Dynamics in the governance of collectiveirrigation systems: Evidence from field experiments in Nicaragua

Abstract

The objective of this study is to analyze the common pool resource appropriation and public good provisiondecisions in a dynamic setting, testing the differences in behavior and performance between lab and field subjects. We performeda total of 45 games in Nicaragua, including 88 villagers in rural communities and 92 undergraduate students. In order to analyze sequential decision making, we introduce a dynamic and asymmetric irrigation game that combines the typical social dilemmas associated to irrigation systems management.In addition, in 9 out of 22 villagers' groups, we implemented a treatment that included the disclosure of subjects' appropriation of the common pool resource. The results reveal that the provision of individuals' appropriation level results in higher appropriation in subsequent rounds. In addition, the results show that non-treated villagers provide more public good than treated villagers but if compared with students the differences are not significant. The results also suggest that appropriation levels are below the Nash prediction of full appropriation, but above the social efficient level. This results in an efficiency loss in the game that can be explained to a large extent by individual decisions on appropriation and public good contribution and by group appropriation behavior.

Keywords: common pool resource, public good, field experiments, dynamic game, irrigation, Nicaragua

1. Introduction

Low investment in operation and maintenance activities is often considered as one of the main causes of poor irrigation performance. While initial irrigation investments are in many cases supported by development and government projects, infrastructure maintenance is often left in the hand of farmers.In those cases of poor on-farm water use efficiency and inefficient water allocationalong the system,the benefits from irrigation infrastructure turn out to be lower than projectedand asymmetries between head and tail-enders of the system emerge (Chakravorty&Roumasset, 1991). This evidence suggests that much of the long-term success of irrigation systems depends on the operational and maintenance activities,which very oftenrequire a certain degree of collective action (Meinzen-Dick, Raju, and Gulati 2002).

Irrigation systems face two simultaneous collective action problems related to common pool resource appropriation and provision decisions (Baland&Platteau, 1996; de Janvry et al., 1998; Janssen et al., 2012). On the one hand, the organization must ensure the public good provision of the physical and ecological infrastructure to distribute and utilize water resources. On the other hand, there exists the irrigation dilemma where the relative positions along the system generate asymmetric access to the resource. Asymmetric access to the resource adds additional complexity to the traditional social dilemma between the individuals' extraction that maximizes individual payoffs, and the group's interest that drives to resource conservation maximizing social payoffs. In their analysis of provision and appropriation in the commons, de Janvry et al. (1998) suggest that the level of provision depends on the rules of appropriation and the quality of cooperation achieved in appropriation.

Inclination to cooperate in social dilemmas has been tested through different experimental games in the form of prisoner's dilemma, voluntary contribution mechanism and the common pool resource game (Cardenas & Carpenter, 2008). A common finding is that the average player tends to deviate from the pure selfish maximizer of individual payoffs, even when there are incentives to free-ride (Cardenas, 2011).These results suggest that individuals' decisions may be mediated by other factors in addition to objective payoffs (Ostrom, 2000; Cardenas, 2009). Gintis (2000) suggest that patterns of pro-sociality and preferences over time and risk are related to environmental outcomes.

In this paper we present the results from field experiments performed in Nicaragua with villagers in rural communities and undergraduate students of a Nicaraguan university (Universidad NacionalAutónoma de Nicaragua, Facultad Regional de Matagalpa). The objective of this study is to analyze the common pool resource appropriation and public good provisiondecisions in a dynamic setting, testing the differences in behavior and performance between lab and field subjects.

In order to analyze sequential resource appropriation and public good provision, we introduce a dynamic and asymmetric irrigation game that combines players interacting in both a common-pool resource appropriation game and in public good provision strategies. Similarly to the setup of Janssen et al. (2011, 2012), our experiment includes two stages: an appropriation stage and a provision stage. In the appropriation stage, a common pool resource, in this case framed as water from an irrigation system, can be extracted. As in Osés-Eraso&Viladrich-Grau (2011), the resource is exogenously given only in the first round, and it is endogenously determined by the agents' extraction and provision strategies in subsequent rounds. In the public good provision stage, subjects decide how much to invest in a public fund to operational and maintenance activities that determines the water available in the irrigation system for the next round. Both stages are played in sequential turns from upstream to downstream positions assigned randomly to players.

Recent studies including the provision problem indicate that differences in experiences with natural resources management do not have a significant effect for most decisions (Janssen et al., 2012; Janssen et al., 2011). In contrast, the expectations of trustworthiness of others in the community determine the initial level of cooperation. The share upstream participants take from the resource affect the cooperative behavior of downstream players, producing a synergic process between efficiency and equity. In this paper, we are interested in showing the relation between appropriation and public good contribution decisions. In this respect, we specifically exploit the results by analyzing these decisions among students and villagers groups.

2. The irrigation game

The irrigation game builds on the common-pool resource experiments developed by Osés-Eraso&Viladrich-Grau (2011, 2007) and Janssen et al. (2011). For the purpose of this game, all variables are measured in points. In our experiment a group of n players share a common pool water resource of F_o points. Each participant is randomly assigned to a position (i.e. P1, P2, ..., P_n) with sequential access to the resource, which remains fixed all over the game. P1 has the first choice to harvest water (i.e. points) from the common pool resource. Then P2 is next to harvest water from whatever amount was left by P1, and so on. In the first round, participants receive an equal endowment of e points, but in the subsequent rounds endowment changes along the game depending on the appropriation and provision decisions. Therefore, after round 1 each player's endowment is endogenously defined (e_{it}). First, each participant, in sequential turns from upstream (P1) to downstream (P_n),makes a decision on how many points x_{it} will extract from the common pool water resource available. Appropriations from the common resource yield an individual marginal benefit of w points, but cause the common resource a marginal reduction of c points. Each point kept (not appropriated) has a marginal value for the agent of α points. Let x_{it} be the appropriation of player i in round t, the appropriation payoff the player obtains in that round will be:

$$z_{it}^A = wx_{it} + \alpha(e_{it} - x_{it}) \qquad (1)$$

where $w > \alpha$. After the appropriation decisions of round t, the remaining common pool resource (F_t^A) is equal to the common pool resource that remained from the previous round (F_{t-1}) less the total common pool resource appropriation by the group. F_t^A is provided to all agents when second stage is initialized:

$$F_t^A = F_{t-1} - c\sum_{i=1}^{n} x_{it} \qquad (2)$$

Second, in the public good provision stage, each player decides how much to contribute to a fund for operational and maintenance activities. Points invested in this fund (y_{it}) result in a marginal reduction of β points of individual's payoffs but yield a marginal increase of the common pool resource in m points. After the public good provision decisions of round t, the remaining common resource that subjects share for the next round of investments is:

$$F_t = F_t^A + m\sum_{i=1}^{n} y_{it} \qquad (3)$$

Under this two-stage asymmetric game, the earnings of each participant in round t is the result of appropriation (x_{it}) and provision (y_{it}) decisions. The resulting payoff z_{it} for player i in round t is, therefore, defined as the appropriation payoff less the public good provision expenditure:

$$z_{it} = z_{it}^{A} - \beta y_{it} \quad (4)$$

Given the dynamic nature of the game, the endowment of subject i in round $t$is defined by the following expression:

$$\begin{cases} e_{it} = e if t = 1, i = 1,2,\dots,n \\ e_{it} = z_{i(t-1)} if t > 1 \end{cases} \quad (5)$$

Appropriation decisions can be taken as long as the common pool resource maintains a positive value. For the purpose of this experiment, decisions can be taken over a maximum of T rounds, but this information is not available to participants. If the last round T is reached, the remaining water resource, F_T, is equally distributed among the four members of the group. Suppose a total number of t^* rounds are played, then the total payoff $z_i$obtained by player i is equal to:

$$\begin{cases} z_{it} + \frac{F_T}{n} if t^* \leq T and F_T > 0 \\ z_{it} otherwise \end{cases} \quad (6)$$

Early-extinction of the game takes place when the common-pool resource takes a negative or zero value in a period $t^*<T$. In order to describe the traditional social dilemma associated with common pool resources we assume that extraction is more efficient from the individual perspective, while non-appropriation is more efficient from the collectiveperspective. Thatis,$w - c < \alpha < w - \frac{c}{n}$ (Osés-Eraso & Viladrich-Grau, 2007; Osés-Eraso et al., 2008). This game also includes a second social dilemma in the public good provision stage as$\frac{m}{n} < \beta < m$.

Via backward induction we find that, with conditions described in the previous paragraph, if participants were rational self-interested individuals they would choose full-appropriation till the resource is depleted and none would invest in operational and maintenance activities. Since the upstream player is expected to invest all his endowment in common-pool resource appropriation, downstream participants will not contribute to public good provision. Therefore, for player 1 there is no benefit to invest when others do not. Thus, the Nash equilibrium for this game is that all invest the initial endowment in common pool resource appropriation and nobody contributes to operational and maintenance activities. However, the social optimum solution, assuming fully cooperating individuals, is achieved when players do not invest in appropriation activities, but invest all their endowment in public good provision activities. These outcomes provide the benchmarks of possible outcomes in the experiment.

3. Experimental design and procedure

Experiments were performed between July and August 2012 with undergraduate students and villagers in Nicaragua. The experiment was presented as an irrigation game both at the university and ruralcommunities. The typical experiment lasted for about two hours, and up to three hours in the rural case. Each participant took partonly in one experimental session. Participants knew who else was participating, but they were not allowed to communicate during the experiment. All players were assigned a code at the beginning of the session in order to ensure anonymity for the game and the surveys. University students were recruited via word of mouth from the economics and agronomy degrees at the Universidad NacionalAutónoma de Nicaragua in the cities of Jinotega and Matagalpa, both located at the Central Region of Nicaragua. Villagers were recruited via word of mouth and flyers inviting participants 14 years and older to take part in the game. Only one person from the same household was allowed to participate in the same group. During the experimental sessions, assistance was offered to those participants who had difficulties with writing and/or arithmetic. In addition, subjects were told that the points earned in the last round would be exchange for cash. On average, earnings per student amounted 2$ and per villager 1$. In the case of villagers, a show-up fee of 1$ was given.

Both in the experiments with students and withvillagers, participants were randomly assigned to the groups.Groups were composed of n=4 players, each of whom received an initial endowment e=20 points. The initial size of the common pool resource is F_o=240 points. At the appropriation stage, each point invested in appropriation yields a marginal (individual) benefit of w=2, and decreases the common pool water resource by c=3. Each unit not invested in appropriation produces a marginal benefit α=1. In the public good provision stage, each point invested in a fund for operational and maintenance activities produces an individual costβ=1 and increases the common pool resource bym=1.5.

After instructions and a practice round, participants played for a maximum of T=10 rounds. The game finished if the group reached 10 rounds, but participants did not know in advance the maximum number of rounds they would play. The remaining common water resource, equally distributed among the group players in the last round, can take any value F_T within the closed interval [0, 360].

Experiments with undergraduate students included 92 participants (23 groups of 4 people), and were performed using pencil and paper. The average age of the students was 21 years (Std. Dev. 2.3), and 46% of them were female. In addition, 86% of them were coming from an urban setting and 62% reported not having any previous experience on water resources management.Group composition is summarized in Table 1.

Experiments in the field were conducted in seven different rural communities in the Department of Jinotega. All the communities are located in the Upper Sub-basin of Rio Viejo. Rio Viejo basin is the major watershed in Nicaragua and includes the Lake Cocibolca, which is the major water reservoir in Central America. A total of 88 subjects, 48 females and 40 males, participated in 22 groups.In the field experiment, we implemented a treatment that included private information. In 9 out of 22 groups, after the 4th round, individual extraction of the common pool resource was made public before the second stage of the game, in which the participants had to decide how much to contribute to operational and maintenance activities of the public infrastructure. The introduction of this new information allows us to test whether providing individual extraction level exerts any sanctioning effect that results in significant differences in subsequent public good provision and extraction levels. The number of groups by sex composition in each treatment is reported in Table 1.

Table 1. Number of groups by sex composition and treatments in rural communities.

Group composition	N student groups (N players)	N villagers groups (N players)	
		T1 no information	T2 information**
4 males	5(20)	3 (12)	2(8)
4 females	8 (32)	5 (20)	2(8)
2 males & 2 females	4 (16)	2 (8)	2(8)
1 males & 3 females	2 (8)	1 (4)	2(8)
3 males &1 female	4 (16)	2 (8)	1(4)
Total	23 (92)	13 (52)	9 (36)

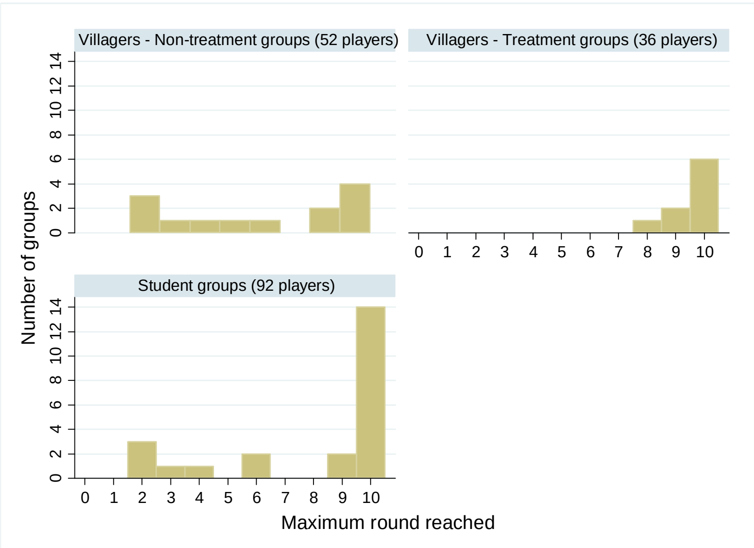
Note: *In these groups, after round four, individual extraction levels were publicly shared among the group members.

Farming is the major source of income in the households of 81 out of 88 participants. The average age of villagers was 34 years (Std. Dev. 13.3). In terms of the maximum level of education attained, 9% had no formal education, 3% are literate, 36% completed primary studies, 34% had secondary studies and 16% received technical or university training.

4. Results

This section reports the main descriptive results, and provides individual and group level analyses of appropriation and public good provision decisions along the game. As shown in Fig.1, most groups in both student and villagers' gamesreached round 10. This shows that most groups managed to not deplete the common pool resource despite individual incentives to invest all the endowment in common pool resource appropriation. It should be noted that in the case of village groups under treatment a higher proportion reached round 10 (6 out of 9 groups) and any of the groups depleted the resource before round 8.

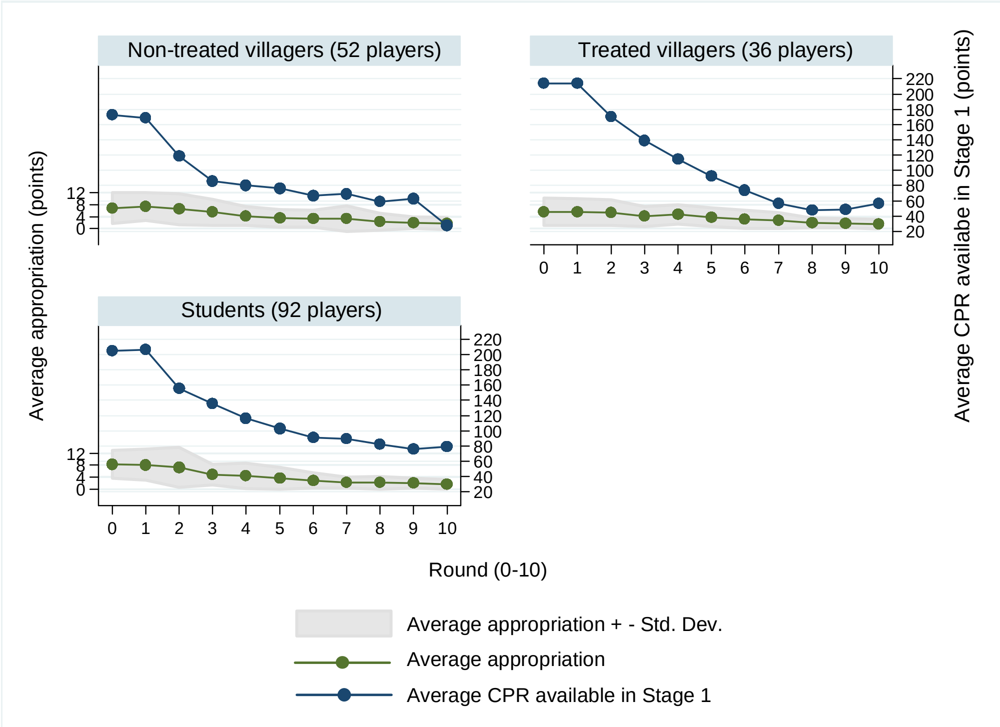
Fig. 1-Group distribution by maximum round reached in the game.



4.1. Appropriation and provision decisions

Data in Fig. 2 shows average appropriation and common pool resource (CPR) available initially at Stage 1 of each round. Results shows that appropriation levels (in green) are below the Nash prediction of full appropriation (blue), but above the social efficient level.

Fig. 2- Average appropriation and available CPR at Stage 1 of each round for each treatment group.

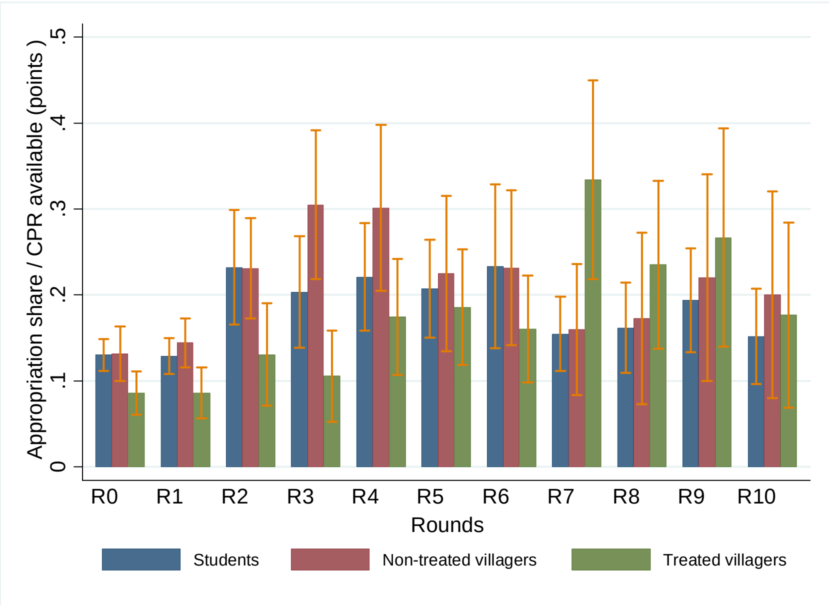


A Kruskal-Wallis test revealed a significant effect of treatment group (i.e. students, non-treated villagers and treated villagers) on appropriation decisions along the game ($X^2_{df=2}$ = 15.10, p-value = 0.0005). Considering appropriation decisions before and after round 4 of the game, there is a significant difference between treatment groups in the appropriation decisions distribution before round 4 ($X^2_{df=2}$ = 18.82, p-value = 0.0001). However, differences in appropriation decisions are not significant after round 4 among treatment groups. A post-hoc test Mann-Whitney-U test showed significant differences between non-treated and treated villagers appropriation decisions (z=3.983, p-value=0.0001).We can conclude that non-treated villagers appropriate more than treated villagers. However, the Mann-Whitney-U test reveals that these differences are only significant when considering appropriation decisions before round 4 (z=3.189, p-value = 0.0014). Non-treated villagers rank higher than treated subjects.There is no significant difference between non-treated and treated subjects after round 4 (z=0.588, p-value= 0.557). Differences in the underlying distributions of the appropriation of students and non-treated villagers are not significant at 5% level of significance (z=-1.924, p=0.054).

In addition to appropriation decisions, we are also interested in looking at the distribution of appropriation decisions with respect to the available CPR at Stage 1 of each round. For this purpose, we generate an additional variable defined as the ratio between CPR appropriation and available CPR. Fig. 3 shows average share appropriation for each round and for each treatment group. A Kruskal-Wallis test shows that treatment group has a significant effect on the share of appropriation with respect to available CPR ($X^2_{df=2}$ = 16.540, p-value= 0.0003). Comparing the samples by pairs, there is a significant difference between treated and non-treated villager's subjects (Mann-Whitney-U test, z = 3.858, p-value= 0.0001). Non-treated subjects rankedhigher. In addition, the difference is also significant between non-treated villagers and students (z = 3.253, p-value= 0.0011). Non-treated villagers rank higher than students.

Jonckheere-Terpstra test for ordered alternatives reveals that, in the case of students, appropriation share decreases along the game (J=-2.501, p-value =0.0062). The test result for non-treated villagers shows that the null hypothesis of same underlying distribution for each round cannot be rejected. In the treated villagers we can conclude that appropriation share increases along the game (J= 2.554, p-value= 0.0053).

Fig. 3- Average share of appropriation with respect to CPR available in Stage 1 of each round. The error bars indicate the confidence interval for each group treatment in each round.



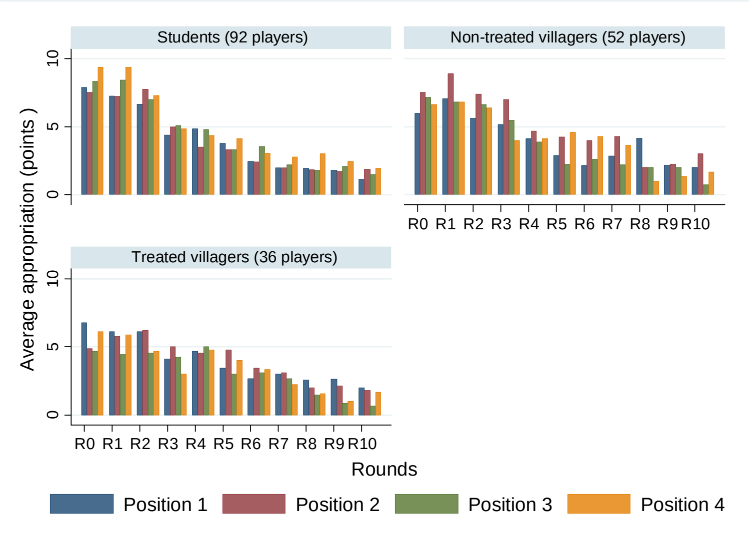
With respect to the common pool resource available at Stage 1 of the game, a Kruskal-Wallis test shows that differences among treatments are significant at the 0.01 significance level ($X^2_{df=2}$= 29.83, p-value = 0.0001). However, a Mann-Whitney-U test shows that differences between treated and non-treated villagers are not significant (z=-1.720, p-value= 0.0855). There is a significant difference between students and non-treated villagers (z=5.147, p-value =0.0000). In this case, students ranked higher.

Differences in the distribution of public good provision decisions are statistically significant among treatment groups (Kruskal-Wallis test, $X^2_{df=2}$= 14.281, p-value= 0.0008). Pairs' comparison shows that there is a significant difference between non-treated and treated villagers (Mann-Whitney-U test, z = 3.919, p-value= 0.0001). Non-treated villagers invest more in public good provision than treated villagers. However, there is no significant difference between non-treated villagers and students (Mann-Whitney-U test, z = -0.951, p-value= 0.3415). Spearman correlation shows that the relationship between appropriation and public good provision decisions is statistically significant in all group treatment's subjects (Students: rho=0.6539, p-value= 0.0000; Non-treated villagers: rho=0.5403, p-value= 0.0000; Treated villagers: rho= 0.4920, p-value= 0.0000).

Overall, these results suggest that non-treated villagers appropriate more than treated villagers. In addition, appropriation share with respect to available CPR is also higher for non-treated than treated villagers, but distribution of the available CPR is not statistically different for both treated and non-treated villagers. With respect to public good provision, non-treated villagers also provide more public good than treated villagers, which confirms the positive and significant correlation between appropriation and public good provision. Distribution of appropriation decisions is not significantly different for students and non-treated villagers. However, appropriation share of non-treated villagers is higher than that of students, while available CPR is higher for students than for non-treated villagers despite there is no significant difference in public good provision among subjects from both groups.

In considering the asymmetry in the order of appropriation decisions, we observe that there is a significant difference in the distribution of average appropriation among positions. Average results are presented in Fig. 4. While in the students treatment group average appropriation increases with players' position (Jonckheere-Terpstra test for ordered alternatives J* = 4.091, p-value= 0.0000), the opposite takes place in the non-treated (J = -1.552, p-value= 0.0603) and treated villagers' groups (J= -2.906, p-value= 0.0018).

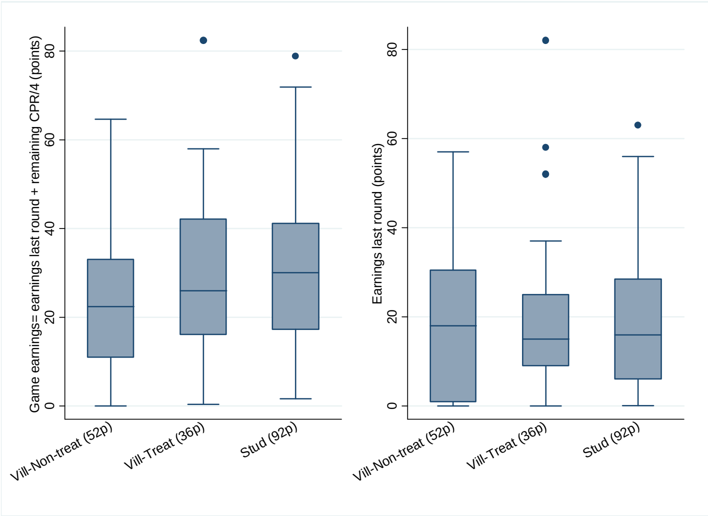
Fig. 4- Average appropriation by player position and treatment group.



4.2. Game and last round earnings

Fig. 5 summarizes game earnings and earnings in the last round by group treatment. As described earlier in the paper, the difference between both variables is due to the CPR available at the last round, which is equally distributed among the four players. Therefore, game earnings equal the private earnings in the last round plus the corresponding share of the CPR. There is no significant difference in the distribution of game earnings among treatment groups (Kruskal-Wallis test, $X^2_{df=2}$= 5.866, p-value= 0.0532), neither in the distribution of earnings in the last round (Kruskal-Wallis test, $X^2_{df=2}$= 0.737, p-value= 0.6919). In addition, we do not find evidence of significant differences in game earnings and last round earnings between treated and non-treated villagers. But we find significant differences in the distribution of game earnings between students and non-treated villagers(Mann-Whitney-U test, z = 2.406, p-value= 0.0161). Students rank higher than non-treated villagers. However, there is no significant difference between students and non-treated villagers earnings in the last round. These results are in line with the previous findings showing the differences in CPR availability between students and non-treated villagers games. Thus, in the case of students there is a larger share of CPR to distribute among group players.

Fig. 5- Game earnings and earnings in the last round by group treatment.

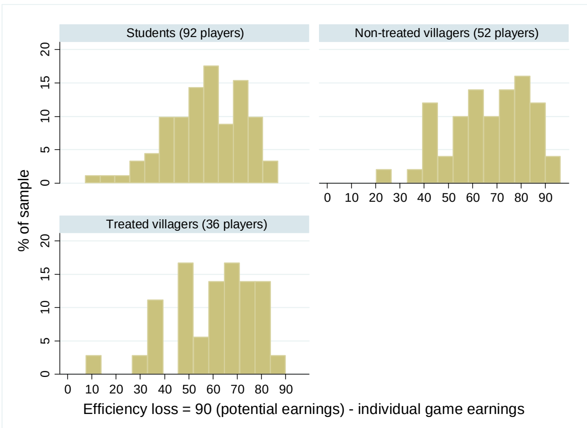


4.3. Individual-level efficiency in the game

Game results can be analyzed on an efficiency basis. For this purpose, we define economic efficiency as the difference between potential earnings and actual earnings. Potential game earnings are considered as the maximum a player can earn subject to all the other players in the group reach that maximum. In this respect, it is not a private optimum, but a socialoptimum. Given our game design, potential earnings amount to 90 points. The difference between potential and actual earnings is considered as a loss of efficiency. In this respect, smaller differences imply smaller losses of the efficiency.

Fig. 6 below shows efficiency loss distribution by treatment. Kruskal-Wallis test suggests that there is a significant difference in efficiency distributions among groups at 5% confidence level ($X^2_{df=2}$= 6.572, p-value= 0.0374). In addition, Mann-Whitney-U test shows that efficiency distribution between treated and non-treated villagers groups is not significantly different (z= 1.471, p-value= 0.1413). However, differences in efficiency distribution between students and non-treated villagers groups are statistically significant (Mann-Whitney-U test, z= -2.539, p-value= 0.0111). We can conclude that non-treated villagers rank higher than students with respect to loss of efficiency.

Fig. 6 – Histogram of efficiency loss by treatment group.



Distribution differences by sex are not statistically significant except in the students' case, in which males experienced higher losses of efficiency than females (Mann-Whitney-U test, z= 2.928, p-value= 0.0034).

There might be different explanations for differences in the loss of efficiency. Thus, given our game design, we can test whether smaller losses of individual economic efficiency arerelated to early resource depletion, as subjects might deplete the resource by appropriating in early rounds and not contributing to public good provision. However, the correlation coefficient between the number of rounds reached at the end of the game and loss of efficiency is not significant. Spearman correlation test suggests that the null hypothesis of independence between efficiency loss and the maximum reached in the game cannot be rejected (rho= 0.0652, p-value= 0.3883). In this respect, there isn't a relationship between the maximum round reached in the game and the loss of individual efficiency.

In addition, we are interested in analyzing to what extent individual characterization as either high or low appropriator and high or low contributor relates to the efficiency loss. For this purpose, we introduce a new variable named appropriator. This variable computes the average individual appropriation behavior along the game and can range between 0, when the individual behaves as a low appropriator in every played round, and 1, when the individual is characterized as a high appropriator in every round. A subject is a low appropriator when his appropriation level is below the groups' average appropriation in a certain round. The opposite holds for a high appropriation. Furthermore, we also introduce a variable accounting for average group composition in terms of number of high and/or low appropriatorsin a group along the game. For a specific round, group (appropriators) composition takes value 1 when all members are high appropriators, 0.75 in case 3 out of 4 players are high appropriators, 0.50 if 2 are high appropriators and 0.25 when only one member is a high appropriator. In a similar way, we define the public good provision behavior as an individual (contributor) and as a group (group contributor composition).

Table 2 reports regression results explaining individual efficiency loss. We present an aggregate model for the three treatment groups and a separate model including a dummy variable that accounts for the treatment group. Breusch-Pagan test for heteroskedasticity reveals that we cannot reject the null hypothesis of constant variance and, therefore, standard errors estimation is robust. As expected, individual appropriation behavior has a negative and significant effect on efficiency loss. However, group aggregate behavior has a positive effect on efficiency loss, which reflects the traditional social dilemma associated with common pool resources. On the other hand, individual contribution behavior has a positive and significant impact on efficiency loss, while group contribution behavior reflects a negative and not significant effect on efficiency loss. The introduction of the treatment group dummy variable decreases the significance of group composition in terms of number of appropriators and increases the significance of the constant, which accounts for the subjects included in the students treatment group. Non-treated villagers correlate positively with higher efficiency losses.

In sum, individual efficiency loss is significantly correlated to individual contribution and appropriation behavior with respect to the group average behavior. In addition, group composition regarding the number of high or low appropriators has also a significant and negative effect on individual efficiency. This effect is not significant when considering group composition in terms of players' contribution to public good provision.

Table 2. Regression results for individual level data explaining game efficiency loss. Between brackets are the standard deviations. We used Ordinary Least Squares, and the significance level is reported by adjusted R^2.

Efficiency loss	Model 1	Model 2
Constant	29.002**	36.576***
	(12.445)	(13.037)
Game duration (round max)	0.977**	1.183**
	(0.495)	(0.522)
Appropriator	-33.731***	-33.544***
	(4.313)	(4.281)
Group appropriator composition	58.750***	36.709*
	(15.689)	(18.618)
Contributor	30.860***	30.446***
	(5.092)	(5.057)
Group contributor composition	-7.522	-7.378
	(18.812)	(0.699)
Non-treated villagers		6.361**
		(3.108)
Treated villagers		-0.598
		(2.946)
N	177	177
Adj. R^2	0.2782	0.2820

***p<0.01, **p<0.05, *p<0.1

5. Conclusions

This paper presents an asymmetric game that combines a common pool resource and a public good game. Collective action problems related to both common pool resource appropriation and public good provision are typically presented in irrigation systems. The experimental design of this game attempts to reflect this type of irrigation social dilemmas and analyze the behavior of students and villagers when confronted with these decisions. The results reveal that there is no significant difference between appropriation decisions of students and non-treated villagers. However, non-treated villagers appropriate more common pool resource than treated villagers, but this difference is only significant before round 4. That is, once private information on others' appropriation level is made public in the treated villagers groups, the difference in the distribution of appropriation decisions between non-treated and treated villagers is not significant. In this respect, the provision of individuals' appropriation level results in higher appropriation in subsequent rounds.

Common pool resource appropriation and public good provision decisions are positively correlated. In this respect, the results show that non-treated villagers provide more public good than treated villagers. However, this difference is not significant between students and non-treated villagers. Both appropriation and provision decisions affect subjects' game earnings. Thus, despite students' individual earnings in the last round are below the ones of non-treated villagers, as the common pool resource is significantly higher for students, game earnings are higher for students than for non-treated villagers.

Our results show, furthermore, that, appropriation levelsare below the Nash prediction of full appropriation, but above the social efficient level. In this respect, there is an efficiency loss in the game, which is higher for villagers than for students. This efficiency loss can be explained to a large extent by individual decisions on appropriation and public good contribution and by group appropriation behavior. In this sense, it is also worth noting the asymmetry in the decision process. While in the case of students' appropriation increases with the position, the opposite takes place in villagers' games. This asymmetry in access might, in turn, affect the efficiency of the game.

References

Baland, J.M. and Platteau, J.P. (1996)*Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* Cambridge University Press.

Cardenas, J.C. (2009) Experiments in Environment and Development.*Annual Review Resource Economics*, 1: 157-182.

Cardenas, J.C. (2011) Social Norms and Behavior in the Local Commons as SeenThroughthe Lens of Field Experiments. *Environmental and ResourceEconomics*, 48: 451-485.

Cardenas, J.C. and Carpenter, J. (2008) Behavioural Development Economics: Lessons from Field Labs in the Developing World. *Journal of Development Studies*, 44: 337-364.

Chakravorty, U. and Roumassset, J. (1991) EfficientSpatialAllocation of IrrigationWater. American Journal of AgriculturalEconomics, 73: 165-173.

De Janvry, A., McCarthy, N. and Sadoulet, E. (1998) EndogenousProvision and Appropriation in theCommons. *American Journal of AgriculturalEconomics*, 80: 658-664.

Gintis, H. (2000) Beyond *Homo Economicus*: Evidence from Experimental Economics. Ecological Economics, 35: 3.

Janssen, M.A., Anderies, J.M. and Cardenas, J.C. (2011) Head-enders as stationary bandits in asymmetric commons: Comparing irrigation experiments in the laboratory and the field. *Ecological Economics*, 70: 1590-1598.

Janssen, M.A., Bousquet, F., Cardenas, J.C., Castillo, D. and Worrapimphong, K. (2012) Field experiments on irrigation dilemmas. *Agricultural Systems*, 109: 65-75.

Meinzen-Dick, R.S., Raju, K.V. and Gulati, A.(2002)What affects organization and collective action for managing resources? Evidence from canal irrigation systems in India.*World Development,*30: 649-666.

Osés-Eraso, N. and Viladrich-Grau, M. (2007) Appropriation and concern for resource scarcity in the commons: An experimental study. Ecological Eocnomics, 63: 435-445.

Osés-Eraso, N. and Viladrich-Grau, M. (2011) The sustainability of the commons: giving and receiving. *Experimental Economics*, 14: 458-481.

Osés-Eraso, N., Udina, F. and Viladrich-Grau, M. (2008) Environmental versus Human-Induced Scarcity in the Commons: Do They Trigger the Same Response? *Environmental and Resource Economics*, 40: 529-550.

Ostrom, E. (2000) Collective Action and the Evolution of Social Norms. *The Journal of Economic Perspectives*, 14: 137-158.