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Effects of Rules in Irrigation Systems: Evidence from Experiments in China[1], India and Vietnam

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Introduction

Irrigation systems are typically classified as common pool resources with two attributes of subtractability and non-excludability. These attributes cause collective action problems in both the provision and appropriation activities. In terms of provision, once water runs through the irrigation channel, any user can extract it regardless of who maintains the channel. Individuals therefore have little incentive to contribute to such maintenance, and would rather wait for others to invest which leads to an under-provision of the resource. In terms of appropriation, selfish individuals have an incentive to appropriate more and more units of water eventually leading to overuse or destruction of the resource (Anderies and Janssen 2013). A solution to the above collective action problems can be provided by suitable allocation rules. The success of self-governance - a process in which major users of the common pool resource are involved over time in making and applying rules to collectively manage the resource has been increasingly documented (Anderies and Janssen 2013, Banaszak 2008).

In three countries of our study, centralized systems, top-down policy delivery and largely objective institutional design process are dominated in irrigation water management. Irrigation users have a limited voice in the crafting of irrigation rules. The operational rules for irrigation governance are made and enforced by: (i) irrigation district commissions, i.e. sub branches of the local government, in China; (ii) district and provincial departments of irrigation and state-owned irrigation companies in Vietnam; and (iii) the Project Committee and the Distribution Committee in India. However in India, the Water Users Associations benefit from “mandatory participation in management of irrigation systems" (Nikku and van der Molen 2008) and thus have some formal influence in the actual decision making. Conflicts are still occurring among not only upstream and downstream agricultural users but also agricultural and industrial users.

In this context, we question the possibility for irrigation users to craft their own rules and their response to externally-imposed and self-crafted rules.

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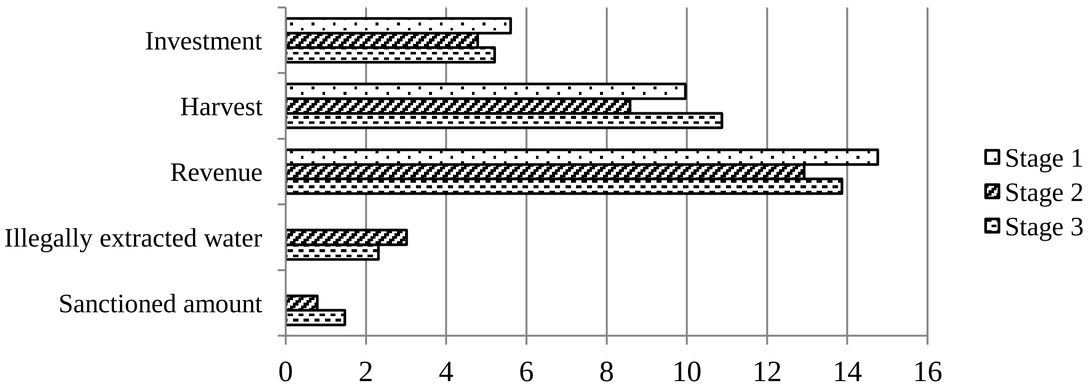
Method

To answer those above questions, we conducted an irrigation behavioral experiment with 180 students and farmers in China, India, and Vietnam. Conducting experiments with students and farmers in China, India and Vietnam we expect to compare the behaviors of different decision-makers: students with no or little experience and farmers who are familiar to irrigation systems in their daily work. The irrigation experiment, firstly introduced by Cardenas et al. (2013), is designed for a group of five players named A, B, C, D, E using only pencil and paper. The players act as irrigation users who are located along an irrigation channel, with player A beings located furthest upstream, and player E furthest downstream. The original experiment of Cardenas and colleagues has two stages. In the first stage, participants play without allocation rules. In the second stage, allocation rules are externally introduced and applied. In our research we add a third stage that allows players to create and apply their own allocation rules. Each stage incorporates ten rounds of play. For each round, the players have to make two decisions: investment into and extraction from the irrigation channel. The investment and extraction decisions are taken confidentially without any communication with other players. At the beginning of each round, each player receives a budget of ten tokens and asked to decide how much to invest in the maintenance of the irrigation channel and how much to keep for themselves. The investment can be any value from 0 to 10 (1 token equates to 1 unit of water). The total amount invested by all five players in the group is announced to all of them and will generate a certain water flow through the channel. The second decision each player has to take is how much water to extract from the channel. This decision is taken in the upstream-downstream order. In the second and third stages, if a player extracts water in a round when they are not allowed to extract by allocation rules, they are randomly sanctioned by the throw of a dice. The revenue of each player in a given round is the sum of water they extracted and the value retained from the investment phase subtracted by illegally extracted water. At the end of each game, all earnings are added together, converted to real money and paid to the players.

Results

Effects of different rules on the average results

As seen in figure 1, on average, externally imposed rules decrease the investment, harvest and revenue of irrigation users whereas self-crafted rules can improve the negative impact of rules.



Note: investment and revenue in tokens; harvest, illegal and sanctioned amounts in water units

Figure 1: Average investment, harvest, revenue, illegal and sanctioned amounts per player per round by stage

In terms of rule violation, illegally harvested water declines and sanctioned amount rises over the stages in all countries. This trend might indicate that there is stronger enforcement of self-crafted rules which leads to a reduction in rule violation.

Effects of different rules on the distribution of investment, harvest and revenue

Figure 2 presents the clear and consistent effects of asymmetric access to resource on the behavior and revenue generated by players.

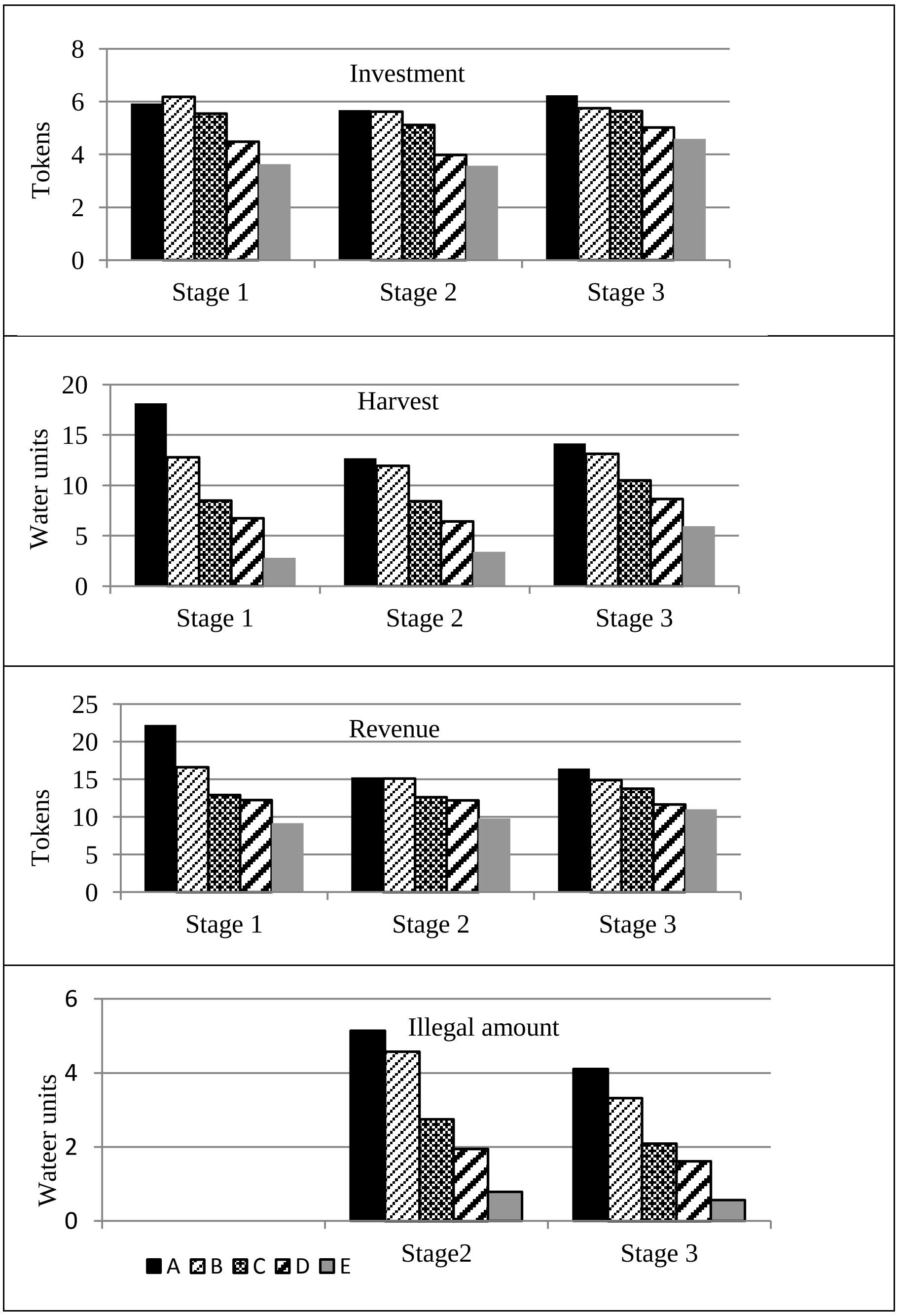


Figure 2: The distribution of average investment, harvest, revenue and illegally extracted water per player per round by players' position over the stages

The more downstream an irrigation player is located the less he or she invests in, harvests, earns and illegally extracts the water. People located high upstream will leave some water for people downstream despite there being no explicit rule forcing them to do so. Conversely, some players at the end of irrigation channel do not extract all water available for them, leaving it unused. The marginal effects of asymmetric upstream-downstream access are more evident in the harvest of water than in investment.

We observe an interesting trend in player behavior over the different stages: the later the stage, the smaller the difference in player behavior and revenue generated at different locations. This means the rules relieve the effects of asymmetric access to resource, allowing a more equal distribution of costs and benefits between the irrigation users.

Conclusions

Our research indicates that in a game situation of irrigation systems, managed as common-pool resources, users can indeed sufficiently communicate to devise rules for self-governing resource harvesting and maintenance. As expected, asymmetric access to the resource creates an unequal distribution of investment and harvest that favors upstream users. These two findings correspond to the research of Cardenas et al. (2011), Cardenas et al. (2013), Janssen et al. (2011a), Janssen et al. (2011b), Janssen et al. (2012).

Our results suggest that within small groups, irrigation users are able to communicate and craft their own rules that create a commitment to high investment and allow strong enforcement for the allocation of rules, leading an improvement in both revenue and equity for irrigation users. Two important policy conditions contributing to equal and efficient distribution of resource are the strong enforcement of rules and the participation of resource users in crafting rules. These two variables often go hand in hand.

An additional lesson can be drawn from our field work to improve the experiment design for further research. Besides bio-physical and social characteristics of an ecological social system, the economic characteristics of activities should be explicitly included in the design. In the current irrigation experiment, the more water players extract the more revenue they achieve. However in agricultural production the linear relationship between input (water) and output (revenue) is often not realistic. Therefore, future development of similar experiments might consider applying the quadratic function of input-output, as suggested by the economic law of diminishing marginal return.

References

Anderies J. M. and Janssen M. A. 2013, Sustaining the Commons, Center for Study of Institutional Diversity, Arizona State University

Banaszak I. 2008, Success and Failure of Cooperation in Agricultural Markets, Evidence from Producer Groups in Poland, Aachen: Shaker

Cardenas, J.C., Rodriguez, L.A., Johnson, N. 2011, Collective action for watershed management: field experiments in Colombia and Kenya, Environment and Development Economics 16, 275-303

Cardenas, J.C., Janssen, M., Bousquet 2013, Dynamics of rules and resources: Three new field experiments on water, forests and fisheries, in List J. and Price M. (Eds.), *Handbook on Experimental Economics and the Environment*, Edward Elgar Publishing, New York

Janssen M.A., Anderies J.M., Joshi S.R. 2011a, Coordination and cooperation in asymmetric commons dilemmas, Experimental Economics 14, 547-566

Janssen M.A., Anderies J.M., Cardenas J.C. 2011b, 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., Worrapimphong K. 2012, Field Experiments on Irrigation Dilemmas, Agricultural Systems, Vol. 109

Nikku, B. R. and van der Molen, I. 2008, Conflict, Resistance and Alliances in a Multi-Governance Setting: Reshaping Realities in the Andhra Pradesh Irrigation Reforms, Energy and Environment 19 (6).