

ENVIRONMENTAL PRESERVATION AND GAME THEORY: A STUDY WITH FISHERMEN AND INDIGENOUS PEOPLE

FABRICIO BARON MUSSI

PONTIFÍCIA UNIVERSIDADE CATÓLICA DO PARANÁ

LAÍS CAROLINI KRUDYCZ

UNIVERSIDADE ESTADUAL DO OESTE DO PARANÁ - UNIOESTE

Resumo

Environmental preservation and sustainability can be considered social dilemmas in the interpretation that all involved would be better off if they cooperated to preserve the environment. However, if everyone does just that, someone else will be in an even better position to use other's efforts solely to their advantage. In this context, and with the objective of promoting cooperation between individuals, some authors suggest the use of economic incentives to preserve a public good, such as the reward and punishment mechanism. The objective of this paper is to understand how cooperation between groups of professional fishermen and local indigenes works for the preservation of Itaipu hydroelectric power plant's reservoir, considering the influence of economic incentives in the equation. Most articles that use field economic experiments analyze isolated groups, and it is difficult to establish a comparison. In order to analyze the cooperation of groups (Delaney; Jacobson, 2014; Shang et al., 2024) that reside near the reservoir of Itaipu hydroelectric power plant and obtain inputs for its subsistence, such as fish and water for consumption and farming, the economic behavioral literature was used (Robert; Broman, 2017; Zhang; Lu; Wang, 2024) and the experimental one (Croson; Gächter, 2010), with an emphasis on examining the cooperation of these groups and the role of the economic incentives in this process (Choi; Ahn, 2013; Lilliu et al., 2023). For the collection of data, the public goods game was proposed, adapted from Fehr and Gächter (2000), naming it this time as 'reservoir game', once the public good under analysis was the Itaipu power plant's reservoir. The choice was made due to the fact that Itaipu hydroelectric power plant is the world's largest energy producer, with its 20 units generating 700 MW, besides having a history of over a decade of joint work with the local fishermen and indigenes in the area by means of its sustainability programs (aimed at preserving the quality of the water in the reservoir, monitoring the ichthyofauna, campaigning to clean the reservoir, promoting the use of techniques for agriculture cultivation without the use of agrotocics), and its reservoir providing water to the cities of the western region of the state of Parana. After a first sequence of six rounds, the experiment considered 2 options for the subjects to handle the outcomes between them: (i) the introduction of the possibility of a player punishing the others, and (ii) the introduction of the possibility of a player rewarding the others, in order to verify the influence of economic incentives in cooperation. The data was then statistically analyzed using descriptive analysis, multivariate regressions, and analyses of variance. After the statistical analysis, and with the results, we returned to the field to conduct in-depth interviews with the leaders of the fishermen and the indigenes groups, to better understand the findings. With the results, we returned to the field to conduct in-depth interviews with the leaders of the fishermen and the indigenes groups, to better understand the findings. As for the fishermen, it was observed that, although the reservoir represents the source of their livelihood, the contributions to the public good did not differ from the average results found in the experimental economic literature regarding the free riding behavior, which in turn was more tolerated than with the indigenes. The fishermen, partially influenced by the nature of their activity

(executed in an extractive and individual manner) did not envision the need of cooperation, even if the public good in question represents their source of income. Tolerance to free riding behavior is due to the recognition of the material needs that other fishermen currently have. In addition, the financial condition of the fishermen, their sense of belonging to the group, and the delegation of responsibilities to the power plant as regards reservoir preservation actions, were the main topics debated to justify the findings of the experiment. The indigenes, in turn, presented a more cooperative behavior as regards the reservoir preservation. Their donations reflected part of the collective thinking, embodied in many of their daily activities, such as agricultural crops and the harvest season, when the indigenes forgo their individual chores to contribute to the group. As for the economic incentives, reward for cooperation proved to be more efficient than the use of sanctions for not cooperating, in both groups. Based on these findings, a number of determinants of cooperation are indicated, followed by a discussion of how many joint project initiatives could be facilitated, better managed, and even complemented, with a view to ensuring sustainability, and also reducing potential management costs, or costs stemming from free riding behavior actors.

Palavras Chave

Sustainability, Cooperation, Public goods game

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1 INTRODUCTION

Environmental conservation and sustainability can be considered social dilemmas in the sense that all involved would be better off if they cooperated with a view to conserving the environment (DU, WU, & WANG, 2016; ROBERT & BROMAN, 2017). However, if all do just so, another agent can be in an even better position to take ownership of other's efforts, aiming exclusively at individual well-being (ANDREONI, 1988). How to balance the interests and minimize the conflicts is recognized as social dilemma, which remains a challenge for water-related management and cooperation environmental preservation. In such context, in order to foster cooperation between individuals, some authors suggest the use of economic incentives envisaging to conserve a public good, such as reward and punishment mechanisms (FEHR & GAECHTER, 2000; SHANG *et al.*, 2024). This paper aims to understand how the cooperation of groups of professional fishermen and indigenous people aiming to conserve the reservoir of the Itaipu hydroelectric power plant occurs, considering the influence of economic incentives in the relationship.

2 THEORETICAL REVIEW

In order to analyze the cooperation of groups (DELANEY & JACOBSON, 2014; BRIDOUX & STOELHORST, 2014) that live near the reservoir of the Itaipu hydroelectric power plant and use it to obtain inputs for their subsistence, such as fish and water for consumption and for crops, we used economic behavioural literature (ROBERT & BROMAN, 2017; SHANG *et al.*, 2024) and experimental literature (CROSON & GAECHTER, 2010), with an emphasis on examining the cooperation of these groups and the role of economic incentives in this process (CHOI & AHN, 2013; WU, WANG, & DAI, 2023).

2.1 STAKEHOLDERS AND COOPERATION

According to Bridoux & Stoelhorst (2014), corporations play a crucial role in promoting social welfare by employing their ability to mobilize their stakeholders for joint creation of value, which may involve a public good dilemma when one observes the high interdependence of tasks and outcomes. While cooperating to jointly generate value is ideal from a collective point of view, stakeholders, when focused on their private interests, tend not to cooperate/contribute to, but rather take advantage of the contributions of other interested parties. However, if everyone did the same, all in consequence would end up in a worse situation (WU *et al.*, 2023, BAHBOUHI, BOUDERBA, ELKOUAY, & MOUSSA, 2024).

For this paper, we adopted the perspective described by Bridoux & Stoelhorst (2014), as regards the recognition that the paths to joint creation of value (sustainability and environmental conservation, in the case of this research) are initiated by collective and individual decisions and actions, embodied in individual cooperative attitudes, with a view to ensuring collective well-being. In addition, not all stakeholders can benefit from the creation /conservation of a public good in the same manner, either due to the dependency relationships of different groups with the public good, or due to their varying levels of interaction (ACKERMANN & EDEN, 2011). The stakeholders selected for this research consist of groups cited in official documents of the Brazilian electricity sector (BRAZIL, 2022) and in the constant assessments made for the designing of economic, social, and environmental indicators for hydroelectric power plants (DOMBI, KUTI, & BALOGH, 2014).

2.2 INCENTIVE MECHANISMS

Rewarding mechanisms become an alternative for the promotion of cooperation, as in the one round public goods game, and when the cost of promoting it is less than the benefit of the recipient (ZHANG, LU, & WANG, 2024), and therefore its use is recommended individually (NARLOCH, PASCUAL, & DRUCKER, 2012). For the latter authors (2012, p.2014): “by raising the individual pay-offs and decreasing free-riding incentives, individual rewards could have a stabilizing effect on collective action due to motivating people to stick to the social norm”. As in agency theory, and in neoclassical economic theory, it is suggested that players will be more motivated to cooperate if their financial returns are higher (LILLIU, RECUPERO, VINYALS, & DENYSIUK, 2023; ZHANG *et al.*, 2024).

As regards punishment mechanisms, Reuben & Riedl (2013) suggest that differences in contribution to the public good may stem from the forms of punishment imposed, so that when there is no punishment, all the involved converge to a free-riding behaviour. While the prediction of punishment in contractual arrangements is interpreted as a mechanism for preventing opportunistic behaviour (WILLIANS, 1985), in public goods game experiments, it is observed the prediction of punishment is a mechanism that seeks to ensure the contributions (FEHR & GAECHTER, 2000), punishing those who choose not to cooperate, while they can still benefit from the public good. In this context, it is observed that some authors have reservations about the magnitude of punishment, recommending that – to be effective – punishment should be high, in a proportion 1:3, or higher (CHOI & AHN, 2013; NIKIFORAKIS & NORMANN, 2008), in the same way as incentives in the form of reward. In such a scenario, the efficacy of incentives, understood as the positive effect of incentives for cooperation on social dilemmas, has been tested in numerous research (CHOI & AHN, 2013; LILLIU *et al.*, 2023).

3 METHODOLOGICAL PROCEDURES

For the collection of data, the public goods game was proposed, adapted from Fehr & Gächter (2000), and from Sefton, naming it this time as ‘reservoir game’, once the public good under analysis was the Itaipu power plant’s reservoir. The choice was made due to the fact that Itaipu hydroelectric power plant is the world’s largest energy producer, with its 20 units generating 700 MW, besides having a history of over a decade of joint work with the local fishermen and indigenes in the area by means of its sustainability programs (aimed at preserving the quality of the water in the reservoir, monitoring the ichthyofauna, campaigning to clean the reservoir, promoting the use of techniques for agriculture cultivation without the use of agrotoxics), and its reservoir providing water to the cities of the western region of the state of Parana. This reservoir serves many purposes for the region population: it serves as the source of water for household consumption, for agriculture and livestock; as a touristic attraction; and as a source of subsistence for the fishing activities in the region. The sample consists of 67 professional fishermen and 63 indigenes, and the experiments were carried out at the headquarters of the fishermen’s colonies, and in the villages, respectively.

With each round, the players received 2 envelopes and 10 coins of R\$1,00 each, choosing how many coins to allocate to a ‘public account created for the conservation of the reservoir’(first envelope), and how many coins to allocate to their respective ‘private accounts’ (second envelope). Unlike the allocation of coins to the individual account of each player, those donated for the reservoir conservation are summed, and right after multiplied by 2 (representing the benefits resulting from the conservation of the reservoir) and redistributed equally among all players, to illustrate the characteristics of a public good (non-exclusive and non-competing).

The results were presented in a projector, round by round, so that each player could take note of their gains, and the gains of the other players.

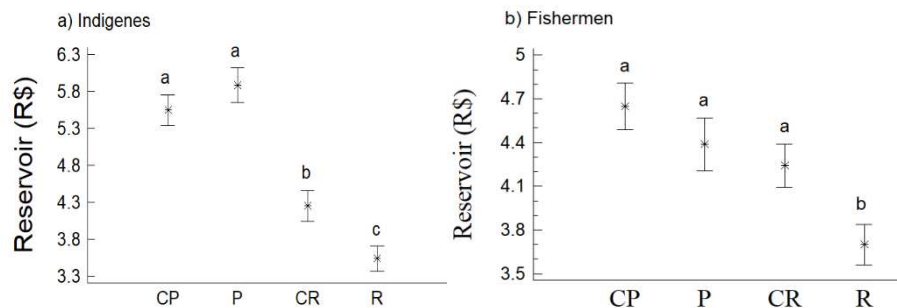
After 6 rounds, the possibility of one player punishing (treatment 1) or rewarding (treatment 2) another was introduced. For this sequence (another 6 rounds), an extra envelope was handed out. In this envelope the player could write the number of the player he/she would like to punish (or reward) and with how many coins. In addition to the rest of the rules, for each coin the player used to punish (or reward), the punished player lost (or received) 4 coins, representing a high punishment (or reward) as suggested in the specialized literature (NIKIFORAKIS & NORMANN, 2008; REUBEN & RIEDL, 2013). At the end of the 6 rounds, there was a draw for each player and – in that lot – the player would keep all the money.

The data was analyzed in order to contrast the differences in the amount received by the reservoir and the appropriations of the individual accounts in the groups. In order to compare the average of resources destined to the reservoir and the appropriations, 4 analyses of variance (ANOVA) with one factor were carried out (type of game, with 4 levels: control that precedes punishment (CP), punishment (P), control that precedes reward (CR), and reward (R)) in a completely randomized experimental design. The differences between factor levels were ensured by the Tukey test. Significant values of $p < 0,05$ were considered. After the statistical analysis, and with the results, we returned to the field to conduct in-depth interviews with the leaders of the fishermen and the indigenes groups, to better understand the findings. Shapiro–Wilks test was performed to test for normal data distribution and a Bartlett test was used to test for homogeneity of variance. When necessary, square-root transformations were used to approximate the normal distribution of residuals and to reduce variance heterogeneity.

4 MAIN FINDINGS

When comparing the contributions of the groups to the conservation of the reservoir, it was observed that the incentives in the form of reward did not prove to be efficient (Figure 1, a- $F_{(3;59)}=17.64$, $p < 0,01$ and Figure 1, b- $F_{(3;59)}=14.09$, $p < 0,01$). On the other hand, the incentives in the form of punishment kept the donations at levels statistically similar to the control rounds, with the exception that little use was made of punishment by both groups. For the donations to the public good, the highest observed average corresponds to the contributions of the indigenes (R\$ 6,09) in the treatment with punishment.

Figure 1: Comparison of donations for the conservation of the reservoir

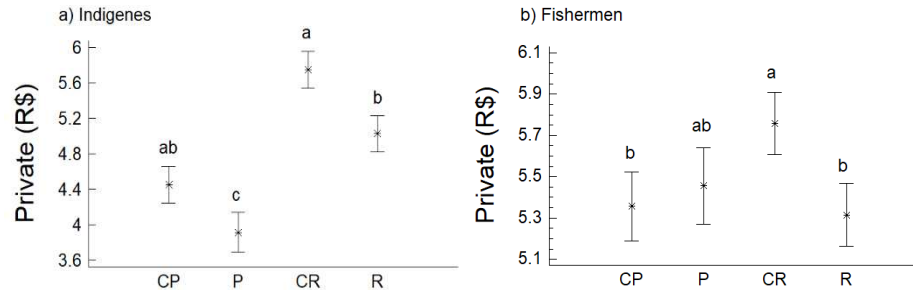


Source: authors.

When comparing appropriations to player's private accounts, statistical differences were observed in reward treatments for both groups (Figure 2, a- $F_{(3;63)}=3.02$, $p=0.04$ and Figure 2, b- $F_{(3;63)}=3.63$, $p=0.02$). In the case of the indigenes, it was found that the players relinquished

their individual gains for several rounds to reward the other members of the experiment, whereas the fishermen rewarded those with smaller gains in the previous rounds.

Figure 2: Comparison of appropriations to private accounts



Source: authors.

After the analysis of the experiment, in-depth interviews were conducted with the leaders of each group in order to better understand the statistical findings. The interviews (to the total of 4) addressed issues related to the decisions made during the experiment, the characterization of the work, the relevance of the reservoir, the low level of punishments, and the use of rewards by indigenous people. Table 1, presented hereunder, synthesizes the findings.

Table 1 – Topics covered in the in-depth interviews with the groups leaders

	Indigene	Fishermen
a.1 – The indigene showed signs of cooperative behaviour; a.2 – The fishermen showed signs of individualistic behaviour;	Cooperative behaviour is a result of social organization, politics and religious order in communities. Guarani's social organization is based on the "extended family", a group that can reach more than 200 people (5 generations). It is important to mention that conflicts are discussed at family level.	Selfish behaviour is observed daily in the disputes over fishing areas considered more productive and in the failure of actions that depend on the community. In the fishermen's view, it is not fair to work collectively, since the use of structures geared to the fishing activity will not be egalitarian.
b – Characterization of: - individual labour; - collective labour;	Both individual and collective labour follow the influence of large family groups. As a group, natives do not get together having centralized power in the hands of one individual, but rather they base their association on the family orientations.	Fishing activity depends on individual effort. The fisherman places his fishing gear in the water on his own, checks and collects the fish captured, and cleans and packs them. Fishermen generally do not work in groups.
c.1) The importance of the reservoir for the community c.2) The importance of group members	The reservoir is located in indigenous lands, hence holding high importance. The reservoir allows the development of fish farming and the use of water for crops. The members of the group are fundamental for the development of these activities.	The reservoir is fundamental for the fishing activity. In strictly labour terms, fishermen consider fish as a resource that belongs to whoever catches them. It follows that the less competition the more fish you catch, as the more will be available for you.
d) Indigenous people and fishermen practically do not punish group members.	Guarani organization is not based on centralized power in the hands of one only individual, thus everyone is responsible for collective results.	Fishermen do not punish as they fear retaliation (something common in the routine of their class) and because they believe that in a future opportunity they will be the ones to get the resources, just as their colleagues did now.

e) Indigenous people represent a group that rewards all its members, and some times relinquish their gains to use their money to reward others.	Natives have no attachment to material belongings, and when they have something they share it with all, not caring for the accumulation of wealth for the future.	
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Source: authors.

5 CONCLUSIONS AND FURTHER RESEARCH

We aimed with this paper to understand how the cooperation of groups of professional fishermen and indigenous people works to conserve the reservoir of the Itaipu hydroelectric power plant, considering the influence of economic incentives. The involved are stakeholders who highly rely on the reservoir, and carry out joint working relationships with the power plant in sustainability projects. Based on the findings, it was verified that the use of reward mechanisms did not present an efficient alternative for the maintenance (and intensification) of contributions to the reservoir. On the other hand, rewards prediction helped prevent free-riding behaviour since, in this treatment, appropriations to the player's private accounts were also reduced.

It was also observed that both the indigenes and the fishermen – for different reasons – presented behaviours divergent to those described in most literature, regarding the use of punishment (CHOI & AHN, 2013), whether due to decentralization of decision-making (in the case of the indigenous people), or the fear of retaliation (in the case of the fishermen), even though the game guaranteed everyone's anonymity. Although not often used, the prediction of punishment mechanism proved to be efficient in maintaining levels of donations to the reservoir at statistically similar levels of other mechanisms.

In order to foster initiatives for joint project, as well as better manage them, one should focus on the particularities inherent to the social organization of each group, which were partially illustrated by the conducted interviews. They show factors that can condition the cooperation of different groups, and must be observed, inclusively in the drafting of terms of cooperation and other contractual instruments foreseeing the participation of groups of fishermen and of indigenous or native populations.

Suggestions for future research include the need to complement the analysis with demographic data of indigenes and fishermen, in order to assess whether such variables can be considered as predictors of cooperative behaviour, and to carry out a more in-depth evaluation of how the social organization of these groups works, as well as their intrinsic rules, and how these might interfere with donations for the preservation of the public good. Another highlight goes to the greater variation in decision-making process of the group of fishermen, particularly as regards the appropriation of coin for their private accounts, providing indications that the way decisions are made by this group is characterized by a greater heterogeneity to the manner of the indigenous people, this observaion representing another opportunity for the continuity of research.

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