Ecological Economics 196 (2022) 107391

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Path dependencies and institutional traps in water governance – Evidence from Cambodia

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ARTICLE INFO

Keywords:
Institutional traps
Water governance
Scarcity
Conditional cooperation
Agent-based modeling

ABSTRACT

In many parts of the world, social norms of cooperation are an important element of decentralized water governance carried out by local communities. Field work in Cambodia documents that some villages have well-functioning water infrastructure and high cooperation, while others have poor infrastructure and low cooperation. We hypothesize that this outcome may be the result of an institutional trap, where initial lack of cooperation leads to poor infrastructure, water scarcity, and low revenues, undermining cooperation further in a vicious cycle. Conditional cooperation may explain why some communities can overcome such an institutional trap. We develop an agent-based model, in which users have to decide how much to contribute to water infrastructure and how much water to extract. This decision is based on economic considerations, but also reputational concerns, where own decisions are evaluated against the social norm. We find that the system features alternative stable states, depending on initial conditions. If the system has initially a functioning water system and high cooperation, prosperity can be created, which facilitates further investments in water infrastructure, fostering cooperation further. If the community features initial scarcity, cooperation is relatively costly, undermining investments in water infrastructure, leaving the community in an institutional trap.

1. Introduction

In many parts of the world, water governance is carried out by local communities (Ostrom, 1990; Lansing et al., 2017). Social norms of cooperation have been identified as key mechanisms to ensure sufficient contributions to maintain a functioning water infrastructure, and also to restrain excessive water use (Lam, 1998). Yet, most studies on self-governance of common pool resources focus on either extraction of common-pool resources (CPR) or investment in public goods (PG) provisioning, but rarely both combined. In many real-world situations, however, both problems are strongly coupled (Gardner et al., 1990). This is especially the case for an irrigation system (Tang, 1992). For example, farmers often need to collectively invest in infrastructure maintenance (PG) so that enough water (CPR) can be maintained in an irrigation system and used by community members. Studying both problems separately thus may undermine the understanding of system dynamics and how it is affected by biophysical and social attributes, but also incentive structures underlying the decisions of harvesting and investing to the infrastructure (Yu et al., 2015). Experimental evidence shows that small group of individuals can overcome the interlinked social dilemmas in an irrigation setting of unequal resource access if communication is allowed (Janssen et al., 2011b), and if the resource variability is not too high (Anderies et al., 2013). The question to what extent the coupling of social dilemmas, in particular the contribution to water infrastructure (PG) and restraining from extracting too much water (CPR), co-evolve endogenously and affects cooperation is the key contribution of this paper.

In this paper, we analyze the co-evolution of social norms of cooperation with regard to (i) investment in water infrastructure and (ii) water extraction with an agent-based model. We observe strong path-dependencies where initial scarcity and poor infrastructure makes the personal sacrifice of cooperating relatively costly. As a result, cooperation erodes, leading to an institutional trap of poor water infrastructure and low cooperation. The opposite can emerge with initial abundance, where cooperation is relatively cheap, and in the long run well-maintained infrastructure, high cooperation, and general prosperity can be observed. Previous research suggests that a system comprising of more conditional cooperators— those who try to align own behavior with the behavior of others— is more likely to be successful in managing common pool resources (Rustagi et al., 2010). This correlation is

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https://doi.org/10.1016/j.ecolecon.2022.107391
Received 2 June 2021; Received in revised form 30 December 2021; Accepted 21 February 2022
Available online 11 March 2022

supported by field work carried out in Cambodia and presented here. However, establishing causality from observational data is a challenge, and our modeling work provides some insights in this regard. While conditional cooperation is typically studied in an experimental or empirical setting, formalizing it in a dynamic framework is not widely considered; but see Richter and Grasman (2013). We formalize conditional cooperation in the model through a reputational mechanism. Individuals have an intrinsic motivation to comply with social norms, and thus deviating from the social norm generates disutility due to psychological costs. Aligning one's behavior with the social norm leads to utility gains (Fehr and Schurtenberger, 2018). One of the main reasons for such psychological cost arising from non-compliance with social norms is due to an internal motivation to preserve a positive self-image or reputation in the society (Brekke et al., 2003; Fehr and Schurtenberger, 2018), which is rooted in the desire to uphold a certain self- or group-identity (Akerlof and Kranton, 2000; Brekke and Howarth, 1998). Cooperative behavior is socially desirable and thus leads to higher reputation, while selfishness (so-called defection) is socially undesirable, which thus leads to lower reputation. Reputational considerations can facilitate cooperation among different partners, especially if the social image or reputation of an individual is known within the community (Nowak and Sigmund, 1998; Milinski et al., 2002). Thus, at the heart of social norm of conditional cooperation lies the moral motive to align own behavior with social norms at large.

There are some studies that have analyzed coupled social dilemmas arising from both CPR extracting and investing to a PG before (Botelho et al., 2015; Solstad and Brekke, 2011). Solstad and Brekke (2011) model the coupled social dilemmas as a two-stage sequential game, in which income surplus from extracting a CPR in the first stage is used for buying a private good and contributing to a PG in the second stage. They find that the possibility to provide the PG serves as a collective interest and hence can help to overcome the social dilemma in CPR extracting. Their results rest on the assumption that in equilibrium, at least some individuals contribute to the public good due to the incentive structure of the game. Economic calculus will determine that the marginal (private) benefits equal the marginal (private) costs of providing the public good. Those individuals who will be richer after the first stage will contribute more as the marginal value of money decreases with wealth. This implies that there is no incentive to become richer by not cooperating in the first stage. This is also reported in irrigation experiments where asymmetric access to resource is considered. Head users in the irrigation system are better off cooperating by not taking too much water relative to the tail users, due to threat of the later not providing the investment to infrastructure maintenance (Janssen et al., 2011a; Anderies et al., 2013). Botelho et al. (2015) expand the model of Solstad and Brekke (2011) and test it in a laboratory setting. For both papers, the sequential nature of the social dilemma is salient, and so is the assumption that at least some individuals will have an incentive to contribute. In a natural setting, however, both assumptions may not be met. Also, in reality the benefit structure of water infrastructure, or PG more generally, is often nonlinear and exhibits thresholds, which is what we consider here. In the next section we present the case of water governance in Cambodia and motivate our model with stylized facts from field experiments. In section 3, the agent-based model will be presented, before presenting the results in section 4. Finally, section 5 concludes.

2. Conditional cooperation and water governance in Cambodia

In Cambodia, irrigation is a key element of water governance, as it is salient for small-scale farming, which is very prevalent in the rural areas. Such a system depends largely on collective action of farmers. In many villages, a *Farmer Water User Community* (FWUC) is present as a self-governing institution and plays a main role in regulating water sharing among farmers, as well as collecting contributions to infrastructure maintenance. The success of the FWUC in maintaining a high quality infrastructure to safeguard water availability is mixed. While in some places the water infrastructure is well-functioning, in others the infrastructure is dysfunctional, due to underlying differences in governance and institutional structure (Mak, 2017). The mutual feedbacks between individual actions and institutions lead to a complex institutional structure, best described as 'institutional bricolage' (Sakketa, 2018), where institutions are the emergent outcome of individual decisions and social interactions. In Ethiopia, field evidence suggests that the presence of conditional cooperators in the system could explain the success in commons forest management (Rustagi et al., 2010). Along the same lines, we hypothesize that the success of user communities to maintain water infrastructure could be linked to conditional cooperation. We explored this in the Kampong Chhnang province of Cambodia, where we run lab-in-the-field experiments with farmers to study conditional cooperation, followed by a survey asking participants to elaborate on their experience with resource scarcity, observed infrastructure quality, and how many users contribute to infrastructure maintenance. The study was reviewed by the Social Sciences Ethic Committee of Wageningen University and registered as a pre-analysis plan; see Richter et al. (2020). For more details on the study area, the conditional public goods game, and the complete survey, please see Schuch et al. (2021).

To measure conditional cooperation, we used the same game as Rustagi et al. (2010). In the game, subjects were endowed with 6 bills of 1000 KHR[1] and were asked to make seven decision rounds on how much to contribute to the public good, knowing what the partner contributes. Using the hierarchical cluster analysis (Fallucchi et al., 2018), the subjects can be classified into five groups: low, medium, and high unconditional cooperators, conditional cooperators, and 'other'; see Schuch et al. (2021) for implementation and experimental procedure. Subjects who are classified into the 'other' behavioral type are those whose contribution scheme does not have a clear pattern. Among these behavioral groups, we are interested in the role of conditional cooperators, who are the ones who try to match the contribution of partners.

Overall, we conducted the games in 21 villages, spread out across three communes. In total, 302 participants played the games (on average, 14 people per village), and 282 participated in the structured survey interviews. Based on the responses, we calculated per village (i) the quality of the irrigation infrastructure, (ii) the contributions to water infrastructure maintenance, (iii) experienced water scarcity, and (iv) the share of conditional cooperators. We asked participants to assess the overall quality of the water infrastructure (e.g. canal system and dam) – how well-maintained it is – in their own village on a five-point Likert scale, where 1 means very poor, and 5 is excellent. We then calculated the average score per village. Also, we asked participants how much money they paid for getting water for irrigating their rice field in their village. Regarding water scarcity, we asked how many times the household experienced irrigation water scarcity in the past 5 years. We then calculated the average reported number of water scarcity events experienced per village.

2.1. Stylized facts from field experiments

Based on the field experiments, Fig. 1 shows that the presence of conditional cooperators is positively associated with better institutional performance and less water scarcity. First, villages that are composed of more conditional cooperators have better quality of infrastructure (Fig. 1a). Second, villages that comprise a large number of conditional cooperators, have more people reporting to pay for water infrastructure maintenance (Fig. 1b). This suggests that conditional cooperation is positively correlated with institutional outcomes.

The results from the field experiments further demonstrate that conditional cooperation is positively correlated with institutional

[1] Khmer Riel. 4000 KHR is about 1 USD.

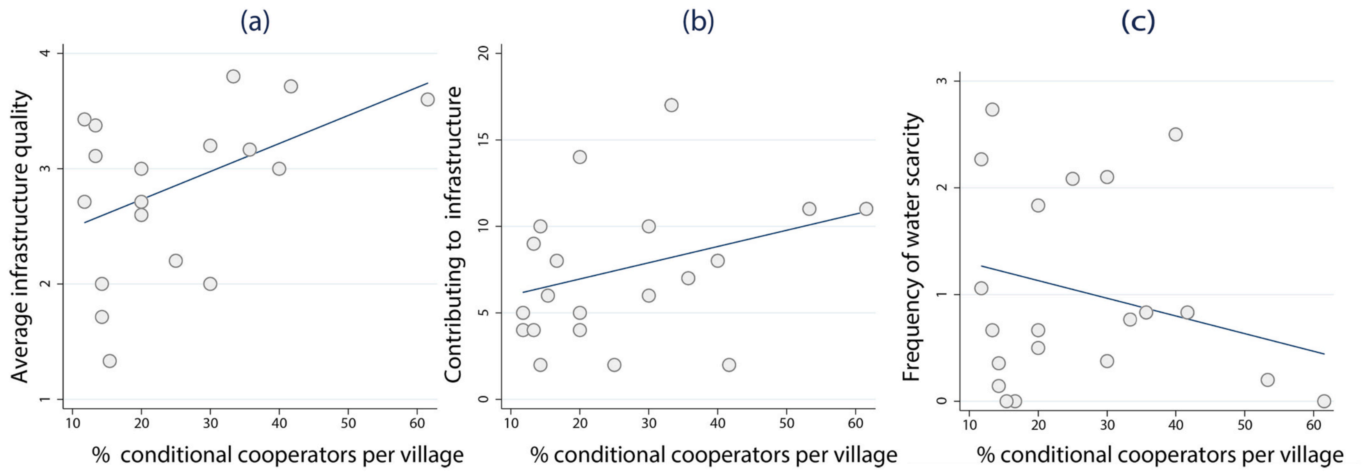

Fig. 1. Conditional cooperation and functioning of institutions across villages in the Kampong Chhnang Province, Cambodia. The institutional performance is measured in terms of (a) infrastructure quality (1 is very poor, and 5 is excellent), (b) number of people paying for water infrastructure, c) frequency of water scarcity.

performance in its role to moderate scarcity (Fig. 1c). The larger the number of conditional cooperators in the village, the less water scarcity has been experienced in the village. There are two obvious limitations to these empirical findings. First, while conditional cooperation has been measured with an experimental game, the other variables are self-reported and therefore not free of bias and error. Second, we can show correlations, but we do not infer any causality, especially because, the quality of institutions, the willingness to support those institutions, and general cooperativeness all potentially influence each other. Nevertheless, some laboratory and field experiments seem to suggest that players' decisions in the games show some degree of consistency with actual decisions in daily resource uses (Janssen and Anderies, 2011). So while our empirical results may not help to disentangle causal channels entirely, they are valuable as they can to inform our modeling work to simulate institutional dynamics 'in silico'.

3. The model

We consider a community consisting of N agents jointly extracting water as a common-pool resource (CPR), and sharing an irrigation infrastructure as a public good (PG). Water is a common-pool resource (CPR) because a unit of water extracted by an agent is not available to others and everyone has access to the water. Water availability is conditional on the state of the irrigation infrastructure. A well-maintained infrastructure can retain more water than a poorly-maintained one. Keeping the infrastructure well-maintained, however, requires the collective effort of all community members. While it is socially optimal to invest in infrastructure maintenance, doing so is individually costly, tempting self-interested individuals to free ride. After all, one can still benefit from the well-maintained infrastructure even without contributing. Similarly, restraining water extraction is collectively optimal, but requires individual sacrifices. Hence, investing in the PG and extracting from the CPR form social dilemmas. In our model, a self-image concern is the mechanism to represent conditional cooperation. Each agent faces two types of decision to be made simultaneously: water extraction and investing in infrastructure maintenance. These decisions affect individual utility in two ways. First, there are monetary consequences related to benefits and costs of agricultural practices and infrastructure investments. Second, cooperation has an effect on self-image, where high levels of cooperation give a positive self-image which translated into a utility gain, while the opposite is true for low cooperation. Cooperation levels are always evaluated against the average behavior in the community, i.e. conditional on social norms. Note that self-image is only one potential interpretation. Our model setup is also consistent with other social mechanisms that encourage cooperative behavior, such as peer pressure, or a loss of reputation. Over time, social learning ensures that successful strategies – those that give high utility – are imitated, while those that give low utility are abandoned.

3.1. Investing in water infrastructure

Agents collectively invest in the infrastructure maintenance. The investment affects water availability, which is shared by all agents in the community. Water availability *(S)* depends on collective investment (M) and water inflow into the system *(Q)* and is given by $S = \varepsilon(M)Q$, where $\varepsilon(M)$ is the infrastructure productivity as a function of the collective investment M. We define Q as a random variable with expected value μ_Q and standard deviation σ_Q, i.e. $Q{\sim}N(\mu_Q, {\sigma_Q}^2)$. We assume that the infrastructure productivity $\varepsilon(M)$ is a step function, as it requires a minimum level of investment μ_1 to be productive and is fully productive when μ_2 is provided (see Fig. 2). This stepwise function is also used in a similar context for characterizing irrigation infrastructure as a public good (Yu et al., 2015). Hence, the system productivity can be expressed as a function of the collective investment $M(t)$ as

$$\varepsilon(M) = \begin{cases} 0 \text{if } 0 \le M(t) \le \mu_1 \\ \dfrac{M(t) - \mu_1}{\mu_2 - \mu_1} \text{if } \mu_1 < M(t) \le \mu_2 \\ 1 \text{if } M(t). > \mu_2 \end{cases} \tag{1}$$

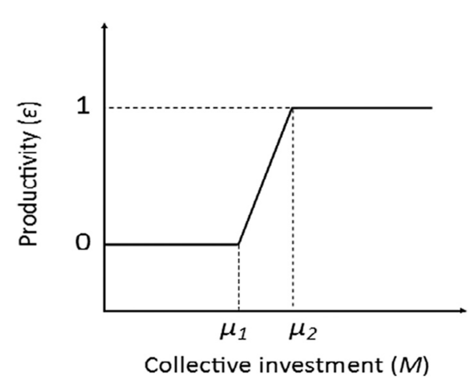

Fig. 2. The relationship between collective investment and system productivity.