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Improvement of water utility management in Tajikistan: reduction in water wastage using a metered tariff system

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ABSTRACT

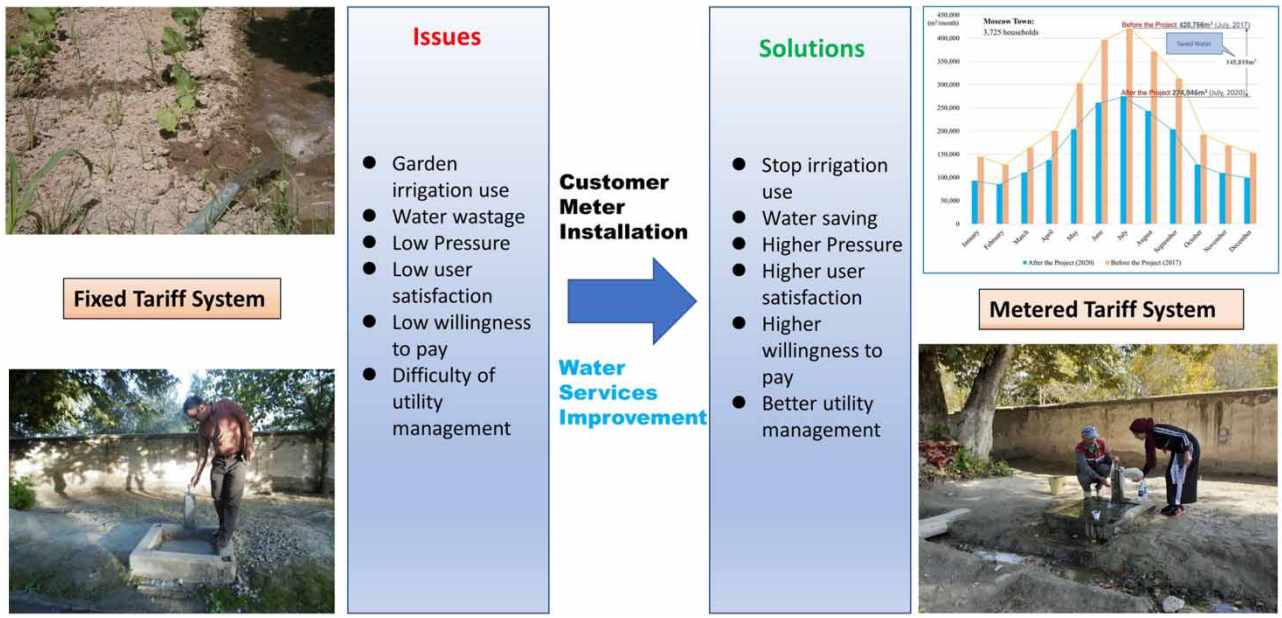
Tajikistan is a country in Central Asia with rich water resources. However, drinking water is used for agriculture and other non-drinking purposes owing to the fixed tariff system. Consequently, the overall level of water services has deteriorated and generated revenue is insufficient for operation and maintenance costs. Therefore, a project aimed to improve the quality of water supply services by providing hardware support, such as construction of wells and renewal of water distribution pipes, was conducted. However, because hardware improvement alone cannot sufficiently enhance water supply services, software support to improve the capacity of Vodokanal (utility) staff, including preparation of a metered tariff system, was implemented through a technical cooperation project. The project successfully raised customer awareness of water conservation, and the water consumption rate was reduced to two-thirds of that before implementation of the project. Additionally, the water quantity, quality, pressure, and supply hours in the target area were significantly improved. Despite the resulting increase in financial burden, customer satisfaction regarding the water supply was enhanced from 51% before the project to 100% in the second half of the project. Simultaneously, the water supply revenue increased by 24% and this increase contributed to sustainable water supply management.

Key words: customer satisfaction, metered tariff, Tajikistan, water conservation, water wastage

HIGHLIGHTS

- In Tajikistan, tap water is used for agricultural purposes.
- To improve water supply services, water supply facilities were improved.
- A project, including the introduction of a metered tariff system, was implemented.
- Water waste was significantly reduced and customer satisfaction greatly improved.
- It is possible that customers prefer good water services to low water tariffs.

GRAPHICAL ABSTRACT



INTRODUCTION

Some countries, such as Samoa in the Pacific Islands and Jordan in the Middle East, are facing severe water shortages due to climate change (Chenoweth *et al.* 2011; Beyerl *et al.* 2018), whereas a few other countries are facing deterioration of water services due to water wastage (Sivakkumar *et al.* 2020; Njoku *et al.* 2022).

Inadequate quality of water services may reduce the level of customer satisfaction, resulting in reduced tariff collection rates and a consequent worsening of water utility management, thus creating a detrimental, vicious cycle. To improve this and change it to a virtual cycle, increasing customer satisfaction by improving water supply services is essential (Ogata *et al.* 2021). In addition, a study conducted in Seoul, South Korea (Han *et al.* 2015) found that customers placed a higher value on water supply services, whereas service providers placed a higher value on affordability.

The Republic of Tajikistan is a landlocked country in Central Asia. Half of the country is at an altitude of 3,000 m or higher. Tajikistan is considered one of the richest countries in the world in terms of water resources; however, only 55% of the country's population had access to safely managed water sources in 2020 (UNICEF and WHO 2021). Therefore, Tajikistan had the lowest water supply level among former Soviet Union Countries and the highest risk of waterborne diseases. In 2004, there were 699 water supply facilities in Tajikistan, of which 113 were non-functional, and 358 did not meet water quality standards (JICA and Kyowa Engineering Consultants Co. Ltd 2007).

Khamadoni District

The population of Khamadoni District in the Khatlon Region of southwestern Tajikistan is approximately 119,000, with 21,000 of these residents living in Moscow Town. Due to ageing facilities and wells, only 52% of the residents had a water supply in Moscow Town, while the remaining residents were dependent on untreated water sources such as rivers and irrigation canals. In addition, inadequate water supply was a major problem during the summer, especially in certain areas of Moscow Town; this was because some households with large vegetable gardens followed the practice of using tap water for irrigation during the summer (Figure 1). Consequently, the amount of water distributed per day was three times higher than the planned amount.

In the rural areas of Khamadoni District, 42 of 57 villages had water supply facilities; however, due to inadequate maintenance and management, only 16 of 47 deep wells were operational. Therefore, more than 70% of the residents were using water from rivers or irrigation canals (JICA and Kyowa Engineering Consultants Co. Ltd 2007), similar to the residents of Moscow Town. There was an urgent need to update and improve the water supply facilities and establish efficient maintenance systems.

Figure 1 | Irrigation use of tap water.

In Tajikistan, water supply services are provided by utilities known as 'Vodokanal' (VK). Water supply improvements in Khamadoni District (Figure 2) were implemented through Khamadoni VK.

Figure 2 | Location of Khamadoni Vodokanal (VK) (United Nations Department of Field Support 2011).

Hardware support was provided through the Grant Aid Project (2008–2013) and software improvements through a technical cooperation project with the Japan International Cooperation Agency (JICA) (2017–2021). The specifics of these cooperation projects are listed in Table 1.

An external consultant oversaw the Grant Aid Project (2008–2013) ex-post evaluation from the end of 2016 to the beginning of 2018. This included a field survey undertaken between February 2017 and May 2017. The key indicators evaluated were relevance, effectiveness, efficiency, impact, and sustainability, with each indicator rated as follows: high, 3; medium, 2; and low, 1. For the overall project, the ratings were as follows: very high, A; high, B; there are some issues, C; and low, D.

The overall project rating for the ex-post evaluation results (JICA 2018) was low (i.e., D). The ratings for the evaluation indicators were 3, 1, 2, 2, and 2, indicating high relevance, low efficiency, medium effectiveness, impact, and sustainability, respectively.

Specific comments highlighted that the project was highly relevant as it was aligned with Tajikistan policies and consistent with the Japanese Aid Policy. Moreover, it was stated that while the project content generally aligned with the plan, the project costs exceeded the budget, and the duration was much longer than initially planned.

Observed positive impacts of the project were that the implementing agencies conducted their own geophysical surveys and constructed wells as planned using equipment procured under the project. Although there were no major problems in terms of the system and associated technology, several issues, including a lack of system training, financial difficulties in undertaking adequate maintenance and repairs, and making capital investments, were found. It was further highlighted that, although the operational indicators were achieved, the overall water supply system was not fully functional, with frequent leakages and issues of customers leaving taps open.

A technical cooperation project was implemented in the Kamadoni District from 2017 to 2021 to address the issues identified in the ex-post evaluation. The issues included improper maintenance of water supply facilities, difficulties in water utility management, and water wastage by customers, which may have deteriorated the functions of the water supply system. The overall objective of the technical cooperation project was to ensure the sustainability of water supply systems in the target areas.

METHODS

The results of the aforementioned evaluation of the 2008–2013 project revealed that the water supply did not improve in the Khamadoni District as initially expected. Therefore, it was proposed to improve the entire water supply service and financial status of the VK by installing water meters in all houses and implementing billing systems based on water consumption. In this context, the technical cooperation project by JICA was implemented in 2017 based on prior experience and the recommendations of the evaluation team of the Grant Aid Project.

Table 1 | Contents of the input through grant aid and technical cooperation projects

Grant Aid Project for Khamadoni VK (hardware support and preliminary operation and maintenance training) 2008–2013	**1,154 mil. JPY (11.8 mil. USD)[a]**
Moscow Town (rehabilitation): Construction of water intake facilities (three deep wells), construction of two new elevated water tanks, renovation of one elevated tank, renewal and installation of new water distribution pipes (32.9 km), construction of 57 standposts, and provision of materials for household connections (1,335 units).	
Two villages (new piped water supply system): Renovation of existing well, construction of elevated water tank, installation of approximately 15 km of water distribution pipes, and construction of 65 standposts.	
Technical Cooperation Project for two VKs (including Khamadoni) (development of technical capacity) 2017–2021	**410 mil. JPY (3.7 mil. USD)[a]**
Japanese experts: Included water service management, customer relations, design, and supervision of service installation, operation, and maintenance. 67.7 PM[b]	
Equipment provision: Included bulk flow meters and related materials, 4,825 household water meters and related materials, portable residual chlorine meters, desktop PCs, and metal detectors.	
Local expenses in Tajikistan: Included fuel, local personnel, and local transport costs.	

[a]Calculated at a rate of 1 USD = 97.6 JPY as of 2013 for grant aid and 1 USD = 110.3 JPY as of 2021 for technical cooperation.
[b]PM, person-months.

The implementing agency of the project in Tajikistan was the Khojagii Manziliyu-Kommunali (KMK), which was the central government agency responsible for managing water utilities, including Khamadoni VK. The project included four outcomes related to Khamadoni VK:

- organizing data for water supply management,
- enhancing the water service management capacity of key staff,
- introducing a metered tariff system, and
- efficient operation and maintenance of water supply facilities.

The approach of the technical cooperation project was that Japanese experts and their project counterparts worked closely together on field projects, mainly involving on-the-job training.

The Khamadoni District, the target area of the project, is close to the border with Afghanistan. Therefore, Japanese professionals avoided this area due to security restrictions. Thus, field activities in those areas mainly involved the Tajikistan national consultants.

The specific project activities were as follows:

First, monthly water production rates, water demand, non-revenue water ratios, and other data required for managing water services were recorded for the project. Furthermore, the project strived to streamline operations and make accounting documents more transparent through the digitization (database creation) of operation and maintenance ledgers, customer management ledgers, and other handwritten records. The number of complaints, meter readings, payment records, and organizational structures of VK was also reviewed and quarterly financial reports were formulated and submitted to KMK. A data management manual was established to improve data management.

Before project implementation, Khamadoni VK was not able to accurately calculate the volume of water production. Thus, the volume was estimated from the capacity of each well (pumping rate per hour) and the operating hours recorded in the register. One bulk flow meter was installed with the water supply system that had been newly constructed through the Grant Aid Project in 2013.

However, as the water distribution pipes from old existing wells did not have bulk flow meters, another bulk flow meter was installed in December 2018 through the technical cooperation project. Therefore, water production was determined to be approximately 3,000,000 m^3 per year until 2018, based on well yields and operating hours. Since then, the two bulk flow meters have been read and recorded on a daily basis, which has enabled the calculation of the amount of water distributed to Moscow Town.

Second, to deepen their understanding of the general management principles of the water services of Tajikistan's counterparts, executives of water service-related organizations from Tajikistan were trained in Japan. This training was designed to increase understanding of the importance of business management from a medium- and long-term perspective, capital investment, securing funds for sustainable management, customer relations, and public relations. After the training completion, follow-up workshops were held for the training participants to discuss measures to improve water services in Tajikistan.

Third, in Khamadoni VK, metering systems were implemented for customers (about 3,000 households), who were required to install individual meters during the project period and a series of training sessions were conducted on meter reading for tariff collection.

As a major activity of the project, various efforts were made on transitioning to a metered tariff system. At the beginning of the project, the distribution pipes that had been installed in Moscow Town during the Soviet era (old distribution system) and those extended by the Grant Aid Project (new distribution system) were separated by operating gate valves. The new water distribution system was classified as Zones 1–5 and the old system as Zone 6 and customer meters were installed in the new system.

A customer database was established using Microsoft Access-based customer management software to facilitate the management of the metered tariff system. The manual for meter readers was updated accordingly based on the manuals from another district where a metered tariff system was already in place. Prior to the commencement of the project, Khamadoni VK staff explained the following to the customers: meter management responsibility, metering system calculation method, construction work details, and the effects of installing meters in each house. After gaining the customer's understanding, the meter installation started.

Meanwhile, on-the-job training was provided to ensure that VK staff responded appropriately to meter failures, on-site water leaks, illegal connections, and customer complaints. When a customer complained during a meter reading, the

meter readers did not address the complaint individually but shared the information with VK's chief customer officers through an established communication system.

Additional on-the-job training was provided to the meter readers on recording meter readings and reporting them to the PC operators and accountants on using the customer management and accounting software, respectively. The metered tariff system was launched in Khamadoni VK in January 2019 and the percentage of residents with a metered tariff system increased from 1 to 68% during the project period. The meter readers made many mistakes in their meter readings and calculations at the beginning of the operation and time was needed to accumulate accurate data. However, these issues gradually declined and by the end of the project, the system operated without problems.

Fourth, to ensure efficient operation and maintenance of the water supply facilities to provide a stable and safe supply of drinking water in the Khamadoni VK, the VK technical staff was trained specifically on the proper operation and management of well pumps and disinfection equipment (bleaching powder dissolution and injection equipment). Figure 3 shows representative activities of the technical cooperation project.

The results of the ex-post evaluation customer survey conducted in May 2017 were adopted as a baseline survey for the technical cooperation project. An endline customer survey was conducted in December 2019. In the baseline survey, 75 randomly selected households in each of the 25 streets of Moscow Town were asked five questions regarding water stability, quality, pressure, supply hours, and overall satisfaction. Participants selected answers to the questions from three options (good, medium, and poor) and the results were rated and analyzed as satisfaction percentages. The endline survey adopted a similar sampling method and questionnaire, with 94 randomly selected households in the 25 streets of Moscow Town, and the results were analyzed as satisfaction percentages.

RESULTS AND DISCUSSION

The transition from a fixed to a metered tariff system in Khamadoni VK has simplified the calculation of billing amounts. Under the fixed tariff system, the annual charge was calculated as follows:

$$\text{Water unit cost} \times \text{number of family members} \times 95\text{L/person/d} \times 30\text{d} \times 12 \text{ months}$$

In cases where the number of family members changed (e.g., because someone moved out), customers were required to submit documents to VK to support the changes. This placed a substantial operational burden on the customers and VK staff. In contrast, the metered charge is simply calculated by multiplying the water unit cost by the metered water volume in the metered tariff system, reducing the time and effort required from the customers as well as Khamadoni VK workload.

The conversion from a fixed to a metered system by the installation of water meters and the increased water service providing the capacity of Khamadoni VK staff during the project period resulted in improvements in water supply services. Figure 4 shows the comparison of the amount of supplied water in Moscow Town between 2017 and 2020.

Figure 3 | Instructions on water distribution data management (left) and customer meter inspection (right).

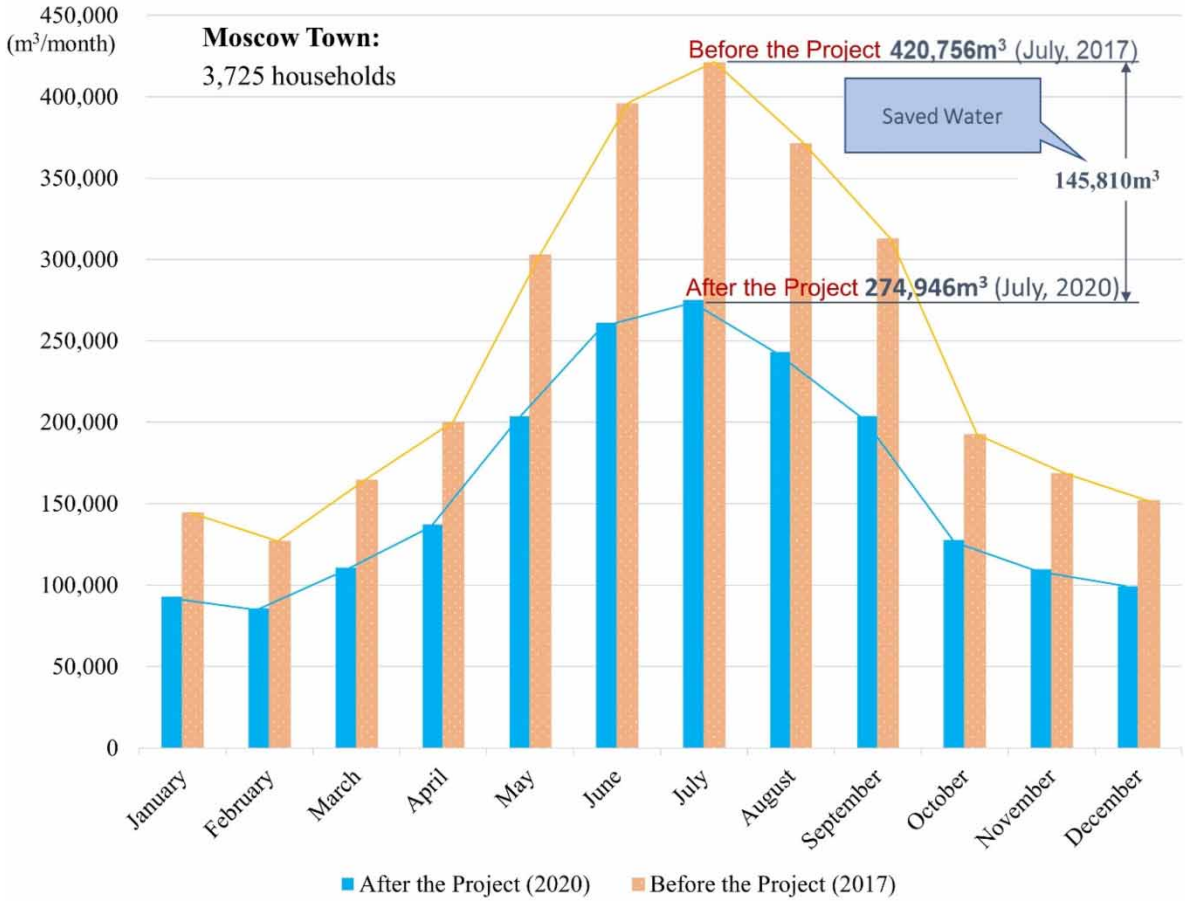


Figure 4 | Volumes of water supply before and after the project in Moscow Town between 2017 and 2020.

The amount of water supply in 2020 decreased significantly throughout the year compared to that in 2017. The yearly amount of water supply decreased by 1 million m^3 (34%) from 2,950,000 to 1,950,000 m^3 in 2017–2020, respectively. In addition, over 145,000 m^3 of water was saved in 1 month, July 2020, the month with the highest water supply demand.

Before project implementation, during the summer months (June–September), water was unavailable in high-elevation areas and the most downstream end of the water supply area, with little or no water pressure even at ground level. However, after the transition to the metered tariff system, the water pressure increased throughout Moscow Town and the majority of households received water as shown in Figure 5.

It is estimated that in the high-altitude areas and in approximately one-third of the downstream areas of the water supply zone, the water pressure increased as 0.5–1 kgf/cm^2 in the water head after the technical cooperation project. The reduction in water wastage also increased the daily water supply from 12 h intermittent supply under the fixed rate system to a continuous 24 h supply.

Moreover, prior to the project, there was no disinfection system and residual chlorine in the supplied water was not monitored. Appropriate disinfection systems and monitoring methods were implemented throughout the project to maintain free residual chlorine levels of >0.1 mg/L at the customer's tap.

Figure 6 shows the customer satisfaction rates in 2017 (baseline survey), when a fixed fee system was used before the project was implemented and those in 2019 (endline survey) during the second half of the project.

The overall satisfaction rate increased from 52 to 100% throughout the project. Customer satisfaction with other subjects such as water supply stability and water pressure increased significantly from 3 to 94% and from 53 to 94%, respectively. The increase in these satisfaction rates was considered effective for water conservation by customers who used taps for irrigation.

After the project, these customers were trying to conserve water because of the metered tariff system.

Figure 5 | Examples showing water supply status in high-elevation areas before (left) and after (right) implementing the project.

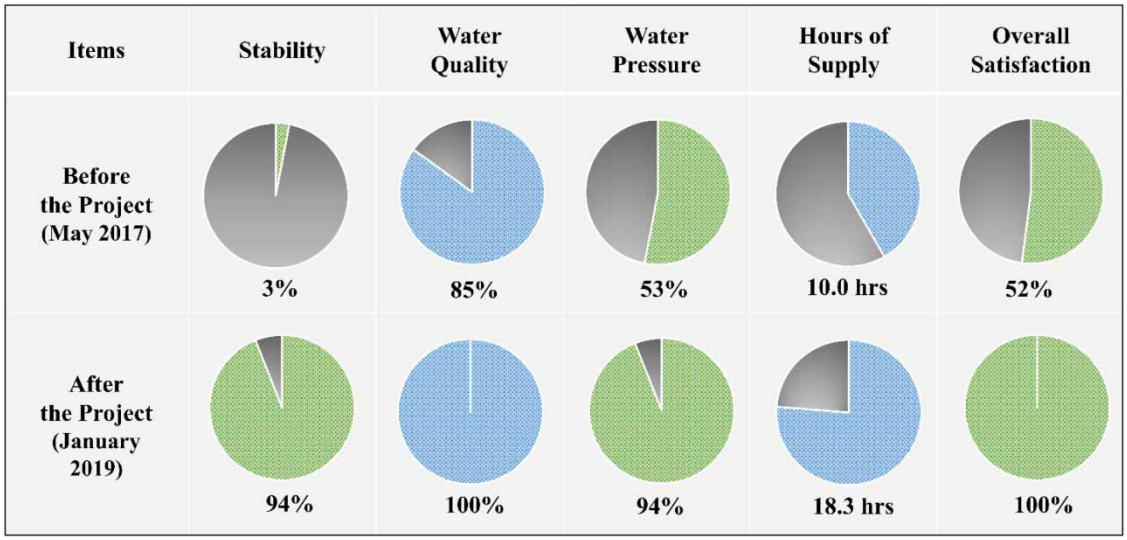


Figure 6 | Results of customer satisfaction surveys before and after the technical cooperation project.

The metered tariff system encouraged water conservation awareness among customers and despite the increase in per-unit water rates, it significantly increased customer satisfaction with water services. This also resulted in an increase in Khamadoni VK's revenue for water tariffs from 762,000 Somoni (86,395 USD) in 2017, at the beginning of the project, to 942,000 Somoni (106,803 USD) in 2021 toward the end of the project (a 24% revenue increase).

CONCLUSIONS

Water utility managers often believe that customers consider low water tariffs to be the most important factor. However, the findings of this project suggest that customers are more concerned about good service than low water tariffs.

This project also revealed that customers were not aware of the deteriorating water services under the fixed tariff system. This was evident from their use of tap water for garden irrigation, which consequently reduced water pressure, water supply hours, and other aspects of water service.

One major factor for the success of this project was that the VK staff explained and demonstrated the benefits of metered water rates to customers in the Khamadoni area based on good practices in another district where a metered water rate

system was already used. Regarding the transition to a metering system, it was determined that the success of the transition was not only due to the physical installation of customer meters but also the simultaneous implementation of various measures. These included the separation of the distribution network, the establishment of a customer database, and the requirement of on-the-job training.

In the JICA cooperation in the Khamadoni District, after updating or expanding the hardware with financial assistance, the transition to a metered tariff system was implemented simultaneously with improvements in the capacity of VK staff to oversee water utility management and field operations. However, for areas that do not require large hardware improvements, such as the renewal and/or expansion of pipe networks, only improvements in the training of utility staff and the transition to metered tariff systems may be sufficient to improve the operational capacity of water utilities.

Therefore, it might be worthwhile if the activities introduced in this study were replicated in wider areas of Tajikistan.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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