

RESEARCH ARTICLE

Cooperation and the management of local common resources in remote rural communities

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Abstract

It is widely recognized that local management of common pool resources can be more efficient and more effective than private markets or top-down government management, especially in remote rural communities in which the institutions may be weak or prone to elite capture. In this paper, we explore the propensity for cooperation in the management of local common resources by introducing a variant of a public goods game among remote rural communities in the state of Odisha, in eastern India. We explore various patterns of cooperation, including free riding behaviour, unconditional cooperation and conditional cooperation, in which individuals' propensity toward cooperation is tied to their beliefs about the level of cooperation among their peers. We find that a significant portion of our sample fall into this latter category, but also that their expectations about the level of contributions among their peers are somewhat malleable.

Keywords: experimental games; India; local common resources; local community goods; voluntary contribution mechanism

JEL classification: C72; Q12; Q32

1. Introduction

In remote rural communities in many low- and middle-income countries, community members must learn to voluntarily cooperate to manage local common pool resources such as land, water and forests. These resources share the non-excludability feature of traditional public goods, yet the use or consumption of these resources necessarily implies there is less that remains to be enjoyed by other members of the community. Yet precisely because these resources produce valuable ecosystem services, there exists

a social dilemma in which individual motives are in direct conflict with socially optimal resource management. In many ways, this social dilemma is due to the absence of centralized institutions that would otherwise provide valuable public governance that could enhance overall social welfare. In the absence of centralized institutions, however, the sustainable management of these community resources requires collective action, often facilitated through decentralized and endogenously formed institutions that promote cooperation through communication and social sanctioning.

In this study, we explore rural community members' propensity for cooperation using a series of experimental games conducted in the Kandhamal and Kalahandi districts in the state of Odisha, India. These two districts are very remote, with a relatively high concentration of members of scheduled tribes and scheduled castes. This marks a notable contribution of the present study. Although there have been some efforts to study behaviour pertaining to local common pool resource management in other developing countries, the present study is one of the first to do so within the context of remote and highly marginalized communities. The experimental games we employ are a variant of public goods game, specifically the voluntary contribution mechanism (VCM). We chose to use the VCM rather than other variants of public games for a few noteworthy reasons. First, the VCM is especially well-suited to measuring participants' propensity toward cooperation and collective action. Although this propensity toward cooperation and collective action need not necessarily pertain to common resource management, this is one area in which collective action is likely to be especially salient to the members of our sample, given that they represent a highly marginalized population in a very remote, sparsely populated region heavily reliant upon shared resources such as forests, rivers and inland water bodies (e.g., ponds or lakes). Relatedly, there are differences in the way in which individual behaviour in these two variants produce externalities on other participants in the game. In the VCM, for example, contributions to the production of the community good produce positive externalities that benefit other participants in the game. To the extent that we wanted these experimental games to have any sort of pedagogical benefits, we were more interested in the potential for encouraging behaviour that might foster positive externalities than we were in trying to discourage behaviour that might impose negative externalities. Finally, given the existing evidence from Cárdenas *et al.* 2017 from the implementation of VCM games within communities across several developing countries, we felt their evidence would provide something of a benchmark against which we could compare the results from our own study, even though we would plausibly expect some differences given the uniqueness of our context and our sample of participants.

As in a general VCM, individuals are provided with an initial endowment, and they must choose how much of this endowment to use for private consumption and how much to contribute toward the production of a local community good. Individuals derive utility from both private consumption as well as consumption of the public good, but there are important distinctions between these two sources of utility. The private consumption good can *only* be enjoyed by the individual. The community good, on the other hand, has properties similar to those of traditional common pool resources, in that the enjoyment of the community good is non-excludable (i.e., it is shared among *all* members of the community, regardless of whether they contribute to its production) but the community good available for enjoyment is both finite and

rival (i.e., there is a limited amount available for enjoyment, and if one member of the community enjoys a share of the community good, it cannot be enjoyed by another member).

The returns to private consumption and the per capita marginal returns to contributions toward the production of the community good are specified such that there is a social dilemma: the game yields a unique (single period) Nash equilibrium in which *no* participant contributes to production of the community good, but deviations from this equilibrium are potentially welfare enhancing, such that the Pareto optimal allocation of endowments for the group is for everyone to invest their entire endowments toward the production of the community good. We employ a version of the traditional VCM that has recently been employed in several other low- and middle-income countries (Cárdenas *et al.*, 2017, Wu *et al.*, 2022) that simplifies the decision space for participants. Rather than participants facing a decision regarding the *proportion* of their endowment to contribute to the community good, we simplify the decision space so participants only have to make a binary decision about whether to contribute or to retain their endowment. While this precludes analysis regarding the level of investment in community goods, it is perhaps more reflective of the true nature of cooperation in remote rural settings, specifically mimicking the “all-in” decision that must often be made regarding cooperation in the management of local community resources.

We introduced additional variants to the VCM to allow us to explore various dimensions of heterogeneity in participants’ contribution decisions. In particular, we explore how private and collective risk condition individual farmers’ willingness to contribute to community goods, under the assumption that stochasticity in the returns to contributions to the community good can erode cooperation. Our baseline experiment consisted of a standard VCM with a one-shot exchange in which the returns to private consumption and the per capita marginal returns to public contributions were fixed and known to all. We followed this baseline experiment with subsequent rounds introducing risk into the private and collective returns, with the order of the private risk and collective risk rounds randomized to prevent order effects. Consistent with the Nash equilibrium outcome, the baseline level of cooperation was rather low, suggesting that the participants in our sample might perceive the self-interested optimality of the strategy of private consumption over the social optimality of community good contributions.

We find that risk has a pronounced impact on individual behaviour, but the *nature* of the risk is crucial: risk affecting the returns on investments toward the production of the community good results in lower levels of cooperation compared with either the baseline or private risk scenarios. Unlike other studies, however, we find that risk affecting the returns to private consumption leads individuals to cooperate more by increasing contributions to the local community good relative to the baseline. These results are driven primarily by the sources of uncertainty. When there is risk in the returns to the community good, there are two sources of uncertainty moving in the same direction to erode cooperation: uncertainty around the decisions others will make and uncertainty around the returns on the community good. When there is risk in the returns to the private good, on the other hand, there are competing uncertainties: uncertainty around the decisions others will make (dampening the propensity toward cooperation) versus

uncertainty around the returns on private consumption (increasing the propensity toward cooperation).

We also consider the effects of group composition on individual behaviour. We consider different aspects of group composition, varying groups based on size (i.e., the number of participants per group), the sex composition of participants (same sex versus mixed sex), and relations (family pairs versus unrelated pairs). Contrary to much of the public goods literature suggesting larger populations are more prone to free-riding behaviour, and contrary to much of the existing literature on public goods games that argues against size effects (in the absence of concomitant reductions in the marginal per capita returns to the community good), we find evidence that larger groups had higher rates of cooperation than smaller groups. The sex composition of groups also emerged as an important determinant of behaviour, with mixed groups exhibiting lower levels of cooperation than single-sex groups. This effect was ameliorated to some degree if the mixing included familial pairs. We interpret this as evidence that cooperation is likely to be highest in more homogeneous groups, but relational proximity may offset the cooperation-eroding effects of group heterogeneity.

We also considered patterns of cooperation. The literature on cooperation has tended to classify individuals in VCMs (and other such games that force participants to confront a social dilemma) as falling into one of three distinct categories: free riders, who are wholly self-interested and refuse to cooperate no matter how great the potential returns from cooperation; unconditional cooperators, who have an overriding sense of altruism and commitment to cooperation; and conditional cooperators, who are willing to pursue the social optimum – but only if they expect a number of their companions to do so as well. We examine individuals' expectations about other participants' contributions, and assess the extent to which these expectations influenced cooperative behaviour. Expectations of higher contributions by other group members emerged as a significant determinant of individual behaviour. Indeed, these perceptions of social cohesion can further encourage cooperation even when there is risk in the returns to either private consumption or in the production of the community good. Interestingly, across all three rounds, *perceptions* of social cohesion are considerably higher than the *actual* levels of cooperation, but these expectations are positively correlated with individual behaviour.

The remainder of this paper is organized as follows. In [section 2](#), we provide some background on the literature examining common property resource management and the ways in which researchers have studied community members' behavior as it pertains to cooperation and collective action. In [section 3](#) we discuss the specifics of the empirical methods used to study individual behavior and how we classify individual behavior based on their expectations of the behavior of their peers. In [section 4](#), we introduce the data used in this study, including data on observed behavior in the context of the experimental games as well as supplementary demographic data from a household survey. In [section 5](#), we discuss our principal results on voluntary contributions to the production of the community good, with particular emphasis on the role of risk in the returns to private consumption or in the marginal per capita returns to investments in the production of the community good. In [section 6](#), we consider heterogeneity in voluntary contributions, specifically by gender and caste, and in [section 7](#), we offer some concluding remarks.

2. Background

In many rural communities in low- and middle-income countries, individuals' livelihoods are inextricably dependent upon local common property resources such as grazing lands; inshore fishing grounds; irrigation facilities such as polders, canals and tanks; subterranean aquifers; forests; and wildlife habitats (Seabright, 1993). Many of these local common property resources take the form of locally-managed natural resources and have properties that are reminiscent of both public goods and open-access resources. Unlike 'pure' public goods, the consumption of locally-managed natural resources is rival: one person's consumption of a finite natural resource necessarily implies that there is less of the resource to be consumed by others in the society. Yet these resources are also not 'purely' non-excludable, since access to these resources can typically be governed by local institutions, even if these are as informal as 'norms' or 'rules of conduct.' An important feature that often emerges in the context of such locally-managed resources is that access to the resource is fairly unrestricted within the community, but the rival nature of consumption shares the principal feature of over-exploitation of the common-pool resources, such as in the (in-)famous "tragedy of the commons" (Hardin, 1968).

Around the world, the value of these resources and the myriad environmental and ecosystem services that they provide have long been recognized, and governments and institutions (such as private markets) have arisen to manage these resources and to provide for their beneficial use by future generations. In many low- and middle-income countries, however, enforcement is often too weak, or communities that manage these resources are often too remote for state intervention to provide a meaningful means to oversee the management of these resources (Bardhan, 1993).

In the absence of a robust governance regime or institutions to provide these community goods or to sustainably manage the use of these local commons, there is an opportunity for local governance and collective action. Indeed, there are many examples in low- and middle-income countries of local communities successfully managing local common resources (Wade, 1987, Ostrom, 1990, Bardhan, 1993). Several researchers have attempted to understand the conditions under which these institutions can foster cooperation in the management of these local commons. Ostrom (1990, ch. 3) in particular details a variety of long-enduring communities that have successfully managed common property resources, both in developed countries as well as low- and middle-income countries. As a result of the numerous field studies that she and her co-authors conducted across these myriad sites, she summarized a series of eight design factors that most of the successful institutions had in common: (1) clearly defined boundaries (i.e., defining who is *in* the community, and who is *out* of the community); (2) congruence between the rules governing the provision and use of resources with local conditions; (3) collective choice arrangements allowing individuals affected by the collective's rules to participate in their modification; (4) the accountability of monitors – who audit the provision and uses of the resource – to the group, regardless of whether they are themselves members of the group (and therefore users of the resource themselves); (5) graduated sanctions with the seriousness or extent of violations of the collective's rules; (6) fast and fair conflict resolution; (7) local autonomy from external government authorities in the management of the

resource; and (8) polycentric governance ensuring that the collectives maintain appropriate relations with other tiers of rule-making authority, such as external government authorities.

Although these conditions are frequently viewed by modern theorists as pre-conditions for the successful management of local commons, and indeed they have been realized even in many low- and middle-income countries, they are far from ubiquitous. Prominent examples emerge from the Indian context. Beteille (1983), for example, documents cases in which access to the common property resources is restricted to relatively privileged members of Indian society, based on, for example, religion and caste. In other cases, the provision of community goods and the management of local commons introduces a social dilemma in the organization of rural societies, in which individual incentives are at odds with social well-being (Cárdenas and Carpenter, 2008). In the midst of such social dilemmas, there is a need for very grassroots-level cooperation. Yet cooperation is often difficult to enforce exogenously, since by its very definition, cooperation is voluntary. While Seabright (1993) has suggested that “cooperation can be habit-forming”, depending on historical and traditional considerations, it has also been observed that cooperation can often be quite fragile, and can be influenced by a number of factors, including trust, social cohesion and risk (Kocher *et al.*, 2015).

When researchers have attempted to study these types of collective action problems, they have typically done so through the lens of prisoner’s dilemma games, which economists frequently cast in terms of a public goods problem (Croson, 2008). Experimental economists have long studied the propensity to cooperate in various forms of public goods experiments, including the VCMs (e.g., Isaac *et al.*, 1984), provision point mechanisms (e.g., Bagnoli and Lipman, 1989), and common pool resource management mechanisms (e.g., Walker *et al.*, 1990). While these mechanisms differ in the nature of the decision that participants make in the game and the manner in which the public goods are generated and distributed to the participants (i.e., the production function), they share a common feature of externalities: each individual affects and is affected by the other participants. Additionally, each game presents participants with a social dilemma in which the dominant strategy results in a socially inefficient Nash equilibrium, while an alternative strategy yields a social optimum (Cárdenas and Carpenter, 2008). Deviations in observed behaviour from the dominant strategy are frequently attributed to a propensity for cooperation, altruism, or various other-regarding motivations.

The primary setting for most of these experiments has been the laboratory, typically with subjects drawn from a pool of university students. A few of these have been implemented in the field (as opposed to a laboratory setting), and some have even been implemented in low- and middle-income countries (e.g., Cárdenas *et al.*, 2000, 2002, Barr, 2001, Carpenter *et al.*, 2004, Karlan, 2005, Meinzen-Dick *et al.*, 2018, Wu *et al.*, 2022). Over the years, some stylized facts have emerged regarding participants’ behaviour in these games. In particular, it is commonly found that initial cooperation rates are in the range of 40–60 per cent, with the level of cooperation steadily declining over successive rounds of the game, presumably as participants learn the dominant strategy. The level of cooperation is strongly correlated with the marginal per capita return (MPCR) on cooperation (a parameter of the public good production function

that defines how the public good is generated and distributed to the participants), with cooperation declining as the MPCR declines, thus suggesting that cooperation is not the result of participants simply making mistakes (Brandts and Schram, 2001). Despite being a dominant strategy, a small minority of participants free ride as an initial strategy. Contrary to what is typically theorized in the public economics literature, the propensity for free-riding does not increase as group size increases, though when combined with a reduction in the marginal per capita returns to cooperation, free-riding does tend to increase (Isaac and Walker, 1988).

Given the frequency with which researchers observed cooperation in these various types of public goods games (a violation of rational self-interested decision making), there were attempts to broadly classify the observed behaviours. Offerman *et al.* (1996), for example, classified participants into five categories based on what they defined as “value orientations.” According to their taxonomy, participants can be classified as (1) competitors, who simply want to be better off than their neighbours; (2) individualists, who try to maximize their own welfare; (3) cooperators, who simultaneously pursue maximizing both their own welfare and the welfare of others in the group; (4) altruists, who unconditionally seek the best for others regardless of the impacts on themselves; and (5) aggressors, diametrically opposed to the altruists, who seek the worst for others, regardless of the impacts on themselves. Others have proposed a simpler taxonomy, consisting of *unconditional cooperators*, acting purely out of altruistic motives; *free riders*, who follow purely self-interested strategies; and *conditional cooperators*, who are willing to cooperate if they expect the overall level of cooperation among their peers to exceed some minimum threshold. Most studies would classify the bulk of their participants as conditional cooperators. Cárdenas *et al.* 2017 found conditional cooperation to be prevalent and that the nature of risk was an important factor in cooperation. In simultaneous move games, conditional cooperation implies that expectations about the actions of others can be an important determinant of cooperation in these environments. Further, the composition of the community may have an impact on the propensity to cooperate. Does the size of the group managing the resource matter for cooperation? For example, is there a greater propensity for people to free-ride amid larger communities, wherein some individuals think they can ‘fly under the radar’ and enjoy the benefits of community goods without making any meaningful contribution to their production? Additionally, are people more prone to cooperate with people that are more similar to them? These are just a few of the questions that the present study aims to examine.

3. Empirical methods

3.1. Voluntary contribution mechanism experimental protocol

The experimental protocol we propose to use to study farmers’ cooperation in the management of local common resources and the provision of community goods is based on a variant of a traditional VCM recently used by Cárdenas *et al.* 2017, who used a framed experiment to understand how private and collective risk condition individual farmers’ willingness to contribute to public irrigation infrastructure. The particular variation of the VCM that we employ allows for risk in both the returns to private consumption and the public goods production function. Risk is obviously

an important part of livelihoods among rural residents in low- and middle-income countries and, given the nature of uncertainty surrounding the returns to common property natural resources and their shared management, gaining additional insight into how individuals respond when facing different sources of risk is of great interest and policy relevance. Experimental evidence has demonstrated that payoff stochasticity can erode cooperation (Bereby-Meyer and Roth, 2006), but Cárdenas *et al.* 2017 have shown that – in some contexts – the nature of the risk (i.e., individual versus collective) matters.

Our experiment consisted of three rounds, each following the same basic structure. The baseline round was designed like a typical, one-shot VCM. In a typical VCM, individuals are given an initial endowment (Z_i), and they must choose how much of this endowment to use for private consumption and how much to contribute to a community good (m_i). Most authors have assumed that participants in the game derive utility from both private consumption as well as consumption of the community good, such that individual i 's utility function be written as

$$U_i = u_i \left[Z_i - m_i + \left(\frac{1}{N} \right) G \left(m_i + \sum_{j \neq i} m_j \right) \right], \quad (1)$$

where $Z_i - m_i$ represents the amount of private consumption and $\left(\frac{1}{N} \right) G(\cdot)$ is the per capita return from the community good. The production function $G(\sum_i m_i)$ here is linear, since the more that is allocated to the community good, the greater the total social benefits. This linearity has two important implications (Croson, 2008). First, subject to appropriate parameterization, this game yields a unique (single period) Nash equilibrium in which no participant contributes to the community good.¹ Second, however, and again subject to appropriate parameterization, is that deviations from this equilibrium are potentially welfare enhancing, such that the Pareto optimal allocation of endowments for the group is for everyone to invest their entire endowments toward the production of the community good.²

If the utility function in equation (1) were indeed the correct specification of the utility function and individuals were only concerned with utility of own consumption, then given the manner in which most of these games are specified, with $u_i(Z_i) > \left(\frac{1}{N} \right) G(m_i + \sum_{j \neq i} m_j)$, then the Nash equilibrium should result. Rather, we allow for an altruism function $\Psi : \mathbb{R}_+ \rightarrow \mathbb{R}_+$ to contribute to individual utility, mapping others' enjoyment of the benefits of the community good to contribute to individual utility:

¹For this to hold, the experiment must be parameterized in such a way that the MPCR to the community good, $1/NG'(\cdot)$, should be less than the return from the private good. This ensures that no individual has a selfish incentive to contribute to the production of the community good.

²For this to hold, the experiment must be parameterized in such a way that the social benefit from all members contributing their endowments to the creation of the community good is greater than the foregone private benefit. This ensures that contributing to the creation of the community good is socially optimal.

$$U_i = u_i \left\{ Z_i - m_i + \left(\frac{1}{N} \right) G \left(m_i + \sum_{j \neq i} m_j \right) + \Psi \left[\left(\frac{N-1}{N} \right) G \left(m_i + \sum_{j \neq i} m_j \right) \right] \right\}. \quad (2)$$

It is perhaps useful to think of $\Psi[\cdot]$ as reflecting individual i 's *indirect* enjoyment of the community good, or, alternatively, individual i 's enjoyment of others' enjoyment of the community good. This altruism function allows for the possibility of cooperation, which would be a deviation from the Nash equilibrium of full private consumption. In designing our experiment, we opted to simplify the participants' decision making and reduced the consumption/contribution decision to a binary one: either they choose to privately consume their endowment, or they choose to contribute to the community good. While the binary nature of our contributions precludes a richer analysis of proportional contributions, the voluntary binary contribution decision is certainly easier for everyone to understand, regardless of education level, and is arguably a closer approximation to the cooperation decisions that the respondents face on a regular basis in their remote rural communities.

Obviously, in a simultaneous move game, the participant does not know the number of co-participants who would be contributing to the community good at the time the decision is made, so [equation \(2\)](#) reflects the realized benefits of a particular outcome, rather than providing a tractable basis for deriving a decision rule. Rather, given the uncertainty in co-participants' cooperation, we assume the participant chooses $m_i = 0$ or $m_i = 1$ to maximize the expected utility that would be derived from either consuming her endowment or contributing her endowment to the community good.

In the baseline round, each participant was given an endowment of one token, and had to decide between private consumption with a return of Indian rupees (INR) 20, or contributing to the production of a community good that would generate a MPCR of INR 10 for each token invested by group members. Notice that the Nash equilibrium condition (i.e., where each player's single period dominant strategy is to contribute nothing to the group fund) still holds ($\text{INR } 10 < \text{INR } 20$), but contributions to the group fund are socially efficient (i.e., Pareto optimal) for group sizes greater than 2. In our experiment, villages were randomly allocated to consist of "small groups" (of 6 participants each) or "large groups" (of 12 participants), so in all cases participants faced the social dilemma of rational self-interest versus social optimization.

In the private risk round, the baseline protocol was modified such that private returns (i.e., the returns to consumption of the endowment rather than cooperation) were stochastic. Under these conditions, there is uncertainty in the returns to both private consumption and contributions to the community good, with the latter due to uncertainty around the decisions of other members of the group (though the MPCR is constant).

Operationally, the game worked very similarly to the one described above, but after the participants allocated their tokens to either private consumption or the group fund, we tossed a fair coin with 50/50 odds of a double-or-nothing return on private consumption. If the coin turned up heads, the private return would be INR 40, whereas

if the coin turned up tails, the private return would be INR 0. Regardless of the decision to keep or contribute one's individual token, each individual would still receive the MPCR of INR 10 per token contributed to the group fund.

In the collective risk round, the baseline protocol was modified such that the MPCR on contributions to the community good were stochastic, while the returns to private consumption were fixed. Under these conditions, there are two sources of uncertainty in contributing to the community good: those associated with the MPCR on contributions to the community good as well as the overall level of cooperation in the game. If an individual retained their token, they would still earn a private return of INR 20. But after the individual decisions were made, we tossed a fair coin, again with 50/50 odds of a double-or-nothing MPCR on contributions to the group fund. If the coin turned up heads, the MPCR on group fund contributions would be INR 20, whereas if the coin turned up tails, the MPCR on group fund contributions would be INR 0.

Each of the three rounds was treated as a one-shot game in which individuals made a binary decision about whether to voluntarily contribute to the public fund. Prior to initiating the first round, participants were instructed of the rules of the game, which the enumerators enforced strictly. In particular, participants were instructed that they could *not* talk amongst themselves; they should *not* announce their decision aloud; if they had a question, they should raise their hand and address their question *only* to the enumerator; their decisions in each round would be kept private and confidential by the members of the research team (including the enumerators themselves); and their *individual* decisions in each group would not be disclosed to the group, but only aggregate outcomes would be disclosed. To avoid learning effects, we did not provide any feedback to participants regarding the outcomes of their decisions until after all experiments were performed. Croson (2008) notes that, in a finitely repeated game, backward induction supports the Nash equilibrium of no group fund contributions, so it is thought that, over the course of several rounds, individuals will effectively learn this dominant strategy. Indeed, many studies reporting on VCM experiments observe contributions to the community good at roughly half of an individual's endowment during the first round, with contributions steadily declining over subsequent rounds as a proportion of the individual's endowment as individuals learn the dominant strategy.

Following Cárdenas *et al.* 2017, we controlled for order effects by randomizing the order of the private risk and collective risk rounds. Roughly half of the sample participants faced the private risk variant of the game following the baseline round, followed by the collective risk variant, while the other half proceeded with the collective risk and then the private risk game following the baseline. In addition to randomizing the group size and the order of the two rounds introducing stochasticity in returns to either private consumption or in the marginal per capita return on contributions to the community good, there were several other elements that were randomized over the course of the study. Specifically, the sex composition of the groups was randomized. In half of the villages in our sample, groups were single-sex groups (either male-only or female-only). So, for example, in a village that was randomly selected to consist of small groups (each consisting of six participants), there would be two groups each with six males and two groups each with six females. In a village that was randomly selected to consist of large groups (each consisting of 12 participants), there would only be one group of 12 males and one group with 12 females. In the other half of the villages, groups were

mixed groups, consisting of 1/2 males and 1/2 females. In this latter half of villages, we also varied the *nature* of the mixing. In half of the villages with groups consisting of both males and females, the groups consisted of familial pairs (e.g., husbands and wives), while in the other half of the villages with mixed groups, the groups consisted of unrelated males and females.

The games were designed to be incentive compatible so that participants had economic incentives to reveal their true preferences in the course of the experiment. Following the completion of all three rounds of the game, one round was selected at random to be the basis for actual cash payments to participants, based upon their decisions and the decisions of others in the group for that round. If either the private risk round or the public risk round was selected as the basis for payment, a member of the enumeration team would flip a fair coin to determine the rate of return on private consumption or the MPCR on contributions to the community fund.

3.2. Determinants of cooperative behaviour

Based on observed behaviour from the baseline round and the modifications in the subsequent two rounds, it becomes clear that the contribution decision is a function of the idiosyncratic utility function u_i , which reflects individual and/or community characteristics $\mathbf{x}_i$ ($u_i \equiv u_i(\mathbf{x}_i)$), the MPCR to contributions to the community good (the production function G), the expected contributions of co-participants, and each individual's unobservable altruism function Ψ . We can write the participants' decision function as

$$m_i = f(u_i^*(x_1, \dots, x_k), G, E \left[\sum_{j \neq i} m_j \right], x_{i,u}; \beta) + \varepsilon_i, \quad (3)$$

where $u^*(\cdot) = u(\cdot)$ when the arguments are deterministic and $u^*(\cdot) = Eu(\cdot)$ when the arguments are stochastic, x_u is some unobservable individual or community characteristics conditioning the contribution decision, β is a vector of coefficients to be estimated, and ε is an idiosyncratic error term capturing random variations in preferences, errors in optimization, etc. Operationally, we control for u^* by including two dummy variables to reflect the existence of risk in returns to private consumption and risk in returns to the marginal returns on community good contributions. The vector of individual and community characteristics included in $\mathbf{x}$ should reflect attitudes toward risk, since there is at least some uncertainty in all scenarios.³ We assume that x_u is uncorrelated with any of other arguments in m ; consequently, given the binary nature of the contribution decision, this equation could simply be estimated as a linear probability model using ordinary least squares.

³In the empirical work that follows, we classify individuals as being very risk averse, moderately risk averse, risk neutral, moderately risk loving, and very risk loving. These classification are based on responses to a survey question in which they select a statement that most closely corresponds to their attitudes toward taking risks, ranging from "I prefer not to take risks at any time, regardless of the potential benefits" (very risk averse) to "I always prefer taking risks over playing it safe, regardless of the potential losses" (very risk loving).

4. Data

The data used in this study come from both a primary survey and a series of experimental games (voluntary contribution mechanisms) conducted in the Kandhamal and Kalahandi districts in the state of Odisha, in eastern India. Both districts are quite remote and heavily rural, with only 7.8 per cent of the population of Kalahandi living in urbanized areas, and less than 10 per cent of the population of Kandhamal living in urban areas according to the 2011 Census of India (the most recent census). Accordingly, both districts are also sparsely populated. Much of Kandhamal is forested and, according to the 2011 census, the population density was only 91 persons per square km. Much of Kalahandi is also covered with a dense forest, though it is less sparsely populated than Kandhamal, with just under 200 persons per square km according to the 2011 census. Consequently, public institutions remain relatively weak, and Kandhamal in particular has been a hotbed for Naxalite-Maoist insurgencies. Both districts consist of a large proportion of members of scheduled tribes (ST) and scheduled castes (SC). These labels are official designations conferred on historically disadvantaged social groups in India, including those members of lower castes formerly referred to as “untouchables.” These official designations were the result of the *Constitution (Scheduled Castes) Order of 1950* and the *Constitution (Scheduled Tribes) Order of 1950*, respectively. These designations confer some advantages on its members, such as *reservations* or quotas meant to ensure political representation and equal opportunities for education and the administrative services. Despite such reservations, however, members of SC and ST communities still suffer economic and social disadvantages.

The sample was drawn from a list of 84 villages selected across Kandhamal and Kalahandi districts in central and southwestern Odisha.⁴ Within each selected village, the survey team identified all households actively engaged in agricultural cultivation with the assistance of the sarpanch (a type of local leader or administrator), and from this list 12 households from each village were randomly selected for participation in our study. One adult man and one adult woman were interviewed from each household for a total initial sample of 1,960 respondents (980 men and 980 women). Each interview contained questions on household agricultural practices, consumption, assets, household composition, decision making, aspirations, and empowerment, as well as laboratory-in-field experiments to elicit preferences with respect to risk, loss, ambiguity and time. Some questions were answered only by the primary decision maker, while others were answered by both respondents. Later that day or the following day, respondents participated in a group game with other respondents in the village.

⁴Since the present study was conducted in the context of a project implemented by the Indian affiliate of the international nongovernmental organization (NGO) CARE, our sample consisted of both villages that had been identified for CARE's programming and those that had not been identified for these CARE programs. The result is 42 pairs of villages, half of which were CARE villages and the other half which were non-CARE villages, for a total sample of 84 villages. In the analysis that follows, however, we do not make any distinction between CARE and non-CARE villages. See Alvi *et al.* (2023) for a more detailed discussion of the sampling strategy employed.

Descriptive statistics for our sample are reported in [table 1](#). By design, our sample consists of half men and half women. On average, the participants in our study are about 40 years old, and have households comprised of roughly five members. Households in the sample had income of roughly INR 3,660 per month, equivalent to about US\$50 per month at the time of the study. The vast majority (95 per cent) of participants are Hindu, with the remainder identifying as Christian. Roughly half of the participants are literate (in the sense that they can both read and write). Roughly 60 per cent of participants are members of STs, and an additional 20 per cent of participants are members of SCs. Only 3 per cent of participants are members of the upper caste. The plurality of respondents indicated being either very or moderately risk averse (about 50 per cent), though 24 per cent report being very risk seeking.

5. Results

5.1. Descriptive analysis of voluntary contributions

Our analysis of the results from our VCM begins with simple descriptive and graphical analysis, before moving on to more rigorous statistical analysis. To begin, we first observe patterns of cooperation – defined as voluntary contributions to the community good – which are illustrated in [figure 1](#), broken out by round (baseline, private risk, collective risk). Based simply on rates of cooperation, we observe 43 per cent of participants contributing to the public fund during the baseline (no-risk) round of the VCM game. This is generally lower than the rates of cooperation observed across four countries in [Cárdenas *et al.* 2017](#), though in that study the authors found rates of cooperation varied quite a bit from country to country. Our results suggest that the nature of risk can have an important effect on voluntary contributions. In the private risk round of the game, contributions increased to a mean of 48 per cent, while in the collective risk round, the contribution rate dips to 41 per cent.⁵

5.2. Classification of cooperative behaviour

From observing participants' contribution decisions in the experimental data, we are able to classify participants as unconditional cooperators, conditional cooperators, or free riders. In particular, we classify participants as unconditional cooperators if they chose to contribute toward the production of the community good in every round of the game, regardless of how they expected other members of the group to behave. Conversely, we classify participants as free riders if they chose to retain their endowment for private consumption in every round, regardless of how they expected other members to behave. We classify participants as conditional cooperators if they are somewhere in between, where they have an inclination toward voluntary

⁵Based on χ^2 tests in differences in proportions (using Yates' continuity correction), the difference in proportions of contributions between the baseline and private risk rounds has a *p*-value of 0.002 and the difference in proportions of contributions between the private risk and collective risk rounds has a *p*-value of less than 0.001; the difference in proportions of contributions between the baseline and collective risk rounds has a *p*-value of only 0.14, so this difference in proportions of contributions is not statistically significant at conventional levels.

Table 1. Descriptive statistics of sample households

Characteristic	Full sample
Age (years)	41.846 (12.743)
Gender (woman = 1)	0.504 (0.012)
Religion (Hindu = 1)	0.953 (0.005)
Marital status (married = 1)	0.957 (0.005)
Literacy (literate = 1)	0.528 (0.012)
Household head (head = 1)	0.484 (0.012)
Household size	5.363 (2.077)
Risk preferences Very risk averse	0.135 (0.008)
Moderately risk averse	0.345 (0.011)
Risk neutral	0.205 (0.010)
Moderately risk loving	0.080 (0.006)
Very risk loving	0.236 (0.010)
Caste General caste	0.029 (0.004)
Other backward caste (OBC)	0.186 (0.009)
Scheduled caste (SC)	0.204 (0.010)
Scheduled tribe (ST)	0.581 (0.012)
Total income (avg. per month, INR)	3,659.011 (2,779.596)
Household has access to irrigation (=1)	0.260 (0.010)
Proportion contributing in baseline round	0.43 (0.49)
Proportion contributing in private risk round	0.48 (0.50)

(Continued)

Table 1. (Continued.)

Characteristic	Full sample
Proportion contributing in collective risk round	0.41 (0.49)
Expected cooperation among peers	0.64 (0.20)
Observations	1,761

Notes: Standard deviations appear in parentheses.

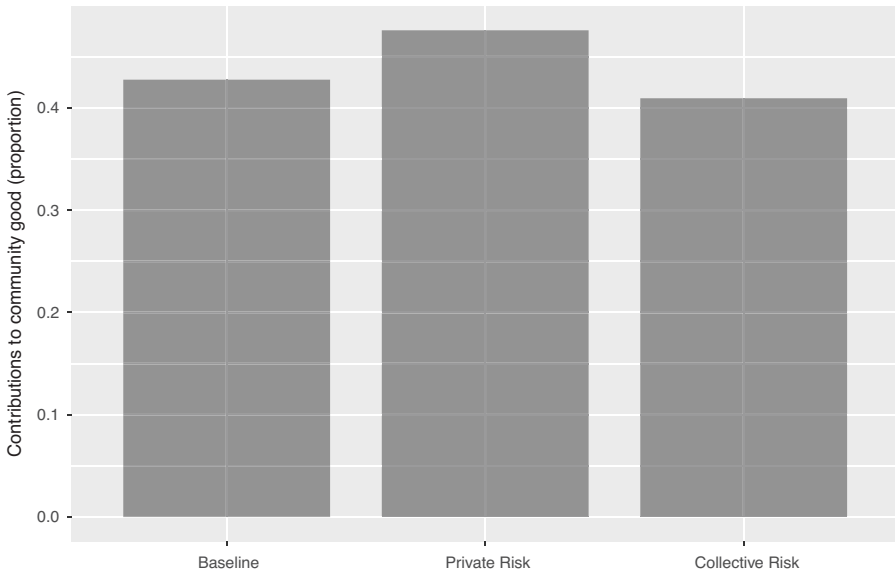


Figure 1. Contributions to the community good, by round.

contribution to the production of the community good, but only if they expect the level of contributions among their peers to exceed some subjective threshold. Based on this classification, we indeed find a significant portion of the participants appear to be acting as conditional cooperators, rather than unconditionally cooperating or free riding. Indeed, out of the 1,767 participants in the experimental games for whom we have a complete set of observations, only 16 per cent could be considered *unconditional cooperators*, acting purely out of altruistic motives, while 26 per cent could be considered as *free riders*. The remaining 58 per cent could be considered *conditional cooperators*. Much of this observed behaviour seems tied to individuals' expectations about the level of cooperation among their peers, which is perhaps an indicator of social cohesion.

In what follows, participants' expectations about the level of cooperation among their peers are based on their self-reported belief about the number of other participants in the game that they believed would contribute to the production of the local good. Prior to each round of the game (no risk, community risk, private risk),

participants were asked to report the number of other participants who they thought would contribute to the production of the local good in that round. These figures were then divided by the total number of participants in that village's version of the game, and these proportions were then averaged over the three rounds. Unconditional cooperators have considerably higher expectations about their peers' behaviour than do conditional cooperators or free riders. Among unconditional cooperators, the average expected level of co-participants' cooperation in the provision of the community good is about 74 per cent, compared with 64 among conditional cooperators, and only 58 among those who opt to free ride. Clearly, as people expect that a greater number of their peers will cooperate, they themselves are more inclined to cooperate, such that increasing the level of expected cooperation among peers is an important step in pushing people toward unconditional cooperation.

5.3. *Determinants of cooperation in voluntary contribution game*

Our statistical analysis assessing the extent to which social cohesion, the nature of risk, and group composition influences individuals' willingness-to-cooperate through voluntary contributions takes the form of linear probability models, with standard errors adjusted for the clustering of contribution decisions at the individual level. To begin, we first examine the effects of members' expectations of peer behaviour. Coefficient estimates from this regression are reported in [table 2](#), column (1). There is very clear statistical evidence that participants' expectations regarding the contributions of their peers has a strong effect on their own degree of voluntary contributions, though we cautiously maintain these relationships are associational rather than causal. Indeed, participants who expect everyone in their group to contribute to the community good are 37 percentage points more likely to contribute to the fund themselves, compared the base average contribution rate of 41 per cent.

In column (2), we look at the effect of risk in the returns to either individual consumption of the endowment or in contributions to the community good. Not surprisingly, when there is private risk, individuals are 4 percentage points more likely to contribute to the community good, perhaps viewing it as a safer vehicle than the more uncertain returns on consuming the endowment. When there is collective risk, on the other hand, individuals are 2 percentage points less likely to contribute to the community good (p -value = 0.09). These results are consistent with previous research (e.g., Cárdenas *et al.*, 2017) that cooperation may be quite fragile, depending on the relative risk of cooperation compared with more self-interested behaviour.

In columns (3)–(4), we consider the effects of group composition, first by examining how group size affects contributions (column (3)), and then examining how the sex composition of the group affects contributions, both for mixed-sex groups in which the groups consist of sets of family members and for mixed-sex groups in which there are unrelated men and women (column (4)). While some studies have demonstrated that group size alone does not seem to be an important determinant of contributions to the community good, we actually find that group size does have a positive effect on contributions. Each additional member in the group increases the likelihood of voluntary contributions by 1 percentage point. While we certainly would not expect this to be a simple linear relationship, it is noteworthy that increasing the group size from

Table 2. Determinants of contributions to community good

Dependent variable: voluntary contributions to community fund	(1)	(2)	(3)	(4)
Intercept	0.410 (0.098)	0.405 (0.099)	0.298 (0.103)	0.429 (0.101)
Expected proportion of cooperators	0.369 (0.032)	0.368 (0.032)	0.389 (0.032)	0.368 (0.032)
Risk in returns to private activity		0.042 (0.014)	0.041 (0.014)	0.042 (0.014)
Risk in returns to community contributions		-0.024 (0.014)	-0.025 (0.014)	-0.024 (0.014)
Group size			0.011 (0.003)	
Group composition: mixed-sex				-0.043 (0.019)
Group composition: mixed-sex, same household				0.033 (0.019)
Total number of observations	5283	5283	5283	5283
Number of individuals	1761	1761	1761	1761
R^2	0.06	0.06	0.07	0.06

Notes: Standard errors adjusted for individual-level clustering in parentheses. In each regression, the dependent variable is a binary indicator for contribution to the community good. All regressions contain additional controls for age, gender (binary), caste (OBC, SC and ST binaries), religion (Hindu binary variable), marital status, household size, total household income, status as household head, literacy, risk preferences and district fixed effects.

six to 12 individuals led to a roughly 7 percentage point higher contribution rate. In this case, there is not an increased tendency for free-riding, even without the potential for punishment or sanctioning for doing so. Rather, it seems as though the participants understand the social dilemma of self-interest versus social optimality, and opt to at least pursue the latter, even at the expense of the former. It should also be noted that, because the ratio of the MPCR to the return on private consumption (in the baseline round) was 1/2, there is a clear social dilemma for group sizes greater than two. For groups of six, full cooperation would result in each individual earning INR 60, whereas if everyone pursued their own self interest, they would each only earn INR 20.

In examining the effect of sex composition, we see that individuals in mixed-sex groups are less likely to contribute than members in groups consisting of members of the same sex. However, the effects are partially ameliorated if the mixed-sex pairs are members of the same household. Individuals in mixed-sex groups consisting of individuals to whom they are wholly unrelated are 4 percentage points less likely to contribute to the community good, while individuals in mixed-sex groups with a family member are only about 1 percentage point less likely to contribute.⁶ In a country like

⁶This total effect consists of the linear combination of the effects for 'mixed-sex' and 'mixed-sex, same household.'

India, where there are still incredibly salient concerns over gender inequality, there is likely a significant amount of distrust among women toward their male peers. Yet this also likely says something about the effects of group heterogeneity more generally. More homogeneous groups likely have greater social cohesion, and this may facilitate greater degrees of cooperation.

Across these different specifications, one factor that explains a great deal of contributions to the community good is the participant's expectations about the proportion of co-participants who are contributing to the community good. Across the different specifications, the marginal effect is between a 37 and 39 percentage point increase in the likelihood of contributions. And these expectations clearly drive much of the observed behaviour. If individuals expected that none of their peers would voluntarily cooperate, their likelihood of voluntary cooperation would be only about 20 per cent. But this also does not mean that it is necessarily easy to tip the scales toward a more-likely-than-not level of voluntary cooperation. On average, in order to achieve a probability of voluntary cooperation in excess of 50 per cent, individuals would need to expect that more than 81 per cent of their peers would be cooperating. Consistent with these results, previous research has pointed to beliefs or expectations as being important determinants of cooperation and contributions to collective action (e.g., Offerman *et al.*, 1996, Fischbacher *et al.*, 2001, Kocher *et al.*, 2015). Consequently, if it is possible to influence these expectations through pro-social programs, there could be important implications for the management of community resources.

6. Heterogeneity in effects leading to voluntary cooperation

In this section, we consider whether some of the determinants of voluntary cooperation analysed in [table 2](#) have heterogeneous effects in our sample based on several social domains, specifically gender and caste. For a number of reasons, largely tied up in religion and culture, women and members of SCs and STs have been historically disadvantaged within Indian society. Only relatively recently have NGOs and civil society organizations made considerable investments in trying to improve upon this situation and empower these marginalized groups.

6.1. Heterogeneous impacts by gender

Since many NGOs and civil society organizations specifically worked with or through women's self-help groups, it is worthwhile to examine whether women behave differently in the VCM when confronted with various sources of risk or varying group dynamics. In [table 3](#), columns (1)–(2), we report the results from regressing voluntary contributions on the determinants of contributions from [table 2](#), but in this case allowing for heterogeneity in the effect of risk (column (1)) or in the group composition (column (2)) based on the gender of the participant. In column (1), we find evidence that the effect of risk on voluntary cooperation is different for men and women. Whereas neither private risk nor public risk has an effect on the likelihood of voluntary cooperation among men in our sample, there are significant – and nearly diametrically opposed – effects of risk on the likelihood of

Table 3. Heterogeneity in determinants of contributions to community good

Dependent variable: voluntary contributions to community fund	(1)	(2)	(3)	(4)
Participant is a woman	0.002 (0.054)	0.034 (0.056)	−0.010 (0.051)	−0.015 (0.051)
Participant is from Scheduled Caste (SC)	−0.119 (0.047)	−0.112 (0.046)	−0.141 (0.054)	−0.137 (0.086)
Participant is from Scheduled Tribe (ST)	−0.098 (0.045)	−0.091 (0.045)	−0.124 (0.050)	−0.069 (0.077)
Risk in returns to private activity	0.019 (0.021)		0.021 (0.031)	
Risk in returns to community contributions	0.017 (0.020)		−0.064 (0.032)	
Group composition: mixed-sex		−0.014 (0.029)		
Group composition: mixed-sex, same household		0.047 (0.028)		
Group size				0.011 (0.006)
Participant is a woman × Risk in returns to private activity	0.046 (0.029)			
Participant is a woman × Risk in returns to community contributions	−0.081 (0.029)			
Participant is from Scheduled Caste × Risk in returns to private activity			0.004 (0.045)	
Participant is from Scheduled Caste × Risk in returns to community contributions			0.062 (0.043)	
Participant is from Scheduled Tribe × Risk in returns to private activity			0.035 (0.037)	
Participant is from Scheduled Tribe × Risk in returns to community contributions			0.046 (0.037)	
Participant is a woman × Group composition: mixed-sex		−0.058 (0.039)		
Participant is a woman × Group composition: mixed-sex, same household		−0.028 (0.037)		
Participant is from Scheduled Caste × Group size				0.004 (0.008)
Participant is from Scheduled Tribe × Group size				−0.002 (0.007)
Total number of observations	5283	5283	5283	5283
Number of individuals	1761	1761	1761	1761
R^2	0.07	0.07	0.06	0.07

Notes: Standard errors adjusted for individual-level clustering in parentheses. In each regression, the dependent variable is a binary indicator for contribution to the community good. All regressions contain additional controls for age, OBC caste (binary variable), religion (Hindu binary variable), marital status, household size, total household income, status as household head, literacy, risk preferences, the expected cooperation of peers in the group, group size and district fixed effects.

women's voluntary cooperation. Specifically, much like we observed with the full sample on average, when there are risks in the returns to private activities, we find that women are 6.46 percentage points more likely to voluntarily contribute to the community good (p -value of 0.005), despite remaining uncertainty about the returns to these cooperative contributions (due to uncertainty regarding the contributions of other group members). When there is risk in the MPCR to voluntary contributions, which compounds the risk to cooperative contributions, our results suggest that women are 6.47 percentage points less likely to voluntarily contribute to the production of the community good (p -value of 0.005), though interestingly, the evidence suggests men are no less likely to contribute to the production of the community good.

We also consider whether there are differences in how group composition affects voluntary contributions between men and women. These results are reported in column (2) of [table 3](#). For men, being in mixed-sex groups in which there are unrelated men and women does not significantly affect the likelihood of voluntarily contributing to the community good, though there is some evidence that participating in mixed-sex groups with female members of the same household may increase men's cooperation (combined effect of 0.03, p -value of 0.16). Group composition has considerably different effects on the likelihood of voluntary cooperation among women. In particular, women are 5.33 percentage points less likely to voluntarily contribute (p -value 0.002) when they are in mixed-sex groups with unrelated men, and although being in groups with men from their own households, the mixed-sex nature of these groups implies they are still 5.33 percentage points less likely to cooperate (p -value of 0.02).

6.2. *Heterogeneous impacts by caste*

In addition to working through women's self-help groups, many NGOs and civil society organizations have worked in areas that have relatively large concentrations of SC and ST individuals, groups that have been historically marginalized. Because of their engagement with these groups, it is an empirical question whether these engagements have affected the social cohesion of these groups. In column (3) of [table 3](#), we report results analysing the determinants of voluntary contributions allowing for interactions between caste and the risk associated with investments in private consumption or the production of the community good, while in column (4) we report results analysing the determinants of voluntary contributions allowing for interactions between caste and group size. Our results suggest that, at least at the time these experimental games were implemented, there was not an appreciable difference in the way members of SC and ST communities responded to risk or group size compared to members of general castes or other backward castes. One exception to this general observation pertains to members of ST communities when confronted with risk to the returns on investments in the private consumption good. Whereas there is not a statistically significant effect among members of general castes and other backward castes, risk in the returns on investments in the private consumption good increases voluntary contributions to the production of the community good by about 6 percentage points among members of the ST community.

7. Conclusion

In this study, we have used a VCM to study cooperation among members of remote rural communities in the eastern Indian state of Odisha. As in many remote rural communities, the communities in our sample are actively engaged in collectively managing myriad natural resources and other local common-pool resources for which neither private markets nor centralized government management emerge as viable governance strategies, either due to the nature of the resource or due to the remoteness of the communities and the ineffectiveness of external enforcement.

The experimental game was designed in such a way that participants always face a social dilemma in which individuals' dominant strategy – retaining one's endowment for personal consumption – is socially inefficient. While rarely as stark as in this experimental setting, this type of social dilemma is a frequent occurrence in many rural contexts in developing countries, and thus this laboratory-in-field type of experiment provides a valuable lens into the decision making dynamics of households confronted with these trade-offs. A concern about the external validity of our empirical results is that the relatively low return in this specific game may not accurately reflect the real-world benefits and costs of local public goods. While acknowledging this limitation, we also note that for many of the participants, the returns in these experiments would be nontrivial and we believe would still be incentive compatible.

With risk being a common – and increasing – presence in the lives of rural households, we set out to see the extent to which cooperation in the management of community resources could be affected by the nature of risk. To do so, we followed the approach introduced in Cárdenas *et al.* 2017 and incorporated uncertainty into both the returns to private consumption as well as in the marginal per capita return to contributions in the community good in subsequent rounds of the VCM.

The results suggest that voluntary cooperation is far from perfect, even in a baseline scenario in which the only element of risk is in the extent of co-participants' cooperation in the VCM. Participants alter their strategies in subsequent rounds when additional risk is introduced, but the nature of the risk largely determines the nature of their adjustments. When the additional risk is constrained to the returns of private activities, there is an increased level of cooperation, whereas risk in the per capita returns to the community good crowds out cooperation. The composition of the group managing the community good is also an important determinant of cooperation. Contrary to what is often conjectured in the context of large-scale public goods – which suggests a propensity for free-riding as the size of the population increases – and contrary to much of the literature on public goods games – which generally finds no evidence of size effects – we find that the propensity for cooperation actually increases with larger groups, perhaps suggesting that group members perceive the social optimality of broader cooperation compared to the social inefficiency of universal defection. Groups that are more homogeneous tend to favour greater levels of cooperation, as introducing gender diversity into groups reduces the level of cooperation, though this effect is partially offset when the gender mixing includes familial pairs.

We find strong evidence that expectations about co-participants' cooperation is an important determinant of a participant's propensity toward cooperation. It seems

plausible that both the level of these expectations as well as the manner in which these expectations translate into individual behaviour could be influenced by external influence. If indeed that were true, the policy implications are nontrivial: if it were possible – by the activities of some external actor like an NGO or civil society organization – to increase the level of social cohesion and raise awareness of the importance of cooperation in the management of common pool resources, then a virtuous cycle could be introduced leading to ever higher levels of cooperation and ever more effective local management of these resources. A question that remains, however, is what level of social cohesion could induce this sort of virtuous cycle? In other words, is there some threshold level of expectations beyond which the combination of unconditional and conditional cooperation would be so high as to ensure near universal cooperation in the management of these common pool resources? The identification of such a threshold and the exploration of the system dynamics that could result from external efforts to push social cohesion closer to this threshold should be a fruitful area of future research.

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Competing interests. The authors declare none.

References

- Alvi M, Ward P, Makhija S and Spielman DJ (2023) Do grassroots interventions relax behavioural constraints and improve adoption of nutrition-sensitive food production systems? *Australian Journal of Agricultural and Resource Economics* **68**, 101–124.
- Bagnoli M and Lipman B (1989) Provision of public goods: fully implementing the core through private contributions. *Review of Economic Studies* **56**, 583–601.
- Bardhan P (1993) Symposium on Management of Local Commons. *The Journal of Economic Perspectives* **7**, 87–92.
- Barr A (2001) Social dilemmas and shame-based sanctions: experimental results from rural Zimbabwe. *Working paper 200111*, Centre for the Study of African Economies, Oxford University.
- Bereby-Meyer Y and Roth AE (2006) The speed of learning in noisy games: partial reinforcement and the sustainability of cooperation. *American Economic Review* **96**, 1029–1042.
- Beteille A (1983) *Equality and inequality: Theory and Practice*. Delhi: Oxford University Press.
- Brandts J and Schram A (2001) Cooperation and noise in public goods experiments: applying the contribution function approach. *Journal of Public Economics* **79**, 399–427.
- Cárdenas JC and Carpenter J (2008) Behavioural development economics: lessons from field labs in the developing world. *Journal of Development Studies* **44**, 311–338.
- Cárdenas JC, Janssen MA, Ale M, Bastakoti R, Bernal A and Chalermphol J (2017) Fragility of the provision of local public goods to private and collective risks. *Proceedings of the National Academy of Sciences* **114**, 921–925. <https://doi.org/10.1073/pnas.1614892114>.
- Cárdenas JC, Stranlund J and Willis C (2000) Local environmental control and institutional crowding-out. *World Development* **28**, 1719–1733.
- Cárdenas JC, Stranlund J and Willis C (2002) Economic inequality and burden-sharing in the provision of local environmental quality. *Ecological Economics* **40**, 379–395.

- Carpenter JP, Daniere AG and Takahashi LM** (2004) Social capital and trust in south-east Asian cities. *Urban Studies* **41**, 853–874.
- Croson RT** (2008) Public goods experiments. In Durlauf SN and Blume LE (eds.), *The New Palgrave Dictionary of Economics: Behavioral and Experimental Economics 2nd Edn*. New York: Palgrave MacMillan, pp. 1–11.
- Fischbacher U, Gächter S and Fehr E** (2001) Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters* **71**, 397–404.
- Hardin G** (1968) The tragedy of the commons. *Science* **162**, 1243–1248.
- Isaac RM and Walker JM** (1988) Group size effects in public goods provision: the voluntary contributions mechanism. *Quarterly Journal of Economics* **103**, 179–199.
- Isaac RM, Walker JM and Thomas SH** (1984) Divergent expectations on free riding: An experimental examination of possible explanations. *Public Choice* **43**, 113–149.
- Karlan DS** (2005) Using experimental economics to measure social capital and predict financial decisions. *American Economic Review* **95**, 1688–1699.
- Kocher MG, Martinsson P, Matzat D and Wollbrant C** (2015) The role of beliefs, trust, and risk in contributions to a public good. *Journal of Economic Psychology* **51**, 236–244.
- Meinzen-Dick R, Janssen MA, Kandikuppa S, Chaturvedi R, Rao K and Theis S** (2018) Playing games to save water: collective action games for groundwater management in Andhra Pradesh, India. *World Development* **107**, 40–53.
- Offerman T, Sonnermans J and Schram A** (1996) Value orientations, expectations and voluntary contributions in public goods. *The Economic Journal* **106**, 817–845.
- Ostrom E** (1990) *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.
- Seabright P** (1993) Managing local commons: theoretical issues in incentive design. *Journal of Economic Perspectives* **7**, 113–134.
- Wade R** (1987) The management of common property resources: finding a cooperative solution. *The World Bank Research Observer* **2**, 219–234.
- Walker JM, Gardner R and Ostrom E** (1990) Rent dissipation in a limited-access common-pool resource: experimental evidence. *Journal of Environmental Economics and Management* **19**, 203–211.
- Wu T, Ward P and Li B** (2022) Experimental evidence on cooperation and coordination in forest and endangered species conservation in China. *Ecology and Society* **27**, article 40.