Bottom up facilitation to improve water management in Vietnam

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Abstract

Background: Safe drinking water management plays an important role on the public health in developing countries. In Vietnam, more than 8,300 water treatment facilities (WTFs) have been constructed to provide safe drinking water to communities. The WTFs, however, the quality and the quantity do not meet the community members' needs mainly due to technical, institutional and community factors. This study assessed the impact of a WTF rehabilitation program designed to improve WTF infrastructure, skills of water management unions (WMUs), and community awareness in three suburban and rural communities in Vietnam.

Findings: We measured the impact of the program through water quality analysis, WTF operation and financial data, and group discussions with WMUs and community members. Following WTF renovation, most of the water quality met the Vietnamese Drinking Water Hygienic Standards in three communities. WMUs improved their management performance. The community awareness activities were effective to improve community members' understanding about the role of the WTF in providing safe drinking water in three communities.

Conclusions: This study demonstrates an effective rehabilitation program for community-managed WTFs. A top-down approach is effective for improving WTF water quality and quantity, however bottom-up facilitation is a key for raising community awareness of sustainable water management.

Key words: drinking water quality, operation, community management, community participation, Vietnam

Background

In many developing countries, access to safe drinking water has been improved to satisfy one of the Millennium Development Goals (1). However, the quality of so-called 'safe drinking water' is not always high. To improve the quality of 'safe drinking water', challenges still remain in developing countries.

Prior to and during the International Decade for Drinking Water and Sanitation (1981-1990), international donor policies were dominated by hardware-type investments using top-down approaches in developing countries (2). Also, water supply was viewed as a public service, thus users received water with no or very small charges. As a result, the low water supply coverage and the poor health impacts remained public health concerns.

Since the mid-1990s, a community management approach has been developed within rural water supply projects (3). Community management results from the experience gained from a long history of community participation (4, 5), but it requires more decision-making, ownership and cost sharing (6). Community management is also viewed as central to long-term sustainability (6).

To improve the sustainability of community-managed water supplies, several success factors have been identified. The first success factor is technical and includes the design of water supply systems (7), and the operation and maintenance skills of water committees (8, 9, 10). The second success factor is institutional and includes the performance of water committees (11, 12). The third success factor involves community and social practices that include community participation (13, 14, 15) and the demand for safe drinking water (10). The fourth success factor is financial and includes water committees' setting affordable water fees, user's willingness to purchase water (5, 16) and the ability to cover maintenance and repair costs (17, 12). And the last success factor is follow-up support that includes the accessibility of

spare parts, training and external technical assistance (18).

The Vietnamese government put a priority to water supply, aiming at public health improvements for the entire population. The Vietnamese government initiated the Rural Water Supply and Sanitation Program in 1982 with support from UNICEF. By the end of 2007, the government, the international NGOs, and the international and local private sectors had constructed more than 8,300 water treatment facilities (WTFs) covering an estimated 40% of the rural population in Vietnam (Internal document of National Center for Rural Water Supply and Sanitation 2007,19). Those WTFs are consisted of similar structures that include aeration, coagulation, precipitation, sand filtration, and chlorination systems.

Ministry of Agriculture and Rural Development estimated that out of 8,300 existing WTFs, one-half of the WTFs, are not managed in a sustainable way (20). Before this study, we investigated the water quality using eighteen parameters in eleven community-managed WTFs in the Red River Delta Region for a period of one year (21). We found that the concentrations of ammonia, arsenic, iron, total coliform, *E.coli* and *Cl.perfringens* in treated water were higher than the Vietnamese Drinking Water Hygienic Standards. This is because that; the WTFs were not designed to remove particular contaminants in raw water which varies at each WTF; long-term operation deteriorated the equipment; the WTF operators operated based on experience without following the instructions or manuals. In addition, Community factors also affected low performance of water management. Through focus group discussions to community members, we found that they knew little about the benefits of safe drinking water, WTF water quality, the role of WTF and water management (22). Therefore, community members were not motivated to pay for WTF water. This situation resulted in an insufficient budget for the Water Management Unions (WMUs) to manage and maintain WTFs (20).

This study assessed the impact of a WTF rehabilitation program designed to improve WTF infrastructure,

skills of WMUs, and community awareness about safe drinking water in three suburban and rural communities in Vietnam.

Methods

Study site

This multiple case studies were conducted in three communities from suburban and rural areas of the Red River Delta Region of northern Vietnam. We selected three study sites based on the two criteria; i) existing water treatment facilities supplying water to more than 500 households, and ii) chemical and microbiological contaminations observed in our previous investigations. From the suburban areas, we selected Huynh Cung Village, the Tam Hiep Commune, the Thanh Tri district of Hanoi, and Ngang Village, the Dai Mo Commune, the Tu Liem district of Hanoi. From the rural areas, we selected the Quang Trung Commune in Vu Ban district, Nam Dinh Province, which is ninety km southeast of Hanoi. The water sources were well water in Huynh Cung and Ngang Villages, and river water in the Quang Trung Commune. Figure 1 shows an example of WTF that consists of aeration, coagulation, precipitation, sand filtration, and chlorination systems.

In line with the Rural Water Supply and Sanitation Program, WTFs were constructed in three communities: Huynh Cung Village in 1996 (funding from MARD); Ngang Village in 1996 (funding from the Tu Liem District People's Committee); and Quang Trung Commune in 2002 (funding from an international NGO). After construction of WTFs, the villages and communes took upon themselves management responsibilities. At the start of the study, a WMU already existed in each village. The core members of the WMUs in Huynh Cung and Ngang Villages are the village leader, sub-group leaders, operators, the first secretaries of the communist party of the village, the leader of the health station and village health workers (one sub-group leader serves concurrently as a village health worker and one village health worker serves concurrently as a Women's Union member). In Quang Trung Commune,

WMU members consisted of the chair of the Commune People's Committee, representatives of the cooperative, operators, the leader of the health station and village health workers.

WTF rehabilitation program

The program lasted two years for Huynh Cung Village and one year for both Ngang Village and Quang Trung Commune between November 2005 and November 2008. The intervention consisted of three components: i) renovation of the WTF infrastructure, ii) training of WMU members, and iii) community awareness activities on safe drinking water.

Renovation of the WTF infrastructure

As for the renovation of WTF infrastructure, the major renovation work was similar although the work varied depending on the specific problems of individual WTF. We replaced existing well pumps with high capacity pumps, improved aeration capability, installed poly-aluminum chloride (PACl) dosing systems to improve the coagulation process, placed new sand in the filtration tanks, installed chlorine dosing systems, expanded the reservoir and installed new flow-meters to check the water quantity.

Training of WMU members

The training of WMU members varied depending on the community due to the abilities of WMU members. However, common approaches were applied. First, we identified the WTF's problems such as water quality, quantity, operation and maintenance status, operator skills and reporting systems. Then, we developed an operation and maintenance manual and guidelines for the WMU based on the problem identification. Then, implemented training programs utilizing the manual and guidelines both in training classes and at the WTF sites. Finally, we monitored the operational procedures and data recording systems regularly.

Community awareness activities

We targeted WMUs and community members for these awareness activities. The topics included water treatment processes, safe drinking water, WMU's water management and water conservation. First, we conducted a series of group discussions with WMUs to identify gaps, problems and solutions. Then, we communicated the topics to community members in a series of workshops. We also distributed newsletters containing the topics and summaries of current activities to all community members. We also organized WTF water and household water quality checks using the test-kits for WMUs. Finally, we developed two flipcharts (6 pages, picture-story style): one for water treatment processes and the other for safe drinking water. We intended the flip charts to be a practical guide for WMU members. Therefore, we conducted training to improve the communication skills of the WMU members on how to effectively deliver the main messages in the flip charts. The WMUs then presented the flip charts during household visits and village gatherings. In addition, village health workers wrote articles about the topics and broadcast information using loudspeakers (fixed to poles on the streets) in each community. We installed the bulletin boards to post leaflets and newsletters. WMUs organized a drawing contest with school children and a poem contest with adults to increase the awareness of the topics.

Data collection and analysis

Water quality analysis

We took two water samples each at the following four points; untreated well or river water before the renovation, treated water before the renovation, untreated well or river water after the renovation and treated water after the renovation in each community. These four points were selected to observe the water quality before treatment and to verify the function of the un-renovated and renovated WTFs. We selected eighteen parameters (color, smell, turbidity, hardness, pH, arsenic, iron, ammonia, nitrate, nitrite, lead, cadmium, manganese, oxidation, TDS (total dissolved solids), chlorine residue, total coliform and *E.Coli*) and performed the analyses using the Standard Methods for the Examination of Water and

Wastewater at a laboratory in the Center of Water and Environment, Hanoi (23).

WTF operation

We collected WTF-related data from the self-reporting, operation records, water loss records and WTF financial records from February 2006 to August 2008.

Problem identification of WMU

To identify water management problems and to propose solutions, we conducted group discussions with each WMU at the baseline. In the group discussions, we applied behavioral and environmental assessment methods used in the PRECEDE-PROCEED model (24). This model is known to be helpful to examine the factors contributing to behavioral change. We first asked the WMU members to list their water management problems and we categorized similar problems together. Then, each member had five points to vote on the topics they thought to be the most important and another five points to vote for the topics which they thought easiest to change. Finally, we made an *importance and changeability* matrix for community members to understand the problems' position and to prioritize them. We discussed the details of the prioritized problems further. Along with the problems, we also identified feasible solutions. One Vietnamese moderator from the National Institute of Nutrition, Vietnam (NIN) facilitated the group discussion and two Vietnamese recorders documented the conversations. Then the moderator and recorders prepared a transcript and confirmed the content with the community members. To understand how the WMU solved the problems, we also conducted the group discussions with each WMU at the end of intervention.

Group discussion with community members

We conducted a series of similar group discussions with eight to ten community members who represent households to listen to their opinions as water consumers. In addition to the group discussions, we

collected information about ongoing activities from village monthly monitoring reports and field visits.

Ethical Consideration

This study protocol (No.1329) was approved by the Research Ethics Committee of the Graduate School of Medicine of the University of Tokyo, Japan on 30 January, 2006. The National Institute of Nutrition, Vietnam also approved this study protocol (No.50) on 11 January, 2006. For group discussions, we made an oral explanation to all the participants and obtained their approval to join the study.

Results and Discussion

Results

The most of water quality and quantity indicators were improved to meet the government standards in three communities (Table 1). Before the renovation, WTFs were not able to reduce the concentrations of arsenic, iron, ammonia and total coliform derived from well water or river water enough to meet the standard. After renovation, however, in Huynh Cung village, the concentrations of these parameters were reduced to meet the standard. In Ngang Village and Quang Trung Commune, the concentration of ammonia was slightly reduced but did not meet the standard. After the renovation, water quantity markedly increased 1.2 to 1.9 fold compared with before the renovation.

Over all, WTF operation, water distribution and financial situation were improved in three communities (Table 2). Before the renovation, flow-meters to control water volume were not available in three communities. However, after the renovation, all the communities started to control water volume and operators were able to measure how much water was distributed to the community. Chlorine dosing also became possible in all the communities. Before the renovation, all the communities had operated WTFs based only on experience, and as a result, the operators were not confident of their operation skills. But after the renovation and the training, the operators followed the instructions in the operation manual.

Moreover, while operational data had not been recorded before the renovation and it was based on the self-reporting, all WTFs started to record such data following renovation. The water supply coverage, calculated based on the report form the WMUs or the community authorities, increased from 65.2% to 75.2% in Huynh Cung Village, from 73.9% to 90.0% in Quang Trung Commune, and Ngang Village retained approximately 99% of coverage throughout the study. In three communities, the treated water cost remained the same or only slightly increased (300 to 500 VND/m^3 = 0.017 to 0.028 USD). By repairing the inaccurate flow-meters and pipeline leakage points, the rate of water loss was reduced from 54.1 to 46.9% in Huynh Cung and from 35.0% to 21.4% in Ngang Village, but in Quang Trung Commune the rate remained unchanged, 42.0% to 42.2%. Although penalties were not enforced against water theft before the renovation, following the renovations, all the communities began to either begin to enforce existing penalties or enacted new penalties. Revenue collected as water fees greatly increased following renovation, especially in Huynh Cung and Ngang Villages. This was due to increased manpower available to oversee the water fee collection system and monitor water loss.

Most of the problems identified in the group discussion was solved by WMU themselves by the end of the rehabilitation program (Table 3). Before the program, the common problems in three communities were mainly technical: lack of knowledge of WMU members about the WTF's operation and maintenance, difficulty in preventing water loss caused by pipeline leakages, inaccurate flow-meters and delays in checking consumption. In Huynh Cung Village and Quang Trung Commune, institutional issues such as the weakness of the WMU were also identified as problems. In Ngang Village, financial issues such as difficulty in increasing water fees were also identified as problems. After the program, technical training helped to solve the technical issues in all the communities. The weakness of the WMU in Huynh Cung Village and Quang Trung Commune was solved by increasing manpower or giving specific responsibilities to members. In Huynh Cung Village, all the other identified problems were also solved. In Ngang Village, the pipeline leakage problem was not solved during the study as the WMU rated low on

changeability (i.e. difficult to address or solve). Community members agreed with the water fee increase for purchasing chlorine as a result of the WMU's communication activities in Ngang Village. The WMU identified this problem as less important, but as having high changeability (i.e. relatively easy to address or solve). In the Quang Trung Commune, the high rates of water loss and pipeline leakages were not solved during this study as the WMU identified as having low changeability.

As shown in Table 4, before the study began, community members in three communities knew very little about the WTF and doubted water quality. But after the community awareness activities, they understood that the role of the WTF was essential in providing safe drinking water and for protecting people from water-born diseases and started to trust WTF water quality. Moreover, community members started paying water fees without complaining, agreed the increase of water fee and started connecting to water distribution pipeline.

Before the study began, community members concerned;

> …Sometimes WTF water is not clean. I found some substances in the bottom of the glass when I let it sit for a while… (housewife in Ngang Village)
>
> …Sometimes WTF water is muddy or has iron or fishy smell... (head of household in Ngang Village)

After the intervention, the opinion changed;

> …I saw clear water and smelled the chlorine. I saw the results of water quality check in the newsletter therefore I now trust that the WTF water is safe… (housewife in Ngang Village)

Before the intervention, the community members in Huynh Cung and Ngang Villages did not receive sufficient water.

> …Only households located near to WTF receive enough water, households far from WTF do not receive enough water... (Village Health Worker in Huynh Cung Village)

After the intervention, even though the water supply coverage increased, WTF water did not reach the households at the end of pipeline in Huynh Cung and Ngang Villages. Therefore, community members started calling for water conservation measures among themselves. In Quang Trung Commune,

community members had enough water from the start of the intervention.

Discussion

The primary finding of this study was that WMUs improved their performance as a result of training and community awareness activities, and this played a key role in sustaining safe drinking water management. For example, after problem identification and discussion of possible solutions, the WMUs specified the responsibilities of its members and improved their solidarity. This finding is supported by a study on community-managed boreholes for water supply which suggests that strengthening of water committees is important since their performance affects the overall sustainability of water supplies (11). Also, in our study, WMUs displayed improved operation and management skills following the training. This finding is consistent with a study conducted in six countries (Benin, Bolivia, Honduras, Indonesia, Pakistan and Uganda) that indicates positive correlations between water committee training and water system sustainability (25). The important point is that WMUs identify their problems and search for solutions by themselves at the beginning of the rehabilitation program. Also, this study recommends developing training programs based on problem identification and actively seeking solutions.

Another important finding was that community members recognized the function of the WTF in providing safe drinking water and trusted the WTF water quality following the community awareness activities. This finding is in line with the six-country study that indicates that community members are better satisfied with the treatment system when they receive enough information about water treatment (25). A similar finding is also reported in an evaluation study of piped water supply systems in Mexico that indicates when community members understand the relationship between safe drinking water and health outcomes, water use increased (26). Comprehensive community awareness activities are essential to increase people’s knowledge of the benefits of safe drinking water.

However, build-up of the capacity of WMUs is not easy at the beginning of a rehabilitation program. As a foreign assistance project, first, we tried to encourage the WMUs to work with the community. However, we failed to reach the community through WMUs. For sustainable management of water in a community, appropriate institutional support such as encouragement, motivation and special technical assistance is necessary (12). However, if the recipient rejects this assistance, how should we respond? This was the dilemma we faced in this study. Our strategy was to go to the people directly. Only after the community members had been convinced that water management is important through bottom-up facilitation and had themselves appealed to the WMUs, did the attitudes of the WMUs change. In a way, the WMUs were positioned between oversight institutions and the community. This evidence is also supported by a previous study which shows that the sustainable community-managed water supply is readily possible when the awareness of community members is generated and WMUs are self-motivated (25, 11). However, the top-down approach seemed to be effective in improving WTF water quality and quantity. We attempted to start by using a bottom-up facilitation process, but the lack of technical capabilities at each location made it difficult to improve water quality and increase water quantity.

In this study, the cost of treated water remained the same or just slightly increased. Through the group discussions, we noted that the increase of 300-500VND/m^3 (15-25%) in water was affordable by the community. With the strong willingness to have a more stable supply of high quality water, people were ready to pay the increased cost. The willingness of people was similarly described in a study conducted in India in which consumers were willing to pay for a reliable and regular water supply (27). In this study, WMUs lead the community discussion and increased the water fees. For example, as shown in Table 3, Ngang Village WMU identified water fee increase as less important, but relatively easy to solve. For other communities, this issue might be difficult to solve (28). As a result of WMU members' good performance and community awareness activities in Ngang Village, the community members understood the advantage of disinfection using chlorine and agreed to the water fee increase.

Moreover, in our study, the WMUs were financially self-sufficient and the management was carried out in the following three steps: first, the infrastructure improvements increased the WTF water quality and quantity, and the water supply coverage was extended; second, community members understood the function of the WTF and the importance of safe drinking water following the community awareness activities, and they recognized that the role of WMUs is important; and third, community members accepted the increased water fees, therefore the collection rate increased. The studies in Africa (10) described a similar situation which demonstrated that the water fee collection was the key for sustainable water management. Therefore, the affordable water fee setting should be carefully studied in water supply projects.

In this study, the concentrations of arsenic, iron and total coliform in treated water met the Vietnamese Drinking Water Hygienic Standards following WTF renovation and WMUs' operational improvements. After the renovation, the concentration of ammonia in treated water was reduced in Ngang Village and Quang Trung Commune, but the concentration did not meet the standard. We could not find applicable and feasible treatment technology in Vietnam. According to the *Background document for development of WHO Guidelines for Drinking-water Quality: Ammonia in Drinking-water*, ammonia "is not of direct importance for health in the concentrations to be expected in drinking-water" (29). As for Ngang Village, however, we confirmed from our water quality data that the ammonia is derived from underground sources and not from livestock manure. In Quang Trung Commune, the concentration of contaminants in untreated river water changes from rainy season to dry season, thus, long-time monitoring might be required to understand the situation.

This study had several limitations. First, we conducted this study only in three communities in the Red River Delta Region. Even though we choose representative communities of the region, a larger number of

rural communities would have resulted in a more comprehensive interpretation. Second, a limited number of water samples were analyzed in this study. The sustainability of the water quality is not warranted. Third, raw water quality might vary depending on the location. Therefore, different water treatment and operation possibilities might be considered according to the specific contaminants and problems. Fourth, we couldn't solve the pipeline leakage problem in this study, even though WMUs made efforts and partial improvements were seen. It is possible that bacterial contamination occurred before ingestion of the treated water, as the practice of boiling water is common at the study sites. Major repair or replacement is possible within the framework of large funding projects. Finally, although the community was convinced by the WTF water quality, some still preferred unsafe water sources, such as rain water or private deep wells due to cost, taste or smell. The impact of this factor on community water management was not considered in this study.

Conclusions

In conclusion, this study demonstrated an effective rehabilitation program for community-managed WTFs in Vietnam. Quality and quantity improvements using a top-down approach was effective. However, the bottom-up facilitation is a key for raising community awareness for sustainable water management.

Abbreviations

ILSI Japan CHP	International Life Sciences Institute Japan Center for Health Promotion
JICA	Japan International Cooperation Agency
NGOs	Non-Governmental Organizations
NIN	National Institute of Nutrition, Vietnam

PACl	Poly-aluminum chloride
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WMUs	Water management unions
WTFs	Water treatment facilities

Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

KT conceived of the study and participated in the filed survey, and drafted the manuscript. DTQ participated in developing the study design, carried out the field survey and its coordination and data collection. NLTH contributed to the data collection, data input. NCK contributed to developing the study design and have given comments to revise the manuscript. MJ provided guidance to develop the study design, data interpretation, and revised the manuscript. All authors read and approved the final manuscript.

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Figure 1: Example of water treatment facility

Table 1. General water quality[*1] and quantity at the WTFs

Huynh Cung village	Before	Untreated well water originally contained arsenic (0.003-0.040mg/l)*[1], iron (6.3mg/l) ammonia (7.7mg/l) and total coliform (1700MPN/100ml). Even after the treatment, the concentrations of arsenic (0.018-0.119mg/l), iron (0.64mg/l), ammonia (7.6mg/l) in treated water were higher than the Vietnamese Drinking Water Hygienic Standards (the Standards)*[2]. The WTF capacity was lower than water demand of community people.
	After	All the tested eighteen water quality parameters including arsenic (0.005mg/l), iron (<0.01mg/l) and ammonia (0.2mg/l) met the standards. The treated water quantity increased markedly. (267m^3/day to 506m^3/day: 1.9 folds)
Ngang village	Before	Untreated well water originally contained iron (14.6mg/l), ammonia (7.4mg/l) and total coliform (43MPN/100ml). Even after the treatment, the concentration of ammonia (4.9mg/l) in treated water was higher than the standards. The WTF capacity was lower than water demand of community people.
	After	The tested seventeen water quality parameters except ammonia (4.5mg/l) met the standards. The treated water quantity increased markedly. (270m^3/day to 320m^3/day: 1.2 folds)
Quang Trung commune	Before	Untreated river water originally contained ammonia (5.5mg/l). Even after the treatment, the concentration of ammonia (4.0mg/l) in treated water was higher than the standards. The concentration of contaminants changed from rainy to dry season.
	After	The tested seventeen water quality parameters except ammonia (3.5mg/l) met the standards. The treated water quantity increased markedly. (349m^3/day to 512m^3/day: 1.5 folds)

*[1:] From the eighteen parameters tested, we present the parameters where untreated well water or river water showed higher concentrations than the Vietnamese Drinking Water Hygienic Standards.

*[2:] The Vietnamese Drinking Water Hygienic Standards: Arsenic (0.01mg/l), iron (0.5mg/l), ammonia (1.5mg/l), and total coliform (0MPN/100ml)

Table 2. WTF operation, distribution and financial details

	Huynh Cung village		Ngang village		Quang Trung commune	
	Before	After	Before	After	Before	After
WTF Operation						
Operation time of WTF (h/day)	20	18	22	16	12	18
Distribution time from WTF (h/day)	4.5	4.5	11.6	13.3	5.7	8.5
Flow-meter to control water volume	None	Yes	Yes	Yes	None	Yes
Water volume distributed from WTF (m^3/day)	267*	506	270	320	349*	512
Chlorine dosing	None	Yes	None	Yes	Yes	Yes
Operational procedure	Experience	Followed instructions	Experience	Followed instructions	Experience	Followed instructions
Recording operation data	None	Recorded correctly	None	Recorded correctly	None	Recorded correctly
Water Distribution						
Total No. of HHs in the village	979	1,183	413	545	1,650	1,650
No. of HHs which received treated water	638	890	409	541	1,219	1,485
Water supply coverage (%)	65.2	75.2	99.0	99.3	73.9	90.0
No. of flow-meters in the village	586	685	597	712	990	1,122
Water volume (L/capita/ day)	32	55	67	67	74	85
Cost of treated water (VND/m^3)	2,500	2,500	2,000	2,500	2,000	2,300
Rate of water loss (%)	54.1	46.9	35.0	21.4	42.0	42.2
Penalty against water theft	None	Enforced	None	Applied	None	Applied
Financial Situation (per month)						
Revenue (VND)	7,065,833	18,376,667	12,842,000	19,435,000	12,524,000	16,553,100
Spending (VND)	6,319,567	10,629,800	5,982,000	9,856,000	7,523,800	11,424,000
Remaining (VND)	746,266	7,746,867	6,860,000	9,579,000	5,000,200	5,129,100

* Operators estimation because of no flow-meter.

Table 3. Water Management Union: before vs. after

Before	Importance ranking	Change ability ranking	After
Huynh Cung village			
Lack of manpower of WMU.	1	2	WMU increased their manpower and gave specific roles to three sub-group leaders. The sub-group leaders started monitoring the pipeline leakages and collecting water fees from households in each sub-group.
Lack of knowledge of WMU members about the WTF's standard operation process.	2	1	WMU received the technical training about the water treatment process and the WTF's standard operation process. Operators started recording the WTF operation and the water distribution to monitor proper operation.
Difficulties in controlling water loss caused by pipeline leakage and inaccurate flow-meters.	3	3	Sub-group leaders tried to detect the pipeline leakages as soon as possible and informed operators for prompt repair. Sub-group leaders started visiting households to check the accuracy of flow-meters.
Weak management structure. (no enforcement of penalties for water theft)	4	4	WMU developed and applied penalties for water theft.
Ngang village			
Difficulty in controlling pipeline leakages due to old water pipe system.	1	4	WMU couldn't solve this problem during the study. WMU tried to mobilize village funds and donations from community people

			to replace broken pipes to new pipes step by step.
Limited experiences and knowledge of WMU in maintaining equipments in the WTF.	2	2	WMU received technical training about operation and maintenance of equipments.
Lack of experiences and knowledge in financial management.	3	3	Villagers newly selected good WMU members. The head of WMU and all WMU members were active.
Difficulty in having an agreement of community people about the water fee increase for purchasing chlorine.	4	1	WMU visited the houses with flip-charts and explained the advantages of disinfection using chlorine. Community members agreed the water fee increase.
Quang Trung commune			
Insufficient organization of WMU.	1	2	WMU specified the responsibility and improved the inter-relationship.
High rate of water loss caused by delaying the consumption check because flow-meters were inside of the premise and were inaccurate.	2	4	WMU couldn't solve this problem during the study.
Lack of knowledge and skills in operation and maintenance of WTF.	3	1	WMU received the technical training and leant water treatment process of WTF, operation and maintenance process and how to prepare chemicals.
Lack of knowledge and practice in recording the WTF operation.	4	1	WMU learnt how to use the record for the operation assessment.
Difficulties in controlling pipeline leakages because the pipelines were installed under the ground.	5	5	WMU couldn't solve this problem during the study.

Table 4. Community awareness: before vs. after

		About WTF	**WTF water quality**	**WTF water quantity**
Huynh Cung village	Before	Did not know the water treatment process	Doubted the water quality	Lack of water
	After	Understood the complicated water treatment process to produce safe water / Paid water fee without complains	Trusted the water quality	The coverage increased, but still lack of water / Called for water-saving each other
Ngang village	Before	No chlorination for disinfection / Needed the fund to purchase chlorine	Doubted the water quality	Lack of water
	After	Understood that the chlorine was important to prevent water-born diseases / Agreed the increase of water fee	Trusted the water quality	The coverage increased, but still lack of water / Called for water-saving each other
Quang Trung commune	Before	Did not know the water treatment process	Doubted the water quality, preferred the rain water	Enough water
	After	Understood the complicated water treatment process to produce safe water / Started connecting to water distribution pipeline	Trusted the water quality, still preferred the rain water	Enough water