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Playing games to save water: Collective action games for groundwater management in Andhra Pradesh, India

Ruth Meinzen-Dick [a,*], Marco A. Janssen [b], Sandeep Kandikuppa [c], Rahul Chaturvedi [d], Kaushalendra Rao [d], Sophie Theis [e]

[a] International Food Policy Research Institute, 2033 K Street, NW, Washington, D.C. 20006-1002, USA
[b] Arizona State University, USA
[c] University of North Carolina–Chapel Hill, USA
[d] Foundation for Ecological Security, India
[e] International Food Policy Research Institute, USA

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ABSTRACT

Groundwater is one of the most challenging common pool resources to govern, resulting in resource depletion in many areas. We present an innovative use of collective action games to not only measure propensity for cooperation, but to improve local understanding of groundwater interrelationships and stimulate collective governance of groundwater, based on a pilot study in Andhra Pradesh, India. The games simulate crop choice and consequences for the aquifer. These were followed by a community debriefing, which provided an entry point for discussing the interconnectedness of groundwater use, to affect mental models about groundwater. A slightly modified game was played in the same communities, one year later. Our study finds communication within the game increased the likelihood of groups reaching sustainable extraction levels in the second year of play, but not the first. Individual payments to participants based on how they played in the game had no effect on crop choice. Either repeated experience with the games or the revised structure of the game evoked more cooperation in the second year, outweighing other factors influencing behavior, such as education, gender, and trust index scores. After the games were played, a significantly higher proportion of communities adopted water registers and rules to govern groundwater, compared to other communities in the same NGO water commons program. Because groundwater levels are affected by many factors, games alone will not end groundwater depletion. However, games can contribute to social learning about the role of crop choice and collective action, to motivate behavior change toward more sustainable groundwater extraction.

1. Introduction

By their very nature, common pool resources like water, fisheries, or forests are easily depleted if there is not effective coordination, because use by one person affects the availability of resources to others, but it is difficult to exclude or regulate users. However, extensive research has demonstrated that self-governance by communities can be very effective for sustainable management of common pool resources by creating and enforcing rules about who can appropriate the common resources, as well as when, where and how (Agrawal, 2001; Anderies and Janssen 2013; Ostrom, 1990). This is especially important at the local level where the state does not have the capacity to set, monitor, and enforce rules on the use of these resources (Meinzen-Dick, 2014).

Yet effective collective action does not always emerge. If self-governance can lead to effective and sustainable outcomes, what can be done to stimulate such solutions? Imposing socially optimal solutions can lead to perverse outcomes because of concerns about procedural justice—the fairness of the decision making process (DeCaro, Janssen, & Lee, 2015) or because they displace (crowd out) moral sentiments that would otherwise prompt people to behave less selfishly (Bowles, 2008; Cardenas, Stranlund, & Willis, 2000). Programs in irrigation and forest management have used community organizers to catalyze collective action, but this is expensive and creates dependencies on external programs and funding (Bruns & Bruns, 2004); in many cases the cooperation is not sustained after the program ends. Thus, it important to find

* Corresponding author.
E-mail address: r.meinzen-dick@cgiar.org (R. Meinzen-Dick).

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ways for people to realize their interdependencies and internalize the value of cooperation.

Although water, as a mobile common pool resource, is challenging to govern, there are many examples of effective collective action to manage surface water (Tang, 1992; Schlager, Blomquist, & Tang, 1994). However, groundwater poses additional challenges, owing to difficulties in observing use and understanding resource dynamics (Schlager, 2007; Verma, Krishnan, Reddy, & Reddy, 2012). Those with the financial ability to sink wells are able to use water relatively autonomously, making it difficult to organize users and control water extraction (Giordano, 2009; Hoogesteger and Wester, 2015; Wester, Sandoval-Minero, & Hoogesteger, 2011). At the same time, the dispersed nature of water use also makes it difficult to implement regulations imposed by the state (López-Gunn & Cortina, 2006). The fact that it is often the wealthier and more influential farmers who have wells can make it even more difficult to regulate their use, either through collective action or state regulations (Hoogesteger & Wester, 2015).[1] Consequences of the failure of governance—by the state or communities–are seen in rapid groundwater depletion in many countries, including notably in hard rock areas of India. Community groundwater budgeting programs show promise in limiting irrigation withdrawals in India, but such cooperation often ends when the project ends (Garduño et al., 2009; Wani et al., 2008). As noted by Shah, Burke, and Villholth (2007:396–397): "To manage groundwater resources properly and to identify effective resource management strategies urgently needed among the poorest agrarian societies, an improved understanding of aquifer behavior has to be combined with an appreciation of the socioeconomic drivers of intensive groundwater use." That understanding of aquifer behavior is needed not just by experts, but by water users themselves, which calls for social learning.

Behavioral experiments have been used extensively to study factors affecting collective action, including for resource governance (Poteete, Janssen, & Ostrom, 2010). Anecdotal observations suggest that doing experimental games in communities can also lead to changes in practices (Cardenas & Carpenter, 2005). Some games have been used for individual learning, but have generally not been tested for social learning. Framed field experiments provide opportunities for dialogue with community members regarding collective action, and the exercises and discussions may offer a safe environment to experience a shared challenge so they can discuss and ponder the significance of the situation. This may lead to changes in community members' views on the valuation and management of the resource. Studying these effects can indicate whether such games can become a tool for strengthening collective action.

This paper presents the use of behavioral games as an instrument for social learning to facilitate self-governance of common pool resources, based on a pilot study on groundwater governance in Andhra Pradesh, India. The games contain elements of role playing games (RPGs) (Barreteau, Le Page, & Perez, 2007) and experimental economics (Ostrom, Gardner, & Walker, 1994; Bousquet et al., 2003) to create an action situation in which participants have a salient collective experience, followed by community level discussion to stimulate co-discovery of new solutions.

We begin with a theoretical review of how behavioral games can contribute to collective resource management, followed by an overview of the groundwater situation in Andhra Pradesh and the potential contribution of the games in improving local understanding of groundwater dynamics and rules for its governance. We then describe the methodology of our study and the results in terms of factors affecting how people played in the games, the influence on local mental models, and broader impact of the games. The discussion and conclusions deal with the potential of games as a facilitation tool for social learning to affect mental models of a resource and for strengthening collective resource governance.

2. Theoretical prospects on the use of behavioral experiments and role playing games

The use of groundwater games has two effects that can explain the potential beneficial impact. First, humans have difficulty understanding causal relationships in dynamic systems. Even highly educated graduate students in engineering fail to correctly describe the dynamics of simple systems like filling a bathtub (Booth Sweeney & Sterman, 2000; Cronin, Gonzalez, & Sterman, 2009). Moxnes (2000) found that the lack of understanding of dynamic systems can explain overharvesting of dynamic resources. Hence, when communities in rural India get access to powerful pumps with free electricity, the consequences of the resulting increased water use on the groundwater level is not evident to them. Especially in hard-rock areas where the aquifer boundaries are complex and where the groundwater levels change rapidly due to monsoon rainfall, we found from discussions in the debriefing and our mental models survey that people's mental model of groundwater levels did include rainfall, but not crop choice.

Mental models are peoples' internal representation of external reality (Hoffman, Lubell, & Hills, 2014) and are assumed to influence decision making of resource users (Jones, Ross, Lynam, Perez & Leitch, 2011). There is increased attention to the role of mental models in natural resource management, but one of the key challenges remains the elicitation of those mental models (Jones et al., 2011). Vuillot et al. (2016) study the relationship between mental models and the actions of resource users, finding that differences in farmer practices can be explained partly by differences in mental models. The biophysical and social contexts, including policies, constrain actions of resource users and explain why they may not make actions in line with their mental models.

As discussed below, the participants in our games have a limited understanding about the nature of the groundwater problem. By demonstrating the inter-relationships between crop choice and water levels, the games may reveal the mismatch between the mental models and the actual dynamics of the system, and may improve the understanding of what affects groundwater levels, and in turn enable the resource users to develop better governance.

The second effect is pedagogical. NGOs have been teaching the use of water budgets in communities, but the changes have been limited after the intervention ends (Garduño et al., 2009). This might be caused by the way information was transmitted. Pedagogical research on the effectiveness of teaching has found that passive dissemination of facts does not stimulate a deep understanding of the problem and a life-long learning. Rather, more active and collaborative learning activities such as educational games stimulate a deeper understanding of complex educational material (Lujan and DiCarlo, 2006).

The use of economic experiments in the classroom has been shown to increase the understanding of economic concepts (Dickie, 2006; Durham, McKinnon, & Schulman, 2007; Ball, Eckel, & Rojas, 2006; Frank, 1997). The performance is measured by test scores compared to control classes who do not use experiments. Ball et al. (2006) assessed the effectiveness of using the Wireless Interactive Teaching System (WITS) in economics classes. Experimental class students obtained on average 3.2 points more than control class students. The experiments had a greater impact on groups that usually have more difficulties learning economics, including women and freshmen. The main explanation for these

[1] However, wealthy individuals may also provide leadership on collective activities. For a review of the effect of heterogeneity on collective action, see Bardhan (1993); Jones (2004); Kurian and Dietz (2013) and Vedeld (2000).

positive results was that students and teachers enjoyed the experimental classes more and as a result, they were more engaged with the materials and the discussions. Frank (1997) compared the results of a group of students who participated in a simple classroom experiment about the use of common-property resources with the results of a control group of students. The students participating in the experiment obtained higher grades than the control students in a test about the "tragedy of the commons".

The way the experiments are implemented has an impact on the outcome. Cartwright and Stepanova (2012) find that reflection on the experience with experiments by writing a report increased the effectiveness. Rousu et al. (2015) show that providing monetary incentives increased the performance in student exams. In a meta-review of serious games in education, Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) found that learning effects were greatest when games were repeated, supplemented with other methods, and players worked in groups. These studies suggest that effectiveness of the use of experiments, at least in education, is increased if the educators can create ways to enhance the engagement of the students.

The hypothesis that experiments can be used as a pedagogical tool to strengthen collective action in practice was partially explored for first time in Cardenas and Carpenter (2005). As a result of many years of field experience with experimental games, the authors noted that experiments provided participants with useful metaphors for their daily lives. They analyzed the learning effect of experimental games in three villages of Colombia by conducting two rounds of experiments, several months apart. One or two days after the first experiments, a workshop was held in each community to discuss the strategies that participants followed during the games as well as other relevant issues related with the management of common pool resources. The role of the workshop in providing cooperation mechanisms and promoting prosocial behavior was believed to be high. The results of the second round of experiments suggest that both new and experienced participants cooperated more in the second round, although Cardenas and Carpenter (2005) also acknowledge that a more-systematic follow-up approach would be needed to obtain more conclusive results.

The present study provides such systematic testing of the effect of collective action games on collective action for natural resource management. Most experimental studies lack a collective debriefing session and can thus contribute to individual learning, but not social learning. To address this shortcoming, our approach includes community-level debriefing to discuss the outcomes of the games and their relevance to the local situation.

There are similarities between the use of such behavioral experiments as a tool for learning and role-playing games (RPGs) used for natural resource management. Many RPGs involve complex interactions, where players are asked to take on different roles, either acting them out or using board games or computer simulations. Shah, Verma and Krishnan (2013) report on the use of a detailed RPG to simulate groundwater irrigated production dynamics and possible reform options in India. Although RPGs are often used as a research tool to understand local ecological knowledge and strategies or to validate models, they are also now being used in interventions to improve management of resources such as irrigation systems, biodiversity, or landscape planning (Barreteau et al., 2007, Bousquet et al., 2003). Villamor and Badmos (2015) report on a recent use of an RPG on grazing management in Ghana, which was replicated across 23 sites, and found that the game did elicit local goals and understanding of their situation, but was limited in facilitating social learning. Dionnet, Kuper, Hammani, and Garin (2008) used RPGs as part of a participatory process for farmers developing collective drip irrigation systems in Morocco, and found that the RPGs could be very useful for the learning process, but there is a challenge in identifying the appropriate level of abstraction that allows farmers to consider different options but also relate this to their own real-life situations (see also Kuper et al., 2009). Although simplified RPGs and complex behavioral experiments are very similar, the latter are generally simpler and more generic, with fewer roles or positions and more predefined outcomes. This makes them easier to replicate across sites, while leaving space for participants to identify the links between the games and their own situations, especially in the context of facilitated community debriefings.

Another difference between RPGs and behavioral experiments is the use of monetary payments in behavioral experiments as salient incentives for decision making. The practice in economics is to provide individual (monetary) rewards so that actions have motivational relevance (Smith, 1982). In RPGs there is no practice of individual financial incentives. Providing different individual payments to participants in behavioral experiments as an activity of NGOs to strengthen collective action is a concern. Differential individual payments are in contrast to common practices of the NGOs. Therefore, we review the practice of individual cash payments in behavioral experiments.

Does the use of monetary rewards in behavioral experiments affect the outcomes? Psychologists and economists have done similar experiments, but psychologists do not use monetary rewards and argue that such monetary rewards will not affect the decisions (Smith and Walker, 1993). Experimental evidence indicates that payments can have an effect. If participants perceive the rewards as a fair contribution for the effort, the results will not be affected by different levels (Gneezy & Rustichini, 2000; Amir, Rand, & Gal, 2012). However, if the monetary reward is very low, this can backfire and participants will put in less effort (Gneezy & Rustichini, 2000). Gneezy & Rustichini (2000) found that it could be more effective to appeal to moral incentives (such as contributing to an important activity) rather than providing a monetary reward. If collective action games are to be part of interventions in communities for resource management, there are legitimate concerns not only about the cost of making significant enough payments, but also that individual payments may cause resentment by those who lose out or are not invited to play. It is therefore important to test whether payment method affects either performance in games or the learning from the games.

In sum, the use of games–an activity that includes elements of role playing games and experimental economics–in communities has potential to increase their understanding of the relationships between their actions and groundwater levels, to frame the problem as a collective action problem, and provide ways to address the collective action problem.

3. Context and potential contribution of groundwater games in Andhra Pradesh

Over 60% of the irrigation and 85% of domestic water in India comes from groundwater (World Bank, 2010). As demand for both water uses grows, it has led to falling water table levels in many areas. This is particularly the case in the state of Andhra Pradesh, which has predominantly hard rock aquifers with patchy areas of groundwater and low storage (World Bank, 2010). Farmers in Andhra Pradesh have historically depended on canal and tank irrigation. While the eastern part of the state, blessed with large rivers like Krishna and Godavari, depended on canal irrigation, the hinterland in the north and south of the state, known as Telengana and Rayalaseema respectively, depended mostly on tanks for irrigation. However, there has been a decrease in state investments in irrigation (Vaditya, 2017) and a decline in the institutions that traditionally facilitated tank management (Shah, 2012; Taylor,

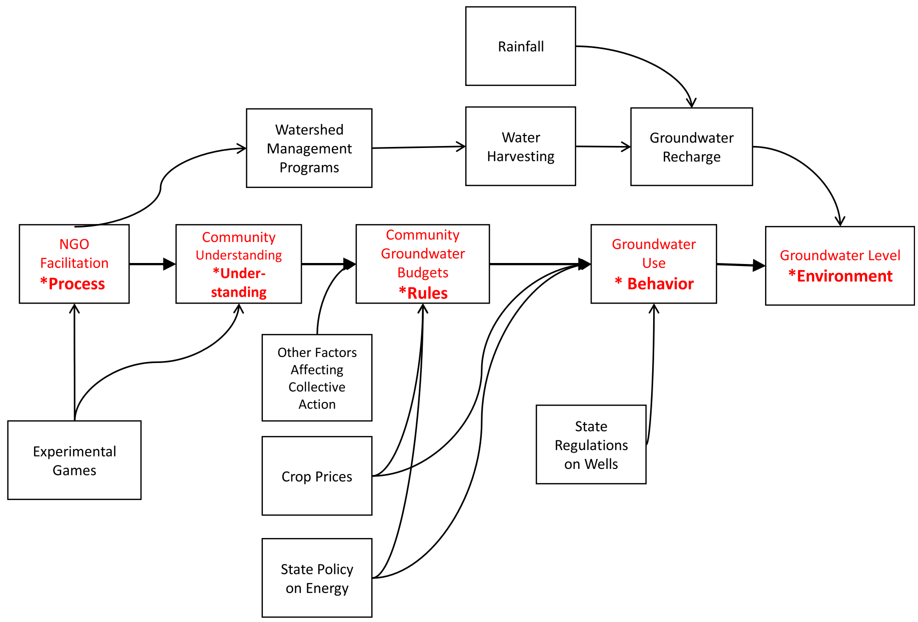

Fig. 1. Conceptual model of factors affecting groundwater levels.

2013). Degradation of forests and common lands in the catchment areas of tanks, and a breakdown in traditional systems that ensured that the catchment areas and feeder channels were maintained has resulted in faster siltation of tanks. Coupled with these factors, the proliferation of intensive cropping techniques involving heavy of use of chemical inputs and water has meant that the demand for water outstripped the ability of traditional sources like tanks and canals to supply, and farmers have increasingly relied on tubewells.

During the last three decades, the number of wells and the land under groundwater irrigation in Andhra Pradesh has almost tripled (Directorate of Groundwater, 2011). In 2008, of the state's 1227 groundwater blocks (sub-district administrative units), 300 were at critical or overexploited levels and 208 were at semi-critical levels (World Bank, 2010).[2] In 2014, deep water levels of over 20 meters were reported in 16 percent of the wells in the state as a whole, and 41 percent of the wells Ananthapur District, our study area (Government of Andhra Pradesh, 2014).

Many factors affect groundwater levels, including natural processes, state policies, local rules, and individual choices that affect the balance of groundwater recharge and extraction (use), as illustrated in Fig. 1 (see also Shah et al., 2007). Environmental factors such as rainfall patterns and the type of substrate determine groundwater recharge rates. Tank irrigation is an important source of recharge, but the decline in tank management reduces recharge (Taylor, 2013). Groundwater recharge can also be improved with the implementation of watershed management and other participatory programs that focus on enhancing the management of groundwater and other natural resources (Giordano, 2009; Gray & Srinidhi, 2013; Kerr, 2007).

On the groundwater use side of the equation, state regulations can have an effect. There are policies regulating the spacing of wells in areas designated as over-exploited, but the implementation of these policies is often weak (Kemper, 2007; Shah, Giordano, & Mukherji, 2012). State policy on energy can influence groundwater use, but electricity tariffs in Andhra Pradesh follow a flat-rate system under which electricity is either free (for pumpsets under 10 horsepower) or a small monthly fee per horsepower for larger pumps, regardless of pumping hours. This encourages inefficient groundwater pumping practices like the operation of borewell pumps with low groundwater levels or leaving pumps switched-on to get supply when the power activates (World Bank, 2009).[3] Crop prices, which are affected by state policy as well as market forces, also influence groundwater use via economic incentives to grow water-consumptive or other types of crops. Taylor (2013) notes that this is compounded by pressures of debt: farmers need high returns to repay the credit they have used to invest in wells and commercial inputs.

Ultimately, groundwater use for irrigation (which is the largest source of groundwater extraction) hinges on the decisions of millions of individual farmers. These decisions are certainly affected by economic pressures and state policies, but can also be influenced by community groundwater rules. But whereas there are many longstanding customary institutions governing surface water in Andhra (c.f. Wade, 1994), these are less common for groundwater irrigation. Part of the reason for this is that surface irrigation has a history of hundreds of years in this area, and it is relatively easy to see the water flows. By contrast, groundwater use has developed rapidly over the last 40 years with the introduction of motorized pumping. The complex hydrology, especially in hard rock aquifers, combined with the lack of visibility of groundwater flows, has limited the emergence of local custom about groundwater. Furthermore, surface irrigation has required collective or state investment to build and maintain, whereas groundwater is tapped through individual investment, so that rules for sharing the water have not been called for (Giordano, 2009; Wester et al., 2011).

The challenges of developing institutions for sharing groundwater are compounded by the power structures around groundwater, where larger landholders and higher castes own a disproportionate share of the wells (Taylor, 2013). In Andhra Pradesh large, medium

[2] In 2014 Andhra Pradesh was divided into two states: Andhra Pradesh and Telangana. State-level figures in this paper refer to the undivided state. All study areas are in the portion that remained Andhra Pradesh.

[3] Water-saving technologies such as sprinkler and drip irrigation may reduce pumping, but do not necessarily reduce groundwater overdraft, if the water "saved" would have percolated back to the water table, or if farmers would then use the pumped water to irrigate more area (Giordano, 2009).

and semi-medium (2 ha and above) landholders together constitute about 2% of the total population but have approximately 27% of the tubewells, compared to 97% small and marginal landholders with 74% of the tubewells. Similarly, Scheduled Castes (SC) and Scheduled Tribes (ST) comprise roughly 28.5% of the total rural population; but own only about 14% of the total tubewells in the state.[4] Thus, any effort to trigger collective action on groundwater in AP must contend with the fact that the fruits of exploiting a shared resource are distributed unevenly owing to power structures, entrenched in caste and class. The strong economic logic of having to maximize productivity, juxtaposed with the power structures mentioned above, creates strong incentive for farmers across castes and landholding categories to participate in or increase the exploitation of groundwater. This has resulted in a decline in groundwater levels, and increased cost of agricultural production. While wealthier farmers have more resources to deepen their wells and may be able to out-compete others, in the long term all face increasing costs, and falling water tables even put domestic water supplies at risk.

There have been a number of programs to stimulate community groundwater management (see Das & Burke, 2013; Garduño et al., 2009; Reddy, Reddy, & Rout, 2014). NGOs play a key role as community mobilizers and facilitators of these programs by raising awareness among community members about the fragility of the resource and the importance of cooperating on provision (e.g. watershed management to enhance recharge) or on expropriation (e.g. limiting groundwater extraction). NGOs use a variety of tools to mobilize community and encourage collective action such as meetings with community members, trainings, Participatory Rural Appraisal (PRA) tools and focus group discussions. Ideally, as a result of these meetings, community groundwater budgets and other sort of rules and agreements are developed among community members to regulate groundwater extraction. Even though the results of these programs have been encouraging in many locations, not all communities have adopted rules governing groundwater,[5] and the long term sustainability of these programs after the external support is removed is still a major challenge (Wani et al., 2008). Thus, the interventions need to lead to community understanding of groundwater and the role of crop choice and extraction on groundwater depletion. As Pahl-Wostl et al. (2007, 2008) notes, social learning that bring stakeholders together to develop capacity and trust needed for collaboration is increasingly important for water management.

Based on a review of factors affecting collective action in other aspects of water and natural resource management (e.g. Agrawal, 2001; Bardhan, 1993; Bouma, Bulte, & van Soest, 2008; Poteete et al., 2010), we can anticipate that biophysical factors such as water scarcity and road access and characteristics of the users, including social capital, trust, and reciprocity among community members may determine whether the community groundwater budgets and other rules developed by the community are enforced.

Experimental games offer an instrument for better understanding how groundwater users make decisions about groundwater use and which drivers favor community mobilization and collective action (Meinzen-Dick et al., 2016). The present study goes beyond using such framed field experiments as an extractive data collection exercise for understanding farmers' decisions, to using them as an input to NGO facilitation processes, to help farmers understand groundwater dynamics and potentially contribute to the formation and application of rules governing groundwater extraction.

Based on the findings of Cartwright and Stepanova (2012) and Rousu et al. (2015) that engagement with players increases effectiveness of the games in education, the games developed for this project relate to the critical problems of groundwater depletion, to raise awareness about the benefits of community cooperation and sustainable groundwater management. The game focuses on crop choice, because growing water-consumptive crops has an important effect on water consumption, and rules governing the crops grown under groundwater are relatively easy to understand and monitor. In his review of local management of groundwater, van Steenbergen (2006) underscores the importance of simple rules with low transaction in providing the basis for community action.

Allowing communication during the game can help community members to realize the importance of establishing norms for a rational exploitation of the resource. As noted by Ostrom (2010:1), "Simply allowing communication, or 'cheap talk,' enables participants to reduce overharvesting and increase joint payoffs contrary to game theoretical predictions." The game can change mental models and improve understanding of the effect of individual crop choice and well use on collective groundwater levels. It also delivers the message that the total benefits and costs for the group are more important than the benefits and costs for the individual. To reinforce the social learning, community wide debriefing sessions after the game discuss the relevance of experimental game to the challenges the community is facing. The game used in this study was designed with these factors in mind.

4. Methodology

This study was a collaboration between two research organizations and two NGOs working to improve natural resource management in rural Andhra Pradesh. The games were framed field experiments that simulated crop choice and groundwater levels. Crop choice was selected as the key decision because it plays a critical role in net water extraction, and is also readily visible, so local rules on crop choice are a viable way to limit groundwater extraction. The games were repeated in the same communities in 2013 and 2014, with modifications of the game, as explained below, and the NGOs have monitored the communities to note whether there have been changes in patterns of groundwater use in the communities where games were played.

For each habitation (local community), the local watershed association was asked to invite a group of 5 men and a group of 5 women from households using groundwater to participate. Each group began with 50 units of groundwater, and players were asked to choose between "Crop A" which took 1 unit of groundwater and gave 2 units of money, and "Crop B" which took 3 units of groundwater and gave 5 units of money. To stress the mutual impact of players' cropping choices and reduce the complexity of the game, all players were assumed to have equal farm size.

The game was explained to participants using a large graphic poster and discussion of how these abstract crops related to local crops with different levels of water consumption and returns (see Fig. 2 for an English version; the one used was in Telugu). Each player chose their crop, and showed their choice in private to the game facilitator. At the end of each round, the total water consumption was announced and shown by lowering the water table on the graphic. Then a fixed amount of recharge was provided (5 units when the games were played in 2013), and a new water table level was announced for the start of the second round. After 2–3 practice rounds, this was repeated for up to 10 rounds,[6] but if the

[4] Distribution of caste and landholding size is from the Census of India (Government of India, 2011); distribution of tubewells is taken from the Minor Irrigation Census (Andhra Pradesh 2007).

[5] This is consistent with the findings of López-Gunn and Cortina (2006) in Spain and Wester et al. (2011) in Mexico, that community self-regulation of groundwater took hold in some places but not others.

[6] Players were not told how many rounds they would play.

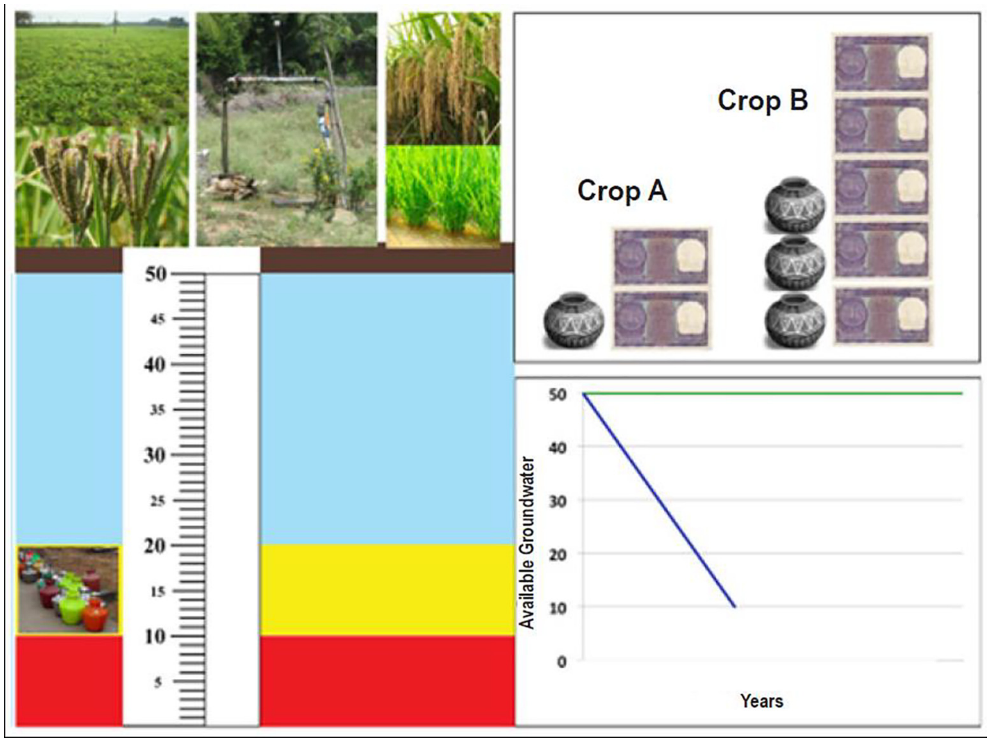

Fig. 2. English version of visual aid used to explain the groundwater game in 2014 and track groundwater levels in the game.

water table went below 10 units, the game was over (see Appendix A for full protocol used in 2014).

The game was designed to simulate a real-life collective action dilemma in crop choice: if all players chose the less water-consuming crop, the water table would be fully replenished each round, but if all chose Crop B, the game would be finished after 4 rounds. Thus, Crop B would give higher initial earnings but less for the total game.[7]

During the first set of up to 10 rounds, players were asked not to communicate. This was followed by a discussion of their experience, and a second set of up to 10 rounds with communication of up to 1 min per round, followed by individual (secret) crop choice.

Based on experience in 2013, two important modifications to the game were made in 2014. The first was prompted by observation that women, on average, were more likely to choose the water-consumptive crop. This was contrary to expectations, because women are generally responsible for collecting domestic water supply, which also depends on groundwater. Qualitative interviews with women in a subset of the communities confirmed that women did, indeed, bear the greatest burden when depletion of groundwater affected availability of domestic water. However, the framing of the game as exclusively dealing with crop choice reduced attention to domestic water. To address this issue, in 2014 the game was modified to include domestic water supplies. In addition to the crop water withdrawals each round, 2 units of water was deducted for domestic water use, and recharge was increased to 7 units. When the water table reached 20 units, participants were told that the domestic supplies were depleted, and it would cost every participant 1 unit of money to get replacement domestic water (however they had played, and whatever the returns were from agriculture). This is consistent with qualitative research that found that, because of fluorosis of the groundwater in many communities, when water tables fell people had to get water from a neighboring village; even where there was not fluorosis, women would have to go to more distant borewells to ask for water and carry it home.

The second modification was to add a large sheet of paper on which the current water level, water withdrawals, and updated water level were recorded on a table, as illustrated in Appendix B. Although the changes in groundwater levels were shown by moving a strip of water down and up the scale on the graphic after each round, many people found it easier to follow this if it was also recorded numerically on a table. In effect, this simulated the records of water table levels from monitoring wells that were promoted as part of the community groundwater management projects, but which were often not sustained after the projects ended (see Verma et al., 2012). Because of these modifications, we cannot say whether changes in game play in 2014 are attributable to repeating the game in the village (not necessarily with the same players) or to the changes in the structure of the game, but the team felt that these changes were important to helping communities understand and relate the game to their own experience.

Games were followed by a debriefing session in which the whole community was invited to participate, either later the same day or the next day. At the debriefing, the facilitators explained the game and presented graphs showing overall group results for each round, by men and women. Those who played the game were invited to talk about what was going on during the game, and what they thought of it. This was followed by a discussion of the implications of the game for the real groundwater situation in their area, and what might be done about it.

The data from the game, which included a record of each players' choices each round and notes on the conversations during the game, was supplemented with a short questionnaire asked to each participant covering individual and household characteristics, agricultural practices, trust-related questions and, in 2014, what the respondent was thinking about during the game. Community-level data collection recorded overall infrastructure, cropping patterns, and trends in groundwater. In the second year

[7] See Meinzen-Dick et al., 2016 and Supplemental Material for the detailed experiment protocol.

Table 1
Variables used to explain crop choices in the game.

Variable	Definition	Range	Mean
Year	Dummy variable indicating second year, when game was revised: 1 = 2014, 0 = 2013	[0,1]	0.5396
Flat Fee	Flat Fee payment	{0, 1}	0.460
Communication	Communication allowed?	{0, 1}	0.501
Available water	Quantity of groundwater available at beginning of round, after recharge	[0, 50]	33.794
Round	Round number in game	[1, 10]	5.493
Years in program	No. of years village had participated in NGO program as of 2013	[6, 20]	11.877
Paved road	Village is on a paved road (distance to paved road is 0)	[0, 1]	0.515
Female	Female participant	{0, 1}	0.499
Education	Highest education level achieved	{0 = none, 1 = adult literacy class, 2 = primary school, 3 = secondary school, 4 = intermediate, 5 = technical school, 6 = university}	2.082
Trust Index	Index based on related questions from the individual survey	[0, 1]	0.788
Age	Participant's age	[20, 86]	39.070
Scheduled Caste/Tribe	Is participant a scheduled tribe or caste?	{0 = Other Backward Castes or Other Castes, 1 = Scheduled Tribe or Scheduled Caste}	0.166
Area owned	Total area of land owned (ha)	[0, n]	2.093

we also conducted "mental models" interviews with four groundwater irrigators per habitation (total 112 interviews), selected by the watershed association, who had not played the game, to see whether there had been any spill-over effects of the games on the understanding of groundwater dynamics and attitudes toward groundwater management in the communities where games had been played, by comparing the treatment sites with results from mental models interviews in the control sites where no games were played. We draw on both the quantitative and qualitative data from the games and mental models interviews, as well as discussions in the communities and with NGO staff in our analysis in this paper.

The sampling frame for the games in both years was the 26 habitations where Foundation for Ecological Security (FES) or Jana Jagriti (JJ) have been working in three mandals (administrative divisions) of Anantapur District of Andhra Pradesh. The FES sites were part of a Water Commons program with a village planning process including participatory rapid appraisal (PRA) techniques and development of resource maps (see Bruns, 2015). To test whether the games had any effect on the communities, one third of the sample was designated as a control, where the games were not played but only the survey and habitation data were collected, plus the mental models surveys described below. To test whether method of payment would affect outcomes of the game, the remaining two-thirds of the sample was split between sites with payments to individual game players based on the "earnings" in the game (Rs 5 per unit of income earned in all rounds of the game),[8] and sites where a fixed donation of Rs 2000 was given to the watershed association, but individual players were not paid.

Habitations were allocated between individual payment (Treatment A), community donation (Treatment B), and control (C) using a stratified systematic sample with a random start. The full set of habitations were listed by watershed (four where FES is working, and three where Jana Jagriti operates), and then by number of houses per habitation within each watershed. We drew a random number between 1 and 3 for the start. That habitation on the list received treatment A (individual payment), then we proceeded down the list with treatment B (flat fee to watershed association), C (control), and so on through the list. Stratified samples are relatively efficient for small sample sizes, and stratifying on watershed and size of community ensures distribution of A, B, and C communities across these key variables. The resulting sample had 9 habitations in treatment A and 8 habitats in treatment B. Finally, to test whether the games have had an effect on community-level rules, we compared sites that played the game with the full sample of habitations where FES had been operating the same Water Commons project community facilitation, but did not include the games.

5. Factors affecting crop choice in the games

Three broad categories of factors are likely to affect players' crop choices in the game: those related to the structure of the game, to the communities, and to the individual players. To assess their influence, we use a logit model with robust standard errors. The dependent variable is a binomial variable indicating whether the participant chose the low water-use crop (Y = 0) or the high water-use crop (Y = 1).[9] Variable definitions, range, and descriptive statistics are given in Table 1.

Features of the game include the overall structure of the game, whether communication was allowed, water level at the beginning of the round, and round number. As noted above, the structure of the game changed from 2013 to 2014, to include a "yellow zone" illustrating depletion of domestic water at 20 units, and a table to track the crop choice, water use, and water table level. We would expect all of these changes to reduce water consumption in the game. However, because the game was changed from one year to another, these changes are captured by comparison of the constant in the regressions from 2013 and 2014.[10] *Communication* (which was only allowed in the second set of 10 rounds) is generally hypothesized to improve cooperative outcomes, so would be expected to decrease water consumptive crop choices (Ostrom, 2010; Cardenas & Carpenter, 2008). *Available water* at the beginning of the round would likely decrease the need for water saving (Bardhan, 1993). The *Round* of the game may also affect choices, either as players become more familiar with the game and group dynamics or become fatigued with the game. If individual payment to participants increases incentives for water consumption, the *Flat fee* variable would be expected to have a negative effect on water-consumptive crop choice.

[8] Individual earnings could range between Rs 200–500 per participant, which is higher than the daily wage of Rs 115 for National Rural Employment Guarantee Act (NREGA) projects.

[9] The independent variables are slightly different than used by Meinzen-Dick et al. (2016), because of observations from the field on the importance of paved roads for market access and a more complete set of indicators on cooperation.

[10] Note that we cannot distinguish the effect of changing the game structure from the fact that the game had been played in the community before, although not necessarily with the same players.

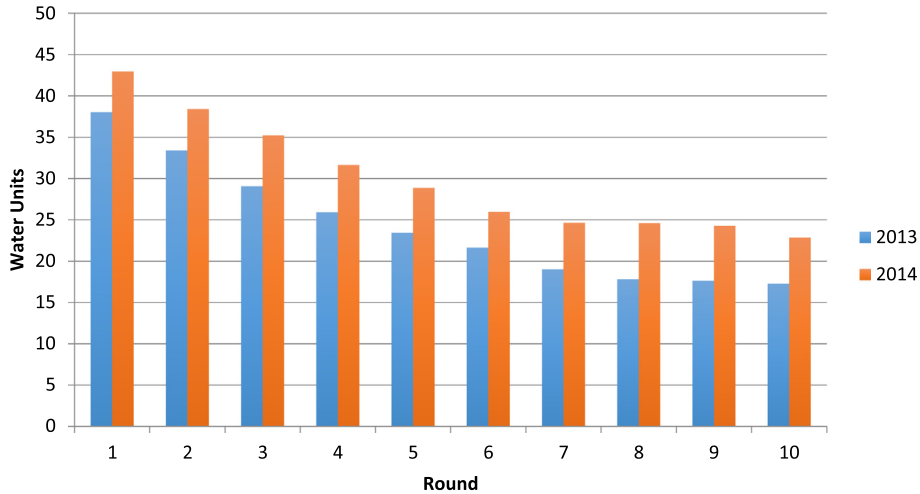

Fig. 3. Average water level at end of each round, 2013 and 2014 groundwater games.

Community variables include the years working with the respective NGO, and location on a paved road. *Years in program* (in 2013) is hypothesized to increase cooperative behavior, because of the influence of the NGOs which have been discussing the importance of water conservation. Note that FES had been working with its villages for around 6 years. JJ had been working with its villages for nearly 20 years. Therefore, this variable also picks up any difference between the NGOs. Because market access increases the profitability of cash crops, which are often more water consumptive, *Paved road* would likely increase choice of water consumptive crops.

Individual characteristics of the players include gender, education, age, caste, and land holding. As noted above, we would expect *Female* participants to play less water consumptively, especially with the revised game. *Education* would be likely to help participants understand the long-term strategy for the game, and choose less water consumptive crops.

Trust and social capital are often associated with higher measures of cooperation and group-oriented behavior (Agrawal, 2001; López-Gunn, 2012). In the context of this groundwater exercise, cooperative behavior is choosing the less water-demanding crop. To test this, we constructed an individual-level *Trust Index* based on a series of survey questions about players' perceptions of the honesty and trustworthiness of their neighbors, normalized to a value between 0 and 1 (See Appendix C). We would expect that those with higher trust in others would be more likely to cooperate, and hence that the index would be negatively associated with choosing the water-consumptive crop.

Finally, *Age, Caste,* and *Area owned* do not have a hypothesized direction of effect. All three variables are associated with higher status, and as noted above, higher caste and larger landholders are more likely to have tubewells. However, they may either take more water, or perceive a responsibility for leadership in collective action.

The average groundwater level at the end of each round in Fig. 3 shows that, early in the game, when water was more abundant, people were more likely to choose the water-consumptive crop, but as the game progressed and the water table went down, they were more conservative and the water table started to plateau. In 2014 the water table was higher in every round than it was in 2013, which could be attributable to modifications in the design of the game or prior experience with the game in the villages led to people choosing less water-consumptive crops.

Table 2 presents the logistic regression results to allow us to examine the factors affecting crop choice. Communication had a significant effect on reducing water consumption in 2014, but not in 2013, which may be related to the design of the game, particularly the use of a table to help players track the decline of the water table. We noted that players often referred to the chart to discuss when they needed to reduce water consumption, especially where literacy rates were higher. In the debriefing, players noted that when they played the game without communication, each person planted the crop according to their own choice, but when they played with communication, they were able to talk to each other and plant low water crops. But while most people abided by the decisions made through discussions, there were a few who would renege on the promises made and free ride, because crop choice was still a secret and there were no penalties for breaking the agreement. Even with such free riders, in 2014 there was a more equal distribution of earnings in rounds with communication than in rounds without.

Available water had a significant and positive effect in 2013 but not in 2014. The positive association is consistent with expectations that people would use more of the resource when it is abundant. The round had a significant negative effect in both years, as people chose less water-consumptive crops in later rounds of each game.

The payment scheme within the game does not have a significant effect in either year: being paid in cash based on simulated crop income in the game did not result in any difference in players' crop choices compared to the sites where the players received only simulated income, even though in the individual payment sites' participants were told that they would be paid Rs 5 per unit of money earned in the game. After we had found no significant difference in 2013, we followed up on this issue in 2014 with additional questions in the post-game survey about what participants were thinking about in the game, as reported on Table 3. When asked about their goal when playing the game, those who were being paid based on the outcome of the game were more likely than those who were not being paid to say they were playing "for fun"; those not being paid were more likely to say they were thinking about the (imaginary) money than those who were actually being paid. Similarly, when asked about how frequently they thought about money during the game, those who were not being paid were significantly more likely to report that they were thinking about the money, even though it was hypothetical money. The fact that 70 percent of individual payment and 60 percent of those who were not paid said that they never thought about money during the game might reflect a reluctance to say they were thinking about money, or that even the individual payments were not sufficient to be salient. However, the individual payments could range from Rs 200–500, which is considerably higher than the daily agricultural or public works wage rate. Furthermore, when we asked those who were paid about their satisfaction with the payment amount, over 80 percent were satisfied or highly satisfied, so it is not likely that lack of a difference between those paid and not paid was because the payments were too low. While there may be some reluctance by those who were paid to admit that they were thinking of the money, these findings indicate that the game creates a simulated environment which is equally salient, whether or not individual players are paid based on outcomes of the game.

The logistic regression results indicate that the number of years a village has been working with their local NGO—FES or JJ—is highly significant. Participants in villages that have been working longer with these NGOs use less water, although this effect was less in 2014 than in 2013. Participants on a paved road were more likely to choose Crop B than Crop A in 2013, which is consistent with the greater potential for commercial crops in those habitations; there was no difference in 2014.

Table 2
Logistic regression for choice of water-consumptive crops in groundwater games, 2013 and 2014.

Variable	2013	2014
Communication	0.0664	−0.3049***
Available water	0.0350***	0.0066
Round	−0.1242***	−0.1829***
Flat fee	−0.0368	−0.0969
Years in program	−0.0462***	−0.0281***
Paved road	0.2585**	−0.1165
Female	0.1789*	0.1154
Education	−0.0868***	−0.0330
Trust Index	−1.7932**	0.8500
Age	−0.0028	0.0000
Scheduled Caste/Tribe	0.0107	0.1944
Land owned	−0.0155	−0.0015
Constant	0.7917	−0.1175
Number of observations	3064	3218
LR chi2(13)	353.61	254.86
Prob > chi2	0	0
Psuedo R2	0.0904	0.0626

Note: ***P < 0.01; **P < 0.05, *P < 0.1. Significance level derived from robust standard errors.

Table 3
2014 post-game survey responses on what players were thinking about during the game, by payment type.

	Individual Payment (Percentage of respondents)	Group payment (Percentage of respondents)
Goal in the game		
For fun	23.96	11.36
To do what I do in real life	39.02	42.05
To earn as much money as I can	0.93	6.82
Victory	36.08	39.77
Frequency thinking about money		
In every round	11.90	12.05
Many times	1.83	5.02
Once or twice	15.56	22.58
Never	70.71	60.35
Satisfied with payment?		
Highly dissatisfied	2.75	
Dissatisfied	0.00	
Neutral	14.65	
Satisfied	9.15	
Very Satisfied	73.46	

In 2013, when all other variables were controlled, women use more water than men (p < 0.10). However, there were no significant gender differences in 2014, which may be related to the inclusion of domestic water in the game. Because women are primarily responsible for domestic water supply to the household, making the explicit link between crop choice and domestic groundwater supplies seems to have had an effect. Education had a significant negative effect on choice of the water-consumptive crop in 2013 but not 2014. This may be because even the less educated players had gained some familiarity with the game, or because the new game structure was easier for less educated players to understand. The Trust Index indicator is negative and highly significant for 2013 but not significant for 2014. This indicates that the first time the game was played, those with higher trust and social connections were less likely to choose the water-consumptive crop, but the second year there was higher cooperation overall. Either repeated experience with the games (in the village, but not necessarily the same players) or the revised structure of the game evoked more cooperation in 2014, outweighing other factors such as education, gender, and trust index scores. Age, caste, and land ownership were not significant in either year.

6. Effects of the games

As illustrated in Fig. 1, the first potential contribution of games is to community understanding. When we developed the games we had not understood how important this could be: we assumed that farmers understood the relationships between growing water-consumptive crops and depletion of groundwater. Therefore, to test whether the games were affecting community understanding, in 2014 we attempted to study whether the games were associated with a change in mental models, by comparing treatment communities (with games) and control communities (where no games had been played).

One-on-one interviews about groundwater and domestic water use were held in all the study sites, treatment villages and controls, to elicit mental models. The interview consisted of several open-ended questions and a series of multiple-choice choices, designed to ascertain what each individual thought about groundwater dynamics as well as how they used water in their day-to-day lives.

NGO staff noted a prevalent attitude of helplessness in these communities over their groundwater difficulties. Game participants, like many other farmers, expressed a common belief that that they had no control over groundwater levels, because it depends on rainfall. To address this perception, the community debriefing meetings were enhanced in 2014 to include a discussion of trends in groundwater and rainfall in the community, showing that even when rainfall was normal, the water table continued to decline. Although everyone's understanding of hard rock aquifers is limited (even that of so-called "technical experts") the role of irrigation withdrawals is important to recognize.

Table 4 presents the average responses to questions to elicit mental models about groundwater, as well as attitudes to regulating groundwater use. In most of the cases there were no significant differences between control communities and those that had played the games. This is not very surprising, given that the interviews were conducted a year after the original games, with only four respondents per habitation, and even those had not been involved in the games (in order to test for spillover from the games to others in the community). However, it is encouraging to note that on three important questions, respondents in the communities that played the games responded more cooperatively: those in the game villages were significantly less likely to say that farmers should be able to grow whatever they want, more likely to say that communities should cooperate to make water available for

Table 4
2014 responses to mental models questions in control villages and where games were played.

Question	Control	Games	Significance
Those with groundwater under their land should be able to make wells and use groundwater	3.893	3.917	
Those with land near surface water, such as streams, canals, or tanks, should be able to use water without any rules limiting their water use	2.607	2.711	
Farmers should be able to grow whatever crops they want, without any rules restrictions	4.214	3.357	***
Communities should cooperate to make sure everyone has access to safe water	4.714	4.476	**
Communities should cooperate to make sure everyone has access to water for agriculture	4.679	4.560	
Communities should cooperate to increase rainwater storage in soil, water bodies	4.464	4.417	
Communities should make rules about use of groundwater, such as about well location	3.893	4.321	*
Do water harvesting structures increase water in wells? (not at all = 1; a lot = 4)	3.893	3.833	
Does taking water from one well affect others? (not at all = 1; a lot = 4)	4.000	3.880	

Note: Unless otherwise noted, all variables are on a Likert scale, with Strongly agree = 5, Strongly disagree = 1; ***P < 0.01; **P < 0.05, *P < 0.1.

everyone, and more likely to say that communities should make rules about use of groundwater.

Participating NGO staff found that the games are an effective way to work with rural communities on the issue of groundwater. Both facilitators and community members enjoyed the games, which created a different dynamic than conventional meetings or PRA exercises. Instead of facilitators trying to give the participants information about groundwater conservation or trying to elicit their existing practices regarding groundwater use or conservation, games offer a way of 'learning while doing.'

Even where players were not paid based on their performance in the game, participants showed a high degree of engagement. People immediately assigned real crop names instead of Crop A and B—usually *ragi* (finger millet), vegetables, red gram and other millets for Crop A and sugar cane and paddy for Crop B. In the rounds with communication, there were often detailed discussions that provided valuable insights into peoples' perceptions and understanding of their interface with groundwater. The discussions that took place before a decision to plant a particular crop, even in a highly controlled game with only two options, illustrated the complex of factors that farmers took into consideration in making that decision. In particular, the high sunk costs of farmers who have sunk borewells puts pressure on them to grow high-value crops to repay the costs, and a decline in tank irrigation has prompted many to grow paddy—a culturally important but water-intensive crop–under groundwater irrigation.

The discussions also challenge assumptions about the impossibility of cooperation on groundwater. In addition to concerns for personal food security and income, players acknowledged other's needs for income and—especially as the water tables dropped near critical levels—concerns to maintain the water levels. When the water table started falling and players realized they could stabilize the water table by all taking Crop A, but not replenish it, players in 12 villages took the initiative to ask if they could choose "no crop" and draw no water but get no income for a round, so that the fixed recharge would exceed withdrawals for that round. Although this was not in the instructions, if players requested it, we allowed it. This option was chosen more often by women than by men (3 vs 1.7 percent of rounds in 2013 and 2014).

A number of farmers also expressed the importance of talking among themselves while making choices about groundwater. They indicated that the rounds played with communication helped them in better gauging each other's concerns, which in turn helped in conserving scarce water resources. However, the effects of communication were limited by the lack of sanctions. Quite a few players pointed out that efforts to conserve groundwater cannot work even if one out of the five players did not stick to the decisions made by the group. The process of discussing and finalizing a crop to sow surfaced the collective action dilemma; that those who did not stick to the collective decision made good money while those who did ended up losing out. Although sanctions were not included in this version of the game, the fact that players identified this gap provided the opportunity for the debriefing sessions to follow up on the possibilities of sanctions.

Community members themselves articulated the challenges of reconciling long term ecological considerations with short term livelihood concerns, and the games allowed them to discuss different mechanisms to find an appropriate middle ground. At least in some of the habitations where the games were conducted, this helped in triggering discussions about the linkages between agricultural practices and the status of groundwater, and about what steps that could be taken in order to slow down the decline.

Overall, the games and debriefing offer a useful tool to challenge dominant narratives about the inevitability of falling groundwater. During the discussions that ensued in the games and debriefing, the field teams were able to question the understanding that groundwater levels are only dependent on rainfall. Greater recognition of the importance of water withdrawals could pave the way for the identification of interventions to improve groundwater outcomes. While the structure of the game did not explicitly address power structures of caste and landholding, the fact that neither of these variables affected players' choices in the game indicates that the games may provide a context in which community members can discuss across these common barriers.

Ultimately, the test of whether these games and debriefing contribute to improving the sustainability of groundwater will be whether new rules and processes are adopted in the treatment communities, as illustrated the theory of change in Fig. 1. The indications to date are that the games are having an effect. Follow-up observations by FES noted that the habitations where games were played show a greater inclination to adopt rules and procedures for governing water resources. Of the 12 habitations where games were played, six adopted some rules for governing groundwater, and eight adopted water registers to inventory the water resources in the village.[11] On the other hand, out of the 4 habitations in the control group where games were not played, only one adopted water rules or water registers. The rules related to construction of water harvesting structures that allow for water percolation; equitable distribution of water; and effective demand side management like the use of crop water budgeting. Water registers, which are village level records of the area, storage capacity, and the purpose of each public and private water resources in the given village, are expected to prove useful for government agencies, community member and other interested parties to understand the condition of different water resources in a village and formulate plans for their restoration and governance.

The sample comparing games and control sites is not large enough to generalize from, but we are able to draw comparisons

[11] Note that rules for governing groundwater and water registers are not mutually exclusive.

based on a much larger set of habitations where FES has worked in Anantapur District. The 16 FES habitations (games plus control sites) were part of a Water Commons project that FES has been implementing in 90 habitations since 2011. The same basic FES activities have been carried out in all of these sites. These include soil and water conservation measures like constructing water recharge structures; working with communities to promulgate habitation and inter-habitation level institutions for governing water resources, including groundwater; and working closely with farmers and other rural households to achieve effective demand-side management, among others. Games and the concomitant post-game surveys and debriefing were the additional activities undertaken in the 12 games sites. Only habitation level surveys were administered in the four control habitations under the games initiative. Half (6 out of 12) of the habitations where games were played adopted rules for governing groundwater, compared to one third (26 out of 78) of the total set where games were not played. Similarly, 67% (8 out of 12) of the habitations that played games adopted water registers, as opposed to 36% (28 out of 78) where games were not played. The substantially higher adoption of rules and water registers in the sites with games are statistically significant ($P < 0.001$), supporting the notion that games have an effect on community-level rules.

7. Taking games forward

While games have become an integral part of FES' engagement with rural communities, especially on issues related to groundwater, a major challenge confronting the practitioner has been to transform the game from a systematic tool for observing participants' behavior and collecting relevant data, to a heuristic tool that is simple enough to be implemented and understood even by people who are not trained in economics or game theory. It is equally important that the game can be easily administered within the time and resource constraints a practicing NGO typically faces. With these practical realities, various changes have been made to the basic game that was played as part of this research. Games provide FES with a tool to engage with the community in an entertaining, engaging manner, which in turn triggers a process whereby the community and the organization learn and move towards solutions together.

Before looking at the various ways in which groundwater games have been adapted as a heuristic tool, we have enumerated some of the limitations to the games that we conducted, that are being taken into account while planning future exercises intended to influence mental models and collective action. These limitations relate to time, scope, tangibility, and predictability.

Time pressure was one of the biggest limitations. In 2013 it was particularly noted that it was difficult to keep women at the games for a long time, given the other demands on their time. In 2014 greater efforts were made to find a time that was more convenient for the women's groups, but considerable distances to the field sites and a tight schedule also meant that it was not possible to undertake iterative visits to a given habitation. Even though the activities that were a part of the games were spread over an entire day, the games plus post-game surveys and discussion with communities on a wide range of aspects pertaining to groundwater proved to be excessively demanding. Being able to do repeated visits to find appropriate times for the games and follow up on the debriefing could have a greater impact. In addition to time in the field, sufficient time is also needed for preparation, planning and training of the field staff. The latter is important to get the appropriate game dynamics, in which the facilitators make the abstract aspects of the game understandable, but let the participants come up with their own answers and ideas. Time constraints also prompt us to limit the complexity of the game and number of variations, which make the games go longer.

Scope: As useful as they are, games alone are not enough to trigger collective action around groundwater. That requires an enabling environment wherein the legitimate economic concerns of the farmers are addressed. This in turn calls for the games to be nested within a larger set of interventions, including tracing the history of water tables and cropping patterns in the area, and providing information on water consumption and returns of different crops so that the community can decide on new cropping patterns. The games are limited in scope to use of groundwater among the small fraction of farmers who currently have access to wells. While the introduction of domestic water did introduce some of the broader distribution issues, it still does not address how currently rainfed farmers might get access to groundwater to increase their productivity. To partially address this, instead of excluding all but the five players, FES now welcomes others to observe the game. If one player has to leave, others can rotate in, to broaden the participation and potential impact of the game.

The games as presently designed also simulate an unrealistic situation in which all farmers have equal endowments. In practice, farmers have different farm sizes, well capacity, dependence on irrigation, wealth, and power. As noted above, this heterogeneity of assets and interests can increase or decrease the likelihood of collective action. The effects of such differences can be included in the game by assigning different farm sizes and impact on the aquifer. We did not find a difference in the simulated choices of participants who have large or small farms in reality. However, it would be useful to carefully observe whether large farmers and local elites take the lead in arguing for water savings during the discussions in the games or community debriefing.

Tangibility: We ran the games using paper score sheets and abstract crops A and B. This is consistent with experimental games in university labs and most framed field experiments. But for social learning, more tangible "game pieces" are helpful, especially in areas with low literacy. Thus, FES has adapted the game to use cards illustrating real crops with low and high water consumption and play money.[12]

Predictability: The versions of the games presented here are quite linear and predictable; the fixed amount of recharge at the beginning of every round meant that the players could work out where they would be several rounds ahead, and they could guess that the games would go on for 10–12 rounds, rather than indefinitely. This contrasts to the long time horizons and fluctuations of rainfall and water availability in practice.

Further iterations of the game in other sites have introduced variable recharge by rolling dice before each season to determine the recharge.[13] It is also possible to allow (or guide) communities to introduce new rules, such as making public crop choices and sanctions for those who break the agreements. FES is now testing out the "co-creation" of games with communities, asking them what they would like to try out, and discussing the applicability of each change to their own situation, e.g. by asking how realistic it would be to have everyone's rabi crop choice made public, or what it would take to be able to sanction those who break the agreements, to trigger discussions among communities regarding collective action around groundwater. FES has also been reaching out to introduce the games to other government and non-government agencies who are concerned with the conservation of groundwater.

[12] We have considered using tablets computers, but these often attract attention to the tool, and distract from the interaction among players. Full guidelines on playing the game are available on http://gamesforsustainability.org/practitioners/.

[13] The sixes were blocked out so that rolling a 6 provided 0 recharge; hence the possible recharge ranged from 0 to 10.

While it is relatively easy to teach facilitators to use the game, it is sometimes a challenge for the facilitating team to refrain from "teaching" participants what are considered key lessons related to resource dynamics and importance of cooperation, and to let them discover and internalize the lessons themselves. Another major challenge for the facilitating team is 'active listening' during the discussions in the rounds with communication. It is important to document and analyze the concerns that participants raise, and address them in the debriefing.

In addition to the ways mentioned above to make the games more practitioner- oriented, the NGO has also started nesting games within larger program interventions. For instance, recently, in select villages in Chittoor district of Andhra Pradesh, games were combined with crop water budgeting. While the former underlined the importance of having rules for appropriation and monitoring of groundwater use; the latter provided guidance for judicious, well-planned, appropriation of this scarce resource. Anecdotal evidence suggests that combining the game with other interventions has the potential to convince the farmers of the need to govern groundwater better: 19 farmers in Chittoor agreed to grow low-water crops like finger millet on part of their land. FES is exploring other avenues to make games an integral part of their interventions to trigger better governance of a scarce and complex resource like groundwater.

8. Conclusions

In this paper we reported on a pilot study to investigate the impact of behavioral games on communities to manage their shared resources and as such evaluate the possibility of using games as an intervention tool. Our approach is rooted in the notion that if groups can self-govern their shared resources, they can craft effective institutional arrangements tailored to their social and biophysical context. The use of games can create a relatively safe space for social learning by discussing governance options and experimenting with alternative arrangements.

Based on fieldwork performed in 2013 and 2014 in which we did the games in 17 communities, we evaluated various types of impact of performing those interventions. We consistently found that the use of individual monetary incentives does not affect the behavior of participants in the games. Surveys performed in the second round of games confirm that participants take the consequences of their decisions seriously, even if there is no monetary stake. This finding is important since the use of individual payments is not desired by NGOs given the potential impact this may have in communities (inequality in payments).

The games are not meant to teach communities to adopt a certain solution. As such it is difficult to evaluate the impact of the games (if we would teach a solution, we could check whether this solution is implemented). However, qualitative assessments by the implementing NGOs and community participants indicated that the games were an effective supplement to ongoing community facilitation processes. Together with the community debriefing sessions, the games contribute to social learning. We also found that the use of games in the community a year before had measurable impact on the understanding of groundwater related decision making within the community, not just the participants of the games. This indicates that the games leave a "footprint" in the communities.

Communities where games were played were significantly more likely to adopt water registers and craft rules for governance of groundwater compared to those communities where games were not played, even though the NGO has applied the same set of other activities in both these categories of habitations. While it would be overstating the case to say games alone were responsible for this development, the games seem to be playing a contributing role, alongside various other factors, in catalyzing communities' move towards better governance of groundwater. We plan to follow up on the treatment vs control communities to see whether the former will also implement these rules and change their behavior regarding groundwater.

As noted in the literature review and in Fig. 1, the games can play a limited role in the overall factors affecting groundwater levels. Rainfall and recharge have a major impact, so efforts to manage recharge remain important. State policies on well spacing could contribute to demand management if they were effectively implemented. Energy and crop pricing policy also have a major role in shaping demand for groundwater. Farmers will not switch to water-saving crops if none are economically viable, particularly in the context of high costs and indebtedness of farmers (Taylor, 2013). Even within community facilitation techniques, games alone are not sufficient: they need to be accompanied by examination of local trends in groundwater and cropping patterns, and information about the water requirements, agronomic, and market information on alternative crops. This is consistent with the finding that even in classrooms, learning effects are greater when games are not an isolated activity, but are supplemented with other methods and repeated to reinforce group-based learning (Wouters et al., 2013).

The conclusion of this pilot study is that the use of resource games should be considered by practitioners as a low-cost participatory tool which could be applied—in conjunction with other measures–to strengthen collective action for shared resources. Originally, framed field experiments have provided key insights on factors that contribute to cooperation; this study indicates that they can also provide a promising tool to stimulate social learning and collective action to improve water governance. Further adaptations of the game, including randomizing recharge and allowing more crop choices, are being explored to help communities explore alternative ways to limit groundwater extraction to sustainable levels. Other games may also simulate—and stimulate—improved governance of surface irrigation systems or other natural resources.

Conflict of interest

The authors state that they have no conflict of interest related to this manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.worlddev.2018.02.006.

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