Games for Triggering Collective Change in Natural Resource Management: A Conceptual Framework and Insights from Four Cases from India

by Thomas Falk, Wei Zhang, Ruth Meinzen-Dick, and Lara Bartels

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Thomas Falk

Wei Zhang

Ruth Meinzen-Dick

Lara Bartels

Environment and Production Technology Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Thomas Falk (t.falk@cgiar.org) is a Senior Scientist - Ecosystem Service and Natural Resources Governance in Innovation Systems for the Drylands Program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India.

Wei Zhang (w.zhang@cgiar.org) is a Senior Research Fellow in the Environment and Production Technology Division of the International Food Policy Research Institute (IFPRI), Washington, DC.

Ruth Meinzen-Dick (r.meinzen-dick@cgiar.org) is a Senior Research Fellow in IFPRI's Environment and Production Technology Division, Washington, DC.

Lara Bartels (lara.bartels@zew.de) is a junior research fellow at the ZEW – Leibniz Centre for European Economic Research, Mannheim, Germany

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ABSTRACT

As resource users interact and impose externalities onto each other, institutions are needed to coordinate resource use, create trust, and provide incentives for sustainable management. Coordinated collective action can play a key role in enabling communities to manage natural resources more sustainably. But when such collective action is not present, what can be done to foster it?

There is growing awareness that the governance of natural resources has to be adapted to the specific context. Interventions are often implemented at small scale, and the potential to scale up facilitation intensive approaches is limited. Moreover, sustainable resource management frequently fails to emerge or breaks down after the project ends.

To date, researchers have typically used behavioral games to study cooperation patterns of communities. Recently, games have been adapted as learning and stakeholder engagement tools to improve management of the commons, strengthen self-regulation of resource use, and enhance constructive interactions among resource users. Combining games with other interventions and tools and facilitated discussions has been proposed as a promising approach to improve collective action institutions through experiential learning — a classic approach in education.

This paper reviews existing literature and synthesizes lessons learned from a series of studies testing the use of behavioral games for institutional capacity development in India. We conclude that, while games alone will not be the solution to all natural resource management challenges games can provide a structured and therefore replicable approach for influencing behavior. They can also improve system understanding, raise awareness, influence norms, facilitate dialogue, train for crisis response, and increase legitimacy of decisions.

Keywords: India, water, forest, behavioral change, facilitation tools, sustainable natural resource management

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ACRONYMS

AP	Andhra Pradesh
FES	Foundation for Ecological Security
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
NGO	Non Governmental Organisation/Non Profit Organisation
NRM	Natural Resource Management
SES	Social-ecological System

1. INTRODUCTION

While a key success factor for efficient commons governance lies in resource users' intrinsic motivation and self-sustained collective governing mechanisms (Ostrom 1990), it is difficult for external actors to support these factors. The development community increasingly realizes that a more appropriate role for them to play is to facilitate and catalyze community-driven processes in seeking solutions to sustainable commons governance. This paper explores the potential of one approach: using experiential learning through games to trigger collective institutional and behavioral change. It is not a silver bullet and there is still much to be learned. However, emerging evidence on the potential of games to support behavioral change in commons management (Cárdenas and Carpenter 2008, Ducrot et al. 2015, Becu et al. 2017, Craven et al. 2017, Ferrero et al. 2018, Flood et al. 2018, Meinzen-Dick et al. 2018, Gomes et al. 2018, den Haan and van der Voort 2018, Rodela et al. 2019) merits greater attention and investment in research and pilot implementation.

There is growing awareness that, to be effective, natural resource rules have to be adapted to the specific social-ecological-technical context (Ostrom 2007 & 2009). This makes it, however, challenging for policy makers and other actors to intervene at scale. Billions of dollars have been spent on natural resource management (NRM) projects, but sustainable resource management too often does not emerge or breaks down after the project ends (Falk et al. 2019). While there are examples of successful facilitation interventions to support communities to craft locally-adapted rules, these are often implemented with limited reach and potential to scale up (Kolavalli & Kerr 2002). Participatory approaches hold promise to ensure solutions and many solution-seeking processes are thus community-driven (Pahl-Wostl and Hare 2004). The key question is how to promote such coordination, rules, and behavior in a participatory way without external imposition and in a low-cost manner that supports large-scale uptake.

Recently, the potential of games as simplified representations of reality received increasing attention (Meinzen-Dick et al. 2017). Approaches cover role-playing games (Barreteau et al. 2001, Bousquet et al. 2002) as well as behavioral games used in experimental economics (Cárdenas & Carpenter, 2008, Janssen et al., 2011a). The games emphasize critical management or interaction patterns relevant for sustainable management and allow actors to make game decision that correspond to real life decisions. We mainly refer to games that are played face-to-face with community members and leaders. Such games can function as facilitation, learning and stakeholder engagement tools (Speelman et al. 2017, den Haan and van der Voort 2018, Shelton et al. 2018). They can support communities to learn about, discuss and explore complexity of social-ecological systems, to empower communities, to strengthen self-regulation of resource use and to enhance constructive interaction of resource users (Speelman et al. 2017, Flood et al. 2018, Shelton et al. 2018, Meinzen-Dick et al. 2018). Cardenas and Carpenter (2008) noted that these types of games can be used as tools to stimulate collective action as they provide participants

with useful metaphors for their daily lives (Meinzen-Dick et al., 2018). An emerging body of literature explores the use of games as an intervention tool to address NRM and sustainability issues (Ducrot et al., 2015; Becu et al., 2017; Craven et al., 2017; Ferrero et al., 2018; Meinzen-Dick et al., 2018), especially their contribution to social and experiential learning.

However, as games gain increasing attention as an intervention tool, there is a danger of designing game-based interventions on the basis of simple and unclear assumptions about human behavior. So far, game-facilitated learning has mainly been assessed on the basis of single case studies (Speelman et al. 2017, Shelton et al. 2018). Den Haan and van der Voort (2018)'s systematic review of 42 publications find that most evaluations of collaborative games focus on assessing cognitive learning, which relates to the acquisition of new or the restructuring of existing knowledge. They found less attention to normative or relational learning (see Baird et al. 2014), which are important for triggering behavioral change. Theories of change are developed making assumptions about causal relationships and formulating expectations about how interventions lead to system changes (Wigboldus & Brouwers 2016). However, the assumptions about human behavior are often simplistic (Levine et al. 2015, World Bank 2015, Schlüter et al. 2017, Michie et al. 2011). Clearer assumptions could help assessing why interventions work or fail, and identify effective ways to influence behavior change (Michie et al. 2008; Davis et al. 2015). Research for development has the explicit objective to contribute to real-life change. For innovations to become relevant at large scale it is therefore essential to communicate to direct participants, development agents (such as extension officers and NGO staff) and donors which returns can be expected from investing in using them (Wilson et al., 2008).

This paper synthesizes the lessons learned from four studies and draws from a literature review to better understand to what extent the experiential learning through games can contribute to behavioral change. Embedding the synthesis into a multi-disciplinary concept of behavioral change helps account for the complexity of human behavior (Schlüter et al. 2017) and to identify how games can trigger change. The next section of the paper presents a conceptual framework of behavior and decision making. We then apply the framework to game-facilitated experiential learning for triggering NRM change in South Asia (Meinzen-Dick et al. 2018, Falk et al. 2019). We then discuss methodological and operational implications which can help making games more effective, efficient, and scalable instruments to trigger behavioral change towards sustainable NRM.

2. CONCEPTUAL FRAMEWORK OF BEHAVIOR AND DECISION MAKING IN NRM

Key concepts and assumptions

Using games as development interventions is based on the assumption that game approaches influence triggers for behavioral change, which eventually contributes to improved social-ecological system outcomes.

This section presents a conceptual framework of behavior and decision making that will help to better understand the role games can play in triggering such change (Figure 2.1). The framework integrates diverse theories and concepts and will clarify our assumptions about behavior. It is beyond the scope of this paper to synthesize and integrate the massive research on human behavior in multiple disciplines. At the same time, debate about underlying assumptions are urgently needed in sustainability and development research, policy, and design of interventions (Meyfroidt 2013, Levine et al. 2015, Davis et al. 2015, World Bank 2015, Schlüter et al. 2017).

The framework is based on methodological individualism, which states that social interactions can be explained as the result of individual actions (Weber 1922). The framework therefore takes the perspective of an individual decision maker and elaborates how this decision maker's actions interact with other actors.

The framework focuses on three types of actions that are particularly important for NRM: *provisioning* or *enhancing* actions, where people support the creation, maintenance, and improvement of resources; and *appropriation* actions, where people subtract from available resources (Hinkel et al. 2015, Costanza et al. 2017; Falk et al. 2018). In addition, sustainable NRM requires *coordination* between individual actions. Such coordination processes entail costly efforts related to establishing, running, enforcing, changing and abolishing institutions (Ostrom 1990, North 1990). We call these efforts *institutional services* (Falk 2008). It is important to recognize that different actors do not only have needs, but also valuable assets that can help to provide institutional services efficiently (Moseley 2004). The provision of institutional services often creates second order social dilemmas. For instance, it is difficult to exclude anybody from the benefits of an effectively enforced rule even if a particular person does not contribute to the enforcement efforts (Falk 2008).

Components of the framework

The framework consists of an outer and inner parts (Figure 2.1). The outer part represents the Social, Economic, Political and Ecological settings in which the social-ecological system operates; what is considered internal and external to the system is typically fuzzy and depends on how system boundaries are defined. The framework takes into account that context influences which institutional (Cox 2012,

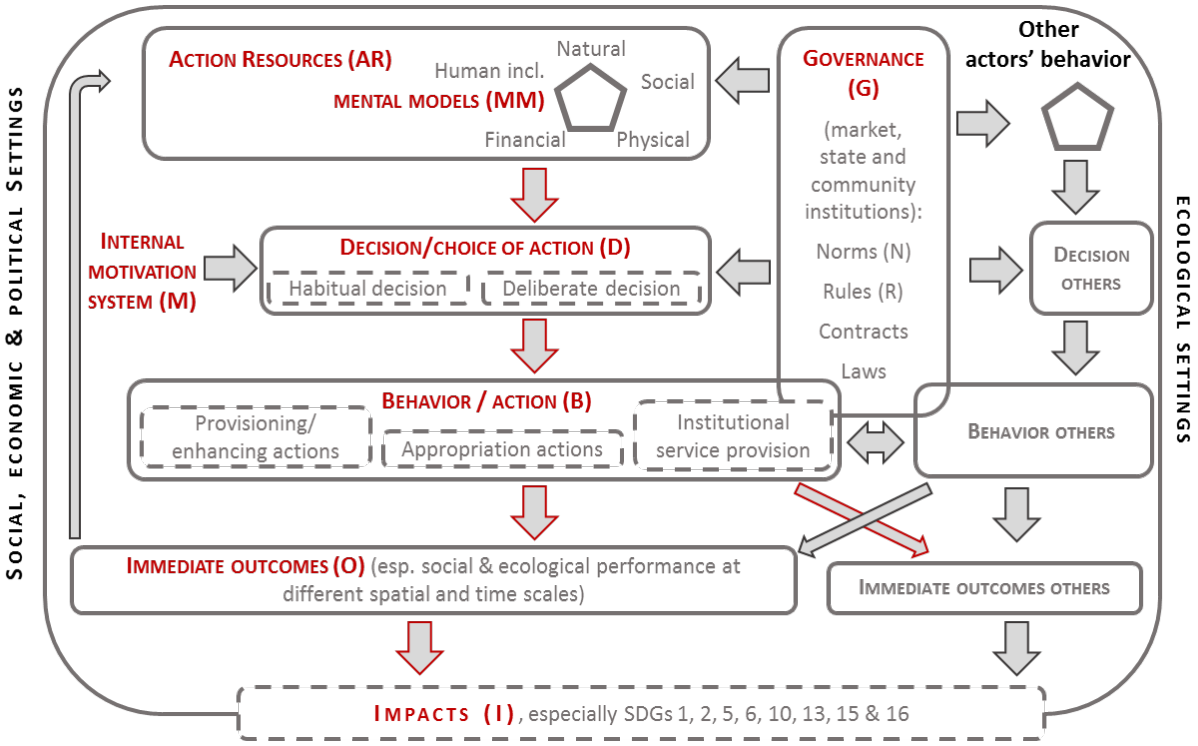
Ostrom 2009) and technological fit (Wigboldus et al. 2016) is likely to produce ecologically and socially desirable outcomes.

The inner part of our conceptual framework contains factors such as an actors' action resources and motivation as well as the governance system. It further replicates the decision-making structure of other unspecific actors to symbolize interactions. The main path of the framework is illustrated on the left side of the inner part of Figure 2.1 with the following steps: 1) Action resources and mental models, 2) Mode of decision making, 3) Behavior or action, 4) Outcomes, and 5) Impacts.

An actor starts with certain mental models and action resources (Di Gregorio et al. 2012), which are endowments conceptualized as the five capital categories of the Sustainable Livelihoods Framework: natural, physical, human, financial and social capital (Ellis 2000). These shape the set of behavioral options of the actor and offer a potential trigger for behavioral change. It is important to emphasize that there are strong linkages between the capital categories. New behavioral options required specific endowment combinations.

With regard to human capital, we emphasize the importance of mental maps or models, which refer to actors' internal representations of prototypical situations (Meyfroidt 2013, Levine et al. 2015, World Bank 2015). Mental models include perceptions about ecological and technical components of the social-ecological system (SES) as well as the perception about the constellation of stakeholders, their perspectives, resources, motives, and roles in the governance framework (Shelton et al. 2018), strongly influence which information an actor takes into account in her decision-making and thus people's behavior (Meyfroidt 2013). Systemic modifications of mental models - such as through games -can trigger behavioral change (Holm-Hadulla et al. 2011).

Figure 2.1: Conceptual framework of behavior and decision making in NRM



Source: Authors.

In the critical step of deciding on the path of action, decision making involves habitual, emotional, and deliberate processes (Kahneman 2003, Graybiel, 2008, Michie et al. 2011, Schlüter et al. 2017). The vast majority of actions are habitual (World Bank 2015; Lerner et al. 2015), are performed virtually unconsciously (Graybiel, 2008) based on default assumptions/mental models (Lerner et al. 2015; Levine et al. 2015, World Bank 2015), and therefore require little effort (Kahneman 2003). Most habits are learned. Once an action has led to desirable outcomes, it is repeated even if the actual outcomes change – until a threshold is reached that provokes a deliberative decision (Graybiel 2008, Levine et al. 2015).

In the deliberation process, a person consciously defines preferences that relate to their perception of likely outcomes and the relative strength of their desires for outcomes (Vroom 1964, Searle 2003). This process involves more time and costs. The framework conceptualizes outcomes as needs (see Maslow 1987 and Max-Neef 1991 for examples of classification of needs) and the deliberation therefore intends to optimize need satisfaction (Frey & Stutzer 2002). Making the diversity of motivations explicit is helpful for understanding human behavior. Preferences and motivation structures adapt through social processes (Gintis 2007), depending on the decision making context (World Bank 2015). We assume a path dependency in dynamic preferences and needs that helps to create expectations about people's behavior.

The most intuitive motivations are physiological needs, which refer to the maintenance of physical health (Maslow 1987). Closely related are safety needs that also strive to stabilize decision-making situations. Without going into detail, we relate the concept of risk preferences (Arrow 1965) to safety needs. In addition, the satisfaction of needs for love, affection, belongingness, and esteem are extremely important for human beings. An important factor in satisfying the need for belongingness is identification with a reference group that shares symbols, customs, norms and values (Maslow 1987, Max-Neef 1991). This indicates a strong link to the norm dimension of the governance framework discussed below. Esteem needs include the desire for status, honour, reputation, respect, prestige, approval, recognition, attention and appreciation (Bentham 1789, Becker 1974, Maslow 1987, Max-Neef 1991, Searle 2003, Frey & Stutzer 2002). They are both a drive in themselves and instrumental in pursuing other needs. People act in socially approved ways to increase their status, which eventually improves their endowments in the future (Griskevicius et al. 2010, Van Vugt et al. 2014). Furthermore, human beings also have many other needs or motivations such as the desire for dignity, pride, self-esteem, self-respect, meaning, regret, strength, achievement, confidence and self-actualisation (Mill 1895, Williamson 1984, Maslow 1987, Max-Neef et al. 1991, Searle 2001: 120, Frey & Stutzer 2002).

Enhancing, appropriation, and institutional service provision actions are of special importance in the context of NRM as they lead to immediate outcomes. The most direct outcomes are the satisfaction of aforementioned needs. Another common outcome of actions is a change in any kind of action resources including the condition of natural resources. The experienced need satisfaction can potentially change mental models (Meyfroidt 2013). The latter outcomes are symbolized by the very left upward arrow in Figure 2.1. In addition, the different outcomes of past actions can contribute to the formation of new habits (Schlüter et al. 2017).

We acknowledge the importance of the point in time when outcomes occur. Generally, people prefer immediate over delayed benefits (Van Vugt et al. 2014). They discount outcomes enjoyed in the future (Samuelson 1937). This phenomenon has an effect in the decision making (Figure 2.1 Box 2) and is a challenge for sustainable NRM which has a long-term perspective.

The framework further emphasizes interactions with other actors. Frequently, NRM actions influence other people's experienced outcomes. There are often incentives to free ride on the enhancing actions of others. Further, there are incentives to overharvest if the resource is non-excludable and rivalrous. In many cases, actors struggle to sense the impact of their actions on themselves and others at different spatial and temporal scales (Van Vugt et al. 2014). In addition, people's appreciation of outcomes strongly depends on reference points (Kahneman 2003) and one such reference point is the outcomes experienced by others. There is evidence that people value a received benefit much higher if their reference group received less; in other words, the difference between own outcomes compared to the

outcomes of others affects people's behavior more than absolute outcomes (Fehr & Schmidt 1999, Van Vugt et al. 2014). The path on the right-hand side of the inner framework illustrates these inter-personal interactions (Figure 2.1). Expectations of these interactions are an essential part of people's mental models (World Bank 2015).

Interactions between actors commonly create undesirable outcomes on the societal level and the possibility of positive gains from collaboration. This creates the need for coordination that can be achieved through effective governance: the combined societal processes organising the appropriation of natural resources, actions enhancing the resilience and productivity of the resource base, and actions providing institutional services (inspired by Ostrom 2009, Woodhill 2010, Loft et al. 2015). Consequences related to governance can redirect decisions. Governance can influence decision making, in particular through impact on the capital availability and need satisfaction. One distinguishes between hierarchical, market and self-organisation as alternative coordination mechanisms. Each mechanism has advantages and disadvantages depending on the context. Which institution fits a particular context depends for instance on the subtractability and excludability of action resources and outcomes.

Actors are not only passive recipients of governance. They provide institutional services starting with negotiating and discussing with others. Jointly coming to agreements forms the basis for context-adapted institutions to be formed (Pahl-Wostl et al. 2007). The common ownership and acceptance of such institutions reduces monitoring and enforcement costs. Coming to agreements requires collecting diverse information and reflecting on various stakeholders' perspectives (Stringer et al. 2006). Initiating such social innovation as a powerful trigger to initiate behavioral change at scale (Wigboldus & Brouwers 2016).

3. DESCRIPTION OF THE CASES

We illustrate the application of our conceptual framework with four studies on learning games in India: 1) a public good game with a groundwater management framing in Andhra Pradesh, 2) a public good game with a surface water framing in Rajasthan, 3) a common pool resource game with a surface water framing in Madhya Pradesh, and 4) a common pool resource game with a forestry framing in Rajasthan and Andhra Pradesh. All four studies were conducted by the International Food Policy Research Institute (IFPRI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with the Foundation for Ecological Security (FES), an Indian NGO devoted to working with local communities to conserve forest, land, and water resources, while improving the lives of people. In this paper we will not describe in detail the results of the games. Interested readers are referred to previous publications of the games as provided below. Using the conceptual framework as a guiding structure for discussion, the focus of the reflection section below is on summarizing the lessons learned regarding games triggering behavioral change.

The first study is a framed public good field experiment conducted in 17 communities in rural Andhra Pradesh. It simulated crop choice and groundwater levels. Crop choices determine the required amount of irrigation water, which constitutes the largest share of India's water consumption. The games were conducted twice in the same communities (in 2013 and 2014). In each community, the local watershed association was asked to invite a group of five men and five women from households using groundwater to participate. Each group began with 50 units of groundwater. In each game round, players were asked to choose between a more profitable but more water consuming crop and a less profitable but more water efficient crop. At the end of each round, the total water consumption was announced. Then, a fixed amount of 5 units recharge was given and the new water table level was announced for the start of the second round. The game was repeated for up to 10 rounds without communication and a further 10 rounds with communication. If the water table went below 10 units, the game was over. Games were followed by debriefing sessions where general observations and implications of the game for the real groundwater management were discussed. The communities were monitored afterwards in terms of changes in their rule formulation. In half of the communities incentivized payments were made – as are common in economic experiments. The other half of the sites received lump sums paid to community funds. Details on this study can be found in Meinzen-Dick et al. (2016 and 2018).

The second study was conducted in south-eastern Rajasthan. The area has a dry climate with large variations of temperature and rainfall. To ensure relevance, the design of the game was based on focus group discussions and FES' expert advice. The village dam management challenges of Rajasthan farmers was replicated by a framed public good experiment where players had to jointly invest in a virtual dam. At the beginning of each game round, players received an initial endowment. The players decided

simultaneously which share of this endowment they wanted to invest. The total of all individual contributions determined the group earning based on a non-linear pay-off function similar to the one in the irrigation games of Cardenas et al. (2008) and Janssen et al. (2011a & b). The group earning was distributed equally among the players (Falk et al. 2019). The pay-off matrix was adjusted to estimates of average maintenance costs of dams as well the typical income derived from dam water based on evaluations done by Singh et al. (2014). All players received incentivized payments. The game was played over five rounds with hidden decisions and without communication. In rounds six to ten the players had the chance to discuss with each other. In the last five rounds a game variation with some changes in the rule was introduced depending on what issues were raised by the players in the previous discussions. Between February and March 2016, 30 randomly selected villages were visited and the games were conducted. To observe any impact of the games, seven out of 30 sites were revisited in December 2017 and the games were played again (for details see Falk et al. 2019).

In the third study, a common pool resource game was used to simulate key aspects of rainwater harvesting for irrigation purposes in Madhya Pradesh. Again, the design and framing was developed based on expert interviews and advice from FES staff. The game includes the challenge of jointly maintaining minor irrigation infrastructure and deciding on the allocation of the available water. It was designed similar to other irrigation games, including a non-linear pay-off function and asymmetric access to the irrigation system (Janssen et al., 2011a; Cárdenas et al., 2008). In half of the communities incentivized payments were made; the other half received lump sums paid to community funds. The game was played over ten rounds. Rounds one to five were played with hidden decisions and without communication. In rounds six to ten the players had the chance to discuss with each other. In April and May 2017, the game was played in 60 rural communities with farmers who live close to a water harvesting structure. The game study was complemented by a baseline and follow up survey of the participating communities as well as 50 control communities to assess the impact of the games (Bartels et al. 2019).

The fourth study was a common pool resource game framed around community forestry management, adapted from Janssen et al. (2013). The game was conducted in 60 habitations in Andhra Pradesh and Rajasthan between 2017 and 2018. In each habitation, two game sessions were carried out, one for men and one for women, with five players in each group. Within each game session, participants played three sets of games: non-communication (6 rounds), communication (7 rounds), and optional election of monitoring and sanction rules (7 rounds), without pre-announcing how many rounds per set would be played. Additionally, two game-level treatments were randomly assigned across habitations: a) performance-based cash payment made to individual participants vs. flat payment to the community; b) simple white game board vs. a color board that ties resource level to ecosystem services. A subsequent

community-wide debriefing meeting was held at each habitation after the games to reflect on the game experience and how the experience relates to the real situations in the community. Participants could share perceptions about the role of forest in people's lives and discuss ideas for improving forest management (Zhang et al. 2019).

Application of conceptual framework on experimental social learning

The presented conceptual framework ignited a creative exchange amongst the authors about different features of the four experimental learning intervention. In particular four aspects were discussed and the following section will summarize the reflection. The acronyms introduced in Figure 2.1 will be used to highlight references to the above described concepts. The four aspects are:

1. Accuracy, complexity, and flexibility of the game framing.
2. Multi-player environment, communication, and group competition.
3. Participatory learning environments.
4. Incentivized payments.

The reflections will lead to conclusions regarding how games can be designed to effectively trigger behavioral change. They will clarify more specific underlying assumptions in relation to the impact pathway. Eventually, this will facilitate assessments of intended and potentially harmful impacts, as well as conditions for realizing impacts.

Accuracy, complexity, and flexibility of the game framing

The authors made conscious framing choices in the four different studies. Positive learning impacts (MM) require that players can relate the gaming situation to a similar situation outside of the game (Medema *et al.,* 2015). The simplified framing of a game can make it easier for participants to understand the link between actions (B) and consequences (O). Many actions have delayed effects that makes it difficult for actors to see causal relations. Similarly, consequences on third parties or ecological processes are often simply not seen, such as the effects of cropping choice and individual water abstraction on groundwater levels (Meinzen-Dick et al. 2018). The compressed nature of the games can help to create awareness for such outcomes at different temporal and spatial scales (Flood et al. 2018). Most learning games are played over multiple rounds. Action-outcome relations in NRM typically take place over long time periods and large spatial scales. The games therefore allow experimentation with immediate feedbacks in a compressed time.

As noted above, three categories of action are particularly relevant for NRM: enhancing and appropriation actions as well as institutional service provision (B). Identifying the specific behavior to be changed and therefore simulated in the game design requires a good understanding of the real NRM challenges and related behavior. For instance, the Madhya Pradesh surface water game was only played in

communities that actually managed village dams. Yet in the implementation we noticed sometimes only too late that the communities where the game was played did not use the dam for irrigation as featured in the game but only for domestic purposes, livestock or fish keeping (M). As a consequence, additional attention had to be paid to site selection.

Learning games will always be a simplification but they can illustrate system dynamics and causal links (Speelman et al. 2017). Especially in cases when resource managers unintendedly harm themselves or others even though there are actually no conflicts between individual and group incentives, better system understanding can change beliefs (MM) and eventually behavior (D). A critical challenge in game design for achieving this is identifying the appropriate degree of *complexity in the framing* (Flood et al. 2018).

There is a trade-off between simplicity and relatability or specificity of the game. Games that target specific beliefs (MM) can be kept relatively simple. Also, if the purpose of the game is to support learning of a more universal behavioral aspect – such as that in social dilemmas cooperation improves group outcomes – the game does not require much complexity. The advantage of simple games is that they are typically easier to facilitate, simple to understand for the players and that they can be adapted into modules or building blocks of games and applied in heterogeneous NRM situations. Following this logic, the AP groundwater game created awareness of casual relations between crop choices and hydrological dynamics, and therefore simplified the many factors affecting the linkages between local actions on groundwater levels.

The disadvantage is that simple games may not adequately capture the complexity of social-ecological systems (MM), if understanding the complexity is critical to learning and behavioral change. Especially in the groundwater and forest games, players questioned the rules and parameters in the game, requesting more system accuracy and complexity to be embedded in the game. The facilitation teams responded to some of these requests. For instance, many groundwater game participants found the constant water recharge level to be unrealistic, as rainfall and recharge fluctuate between years. Thus, subsequent variations of the groundwater game as an intervention allow for randomizing the amount of recharge based on the roll of the dice (Meinzen-Dick et al. 2017). Both surface water games used a more context-specific framing. The pay-offs were adjusted to typical values of the region. As a consequence the relation between game action and game outcomes was more similar to the relation of real-life action (B) and real-life outcomes (O).

Combining behavioral game features with system simulation models is one approach that has been used to capture a greater social-ecological system complexity (Barreteau et al. 2001, Sterman 2006, Rajabu 2007, Scholz et al. 2014, Lohmann et al. 2014, Falk et al. 2016, Speelman et al. 2017, Meinzen-Dick et al. 2018). Such games more realistically simulate coordination challenges and can more directly

facilitate negotiations and institutional change (G). The more intensive consideration of socio-political complexity creates stronger relevance for public policies (Gomes *et al.,* 2018).

One disadvantage of more complex games is that they often require more time to be played (Flood et al. 2018). A game needs to be long enough to create a memorable experience and short enough to respect participant's time constraints. The groundwater game found that women were particularly time constrained and in some cases depleted the groundwater faster so they could end the game. Finding appropriate timings for women to play the game reduced this problem in the second round of groundwater games. As another disadvantage, more complex and tailor-made games are applicable only to a limited geographic context (Speelman et al. 2017) and they are often more difficult to run (Flood et al. 2018) requiring additional capacity of facilitators. Facilitation intensity limits scalability of most participatory approaches (Flood et al. 2018) because of the limited number of strong facilitators (Kolavalli & Kerr 2002). In the case of the Madhya Pradesh surface water game we increased the likelihood NGO field staff and government extension officers use the game tools by developing a mobile application that guides the facilitator through the different steps of the game.

Flexible designs are another way of addressing connectability of the game experience to real world, and geographical applicability of a game. Flexible game design approaches have been demonstrated e.g. by Lohman et al. (2014) and Falk et al. (2016). In their game, the framing was adjusted to the real life situation (e.g. land and herd size) of players (AR). In the AP groundwater game, participatory design elements were added by offering alternative framings for water extraction decisions, and variable groundwater recharge. In the Rajasthan surface water and the forest games, game variations such as subsidies, the possibility to punish, or unequal benefit sharing were optionally played (G). Depending on what players discussed, the facilitator would introduce one of the variations. This process helped the players to discuss and understand particular aspects of the management and coordination challenges, and made them feel that their specific demands are addressed.

Multi-player environment, communication, and group competition

The major difficulty in understanding wicked NRM challenges is often not the bio-physical complexity but the social system complexity with actors' conflicting agendas, power relations and beliefs (Pahl-Wostl et al. 2008, Speelman et al. 2017, Schlüter et al. 2017, O'Keeffe 2018). This is one reason why most learning games are designed as multiplayer games that have a social learning dimension where players share concepts and eventually harmonise their mental models (MM). Multiple studies have shown that social interaction in games improves cooperation (Ostrom 2005, Balliet 2010) (B). Social interaction and learning are fruitful complements to formal presentations of abstract knowledge that are common in many forms of teaching (Pahl-Wostl and Hare 2004, Flood et al. 2018). It activates people's deeply rooted impulses of curiosity, to wonder, to know, to explain, and to understand (Maslow 1987, Max-Neef 1991).

The interaction allows players to receive signals about other's willingness to cooperate, creates a group identity, supports developing shared norms and allows to coordinate (Balliet 2010) (G). Furthermore, many local level NRM decisions are made under observation of neighbors. In such situations, allowing communication and disclosing decisions often creates a stronger link between the game and real-life experiences (Meinzen-Dick et al. 2016).

Our studies confirm the positive effect of communication. The chance to communicate and debriefing session were implemented in all our games. At the beginning of the games we used the common practice in behavioral economics to prevent players from talking and asking them to make decisions in private. The learning expressed in changing game behavior is much slower in these early game rounds than when discussion was permitted in later rounds (e.g. observed in our Madhya Pradesh game, Bartels et al. 2019). We observe that game rounds without communication are more stressful for the players, although they do increase the appreciation for the importance of communication when it is allowed. One purpose of the games is to create a joyful learning environment. Both players and bystanders laughed and enjoyed our games when communication was allowed. An entertaining environment that motivates listening may have additional positive effect on social learning (Hertzog et al. 2014, Speelman et al. 2017, Max-Neef et al. 1991).

Recognizing constraints for women to speak freely in front of men in the Indian contexts where our games were played, we segregated the games into all-male and all-female groups so that women would feel comfortable during the games. We then brought men and women together for the community debriefing. Even there, it was more effective if we conducted small group discussions among women and men, then had representatives of those groups raise points in the larger group.

The combination of playing the games over multiple rounds and encouraging discussions provokes deliberation processes (D). While baseline assessments in our study indicated that there are habits of not making sufficient efforts to manage resources sustainably, the players connected the game to their real life experiences and discussed the need to change behavior. Players in all three water games expressed that they were not aware of how their actions interact with other community members (O), but the game helped them to better understand such interactions and motivated them to deliberate on alternative management (B). The games allow to go even a step further. The artificial space allows to test new strategies (Speelman et al. 2017). And if games are designed in a way that players have a chance to jointly find better strategies, new habits can be created. Positive and negative experiences regarding the outcomes of actions contribute a) to the formation of new habits (D) (Schlüter et al. 2017), b) internalised norms, c) socially sanctioned norms based on others' (dis-)approval, as well as d) more conventionally enforced rules, laws and contracts based mainly on material enforcement mechanisms (G) (Falk et al. 2012).

The critical challenge is to find game designs that steer actors toward improved and sustained welfare while also allowing them to make their own choices (Thaler and Sunstein 2003; Sunstein 2018). Conversely, negative game experiences can support undesirable habits and actually do harm. Pro-social experiences are therefore important in social learning games. This should not be misunderstood as manipulating the players. Yet, the learning environment should allow them to find solutions especially in situations where they can at least theoretically talk and coordinate with each other.

One entry point for changing institutions are revisions of mental models (MM). Increasing awareness of interactions between different players' actions is of special importance. Given the common pool resource or public good character of many natural resources, individual incentives in their management are often in conflict with group interests (Ostrom 1990). By increasing awareness of social dilemmas, games can help connect specific behaviour to deeply rooted fairness values and in this way mobilise or create more specific internalised norms (G). In addition, games can support changing expectations about the behavior of others as parts of mental models. Positive game experiences can create trust required for fruitful collaboration (Hertzog et al. 2014, Meinzen-Dick et al. 2016). The water games had an effect on mental models because they helped participants to see connections that had not been apparent. By contrast, the forestry game used a social dilemma related to cutting trees, which most communities already recognized as having negative consequences, and had developed rules against tree felling.

Typically researchers try to avoid causing conflicts. Yet a game could surface a hidden smoldering conflict (Shelton et al. 2018) and in this way contribute to questioning current practices (Hertzog et al. 2014) and resolving it in a way that leads to more sustainable NRM (O) (Rajabu 2007, Flood et al. 2018). The participatory character of the games allows stakeholders to learn about each other's perspectives (MM). Even if no solution is found, games can reveal others' strategies and divergent opinions concerning the problem (Scholz et al. 2014, Hertzog et al. 2014). At the same time, better coordinated actions can certainly also lead to harmful outcomes (Shelton et al. 2018). And by far not every conflict is fruitful. An important conclusion of the Do No Harm concept is that facilitators need to make efforts to predict potential impacts of interventions. This requires understanding the setting of potential conflicts as the interventions can unintendedly affect the setting in negative ways (Anderson 2004).

Learning games can make use of another social interaction phenomenon. Within-group social dilemmas can be mitigated by between-group competition (Darwin 1871, Wilson 1975, Traulsen & Nowak 2006, Waring 2010, Van Vugt et al. 2014). The between-group competition aligns individual and group interests (M). It is therefore critical to take into account how and at what scale people develop group identities. Games can strengthen or form new identities (Pahl-Wostl et al. 2007). People sharing a

common identity more strongly take the outcomes of other group members into account (Waring 2010) that supports pro-social norms. In the Madhya Pradesh water game, we experimented with two groups playing simultaneously and observing each other. We saw that this was an additional motivation for positive learning. The between group competition strengthened within group cooperation and made use of the reference points effects of human reasoning (Bartels et al. 2019, Bornstein *et al.,* 2002; Gunnthorsdottir and Rapoport, 2006; Tan and Bolle, 2007).

Participatory learning environments

Games offer a space for learning by experiencing, reflecting and experimenting in contrast to conventional one-way teaching or costly learning by doing in real life (Barreteau et al. 2001, Hertzog et al. 2014, Meinzen-Dick et al. 2018, Shelton et al. 2018). They create a relatively safe forum for a joint (self-)reflective inventing and negotiating of own rules including enforcement mechanisms (G) (Woodhill 2010, Hertzog et al. 2014, Speelman et al. 2017, Flood et al. 2018, Shelton et al. 2018, Meinzen-Dick et al. 2018).

This is in contrast to approaches where facilitators impose rules that theoretically should improve the performance of groups. There is multiple evidence where this did not lead to better performance (Ostrom et al., 1992, Cárdenas et al. 2000, Vollan 2008, Falk et al. 2012, Traulsen et al. 2012, Janssen et al. 2013). Vollan (2008) found that people's support to new regulations positively affects their compliance. If players agree on a rule in the game it becomes easier to transfer this rule into real life. New rules can thereby gain additional legitimacy, which later on reduces costs of enforcement (Falk et al. 2012). Games can support the identification of locally adapted solutions and improve participants' feeling of ownership of the solution. A strong motivation for developing the NRM games has been to support adapted governance and institutional fit (G), which is needed given that, in our sessions, even at small geographical scale different communities propose different rules.

Related is that games provide an informal space where actors can leave entrenched positions (Pahl-Wostl et al. 2007). In the game space, power constellations may be less prominent, which can help bring the voices of different sub-groups to the table (AR). This can go as far as using games as a conflict resolution tool (Rajabu 2007). Many farmers feel powerless in changing governance (B, G). The game can create stronger confidence that they are able to address the challenges and that rules can show effects. It can also create a belief that the player has a responsibility to act (Schwartz 1977). In cases when players encounter positive impacts of simulations of laws or markets in the game, this experience can strengthen their confidence in the respective institution well as their capacity and willingness to invest in rules, policies or market opportunities (Pahl-Wostl et al. 2007, Wigboldus et al. 2016) (B).

A challenge we experienced in participatory processes is the temptation of game facilitators to hint, give advice or ask suggestive questions. While this is a way to include expert knowledge into the

discussion, it often creates a feeling amongst participants of being seen as deficient and pressured to give an answer they do not really support. Often, people do not like outsiders teaching them, unasked. In the MP surface water game we complemented the games with open questions based on NRM and governance theories and concepts to make participants think and discuss critical aspects of the problems. Open ended questions make people think, activate also the emotional dimension of the decision situation, and create a connection between participants and the facilitation team. They can motivate the players to ask their own questions which can again be given back to the group. Sensitive probing can then still be helpful when responses of participants are packaged into new open-ended questions to deepen the conversation and to relate the game experience more strongly to real life challenges. Consequently, unlocking the games' participatory institutional change potential requires non-prescriptive facilitation (Shelton et al. 2018). Well trained facilitators who can flexibly react to group dynamics can strongly support the creation of a creative group learning exercise beyond established power relations (Flood et al. 2018). Having the patience to let participants find their own solution is a pedagogical skill that needs to be learned by facilitators, who are often used to more conventional teaching (Meinzen-Dick et al. 2018). This required special capacity development efforts in all four game interventions.

Incentivized payments.

The authors experimented with different game features and remunerations depending on choices and group outcomes deserve special attention. Respondents are thought to reflect their choices more carefully and consider trade-offs under their actual preferences (M) when expecting incentivized payments (Mørkbak et al., 2014). There is neuroscientific evidence that monetary rewards activate the brain area that is important for deliberative action choices (Zink et al. 2004, Graybiel 2008). Incentivized payments, in some cases, would accordingly support a shift from a habitual to a deliberative behavioral mode (D). Nevertheless, NGOs and other development agents are reluctant to distribute unequal monetary rewards. Some experimentalists - mainly in psychology - argue that more intrinsic motivations are strong enough to reveal people's behavioral patterns (Smith and Walker 1993, Meinzen-Dick et al. 2018, Bartels et al. 2019).

In Madhya Pradesh, communities that played the surface water game with incentivized payments were significantly more likely to engage in dam maintenance activities after the game was played compared to a control group (Bartels et al. 2019). In the community forestry game, incentivized payments lowered harvest for both men and women groups in Andhra Pradesh and men group in Rajasthan, suggesting a possible "crowding-in" effect on pro-social behavior. In the Andhra Pradesh groundwater game, no effect of the payment methods could be found (Meinzen-Dick et al. 2018)

5. CONCLUSIONS AND IMPLICATIONS

The reflections on the four game studies using the structure of our framework lead us to a number of conclusions. The games provide a structured and therefore replicable approach for influencing behavior. They can improve system understanding, raise awareness, influence norms, facilitate dialogue, train for crisis response, and increase legitimacy of decisions. Noteworthy is the possible societal spill over effect of institutional services resulting from NRM interventions on the governance of other shared resources. As a consequence, games can be a cheaper and faster - while still effective - instrument for facilitating behavioral changes, compared to other more continuous participatory approaches (Meinzen-Dick et al. 2018). Their strength lies in facilitating bottom-up processes, something that still challenges government and civil society development agents to do at large scale.

We acknowledge that games alone will not be the solution to all NRM challenges (Meinzen-Dick et al. 2018). Social learning and institutional innovation is more likely to occur in repeated interactions and in combination with other interventions such as Focus Group Discussions and participatory water planning tools (Kolavalli & Kerr 2002, Stringer et al. 2006, Woodhill 2010, Flood et al. 2018, Meinzen-Dick et al. 2018). The scaling challenge is therefore to develop effective and efficient intervention packages – potentially containing games as one element (Meinzen-Dick et al. 2018). Decades of research on institutions came to the conclusion that rules need to fit to the context (Ostrom 2007, Cox 2012). The games are an approach to trigger institutional change in a way that institutions will be adapted to specific context conditions at large scale. The key challenge in meaningfully contributing to behavioral change using games lies in designing and using the right game for the right purpose. Games thereby need to fit a) to a critical NRM challenge to be addressed, b) to the right trigger for behavioral change, and c) to the capacity of the change facilitators.

Which actions/behavior to change?

It is important to be conscious about what kind of behaviour one wants to change. In the NRM context, games can influence provisioning, appropriation and institutional service provision actions. Keeping these categories in mind, change facilitators need to be aware which specific actions require attention. Questions to be asked are: What shared resources need to be better managed? At what scale do social dilemmas occur? Who has an interest in and the power to changing the specific actions? Which actions are perceived to be of high relevance by actors? Too often communities are addressed by interventions that are perceived to be important by outsiders only, not taking the specific context into account. Finding interventions that address the specific NRM challenges is a serious challenge for change facilitators.

Which triggers can change behavior?

NRM interventions to be scaled need to correspond to an articulated scaling strategy (Wigboldus & Brouwers 2016, Wigboldus et al. 2016). In the context of our framework this means that change facilitators need to identify the most potent triggers for changing behavior. This requires to also to analyze the action resources, motives, norms and rules, and modes of decision making of stakeholders who have the power to change the targeted NRM. Such an assessment then allows to identify which tools can best trigger which entry point for transformational and/or evolutionary behavioral change. Clarity on which actor is targeted using which trigger determines how a game should be designed in terms of the different design aspects discussed above. This clarity is also important to avoid unintended changes. It is easy to design a game which provokes uncooperative behaviours.

What is the capacity of the change facilitators?

Intervention tools like games need to fit the time, experience, and resource constraints of change facilitators (Meinzen-Dick *et al.,* 2018). This includes respecting common practices of change facilitators such as reluctance of NGOs to make individual payments to intervention participants (Meinzen-Dick et al. 2018). Game designs can respond to capacity constraints, including use of digital technologies such as mobile apps.

Assessing impacts

Claims that the right intervention was used for the right purpose need to be testable. Measuring the impact of games is still under-researched (Speelman et al. 2017, Shelton et al. 2018). This is not a trivial task. Interventions related to natural resource governance require a complexity to be effective, which makes it difficult to measure their impact with acceptable validity (Deyle & Slotterback 2009, Flood et al. 2018). When introducing a new irrigation technology or an insurance instrument, everyone immediately understands which impact this can create. Mental model shifts and changes in NRM are a much fuzzier field (Woodhill 2010). Measurable impacts are typically indirect and happen over long time frames. Assessing governance changes requires higher units of analysis (e.g. communities, rather than individuals), making it difficult to get sufficient sample sizes for statistical significance. This is one reason why donors and governments often focus on technical water management solutions (Pahl-Wostl et al. 2008) rather than addressing governance challenges.

The conceptual framework presented in this paper can provide a structure for such impact assessments. It is worth considering a stepwise approach: measuring indicators for changes in knowledge and institutions, changes in behavior and, finally, changes in actual social and ecological outcomes. Many impact assessment approaches for social learning interventions are limited to assessing changes to knowledge. In particular biophysical assessments are a challenge (Shelton et al. 2018). Advances in

remote sensing could potentially offer new low-cost opportunities. A challenge for rigorous impact assessments is that random sampling can be in conflict with the objective to target the ones who need the intervention most, express the strongest demand, and who are expected to change a specific behavior. Self-section is a powerful supporting factor for change.

The way forward

Acknowledging the diversity of intervention tools developed, we conclude that there is a critical need to guide practitioners in selecting the right tools for the right purpose. This calls for developing a support tool for selecting intervention instruments.

Combining the conceptual thinking of scientists with the applied and context knowledge of NGOs and government partners was essential in the development of all four described games. The integration of various bodies of knowledge, perspectives and approaches co-produces socially robust, context-specific, relevant and holistic solutions (Aeberhard and Rist, 2009; Jahn et al., 2012; Scholz and Steiner, 2015). Eventually, this increases the likelihood for the solution to be later adopted (Bracken et al., 2014; Hirsch Hadorn et al., 2006; Lang et al., 2012). Co-design processes create a feeling of ownership, increase trust and stimulate commitment among participants. This increases the legitimacy and impact of the research for development outcomes (Fiorino, 1990; Stirling, 2008). Co-design processes are at the same time challenging. It is important for all involved parties to move beyond their individual agendas and comfort zones. In combination with awareness of the context, anticipation of effects and paying attention to the governance framework this can form the basis for responsible scaling strategies (Wigboldus & Brouwers 2016).

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Fax: +1-202-862-5606
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