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Sustainability Assessment of the Rural Clean Water Supply System in Hai Phong City

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Abstract

Since the end of 2019, 92.1% of rural households in Hai Phong city had been able to access and use clean drinking water, which meets national standards as a result of developing a clean water supply system consisting of 205 plants with various management models. The authors applied the desk-study method to collect and review literature research, select a group of six criteria, and then applied the criteria to assess the system's sustainability based on Likert's 3-point scale. The results show that criteria scores ranged from 1.9 points to 2.5 points, while the total score of the whole system is 12.9 points - reaching an average sustainability level. The authors propose that in order to improve the sustainability of the clean water supply system in the rural areas of Hai Phong city in the future, management agencies and investors need to apply a solution of propagating rural people to increase their usage volume of clean water, which will help to increase the actual operating capacities of the plants, thereby increasing the revenue and profits of plant investors.

Keywords

Clean drinking water, rural clean water supply system , sustainability, Hai Phong

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Introduction

The goal of ensuring clean water for people in general and especially rural people, in particular, has become one of the United Nations millennium development goals since 2000 (UNICEF & WHO, 2015). This goal was concretized in the National Strategy and Program on Rural Water Supply and Sanitation up to 2020 in Vietnam with the goal that “All rural people have access to clean water according to national standards with a quantity of at least 60 liters/person/day” (Prime Minister, 2000). Using clean and hygienic drinking water is one of the essential living needs to ensure the quality of life of all people. Therefore, it is necessary to manage rural clean water to ensure the harmonization of interests between the parties in the provision and use of clean water for all rural residents in a full, fair, and sustainable manner (ILO, 2019).

Hai Phong is one of the five first-class cities and the sixth most populated city in Vietnam, of which the rural population makes up 54.4% (General Statistics Office, 2019). Recently, Hai Phong has been seen as a leading locality in the country in completing national target programs on rural clean water. According to the Report of the Department of Agriculture and Rural Development of Hai Phong city (2019), 92.1% of rural households had accessed to and used clean drinking water which meets national standards. This rate was much higher than the national average rate (53.5%) and the rates of other provinces and cities such as Hanoi (75%) and Quang Ninh (68%) (Luong Van Anh, 2019). This result had been achieved by the efforts of the local government to develop a water supply system in the rural areas with 205 water treatment plants with various management models (Department of Agriculture and Rural Development of Hai Phong city, 2019). However, in managing and operating the clean water supply system, there have been many shortcomings: (1) some areas have not been provided with clean water, (2) the quality of drinking water has not been guaranteed, and (3) many of the plants have been operating in a moderate or inefficient status (Hien Anh, 2016; Department of Agriculture and Rural Development of Hai Phong city, 2017). These shortcomings show that the current situation of the clean water supply system in the rural areas of Hai Phong city is not sustainable. Therefore, this study aimed to assess the sustainability of the rural clean water supply system in Hai Phong according to a group of specific criteria, and thereby proposing appropriate solutions to enhance the sustainability of the system to sufficiently meet the continuous demands of rural people in the city in the future.

Research Methods and Criteria

Research methods

The authors applied the desk-study method to review studies and documents related to sustainability assessments of rural clean water systems. The terms “sustainability of rural water supply”, “sustainable criteria to assess rural water supply”, and “factors affecting the sustainability of rural water supply” were used to search documents in ProQuest's database, Google Scholar, and Research Gate. The collected relevant documents were synthesized and analyzed to find a group of representative criteria suitable for assessing the sustainability of the rural clean water system in Hai Phong city.

In addition, the authors synthesized the specialized reports of the People's Committee of Hai Phong city and the Department of Agriculture and Rural Development of Hai Phong city to collect secondary data on the operation status of the system of rural water supply plants in the city. The collected data were synthesized, analyzed, and represented by the authors through tables and graphs to illustrate the research content. The descriptive statistical method and comparative statistics were used to evaluate the overall sustainability of the rural clean water supply system in Hai Phong city.

Selection of criteria to assess the sustainability of the rural clean water supply

The formation, operation, and exploitation of rural clean water systems involve all actors in the system: from state management agencies, governments at all levels, investors, and households living in the area. Due to the characteristic of the water supply service as an essential public service that serves the daily lives of the people, the sustainability of the system is set as a top goal.

Many studies have mentioned good criteria that are the basic factors determining the sustainability of water supply systems. Accordingly, studies referring to the sustainability of clean water systems in rural areas all agreed that the sustainability of a system is reflected in its ability to provide water continuously over time, and not having negative impacts on the environment. However, Brikké & Rojas (2001) extended the definition of the sustainability of rural clean water systems when it comes to sustainability in terms of governance, operations, maintenance, cost, and community management. Peter & Nkambule (2012), Ibrahim (2017), and Jimenez-Redal *et al.* (2018) generalized these criteria into technical, social, environmental, financial, trust, and organization of the sustainability factors. In addition, many studies were concerned with the availability of the services, the satisfaction of water users, and the level of household payment for clean water (Montangero, 2009). Inheriting the above research results, the study of Domínguez *et al.* (2019) came up with 17 criteria with 95 quantifiable sub-criteria to assess the sustainability of the clean water system in Colombia. The tool's completeness was represented by its extensive attributes and metrics that provide a powerful analytical framework of the state of the system, help identify improvement strategies, and monitor the management of the system over time.

In Vietnam, Hoang Thai Dat & Manh Quan Phuc (2007) addressed a group of six criteria to assess the sustainability of the water supply in Bac Giang province. In 2012, the Ministry of Agriculture and Rural Development, the state management agency of the rural clean water sector, also issued a set of criteria for evaluating the sustainability of a water supply system according to Criterion 8 in the Clean Water Monitoring and Evaluation set by the Ministry of Agriculture and Rural Development (2012) with five sub-criteria. In this study, the authors selected a group of six criteria as described in **Figure 1** and scoring system as described in **Table 1**. The set of six sustainability assessment criteria showed the synthesis and inheritance of the standard views on sustainability of water systems as stated above by international scholars and organizations. Then, the average score for each sustainability criterion of the rural clean water supply system of Hai Phong city was calculated following the formula presented in **Table 2**.

The total sustainability score of system was determined by the following formula:

$$E = \sum_{i=1}^{6} Vi$$

where E is the total score representing the system's sustainability and Vi is the score of

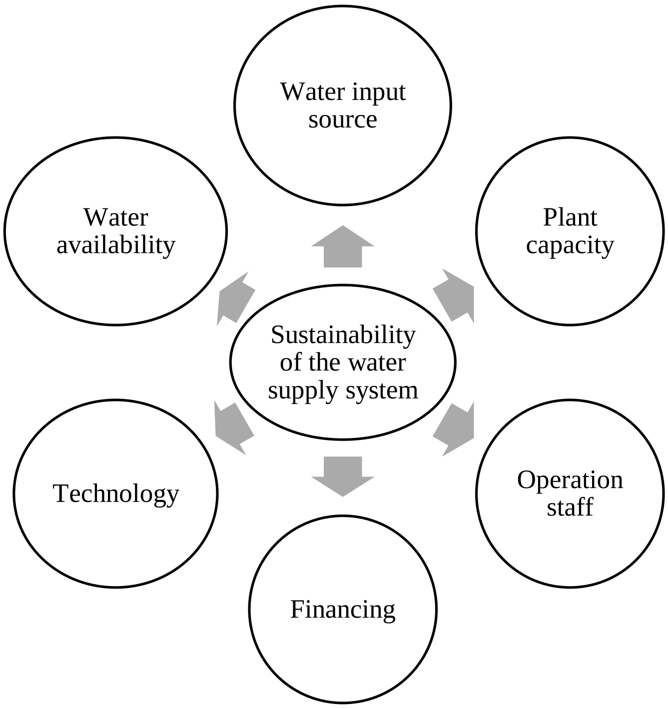

Figure 1. Six criteria to assess the sustainability of the rural clean water supply

Source: Hoang Thai Dat & Manh Quan Phuc (2007); Ministry of Agriculture and Rural Development (2012)

Table 1. Scoring the sustainability of the rural clean water supply

Criteria	Sustainability Scores		
	Not sustainable (1 point)	Fairly sustainable (2 points)	Sustainable (3 points)
Water input source	Water flow is not stable, water is polluted (contains a lot of rubbish and dirt)	The water flow is stable, the water level fluctuates no more than 1 meter, there is a risk of pollution	The water flow is stable, easy water collection conditions, water is unpolluted (with little trash and dirt)
Plant capacity	Actual capacity is less than 50% of the design capacity	Actual capacity is from 50% - 60% of the design capacity	Actual capacity is greater than 70% of the design capacity
Operation staff	Have no specific assigned responsibilities, training, or professional guidance	Have assigned responsibilities, but no training or professional guidance	Have assigned responsibilities, training, and professional guidance
Financing	Deficit	Cost recovery	Have profit
Technology	Outdated technology, water loss rate > 35%	Suitable technology, water loss rate 25-35%	Modern technology
Water availability	Stops working or pumps hourly, water supply interruption period is more than 1 month per year	Occasionally interrupted, water supply interruption period is less than 1 month per year	Always stable, uninterrupted

Source: Hoang Thai Dat & Manh Quan Phuc (2007); Ministry of Agriculture and Rural Development (2012).

Table 2. The average score for each sustainability criterion of the rural clean water supply system

Criterion	Score	Number of plants	Percentage (%)	Average score
Sustainable	3	N3	N3/N	3xN3/N
Fairly sustainable	2	N2	N2/N	2xN2/N
Not sustainable	1	N1	N1/N	1xN1/N
Total		N = N1 + N2 + N3	100.0	1xN1/N + 2xN2/N+ 3xN3/N

each sustainability criterion (from 1 to 3 points). If the E score ≥ 15 points, the system operates sustainably. If E reaches 12-15 points, the system operates fairly sustainably. If the E score is 6-12 points, the system does not operate sustainably.

Results and Discussion

The clean water supply system in Hai Phong city

According to the review results of the rural state budget system of the Department of Agriculture and Rural Development of Hai Phong city (2019), currently, the city had 215 facilities providing clean water to rural areas (**Table 3**). These facilities were built in the period from 1997 to 2016 under the National Target Program on Rural Clean Water and Sanitation.

Small-capacity water plants were built in seven suburban districts, with an average of 1.5 water supply plants in each commune. This rate was especially high in An Lao, Kien Thuy, and Thuy Nguyen districts (**Table 4**). Meanwhile, Cat Hai island district had only two water plants built, not enough to supply all the communes in the area.

Under the policy of socializing of the National Target Program on Rural Clean Water and Sanitation, the rural clean water supply plants in the area were built from capital contributed by different investors. Therefore, the water supply plants in the area also had differences in their operational management models. As shown in **Table 5**, the plants were managed by private enterprises and individual business households dominated in quantity compared to the cooperative model and the Commune People's Committee model.

However, up to the present time, the inspection of the Department of Agriculture and

Table 3. Summary of the rural clean water plants in Hai Phong city

Capacity	Number of plants	Water quality standard	Water supply area	Total area
Small-capacity (200-500m^3 per day)	205	QCVN02, QCVN01	Only supply rural areas	141 communes in 7 districts
Large capacity (> 1000m^3 per day)	10	QCVN01	Mainly supply urban areas, supplemental supply to rural areas	57 communes and towns

Source: Department of Agriculture and Rural Development of Hai Phong city (2019).

Table 4. Allocation of the rural clean water supply plants

No.	District	Number of communes	Number of plants	Plants per commune
1	An Duong	15	18	1.2
2	An Lao	15	33	2.2
3	Cat Hai	10	2	0.2
4	Kien Thuy	17	36	2.1
5	Tien Lang	22	22	1.0
6	Thuy Nguyen	35	61	1.7
7	Vinh Bao	29	33	1.1
	Total	143	205	1.5

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Table 5. Management models of the rural clean water supply plants

Management model	Number of plants	Percentage (%)
Commune People's Committee	2	1.0
Private enterprises	96	46.8
Cooperative	17	8.3
Individual business households	90	43.9
Total	205	100.0

Source: Department of Agriculture and Rural Development of Hai Phong city (2017).

Rural Development of Hai Phong City in 2019 showed that 205 water supply plants for rural areas had been built but there were 44 plants built in the same location, indicating that these are expansions of existing water supply plants. The fact is that only 110 plants have been still in operation, while the rest have been shut down or converted to water transfer stations for urban water plants (**Table 6**). Among the "in operation" plants, there were only 19 plants that had increased their capacity from 1000 to 6000m^3 per day or improved the quality of the water supply to meet the National Technical Standards for drinking water (QCVN01: 2009/BYT).

Thanks to those water supply plants, by the end of 2019, the percentage of rural households having access to and using clean water meeting the QCVN02:2009/BYT standards or higher was 92.1% (of which the rate of households using QCVN02: 2009/BYT water was 55.2%, and the rate of households using QCVN01: 2009/BYT was 36.9%).

Table 6. Classification of water plants according to their operational status

Operational status	Number of Plants
In operation	110
Shut down	30
Converted to water transfer stations for urban water plants	21
Built in the same location (expansion)	44
Total	205

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Table 7. The situation of water input sources of the rural clean water plants

Situation of water input sources	Number of plants	Percentage (%)	Average score
Stable water flow, water is unpolluted	109	53.2	1.6
Stable water flow, a risk of pollution	83	40.5	0.8
Unstable water flow, water is polluted	13	6.3	0.1
Total	205	100.0	2.5

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Table 8. Actual capacities of the water plants

Actual capacity as a percentage of the design capacity	Number of plants	Percentage (%)	Average score
> 70%	83	40.5	1.2
50-70%	15	7.3	0.1
< 50%	107	52.2	0.5
Total	205	100.0	1.9

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

The sustainability of the clean water supply system in Hai Phong city

Sustainability of the water input sources

The lack of planning for the rural clean water system had led to the fact that the water input sources of more than 46% of the water plants in the area were heavily polluted or at risk of pollution, and this risk was mainly concentrated in the area of the two districts Thuy Nguyen and An Lao (**Table 7**). The reason was that the majority of the plants get their water input from sources like irrigation canals, which contained a lot of waste because these canals had not been invested in regularly for renovations (Bich Hoa, 2016). This had a great influence on the quality of the output water, especially in the context that the water treatment systems of the plants were not advanced and modern.

Sustainability of plant capacities

According to each plants' registration, most of the plants had small design capacities of 200-500 m^3/daily. However, a majority of them were operating at an actual capacity of less than 50% of their designed capacity (**Table 8**).

The reason was attributed to the insufficiency or degradation of the plants' treatment systems, which include sedimentation tanks, storage tanks, and chlorine pumps, etc. On the other hand, water loss still occurred due to the use of unqualified, old, and outdated water measuring equipment, which also affected the operating capacities of these plants (Nhat Minh, 2015).

Sustainability of the operation staff

The classification of the water supply plants in the area shows that most of the water plants were managed and operated by investors who were private enterprises or individual business households. Interviews with representatives of the water plants in the research area showed that the water plants were managed according to the traditional model with 3-5 staff. These personnel were not well trained in the management of the water plants but were often relatives of these investors who had taken advantage of opportunities to create jobs. Therefore, it could be seen that the management and operation of the plants are not methodical and effective. The average score for this sustainability criterion reached 2.1 points (**Table 9**).

Sustainability of financing

Due to the regulation that each region has only one water supply unit, small capacity water plants could not expand their operational areas, but could only provide water services in a specific area. On the other hand, for current customers, not all of them have been using clean water from water plants as the main source of their domestic household water but only using a minimum amount of the water supplied (Nguyen Thi Thu Quynh *et al.*, 2018). This affected the revenue of the water plants which may not increase but may also decrease. Moreover, compliance with regulations on selling clean water at a pre-determined price set by the City People's Committee made the water plants not only passively run their business but also not ensure their expected profit. Survey results of the owners of water plants in the research areas show that most of the water plants that are in operation could only collect recovery costs, the rest of them had to stop operation or converted to transfer stations. On the other hand, 39 plants were operating with an actual capacity greater than the designed capacity (Department of Agriculture and Rural Development of Hai Phong city, 2019). This implies that their revenue was higher than expected, and they were profitable in the clean water service business (**Table 10**). The average rating of this criterion was 1.9 points.

Sustainability of technology

According to the inspection report of the Hai Phong Department of Agriculture and Rural Development (2019), most of the water plants in the province had outdated water treatment technology (accounting for 24%) or only had suitable technology to produce water which meets the QCVN02 standard (accounting for 67%) (**Figure 2**). At their current level of technology, these plants were not eligible to upgrade and improve the treatment system to ensure the quality of the output water meets the QCVN01 standard for drinking water. The average score for this criterion was 2.4 points.

Table 9. Operation staff of the water supply plants

Operation staff	Number of plants	Percentage (%)	Average score
Staff have assigned responsibilities, training, and professional guidance	55	26.8	0.8
Staff have assigned responsibilities, but no training or professional guidance	112	54.6	1.1
Staff have no specific assigned responsibilities, no training, and no professional guidance	38	18.5	0.2
Total	205	100.0	2.1

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Table 10. Financial situations of the water supply plants

Financial status	Number of plants	Percentage (%)	Average score
Gain profit	39	19.0	0.6
Cost recovery	115	56.1	1.1
Loss	51	24.9	0.2
Total	205	100.0	1.9

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

The reason for the outdated technology was that many of the plants had been in operation for a long time (since the 1999-2003 period), so they were now out of date and in various stages of deterioration. Unfortunately, due to the unfavorable financing situation, the revenue was not enough to cover costs, so they did not have enough accumulated capital to invest in renovating and upgrading works.

Sustainability of water availability

Water availability reflects the ability to supply water stably to serve the regular and continuous needs of the people. Survey results showed that, in addition to the 38 plants that have stopped operating, there were still three plants operating in moderation (**Table 11**). The proportion of water plants supplying infrequent and continuous water supplies accounted for 40%. Only 40% of the plants were capable of supplying water regularly and continuously. The average score for this criterion was 2.2 points.

Thus, the synthesis of the assessment results according to all six criteria for the sustainability of the system of water plants in the area showed that the total score of all six criteria was only 12.9 points, corresponding to the level of fair sustainability. Among the six criteria, the highest sustainability criteria was the water input source and technology, while plant capacity and financing criteria were the two lowest (**Figure 3**). However, the assessment report of the Department of Agriculture and Rural Development of Hai Phong City (2019) on the sustainability statuses in the operation of the rural clean water plants in the Hai Phong city was much more optimistic as described in **Figure 4**.

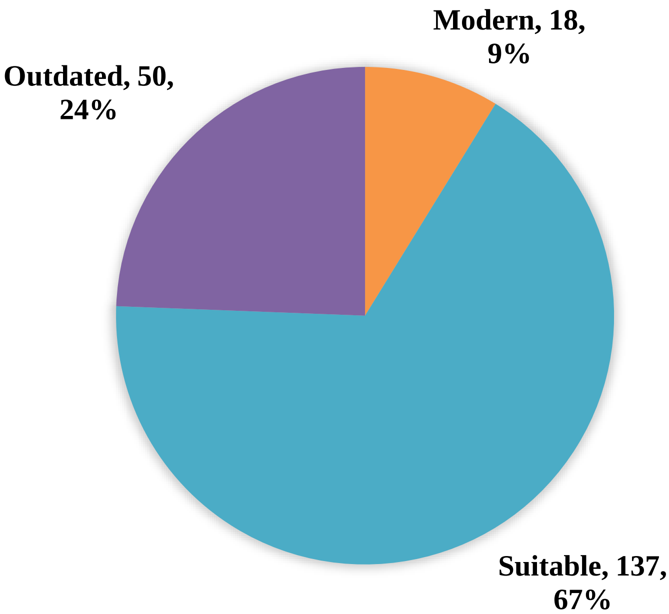

Figure 2. Current treatment technology of water plants

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Table 11. Water availability

Water availability level	Number of plants	Percentage (%)	Average score
Regular and continuous	83	40.5	1.2
Infrequent and continuous	81	39.5	0.8
Stopped or operating in moderation	41	20.0	0.2
Total	205	100.0	2.2

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

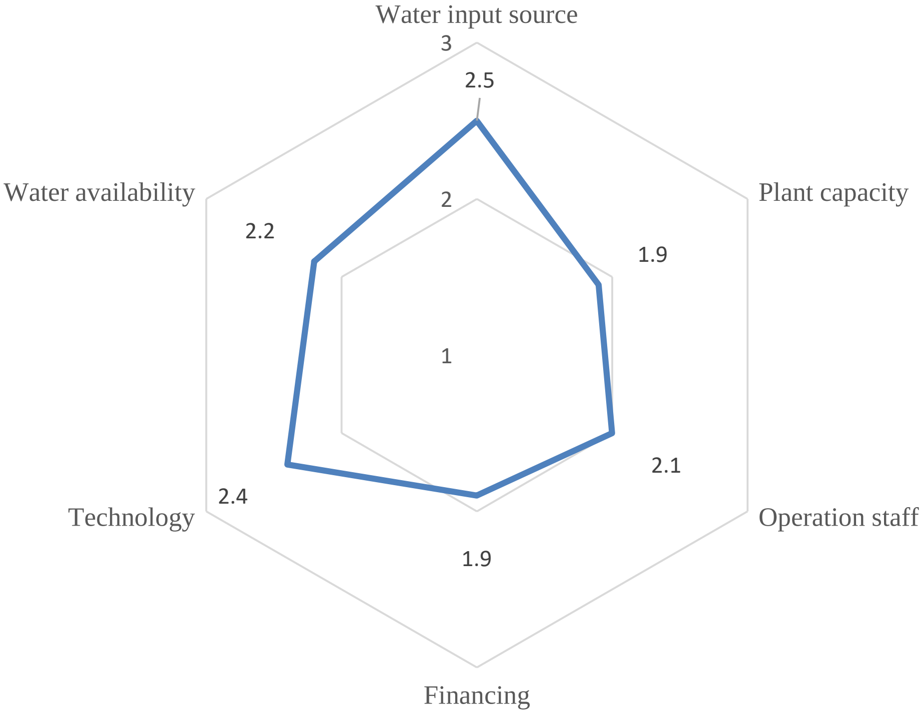

Figure 3. Matrix of the sustainability scores

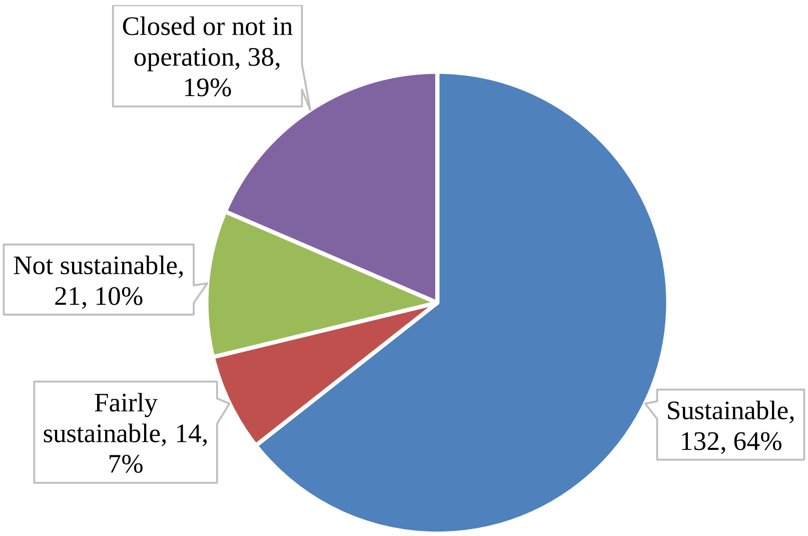

Figure 4. Sustainable statuses of the rural clean water plants

Source: Department of Agriculture and Rural Development of Hai Phong city (2019)

Solutions to improving the sustainability of Hai Phong's rural clean water system

Based on the analysis above, it can be said that the sustainability of Hai Phong's rural clean water system was not in as good condition as expected. The lowest sustainability scores were related to the plant capacity, financing, and operation staff criteria as addressed in **Figure 3**. Therefore, in the future, a number of solutions should be done in order to improve the sustainability of the systems.

First, toward the financing and plant

capacity criteria: the state management agency on rural clean water as well as the water supply plants need to strengthen propaganda to the local people about the importance of clean water and the need to appropriately increase in their clean water level usage, which in turn increases the demand for water and increases the actual capacities of the plants. Because an increase in the operating capacity also contributes to increases in revenue and profits, plant owners will then have the ability to reinvest in technology upgrades and improve the regular water supply capacities of the plants in the future, eventually ensuring enhanced sustainability in providing safe clean water services for daily life and improving the quality of life of people in rural areas in Hai Phong city.

Second, toward the financing criterion: water quality should be ensured to gain the trust of consumers and encourage households to consume more water. Thus, this needs to be guaranteed not only through the commitments of the water supply plants but also through regular checks of the plants by the water management agencies.

Third, toward the operation staff: the water supply plants should improve the working capacity of the operation staff. The operation staff should be regularly trained in terms of not only technical practices in water treatment management but also good practices in providing customer service for water consumers.

Conclusions

The synthesis and evaluation of the current situation of the entire rural clean water system in Hai Phong city according to the six selection criteria revealed that the sustainability of the system was at a reasonably sustainable level. Many of the sustainability criteria are not yet guaranteed. The sustainability criteria scores ranged from 1.9, for plant capacity and financing, to 2.5, for water input source, with the total score of the whole system was 12.9 points out of 18.0 points. Based on this situation, we propose that in order to improve the sustainability of the clean water supply system in the rural areas of Hai Phong city in the future, management agencies and investors need to apply some solutions, including: (1) strengthening propaganda to the people about the importance of clean water and using appropriate amounts of water to increase demand and increase the actual capacity of plants; (2) ensuring the water quality, and (3) improving the working capacity of the operation staff.

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