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

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A B S T R A C T

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

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

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[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).