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RESEARCH ARTICLE

A *Community Management Plus* Model for the Governance of Rural Drinking Water Systems: A Comparative Case Study of Pond Sand Filter Systems in Bangladesh

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Rural drinking water systems (RDWS) in Bangladesh and elsewhere fail more often than we would want. The acknowledgment that pure community management models will not reverse this trend is growing: RDWS users need support. In an attempt to further understanding what this support could look like we in particular zoom in on the role of public agencies. We ask, (i) what conditions explain variation in collective action among the end-users of an RDWS? and, (ii) what conditions explain variation in collaboration between RDWS end-users and a public agency? We lean on concepts and insights borrowed from the commons literature. After all, rural drinking water systems can be framed as a commons: its users face appropriation and above all provision dilemmas, that must be solved to avoid failure. Based on this literature we develop a list of enabling conditions for (i) collective action among RDWS end-users, and (ii) collaboration between RDWS end-users, and a public agency. We applied these lists to study the governance of 30 pond sand filter (PSF) systems in the Southwestern coastal area in Bangladesh. Computing correlation, we find that large group size, interdependency among the group members, heterogeneity of endowments, a high level of dependence on resource system, locally devised access and management rules and well-working collaboration between PSF users and the public agency are significantly associated with the occurrence of collective action among PSF users. We also find that the latter (i.e. collaboration between PSF users and the public agency) is positively influenced by transparency and inclusive decision-making procedures, but mostly by a relation that is characterized by trust.

Keywords: Rural drinking water systems; pond sand filters; common pool resources; enabling conditions; community management; Bangladesh

1. Introduction

Pond sand filter (PSF) systems were introduced in Bangladesh in the early 1990s (Hoque, 2009). They are considered a low-tech, easy-to-operate drinking water infrastructure that can provide reasonably priced,[1] safe drinking water, reliably. PSF consists of a hand pump to pump water from a pond into a raised filter bed containing gravel and sand. After passing through the filter, drinking water is stored in a filter chamber from which it can be collected via a tap. Not only the technology is relatively simple, but also the governance arrangements seem straightforward enough: The number of actors and actor interactions is

[1] Harun & Kabir (2013) estimate that installing a PSF system in Bangladesh costs between $500–750. A PSF can serve up to 100 families, so installation costs could be as little as $5/household. Annual maintenance costs are estimated by them to amount to $50, or, $0.50 per household/year.

limited, and roles and responsibilities are clearly defined and not very complex: According to the National Policy for Safe Water and Sanitation (1998) local governments (i.e. *Union Parishad* and *Upazila Parishad*) select PSF sites, based on two criteria: the scarcity of drinking water in a community and the availability of a suitable pond. Subsequently, the Department of Public Health and Engineering (DPHE) is responsible for the installation of the infrastructure and can also be called upon in case of a need for big repairs, later. PSF users are responsible for operating and maintaining their drinking water system. To this end, they select a designated caretaker who is to be paid through user contributions. A committee comprising of five PSF users should take responsibility for organizing overall PSF management. A maintenance committee is usually selected in a general community meeting (Ansari & Roy, 2010). In its PSF guidelines, WaterAid Bangladesh (2006) advises forming PSF management committees comprising 6–10 members, including a head, a caretaker, regular members of which minimally two are female.

With roles and responsibilities allocated to communities, a public agency (DPHE) and local authorities, the governance arrangements for PSF correspond with what Hutchings et al. (2015) would call *community management plus model* i.e. management responsibilities are primarily assigned to the end-users of the drinking water system, but actors external to the community provide support where and when needed. With regard to *community management plus*, we assume that for the *community management* part to work, PSF end-users need to solve a basic collective action problem. For the *plus* part to be effective, our research design is based on the assumption that the users of PSF need to collaborate well with the public agency, DPHE. (For details regarding the theoretical underpinnings of this assumption, see section 2, below).

The problem we address in this study is the following. In spite of the simple technology and seemingly straightforward governance arrangements, PSF has not quite delivered on its promise. In their study of arsenic mitigation technologies in Southeastern Bangladesh, Hossain et al. (2015) find levels of abandonment of PSFs of 87%.[2]

PSF is based on a very simple technique, it produces safe drinking water, it is easy to build, easy to operate, maintain and fix, it is not prohibitively expensive, it has been aggressively promoted by NGOs and government agencies, and still we see it failing on an unsettlingly large scale. The aim of this study is to unveil some of the causes of this less-than-expected performance of PSF in Bangladesh. In order to narrow down this broad empirical question, we particularly zoom in on reasons that may have contributed to the non-optimal performance of the *community management plus* governance arrangement that applied to PSF.

Although we study PSF in Bangladesh, it is our ambition to formulate more general claims about the development of better *community plus management models* for rural drinking water systems. Apart from establishing if and to what extent generic preconditions for collective action in the context of shared resource governance also apply to rural drinking water systems, we in particular also zoom in on the effect of public agency support to community management. Our research questions are twofold: What conditions explain variation in *collective action among the end-users of PSF systems* in Southwestern coastal areas[3] of Bangladesh? What conditions explain variation in *collaboration between PSF end-users and DPHE* in that same area*?*

2. Theory

Public provision models for rural drinking water systems have not had the expected impact on coverage and access due to among other things fiscal constraints, a lack of knowledge of communities' needs and preferences, and corrupt civil servants (Isham & Kähkönen, 1998). The performance of private service models has been questioned as well – e.g. Bandyopadhyay (2016) finds that private enterprises in targeting water delivery in rural India suffer from issues related to financial viability and social equity. The answer to questions related to the impact of alternatively allocating responsibilities to the private sector remains largely contested (Prasad, 2006). As a consequence, interest emerged in the 1990s in so-called community management models, where communities are supposed to operate and maintain the drinking water systems largely by themselves (Hutchings et al. 2015; Carter et al., 1999; Naiga et al, 2015). For community management, a form of self-governance, to succeed, institutional arrangements are needed that facilitate and foster collective action among users (Ostrom, 1990).

Naiga et al. (2015, p.239) show that this is possible. They speak of local self-governance of drinking water provision systems as "a third way between central state provision and privatization." In their review

[2] The intervention area of the study extends to 142 villages in Bangladesh's southeast covering an area of 18,386 hectares of land with a population of about 220,000 as of 2003.

[3] PSF technology is almost exclusively deployed in this particular region of the country.

of the (still relatively sparse) literature that has looked at drinking water provision systems from a shared resource or commons perspective, they point at the work of Madrigal et al. (2011), Imoro & Fielmua (2011), and Chitonge (2011) that shows that communities *can* be successful in the self-governance of local water infrastructure. From these pieces of literature emerges a list of preconditions for the success of (pure) self-governance that includes but is not limited to (i) the characteristics of the physical system (e.g. boundary clarity), (ii) the attributes of the group (e.g. group size, leadership), (iii) the governance system (e.g. rules clarity), and (iv) the action arena (e.g. monitoring, sanctioning, conflict resolution) (Naiga et al., 2015). Madrigal et al. (2011) add the importance of (i) downward accountability, and (ii) working rules specifically regarding tariff collection and infrastructure maintenance tasks, to the list of conditions that promote better financial health, infrastructure condition, and user satisfaction.

However, almost without exceptions authors point at the difficulty for local user groups to pull this off without any form of support. Naiga et al (2015, p.239) mention a reality that besides the direct users of the infrastructure involves "multi-level networks of actors sharing the responsibilities and related scopes of action." Also, Madrigal et al. (2011) acknowledge the role of external actors and warn for an overreliance on support as this can undermine user group motivation. Braimah & Fielmua (2011, p.85) conclude that "local level institutions need the support and encouragement of the district and regional level institutions."

Although crafting and self-imposing rules to credibly neutralize free-riders – i.e. side-stepping those within the group that do not contribute enough, or that extract too much – is possible, it is also notoriously difficult for communities of shared resource users to pull this off without help (Barnes & Van Laerhoven, 2013, 2015). Therefore, apart from solving collective action problems, community management models need a *plus* in the form of well-working collaboration with a support entity, for example, a public agency. What are the theoretical underpinnings regarding conditions that explain (i) collective action among users of a shared resource such as PSF, and (ii) collaboration of shared resource users and a support entity such as a public agency?

Collective action among users of shared rural drinking water systems

A rural drinking water systems such as a PSF is a classic example of a shared resource system. Multiple actors – ranging from end-users to international donors – are or can be involved in the provision of the physical infrastructure (i.e. the *resource system*, or stock) and the production of drinking water (i.e. the *resource units*, or flow). Individual users of a shared resource system face a *provision dilemma* when costs related to the investment in a resource system are private, whilst the benefits are shared among all users of that system. As a result, rational actors are tempted to under-invest in the provision of the resource system. *Appropriation dilemmas* occur when the benefits related to the extraction of harvestable units from the resource system (in this case, water) are private, whilst the costs of doing that (e.g. a decreasing production capacity of the resource system), are shared among the entire group of resource users. As a result, rational actors are drawn to over-harvesting units from the resource system. The combined effect of underinvestment in and over-harvesting from the resource system would result in an unavoidable resource system collapse, a.k.a. a tragedy of the commons (Hardin, 1968). The primary task of a governance system for shared resources is to neutralize and turn around the incentives that would otherwise have individual actors engage in behavior that would lead to the collapse of the drinking water system. This can be done through state regulation, privatization, self-governance, or a combination, thereof (Ostrom et al., 1992). **Figure 1** uses the building blocks of the SES framework (Ostrom, 2007) – i.e. interactions around (i) a resource system, (ii) resource units, (iii) users, and (iv) a governance system – to illustrate this.

Based on the work of Ostrom (1990), Baland and Platteau (1996), and Wade (1988), Agrawal (2001) provides a review of enabling conditions for collective action among the users of a shared resource. In presenting his findings he follows the structure of the Institutional Analysis and Development (IAD) framework (e.g. Ostrom 2005) and differentiates between conditions pertaining to the *resource system characteristics*, *group characteristics*, the *institutional arrangements*, and the *external environment*, respectively. He adds to that a group of conditions that are related to the *relationship between resource system characteristics and group characteristics*, and the *relationship between the resource system and institutional arrangements*. The continuing relevance of conceptualizing and clustering enabling factors for collective action among the users of a shared resource in this way is illustrated by more recent work by for example Barnes & van Laerhoven (2013), Baggio et al. (2016), and Cox et al. (2010), who confirm the validity of the institutional design principles – an important pillar upon which Agrawal's list rests. Work by for example Cole et al. (2019) not only shows the value of using the IAD framework as a guiding principle, but it also shows the intimate connection between the IAD, and the SES framework. When developing the concept of coupled

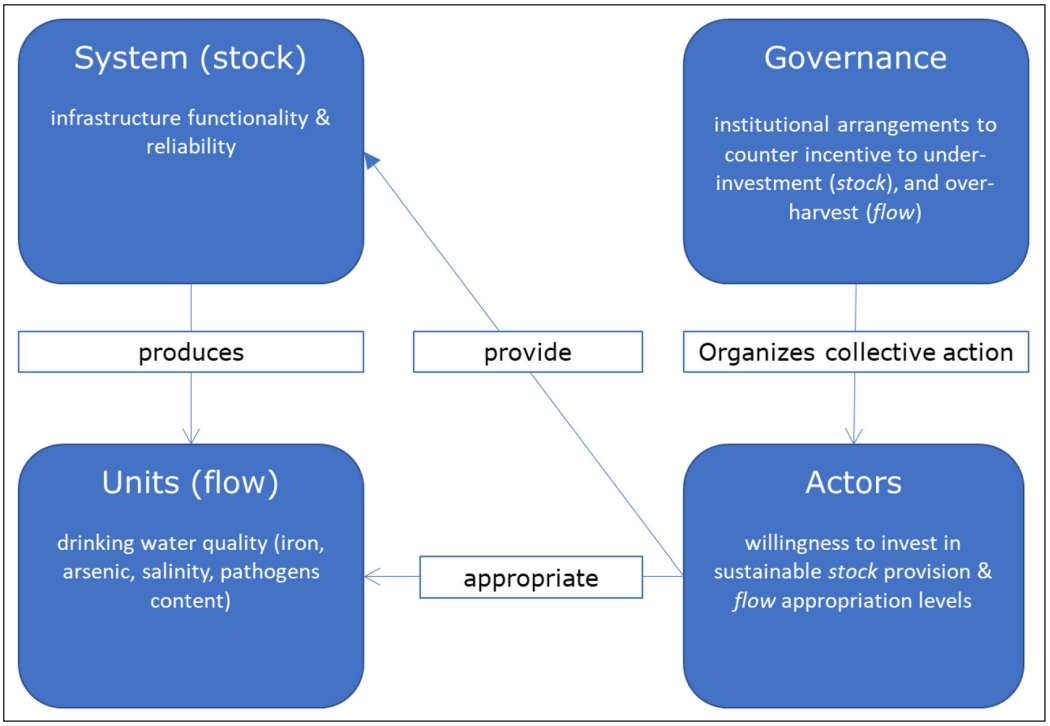

Figure 1: A system-analytical approach to governing shared resource systems (based on Ostrom, 2007).

infrastructure systems (CIS), Anderies et al. (2016) use Ostrom's design principles, the IAD and the SES framework as part of the foundation.

We, therefore, use the enabling conditions listed by Agrawal (2001) as a starting point for our analysis of collective action in the specific context of the governance of rural drinking water systems, but discard those related with *resource system characteristics* (as we assume that they do not vary across cases) and with the *relationship between the resource system and the institutional arrangements* (as the matching between harvesting and regeneration, and thus the risk of over-exploitation are not an issue with PSF[4]). Conceptually, this interpretation leads to the following (**Figure 2**).

The way in which we have clustered the enabling conditions for collective action among rural drinking water system users, and the way in which each one of the clusters is filled with a particular set of conditions in **Figure 2** (above) is mirrored in our questionnaires, as can be derived from **Table 2** (see below).

Collaboration between rural drinking water system users and a public agency

Carter et al. (1999, p.296) hold that for community management models to work, among other things, arrangements for support of community-level organization should be clearly set out. Also, Harvey and Reed (2007, p.365) holds that "[i]f community management systems are to be sustainable, they require ongoing support." Hutchings et al. (2015) and Hutching et al. (2017) provide a useful overview of the literature that have taken a stab at conceptualizing 'support' in the context of community management models. Hasan et al. (2020) show how support could come from NGOs. In this paper, we attempt to fill in an important knowledge gap in the domain of rural drinking water governance in Bangladesh (and presumably, elsewhere) by particularly looking into the interactions of a public agency (DPHE) and water users.

One of the clusters of enabling conditions proposed by Agrawal (2001, see above) regards the role of the state (under *external environment*). He mentions that (i) governments should not undermine local authority, (ii) there must be supportive external sanctioning institutions, (iii) there must be appropriate levels of external aid to compensate local users for conservation activities, and, (iv) there must be nested levels of appropriation, provision, enforcement and governance. For the analysis of our particular case, we chose to remove these conditions as we deem them to be not particularly relevant for a context of rural drinking water system governance in Bangladesh. Here, the government is the one promoting community

[4] PSF doesn't allow for the storage of drinking water, so they are unable to solve the particular problem of drinking water scarcity during the dry season. Drinking water scarcity during the dry season is not caused by the over-harvesting of water from the PSF.

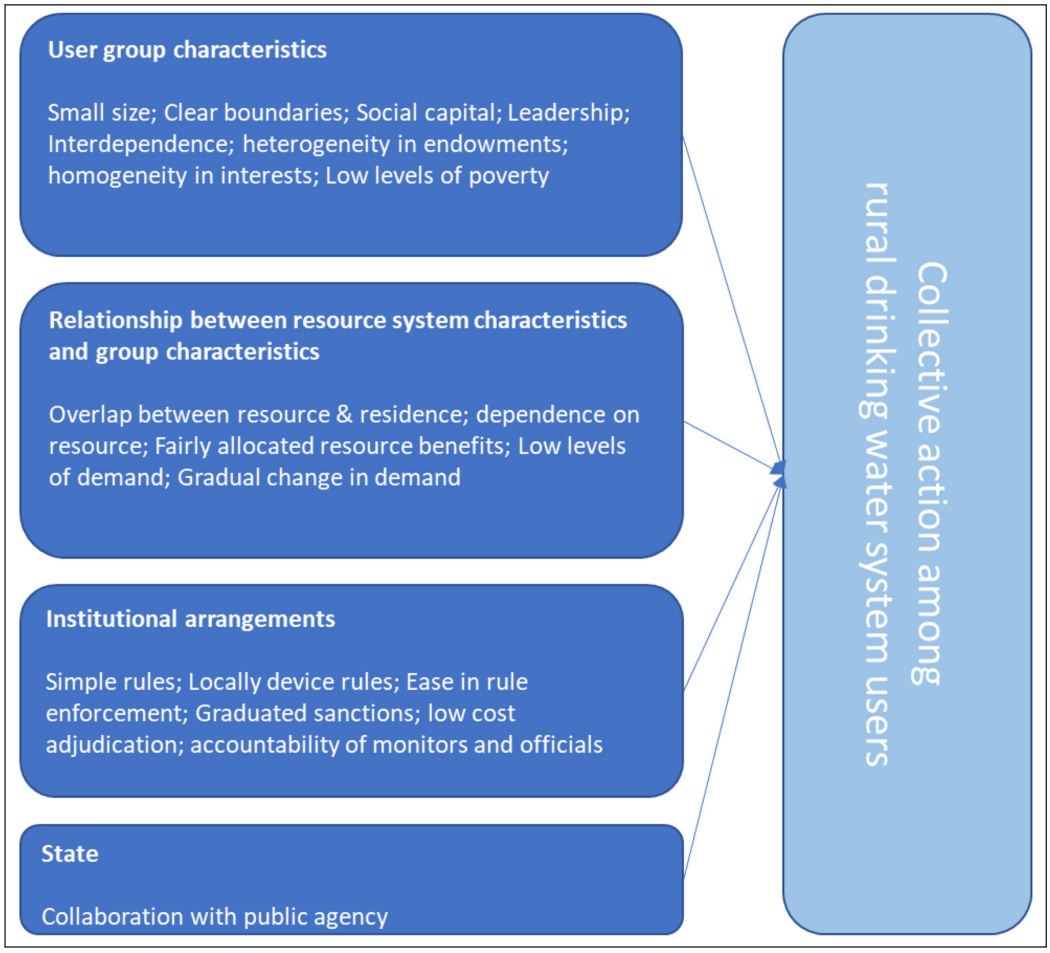

Figure 2: Conditions for collective action among rural drinking water system users (based on Agrawal (2001)).

management, so we expect that they will not undermine local authority and that they will not tolerate the breaking of rules that regard the management of such systems. Compensation for conservation activities does not apply, here.

We do however feel that *the state* can be expected to play a role in determining the success of rural drinking water governance and will, therefore, seek to specify the enabling conditions for collaboration between rural drinking water system users and public agencies. In an attempt to tease out the enabling conditions for collaboration between rural drinking water system users and public agencies we look at clusters of conditions related to *user group characteristics* (see Agrawal, 2001), *public agency characteristics* (technical capacity, human and financial resources), the *relationship between RSDS users and the public agency* (trust, communication), and the *institutional arrangements* (inclusive decision-making, clarity on tasks and responsibilities, and transparency) (Ansell and Gash, 2008; Huxham, 2003). This interpretation leads to the following conceptual model (**Figure 3**).

The way in which we have clustered the enabling conditions for collaboration between the agency (DPHE) and the PSF users, and the way in which each one of the clusters is filled with a particular set of conditions in **Figure 3** (above) is mirrored in our questionnaires, as can be derived from **Table 4** (see below).

3. Methods

The study employs a comparative case study approach. It was conducted in the Southwestern coastal areas of Bangladesh which is characterized by drinking water scarcity due to salinity intrusion, arsenic contamination, tidal surges, and drought (Mahmuduzzaman et al., 2014). Hoque (2009) finds that in this area between 15–30 million people lack year-round access to safe drinking water. The main sources of drinking water are surface water from ponds, pond sand filters (PSF), and rain water harvesting systems (RWHS). Often, neither shallow nor deep tube-well pumps are feasible due to a lack of suitable aquifers at reasonable depths (Hoque et al., 2004). To keep control variables constant, we focus on one particular

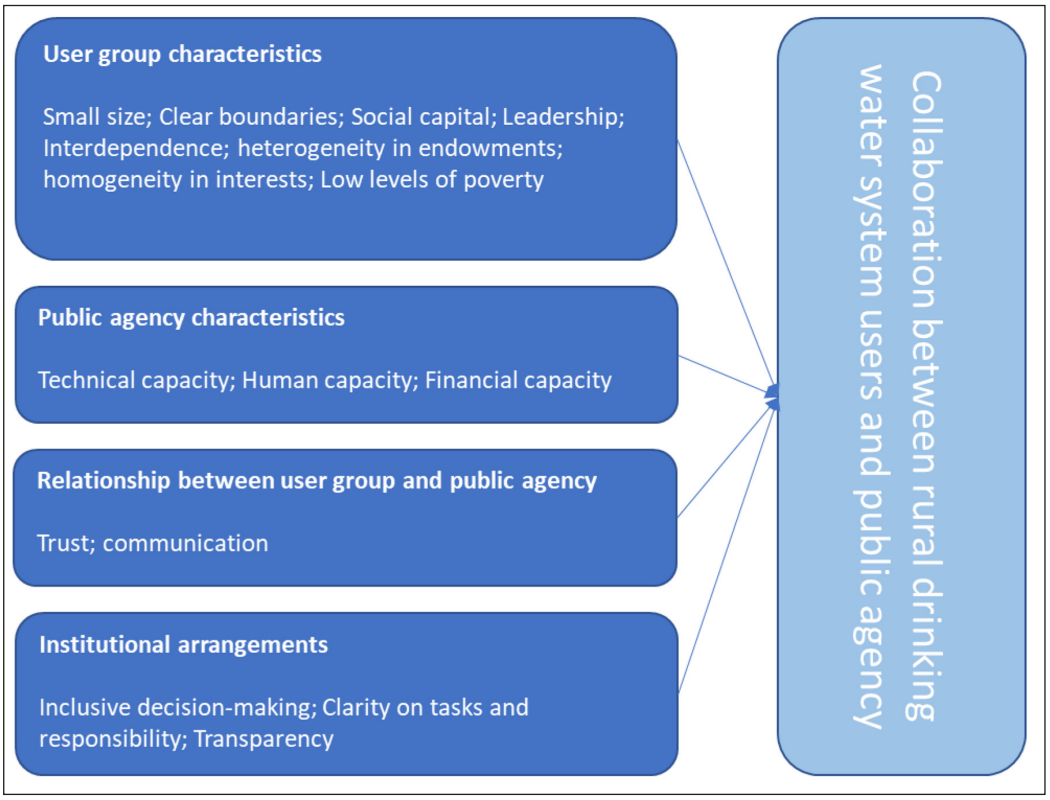

Figure 3: Conditions for collaboration between rural drinking water system users and public agency (based on Agrawal (2001), Ansell & Gash (2008), and Huxham (2003)).

rural drinking water system, namely pond sand filter (PSF). We consider this to be explorative rather than explanatory research that serves scoping purposes, more than anything else. The objective therefore is to generate rather than to robustly test hypotheses. Favoring depth over breadth we work with a (limited) sample of 30 cases, only.

We developed an interview topic list with the specific aim of operationalizing the enabling conditions for (i) *collective action among PSF* users and (ii) *collaboration between PSF users and the public agency*. Separate topic lists were used with different types of respondents (i.e. PSF users and DPHE officials), in particular, the topic list for DPHE officials contained questions on the agency's perceived capacity. The topic lists came accompanied by prompts and examples for the interviewer to use in case respondents seemed to have problems understanding or interpreting the questions as we intended.[5]

We selected a sample of 30 PSF sites as follows. As no complete and accurate list of PSF sites is available, we could not rely on random sampling, but had to resort to purposive sampling, instead. Based on the time and the resources at our disposal, and on the length of our questionnaire, we established we could include 30 sites in our study. In order to account for variation in DPHE support, we first selected 3 districts in the Southwestern coastal zone of Bangladesh from which to sample: Khulna, Bagerhat, and Satkhira. As districts overlap with DPHE jurisdictions, this would allow us to capture the potential impact of varying capacities of DPHE on the relation of the agency with PSF users. We then proceeded to select three *unions*, the lowest tier of local government in Bangladesh – one union in each one of the selected districts: Dacope (Khulna), Dhopakhali (Bagerhat), and Ishwripur (Satkhira). In each union, we selected a sample of 10 PSF sites. These 10 sites accounted for between 11–24% of all PSF sites in the respective unions in our sample. Close to similar conditions between the unions in terms of drinking water scarcity, and socio-economic, geographic, and climatic conditions helped us to keep intervening control variables as constant as possible.

Data was collected in November-December, 2018. Per site, we conducted one structured interview with the local user group (with 8–12 users including PSF user committee members – see the introduction, paragraph 1) (i.e. 30 group interviews in total), and with 6 key informants pertaining to the relevant branches of the

[5] The questions on these topic list are reproduced in **Tables 1–4**. The specific questions for DPHE representatives that were used for this study regards the questions about technical capacity, human resources, and financial resources (see **Table 4**).

relevant public agency (i.e. the Department of Public Engineering and Health, DPHE), that had the PSF site in question falling under its jurisdiction.

We pre-tested the topic list aimed at PSF users in eight communities that were part of our sample. The topic list meant for DPHE officials were pre-tested at the level of the districts from which our sample of unions was drawn. Pre-testing didn't lead to changes in the original design of the topic list.

In the group discussions with PSF users, answers to the questions from the interview topic list were generated by consensus. Reaching consensus on answers was facilitated by the interviewer who made sure that the discussion about a question wasn't dominated by the group's leadership. The interviewer always explicitly sought to include the opinion of female participants. With few exceptions, groups were able to formulate consensus-based responses.

All interviews were recorded on a digital voice recorder. Additionally, data was collected by reviewing official documents, field reports, and annual reports collected from the DPHE office, Upazila Parishad, and Union Parishad. By relying on these various sources and methods we are confident that the reliability of our data and the validity of our results have not been significantly compromised.

We first compare the group of PSF sites *with evidence* of moderate to strong collective action with the group of sites *with no evidence* of collective action in terms of their average scores on the variables from our framework (**Figure 2**). We then compare the group of PSF sites *with evidence* of collaboration between the users and DPHE with the group of PSF sites *with no evidence* of such forms of collaboration in terms of their average scores on variables from our framework (**Figure 3**). The purpose of this comparison is to explore if we can begin to understand variation in (i) collective action between the users of a shared PSF system and in (ii) collaboration between PSF users and the public agency. We do this using a quasi-experiment, with ex-post data collection and analysis.

Due to the relatively low number of observations (n = 30), we are unable to perform regressions. As we compare two groups (i.e. PSF sites with vs. sites without collective action or collaboration) in terms of their average scores on a set of binary categorical measures, we calculated Chi^2 coefficients, instead. We first report a summary of the results from which the distribution of the scores on the variables across both groups can be easily derived. We then proceed to present the results of the Chi^2 tests.

4. Results

Enabling conditions for collective action among Pond Sand Filter users

We established the level of collective action among PSF users in the following way (**Table 1**).

The resulting scores for collective action among PSF users were correlated with the scores for each one of the enabling conditions for collective action suggested in the literature on the governance of shared resources. The results of the correlation analysis are reported in **Table 2**.

Table 1: Calculation of collective action among PSF users.

Questionnaire question	Distributions of the answers	
1. Do or did you have a user committee?	Yes:	13
	No:	17
2. Does or did the user committee actually meet?	Yes:	6
	No:	24
3. Are maintenance and operation tasks shared among all members or out-sourced to one person?	Shared:	6
	Out-sourced:	24
4. Have multiple group members made contributions to cover part of the installation costs, or are these costs covered by one single member	Multiple members	8
	Single member	22
5. Do or did multiple group members contribute to cover costs related to maintenance and operation, or where/are these costs covered by one single member	Multiple members	17
	Single member	13

Determining Collective Action Variable Value:

- Add scores for indicators 1–5
- Sum = 0–1: no or weak collective action (0)
- Sum = 2–5: moderate or strong collective action (1)

Table 2: Correlation results for collective action among PSF users.

Enabling conditions for collective action among PSF users	Interview question	Answer categories	Frequency Collective action = moderate/ high (n = 14)	Frequency Collective action = weak/ absent (n = 16)	Pearson Chi²	Sign. (2 tailed)
User group characteristics						
1. Small size	How many households are (were) allowed to use this PSF?	0 = >100 1 = ≤100	0 = 12 1 = 2	0 = 7 1 = 9	5.662	0.017**
2. Clearly defined boundaries	Is it clearly defined who is allowed to use the PSF?	0 = no 1 = yes	0 = 14 1 = 0	0 = 16 1 = 0	n.a.	n.a.
3. Past successful experiences—social capital	How many types of collective action (not related with PSF) did the community engage, previously? (shrimp farming, cooperative, irrigation, mosque construction, canal excavation, river embankment, and/or other)	0 = 0–1 1 = 2–4	0 = 8 1 = 6	0 = 6 1 = 10	1.158	0.282
4. Appropriate leadership—young, familiar with changing external environments, connected to local traditional elite	Does or did the user group have appropriate leadership? (composed from the answers to questions about capacity, connectedness, and fairness of leader)	0 = no 1 = yes	0 = 3 1 = 11	0 = 8 1 = 8	2.625	0.105
5. Interdependence among group members	The members of user group depend on each other's contribution for well-functioning of PSF (composed of the answers to questions about interdependence regarding money, knowledge and labor)	0 = weak 1 = strong	0 = 2 1 = 12	0 = 11 1 = 5	9.020	0.003***
6. Heterogeneity of endowments	There are members that can step up to cover unforeseen costs	0 = no 1 = yes	0 = 0 1 = 14	0 = 3 1 = 13	2.917	0.088*
7. Homogeneity of identities and interests	All the members of user group have the same background in term of political identity (note: no variation observed with regard to ethnic and religious heterogeneity)	0 = no 1 = yes	0 = 4 1 = 10	0 = 3 1 = 13	0.403	0.526
8. Low levels of poverty	All the members of user group are capable to pay the contributions required for the installation of PSF (note: for all sites it was indicated that everyone is able to contribute to maintenance and operation)	0 = no 1 = yes	0 = 11 1 = 3	0 = 11 1 = 5	0.368	0.544
Relationship between resource system characteristics and group characteristics						
9. Overlap between user group residential location and resource location	How much time users have to spend on collecting water?	0 = >.5h 1 = ≤.5h	0 = 6 1 = 8	0 = 5 1 = 11	0.433	0.510

(Contd.)

Enabling conditions for collective action among PSF users	Interview question	Answer categories	Frequency Collective action = moderate/ high (n = 14)	Frequency Collective action = weak/ absent (n = 16)	Pearson Chi²	Sign. (2 tailed)
10. High levels of dependence by group members on resource system	What is/was the most important drinking water source during the dry season for the user group members?	0 = not PSF 1 = PSF	0 = 1 1 = 13	0 = 8 1 = 8	6.531	0.011**
11. Fairness in allocation of benefits from resource system	Do you think that fairness is maintained in the allocation of PSF water among the user group?	0 = no 1 = yes	0 = 2 1 = 12	0 = 1 1 = 15	0.536	0.464
12. Low levels of user demand	What is the estimated total quantity of drinking water (liter) used by a household on average per day?	0 = >40 liters 1 = ≤40 liters	0 = 4 1 = 10	0 = 4 1 = 12	0.049	0.825
13. Gradual change in levels of demand	Did the demand for PSF water increase sharply over the last few years?	0 = yes 1 = no	0 = 1 1 = 13	0 = 1 1 = 15	0.010	0.922
Institutional arrangements						
14. Rules are simple and easy to understand	Are the rules formulated in a clear way such that everybody understands and applies them in the exact same way?	0 = no 1 = yes	0 = 1 1 = 13	0 = 3 1 = 13	0.871	0.351
15. Locally devised access and management rules	Who formulated the working rules for PSF usage and management?	0 = others 1 = users	0 = 5 1 = 9	0 = 11 1 = 5	3.274	0.070*
16. Ease in enforcement of rules	Do or did you experience difficulties enforcing the rules that apply to PSF usage and management?	0 = yes 1 = no	0 = 8 1 = 6	0 = 7 1 = 9	0.536	0.464
17. Sanctions	Do you have rules that regard the sanctioning of rule breaking?	0 = no 1 = yes	0 = 10 1 = 4	0 = 8 1 = 8	1.429	0.232
18. Availability of low-cost adjudication	Do you have a mechanism to settle internal disputes related with PSF?	0 = no 1 = yes	0 = 6 1 = 8	0 = 9 1 = 7	0.536	0.464
19. Accountability of monitors and other officials to users	Do you have a mechanism to hold monitors and user committee members accountable?	0 = no 1 = yes	0 = 12 1 = 2	0 = 14 1 = 2	0.021	0.886
State						
20. Collaboration with public agency	Do or did you collaborate with the Department of Public Health and Engineering (DPHE)? (composed of answers to questions about DPHE support with regard (i) PSF installation, (ii) formation of a user committee, and (iii) repairs) (see table 4, below)	0 = no 1 = yes	0 = 3 1 = 11	0 = 11 1 = 5	6.718	0.010**

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.00$.

Enabling conditions for collaboration between PSF users and DPHE

The level of collaboration between PSF users and the DPHE – was established in the following way (**Table 3**).

The resulting scores for collaboration between PSF users and DPHE were corelated with the scores for each one of the enabling conditions for collective action suggested in the literature on the governance of shared resources. The results of the correlation analysis are presented in **Table 4**.

These results seem to point to the fact that the variables that are claimed to affect the patterns of interactions and outcomes in the generic literature on the governance of shared resource systems, in some ways do but in others don't appear to be applicable to the shared local drinking water systems in particular. Tentatively and in broad strokes, we would conclude that our results hint at the importance of (i) interdependence among group members, (ii) a high level of dependence of the users on PSF, and (iii) the presence of collaboration with the public agency (DPHE) for the organization of collective action among PSF users. The establishment of meaningful collaboration between PSF users and the public agency appears to be helped by (i) interdependence among group members, (ii) trust between PSF users and public agency representatives, and (iii) transparency in decision-making and operation. We will now proceed to discuss these and other outcomes in more detail.

5. Discussion and conclusion

Discussion of the findings

Collective action among Pond Sand Filter users

With regard to our analysis of the enabling conditions for collective action among the users of PSF, it is striking that none of the 30 sites we studied had installed boundary rules, i.e. they did not deny access to persons that did not belong to the user group, and that consequently had not contributed to installation, operation and/or maintenance costs. In their study of the introduction of another drinking water technology (i.e. managed aquifer recharge or MAR) in the same area, Hasan et al. (2020) find that social norms prevent the formulation of rules that would restrict access to drinking water points. Still, setting boundaries for a shared resource is among the strongest predictors of successfully solving provision and appropriation dilemmas (Cox et al., 2010).

It is furthermore notable that for all sites we find PSF users reporting that they have the financial means to contribute to operation and maintenance of the PSF – at 73% of all PSF sites in our study users indicate that they also have the means to contribute to the installation of the infrastructure. Contrary to conventional wisdom, PSF failure is largely unrelated to the inability to pay for it. There is of course a distinction between having the means and using them, as studies on willingness-to-pay have shown (e.g. Dey et al., 2018).

Somewhat unexpected is the direction of the significant association between group size and the occurrence of collective action among the PSF end-users. Were we would tentatively assume that smaller groups increase the chance of interaction and hence the building of trust between individuals (which in turn would lower the transaction costs associated with collective action) (Poteete and Ostrom, 2004), we find that in our set larger groups show signs of collective action significantly more often than smaller groups. This may be related to efficiency gains resulting from economies of scale (Van Laerhoven, 2010) – i.e. when fixed operation costs (e.g. the payment of a caretaker) are spread over a larger group, the per person contribution drops.

Table 3: Calculation of collaboration between PSF users and public agency (DPHE).

Questionnaire question	Distributions of the answers	
DPHE collaborated with regard to the installation of the PSF	Yes	12
	No	18
DPHE collaborated with regard to the formation of an operation and maintenance committee	Yes	6
	No	24
DPHE collaborated with regard to repair and maintenance activities	Yes	4
	No6	26

Determining Collaboration Variable Value:

- Add scores for indicators 1–3
- Sum = 0 = no collaboration (0)
- Sum = 1–3 = moderate or strong collaboration (1)

Table 4: Correlation results for collaboration between PSF users and public agency (DPHE).

Enabling conditions for collaboration between users and public agency	Interview question	Answer categories	Frequency Collaboration = moderate/ strong (n = 16)	Frequency Collaboration = absent (n = 14)	Pearson Chi^2	Sign. (2 tailed)
User group characteristics						
1. Small size	How many households are (were) allowed to use this PSF?	0 = >100 1 = ≤100	0 = 10 1 = 6	0 = 9 1 = 5	0.010	0.919
2. Clearly defined boundaries	Is it clearly defined who is allowed to use the PSF?	0 = no 1 = yes	0 = 16 1 = 0	0 = 14 1 = 0	n.a.	n.a.
3. Past successful experiences—social capital	How many types of collective action (not related with PSF) did the community engage, previously?	0 = 0–1 1 = 2–4	0 = 8 1 = 8	0 = 6 1 = 8	0.153	0.696
4. Appropriate leadership	Does or did the user group have appropriate leadership?	0 = no 1 = yes	0 = 4 1 = 12	0 = 7 1 = 7	2.010	0.156
5. Interdependence among group members	The members of user group depend on each other's contribution for well-functioning of PSF	0 = weak 1 = strong	0 = 3 1 = 13	0 = 10 1 = 4	8.438	0.004***
6. Heterogeneity of endowments	There are members that can step up to cover unforeseen costs	0 = no 1 = yes	0 = 1 1 = 15	0 = 2 1 = 12	0.536	0.464
7. Homogeneity of identities and interests	All the members of user group have the same background in term of political identity	0 = no 1 = yes	0 = 2 1 = 14	0 = 5 1 = 9	2.249	0.134
8. Low levels of poverty	All the members of user group are capable to pay the contributions required for the installation of PSF	0 = no 1 = yes	0 = 12 1 = 4	0 = 10 1 = 4	0.049	0.825
Public agency characteristics						
9. Technical capacity	This DPHE branch has sufficient technical capacity to perform its tasks with regard to the PSF of this community	0 = no 1 = yes	0 = 4 1 = 12	0 = 6 1 = 8	1.071	0.301
10. Human resources	This DPHE branch has sufficient human resources to perform its tasks with regard to the PSF of this community	0 = no 1 = yes	0 = 7 1 = 9	0 = 3 1 = 11	1.674	0.196
11. Financial resources	This DPHE branch has sufficient financial resources to perform its tasks with regard to the PSF of this community	0 = no 1 = yes	0 = 7 1 = 9	0 = 3 1 = 11	1.674	0.196

(Contd.)

Enabling conditions for collaboration between users and public agency	Interview question	Answer categories	Frequency Collaboration = moderate/ strong (n = 16)	Frequency Collaboration = absent (n = 14)	Pearson Chi²	Sign. (2 tailed)
Relationship between user group and public agency						
12. Trust	We trust that DPHE will help us to operate our PSF (composed of the answers to questions about users trusting DPHE to help with running the user groups and effectuating repairs)	0 = no 1 = yes	0 = 7 1 = 9	0 = 13 1 = 1	8.103	0.004***
13. Communication	Do PSF users and DPHE communicate regularly?	0 = no 1 = yes	0 = 9 1 = 7	0 = 6 1 = 8	0.536	0.464
Institutional arrangements						
14. Inclusive decision-making	DPHE takes the opinion and interests of our user group into account	0 = no 1 = yes	0 = 0 1 = 16	0 = 3 1 = 11	3.810	0.051*
15. Clarity on roles and responsibilities	The respective tasks and responsibilities of our user group and DPHE are clear and well-understood	0 = no 1 = yes	0 = 15 1 = 1	0 = 14 1 = 0	0.905	0.341
16. Transparency	Decision-making and operation of DPHE with regard to our PSF is transparent	0 = no 1 = yes	0 = 12 1 = 4	0 = 14 1 = 0	4.038	0.044**

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.00$.

Our results hint at the importance of (i) having group members with heterogenous endowments, and (ii) having locally devised rules. The correlations are significant but not very strong. With regard to heterogeneous endowments, we observe that better-off families often play a decisive role in setting up and operating successful drinking water infrastructures. This is congruent with the argument of Olson (1965) that successful collective action may require a disproportionate effort of some. It remains to be seen if this is positive or negative, in the end: On the one hand, such families can step up when needed (and others are not able to). On the other, one could also see how over-reliance on just one person or family could exacerbate existing inequality and dependence relations (see also Vedeld, 2000). The importance of locally devised rules has been recognized as one of the crucial design principles for the successful governance of other types of shared resources, as well (Ostrom, 1990; Cox et al., 2010). It is somewhat unexpected that this correlation is rather weak in the case of PSF. We suspect that this could be related to the fact that given the low level of institutional complexity, there wouldn't be much difference between locally devised and imposed rules, anyway.

Our strongest results regard the associations of collective action among PSF users with (i) the existence of interdependence among group members, (ii) a high level of dependence of the users on PSF for satisfying their drinking water needs, and (iii) the presence of collaboration with DPHE. Our finding that interdependence among group members correlates with the occurrence of collective action in the case of PSF, coincides with earlier findings for other types of shared resources (Baland and Platteau, 1996; Wade, 1988). We find that collective action is observed significantly more often in our sample when PSF users report to having no alternative drinking water source at their disposal. The result that salience is important is in line with similar findings for other types of shared resources (e.g. Ascher, 1995; Gibson, 2001). The fact that our cases where collective action does take place do significantly more often report to collaborate with DPHE, than the cases in our sample that don't, supports the claim that community management models benefit from a *plus*. (e.g. Hutchings et al. (2015); Hutching et al. (2017); Hasan et al., 2020).

Collaboration between Pond Sand Filter users and the Department of Public Health and Engineering

What do our results tell us about the drivers of collaboration between PSF users and DPHE? A first striking result from our explorative analysis is that there is a close to total lack of clarity on the roles and responsibilities of both partners (i.e. PSF users and DPHE) with regard to PSF management. Although national policies offer guidelines, these guidelines may be too generic. They do for example not stipulate that DPHE should make an effort to create clarity on roles and responsibilities.

Apart from the interdependence between group members, none of the other conditions related to the user group characteristics[6] seem to have an effect on the presence or absence of collaboration of PSF users with DPHE. This appears somewhat counter-intuitive to us, as we would have expected that it would emerge more strongly from our study that presence or absence of collaboration depends on group characteristics.

It is furthermore striking and maybe unexpected that the characteristics of the public agency do not seem to account for variation, either. Public agency capacity in terms of human resources, financial means, and technical knowledge, is not significantly correlated with whether or not they engage in a collaborative relationship with PSF users. The natural reflex of policy makers is often to transfer resources and training to agencies in an attempt to improve agency performance. This result hints at the fact that there might be more to it (see for example Kaufmann et al., 2019).

Institutional arrangement seems to explain some of the variations. The correlation of collaboration with (i) inclusive decision-making and (ii) transparency is significant but weak. Decision-making that involves users and DPHE is perceived as being inclusive most of the time. For the three cases where respondents indicate that it isn't, we report no to weak collaboration. In most of the cases we compared, respondents report that DPHE's ways with regard to PSF are mostly not transparent. For the four cases where respondents indicate that DPHE is transparent, we report moderate to strong collaboration.

The strongest correlation we find regards the role of trust. This is very much in line with the role assigned to trust in many earlier studies on collective action in context of shared resource management (see for example Kramer et al., 1996).

[6] Group size, group boundaries, social capital, leadership, heterogeneity in endowments, homogeneity in identities and interests and poverty do al not correlate with collaboration.

Our contribution to the literature

Our findings do not diverge significantly from the results of the (relatively few) earlier studies that have framed community-based drinking water delivery systems as commons, but rather add detail and nuance. Like us, Naiga et al. (2011) use Ostrom's design principles (Ostrom 2009) and the building blocks from the IAD framework (Ostrom 2015) to guide their inquiry regarding the factors that affect the success of local collective action. Like us, they prove the validity and usefulness of a commons approach in this particular field. Like us, Naiga et al. (2011) as well as Madrigal et al. (2011) show the value of looking beyond local collective action potential and point at the need to consider the relation between user groups and external support entities, when trying to unravel the reasons behind success and failure of community-based drinking water delivery systems. The nuance and detail that we think we add regards the following.

In our opinion, our contribution to the literature is two fold. Firstly, we contribute to the commons scholarship. For their analysis, van Laerhoven et al. (2020) compiled a data set consisting of 3,452 titles, indexed by Scopus, that present studies on commons or common pool resources. Only 10 of the titles mention the term 'drinking water' in either the title, the abstract, or the keywords. In our study, we show that concepts and insights gained by commons scholars are to a certain extent applicable to shared rural drinking water systems, as well. This observation is congruent with earlier findings. For example, Van Laerhoven & Ostrom (2007) speak of "The Big 5" when discussing the disproportionate attention in the study of the commons to forests, fisheries, rangeland, irrigation system, and water (i.e. not drinking water). In our study, we show that despite the sparse attention so far, conceptually it does make sense to approach the analysis of rural drinking water systems from a commons perspective. Just as in the case of other types of commons, the users of this shared resource will need to solve appropriation, and above all provision dilemmas, in order to avoid failure and abandonment. Our study adds nuance to the generic lists of enabling conditions (Agrawal, 2001), or design principles (Cox et al., 2010) for the successful governance of the commons. Just like Baggio et al. (2016) show how enabling conditions for success vary significantly between governance arrangements for forests, fisheries, and irrigation systems, respectively, we show that also rural drinking water systems' governance responds to its particular dynamic. A dynamic according to which (for example) group size plays another than expected role, and salience (i.e. dependence on the resource) may be more important than for certain other types of commons.

The most important nuance that we add to the generic list of enabling conditions for sustainability on the commons regards the role of *the state*. This brings us to our second contribution to the literature: Our study adds to the growing understanding of how support can increase the likelihood of success of community management service models. In that sense, we build on and further develop notions put forward in the works of for example Hutchings et al. (2015), Hutchings et al. (2017), Carter et al. (1999), and Harvey and Reed (2007). Before, we have looked at how support to communities can be given by NGOs (Hasan et al., 2020). In this article, we have complemented these insights by particularly zooming in on the possible supportive role of public agencies. This supportive role differs from the general conditions listed by Agrawal (2001). Agrawal mentions that governments should not undermine local authority and must offer supportive institutions for the enforcement of rules, and the sanctioning of infractions. We make a more detailed case for what goes into a successful collaboration between drinking water system users and the state, by zooming in on the characteristics of the users and the public agency, the nature of the relation between both, and the institutional arrangements in place.

Future research

One thing that stood out in our interviews was the stark contrast between the claim in the literature that boundary rules (i.e. who can and who cannot use the system?) are key to success, on the one hand, and our respondents pointing out that local norms and values prevented the exclusion of other (non-contributing) community members, on the other. Exclusion is not only a taboo in communities, but human right organizations are also making an ever-stronger case that access to water is, in fact, a human right (e.g. Rashid, 2009). The practical implications of a rigid application of the proportionality principle in a context where the reciprocity norms of a community stretch far beyond the commons in question are worth digging into, in future research. Our literature search led to two frameworks that included *enabling factors* only. Future research may want to zoom in on factors that *hinder* collective action among resource users, and collaboration between users and support entities in a way that goes beyond looking at the effect of the absence of enabling factors.

The explorative nature of our analysis prevented us from going beyond a rather rudimentary measurement of collective action and collaboration, and the conditions that may enable these. Agrawal (2001) and Baggio

et al. (2016) have explored the importance of configurations or preconditions for success. Our attempt to replicate the approach of Baggio et al. (2016) to detect the importance of co-occurrence or configurations of indicators didn't yield significant results. Overall and also with specific regard to the possible importance of configurations, the robustness of our findings can be increased by the employment of more sophisticated statistics. For that, it is needed that the current data set gets expanded with more cases and observations. Future research may also want to look into ways to operationalize the conditions more validly (i.e. by means of other types of questions), or more nuancedly (i.e. by means of other than binary scales). The biggest challenge we see regards the unpacking of trust as a predictor of collaboration between rural drinking water systems and public agencies. We acknowledge that in our current explorative analysis it remains unclear for example what the causal direction might be (i.e. does trust 'cause' collaboration, is it the other way around, or a bit of both?). Untying this knot is important, as the presence of public agency support appears to contribute importantly to the success of a rural drinking water system.

Our recommendations for champions of rural drinking water systems

Based on our findings, we would recommend the following to those involved in rural drinking water provision in Bangladesh or similar regions, elsewhere in the world. It appears to us that in spite of the apparent reluctance to do so, attempts should be made to set boundary rules that determine who can use the system. This is important to guarantee that benefits associated with appropriation (access to water) are proportional to provision costs (i.e. contributions to the operation and maintenance of the system). Second, form user groups that are large enough to achieve economies of scale – i.e. there should be enough members to pool the money needed for covering (unanticipated spikes in) operation and maintenance costs. Third, as working together is something you can learn, it would make sense to form groups with members that collaborated for other types of purposes, before. Fourth, make sure that your attempt to introduce a new and improved drinking water system is demand rather than supply-driven – i.e. the system you bring should be salient to the prospective users. Fifth, involve the users of the drinking water system in the crafting of all rules regarding its governance – i.e. both the operational and the collective choice rules. Finally, guarantee that a community management model can rely on a *plus*, i.e. a safety net in the form of support from (for example) a public agency. And in doing that, invest enough effort and time in creating trust between the users and the entity that is to support their community management endeavor, and in transparency with regard to the making and enforcing of rules.

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Competing Interests

One of the co-authors of this article, Frank van Laerhoven, is a co-editor-in-chief of this journal. In compliance with journal policy, he has had no role whatsoever in quality assessment and, subsequently, editorial decision making.

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