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Capacity Building for Water Management in Peri-Urban Communities, Bangladesh: A Simulation-Gaming Approach

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Abstract: Peri-urban areas in the global south are experiencing over-exploitation and contamination of water resources as a result of rapid urbanisation. These problems relate to the ineffectiveness of the underlying institutions in this dynamic, multi-actor context. Institutions need to be considered during problem solving; however, peri-urban communities have limited insight into their institutional context. This research examines the extent to which problem solving capacity can be improved through gaming-simulation methods. A game-based approach is tested in a capacity building workshop with peri-urban communities in Khulna (Bangladesh). A role-playing game designed from game theory models is used to examine local drinking water problems through an institutional lens. Workshop evaluation shows that through role-play, participants learned about strategies in drinking water supply (in both the current and future scenarios) and about the potential to address water quality issues through cooperative groundwater monitoring. Results also show improved problem understanding with regards to institutions, actor strategies, and problem-solving constraints. Participants valued the interactive medium for comparing and evaluating strategies. This paper highlights limitations in game design and its implementation, and offers ways to address this in future applications.

Keywords: drinking water management; peri-urban; institutions; gaming-simulation; groundwater; capacity building

1. Introduction

Water resource management during urbanisation is becoming increasingly problematic in the Global South given the rate at which development is occurring. In the coming decades, Asia and Africa will experience rapid urbanisation compared to other regions, and 66% of the global population is expected to be urban by 2050 [1]. Therefore, attention must be paid to water governance, particularly in peri-urban contexts, where the transition from rural to urban landscapes occurs. "Peri-urban" is defined, according to Narain [2], as a transition zone in close proximity to urban centers experiencing a two way flow of goods, services, and population. Here, urbanisation processes are visible in the changing land use, economic activities, and population [2,3]. Achieving sustainable and equitable water management in peri-urban areas is important, given that they are the cities of tomorrow.

The institutional context is relevant for understanding and addressing peri-urban water management problems. Here, institutions are defined as formal and informal 'rules' that structure interactions and behaviour in society [4]. Formal rules include laws, policies, and regulations, while informal rules refer to customs, codes of conduct, and taboos [5]. With regards to water management, institutions exist to facilitate coordination over its use and allocation. For example, service providers can use water tariffs, a type of rule intended to regulate water usage. In this way, institutions serve a function in society by offering guidance during the problem solving process.

In peri-urban areas, however, these institutions are often ineffective. Typically, institutions are arranged along rural and urban (administrative) boundaries, with peri-urban governance defined by rural institutions [6]. These traditional rural institutions are unable to support the needs of communities in such a dynamic context. In some cases, peri-urban institutions are fragmented or overlapping. As a result of this, identifying which rules apply, or who has what roles and responsibilities in a given situation, is challenging. Moreover, peri-urban areas are much more socially-heterogeneous than rural villages [3]. Often, multiple actors with varying interests are competing for the same resources. Balancing actor needs is an important part of peri-urban governance, but requires supportive institutional arrangements. Without it, peri-urban communities can become marginalised from essential public services.

Examples of ineffective institutional arrangements can be found in peri-urban Khulna (Bangladesh). Here, urbanisation is rapid and largely unregulated. Despite being located in the water-rich Ganges delta, peri-urban communities face drinking water insecurity. Access to safe drinking water supply is limited in many communities. Conflicts have also emerged between peri-urban and urban water users over access to groundwater, an important source of drinking water. For example, in nearby Phultala (north of Khulna city), peri-urban residents organised protests and filed a legal case against a large-scale groundwater abstraction project by Khulna city [7]. Declining groundwater levels and contamination from iron, salinity, arsenic, industrial, and wastewater contamination is also reported in this region [8,9]. Together, this provides a clear signal that existing institutions are unable to support sustainable or equitable water management outcomes.

Even though peri-urban communities are adversely affected by the outcomes of institutional design, they have limited insight into their institutional context. This is the result of isolation from formal decision-making arenas that limits access to information about institutions and the actors operating within decision-making arenas who apply these institutions. As a result, peri-urban communities have limited ability to formally intervene. This has been observed in peri-urban Khulna, where residents have previously resorted to informal strategies given their isolation from formal policy arenas [7]. Research from other peri-urban contexts also signals a lack of participatory interventions [10]. Thus, there is a need to support the problem solving efforts of peri-urban communities by closing this knowledge gap and building capacity to navigate policy arenas.

This paper explores the use of gaming-simulation methods to support problem solving through capacity building at the local community level. A game-based capacity building workshop is piloted with residents from peri-urban Khulna. During this workshop, participants used role-play to explore strategies to address the drinking water problems that are currently affecting them. Evaluation findings from this workshop are used to answer the following research question:

To what extent does the game-based workshop improve communities' problem understanding and capacity to intervene in peri-urban problems?

The paper is structured as follows. The theories in Section 2 explain the potential of using gaming-simulations to support peri-urban communities. Section 3 describes the materials and methods used to design the role-playing game and the workshop, as well as the evaluation framework and protocols used in this study. A brief introduction to the case study follows in Section 4, specifically, the drinking water problem in peri-urban Khulna. Results in Section 5 describe the role-play activities by participants during the workshop and evaluation of the game, workshop, and learning outcomes. The discussion in Section 6 reflects upon the pilot study, its limitations, and potential future research.

Conclusions on the use of gaming-simulation methods with peri-urban communities are presented in Section 7.

2. Theory and Concepts

Gaming-simulation methods have appeared in the policy analyst toolkit since the 1960s in response to the need for human-centered approaches that incorporate the socio-political complexity of public policy issues [11]. Since then, different kinds of games have emerged in fields relevant to the area of application in this research: resource management [12–14], urban planning [15], and peri-urban conflicts [16].

Game design handbooks by Duke [17] and Greenblat [18] explain that design starts by defining the game's purpose. The purpose helps select the most appropriate gaming-simulation method. Bots and van Daalen [19] describe different functional uses of games to support policy processes. Here, gaming-simulations can serve as a laboratory for research and analysis, a medium for design and recommendation, a practice ring for strategic advice, a negotiation table for mediation, a consultative forum for democratisation, and finally, a parliament to clarify values and arguments. It is common for there to be more than one purpose, in which case, the designer must prioritise one, as the process of game design involves making trade-offs such as this [18].

In situations where stakeholders are marginalised from policy processes, gaming-simulation can be used for learning to achieve integrative negotiation within policy processes [16]. Here, learning also extends to the interactions occurring within policy arenas. Role-playing games offer a useful medium to achieve learning in this regard. Players can examine a problem by experiencing how different actors behave (within a set of institutions). One function of games is to serve as a 'virtual practice ring' for stakeholders to experiment with different strategies before formally entering the policy arena [9]. Here, the game can simulate decision-making arenas, where players use role-play to build negotiation skills before entering real-world negotiations. In this way, role-play can offer marginalised actors strategic support during the problem solving process.

Designing a role-playing game that simulates a real-world problem requires abstracting relevant details about the problem. These details help select the appropriate boundaries and inputs in the game. In this way, real-world phenomena can be mimicked in the roles, rules, and incentives in the game (Meijer and Hofstede, 2003 cited in [20]). One way of abstracting from the real world is with the help of game theory models. Game theory modelling is a method used to structure and analyse strategic behavior. The logic and analytical rigor of game theory is useful for interpreting real-world decision making phenomena in multi-actor situations [21,22]. They help illustrate how outcomes result from strategic interactions between actors based on their preferences, values, and objectives [23].

The literature highlights several similarities between the design schemas of game theory models and gaming-simulations. The same inputs used for constructing game theory models are also needed for game design. Models formalise strategic behaviour in the form of a 'game' consisting of players, actions, and payoffs on resulting outcomes [24]. These same inputs may be used by game designers to map the formal structure of a game [25]. Moreover, the focus on decisions and outcomes in game theory provides the building blocks for meaningful play [25].

Game theory models implicitly specify the 'rules' of the game. This offers additional design details for game designers with regards to the order of play, information in the game, and resources available to players. In the real-world, these rules are given by formal and informal institutions. In this way, the institutional context of the problem can be incorporated into the game's design. There are two ways of specifying rule conditions in the model. Non-cooperative game theory is used to structure conflicts within a fixed set of rules, where actors adopt a self-optimising attitude to meet their own objectives [23,26]. In cooperative game theory, the game assumes a willingness to communicate, coordinate actions, and pool resources by actors in the game [26,27]. Thus, different types of game theory models may be used to design role-playing situations where players can experiment with different strategies under the existing set of institutions, or experiment with collective action by changing or creating new institutions.

This study explores the use of gaming-simulation methods to support peri-urban communities in on-going problem solving efforts. In peri-urban contexts, communities have limited insight into formal policy arenas and negotiation experience. Simulating peri-urban problems as a role-playing game offers a medium for communities to explore the problem through its multi-actor environment, and experiment with problem solving strategies in a safe, virtual environment before engaging in real-world negotiations. Therefore, a role-play game is well-suited to the capacity-building needs of the beneficiaries in this context.

Designing a role-playing game for this purpose requires integrating unique features about the problem and the peri-urban context. The authors have previously developed a structured and participatory approach to help in this regard [28]. It begins by identifying the community's most pressing problem. Then, this problem is framed through an institutional lens, and relevant formal and informal institutions are mapped using the Institutional Analysis and Development framework [29]. Next, the focus shifts to the decision making arenas. Here, game theory models are used to examine how institutions are operationalised through actor interactions and the outcomes of these interactions. This research experiments with translating game theory models into a role-playing game to improve problem-solving capacity within peri-urban communities.

As peri-urban problems are multi-actor in nature, game theory models serves as the starting point in game design. Inputs from the models are used to define roles, rules, and incentives in the game, and identify potential scenarios for players to explore through role-play. The dynamic nature of peri-urban contexts is also incorporated by designing a game where players start with the existing peri-urban problem (starting conditions), after which new elements are introduced during the game [17]. In this way, players can identify appropriate strategies to peri-urban problems as they evolve.

3. Materials and Methods

3.1. Data Collection and Model Development

The village that participated in this study is situated approximately 7 km outside Khulna city. To protect the privacy of the study area, the village's name is kept confidential. This research is conducted as part of the Shifting Grounds project, that aims to support institutional change for pro-poor, sustainable, and equitable peri-urban groundwater management in the Ganges delta [30]. It is through this project that the authors first connected with the village in October 2014. Since then, extensive research and capacity building initiatives have been conducted. One of the main concerns in this village is access to safe drinking water supply. This problem was highlighted during early discussions with the community as part of the Shifting Grounds project. This game-based intervention was designed to offer insight into this drinking water problem.

Primary data about this problem was collected during two field visits by the primary author in 2015 and 2017. The 2015 field visit comprised 13 key informant interviews with government agencies and academic institutions, and a focus group discussion with 27 village residents. During this time, discussions covered the institutions, actors, interactions, and outcomes associated with drinking water supply. The second field visit in 2017 was used to identify actor values and preferences in resolving both water supply and water quality aspects of this problem, now and in the future. It consisted of 19 key interviews with residents (from peri-urban and urban areas), government agencies, a bottled water company manager, and a focus group discussion with 10 residents from the village. All meetings lasted between 30 and 90 min, were semi-structured, and were organised using snowball sampling methods. Co-authors from the local NGO partner Jagrata Juba Shangha (JJS) served as translators. To supplement this primary data, secondary sources such as government websites and Shifting Grounds reports were also used as inputs.

Using this data, game theory models were constructed. Detailed steps followed in early versions of these models were based on the initial 2015 field visit, and are available in Gomes, Hermans, and Thissen [28]. Since then, models have undergone several revisions as new details emerged about the problem. Over time, participatory research revealed the existence of several smaller but inter-connected problems, such as the lack of drinking water infrastructure, poor drinking water quality, and future changes in water services as a result of urban expansion from Khulna city. These sub-problems were modelled as individual games, each defined by their own institutional arrangements and multi-actor interactions. This study uses inputs from three game theory models. Model 1 is on the existing (peri-urban) drinking water supply situation, and model 2 is on the future (urban) drinking water supply situation. Both are modelled as non-cooperative games using Gambit [31]. Model 3 focuses on water quality aspects of the problem, more specifically, groundwater quality, and explores cooperative strategies to improve monitoring. Solutions in this cooperative game theory model were analyzed using R [32].

3.2. Game Design

Three short role-playing games were designed using inputs from the corresponding game theory model. This included the players, their roles, actions, resources, and potential outcomes in the game. Game 1 is about the existing drinking water supply situation, game 2 on the future drinking water supply situation, and game 3 on groundwater monitoring.

Initial game design proposals were discussed with local experts and project partners for context-specific feedback. Thereafter, two test sessions were conducted at Delft University of Technology (Netherlands). The final game was also played with researchers from Khulna University of Engineering Technology in March 2018. As this game was designed for peri-urban residents, it was translated into the local language (a dialect of Bangla) by the co-authors from JJS. Two half-day training sessions were held with facilitators at JJS offices in Khulna to familiarise them with the game and other provided supporting materials, such as the facilitator script.

In each game, participants are assigned a role. Each game has several strategic players. These players consciously made decisions in the game based on their objectives, using the actions and resources available to them. In games 1 and 2, there were also non-strategic (or chance players). Their actions during the game were selected by rolling a dice. Each player was given various cards that described their role, actions, and resources (assets) that a player can use during the game. All players had at least two actions to choose from. Action cards also specified the conditions for each action. For example, some actions could only be used in combination with a resource card. Examples of the aforementioned game materials can be found in the supplementary materials.

Role-play in each game was based on the game's objective. The objective in games 1 and 2, was for residents to obtain drinking water supply. Therefore, residents moved first in these games. Their actions determined who would move next in the game, and so on. The combination of actions by different players produces an outcome. The outcome could be a type of drinking water supply or no water supply at all. From game theory models, we had identified the set of all possible outcomes in each game. After each round, players had to rate their satisfaction (happy, indifferent, or sad) with the outcome using a scorecard (see supplementary materials for an example). The scoring was based on that player's values. Multiple rounds allowed players to draw comparisons between the strategic outcomes.

The objective in game 3 was slightly different. The first round of this game focused on non-cooperative strategies. It represents the status-quo of groundwater monitoring in peri-urban Khulna. Each player in this round had to identify the locations where groundwater data was individually collected. A groundwater crisis situation was then introduced in round 2 of the game. It prompted players to explore more collaborative groundwater monitoring strategies. Participants were given 15 min to negotiate agreements. Thereafter, they had to describe the locations, terms, and conditions for cooperative monitoring that was agreed to. All possible non-cooperative and cooperative outcomes in this game were identified from the model. Participants used their scorecards to rate their level of satisfaction with both non-cooperative vs cooperative groundwater monitoring strategy.

All three games were facilitated with the help of a game board (Figure 1). It described the physical geography of a fictional peri-urban area outside a city boundary (demarcated by a red line). Its design was closely based on the geography of peri-urban Khulna. The game board was used to indicate the location of players (orange circles) and their actions during the game (white rectangles). Outcomes were also visualised on the game board using drinking water icons, which described the type of drinking water supply that resulted in each round (Figure 1 top row). In game 3, groundwater monitoring icons (Figure 1 bottom row) were used to identify the locations of non-cooperative (different coloured icons) and cooperative groundwater monitoring (blue icons). The game board was customised for each game as needed. In session 2, urban expansion was visualised by extending the city boundaries with colored tape and adding city icons (Figure 1 middle row) in the expanded areas to indicate urban development. During game 3, players who had agreed to cooperate were connected on the board with coloured tape.

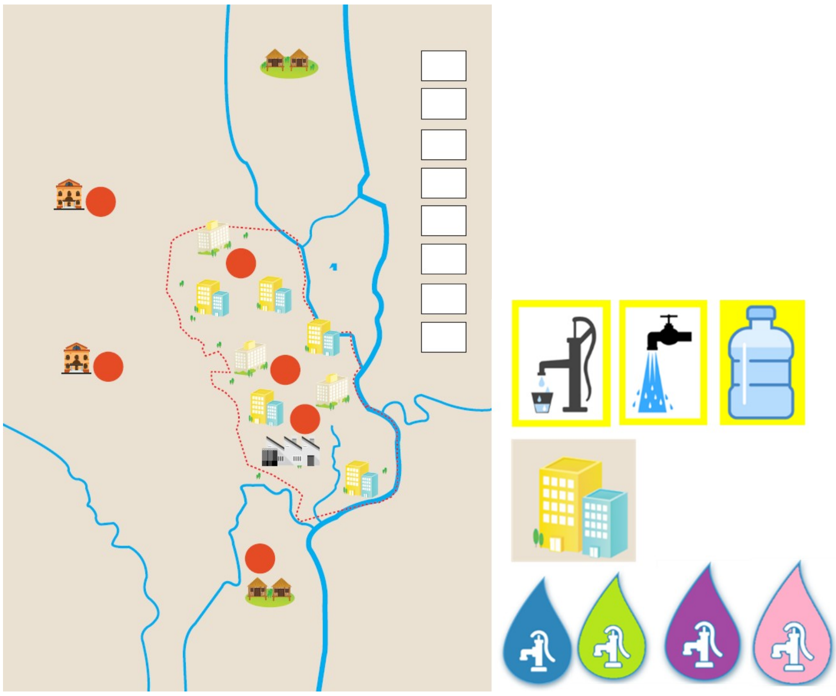

Figure 1. Game board (**left**); Game board pieces: (**top row**) drinking water icons, (**middle row**) city icons, (**bottom row**) groundwater monitoring icons.

3.3. Design and Evaluation of Gaming-Simulation Workshop

All three games were played as part of a gaming-simulation workshop. The one-day workshop was held on 27 March 2018 at a venue in Khulna city. Four facilitators from JJS were present, including a main facilitator who conducted the workshop, one observer who recorded workshop proceedings, and two co-facilitators who organised game materials, assisted participants, and recorded discussions during the debriefings. The game designer (primary author) was also present to answer questions related to the game or workshop activities.

The workshop was attended by 9 participants from the peri-urban village that were formally invited by JJS. They included 6 female and 3 male participants. Participants represented key stakeholder groups from the community. Six participants were from the negotiation group that regularly participated in community meetings organised by JJS as part of the Shifting Grounds project. The remaining 3 represented recent migrants and low-income households from the village. All participants signed a consent form and were remunerated for travel costs to the venue.

The overall workshop design, including its structure, specific activities, and time management plan, is shown below in Figure 2. In the introductory session, facilitators presented the workshop's objectives, introduced participants to the role-playing format, and conducted the pre-workshop evaluation. This was followed by the three role-playing games. The sequencing of games was important. We assumed that the existing situation is most familiar to peri-urban residents, and hence, is a suitable starting point. The (future) urban water supply game was played next, given that it closely resembled game 1, extending it with a long-term perspective to the problem. This was followed by game 3, where participants focused on water quality aspects of the problem, and explored non-cooperative and cooperative groundwater monitoring strategies.

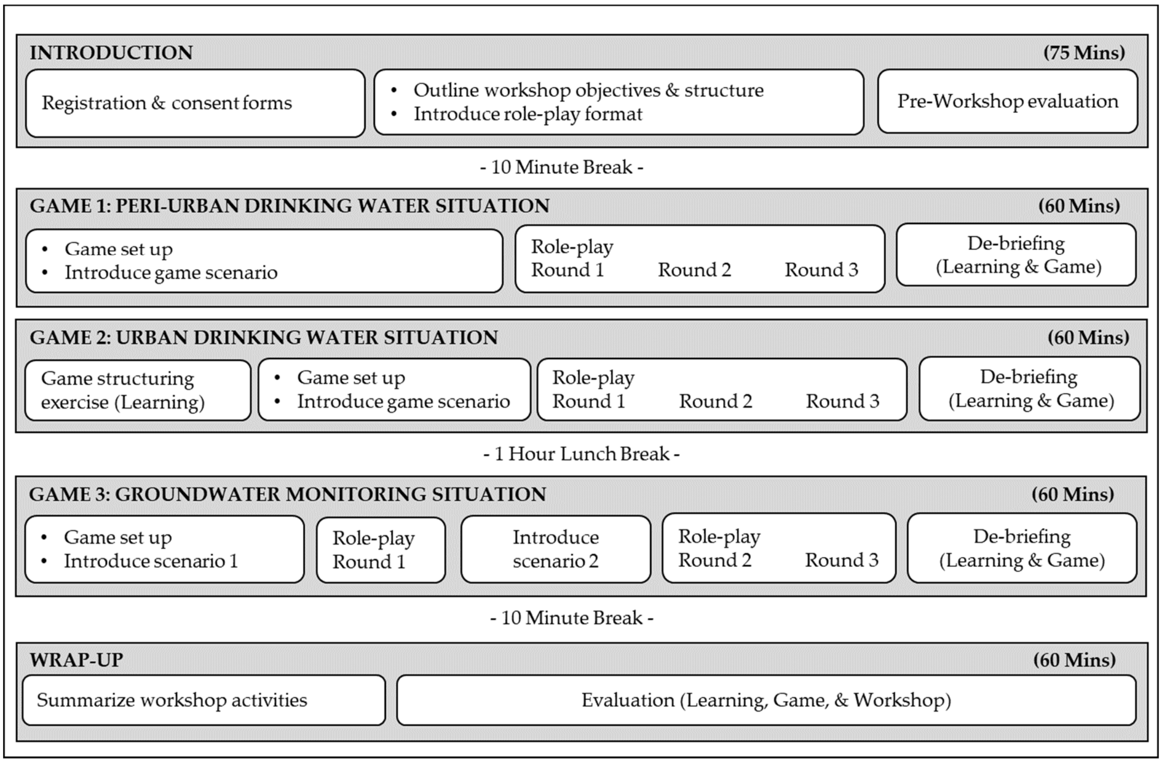

Figure 2. Overview of workshop structure.

Facilitators began each game with an introduction to the drinking water situation to be examined and the objective of the game. Next, game materials were distributed and roles were assigned. Depending on the number of roles available, participants were individually assigned a role, or worked in groups of 2–3 persons. Multiple rounds were played in each game, and each outcome was evaluated by the players. In game 1, a trial round was played at the beginning to familiarise players with the game materials. Each game concluded with a de-briefing exercise, led by the facilitator.

A wrap-up session concluded the workshop with a summary of activities and final evaluations of the game, workshop, participant experience, and learning.

Assessing the impact of this gaming-simulation workshop required a suitable evaluation framework. Different frameworks offer suitable starting points for this [33–35]. Evaluation in this study, shown below in Figure 3, draws from Thissen & Twaalfhoven [34]. It is designed around three components: the input, activity, and result. Specific evaluation criteria and sub-criteria are specified for each component, taking cues from Midgley et al. [35].

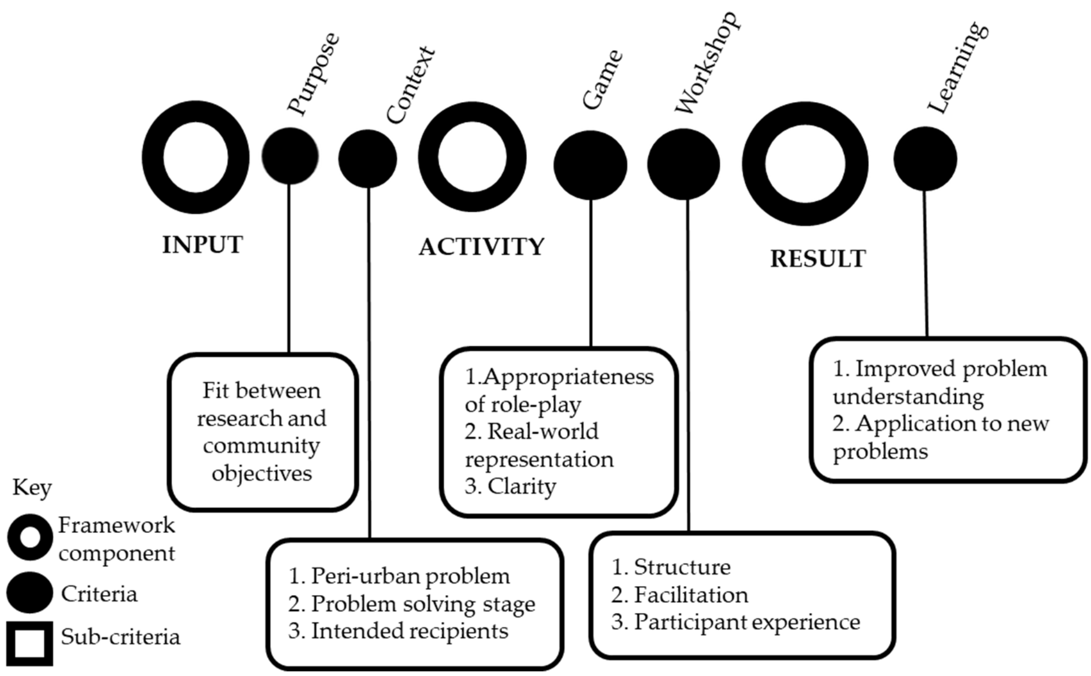

Figure 3. Evaluation design (adapted from [33–35]).

The inputs refers to the purpose of the game. Examining the fit between designer and community objectives is a principle of good game design and offers a basis for reasoning the successes or failures experienced. Context refers to inputs beyond the control of the designer, thus representing important design boundaries. Contextual attributes included appropriateness to the type of problem being addressed, stage of problem solving, and intended recipients. The activity is evaluated with respect to the game, workshop, and overall participant experience. Game criteria refers to the appropriateness of role-play, real world representation, and clarity of the game. Workshop criteria includes its structure and facilitation.

Finally, results refer to participant learning. Learning was evaluated in two ways. First, we examined the extent to which participants' problems with understanding were improved. This was done by comparing problems of understanding at the start of the workshop (as a pre-workshop discussion) and after each game during the workshop (de-briefing). Second, we identified higher-order learning outcomes. For this, a game-structuring exercise was conducted after the first game. Participants were presented with a new problem situation and asked to name the actors, actions, resources, and values. This exercise was used to assess whether knowledge and insights from the previous game could be applied to similarly structure other types of peri-urban problems.

The evaluation medium was facilitated group discussions using flip charts. Different evaluations were structured throughout the workshop (Figure 2). Participants also filled out a post-workshop questionnaire in the wrap-up session. It was used to assess their overall workshop experience. During the workshop, observations were recorded by one of the facilitators on a process record form. This included the questions asked by participants during the games and outcomes of role-play activities. Evaluation results were later translated into English, coded in Excel, and analysed qualitatively.

4. Case Study: Drinking Water Problems in Peri-Urban Khulna

In this peri-urban village, groundwater is the primary source of drinking water. The village is officially part of the rural jurisdiction. Currently, residents have two strategic options to access groundwater. One is to apply for a public tube well from the Water and Sanitation (WATSAN) committee. The other option is to invest in a private tube well. Compared to public tube wells that are subsidised by the government, private tube wells are expensive. Therefore, most households prefer public over private tube-wells, as not everyone has the financial means to invest in the latter.

Approval from the WATSAN committee is needed before a public tube-well can be installed. This committee operates at the sub-district (upazilla) level, as per the formal rules of the rural administration. They can either reject an application or approve it by issuing a tube-well licence. There are two reasons why the committee might not approve an application. First, given that most members of the WATSAN committee are elected, there is a need to appease their local constituency. This can lead to an inequitable distribution of tube-well licenses, with preference given to villages with stronger ties to WATSAN members. Second, license quotas (or tube-well funding) are limited. In this village, applications are rarely approved.

If a license is approved, the Department of Public Health Engineering (DPHE) manages the installation process. This begins by selecting a site to install the public tube-well. This can be done based on an assessment of local groundwater conditions, or based on the preference of the applicant. Discussions highlight a preference for the latter, as local aquifer data is limited. Thereafter, DPHE hires a mechanic to install the tube-well. Mechanics are hesitant to accept these installation contracts, as the terms state that payment depends on the success of tube-well installations. In other words, mechanics are not paid for tube-wells that supply poor quality or limited groundwater volume. If sites are selected without assessing local groundwater conditions first, then installation contracts can be risky for mechanics.

As mentioned, the village can also invest in a private tube well. Officially, this also requires a licence; however, it is currently unregulated, as the government is aware of the gap in rural drinking water supply. Here also, mechanics are hired to install a private well, except they are paid irrespective of the viability of the tube-well site. Therefore, there is no risk for mechanics to accept private tube-well installation contracts. The risk instead is borne by the village, as a non-viable tube-well would result in financial losses for the investor.

In the future, drinking water supply in this village is likely to change from rural to urban service providers as proposals to expand city boundaries are currently under review. Thereafter, peri-urban villages will become part of the urban jurisdiction. In this urban scenario, residents have four strategies to obtain drinking water supply. First, they can apply for piped water supply at the city's Water and Sanitation Authority (WASA). Currently, Khulna WASA supplies treated surface water via pipelines. To reduce the pressure on groundwater, they are investing in new supply projects to increase the capacity and coverage of the piped supply network. However, these on-going projects are designed to meet the needs of the current population. Piped supply in these future urban areas depends on the availability of additional water supply projects. Therefore, in future, this option may not be available to residents.

A second option is to apply for a public tube-well from the city's WASA. Here, there is the risk that public-tube-wells might be unuseable if the installation site is non-viable. However, the costs for using a public-tube well are less than those of piped supply. It is also less convienient compared to a household connection. Depending on their financial capacity, residents might prefer public tube-wells. A third option is to invest in private tube-wells. Similar to the peri-urban scenario, mechanics are hired to install private tube-wells, and there is a risk for residents that the site will be non-viable. Moreover, the costs of a private tube-well are significantly more than those of a public-tube well, making it a less affordable option.

Finally, the fourth option is to purchase drinking water from (private) bottled water companies. In Khulna, there are several informal suppliers. They typically sell large jars of packaged groundwater. This option is only accessible to households who can afford it. These companies are expected to test drinking water quality; however, it is likely that this is not always done, especially by those operating illegally. Similarly, in the future, bottle water companies can only supply if they are able to meet the demand and recover the higher distribution costs (from supplying to customers in more remote areas of the city).

The village's drinking water problem also relates to groundwater quality. Residents have the impression that good quality water is only accessible from deeper aquifers. Rural providers are unable to ensure safe drinking water quality due to limited knowledge of groundwater conditions. This points to a gap in groundwater monitoring. This monitoring gap is also a concern for other government actors. Several actors highlighted a need for coordinated groundwater monitoring. In Bangladesh, groundwater is monitored by several government agencies as part of their mandate. Residents also informally monitor groundwater to meet daily household needs. They mentally record the quantity and quality available from different tube-wells in the village. This is done by observing seasonal changes in the volume available from tube-wells, and using sensory signals like taste, odor, and color of groundwater. Health issues from drinking contaminated water is also an indicator of poor water quality.

A game theoretic representation of the existing and future drinking water supply and groundwater monitoring problems, can be found in the supplementary materials. The role-playing games in this study are designed to help communities explore this problem.

5. Results

5.1. Strategies Explored through Role-Play in the Capacity Building Workshop

Participants played multiple rounds of each role-playing game during the workshops. The results of each round in games 1, 2 and 3 are summarised below in Table 1.

Table 1. Overview of strategies explored during the three games.

Game	Strategy	Outcome
	1. Peri-urban drinking water supply	
Round 1	License for public tube-well application approved but aquifer assessment pre-installation finds site non-viable, so installation is halted.	No drinking water supply in peri-urban village available
Round 2	Investment in private tube-well is successful, as installation site is discovered to be viable for groundwater.	Peri-urban village receives drinking water supply via private tube-well
Round 3	Application for public tube-well not approved by WATSAN committee as all licences are issued elsewhere.	No drinking water supply available for peri-urban village
	2. Urban drinking water supply	
Round 1	Application for piped water supply is approved by urban drinking water provider.	Residents get drinking water supply via piped network supplying treated surface water
Round 2	Bottled water companies refuse to sell water to residents of former peri-urban area.	No drinking water supply available for newly urban residents
Round 3	Failed investment in private tube-well as installation site is discovered as non-viable after installation.	Residents must either use the poor quality, unreliable groundwater from private tube-well or look for other alternatives
	3. Groundwater monitoring	
Round 1	Individual (non-cooperative) monitoring by residents, DPHE, DOE	Fragmented groundwater data from different areas is insufficient for decision-making purposes
Round 2	Joint (cooperative) monitoring by residents and DPHE, while DOE monitors groundwater separately.	Sharing of groundwater data and better knowledge of aquifer conditions in peri-urban areas only

5.1.1. Game 1: Peri-urban Drinking Water Supply

In this game, participants explored the existing (peri-urban) drinking water supply situation. The players in this game included peri-urban (residents), WATSAN committee (chairman), DPHE (engineer), a mechanic, and the two chance players—nature and other unions. Nature determined the viability of a tube-well installation site, whereas the chance player 'Other unions' decided the total number of applications received by the WATSAN committee.

In round 1, residents applied for a public tube-well, the cost for which was paid using monetary resources. The WATSAN committee approved a tube-well license for the village. Thereafter, DPHE opted to assess aquifer conditions beforehand, as groundwater data was available (as a resource card). However, nature revealed the site to be non-viable, so installation was halted. Therefore, the outcome of round 1 was a return to the status quo or no drinking water supply for the village. Figure 4 shows how game play was depicted on the game board in this round. Although this strategy is the village's preferred solution to the drinking water problem in reality, scorecards in the game showed mixed feelings towards this outcome. Residents and the mechanic were unhappy, whereas the WATSAN committee and DPHE were satisfied overall, despite the outcome.

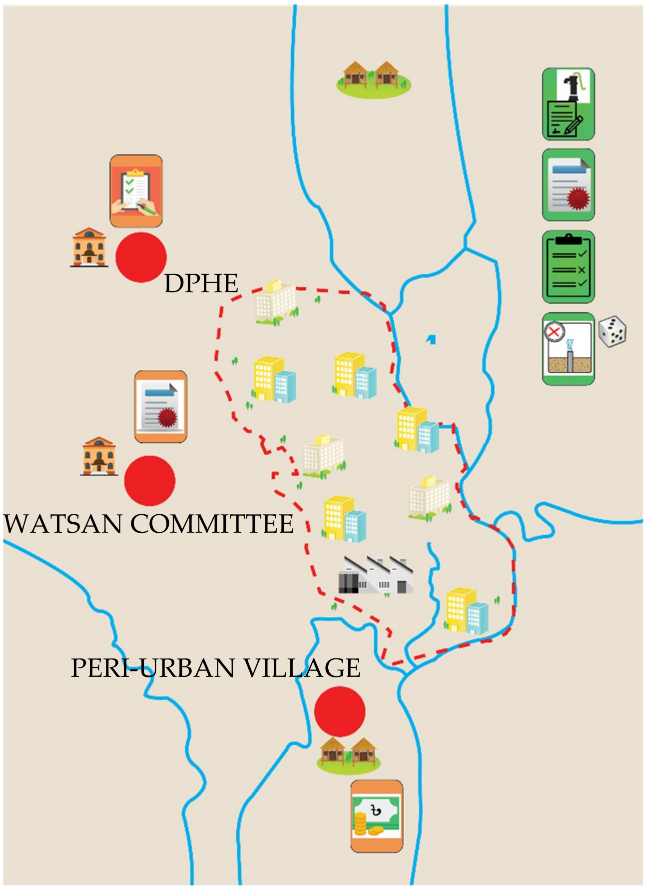

Figure 4. Game play in round 1 (Game 1).

In round 2, residents explored a different strategy. Residents used their monetary resources to invest in a private tube-well by hiring a mechanic. As groundwater data was unavailable (as a resource card) to both residents and the mechanic, no aquifer assessment was conducted prior to installation. Nature discovered the site as viable, resulting in reliable, good quality, although more expensive drinking water supply. Everyone except DPHE was satisfied with this outcome. Therefore, private tube wells are a more favorable strategy for peri-urban residents, despite the higher costs and associated risks. It is possible that residents are willing to pay for reliable, safe drinking water services. However, their decision to re-visit a more affordable option in round 3 also suggests otherwise.

In round 3, residents decided to re-visit the public drinking water option. This time, other unions also submitted tube-well applications to the committee. In this case, the committee decided to allocate all licenses to the other unions. This meant no drinking water supply for residents. As expected, they were unhappy with this outcome, while the committee and DPHE had mixed feelings, and the mechanic was satisfied.

5.1.2. Game 2: Future Drinking Water Supply

In game 2, participants explored the (future) urban drinking water supply situation. The players included former peri-urban village (residents), WASA (engineer), bottled water company (manager), the mechanic, and nature (chance player).

In round 1, residents applied for a piped water supply connection from WASA (paid using resource cards). The availability of piped water supply projects (a resource for this player) made it possible for WASA to extend good quality, reliable piped water supply (Figure 5). In round 2, residents opted to purchase bottled water; however, they were refused by the bottled water company due to low production volumes (as stated on their resource card). This meant a return to the status quo for residents. Thereafter, they reverted to a familiar strategy in round 3 and paid a mechanic to install a private tube-well. However, following installation, the site was discovered to be non-viable by nature. Thus, the outcome of this round is a failed tube-well installation, financial losses, and no water supply.

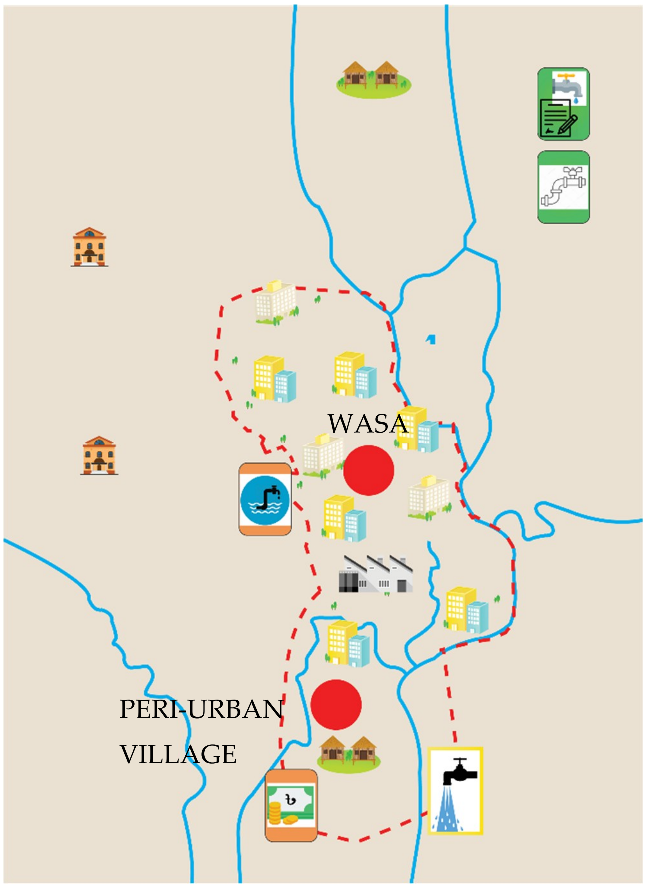

Figure 5. Game play in round 1 (Game 2).

The scorecards in game 2 shows that residents were successful only in the piped water supply strategy (round 1). This outcome was considered satisfactory by both WASA and residents, although it scored poorly with respect to affordability by residents. The mechanic was indifferent, and the bottled water company was unhappy with this outcome. By comparison, round 2 was considered unsatisfactory by almost all players except for the mechanic, who was indifferent to the result. In round 3, the outcome was poorly scored by residents as well as the bottled water company, while WASA was indifferent and the mechanic was happy, as they were paid for installation services despite the outcome.

5.1.3. Game 3: Groundwater Monitoring

There were three players in game 3: DPHE (engineer), village (residents), and the (water quality analyst) from the Department of Environment (DOE). In round 1, players identified the locations in which they were each collecting groundwater data as part of their monitoring efforts. This outcome is shown in Figure 6. The action cards indicated that DPHE collects groundwater data only in non-urban areas from public tube-wells at limited times of the year. Residents monitor both private and public tube-wells used for drinking purposes within their village. The DOE's monitoring locations meanwhile are only within city areas, as per the instructions from higher levels of the department. Scores in this round varied. Residents were indifferent to this outcome, as informal methods are, to some extent, helpful in managing daily water needs. DOE was satisfied overall, while DPHE was only partially satisfied, presumably as the data collected is insufficient and unreliable for decision-making purposes.

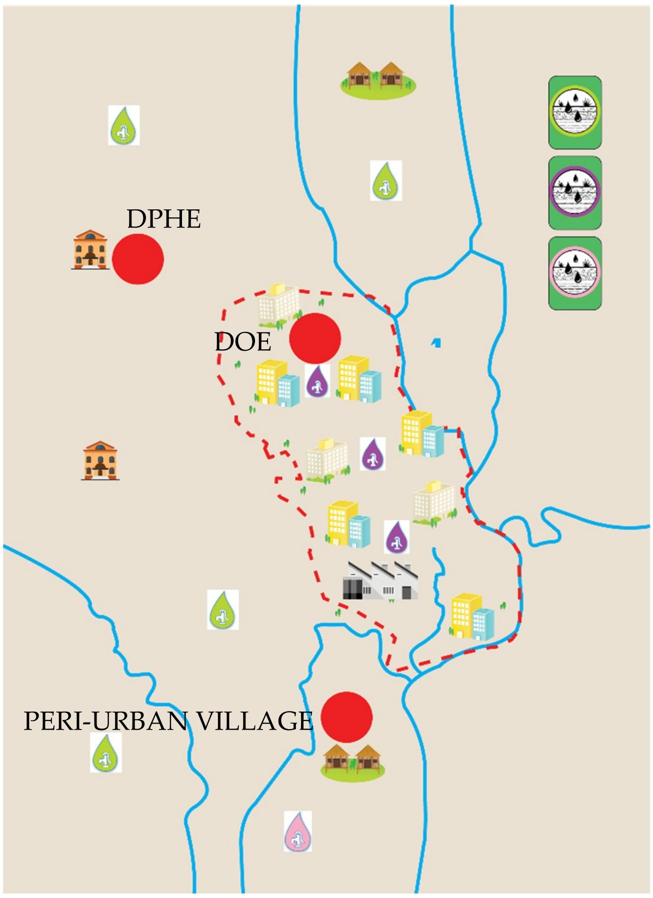

Figure 6. Game play in round 1 (Game 3).

In round 2, players explored cooperative groundwater monitoring strategies in response to a groundwater crisis. Following negotiations, participants explained that a full consensus between all 3 players could not be reached, as they were unable to partner with the DOE. Only residents and DPHE agreed to share knowledge and information about groundwater conditions from their respective monitoring areas. Periodic meetings were arranged for this. Compared to round 1, all 3 players were satisfied with the outcome of round 2. Only groundwater availability was scored poorly by residents. A likely explanation for this is that collaborations with DPHE might improve groundwater quality given the shared interest, more so than groundwater level monitoring.

5.2. Evaluation of Role-Playing Game

The appropriateness of role-play was evaluated during the workshop. In the introductory session, participants expressed their familiarity with role-play through local dramas (e.g., theatre) and cultural events. Moreover, local experts had highlighted that in this context, 'games' are typically associated with informality and playfulness. Therefore, we purposefully referred to the games only as role-play activities during the workshop. Despite participants familiarity, significant time was spent initially to ensure understanding of the game materials (30 min) and to complete role-play activities (50 min) in game 1. Games 2 and 3 by comparison were completed much more quickly (e.g., 10 min for role-play in game 2), with less assistance and greater confidence observed among the participants.

The wrap-up discussion revealed that participants enjoyed the role-play very much, as it provided information about the problem and the institutions. Participants expressed an interest in disseminating knowledge gained from this workshop with others in their village. They requested support from JJS to provide game materials for this. This indicates that knowledge sharing is one of the wider impacts of this workshop. With regards to problem solving, the workshop highlighted the need for collaboration and showed how residents can conduct this with authorities. One participant also suggested that the game-based approach could be applied to examine other problems and used to facilitate multi-stakeholder workshops between the community and authorities.

Local residents from this village varied in their level of education, literacy, and socio-economic background. Therefore, significant effort was made to ensure materials were easy to understand by translating them using a previously-developed glossary of local terms. Game testing and facilitator training sessions helped identify potential questions that might be raised, or points of confusion. During the debriefings, we evaluated the clarity of all three games. Participants felt that role of description cards could be simplified further, and in some cases, be more specific. On the other hand, they were positive about the game board, particularly the visualisation of rural-urban boundaries (Game 2) and negotiation outcomes (Game 3). Similarly, scorecards were well received, and were considered useful for comparing strategies.

The game's representation of the real-world had mixed reviews. Some participants highlighted missing details such as, for example, politics at the WATSAN committee (due to pressure from higher level authorities and local communities). Similarly, the practice of groundwater monitoring was, in reality, much more limited compared to what was observed in session 3. On the other hand, preferential allocation of tube-wells by the committee to other unions over the village was considered accurate. On the positive side, participants experienced the complexity of problem solving through this game. Both nature and player's resources (for example, financial constraints) were found to strongly influence the outcome, especially in game 2. In game 3, participants compared negotiations in the game to multi-stakeholder meetings held by JJS as part of the Shifting Grounds project. In other words, participants recognised that real-world negotiations to address peri-urban problems often requires third-party involvement and support.

5.3. Workshop Evaluation

The three games were explained well according to the participants, despite problems understanding the materials in game 1. They noted that some participants needed more help than others, as not everyone had the same level of problem understanding. Those who had participated in project meetings in the past felt more comfortable discussing local issues, whereas additional background information about actors was required by first-time participants. The time allocated for each game was considered appropriate, aside from the negotiation round in game 3 and in game 1, where more time was needed. It was suggested that the game materials could also be shared prior to the workshops to give residents more time to understand them.

Facilitation was overall positive, although it was highlighted that facilitators needed further training on the order of play. This is also visible in the video footage of the workshop. Despite the use of local terminology, participants misinterpreted certain elements of the game. Efforts to involve facilitators—who have knowledge about the local context and culture—earlier in the design process might prevent this. Significant time and effort was spent preparing facilitator scripts and conducting training sessions. This was found to be very valuable during the workshop. Although facilitators had no prior experience with gaming-simulation or game theory modelling, their expertise and relations with the community were valuable during the workshop. Participants felt comfortable, and did not hesitate to ask questions or communicate their feedback as a result.

A post-workshop questionnaire was used to evaluate overall participant experience. Respondents expressed that the workshop made them feel happy (75%), sad (18%), and inspired (9%). The workshop was convenient to attend for peri-urban residents, at an appropriate venue, and with sufficient refreshments and breaks. Finally, 60% would have preferred the workshop to be longer in duration, while the remaining considered it appropriate.

5.4. Evaluation of Learning Outcomes

The pre-workshop assessment in the introductory session (Figure 2) represents the initial problems with understanding among the participants. Community members explained that their drinking water problem relates to several aspects: poor groundwater quality (due to salinity and iron contamination), inconvenience of water collection from distant sources, groundwater depletion (seasonal scarcity), and wasted investments in tube-wells (as residents do not know the exact layer to abstract groundwater from). When asked which actors were involved in this problem, participants only listed women. It is true that women are most affected given their responsibility for household water collection. As 6 of the 9 participants in this workshop were female, this response is not entirely surprising. In reality, however, the problem involves several actors. It is possible that this question was misinterpreted by participants as the actors ‘affected’ by the problem, or it represents a very narrow perception of the problem’s scope or boundary.

Participants described two potential solutions to this problem. First, they see a need to identify the appropriate groundwater layer. This strategy requires support from the sub-district chairman and local Members of Parliament. Until now, the village has been unable to achieve this. Another solution would be to install a water treatment plant nearby, although it was not mentioned who would be responsible for providing this solution. The community recognises that they have a role to play in the problem solving process. Participants explained that they need to present a united front while requesting solutions from the authorities. They added that this type of collective action is not new to the village, but was practiced regularly, i.e., every time they apply for a public tube-well.

The de-briefings conducted after each game highlighted the learning that resulted from role-playing activities. Participants’ understanding of the tube-well licensing process was improved through game 1 (peri-urban situation). They learned that access to financial resources does not guarantee access to groundwater, given the important role of nature in the success of tube-well installations. Tube-well quotas was also a previously unknown factor in the decision making process of the committee prior to this workshop. When asked if they discovered new actors through this game, several were mentioned, such as the DPHE, WATSAN chairman, nature, and villages. Participants likely misunderstood this de-briefing question, as these actors were previously mentioned during field interviews and in the pre-workshop evaluation. Although game 1 did not result in a new solution strategy, the strategy in round 2 was considered most satisfactory, and is reflected in the scorecards. Furthermore, participants learned that not all strategies lead to satisfactory outcomes (especially for peri-urban residents), and that different strategies require interaction with different actors.

Game 2 (future urban situation) provided insight into the application process for piped water supply. It highlighted the fact that the option to purchase bottled water depends on the availability of financial resources. This was a newly-discovered problem for participants. Moreover, in the event that future drinking water options (piped water supply or bottled water) are unavailable, residents need to fall back on existing strategies (private or public tube-wells) to access drinking water. Participants learned that not all actors are satisfied with the same outcome. For example, bottled water companies were unhappy in all 3 rounds, although generally, round 1 (piped supply) was considered satisfactory by most players. In this way, participants discovered a new solution to the drinking water problem from game 2, namely, piped water supply. The session also led to the discovery of two new actors: bottled water companies and WASA.

The main learning from game 3 relates to coordination with regards to groundwater monitoring. Participants noted that, in reality, both DPHE and residents are unwilling to monitor groundwater. But residents now feel they have a role to play, by informing the authority about the (local) groundwater situation. They see a benefit from collaborating with the other players to identify a suitable groundwater layer. In round 2, residents could collaborate with DPHE but not the DOE. Participants did not see a need to collaborate with the DOE, as DOE operates primarily in city areas. It is likely that the DOE's role was not fully understood during the game. Players found resources helpful while negotiating agreements. However, it is possible that player resources cards (assets) were mistaken for physical water resources by some participants and/or facilitators. The response to this question suggests this.

Evaluating the transferability of problem structuring to other local problems was based on a game structuring exercise at the start of session 2. Participants were asked to list the basic game elements (actors, their actions, values, roles, and resources) in the future drinking water scenario. Only two actors were listed during this exercise: Khulna WASA and KCC, together with some details about their role, values, actions, and resources. This exercise shows that learning from game 1 could be easily applied to structure other peri-urban problems, although only to a limited extent. This is understandable, given the availability of information about this future scenario.

6. Discussion

Workshop results show clear improvements in problem understanding, as reported by participants. At the same time, this gaming-simulation workshop was part of a larger project, and the impacts of both the larger project activities and this specific intervention are hard to disentangle. The understanding of participants prior to the workshop was already partly fed by earlier interactions with the project's researchers and trainers about the drinking water problems and about negotiation plans. Even then, it is clear that the workshop was successful in communicating some of the key insights about institutions and strategic interactions to the local community members.

We are aware that this pilot study provides a limited basis for more general conclusions about the uses of gaming-simulation methods to support peri-urban communities. The authors have conducted this workshop with government actors from peri-urban Khulna on 28 March 2018. A follow-up workshop was also conducted by JJS in July 2018 with the same village. We are also currently exploring opportunities to use game-based capacity building to strengthen polder management elsewhere in Bangladesh. These case studies lie outside the current scope of this paper, however, they provide a basis for broader reflection in the future.

Although this pilot study shows the benefits of role-playing methods, this intervention had its limitations, given the constraints of the methods and boundaries selected for its design. Game theory models were the starting point in game design. These models are limited by the number of players that are used to structure the game; this necessitated simplifying the game's design and the level of detail about the problem. Therefore, it was not surprising that participants highlighted missing details. We argue that the problem boundaries used to design this game were appropriate at this stage of the problem solving process. At the same time, it is clear that a game theoretic analysis, and using a game to communicate its results, likely produces a different experience for participants compared to a game designed more for play.

The role-playing game focused problem examination onto the institutional context. The peri-urban system is far more complex, with biophysical changes (land use, groundwater use) and socio-economic changes (livelihoods, population, economic conditions) occurring simultaneously. In other words, the 'wicked' nature of this problem is only partially captured in the game. The physical and socio-economic context was still being researched by project partners, and therefore, could not be used as inputs in the game's design. On the other hand, had these results been available, their full inclusion might also have led to a more complex game that ran the risk of not being playable or easily understandable by the community. Striking the right balance here, therefore, remains an issue for further deliberation.

There is scope to improve the game design process as well. Through field visits, the community contributed inputs for the game used in this study, but was not directly involved in the game's design. A model building workshop could be used to more directly co-create the game theory models with community representatives, which would thereafter translated into a game by researchers and played by the community in a follow up workshop. Another possibility would involve creating a semi-structured game, where participants have the ability to add new game materials (actors, roles, actions, or resources) during the workshop. Follow up research can explore this and other participatory game design approaches.

We do not want to claim that this single gaming workshop could have been done in isolation of other community capacity building activities. We believe that this workshop has made a valuable contribution though, as part of a stream of work and activities in a larger project. However, even this larger stream of work is limited in its expected results—and these limitations thus also apply to our game-based workshop. Community empowerment and capacity building is not something to be achieved in a single workshop, or even by one project that runs for a few years. It requires much more than this. In this case, for instance, some of the very powerful and influential actors have not been willing to truly engage with the project, such as private sector companies and land development actors. This is not unique for this case, and also, does not mean that communities cannot be supported so that they can have a stronger voice and role in future processes.

In this case, government agencies have been more responsive and willing to participate. Here, the game-based workshop also offers a vehicle for direct interaction, playing it jointly with local community and government representatives. Similarly, now that this medium is available and known, it can be used within the community to extend the dialogue and understanding to community groups beyond the workshop participants and to other neighboring communities. Both these ideas for future use were put forward by the community participants, suggesting that they do see the value of the gaming workshop.

7. Conclusions

The pilot workshop in peri-urban Khulna indicates that gaming-simulation (in this case, a role-playing game) offers a practical and visual medium for peri-urban communities to examine local problems through an institutional lens. This method was well-suited to the context and the workshop participants. Role-play fostered interactions and active discussions on a complex multi-actor problem. It also helped communicate insights about institutions, often an abstract concept, in a way that is easy to understand and apply to strategic problem solving. Moreover, it revealed the dynamic nature of peri-urban problems as a result of urbanisation. Participants' understanding of problems improved with regards to the multi-actor interactions that exist in peri-urban problems, evaluation and comparison of strategies to address local problems, and the benefits and challenges of cooperation.

The use of gaming-simulation methods to support peri-urban communities requires a simple game design by selecting the appropriate level of detail. In this study, game theory models were used to design games of this nature. Key elements of game theory models such as players, actions, outcomes, and payoffs can be easily translated into a role-play game. However, while simple role-play is recommended to start with, we also recognise that, over time, capacity building activities should address more complex aspects of the problem.

This research provides a basis for improving the game design process and replicating this approach elsewhere. Future uses of gaming-simulation methods for strategic exploration can experiment with even more participatory game design processes with the local community. Overall, this pilot study shows that gaming-simulation methods can be a suitable and useful medium to support problem solving by peri-urban communities in the global south.

Supplementary Materials: The following are available online at http://www.mdpi.com/2073-4441/10/11/1704/s1, Figure S1: Non-cooperative game theory model of peri-urban drinking water supply, Figure S2: Non-cooperative game theory model of future (urban) drinking water supply, Figure S3: Cooperative game theory model of groundwater monitoring, Figure S4: Role description card for peri-urban residents, Figure S5: Action card for residents in session 2 (**a**) Front; (**b**) Back, Figure S6: Resource card for residents (**a**) Front; (**b**) Back, Figure S7: Scorecard for residents in session 1, Table S1: Description of outcomes in the model of peri-urban drinking water supply, Table S2: Description of outcomes in the non-cooperative model of urban drinking water supply, Table S3: Description of outcomes in the cooperative model of groundwater monitoring.

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