efforts under the three institutions; the baseline management, PES, and CES. Section B.4 considers how h and g and, accordingly, λ are determined in Stage 1. Section B.5 extends the analysis and incorporate the negative externality of forests caused by economic activities. Section B.6 focuses on the specific case with an additively separable utility function and provides a numerical example.

B.2 Stage 2: Individual Effort Choice Under Each Regime

B.2.1 Community-Based Baseline Forest Management (base)

Under the baseline management system (**base**), no external financial reward is provided. Communities rely solely on the intrinsic benefits of forest conservation. Individual $i's$ utility is:[4]

[3] To avoid unnecessarily complicating the mathematical expression, the function $\lambda(\cdot)$ does not explicitly include the variables of baseline social capital and leadership quality.

[4] When altruism is considered, the objective function of individual i is often defined as the weighted sum of their own utility and the utility of other individuals. Although we do not

$$u_i = U(M_{i,base},\ B) \tag{1}$$

where $M_{i,base}$ denotes the monetary gain for individual i, and B denotes the gains from forest stock improvement which is represented as

$$B = \alpha\gamma \sum_i e_i / N \tag{2}$$

Regarding the shape of the utility function, we make the following general assumptions.

Assumption 3: $\partial U/\partial M_{i,m} > 0,\ \partial U/\partial B > 0,\ \ \partial^2 U\big/\partial M_{i,m}^2 \leq 0,$

$$\partial^2 U/\partial B^2 \leq 0,\ \ \partial U^2/\partial M_{i,m}\partial B \geq 0, \quad m = base, PES, CES.$$

The labor-time constraint is

$$x_i + \left(\frac{c}{2H(h_{base})\lambda_{base}}\right) \cdot e_i^2 = \bar{L} \tag{3}$$

where $H(h_{base})$ represents the factors that enhance the effectiveness of cooperation among community members, such as coordination technology and social capital, which is the second channel through which ingroup altruism influences the effort decisions (see Subsection B.1.4). Hereafter, $H(h_{base})$ is denoted by H_{base}. Based on the above formulation, we assume that H takes a positive value. Also, because an increase in ingroup altruism is considered to enhance the coordination technology and increase social capital. Thus, we assume the following inequalities.[5]

explicitly incorporate such a channel through which altruism affects effort decisions, even if we introduce this third channel, the results do not change essentially.

[5] This channel can also be included within the function of λ: $\lambda(h, g, H(h))$. Here, for simplicity, we adopt the form of $H(h) \cdot \lambda(h, g)$. Moreover, we do not explicitly consider the monetary and psychological costs of investing in the coordination technology and social capital.

Assumption 4: $H > 0, \quad \frac{dH}{dh} > 0.$

Community members do not receive any payments for their forest management activities from an external organization in the baseline management. Thus,

$$M_{i,base} = x_i = \bar{L} - \left(\frac{c}{2H(h_{base})\lambda_{base}}\right) \cdot e_i^2 \qquad (4)$$

Each individual maximizes their utility, (1), subject to the labor-time constraint, (3). Substituting (2) and (4) into (1), we obtain[6]

$$u_{i,base} = U(\bar{L} - \left(\frac{c}{2H_{base}\lambda_{base}}\right) \cdot e_i^2,\ \alpha\gamma \sum_i e_i / N)$$

Then, the first-order condition (FOC) for individual i is:

$$\frac{\partial u_{i,base}}{\partial e_i} = -\frac{\partial U}{\partial M_{i,base}} \frac{ce_i}{H_{base}\lambda_{base}} + \frac{\partial U}{\partial B} \frac{\alpha\gamma}{N} = 0$$

(5)

From Assumption 3, the second-order condition (SOC) is satisfied:

$$\frac{\partial^2 u_{i,base}}{\partial e_i^2} = \frac{\partial^2 U}{\partial M_{i,base}^2} \left(\frac{ce_i}{H_{base}\lambda_{base}}\right)^2 - \frac{\partial U}{\partial M_{i,base}} \frac{c}{H_{base}\lambda_{base}} + \frac{\partial^2 U}{\partial B^2} \left(\frac{\alpha\gamma}{N}\right)^2 < 0$$

Moreover, it is obtained that

$$\frac{\partial^2 u_{i,base}}{\partial e_j \partial e_i} = \frac{\partial^2 U}{\partial B^2} \left(\frac{\alpha\gamma}{N}\right)^2 < 0, \qquad i \neq j,$$

which implies that strategic substitutes hold for efforts among community members. Consider the following matrix:

[6] This optimization can also be solved using the Lagrange multiplier method.

$$\begin{pmatrix} \frac{\partial^2 u_{1,base}}{\partial e_1^2} & \frac{\partial^2 u_{1,base}}{\partial e_1 \partial e_2} & \cdots & \frac{\partial^2 u_{1,base}}{\partial e_1 \partial e_N} \\ \frac{\partial^2 u_{2,base}}{\partial e_2 \partial e_1} & \frac{\partial^2 u_{2,base}}{\partial e_2^2} & \cdots & \frac{\partial^2 u_{2,base}}{\partial e_2 \partial e_N} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{\partial^2 u_{N,base}}{\partial e_N \partial e_1} & \frac{\partial^2 u_{N,base}}{\partial e_N \partial e_2} & \cdots & \frac{\partial^2 u_{N,base}}{\partial e_N^2} \end{pmatrix}$$

From Assumption 3,

$$\frac{\partial^2 u_{i,base}}{\partial e_i^2} < \frac{\partial^2 u_{i,base}}{\partial e_j \partial e_i} < 0, \qquad i \neq j,$$

holds. Therefore, all leading principal minors of odd order of the matrix are negative and that all leading principal minors of even order of the matrix are positive. Thus, the stability condition is satisfied.

Let circumflex (^) denote the equilibrium value in the second stage. In equilibrium, it holds that

$$\hat{e}_{i,base} = \hat{e}_{j,base} = \hat{e}_{base}, \qquad i \neq j.$$

Accordingly, $\alpha\gamma \sum \hat{e}_{base}/N = \alpha\gamma\hat{e}_{base}$ and

$$\hat{u}_{base} = \widehat{U}_{base} = U\big(\widehat{M}_{base}, \widehat{B}_{base}\big) = U(\bar{L} - \left(\frac{c\,\hat{e}_{base}}{2H(h_{base})\lambda_{base}}\right) \cdot \hat{e}_{base}^2,\ \alpha\gamma\hat{e}_{base})$$

hold. Then, from Eq. (5), the following condition holds in equilibrium regarding the effort of each individual under the baseline management:

$$\hat{e}_{base} = \frac{\partial\widehat{U}_{base}/\partial B}{\partial\widehat{U}_{base}/\partial M_{i,base}} \cdot \frac{\alpha\gamma}{N} \cdot \frac{H_{base}\lambda_{base}}{c} \tag{6}$$

or

$$(\Omega_{base} =) - \frac{\partial\widehat{U}_{base}}{\partial\widehat{\widehat{M}}_{base}} \frac{c\hat{e}_{base}}{H_{base}\lambda_{base}} + \frac{\partial\widehat{U}_{base}}{\partial\widehat{B}_{base}} \frac{\alpha\gamma}{N} = 0 \tag{7}$$

Then, the following inequalities are obtained.

$$\frac{\partial\Omega_{base}}{\partial\hat{e}_{base}} = \frac{\partial^2\widehat{U}_{base}}{\partial\widehat{M}_{base}^2} \left(\frac{c\hat{e}_{base}}{H_{base}\lambda_{base}}\right)^2 - \frac{\partial\widehat{U}_{base}}{\partial\widehat{M}_{base}} \frac{c}{H_{base}\lambda_{base}} + \frac{\partial^2\widehat{U}_{base}}{\partial\widehat{B}_{base}^2} \left(\frac{\alpha\gamma}{N}\right)^2 < 0$$

$$\frac{\partial^2 \Omega_{base}}{\partial N} = -\frac{\partial \widehat{U}_{base}}{\partial \widehat{B}_{base}} \cdot \frac{\alpha\gamma}{N^2} < 0$$

$$\frac{\partial^2 \Omega_{base}}{\partial \gamma \partial \hat{e}_{base}} = -\frac{\partial^2 \widehat{U}_{base}}{\partial \widehat{B}_{base}} \cdot \frac{\alpha\gamma}{N} \cdot \alpha \hat{e}_{base} + \frac{\partial \widehat{U}_{base}}{\partial \widehat{B}_{base}} \cdot \frac{\alpha}{N} > 0$$

These three inequalities indicate that (i) the larger the number of community members the smaller the effort of each community member, and (ii) the larger the physical productivity of effort in enhancing forest stock the greater the effort of each community member. Because an additional effort by individual i is equally shared by all community members, the larger the number of community members, the smaller the gains of individual i from their own additional effort. Therefore, each individual has less incentive for inputting labor into forest management activities as the number of community members becomes larger. Contrarily, the larger the physical productivity of effort in enhancing forest stock, the larger the gains of individual i from their own effort.

B.2.2 Payment for Ecosystem Services (PES)

Under PES, communities receive external payments $S(E) = \beta \cdot E$ where $\beta > 0$ represents the per-unit payment rate. Total payments are distributed equally among community members. In this case, the monetary gain of individual i is the sum of income from economic activities and revenue from PES system:

$$M_{i,PES} = x_i + \frac{\beta \sum e_i}{N} \tag{8}$$

Then, Individual utility is:

$$u_i = U(M_{i,PES},\ B) \tag{9}$$

The definition of B is the same as the baseline management, (2). The labor time constraint is rewritten as:

$$x_i + \left(\frac{c}{2H(h_{PES})\lambda_{PES}}\right) \cdot e_i^2 = \overline{L}, \tag{10}$$

where $H(h_{PES})$ $(= H_{PES})$ represents the factors that enhance the effectiveness of cooperation among community members under PES. Substituting (10) into (8) and, then, substituting (2) and (8) into (9), we obtain

$$u_{i,PES} = U(\bar{L} - \left(\frac{c}{2H_{PES}\lambda_{PES}}\right) \cdot e_i^2 + \frac{\beta \sum e_i}{N},\ \ \alpha\gamma \sum_i e_i/N)$$

The FOC for individusl i under PES is:

$$\frac{\partial u_{i,PES}}{\partial e_i} = -\frac{\partial U}{\partial M_{i,PES}}\left(\frac{ce_i}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right) + \frac{\partial U}{\partial B}\frac{\alpha\gamma}{N} = 0$$

(11)

We assume that the marginal opportunity cost of labor input for forest management is sufficiently larger than the marginal benefit from the payment from the external organization under PES: That is, $ce_i/H_{PES}\lambda_{PES} > \beta/N$. When this inequality is not satisfied, the corner solution may arise, in which each individual input all of their labor time for forest management activities. This is not realistic when considering the real situation and, thus, we focus on the interior solution.

Similar to the baseline forest management, from Assumption 3, the SOC is satisfied.

$$\frac{\partial^2 u_{i,PES}}{\partial e_i^2} = \frac{\partial^2 U}{\partial M_{i,PES}^2}\left(\frac{ce_i}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right)^2 - \frac{\partial U}{\partial M_{i,PES}}\frac{c}{H_{base}\lambda_{base}} + \frac{\partial^2 U}{\partial B^2}\left(\frac{\alpha\gamma}{N}\right)^2 < 0$$

Moreover, it is obtained that

$$\frac{\partial^2 u_{i,PES}}{\partial e_j \partial e_i} = -\frac{\partial^2 U}{\partial M_{i,PES}^2}\left(\frac{ce_i}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right) \cdot \frac{\beta}{N} + \frac{\partial^2 U}{\partial B^2}\left(\frac{\alpha\gamma}{N}\right)^2, \qquad i \neq j.$$

Because the first term of the cross partial derivative is positive, the sign of the cross partial derivative is ambiguous generally.

Consider the following matrix:

$$\begin{pmatrix} \frac{\partial^2 u_{1,PES}}{\partial e_1^2} & \frac{\partial^2 u_{1,PES}}{\partial e_1 \partial e_2} & \cdots & \frac{\partial^2 u_{1,PES}}{\partial e_1 \partial e_N} \\ \frac{\partial^2 u_{2,PES}}{\partial e_2 \partial e_1} & \frac{\partial^2 u_{2,PES}}{\partial e_2^2} & \cdots & \frac{\partial^2 u_{2,PES}}{\partial e_2 \partial e_N} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{\partial^2 u_{N,PES}}{\partial e_N \partial e_1} & \frac{\partial^2 u_{N,PES}}{\partial e_N \partial e_2} & \cdots & \frac{\partial^2 u_{N,PES}}{\partial e_N^2} \end{pmatrix}$$

From Assumption 3, if $\partial^2 u_{i,PES} / \partial e_j \partial e_i < 0$,

$$\frac{\partial^2 u_{i,PES}}{\partial e_i^2} < \frac{\partial^2 u_{i,PES}}{\partial e_j \partial e_i} < 0, \qquad i \neq j,$$

holds. Then, all leading principal minors of odd order of the matrix are negative and that all leading principal minors of even order of the matrix are positive. Thus, the stability condition is satisfied. Even if $\partial^2 u_{i,PES} / \partial e_j \partial e_i > 0$, if $ce_i / H_{PES}\lambda_{PES} > 2\beta / N$ holds, the absolute value of $\partial^2 u_{i,PES} / \partial e_i^2$ is larger than that of $\partial^2 u_{i,PES} / \partial e_j \partial e_i$. Therefore, the stability condition is likely to hold. In the following, we assume that the stability condition is satisfied under PES.

In equilibrium, it holds that

$$\hat{e}_{i,PES} = \hat{e}_{j,PES} = \hat{e}_{PES}, \qquad i \neq j.$$

Accordingly, $\alpha\gamma \sum \hat{e}_{PES} / N = \alpha\gamma \hat{e}_{PES}$ and

$$\hat{u}_{PES} = \widehat{U}_{PES} = U(\widehat{M}_{PES}, \widehat{B}_{PES}) = U(\bar{L} - \left(\frac{c\,\hat{e}_{PES}}{2H_{PES}\lambda_{PES}}\right) \cdot \hat{e}_{PES}^2 + \beta \hat{e}_{PES},\ \alpha\gamma \hat{e}_{PES})$$

hold. Then, from Eq. (11), the following condition holds in equilibrium regarding the effort of each individual under PES:

$$\hat{e}_{PES} = \left(\frac{\partial \widehat{U}_{PES} / \partial B}{\partial \widehat{U}_{PES} / \partial \widehat{M}_{PES}} \cdot \frac{\alpha\gamma}{N} + \frac{\beta}{N}\right) \frac{H_{PES}\lambda_{PES}}{c} \tag{12}$$

or

$$(\Omega_{PES} =) - \frac{\partial \widehat{U}_{PES}}{\partial \widehat{M}_{PES}} \left(\frac{c\hat{e}_{PES}}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right) + \frac{\partial \widehat{U}_{PES}}{\partial \widehat{B}_{PES}} \frac{\alpha\gamma}{N} = 0. \tag{13}$$

B.2.3 Competition for Ecosystem Services (CES)

Under CES, the basic scheme of the external payment is the same as that of PES in the sense that the reward is paid according to the effort of the community. However, the per-unit payment received by a community also depends on its relative total effort compared to the effort of another randomly selected community. Let asterisk (*) denotes the other community and, accordingly, E^* denotes the other community's total effort. We assume that the unit payment rate is given by:[7]

$$2\beta \cdot \pi = 2\beta \cdot \frac{E}{E+E^*}.$$

When the total effort of this community is the same as that of the other community ($E = E^*$), the payment rate is equal to β. If the total effort of this community is greater (smaller) than that of the other community, the payment rate is larger (smaller) than β. In this case, the monetary gain of individual i is the sum of income from economic activities and revenue from an external organization under the CES system:

$$M_{i,CES} = x_i + \frac{2\beta \sum e_i}{N} \cdot \frac{E}{E+E^*} \tag{14}$$

Then, individual utility is:

$$u_i = U(M_{i,CES},\ B) \tag{15}$$

The definition of B is the same as the baseline management, (2). The labor time constraint is rewritten as:

$$x_i + \left(\frac{c}{2\cdot(H(h_{CES})+G(g_{CES}))\cdot\lambda_{CES}}\right) \cdot e_i^2 = \overline{L} \quad ,$$

(16)

[7] In the contest theory, it is sometimes assumed that the winner gains all of the fixed prize. Then, one of the representative winning probability function is $\pi(E, E_*) = E/(E + E_*)$. See, for example, Nitzan and Ueda (2011).

where $H(h_{CES})$ $(= H_{CES})$ represents the factors that enhance the effectiveness of cooperation among community members under CES. Moreover, $G(g_{CES})$ $(= G_{CES})$ represents the effect of outgroup generosity on the effectiveness of cooperation through the motivation to win under CES. This factor is the second channel through which outgroup generosity influences the effort decisions (see Subsection B.1.4): The greater the outgroup generosity, the weaker the motivation of the community to win under CES. Conversely, we consider that outgroup generosity is neutral under the baseline management and PES, because there is no competition between communities and, accordingly, under these institutions, the actions of members in other communities have no impact on the benefits of this community generated by the forest management efforts. Moreover, based on the above formulation, we assume that $H + G$ takes a positive value. Thus, we set up the following assumptions.

Assumption 5: $G(g_{base}) = G(g_{PES}) = G(g_0) = 0, \quad \frac{dG}{dg} < 0, \quad H + G > 0.$

Because of the first assumption in Assumption 5, we do not explicitly include G(·) in the utility functions under the baseline management and PES.

Substituting (16) into (14) and, then, substituting (2) and (14) into (15), we obtain

$$u_{i,CES} = U(\bar{L} - \left(\frac{c}{2\,(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right)\cdot e_i^2 + \frac{2\beta\sum e_i}{N}\cdot\frac{E}{E+E^*},\;\; \alpha\gamma\sum_i e_i/N)$$

(17)

The FOC is given by

$$\frac{\partial u_{i,CES}}{\partial e_i} = -\frac{\partial U}{\partial M_{i,CES}}\left(\frac{ce_i}{(H_{CES}+G_{CES})\cdot\lambda_{CES}} - \frac{2\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2}\right) + \frac{\partial U}{\partial B}\frac{\alpha\gamma}{N} = 0$$

(18)

Also, the second partial derivative with respect to e_i is

$$\frac{\partial^2 u_{i,CES}}{\partial e_i^2} = \frac{\partial^2 U}{\partial M_{i,CES}^2}\left(\frac{ce_i}{H_{PES}\lambda_{PES}} - \frac{2\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2}\right)^2 - \frac{\partial U}{\partial M_{i,CES}}\cdot\left(\frac{c}{H_{base}\lambda_{base}} - \frac{4\beta}{N}\cdot\frac{E^{*2}}{(E+E^*)^3}\right)$$

$$+\frac{\partial^2 U}{\partial B^2}\left(\frac{\alpha\gamma}{N}\right)^2 .$$

Because the second term is not necessarily negative, the SOC is not necessarily satisfied globally. However, the external payment is not very large as compared with the marginal opportunity cost of inputting labor time for forest management activities, the sign of the parenthesis in the second term is positive. In such a case, the SOC is satisfied.

Furthermore, cross partial derivatives are obtained as follows:

$$\frac{\partial^2 u_{i,CES}}{\partial e_j \partial e_i} = -\frac{\partial^2 U}{\partial M_{i,CES}^2}\left(\frac{ce_i}{H_{CES}\lambda_{CES}} - \frac{2\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2}\right)\cdot\frac{2\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2} + \frac{\partial U}{\partial M_{i,CES}}\cdot\frac{4\beta}{N}\cdot\frac{E^{*2}}{(E+E^*)^3}$$

$$+\frac{\partial^2 u_{i,CES}}{\partial B^2}\left(\frac{\alpha\gamma}{N}\right)^2, \qquad i \neq j.$$

$$\frac{\partial^2 u_{i,CES}}{\partial e_k^* \partial e_i} = \frac{\partial^2 U}{\partial M_{i,CES}^2}\left(\frac{ce_i}{H_{CES}\lambda_{CES}} - \frac{2\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2}\right)\cdot\frac{2\beta}{N}\cdot\frac{E^2}{(E+E^*)^2} - \frac{\partial U}{\partial M_{i,CES}}\frac{4\beta}{N}\cdot\frac{EE^*}{(E+E^*)^3}<0,$$

where k is the index for the members of the other community, which are the rival community under CES. Consider the following matrix:

$$\begin{pmatrix}
\frac{\partial^2 u_{1,CES}}{\partial e_1^2} & \cdots & \frac{\partial^2 u_{1,CES}}{\partial e_1 \partial e_N} & \frac{\partial^2 u_{1,CES}}{\partial e_1 \partial e_1^*} & \cdots & \frac{\partial^2 u_{1,CES}}{\partial e_1 \partial e_N^*} \\
\cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\
\frac{\partial^2 u_{N,CES}}{\partial e_N \partial e_1} & \cdots & \frac{\partial^2 u_{N,CES}}{\partial e_N^2} & \cdots & \cdots & \frac{\partial^2 u_{N,CES}}{\partial e_N \partial e_N^*} \\
\frac{\partial^2 u_{1,CES}^*}{\partial e_1^* \partial e_1} & \cdots & \cdots & \frac{\partial^2 u_{1,CES}^*}{\partial e_1^{*2}} & \cdots & \frac{\partial^2 u_{1,CES}^*}{\partial e_1^* \partial e_N^*} \\
\cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\
\frac{\partial^2 u_{N,CES}^*}{\partial e_N^* \partial e_1} & \cdots & \frac{\partial^2 u_{N,CES}^*}{\partial e_N^* \partial e_N} & \frac{\partial^2 u_{N,CES}^*}{\partial e_N^* \partial e_1^*} & \cdots & \frac{\partial^2 u_{N,CES}^*}{\partial e_N^{*2}}
\end{pmatrix}$$

If the external payment is not very large as compared with the marginal opportunity cost of inputting labor time for forest management activities, that is, if

$$\frac{ce_i}{H_{CES}\lambda_{CES}} > \frac{4\beta}{N}\cdot\frac{E^2+2EE^*}{(E+E^*)^2}$$

holds,

$$\frac{\partial^2 u_{i,CES}}{\partial e_i^2} < \frac{\partial^2 u_{j,CES}}{\partial e_j \partial e_i} < 0, \qquad i \neq j, \quad \text{and} \quad \frac{\partial^2 u_{i,CES}}{\partial e_i^2} < \frac{\partial^2 u_{j,CES}}{\partial e_k^* \partial e_i} < 0$$

holds. Then, all leading principal minors of odd order of the matrix are negative and that all leading principal minors of even order of the matrix are positive. Thus, the stability condition is satisfied. In the following, we assume that the SOC and stability condition are satisfied under CES.

For simplicity, we focus on the case in which two identical communities engage in competition for the external payment under CES, which implies that the degrees of cooperation determined in the first stage are always the same: $H_{CES} = H_{CES}^*$, $G_{CES} = G_{CES}^*$, $\lambda_{CES} = \lambda_{CES}^*$. Note also that $N = N^*$. Then, in equilibrium, it holds that

$$\hat{e}_{i,CES} = \hat{e}_{j,CES} = \hat{e}_{CES} = \hat{e}_{CES}^*, \qquad i \neq j.$$

Accordingly, $\alpha\gamma \sum \hat{e}_{CES}/N = \alpha\gamma\hat{e}_{CES}$ and

$$\hat{u}_{CES} = \hat{U}_{CES} = U\big(\hat{M}_{CES}, \hat{B}_{CES}\big) = U(\bar{L} - \left(\frac{c\,\hat{e}_{CES}}{2\cdot(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right)\cdot \hat{e}_{CES}^2 + \beta\hat{e}_{CES},\ \alpha\gamma\hat{e}_{CES})$$

hold. Then, from Eq. (18), the following condition holds in equilibrium regarding the effort of each individual under CES:

$$\hat{e}_{CES} = \left(\frac{\partial\hat{U}_{CES}/\partial B}{\partial\hat{U}_{CES}/\partial\hat{M}_{CES}} \cdot \frac{\alpha\gamma}{N} + \frac{3\beta}{2N}\right)\frac{(H_{CES}+G_{CES})\cdot\lambda_{CES}}{c}$$

(19)

or

$$(\Omega_{CES} =) - \frac{\partial\hat{U}_{CES}}{\partial\hat{M}_{CES}}\left(\frac{c\hat{e}_{CES}}{(H_{CES}+G_{CES})\cdot\lambda_{CES}} - \frac{3\beta}{2N}\right) + \frac{\partial\hat{U}_{CES}}{\partial\hat{B}_{CES}}\frac{\alpha\gamma}{N} = 0$$

(20)

B.3 Comparative Statics

Let us now compare equilibrium efforts across institutions.

B.3.1 Essential effect of institutions (Holding the degree of cooperation constant)

First, we assume that institutional changes do not influence ingroup altruism and outgroup generosity, which implies:

$$h_{base} = h_{PES} = h_{CES}, \quad g_{base} = g_{PES} = g_{CES} = g_0,$$

$$\lambda_{base} = \lambda_{PES} = \lambda_{CES}, \quad H_{base} = H_{PES} = H_{CES}, \quad G(g_{ces}) = 0.$$

Then, the following result is obtained.

Proposition 1. Essential effect of institutions: *Suppose that institutional changes do not influence ingroup altruism and outgroup generosity. Then, (i) the equilibrium effort under PES is necessarily greater than that under the baseline management. Moreover, consider the symmetric equilibria both under PES and CES when the two communities competing with each other in the CES are identical. Then, (ii) the equilibrium effort under CES is greater than that under PES.*

Proof: To verify (i) to hold, compare Eq. (5) with Eq. (11). For any given effort level of i, e_i, and the sum of other community members' effort levels, $\sum_{j=-i} e_j$, the second terms in the right-hand sides of both equations are the same.

Because each individual receives an additional revenue from the outside organization under PES, the marginal opportunity cost of inputting an additional unit of labor into the forest management activities under PES, $ce_i/H_{PES}\lambda_{PES} - \beta/N$ in (11), is smaller than that under the baseline management, $ce_i/H_{PES}\lambda_{PES}$ in (5) for any given e_i. In other words, the marginal benefit of making an additional effort under PES is larger than that under the baseline management. The difference in the marginal opportunity cost gives each community member a greater incentive for making efforts under PES than under the baseline management.

Moreover, it holds from Assumption 3 that the marginal utility of income under PES ($\partial U/\partial X_i$ in Eq. (11)) is smaller than that under the baseline forest management ($\partial U/\partial x_i$ in Eq. (5)) for any given e_i and $\sum_{j=-i} e_j$. Thus, when $\lambda_{base} = \lambda_{PES} = \lambda_{CES}$ and $H_{base} = H_{PES} = H_{CES}$ hold, the absolute value of the first term in Eq. (11) is smaller than that in Eq. (5) for any given $\tilde{e}_i$ and $\sum_{j=-i} e_j$. Because the first terms of both Eqs. (5) and (11) are negative, it holds that

$$\left.\frac{\partial u_{i,PES}}{\partial e_i}\right|_{e_i=\hat{e}_{base}} > 0 \qquad \text{for any given } \sum_{j=-i} e_j$$

Thus, the equilibrium effort under PES is greater than that under the baseline management.

Next, to verify (ii) to hold, , compare the conditions in the equilibria under PES and CES when individuals and communities are identical: Eq. (13) with Eq. (20). Because the value in the parenthesis in Eq. (20) is smaller that under that in (13) for any given e_i, the marginal opportunity cost of inputting an additional unit of labor into the forest management activities under CES is smaller than that under PES. In other words, the marginal benefit of making an additional effort under CES is larger than that under PES. The difference in the marginal opportunity cost gives each community member a greater incentive for making efforts under CES than under PES.

Moreover, for any given effort level of i, $\check{e}_i$, and the sum of other community members' effort levels, $\sum_{j=-i} \check{e}_j$, the second terms in the right-hand sides of both equations are the same. Also, the marginal utility of income in Eq. (13), $\partial \widehat{U}_{PES}/\partial \widehat{M}_{PES}$, is the same as that in Eq. (19), $\partial \widehat{U}_{CES}/\partial \widehat{M}_{CES}$, for any given $\check{e}_i$ and $\sum_{j=-i} \check{e}_j$ as far as the sum of the efforts of community members are the same in both communities. Because the first terms in both equations are negative, it holds that

$$\left.\Omega_{i,CES}\right|_{e_i=e_j=\hat{e}_{PES}} > 0$$

Thus, the equilibrium effort under CES is greater than that under PES when considering the symmetric equilibria in both PES and CES. ■

Note that, under the assumption that institutional changes do not influence ingroup altruism and outgroup generosity, the labor input needed for creating each unit of effort is the same under the three forest management institutions. Thus, when the effort under PES (CES) is greater than that under the baseline management (PES), the labor input for economic activities of each community member is greater under the baseline management (PES) than under PES (CES).

B.3.2 Effect of ingroup altruism

Second, we allow for a change in ingroup altruism (h). Similar to the previous subsection, we assume that institutional changes do not influence outgroup generosity (g). The evolution of ingroup altruism may depend on two distinct, opposing mechanisms. First, because the payments under PES and CES are made to the total effort of the community, implementation of PES or CES gives community members incentive to care about other members, which implies an increase in ingroup altruism. In this case, $h_{PES} > h_{base}$ and $h_{CES} > h_{base}$. Second, under PES and CES, monetary compensation will be added compared to the baseline management. Then, when community members make their effort decisions based on the monetary incentive, social norm, including ingroup altruism, may be crowded out, which implies decreases in h_{PES} and h_{CES}. In such a case, $h_{PES} < h_{base}$ and $h_{CES} < h_{base}$ holds.

Recall that we assume that $\partial\lambda/\partial h > 0$ (Assumption 1) and that $\partial H/\partial h > 0$ (Assumption 4). Thus, if the introduction of PES or CES enhances ingroup altruism, the degree of cooperation under PES or CES is greater than that under the baseline management. Then, we obtain the following result.

Proposition 2. Effect of ingroup altruism: *Suppose that (a) the introduction of PES or CES enhances ingroup altruism, and that (b) the increase in ingroup altruism is greater* *under CES than under PES. Then, (i) the equilibrium effort under PES is necessarily greater than that under the baseline management. Moreover, consider the symmetric equilibria both under PES and CES when the two communities competing with each other in the CES are identical. Then, (ii) the equilibrium effort under CES is necessarily greater than that under PES.*

Proof: To verify (i) to hold, compare Eq. (5) with Eq. (11). When the introduction of PES enhances ingroup altruism and, accordingly, the degree of cooperation under PES is greater than that under the baseline management, $ce_i/H_{base}\lambda_{base} > ce_i/H_{PES}\lambda_{PES}$ for any given e_i, which implies that the marginal opportunity cost of inputting an additional unit of labor into the forest management activities under PES is smaller than that under the baseline management. In other words, the marginal benefit of making an additional effort under PES is larger than that under the baseline management. Moreover, the essential impact of competition realizes the larger amount of effort under PES than that under the baseline management (Proposition 1 (i)). Thus, when (a) in Proposition 2 is satisfied, the equilibrium effort under PES is necessarily greater than that under the baseline management.

Next, to verify (ii) to hold, compare the conditions in the equilibria under PES and CES when individuals and communities are identical: Eq. (13) with Eq. (20). When the ingroup altruism and the degree of cooperation under CES is greater than those under PES, $ce_i/H_{PES}\lambda_{PES} > ce_i/H_{CES}\lambda_{CES}$ for any given e_i, which implies that the marginal opportunity cost of inputting an additional unit of labor into the forest management activities under CES is smaller than that under PES. In other words, the marginal benefit of making an additional effort under CES is larger than that under PES. Moreover, the essential impact of competition realizes the larger amount of effort under CES than that under PES (Proposition 1 (ii)). Thus, when (b) in Proposition 2 is satisfied, the equilibrium effort under CES is necessarily greater than that under PES. ■

By contrast, if the introduction of PES or CES reduces ingroup altruism, the degree of cooperation under PES or CES is smaller than that under the baseline management. For example, as noted above, the external payment systems may crowd out social norm and, accordingly reduces ingroup altruism. In such a case, if the ingroup-altruism-reduction effect dominates the essential institutional effect described in the previous subsection, the equilibrium effort is smaller under PES than under the baseline management. Moreover, the reduction in ingroup altruism may be larger under CES than under PES, because competition may further amplify the effect of monetary incentives. In such a case, if the ingroup-altruism-reduction effect dominates the essential competition effect, the equilibrium effort is smaller under CES than under PES.

B.3.3 Effect of outgroup generosity

Third, we consider the effect of a change in outgroup generosity. The evolution of outgroup generosity under CES may also depend on two distinct, opposing mechanisms. First, under CES, forest management efforts are determined while considering the situation of the other community despite being anonymous. This consideration may increase concern for and knowledge about the other village and may lead to increased outgroup generosity, which implies an increase in g. In this case, $g_{CES} > g_0$ holds. Second, the incentive to compete and win exists, as doing so yields greater gains, creating an effect where community members prioritize themselves over the members of the other community, which implies a decrease in g_{CES}. In such a case, $g_{CES} < g_0$ holds.

Recall that we focus on the situation in which $\partial\lambda/\partial g < 0$ (Assumption 1) and $\partial G/\partial g < 0$ (Assumption 5) hold.. Then, considering the effect of a change in outgroup generosity on the marginal opportunity cost of inputting an additional unit of labor into the forest management activities or the marginal benefit of making an additional effort, we obtain the following result[8].

Proposition 3. Effect of outgroup generosity: *Suppose that the introduction of CES reduces outgroup generosity. Then, the equilibrium effort under CES is necessarily greater than that under PES.*

By contrast, if the introduction of CES enhances outgroup generosity, the outgroup-generosity-enhancement effect may dominate the essential competition effect. In such a case, the equilibrium effort under CES is smaller than that under PES or under the baseline management.

The labor input into economic activities when ingroup altruism and/or outgroup gerosity change across management institutions is noteworthy. The labor input required to create a certain units of effort is smaller under PES (CES) than under the baseline management (PES). Thus, even if the equilibrium effort under PES (CES) is greater than that under the baseline management (PES), it is possible that the allocation of labor time to private economic activities is larger under the baseline management (PES) than under PES (CES).

B.4 Stage 1: Determination of Cooperation, In-group Altruism, and Out-Group Generosity

In this section, we describe how ingroup altruism (h), outgroup generosity (g) and, accordingly, the degree of cooperation (λ) are determined in Stage 1. The key question

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[8] Since the way h and g affect the effort decision is the same and, accordingly, the proof process for the effect of outgroup generosity is the same as that of ingroup altruism, we omit the proof for Proposition 3.

is: what mechanisms generate $h_{CES} > h_{PES} > h_{base}$, $g_{CES} < g_o$, and $\lambda_{CES} > \lambda_{PES} > \lambda_{base}$, which satisfy the prerequisites for Propositions 2 and 3 in the previous section to hold. To this end, we provide two alternative behavioral mechanisms.

B.4.1 Mechanism 1: Enhancement of cooperation and improvement of its effectiveness through ingroup altruism

Monetary incentives through the payment from an external organization and the competition scheme with external groups triggers psychological mechanisms and increases ingroup altruism, which strengthens within-group bonds and the degree of cooperation through the following channels:

1. Common identity: Facing external challenges (both monetary incentives and competition) create salient group boundaries and shared purpose. The group develops a "we are in this together" mentality.
2. Coordination technology: Those external challenges also requires better communication, planning, and coordination. These investments in coordination infrastructure have positive spillovers on social cohesion and, accordingly, enhances the effectiveness of cooperation.
3. Trust building: Strengthened identity builds general trust and reciprocity norms. Individuals also learn that they can rely on each other. Then, the effectiveness of cooperation is enhanced.

Crucial property is that these processes enhance within-group cooperation without affecting attitudes toward other communities. The "common challenge" is not perceived as a zero-sum conflict with rivals. Thus, in terms of this psychological process,

$$g_{CES} = g_0$$

holds. Moreover, this psychological process implies that the first inequality of Assumption 1 holds. Thus, the first channel ensures that

$$\lambda_{CES} > \lambda_{PES} > \lambda_{base}$$

holds.

The second and third channels improves the effectiveness of the cooperation through an increase in $H(\cdot)$. As compared with PES, an additional external challenge is incorporated into CES, which is competition with the other community. Thus, improving coordination technology and building trust are more significantly promoted under CES than PES.

B.4.2 Mechanism 2: Parochial Altruism

Competition activates evolutionary mechanisms shaped by ancestral intergroup conflict:

1. Ingroup favoritism: Competition increases the salience of group membership and triggers preferential treatment of in-group members. The psychology of "us versus them" becomes activated.
2. Outgroup derogation: The zero-sum nature of the contest creates psychological opposition to rival groups. Rivals are not just competitors but adversaries whose success directly harms one's own group.
3. Linked preferences: The same psychological process that enhances in-group cooperation (viewing the group as under external threat) mechanically reduces out-group generosity. These are joint products of a common mechanism.

Crucial property is that enhanced ingroup cooperation and reduced outgroup generosity are inseparable outcomes of the same psychological mechanism. One cannot be activated without the other.

Because competition decreases outgroup generosity (g), from the second inequality of Assumption 1, it holds that

$$\lambda_{CES} > \lambda_{PES} = \lambda_{base} \quad \text{for any given } h.$$

Moreover, from Assumption 5, it holds that

$G(g_{CES}) > 0$.

B.4.3 Prerequisites for Propositions 2 and 3

It is easily verified that the prerequisites for Propositions 2 and 3 hold, when Mechanisms 1 and 2 work as described. The hypotheses of the social experiment are based on these mechanisms.

B.4.4 General cases

We have so far focused on the situation in which $h_{CES} > h_{PES} > h_{base}$ and $g_{CES} < g_{PES} = g_{base}$. However, there are generally other possible scenarios. For example, as noted in the previous section, when community members make their effort decisions based on only the monetary incentive under PES and CES, social norm, including ingroup altruism, may be crowded out. In such a case, $h_{PES} < h_{base}$ and $h_{CES} < h_{base}$ holds. Another example is that, under CES, forest management efforts are determined while considering the situation of the other community despite being anonymous. This consideration may increase concern for and knowledge about the other village and may lead to increased outgroup generosity, which implies an increase in g. Thus, $g_{CES} > g_0$ holds. Thus, allowing for the situations in which ingroup altruism is weaker under CES (PES) than PES (the baseline management) and/or outgroup generosity is stronger under CES (PES) than PES (the baseline management), we can examine the relative effort under CES (PES) compared with PES (the baseline management) in situations in which the prerequisites underlying Propositions 2 and 3 do not hold. In those situations, different outcomes may arise. Further empirical research is needed to understand how changes in institutional frameworks affect altruism.

B.5 Negative externality on forests caused by economic activities

We have not so far considered any externality on forests caused by economic activities. However, there is a possibility that this type of negative externality could arise. For example, consider the scenario where villagers practice shifting cultivation in the area surrounding forests. As the area under shifting cultivation expands and the rotation cycle accelerates, negative impacts not only on the cultivated land itself but also on the surrounding forests through changes in waterways and vegetation increase. In this section, we will briefly examine whether the arguments presented in the previous sections remain valid even when this factor is incorporated in to the theoretical model.

B.5.1 Production Function with negative externality

As assumed in the previous sections, we assume a linear relationship between effort and forest stock improvement: The ecological benefit from improved forest stock is $\alpha\gamma E$, where $E = \sum_i e_i$. In addition, we introduce negative externality caused by economic activities, which is assumed to depend on the total economic activities of community members: $\sum_i x_i$. We assume that the marginal external damage on forests is constant, which is denoted by θ. Then, the negative externality is defined as $\theta \sum_i x_i$, and the forest stock improvement (the total benefit) considering both forest management and economic activities are written as $\alpha\gamma E - \theta \sum_i x_i$. Each individual receives an equal share of the total benefit, that is: $(\alpha\gamma E - \theta \sum_i x_i)/N$. Furthermore, the cost of labor allocation for forest management activities is the same as that without externalities (B.1.3).

For the analysis in this section, we set up the following assumption.

Assumption 6: $\frac{\partial U}{\partial M_{i,m}} > \frac{\theta}{N}\frac{\partial U}{\partial B}, \quad m = base, PES, CES.$

Assumption 6 implies that the gains from a small increase in the labor input into economic activities is greater than the losses from an increase in the negative externality on forests caused by the small increase in economic activities for each individual. If this assumption is not satisfied, there is a possibility that a corner solution—in which all working hours are devoted to forest management—emerges at the equilibrium. We exclude such a possibility.

B.5.2 Utility and efforts in equilibrium

We describe the utility function and examine the equilibrium effort in each institutional regime. Indiividual utility under the baseline management is:

$$u_i = U(M_{i,base},\ B)$$

where $B = (\alpha\gamma E - \theta\sum_i x_i)/N$ and $x_i + ce_i^2/(2H_{base}\lambda_{base}) = \bar{L}$. Thus, the utility is rewritten as

$$u_{i,base} = U(\bar{L} - \left(\frac{c}{2H_{base}\lambda_{base}}\right)\cdot e_i^2,\ \left(\alpha\gamma E - \theta\sum_i(\bar{L} - \left(\frac{c}{2H_{base}\lambda_{base}}\right)\cdot e_i^2)\right)/N)$$

The FOC is

$$\frac{\partial u_{i,base}}{\partial e_i} = -\frac{\partial U}{\partial M_{i,base}}\frac{ce_i}{H_{base}\lambda_{base}} + \frac{\partial U}{\partial B}\frac{1}{N}\cdot\left(\alpha\gamma + \theta\frac{ce_i}{H_{base}\lambda_{base}}\right) = 0$$

(21)

From Assumption 3, the SOC is satisfied:

$$\frac{\partial^2 u_{i,base}}{\partial e_i^2} = \frac{\partial^2 U}{\partial M_{i,base}^2}\left(\frac{ce_i}{H_{base}\lambda_{base}}\right)^2 - \left(\frac{\partial U}{\partial M_{i,base}} - \theta\frac{\partial U}{\partial B}\right)\frac{c}{H_{base}\lambda_{base}} + \frac{\partial^2 U}{\partial B^2}\frac{1}{N^2}\cdot\left(\alpha\gamma + \theta\frac{ce_i}{H_{base}\lambda_{base}}\right)^2 < 0$$

Moreover, it is obtained that

$$\frac{\partial^2 u_{i,base}}{\partial e_j\partial e_i} = \frac{\partial^2 U}{\partial B^2}\frac{\alpha\gamma}{N^2}\cdot\left(\alpha\gamma + \theta\frac{ce_i}{H_{base}\lambda_{base}}\right) < 0, \qquad \frac{\partial^2 u_{i,base}}{\partial e_i^2} < \frac{\partial^2 u_{i,base}}{\partial e_j\partial e_i} < 0, \quad (i \neq j).$$

Thus, the stability condition is also satisfied. In equilibrium, it holds that

$$\hat{e}_{i,base} = \hat{e}_{j,base} = \hat{e}_{base}, \quad i \neq j.$$

Accordingly, individual utility in equilibrium is given by

$$\hat{u}_{base} = \hat{U}_{base} = U\left(\hat{M}_{base}, \hat{B}_{base}\right) = U(\bar{L} - \left(\frac{c\,\hat{e}_{base}}{2H_{base} \cdot \lambda_{base}}\right) \cdot \hat{e}_{base}^2,\ \alpha\gamma\hat{e}_{base} - \theta\hat{x}_{base}).$$

The following condition holds in equilibrium regarding the effort of each individual under the baseline management:

$$\hat{e}_{i,base} = \frac{\partial\hat{U}_{base}/\partial B}{\partial\hat{U}_{base}/\partial\hat{M}_{base} - \partial\hat{U}_{base}/\partial B \cdot \theta/N} \cdot \frac{\alpha\gamma}{N} \cdot \frac{H_{base}\lambda_{base}}{c}$$

or

$$(\Omega_{base} =) - \frac{\partial\hat{U}_{base}}{\partial\hat{M}_{base}} \frac{c\hat{e}_{base}}{H_{base}\lambda_{base}} + \frac{\partial\hat{U}_{base}}{\partial\hat{B}_{base}} \frac{1}{N} \cdot \left(\alpha\gamma + \theta\frac{c\hat{e}_{base}}{H_{base}\lambda_{base}}\right) = 0.$$

In a similar way, the FOC under PES is obtained:[9]

$$\frac{\partial u_{i,PES}}{\partial e_i} = -\frac{\partial U}{\partial M_{i,PES}}\left(\frac{ce_i}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right) + \frac{\partial U}{\partial B}\frac{1}{N} \cdot \left(\alpha\gamma + \theta\frac{ce_i}{H_{PES}\lambda_{PES}}\right) = 0$$

(22)

In equilibrium, it holds that $\hat{e}_{i,PES} = \hat{e}_{j,PES} = \hat{e}_{PES}$ $(i \neq j)$. Accordingly, $\alpha\gamma\sum\hat{e}_{PES}/N = \alpha\gamma\hat{e}_{PES}$ and

$$\hat{u}_{PES} = \hat{U}_{PES} = U\left(\hat{M}_{PES}, \hat{B}_{PES}\right) = U(\bar{L} - \left(\frac{c\,\hat{e}_{PES}}{2H_{PES}\lambda_{PES}}\right) \cdot \hat{e}_{PES}^2 + \beta\hat{e}_{PES},\ \alpha\gamma\hat{e}_{PES} - \theta\hat{x}_{PES})$$

hold. Then, the following condition holds in equilibrium regarding the effort of each individual under PES:

$$\hat{e}_{PES} = \frac{\partial\hat{U}_{PES}/\partial B \cdot \alpha\gamma + \partial\hat{U}_{PES}/\partial X_i \cdot \beta}{N \cdot (\partial\hat{U}_{PES}/\partial\hat{M}_{PES} - \partial\hat{U}_{PES}/\partial B \cdot \theta/N)} \cdot \frac{H_{PES}\lambda_{PES}}{c}$$

[9] Since the SOC and stability condition are satisfied with similar conditions as the case without externalities under PES and CES, we omit the description of those conditions for brevity.

or

$$(\Omega_{PES} =) - \frac{\partial \widehat{U}_{PES}}{\partial \widehat{M}_{PES}}\left(\frac{c\hat{e}_{PES}}{H_{PES}\lambda_{PES}} - \frac{\beta}{N}\right) + \frac{\partial \widehat{U}_{PES}}{\partial \widehat{B}_{PES}}\frac{1}{N} \cdot \left(\alpha\gamma + \theta \frac{c\hat{e}_{PES}}{H_{PES}\lambda_{PES}}\right) = 0 \quad .$$

(23)

Moreover, the FOC under CES is obtained:

$$\frac{\partial u_{i,CES}}{\partial e_i} = - \frac{\partial U}{\partial M_{i,CES}}\left(\frac{ce_i}{(H_{CES}+G_{CES})\cdot\lambda_{CES}} - \frac{2\beta}{N} \cdot \frac{E^2+2EE^*}{(E+E^*)^2}\right) + \frac{\partial U}{\partial B}\frac{1}{N} \cdot \left(\alpha\gamma + \theta \frac{ce_i}{(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right) = 0 \quad (24)$$

As in B.2.3, we focus on the case with two symmetric communities: $H_{CES} = H^*_{CES}$, $G_{CES} = G^*_{CES}$, $\lambda_{CES} = \lambda^*_{CES}$, $N = N^*$. Then, in equilibrium, it holds that $\hat{e}_{i,CES} = \hat{e}_{j,CES} = \hat{e}_{CES} = \hat{e}^*_{CES}$ $(i \neq j)$. Accordingly, $\alpha\gamma \sum \hat{e}_{CES}/N = \alpha\gamma\hat{e}_{CES}$ and

$$\hat{u}_{CES} = \widehat{U}_{CES} = U(\widehat{M}_{CES}, \widehat{B}_{CES}) = U(\bar{L} - \left(\frac{c\,\hat{e}_{CES}}{2\cdot(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right)\cdot \hat{e}^2_{CES} + \beta\hat{e}_{CES}, \alpha\gamma\hat{e}_{CES} - \theta\widehat{x}_{CES})$$

hold. Then, the following condition holds in equilibrium regarding the effort of each individual under CES: :

$$\hat{e}_{CES} = \frac{2\partial\widehat{U}_{PES}/\partial B\cdot\alpha\gamma + 3\partial\widehat{U}_{PES}/\partial X_i\cdot\beta}{2N\cdot(\partial\widehat{U}_{CES}/\partial\widehat{M}_{CES} - \partial\widehat{U}_{CES}/\partial B\cdot\theta/N)} \cdot \frac{(H_{CES}+G_{CES})\cdot\lambda_{CES}}{c}$$

or

$$(\Omega_{CES} =) - \frac{\partial \widehat{U}_{CES}}{\partial \widehat{M}_{CES}}\left(\frac{c\hat{e}_{CES}}{(H_{CES}+G_{CES})\cdot\lambda_{CES}} - \frac{3\beta}{2N}\right) + \frac{\partial \widehat{U}_{CES}}{\partial \widehat{B}_{CES}} \cdot \frac{1}{N} \cdot \left(\alpha\gamma + \theta \frac{ce_i}{(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right) = 0$$

(25)

B.5.3 Comparative statics

First, let us examine the effect of the introduction of negative externality on forests caused by economic activities on the equilibrium effort in each institution. For the baseline management, compare Eq. (21) with Eq. (5). In Eq. (21), there is an additional term in the parenthesis: $\theta c e_i/(H_{base}\lambda_{base})$. This term represents the gains from a marginal decrease in the labor input for economic activities because the negative externality on forests decreases. Thus, as compared with the case without such a negative externality, each individual has a greater incentive to input their time for forest management activities. Similarly, comparison of Eqs. (11) and (22) reveals the increase in the incentive to increase forest management activities under PES, while comparison of Eqs. (18) and (24) reveals the increase in the incentive to increase forest management activities under CES.

Next, we discuss if the results obtained in Section B.3 (Propositions 1, 2, and 3) are also obtained in the presence of negative externality on forests caused by economic activities. Comparison of Eqs. (21), (22), and (24) reveals that if $h_{base} = h_{PES} = h_{CES}$ and $g_{base} = g_{PES} = g_{CES} = g_0$ hold, the additional term in these FOCs with externalities as compared with those without externalities are the same for any given $\tilde{e}_i$: That is,

$$\theta c\tilde{e}_i/(H_{base}\lambda_{base}) = \theta c\tilde{e}_i/(H_{PES}\lambda_{PES}) = \theta c\tilde{e}_i/(H_{CES}\lambda_{CES}) .$$

This equality implies that the difference in the marginal utility from an increase in the effort for forest management activities between in the presence and absence of externalities is the same for all institutions, the baseline management, PES, and CES, given any $\tilde{e}_i$. Therefore, the basic effect of PES and CES on incentives for forest management functions in the same way as when there are no negative externalities caused by economic activities. In other words, the relative strength of incentives for forest management across these institutions is the same as when there are no externalities. Consequently, Proposition 1 holds even when negative externalities exist.

Furthermore, the effect of changes in ingroup altruism and outgroup generosity on the FOCs is the same regardless of whether externalities are present or absent. Therefore, if the prerequisites of Propositions 2 and 3 hold, the presence or absence of externalities does not alter the results of Propositions 2 and 3.

B.6 The case with an additively separable utility function

We now focus on the specific simple case with $\partial^2 U/\partial x_i^2 = 0$, $\partial^2 U/\partial B^2 = 0$, and $\partial U^2/\partial x_i \partial B = 0$ (see Assumption 3 in B.2.1), by which we illustrates how ingroup altruism and outgroup generosity affect the relationship between the effort levels of the three different institutions. Without loss of generality, we assume that there is no negative externality on forest caused by economic activities.

We consider the following additively separable utility function under the baseline management:

$$u_i = x_i + B$$

Then, using the labor-time constraint (Eq. (3)), the utility can be written as:

$$U_{i,base} = \left(\frac{\alpha\gamma}{N}\right) \cdot E - \left(\frac{c}{2H_{base}\lambda_{base}}\right) \cdot e_i^2 + \bar{L}.$$

In this case, the FOC, the equilibrium effort, and the equilibrium utility under the baseline management are given by

$$\frac{\partial U_{i,base}}{\partial e_i} = \frac{\alpha\gamma}{N} - \frac{ce_i}{H_{base}\lambda_{base}} = 0$$

$$\hat{e_i}(h_{base}, g_{base}) = \frac{H_{base}\lambda_{base}}{c} \cdot \frac{\alpha\gamma}{N}$$

$$\hat{U}_{i,base} = \frac{(\alpha\gamma)^2 \cdot H_{base}\, \lambda_{base}(2N-1)}{2cN^2}$$

Similarly, the utility, the FOC, the equilibrium effort, and the equilibrium utility under PES are given by

$$U_{i,PES} = \left(\frac{\alpha\gamma+\beta}{N}\right) \cdot E - \left(\frac{c}{2H_{PES}\lambda_{PES}}\right) \cdot e_i^2 + \bar{L}$$

$$\frac{\partial U_{i,PES}}{\partial e_i} = \left(\frac{\alpha\gamma+\beta}{N}\right) - \left(\frac{c}{H_{PES}\,\lambda_{PES}}\right) \cdot e_i = 0$$

$$\hat{e}_{PES}(h_{PES},\ g_{PES}) = \left(\frac{H_{PES}\,\lambda_{PES}}{cN}\right) \cdot (\alpha\gamma + \beta)$$

$$\widehat{U}_{i,PES} = \frac{(\alpha\gamma+\beta)^2 \cdot H_{PES}\,\lambda_{PES}(2N-1)}{2cN^2}$$

Moreover, the utility, the FOC, the equilibrium effort, and the equilibrium utility under PES are given by

$$U_{i,CES} = \left(\frac{\alpha\gamma}{N}\right) \cdot E + \left(\frac{2\beta E}{N}\right) \cdot \frac{E}{E+E^*} - \left(\frac{c}{2(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right) \cdot e_i^2$$

$$\frac{\partial U_{i,CES}}{\partial e_i} = \frac{\alpha\gamma}{N} + \frac{2\beta}{N} \cdot \frac{E^2+2EE^*}{(E+E^*)^2} - \left(\frac{c}{(H_{CES}+G_{CES})\cdot\lambda_{CES}}\right) \cdot e_i = 0$$

When considering the symmetric equilibrium, it is obtained that

$$\hat{e}_{CES}\,(h_{CES}, g_{CES}) = \left(\frac{(H_{CES}+G_{CES})\cdot\lambda_{CES}}{cN}\right) \cdot \left(\alpha\gamma + \frac{3\beta}{2}\right)$$

$$\widehat{U}_{i,CES} = \frac{(\alpha\gamma+3)/2)^2 \cdot (H_{CES}+G_{CES})\cdot\lambda_{CES}\cdot(2N-1)}{2cN^2}$$

Note that a key advantage of using this specific utility function form is that it allows for easy comparison of equilibrium utilities across different institutional regimes.

We now use the following baseline parameters and functional forms:

$N = 4$ (community size)

$\alpha\gamma = 10$ (intrinsic benefit)

$c = 1$ (baseline cost)

$\beta = 2$ (PES payment rate)

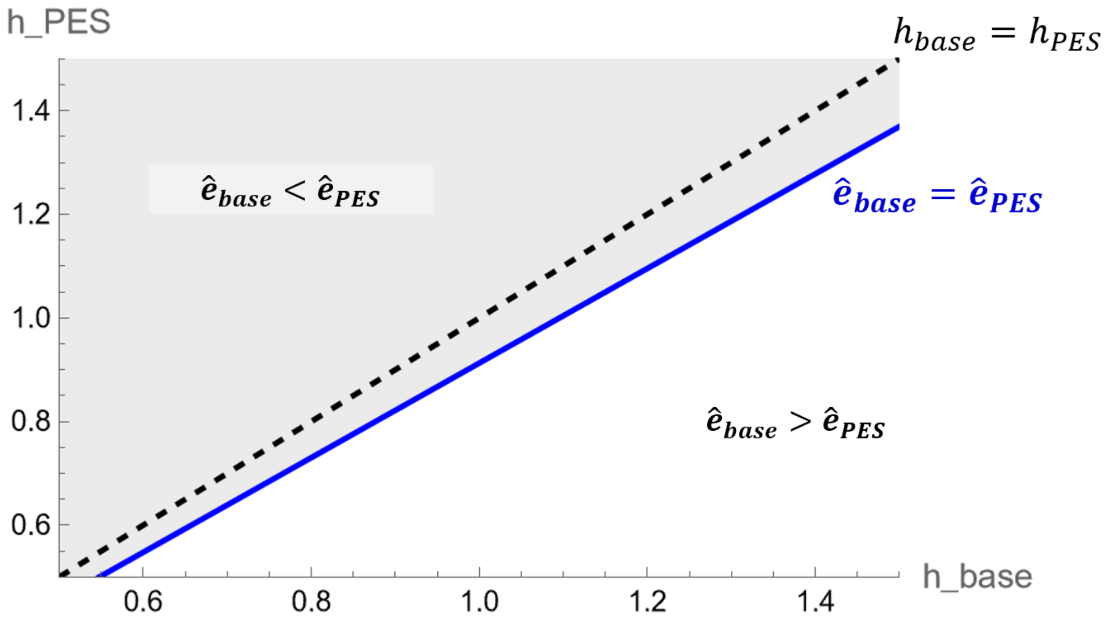

Figure B,1. Comparison of efforts under the baseline management and PES.

$g_{base} = g_{PES} = g_0 = 0$ (Outgroup generosity under the baseline management and PES)

$\lambda = 0.8h - 0.2g$ (the degree of cooperation depending on ingroup altruism and outgroup generosity)

$H = h$ (social capital)

$G = -g$ (parochial altruism)

Note that the results are not influenced by the parameter values and functional forms as far as the basic assumptions (Assumptions 1, 2, 3, and 4) are satisfied.

First, let us compare the equilibrium effort in the second stage under PES with that under the baseline management. Based on the parameter values and the functional forms, it is obtained that

$$\hat{e}_{base} = 2\, h_{base}^2, \qquad \hat{e}_{PES} = 2.4\, h_{PES}^2.$$

The blue line in Figure B.1 shows the locus of the combinations of ingroup altruism (h_{base} and h_{PES}) where the equilibrium efforts under two institutions are the same. Above this line (shaded in light gray), the equilibrium effort under PES is larger than that under the baseline managements. Even if ingroup altruism is not influenced by the introduction of PES ($h_{base} = h_{PES}$), the monetary incentive increases

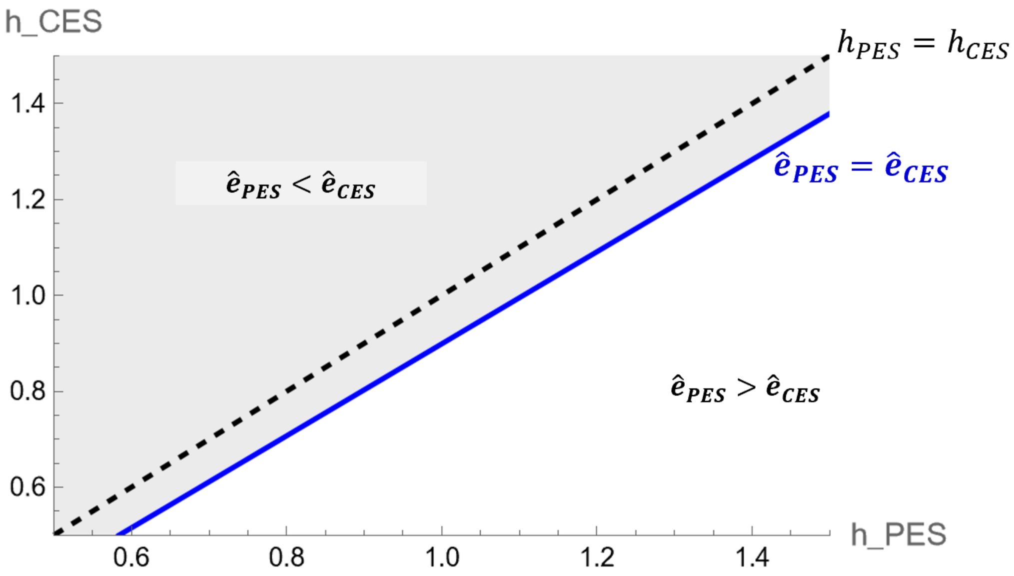

Figure B.2. Comparison of efforts under PES and CES with fixed g_{CES}.

the effort amount, which is consistent with Proposition 1. However, if the introduction of PES significantly decreases ingroup altruism (below the blue line), the equilibrium effort under PES is smaller than that under the baseline management.

Second, let us compare the equilibrium effort in the second stage under CES with that under PES. To focus on the relationship between ingroup altruism under both institutions, we assume the value for outgroup generosity under CES:

$$g_{CES} = -0.1.$$

Based on the parameter values and the functional forms, it is obtained that

$$\hat{e}_{CES} = 3.25 \cdot (0.02 + 0.8h_{CES}) \cdot (0.1 + h_{CES}).$$

The blue curve in Figure B.2 shows the locus of the combinations of ingroup altruism (h_{PES} and h_{CES}) where the equilibrium efforts under two institutions are the same. Above this curve (shaded in light gray), the equilibrium effort under CES is larger than that under PES. Even if ingroup altruism is not influenced by the introduction of a competition scheme ($h_{PES} = h_{CES}$), it is clear that an increase in outgroup generosity and competition work for increasing the effort amount. . However, if the introduction of CES significantly decreases ingroup altruism (below the blue curve), the equilibrium effort under CES is smaller than that under PES.

$h_{PES} = 1.$

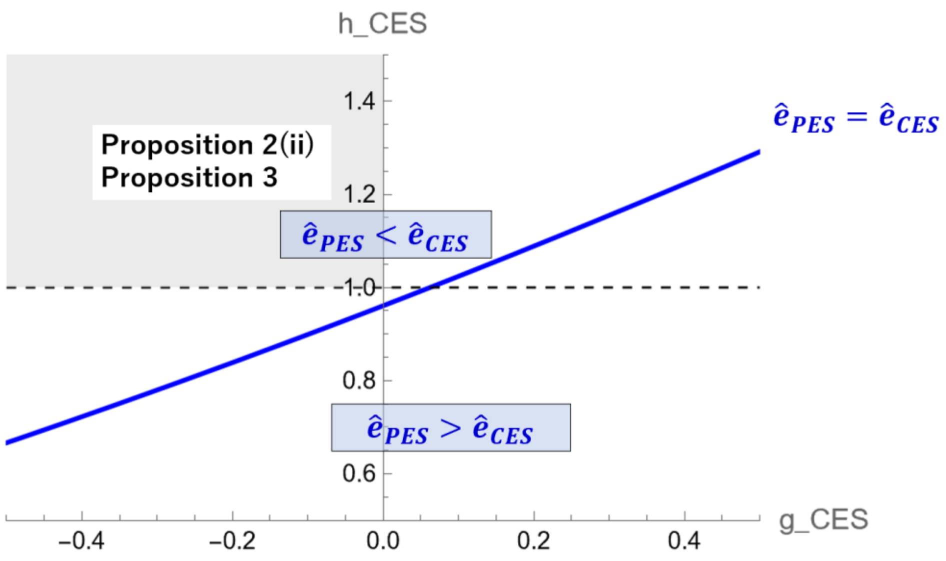

Figure B.3. Comparison of efforts under PES and CES with fixed h_{PES}.

Third, we focus on the relationship among ingroup altruism under CES, outgroup generosity under CES, and compare the equilibrium efforts under PES and CES. To this end, we remove the fixed parameter value of $g_{CES}(= 0.9)$ and, instead, assume ingroup altruism under PES:

In this case, based on the parameter values and the functional forms, it is obtained that

$$\hat{e}_{PES} = 2.4, \quad \hat{e}_{CES} = 3.25 \cdot (0.8h_{CES} - 0.2g_{CES}) \cdot (h_{CES} - g_{CES}).$$

The blue curve in Figure B.3 shows the locus of the combinations of ingroup altruism and outgroup generosity under CES (h_{CES} and g_{CES}) where the equilibrium efforts under two institutions are the same. Above (below) this curve, the equilibrium effort under CES is larger than that under PES. We assume that $h_{PES} = 1$ and $g_{PES} = 0$, and $\hat{e}_{CES} > \hat{e}_{PES}$ obviously hold when $h_{CES} > 1$ and $g_{CES} < 0$ (the area shaded in light gray), which is consistent with Propositions 2(ii) and 3. However, if the introduction of CES significantly decreases ingroup altruism or increases outgroup generosity (below the blue curve), the equilibrium effort under CES is smaller than that under PES.

Appendix C: Survey Instrument

Informed Consent

Forest Management Experiment in Chittagong Hill Tracts

(Arranayk Foundation / University of Chittagong / Waseda University)

You are asked to take part in a research project described below. The researchers will explain what you will do in the survey in detail. This consent form gives you the information you will need to help you decide whether to be in the study or not. You must be 18 years old or older to take part in this research project. You can freely ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not.

***Description of the project*:** The project aims to study how a training and payment scheme for forest management can improve community-based forest management and conservation in the Chittagong Hill Tracts (CHT). You are being invited to take part in an interview to collect information on livelihood and forest management in the Village Common Forest. The interview will take about 45 minutes.

***What you will do*:** If you decide to take part in this study, here is what will happen. You will be asked to make answers for series of questions. **You will receive 300 BDT as a participation fee when you complete the interview.**

***Benefit of this study*:** It is unlikely that you will incur any risks or will experience any discomfort as a result of participating in this study. There may not be direct benefit to you from your participation. However, we hope that, in future, other people might benefit from this study because the purpose of this research is to help the government and international organization to plan regional and forest policies.

Confidentiality: The information you provide during this research will be kept confidential to the extent permitted by law. The information collected from you during the interview will be entered to an anonymous database and will not be shared with anyone other than the members of our research team.

***Right to refuse*:** The decision to take part in this research is up to you. It is not mandatory for you to participate. If you decide to take part in the study, you may quit at any time. Whatever you decide will in no way penalize you. If you wish to quit, you simply inform the researcher of your decision. In the questionnaire, you may choose not to answer any questions to which you do not want to answer.

***Right and complaints*:** If you are not satisfied with the way this study is performed, you may discuss your complaints with Dr. Takahashi, Dr. Mosharraf, and/or other researchers and assistants, anonymously, if you choose. The contact information of the researchers are as follows.

Principal Investigator	Local Research Manager	Project Implementer
Dr. Ryo Takahashi	**Prof. Mohammad Mosharraf Hossain**	**Md. Emranul Islam**
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Questionnaire

0. Please record the following items in Kobo toolbox

- Name of interviewer
- Interview day
- Starting and ending time

- Name of VCF (it is better if the list is pre-loaded)
- GIS location of the interview (if such a function is available in Kobo toolbox)

1. About the respondent

1-1. Name of respondent

1-2. Name of para

1-3. Telephone number

Note to enumerators: We may resurvey the same person in two years, so please correctly enter the name and telephone number of the respondent.

1-4. Are you currently a member of the VCF committee?

1. Yes, I am member, 2. Yes, I am member and Karbari, 3. No

1-4-1. If yes to 1-4, briefly describe your role as a committee member. (   )

1-4-2. If yes to 1-4, in which year did you join the committee in ***the current term***? Note that even if you served in multiple terms, please answer the year you started the current term. [Year]

1-4-3. If yes to 1-4, has your committee held any meetings in the past 12 months to discuss the management or use of the VCF?

1. Yes, 2. No

1-4-4. If yes to 1-4-3, how many days in the past 12 months did you attend those meetings? [Days]

1-4-5. If yes to 1-4-3, how much did you speak or express your opinions during the discussions? [CODE]

1. Spoke very actively at every meeting, 2. Spoke at least once at every meeting, 3. Spoke occasionally, 4. Did not speak at all

1-5. How many years ***in total*** have you served as a VFC committee member? Please include all the current and past terms. [Years]

1-6. What is your relationship with your household? [CODE]

1. Household head, 2. Spouse, 3. Sibling, 4. Child, 5. Father, 6. Mother, 7. Grandchild, 8. Other relatives, 9. Other, specify (   )

1-7. What is your gender?

1. Male, 2. Female, 3. Prefer not to specify

1-8. How old are you at the time of the interview? [Years old]

1-9. What is your ethnic tribe? [CODE]

1. Chakma, 2. Marma, 3. Tripura, 4. Tanchangya, 5. Mro, 6. Lushai, 7. Khumi, 8. Chak, 9. Khiyang, 10. Bawm, 11. Pangkhua, 12. Other, specify ( )

1-10. What is your religion? [CODE]

1. Muslim, 2. Buddhism, 3. Hindu, 4. Christianity 4. ADD codes, 99. Other, specify ( )

1-11. Briefly describe your current primary occupation. [Describe]

1-12. How much is your average ***monthly income*** in the past one year, including income from agriculture and forest activities? [BDT]

1-13. What is your total years of schooling completed? [Years]

1-14. What are the three most important sources of income for your household at present? (Please rank in order of importance: 1 = most important)

1st:_______________, 2nd: _______________, 3rd: _______________

1-15. In the past two years, has your household started any new small business or income-generating activity?

1. Yes, 2. No

1-15-1. If yes, Please describe the activity.

2. About the VCF and Jhum

2-1. Which resources have you extracted from the VCF in the past 12 months? Please select all that apply. [CODE]

1. Timber, 2. Firewood, 3. Bamboo, 4. Fodder grass, 5. Banana, 6. Medicinal plants

2-1-1. If any of the options are selected, how many kilograms of each resource do you typically extract in a month?

a. Timber ( ) kg
b. Firewood ( ) kg
c. Bamboo ( ) kg
d. Fodder grass ( ) kg
e. Banana ( ) kg
f. Medicinal plants ( ) kg

2-2. Who determines the rules of the use of VCF resources?

1. Headmen, 2. Karbari, 3. VCF committee members, 4. Other, specify ( )

2-3. In your VCF, is there a limit on the maximum amount of each resource that one household can collect? If yes, describe the limit (in terms of days, kgs, or other unit).

1. Yes, and the limit is ( ). 2. No limit. 3. This recourse is not available.

a. Timber
b. Firewood
c. Bamboo
d. Fodder grass
e. Banana
f. Medicinal plants

2-4. What type of rule changes were made? (Select all that apply)
1. Stricter harvesting limits, 2. Restrictions on grazing, 3. Restrictions on timber extraction, 4. New monitoring requirements, 5. Other (specify: ______)

2-5. How do you evaluate the changes in the forest condition of your VCF over the past 10 years?
1. Degraded, 2. No change, 3. Regenerated

2-6. What type of rule changes were made? (Select all that apply)
1. Stricter harvesting limits, 2. Restrictions on grazing, 3. Restrictions on timber extraction, 4. New monitoring requirements, 5. Other (specify: ______)

2-7. How do you anticipate the forest condition of your VCF over the next 10 years?
1. Will degrade, 2. No change (sustain), 3. Will regenerate

2-8. Do you do shifting (jhum) cultivation?
1. Yes, 2. No

2-6-1. If yes to 2-6, how much area did you cultivate now and 10 years ago?
Now ( ) acre
10 years ago ( ) acre

2-9. How do you evaluate the changes in the size of shifting cultivation areas by all the members of your para in the past 10 years?
1. Decreased, 2. No change, 3. Increased, 4. No shifting cultivation in my para.

2-10. How do you evaluate the changes in the pace of rotation of shifting cultivation in the past 10 years?
1. Decreased, 2. No change, 3. Increased

2-11. Compared to two years ago (before the start of this program), has the total area of agricultural land cultivated by your household changed?
1. Decreased, 2. No change, 3. Increased

If increased or decreased:

2-11-1. By how many hectares has your household's flat (permanent) agricultural land changed?

2-11-2. By how many hectares has your household's shifting cultivation (jhum) land changed?

3. VCF management

3-1. Have you conducted thinning trees in the VCF in the past 12 months?
1. Yes, 2. No

3-1-1. If yes, how many days of the last 12 months have you spent on thinning in the VCF? [Days]

3-2. Have you conducted pruning trees in the VCF in the past 12 months?
1. Yes, 2. No

3-2-1. If yes, how many days of the last 12 months have you spent on pruning in the VCF? [Days]

3-3. Have you participated in guarding the VCF in the past 12 months?
1. Yes, 2. No

3-3-1. If yes, how many days of the last 12 months have you spent on guarding the VCF? [Days]

3-4. Have you participated in VCF monitoring in the past 12 months?

1. Yes, 2. No

3-4-1. If yes, how many days of the last 12 months have you spent on monitoring the VCF? [Days]

3-5. Have you conducted tree planting in the VCF in the past 12 months?

1. Yes, 2. No

3-5-1. If yes, how many days of the last 12 months have you spent on tree planting in the VCF? [Days]

3-6. If you know the total number of trees that have been planted in the VCF in the past 12 months, please specify the number. Please answer this question only if you know the precise number of trees planted. [Number]

3-7. In your VCF, are members allowed to pasture their livestock in the VCF?

1. Yes, 2. No

3-7-1. If yes to 3-7, do you pasture your livestock in the VCF?

1. Yes, 2. No

3-8. Have you observed any illegal logging in the VCF in the past 12 months?

1. Yes, 2. No

3-9. Have you observed illegal activities in the collection of other resources in the VCF in the past 12 months?

1. Yes, 2. No

3-10. Have you observed illegal activities in the collection of other resources in the VCF in the past 12 months?

1. Yes, 2. No

3-11. Does your VCF currently impose sanctions on individuals who violate forest rules?

1. Yes, 2. No

3-11-1. What types of sanctions are used? (Select all that apply)

1. Monetary fine, 2. Labor contribution, 3. Warning, 4. Temporary restriction of forest access, 5. Other (specify: ______)

3-11-2. In the past 12 months, have sanctions been applied in practice?

1. Yes, 2. No

3-11-3. If yes, Approximately how many times were sanctions applied in the past 12 months?

3-12. In the past 12 months, has the committee conducted outreach or communication activities with community members regarding forest conservation?

3-13. Overall, how actively have you been involved in forest management activities in the VCF?

1. Very actively involved, 2. Actively involved, 3. Somewhat involved 4. Slightly involved, 5. Rarely involved, 6. Not involved at all

3-14. How actively do you think members of the VCF committee (excluding yourself if you are a committee member) have been involved in forest management activities in the VCF on average?

1. Much more actively involved, 2. More actively involved,

3. Somewhat more actively involved, 4. About the same as me
5. Somewhat less actively involved, 6. Less actively involved
7. Not involved at all

4. About Social Preference

We will now ask you to make some simple decisions as part of a short game. You will face three different scenarios. In each scenario, you will receive 150 BDT and will be asked to decide how to allocate this amount of money. After you complete all scenarios, one of your decisions will be randomly selected, and your actual payment will be made based on that selected decision.

4-1. You will receive 150 BDT to participate in this task. You may decide how much of this amount you would like to give to another anonymous participant in this survey. Survey participants include members of the VCF management committee and 10 randomly selected households from the community. The other person will not know your identity, and you will not know theirs. You can give any amount from 0 to 150 BDT. If you choose 0 BDT, you will keep the entire 150 BDT for yourself. Your choice is real: the payment you and the other participant receive will be based on the amount you decide. How much would you like to give to the other participant? [BDT]

4-2. You will receive 150 BDT to participate in this task. You may decide how much of this amount you would like to give to an anonymous person from another para in the Chittagong Hill Tracts that is assigned to the same program as yours. The other person will not know your identity, and you will not know theirs.
You can give any amount from 0 to 150 BDT. If you choose 0 BDT, you will keep the entire 150 BDT for yourself. Your choice is real: the payment you and the other participant receive will be based on the amount you decide. How much would you like to give to the other person? [BDT]

4-3. You will receive 150 BDT to participate in this task. You may decide how much of this amount you would like to give to an anonymous person from another para in the Chittagong Hill Tracts that is not participated to this research project. The other person will not know your identity, and you will not know theirs.
You can give any amount from 0 to 150 BDT. If you choose 0 BDT, you will keep the entire 150 BDT for yourself. Your choice is real: the payment you and the other participant receive will be based on the amount you decide. How much would you like to give to the other person? [BDT]

Now, we would like you to complete another task involving decisions about money. This task is similar to the previous one. You will face two different scenarios, and in each scenario you will make decisions about how to allocate money.

In each scenario, you will be matched with an anonymous person, and you will play a money-based game. Your identity will not be revealed to the other person, and theirs will not be revealed to you.

In this game, you receive 300 BDT. You may choose to send 0 BDT, 100 BDT, or 300 BDT to the person you are matched with. Any amount you send will be tripled for them. For example, if you send 100 BDT, the other participant will receive 300 BDT; if you send 300 BDT, they will receive 900 BDT.

After receiving the tripled amount, the other participant may decide how much to return to you. They will choose one of five options: 0%, 25%, 50%, 75%, or 100% of the tripled amount.

Your final payment in this game will depend on the amount you choose to send and the amount the other participant decides to return.

Before making your decisions, please note that you will first be asked how much you would like to send as the first mover. You will then be asked how much you would return if you were in the role of the recipient.

4-4. [Same para] You are matched with **another anonymous participant from your para**. How much of the 300 BDT would you like to send to the other participant from your para? Please choose one of the following options:

1. 0 BDT (not to send) 2. 100 BDT 3. 300 BDT

[Same para] Next, we would like you to consider the case in which you are the recipient. We will ask about your decision in two situations: when the other participant sends you 100 BDT and when they send you 300 BDT. In each case, the amount they send will be tripled before it reaches you. Your decisions will directly determine the actual payments for you and the other participant.

4-5. [Same para] Suppose the other participant sends 100 BDT. This amount will be tripled, and you will receive 300 BDT. How much of the 300 BDT would you like to return to the **other participant**? Please choose one of the following options:

1. Return 0 BDT (you keep 300 BDT) 2. Return 80 BDT (you keep 220 BDT) 3. Return 150 BDT (you keep 150 BDT) 4. Return 220 BDT (you keep 80 BDT) 5. Return 300 BDT (you keep 0 BDT)

4-6. [Same para] Suppose the other participant sends 300 BDT. This amount will be tripled, and you will receive 900 BDT. How much of the 900 BDT would you like to return to the **other participant**? Please choose one of the following options:

1. Return 0 BDT (you keep 900 BDT) 2. Return 230 BDT (you keep 670 BDT) 3. Return 450 BDT (you keep 450 BDT) 4. Return 670 BDT (you keep 230 BDT) 5. Return 900 BDT (you keep 0 BDT)

4-7. [Another para] You are matched with **an anonymous person from another para that is assigned to the same program as yours**. How much of the 300 BDT would you like to send to the other participant from your para? Please choose one of the following options:

1. 0 BDT (not to send) 2. 100 BDT 3. 300 BDT

[Another para] Next, we would like you to consider the case in which you are the recipient. We will ask about your decision in two situations: when the other participant sends you 100 BDT and when they send you 300 BDT. In each case, the amount they send will be tripled before it reaches you. Your decisions will directly determine the actual payments for you and the other participant.

4-8. [Another para] Suppose the other participant sends 100 BDT. This amount will be tripled, and you will receive 300 BDT. How much of the 300 BDT would you like to return to**e**? Please choose one of the following options:

1. Return 0 BDT (you keep 300 BDT) 2. Return 80 BDT (you keep 220 BDT) 3. Return 150 BDT (you keep 150 BDT) 4. Return 220 BDT (you keep 80 BDT) 5. Return 300 BDT (you keep 0 BDT)

4-9. [Another para] Suppose the other participant sends 300 BDT. This amount will be tripled, and you will receive 900 BDT. How much of the 900 BDT would you like to return to **the anonymous participant in the same program**? Please choose one of the following options:

1. Return 0 BDT (you keep 900 BDT) 2. Return 230 BDT (you keep 670 BDT) 3. Return 450 BDT (you keep 450 BDT) 4. Return 670 BDT (you keep 230 BDT) 5. Return 900 BDT (you keep 0 BDT)

4-10. The research team plans to donate 150 BDT to a randomly selected community outside your para that is assigned to the same program as yours in the Chittagong Hill Tracts. This donation will benefit only that community and has no effect on you or your para. Your decision is private. You may choose to stop this donation. If you choose to stop it, no

donation will be made. There is no cost to you regardless of your decision.
Do you want to allow the donation or stop it?

1. Yes, stop the donation 2. No, allow the donation

I want to know how much you trust different groups of people. How much do you feel you can trust the people in the group? Choose the answer from the following codes:

1. Trust a lot, 2. Trust somewhat, 3. Trust just a little, 4. Not trust at all

4-11. Person in your family
4-12. Person in your para
4-13. Person in other communities in CHT that consist of the ***same*** tribes/ethnic groups/religions as you
4-14. Person in other communities in CHT that consist of ***other*** tribes/ethnic groups/religions as you
4-15. Person outside Chittagong Hill Tracts
4-16. Please tell me, in general, how willing or unwilling you are to take risks. Please answer by choosing a number from 0 to 10, where 0 means “completely unwilling to take risks” and 10 means “very willing to take risks.”

The following are hypothetical questions.

4-17. Would you prefer to receive 600 BDT tomorrow or 800 BDT after one month?
1. 600 BDT tomorrow, 2. 800 BDT after one month
4-18. Would you prefer to receive 600 BDT tomorrow or 1,000 BDT after one month?
1. 600 BDT tomorrow, 2. 1,000 BDT after one month
4-19. Would you prefer to receive 600 BDT tomorrow or 1,200 BDT after one month?
1. 600 BDT tomorrow, 2. 1,200 BDT after one month

Please choose the scale to which the following statements describe you. [CODE]

1. Exactly like me, 2. Mostly like me, 3. Somewhat like me, 4. Neutral, 5. Somewhat not like me, 6. Mostly not like me, 7. Not at all like me

4-20. I see myself as someone who enjoys winning and hates losing.
4-21. I see myself as someone who enjoys competing, regardless of whether I win or lose.
4-22. I see myself as a competitive person.
4-23. Competition brings the best out of me.
4-24. When I play my favorite game with my friends, it's more fun when everyone contributes money for a prize for the winner.

Please choose the scale to which you agree with the following statements. [CODE]

1. Yes, very much, 2. Yes, somewhat, 3. Neutral, 4. No, somewhat, 5. Not at all

4-25. I feel it is unfair when someone receives more rewards with less effort than I do.

4-26. I feel uncomfortable when someone receives better treatment than I do, even though we have put in the same amount of effort.

4-27. People in society should be treated the same as those who have put in effort, even if they themselves have not made much effort.

4-28. Everyone should have opportunities that are as equal as possible

4-29. Extreme disparities in rewards should be avoided, even when there are differences in performance.

4-30. It is natural that there are some differences in rewards between people when differences in ability and effort are taken into account.

This is the end of the interview. Thank you very much for your cooperation.