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Is the Co-Management of Water Supply Facilities Possible in Rural Bangladesh?: Analyses of a caretaker system and water users' participation

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Abstract

Rural areas of Bangladesh face safe water supply challenges. In addition to traditional hard infrastructural issues related to design and construction, such challenges are caused by soft infrastructural issues like the underdevelopment of the institutional system required for the adequate operation and maintenance (O&M) of infrastructure.

This paper aims to analyze the caretaker system for O&M that has been widely adopted in rural areas of Bangladesh and to discuss the possibility of co-managing O&M activities between caretakers and other water users. Interviews were conducted to investigate the awareness and perceptions of caretakers and other water users in the Gazipur, Khulna, and Chattogram districts, as well as that of the Department of Public Health Engineering (DPHE) personnel. DPHE is the government agency responsible for water supply services in rural Bangladesh.

From the institutional system perspective, as defined by DPHE, caretakers bear full responsibility for the O&M of their water supply facilities. However, many caretakers do not conduct comprehensive or sufficient O&M activities due to insufficient awareness, technical capacity, and financial limitations. As an on-the-ground response to this situation, some caretakers expressed a willingness to co-manage their facilities with other water users. This trend is especially prevalent for "alternative water supply options," defined in this study as arsenic iron removal units and small-scale piped water supply systems. In addition, 38% of the target water supply facilities under this study were used by different *gushuti* (extended paternal families), particularly in the case of alternative water supply options.

The results of this study indicate that the following factors can be correlated with whether a caretaker would choose to adopt a co-management system: (1) whether multiple gushutis are using the water supply facility, (2) the complexity of the required O&M activities, and (3)

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the cost burden of the O&M activities.

Further, this study identified the limitations of the on-the-ground responses. DPHE has not fully established the institutional structures necessary to support the caretakers and water users. Such structures could include setting clear regulations, exchanging documents and information, building consensus, and providing technical support for the water supply facilities' ownership, handover, and O&M activities. Official collaboration and establishing protocols among DPHE, caretakers, and water users are required to strengthen the implementation of O&M activities and solve facility-level technical problems.

One potential solution for the cost burden issue is tariff collection, a shared responsibility among caretakers and water users. Many water user interviewees indicated a willingness to pay. However, their proposed amount was relatively low compared to that identified in other studies. In situations where donors had made water tariff interventions, the amount users were willing to pay tended to be higher. This implies that collecting water fees from users may be possible if awareness is raised.

Key words: water supply; operation and maintenance; co-management; Bangladesh

1. Introduction

Access to safe drinking water is essential for achieving basic human rights (United Nations 2010). Therefore, the supply of safe drinking water is high on the public interest scale. This study focuses on the operation and maintenance (O&M) of water supply facilities, which are crucial for a sustainable drinking water supply. It investigates a practical O&M system of water supply facilities in Bangladesh, which has historically lacked co-management implementation among users. In particular, the study determines the current O&M system (caretaker system) adopted throughout Bangladesh and discusses the possibility of a co-management O&M style.

1–1. Situation of the safely managed water supply in Bangladesh

Following the discovery of arsenic contamination of groundwater in Bangladesh in the 1990s, organizations such as government agencies, development donors, and NGOs have been implementing various activities to supply arsenic-free water. In 2016, Target 6.1 ("By 2030, achieve universal and equitable access to safe and affordable drinking water for all") of the Sustainable Development Goals (SDGs) was set, with "safely managed water" defined as in Table 1. In response to these international trends, the Bangladeshi government established a national target of 75% of the population having access to safely managed water by 2025 (GoB 2020).

According to the Multiple Indicator Cluster Survey data (UNICEF 2019), 42.6% of the population have access to safely managed water, below the national target. Report data suggested that water quality was a significant impediment to this target, especially fecal contamination rather than arsenic contamination (UNICEF 2019). In general, the causes of fecal contamination at water sources are hard infrastructural issues, such as inappropriate site selection, design, and construction, and soft infrastructural issues, such as negligence and water pollution, given inappropriate O&M of water supply (WEDC 2010).

1–2. Water supply facilities in Bangladesh

Before discussing the O&M of water supply facilities, we would like to confirm the facilities commonly installed in Bangladesh. The water supply system in Urban areas such as the capital of

Table 1.

Definition of "safely managed drinking water."

(1) A water source is an 'improved' source (e.g., piped water, boreholes or tubewells, protected dug wells, protected springs, rainwater, water kiosks, and packaged or delivered water). (2) A water source is 'accessible on premises.' (3) Water is 'available when needed.' (4) Water is 'free from fecal and priority chemical contamination.'

Source: WHO & UNICEF 2019

Table 2.

Public water supply facilities commonly installed in rural areas of Bangladesh.

Water supply facility			Characteristic
Point-source water supply facility	Tubewell	Shallow tubewell (STW)	It is a well for extracting groundwater and is the main water supply facility installed throughout Bangladesh. The facilities are broadly divided into shallow (depth of less than 60 m) and deep (depth of more than 60 m) wells. Deep wells are constructed as a measure against arsenic. Hand or electric submersible pumps are installed to pump water. The necessary O&M is mainly pump repair.
	Alternative water supply options	Deep tubewell (DTW)	
		Arsenic iron removal plant (AIRP)	In this water supply facility, arsenic and iron in groundwater are coprecipitated by oxidization while passing through a water channel in the facility, after which a slow sand filter removes sediment to obtain potable water. O&M requires pump repair, periodic cleaning, and replacement of water channels and sand filters.
Piped water supply facility		Small piped water supply system (SPWSS)	This facility's primary water source is groundwater, extracted from a tubewell using an electric pump. Pumped water is collected in an elevated tank and distributed through a water supply pipe by gravity. Multiple public tap stands are often installed, or water is supplied to each household. O&M includes tasks such as repairing pumps and electronic controls, cleaning tanks, and repairing leakage of water pipes.

Source: Created by the author, based on DPHE and Japan International Cooperation Agency (JICA) 2021

Dhaka is mainly a piped water supply system, in which water is purified and distributed to each household by pipeline, as is the case in Japan. Rural areas commonly use point-source water supply facilities,[1)] such as tubewells with hand pumps and "alternative water supply options."[2)] In recent years, small piped water supply facilities have been installed in the center of rural areas. The water supply facilities in rural areas of Bangladesh are mainly constructed by the Department of Public Health Engineering (DPHE), an external agency of the central government. Subsequently, they are transferred to residents for use. Table 2 details the water supply facilities constructed by DPHE covered in this paper. Other examples include dug wells that use surface groundwater as a water source, pond sand filters that remove organic matter from pond water sources by a slow sand filter, and rainwater harvesting that uses rainwater as a water source.

1–3. Operation and maintenance system of Water supply facilities in rural areas

Bangladesh's policy adopted a water user participation approach with cost-sharing among them for O&M of water supply facilities in rural Bangladesh to secure sustainable and equitable drinking water (GoB 1998). A user participation approach for O&M of water supply facilities has been the mainstream

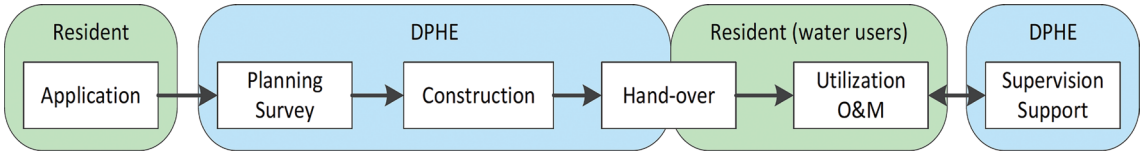


Figure 1.
Flow from water supply construction to utilization

method worldwide since the 1990s. The 1992 Dublin Statement stated as one of its principles, "water development and management should be based on a participatory approach, involving users, planners, and policy-makers at all levels" (United Nations 1992). Moreover, Target 6.b of the SDGs states: "Support and strengthen the participation of local communities in improving water and sanitation management." Additionally, the World Water Vision 2025 in 2000 recommended that water users bear the cost of water supply facility O&M (World Water Council 2000). Therefore, O&M costs are generally collected from water users as tariffs. Accordingly, Bangladesh is adopting O&M methods that follow global trends.

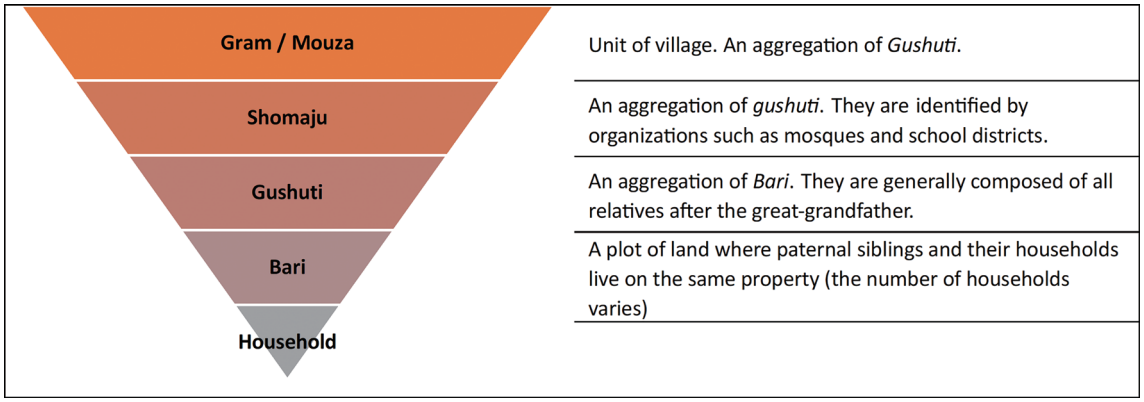
In rural Bangladesh, residents apply for the construction of water supply facilities through local government institutions, with the DPHE planning and conducting surveys before construction. Subsequently, constructed water supply facilities are handed over to users who begin using them (Figure 1).

The O&M system in rural Bangladesh involves one representative water user becoming a caretaker, who is then solely responsible for all O&M activities, including the cost burden. There are hardly any collaborative O&M activities with the participation of water users other than caretakers.

Many water supply facilities have not been properly managed and, in many cases, have been confirmed to be abandoned after a breakdown. For example, of the approximately 970,000 public alternative water supply facilities installed nationwide by 2009, 29% are reportedly out of operation (DPHE and JICA 2010). Additionally, in Chaugachha Upazila, Jessore District, two years after construction, 60% (n=170) of water supply facilities were abandoned after their breakdown (Sawahashi, 2014). Furthermore, in Jessore District, of the 567 alternative water supply facilities, only 45% met water quality standards and were properly managed (UNICEF and JICA 2005). Thus a relatively high percentage of constructed water supply facilities are being abandoned, including pollutied ones.

2. Problem setting and previous research

Considering the functionality status of the water supply facilities described above, it may be impractical for the current caretaker to solely conduct all O&M activities, including cost-sharing, solely. Following global trends, concepts such as "user participation" and "stakeholder involvement" have been adopted. Moreover, it may be better to consider introducing a method by which multiple people share O&M responsibilities to improve the high abandonment rate of water supply facilities and alleviate



(Source: created by the author, based on interviews with DPHE staff)

Figure 2.

Village composition

water pollution.

In that case, could O&M implementation in which multiple people share responsibility and jointly conduct O&M activities in Bangladesh, where caretakers have solely implemented O&M so far? To consider this possibility, the characteristics of Bangladeshi communities and the history of caretaker appointments need to be reviewed.

Union Parishad is the smallest administrative boundary in rural areas. However, there are villages under Union Parishad which are divided by geographical elements. A village is called a *gram* or *mouza* and is structured as in Figure 2.

The smallest local unit of a village is called *bari*. It is generally a plot of land where paternal brothers and their households live on the same property. Therefore, the number of households in a *bari* varies per the number of brothers. Next, several *baris* form a *gushuti*, generally consisting of relatives from the same great-grandfather. Further, the assembly of some *gushutis* forms a *shomaju*, usually identified by elements such as a mosque or school borders. Therefore, *gushuti* may comprise only paternal relatives or residents with different kinship backgrounds, such as multiple paternal relatives or other households (per interviews with DPHE staff).

In Bangladesh, the *gushuti*, a group of paternal relatives with the same great-grandfather, is recognized as a social unit; moreover, the *shomaju* conducts conflict resolution and religious activities, given its characteristics (Tani 2004). Nevertheless, despite the strong ties of paternal relatives and the *shomaju*'s implementation of communal roles, there is no formal or informal leadership in rural areas. Furthermore, Bangladeshi society lacks the concepts of cooperation and unity and mainly follows pragmatic individualism; cooperative organizations are challenging to function (Maloney 1988; Fujita 1998). Therefore, although organizations have been established through microfinance and international organizations' activities since the 1990s, voluntary community activities are rarely conducted by residents (Murayama 2000).

Considering the characteristics of Bangladesh from the perspective of facility ownership, there is

(Source: created by author)

Figure 3.
Target districts

generally a specific owner for a facility. There is less awareness of the cooperativity of the area and publicness and fairness for the use of water supply facilities in rural areas. Thus, only some facilities are recognized as common properties for collaborative management (Tani 2001; Tsutsui and Tani 2009). Moreover, the Muslim culture of Bangladesh has a custom of one-way gifts (Nishikawa 1994); thus, it may be challenging to share responsibility.

Meanwhile, according to the OECD (2020), household water tariffs are 2–6% of their disposable income, and similar results were reported in Bangladesh. The survey conducted at alternative water supply facilities in rural Manikganj District showed their willingness to pay was 2.3% of the average income (Manago et al. 2011).

In response to the prior literature review, this study aims to ascertain the current state of the caretaker system in rural Bangladesh to discuss the possibility of co-managing O&M among caretakers and other water users and factors that could increase its likelihood.

3. Research method

3–1. Survey area

In Bangladesh, there are challenges to groundwater use, such as arsenic contamination groundwater

Table 3.

Survey subjects

Target region	Target facility	Subjects
DPHE	—	Headquarters: 5 people Upazila office: 3 people
Khulna District (Dumria Upazila)	Deep tubewell (DTW): 7 facilities Shallow tubewell (STW): 1 facility Arsenic iron removal plant (AIRP): 2 facilities	Caretakers: 10 people Water users: 30 people (breakdown: 19 men, 21 women)
Gazipur District (Kaliakoir Upazila)	STW: 6 facilities DTW: 3 facilities Small piped water supply system (WPWSS): 2 facilities	Caretakers: 11 people Water users: 25 people (breakdown: 13 men, 23 women)
Chattogram District (Anuwara Upazila)	DTW: 8 facilities	Caretakers: 8 people Water users: 24 people (breakdown: 13 men, 17 women)

decline caused by excessive pumping due to population growth. Target areas—Khulna, Gazipur, and Chattogram Districts (Figure 3)—were selected from the western, central, and eastern regions, respectively.

3–2. Survey methods and subjects

The study surveyed staff at the DPHE headquarters and district officers responsible for the construction and supervision of public water supply facilities and water users. There are 1,096 engineers at the DPHE (DPHE 2021), and five headquarters staff and three Upazila office staff (one each in three Upazila) were interviewed. DPHE staff were interviewed on how to appoint caretakers and how to hand over water supply facilities to water users.

Regarding water users, a total of 108 water users at 29 water supply facilities were targeted in the three districts. Two to four water users (including the caretaker of each facility) per facility were interviewed (see Table 3). The interviewees of the water users beyond the caretakers were selected from adults who came to fetch water at the time of the survey. We conducted semi-structured interviews with the survey subjects on the status of the water supply, the willingness to implement O&M for the water supply facility, and the economic circumstances of households.

This survey was conducted through JICA's technical cooperation project, which the author (Kadokami) joined as a consultant. In addition, local travel has not been allowed since the terrorist attack in 2016. Thus, the field surveys and interviews with water users were conducted through DPHE staff.

4. Survey results

4–1. Interview results at the Department of Public Health Engineering

4–1–1. Caretaker appointment and facility handover methods

According to the DPHE staff, the DPHE newly introduced the caretaker system following Bangladesh's independence from Pakistan in the 1970s. To construct a new water supply facility, ten households must make an official request by submitting an application letter and contribute a partial construction cost and land. Therefore, a (male) representative of the household providing the land is generally appointed as the caretaker. The household providing the land is wealthier than other households and typically contributes both land and construction costs. Thus, it is common for wealthy family representatives to be appointed caretakers. Although this appointment method is customary, it is not documented.

After construction, water supply facilities are handed over from the DPHE to water users. However, there is no administrative procedure for this handingover process. DPHE officials noted that O&M training and other water users' involvement in O&M were hardly conducted. They pointed that there are some cases that some projects exchange documents for facility handover and provide O&M training. Additionally, there was no clear legal provision regarding property ownership.

4–1–2. Awareness relating to the operation and maintenance of target facilities

The DPHE understood that the caretakers generally conducted O&M of the water supply facilities. The DPHE did not mind whether other water users supported the caretaker for O&M implementation. A core breakdown of tubewells is a cylinder part inside a hand pump. Tubewells are widely installed nationwide in Bangladesh. Thus, private technicians can repair them at a relatively low cost. Therefore, the DPHE recognized that the tubewell O&M was not a problem for caretakers.

Meanwhile, arsenic iron removal plants (AIRPs) and small piped water supply systems (SPWSSs) have simple water treatment facilities such as sand filters. Periodic maintenance is required (e.g., cleaning channels and sand replacement). Hence, a certain degree of specialized knowledge and costs are necessary for O&M. Some DPHE staff pointed out that this situation may be challenging for caretakers alone. Furthermore, the DPHE staff were willing to provide support upon request by the caretakers. Conversely, some DPHE staff opined that the DPHE does not need to provide support if no support requests were made.

4–2. Survey results on water users' awareness

4–2–1. Awareness of ownership of the water supply facilities

Abandonment of public water supply facilities after a breakdown likely stems from caretakers (or other water users) waiving their O&M responsibility. Assumedly, the decision to abandon the facility was closely associated with the awareness of water supply facility ownership, and an interview was

conducted about it.

Regarding the facility handingover after the construction by the DPHE, water users noted that formal procedures (e.g., document-based consensus building) were not conducted for any of the target facilities (n=29). Therefore, it was unclear who the owners of the facilities were after construction, and 70% of users thought that water supply facilities were not public properties.

Additionally, 18 facilities (approximately 70%) were used only within the *gushuti* (between the paternal families), and no significant differences were observed between shallow tubewell (STW) and deep tubewell (DTW). Meanwhile, facilities other than tubewells (AIRPs and SPWSSs) were used by residents exceeding the range of a *gushuti*. They were used by specific communities such as *shomaju*. No significant regional differences were observed in the results.

4–2–2. Operation status of target water supply facilities and O&M system

Of the 29 facilities surveyed, 28 were operating without major problems more than one year after construction. One facility (SPWSS) had its solar panels broken down within a year of construction, and the water supply pumps stopped operating. Subsequently, no repairs were made; in fact, it was not in use at the time of this survey. Regarding the O&M system, all the targeted point-source water supply facilities (n=27) adopted the caretaker system. For the SPWSSs (n=2), a water user group (WUG) was established with DPHE's support under a World Bank project. However, as with the point-source water supply facilities, land providers were appointed caretakers, and the caretakers conducted all O&M activities. Other water users are responsible for supporting the caretakers as necessary.

From the opinions of water users on the status of collaboration with DPHE, half of the respondents (n=89) answered that there was insufficient support from the DPHE. Furthermore, over 90% of the caretakers needed technical support from the DPHE. Most caretaker have sought technical support from the DPHE, but 28% of the caretakers (n=29) have not contacted the DPHE even once after the construction of the water supply facility. Indeed, 72% of caretaker has contacted the DPHE when a visible breakdown (e.g., a pump breakdown) occurred that required external support. However, there are also reported cases in which the caretakers received no support despite contacting the DPHE.

4–2–3. Caretakers' roles, willingness to share O&M activities, and capacity for O&M

The survey of the caretakers confirmed that all but one water supply facility had representatives of land provider households appointed as the caretakers. Of the 29 targeted facilities, five had female caretakers. However, in all cases, the original caretaker was the male head of the household. Upon his death, his widow took over the caretaker role.

As in Figure 4, 25% of the respondents noted that they assumed the caretaker role because of land provision. In contrast, nearly 70% said they did so because of an awareness of the contributions to society.

Although all target caretakers were aware of their roles, approximately 40% were unaware of the responsibility for O&M implementation, and 14% did not implement any O&M activities.

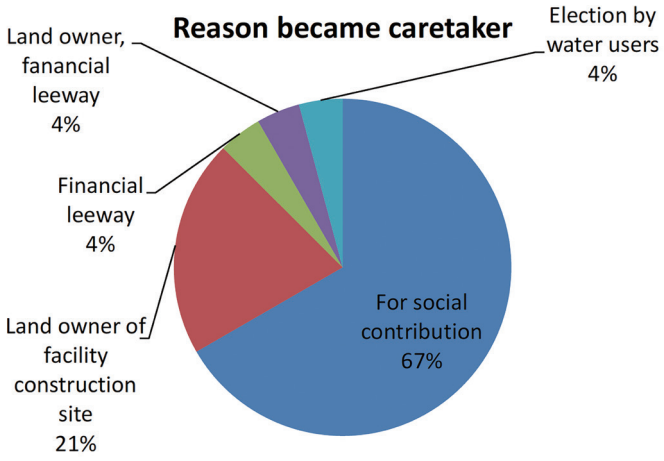


Figure 4.
Reasons for assuming a caretaker's role (n=29)

Table 4.
Caretakers' awareness of sharing roles with other users

		Agreement (percentage of valid responses)	Disagreement	No response
Shallow tubewell		5 (83%)	1	1
Alternative water supply option	Deep tubewell	9 (64%)	5	4
	Arsenic iron removal plant; small piped water supply system	4 (100%)	0	0
Total		18 (75%)	6	5

All caretakers who were aware of the responsibility for O&M implementation knew that they were responsible for cleaning the facility's vicinity and checking the pump operating status. However, the number of caretakers aware that repairing a malfunctioning pump was one of their responsibilities was relatively low (60%). AIRP caretakers were unaware of the necessity of filter cleaning and replacement as one of O&M's activities.

Caretakers conducting O&M activities generally completed them alone. The activities were only basic, such as confirming the operating status of the water supply facility, cleaning the facility's vicinity, and simple pump repair. Moreover, the caretakers pointed out that they could not respond to complex or costly maintenance on their own.

From the results of the intention survey, 75% of the caretakers who responded (n=24) indicated their agreement with sharing the caretaker roles with other water users by establishing a water user association (Table 4). Five caretakers did not respond because they had no idea about it. The reason for disagreement was the fear of losing power over the water supply facility management. They want to

Table 5.

Caretakers' intentions for collaboration of O&M activities with other uses

		Agreement (percentage of valid responses)	Disagreement	No response
Shallow tubewell		6 (86%)	1	0
Alternative water supply option	Deep tubewell	16 (84%)	3	3
	Arsenic iron removal plant; small piped water supply system	4 (100%)	0	0
Total		22 (85%)	4	3

Table 6.

Water users' willingness to pay for water tariff

		Agreement (percentage of valid responses)	Disagreement	No response
Shallow tubewell		21 (87%)	3	0
Alternative water supply option	Deep tubewell	53 (78%)	15	0
	Arsenic iron removal plant; small piped water supply system	15 (100%)	0	1
Total		89 (83%)	18	1

keep control over the facility because they provided the land and paid part of the cost burden. From the perspective of the type of water supply facility, all AIRP and SPWSS caretakers agreed to share their roles, and DTW and STW caretakers agreed with 64% and 83% in agreement, respectively.

An awareness survey showed that, of the caretakers who responded (n=26), 85% agreed to implement O&M activities with other water users (Table 5). Three caretakers did not respond because they had no idea about it. The reason for the disagreement was similar to those for sharing the caretaker's roles. As the caretaker provided the land and beard a part of the cost burden, they feared losing the power over the management of the water supply facility. From the type of water supply facility perspective, the agreement rates by caretakers for DTW, STW, and alternative water supply options were 84%, 86%, and 100%, respectively.

4–2–4. Water users' intentions of O&M implementation and willingness to pay for water tariffs

The results on the awareness of water users other than caretakers (n=79) revealed that 95% of respondents could implement O&M activities together with the caretakers. 98% and 43% of other water users have already been cooperating in cleaning the facility and around and checking the facility's

Table 7.

Water users' average of monthly household income and payable tariff amount

			Average household monthly income (response range)	Monthly payable tariff amount (response range)
Shallow tubewell		Caretaker	10,429TK (7,000–18,000TK)	24TK (0–100TK)
		Other water user	10,824TK (5,000–30,000TK)	28TK (0–100TK)
		Average	10,708TK (5,000–30,000TK)	27TK (0–100TK)
Alternative water supply option	Deep tubewell	Caretaker	13,944TK (8,000–20,000TK)	14TK (0–50TK)
		Other water user	12,880TK (3,000–50,000TK)	13TK (0–20TK)
		Average	13,162TK (3,000–50,000TK)	13TK (0–50TK)
	Arsenic iron removal plant	Caretaker	12,500TK (10,000–15,000TK)	35TK (20–50TK)
		Other water user	12,167TK (10,000–15,000TK)	23TK (10–50TK)
		Average	12,250TK (10,000–15,000TK)	26TK (0–50TK)
	Small piped water supply system	Caretaker	10,000TK	85TK (20–150TK)
		Other water user	19,800TK (10,000–40,000TK)	98TK (20–150TK)
		Average	17,000TK (10,000–40,000TK)	94TK (20–150TK)

operation status, respectively. For the two targeted SPWSSs, WUG has been established, but little time has passed since the construction of these facilities; thus, O&M activities have not yet been implemented in earnest. These two SPWSSs had set water tariffs following interventions from the World Bank project. Nevertheless, the water users commented that the tariff-setting process was unclear.

Table 6 shows that 83% of water users were willing to pay the water tariffs. From the perspective of water supply facility types, all AIRP and SPWSS users were willing to pay the water tariffs. Among tubewell water users, those for DTWs had a slightly lower tendency to pay, with a rate of 80%. Currently, water tariffs are not set and collected at all tubewells and AIRPs.

Table 7 shows the average monthly household income and monthly payable amount per water supply facility. Of the 108 respondents, approximately 44% of households had at least one family member earning an income, and the average household monthly income was approximately 12,800 TK (approximately 18,000 Japanese yen). Further, 67% of the responding households were self-employed (e.g., rickshaw drivers or farmers), and the average household monthly income fluctuated on a seasonal basis.

Regarding the payable amount as water tariffs, the average amount among respondents (n=90) was

18 TK (approximately 25 Japanese yen) per month. The amount at alternative water supply facilities, especially at SPWSSs, was higher than other facilities.

5. Discussion

5–1. Factors for the abandonment of water supply facilities and the effectiveness of the caretaker system

Although WUG was established at the piped water supply facilities, all targeted facilities adopted the caretaker system, and the caretakers generally conducted O&M activities alone. Of the 29 target facilities, 28 operating facilities were constructed more than one year ago, and the operational status was high even relative to the previous reports (DPHE and JICA 2010; Sawahashi 2014; UNICEF and JICA 2005).

The O&M activities conducted by the caretakers were limited to simple tasks, such as confirming the operating status of the water supply facility and cleaning the facility's vicinity. Moreover, the caretakers could not respond to complex and expensive maintenance. Regarding the caretakers' awareness of the necessary O&M activities, the necessity of pump repair was slightly low at approximately 60%, and the awareness of cleaning and replacing filters for AIRPs was not confirmed. From the above results, it is difficult to evaluate whether the caretakers performed their responsibilities sufficiently as required. This situation seems to stem from unclear regulations regarding the ownership and management of water supply facilities, the lack of administrative delegation procedures for awareness raising and consensus building, and insufficient training and support provision.

In addition to the above, the caretakers have no formal collaboration system with the DPHE. The DPHE staff noted that they would provide support if the caretakers made requests, but hey would not need to provide any support if no request was made. Accordingly, obtaining support from the DPHE depends on the caretakers' voluntary actions at present. Given the current state of O&M activities and the frequency of contact with the DPHE, the caretakers contact the DPHE only when the facility has broken down to the extent that they cannot deal with the issue. Under this situation, facility repair requires more time and cost than periodical O&M. The caretakers cannot respond to such a serious condition, and consequently the water supply facilities would be abandoned.

The results clarified that the current caretaker system imposes a significant burden on the caretaker regarding both technology and cost aspects, which induces a high risk of water supply facilities being abandoned following a breakdown or abnormality.

5–2. Possibility of sharing caretaker's roles and joint implementation of O&M activities

Could caretakers who conduct O&M activities with the awareness of their social contribution, share their roles and manage their water supply facilities with other water users? The survey results show that 75% of the caretakers agreed to share their roles with other water users, and 85% agreed to jointly conduct O&M activities with other water users jointly. Further, 95% of other water users expressed their intention to implement O&M activities with the caretakers. These results differed from

the previous reports that highlighted the challenges for organizations for cooperation to function (Tsutsui and Tani 2009) and the existence of a belief in one-way gifts (Nishikawa 1994).

When breaking down by facility, tubewell users had an agreement rate of 64–86%. In contrast, AIRP and SPWSS users had an agreement rate of 100% regarding caretaker role-sharing and O&M joint implementation. However, some caretakers opposed sharing their roles and co-management of the water supply facility with other water users since they want to keep control over their facility due to the provision of the land and part of the cost burden for the construction of the facility. The results indicate the following factors can be correlated with whether caretakers would choose to adopt a co-managing system: (1) whether the water supply facility is being used between different kinship relations (*gushuti*), (2) the complexity of the required O&M activities, and (3) the cost burden for the construction and O&M activities.

5–3. Possibility of water tariff collection

At least, collecting tariffs from other water users is desirable to reduce the cost burden of the caretakers. 83% of water users (both caretakers and other water users) showed a willingness to pay—a relatively high percentage of willingness to pay for the alternative water supply options.

Regarding the payable amount for water tariff, the average amount of 18 TK per month relative to the average household monthly income of 12,800 TK was indicated, accounting for only 0.1% of the average household income. The payable amount for SPWSSs, where project intervention was present, tended to be slightly high, and it was 0.5% of the average household monthly income. Evidently, the willingness to pay for water tariffs in the target districts was extremely low relative to previous research (OECD 2020; Manago et al. 2011). Nevertheless, it is significant that water users showed a willingness to pay even if their proposal was relatively low compared to that indicated in other studies.

External interventions, such as DPHE training and tariff collection experiences, may have influenced differences in payable amounts for each water supply facility. Therefore, willingness to pay of water tariffs may change when the DPHE explains the necessity of O&M activities with a long-term perspective and involve all water users for water tariff setting and collection.

6. Conclusion

Rural areas of Bangladesh face safe water supply challenges. The reasons are both hard infrastructure issues (e.g., inappropriate site selection, design, and construction) and soft infrastructure issues (e.g., breakdown and water pollution by inappropriate O&M activities). This paper analyzed the caretaker system for O&M that has been widely adopted in the rural areas of Bangladesh and discussed the possibility of co-managing O&M activities between caretakers and other water users, which has historically been recognized as challenging. Interviews were conducted to investigate the awareness and intentions of DPHE staff members, caretakers and other water users at 29 water supply facilities (tubewells, AIRPs, SPWSSs) in three districts of Bangladesh.

Many caretakers and other water users agreed with sharing caretaker responsibilities and joint implementation of O&M activities. This trend is especially prevalent at AIRPs and SPWSSs. Therefore, the results indicate the following factors can be correlated with whether caretakers would choose to adopt a co-managing system: (1) is the water supply facility being used between different kinship relations (*gushuti*), (2) the complexity of the required O&M activities, and (3) the cost burden for the construction and O&M activities.

Further, this study identified the lack of clear regulations between the DPHE and caretakers on water supply facility ownership and management, administrative delegation procedures for awareness raising and consensus building, and insufficient training and support provision. According to these limitations, a discrepancy has been identified between DPHE and water users regarding ownership and O&M responsibility. Strengthening collaboration between the DPHE and water users and providing support for overcoming the noted limitations are essential for promoting the implementation of necessary O&M activities and mitigating technical problems.

Regarding the financial issue, the collection of water tariffs is one of the ways to reduce the financial burden of the caretakers. Many respondents were willing to pay, although the payable amount was low. However, water users at SPWSS with an external intervention for tariff setting showed a slightly higher willingness to pay than those at other water supply facilities without any external intervention. Consequently, it seems possible to change users' awareness of the payable tariff amount through a transparent process for tariff setting and the provision of training by the DPHEon collecting water tariffs.

Notes

1) Water supply facilities other than tubewells installed in locations with arsenic contamination, low water tables, and other geographic problems.
2) Water supply facilities where a water inlet or faucet is installed at the same location as the water source.

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