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Performance Evaluation Of Shankarnagar Water User's Committee, Rupandehi, Nepal

Shishir Acharya[1], Khetraj Dahal[2*], Sujeet Dhakal[3], Sita Ghimire Mainali[4]

[1]*Department of Construction Engineering and Management, Lumbini International Academy of Science and Technology, Manbhawan, Lalitpur, Nepal. acharyashi1995@gmail.com*

[2]*Department of Construction Engineering and Management, Lumbini International Academy of Science and Technology, Manbhawan, Lalitpur, Nepal, dahalkhetraj@gmail.com*

[2]*Department of Structural Engineering, Lumbini International Academy of Science and Technology, Manbhawan, Lalitpur, Nepal, sujeetdhakal245@gmail.com*

[4] *Independent Consultant of Real State, NC, USA, sitadidi@gmail.com*

Abstract

National coverage of basic water supply and sanitation in Nepal improved significantly between 2014 and 2019, increasing from 83.59% to 87.88% for water supply and from 72.22% to 98.32% for sanitation. However, many completed water supply schemes face functionality challenges: only 28.14% are functioning well, while the rest require varying levels of repair, rehabilitation, or reconstruction. This study assesses the performance of the Shankarnagar Water Supply Consumers and Sanitation Association (SWSCSA) as a representative water utility. Performance was evaluated in terms of physical condition, functionality, quality of service, and operational and financial management. Primary data were collected through household surveys, key informant interviews, focus group discussions, site visits, and water quality testing, while secondary data were obtained from official documents, reports, and published literature. Key performance indicators were grouped into three categories: quality of service, operational performance, and financial performance. Quality of service indicators included water quality, quantity, and affordability. Operational performance was assessed using metering ratio, staff productivity, energy consumption, and non-revenue water (NRW). Financial performance was evaluated using the cost recovery ratio (CRR), maintenance cost as a proportion of operating cost, and revenue collection ratio (RCR).

Keywords: Water Consumers and Sanitation Association, Current Functionality Index, Physical Structure Index, Quality of services, operational performance, financial performance.

1. Introduction

The Ministry of Water Supply oversees the government-funded Ushers Community Water Supply and Sanitation Project. This project is being implemented by the Department of Water Supply and Sewerage Management (DWSSM). Since the fiscal year 2011–12, the Ushers Community Water Supply & Sanitation Project has been in operation. The public-private partnership (PPP) model serves as the conceptual foundation for the Ushers Community Water Supply & Sanitation Project. In contrast to the conventional system, our initiative aims to guarantee improved quality and service level. After the community promised to contribute 30% of the project's overall implementation costs, it was put into action. 10% of the total cost must be paid in cash up front; the remaining amount may be covered by labor or monetary contributions.

According to the Ushers Community Water Supply and Sanitation Project, Project Implementation Directives - 2072 , the basic aim of the Ushers Community Water Supply and Sanitation Project is to provide improved service level from the conventional basic level of services in response to the changes in the living style of people, on-demand and cost-sharing basis with cost recovery principle. The project has the following additional objectives:

In recent years, Nepal has made significant socioeconomic progress. The rate of literacy has increased, poverty has decreased, gender disparities have diminished, and social inclusion has improved. Nepal is now aiming to achieve the Sustainable Development Goals and emerge out of the category of least-developed countries [13].

* *Corresponding author*

The primary objective of Nepal's rural water supply and sanitation national policy of 2004 was to provide a safe, accessible, and adequate water supply with sanitation facilities to all Nepalese people, with backward people and ethnic groups receiving priority. It has introduced a policy for the renovation and rehabilitation of the water supply system, as well as an emphasis on improving the community's capacity to handle water supply and system management. Until 2014, 15.3 percent of the population had access to a higher-quality water supply system.

Based on the report entitled "Depiction of Water Supply and Sanitation Status-2075" [3], the commitment towards achieving basic water and sanitation service for all by 2017 could not be met. Therefore, the target is revised to achieve by the end of 2019. The service is categorized based on four indicators namely water quantity, accessibility, continuity, and quality. The national level of basic water supply coverage is improved from 83.59% (2014) to 87.88% (2019). Similarly, the national level of basic sanitation facility coverage improved from 72.22% (2014) to 98.32% (2019). Meanwhile, 19.00% of the total population are getting treated drinking water and 51.69% of the total population are getting water through a piped network from about 43 thousand small and large water supply projects. This is the result of the combined effort put forth by the government and non- government organizations.

2. Methodology

At first problem was identified, then data was collected through primary method (Field Observation, In Depth Interview, Focus Group Discussion, Questionnaire Survey etc.) and secondary method (Published Literature, Thesis, Articles, Journals, Reports, Database etc.) and finally result was obtained and discussed.

2.1 Study Area

The Water Supply Consumers and sanitation Association is located at Tilottama Municipality of Rupandehi district in Lumbini Province. The water supply system covers four wards viz. 1, 2, 3, and 4 of the municipality. The project area is at a distance of 11 km southeast of Butwal sub-metropolitan city and 20 km north of Bhairahawa Municipality. It is connected with 6 lane Bhairahawa-Butwal Highway. After the successful construction of the project, the water supply system is being managed by WCSA.

2.2 Universe and Population of the Research

The Universe of this research study is the four wards 1, 2, 3, and 4 of Tilottama Municipality of Rupandehi district. The project has to cover 8450 households and about 68,000 populations. So far, the project has covered 8,331 households and about 66,500 population.

2.3 Sample Size and Technique

The project area has a total of 8350 households and a population About 68,000. Out of total households, only 8,331 households with a population of about 66,500 are getting water from the water supply system. Since the population of sampling is known and for qualitative versus quantitative study, the stratified random sampling method was adopted to interview 382 beneficiary populations. The sample size was calculated by using Slovin's Formula and the calculated sample size from each ward is shown in Table 2.1 below.

$$\mathbf{n = N/ (1+Ne^2)} \qquad \text{Equation (1)}$$

Where,

n = sample size, N = population size, e = acceptable margin of error (5-10)% adopted (10%)

Table 2.1. Sample Size Calculation in each ward of the Study Area

Ward Number	No. of Taps	Sample Size	
		Calculated	Adopted
1	1854	94.88	95
2	2664	96.38	97
3	2491	96.14	97
4	1322	92.96	93
Total	**8331**		**382**

2.4 Quality of Service

The Technical performance of the project was assessed by following indicators and compared with established benchmarks.

2.4.1 Water Quality

According to [5], samples from the designated collection sites should be representative of the system or its primary components. Additionally for each treatment plant there should be at least one sample connection location immediately immediately after the treated water output [5]. Similarly according to [14] there should be one microbiological per 5000 population. Eight water samples were collected for analysis of water quality. All the collected Eight water samples were tested at the SWSCSA laboratory in Yogikuti rupandehi in order to determine the physical, chemical, and microbiological characteristics. These obtained data were then evaluated. This evaluation assisted to determine the drinking water quality provided by this organization is suitable or not for drinking directly affecting human health in future.

2.4.2 Water Quantity

This indicator helps to identify the water supply coverage of the service area. It is the total volume of water used by a person per day for daily uses. For rural areas, the per capita consumption is taken as 45 lpcd while for urban areas it is 100 lpcd which denotes basic level service and medium level service respectively. To calculate water quantity, the formula was used from researchs conducted by [12;6], total authorized domestic water consumption was determined with the help of software of organization for billing and data storage and number of population served was calculated with the help of total number of household connection and average number of family member per household in service area which was obtained through national census data.

$$\text{Water Quantity (LPCD)} = \frac{\text{Total authorized domestic consumption}}{\text{Total population served}} \qquad \text{Equation (2)}$$

2.4.3 Water Affordability

Water affordability means people can pay their water bills without financial hardship, ensuring costs are fair for all income levels. Affordability is closely linked to GNI because poorer countries with low GNI struggle more to make water affordable, as even small bills burden families. Conversely, richer countries have more resources to subsidize costs and improve infrastructure, making water easier to afford for their populations. In this study, secondary data from water supply institution and Nepal's census helped to calculate total water revenue and population served, while Gross National Income (GNI) figures came from the government's economic survey from Ministry of Financial. On the basic of formula provided by (Saleem, 2020; Joshi et al., 2020) per capita consumption was calculated by

$$Per\ capita\ consumption\ (\%\ of\ GNI)\ \frac{(Total\ water\ revenue/total\ poulation)}{GNI} * 100 \qquad \text{Equation (3)}$$

2.4.4 Operational performance

In the water supply sector, operational performance is all about how well the system provides safe, reliable water to people when they need it. It includes staff ratio, metering ratio, non-revenue water and energy consumption. The required formula to calculate value of all those indicators was used on the basic of research [12;6].

2.4.5 Metering Ratio

The metering ratio is a critical component which is used for assessing the operational performance of water supply organizations. It involves the measurement of water input versus output, helping to identify discrepancies such as water losses, which can significantly impact financial and operational efficiency. Effective metering and ratio analysis can enhance the management of water supply systems by providing insights into areas of inefficiency and potential improvement. Metering all water connections is essential in order to introduce volumetric based tariff structure for water charges, the benchmark value for which is 100 percent but national average benchmark is found to be 96 percent [1]. To calculate meter ratio, secondary data was used from data provided by organization during field visit.

$$\text{Extent of Metering Conn (\%)} = \frac{\text{No of meter installed}}{\text{Total No of Registered water conn}} * 100 \qquad \text{Equation (4)}$$

2.4.6 Staff Ratio

The staff ratio is a critical component in evaluating the operational performance of water supply organizations. It reflects the efficiency and effectiveness of personnel management within these utilities, impacting overall service delivery and operational costs. The staff ratio, often expressed as the number of employees per connection or per volume of water supplied, provides insights into labor productivity and resource allocation. This indicator is particularly significant in assessing the balance between workforce size and operational demands, which can influence the financial sustainability and service quality of water utilities. From field visit information about number of existing staff in organization was collected which was secondary data used in this research. Here, staff ratio is expressed as number of staffs per 1000 water supply connections (Hamdan et al., 2021).

2.4.7 Energy Consumption

Energy consumption directly impacts both economic efficiency and environmental sustainability. Efficient energy management in water supply systems is essential to reduce operational costs, minimize environmental footprints, and ensure reliable service delivery. Energy consumption of SWSCSA was found through electricity consumed bill and payment bill prepared by NEA office as well as information provided by office assistant of Association. Energy consumption rates in water supply systems vary significantly based on geographical, technological factors, system design, and operational practices [10].

$$\text{Energy Consumption (kwh/m3)} = \frac{\text{Average daily energy consumption (kwh)}}{\text{Average daily water production(m3)}} \qquad \text{Equation (5)}$$

2.4.8 Non-Revenue Water

Non-revenue water (NRW) is a key metric for evaluating the efficiency of water utilities. It represents the difference between the volume of water produced and the volume billed to consumers, encompassing both physical losses (leakages) and commercial losses (theft, metering inaccuracies). Effective management of NRW is essential for improving the efficiency and sustainability of water supply systems [2]. Non-revenue water was determined with the help of total water production which was determined from data provided by office and with the help of average authorized bill consumption.

$$\text{Non Revenue water}(\%) = \frac{\text{Total Value of non Revenue Water Production}}{\text{Total water Production}} * 100 \qquad \text{Equation (6)}$$

2.4.9 Financial Performance

2.4.9.1 Cost Recovery Ratio

It is an important financial metric used by water supply organizations to know how well revenue covers the expenses of delivering water services. This ratio helps to evaluate financial sustainability and efficiency. It also indicates whether the system can operate without needing outside financial help. The ratio is calculated by dividing total revenue by total costs, which include operational, maintenance and capital expenses. It is essential for ensuring that water utilities can keep providing services while also investing in system upgrades and expansion (Mishra, 2019).To calculate cost recovery ratio, Secondary data was used like annual audit reports of both fiscal years and other necessary information provided by WSUC of organization. The formula to calculate cost recovery ratio is

$$\text{Cost Recovery Ratio} = \frac{\text{Total Water revenue billed}}{\text{Total operational expenses}} \qquad \text{Equation (7)}$$

2.4.9.2 Maintenance cost as a proportion of operation cost (%)

The financial performance of a water supply organization is heavily influenced by the balance between operation and maintenance costs. Maintenance costs often represent a significant portion of the total operational expenses, and their optimization can lead to improved financial outcomes. Inadequate maintenance can lead to system failures and increased long-term costs. Many water utilities face challenges in funding maintenance activities due to prioritization of capital investments over operational expenses. Addressing this issue requires a shift in funding priorities and the adoption of comprehensive cost models to ensure sustainable water service delivery [9].

$$\text{Maintenance cost as a proportion of operation cost} = \frac{Total\ Maintenence\ Cost(\ Rs)}{Total\ Operational\ Cost\ (\ Rs)} * 100 \qquad \text{Equation (8)}$$

2.4.9.3 Revenue Collection Ratio

The revenue collection ratio is a critical indicator of financial performance, reflecting the ability to efficiently collect payments for services rendered. This ratio is influenced by various factors, including operational efficiency, billing systems, and community engagement. A higher revenue collection ratio indicates better financial health and sustainability of the water supply organization [8].To calculate revenue collection ratio, secondary data was used which was collected during field visit to organization and with the help of annual audit report and billing software of organization.

$$\text{Revenue Collection Ratio}\ (\%) = \frac{\text{Total water Revenue Collected}}{\text{Total water Revenue billed}} * 100 \qquad \text{Equation (9)}$$

2.4.9.4 Functionality Index

The functionality indicators focus on whole year supply, adequate staff including technical, administration, operation and maintenance fund. To calculate functionality index primary and secondary data were mainly used and information regarding this data were collected through focal group discussion, interview with key person of organization like chairperson, accountant and office assistant. Additionally proper field visit was done with office staff, maintenance team and chairperson also to collect data used in calculation functionality index. The functionality indicators that have been used by the National Management Information Project [11] and being cited by (Mishra, 2019), was used in this research as shown in following Table 3.2. And formula for calculating Functionality index was used as:

$$\text{Functionality index}\ (\%) = \frac{\text{Total marks obatin as per condition}}{\text{Total full marks of indicators}} * 100 \qquad \text{Equation (10)}$$

2.4.9.5 Physical Structure Index

This index gives the physical status of the system to sustain the services. There are different physical water supply structure components which were evaluated, each having 10 marks and total marks for overall nine components was assigned to be 90. Efficiency of the physical structure was calculated using the equation:

$$\text{Physical structure index (\%)} = \frac{Overall\ situation\ as\ per\ scale}{Total\ full\ marks} * 100 \qquad \text{Equation (11)}$$

3. Results And Discussions

The main objective of the research is the assessment of the overall performance of the water supply system. To fulfill this objective, the water supply system is analyzed based on various performance indicators. The performance indicators are divided into three basic performance areas namely; quality of services, operational performance, and financial performance. The research work was carried out based on the data and documents from DWSSM, User's Association, field visit, questionnaire survey, Key informant's interview, and the following results were found depicting the real picture regarding the overall performance of the water supply system.

3.1 Quality of Service

The primary objective of WCSA is to provide high-quality services that satisfy the needs of water users. In addition, analyzing service quality is crucial for WCSA to manage resources effectively and achieve efficient, effective, and sustainable performance across its operations. For this study, three key performance indicators were used to assess the quality of service in the water supply system: water quality, water quantity, and water affordability. The findings for each of these indicators are discussed in the following sections.

3.1.1 Water Quality

The water quality indicator of the water supply project was measured as a percentage of the water sample that passed the standard divided by the total tests carried out.

3.1.2 Water Quantity

Table 3.2. Quantity of Water

S.N.	Particulars	Value
1	Total authorized domestic consumption (lpd)	1,35,00,000
2.	Population served	66,500
3.	Water quantity (lpcd)	203.00

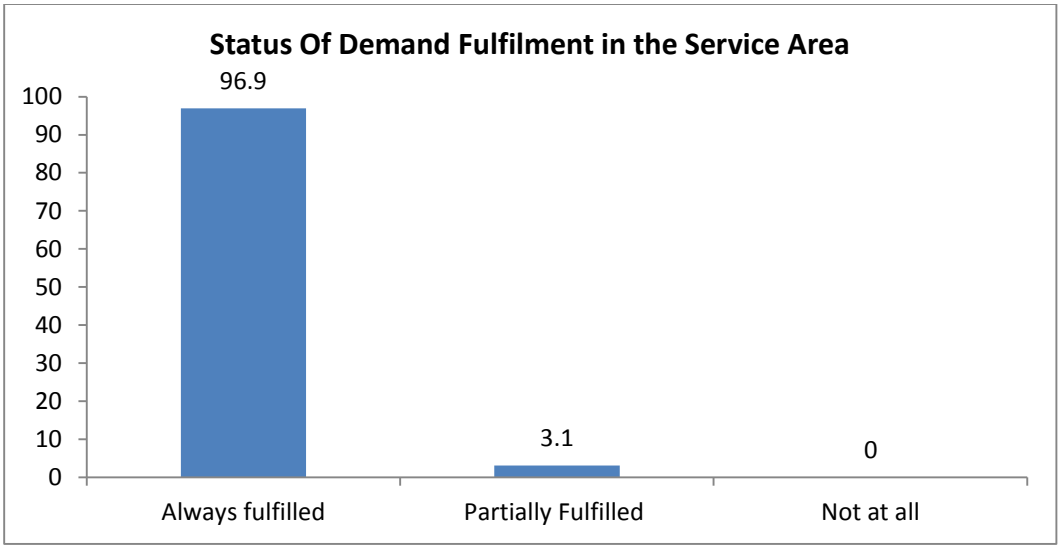

Figure 3.1. Status of Water Demand Fulfillment in the Service Area

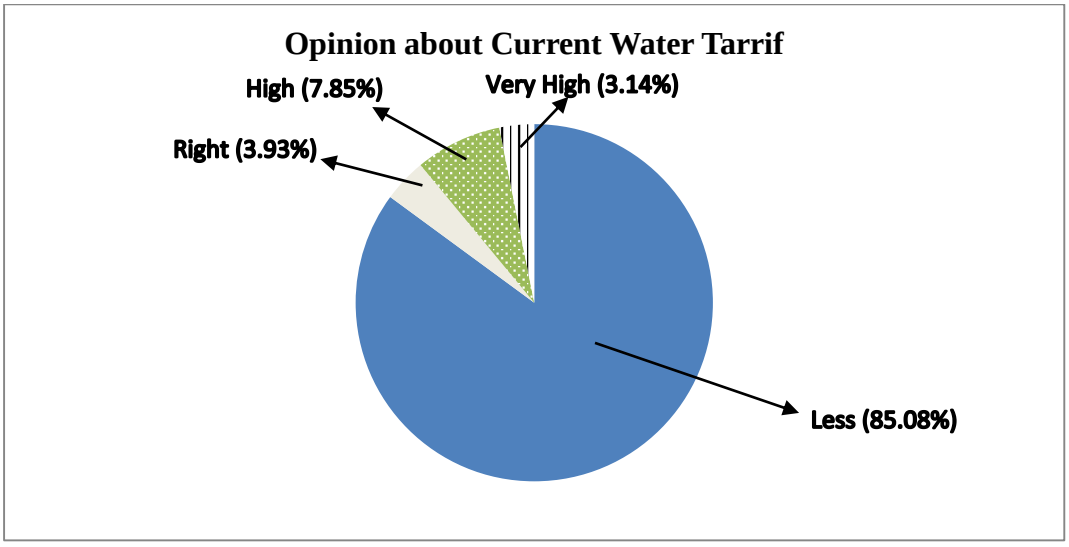

Figure 3.2. Opinion about Current Water Tariff

3.1.3 Distribution System

Table 3.3. Distribution System and Capacity Of tank

Overhead Tank	**Tank 1**	**Tank 2**	**Tank 3**
Total Capacity liter	4,50,000	4,50,000	4,50,000
Production Capacity per hour Liter	3,50,000	1,20,000	1,80,000
Type of Distribution System	Dead-End	Dead End Type Radial	Dead-End

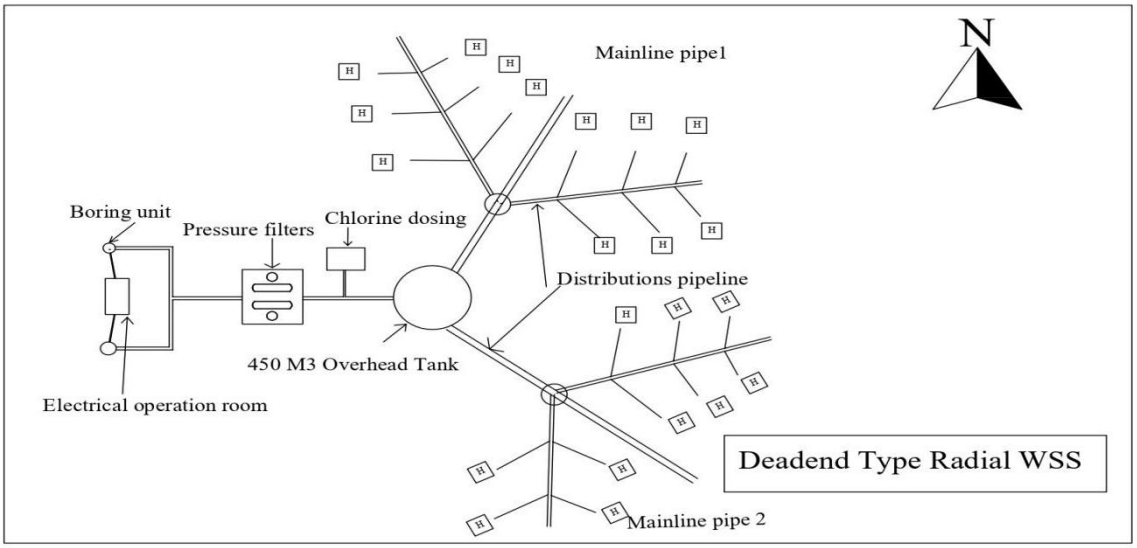

Figure 3.3. Lay out of dead end radial water supply system for tank 2

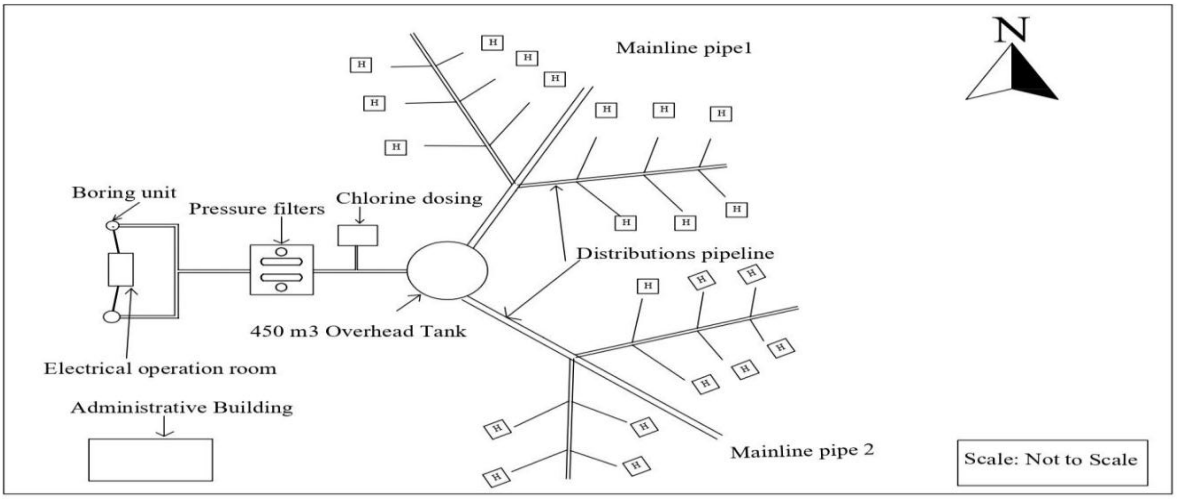

Figure 3.4. Lay out of dead end radial supply system for tank 1 and tank 3

3.2 Operational Performance

3.2.1 Metering Ratio

For this study, the metering ratio was calculated as the total number of water meters installed divided by the total number of registered water connections, expressed as a percentage, regardless of whether the meters were in use. The achieved performance score for this indicator was 100% (Table 3.4). The national average metering ratio for water service providers was 93.4% [13].

Compared to the national average, WCSA's result reflects excellent practice in managing water production, consumption, losses, billed water, and Non-Revenue Water (NRW). Furthermore, the high metering ratio has supported WCSA in implementing a structured tariff system, generating sufficient revenue to cover all operational expenses, including operation and maintenance (O&M) costs (Table 3.4).

Table 3.4. Metering Ratio

Fiscal Year	2080/81	2081/82
No. of registered water connections	806	8331
No. of meters installed	8061	8331
Metering ratio (%)	100	100

3.2.2 Staff Productivity Index

Table 3.5 Staff per 1000 Water Connections

Fiscal Year	2080/81	2081/82
No. of registered water connections	8061	8,331
No. of Staff	21	21
Staff per 1000 water connections	2.6	2.52

3.2.3 Energy Consumption

Table 3.6 Energy Consumption

Particulars	Value	Unit
Average daily water production	13500	m^3/day
Average daily energy consumption	4833	kWh
Energy consumption	0.358	kWh/m^3

3.2.4 Non-Revenue Water (NRW)

For assessing the NRW of the water supply system, it was calculated as the difference between the total water production and the billed authorized water consumption and expressed as the percentage of the total water production (Table 4.8).

Table 3.7. Non-Revenue Water (NRW)

Particulars	Value		Unit
	2080/81	2081/82	
Average daily water production	13000	135000	m^3/day
Average billed authorized water consumption	11050	11745	m^3/day
NRW	11.76	8.7	%

3.3 Financial Performance

To provide sustainable, reliable, and high-quality water services, WCSA must ensure proper operation of its functional components while maintaining financial sustainability. Financial sustainability is crucial for water supply providers, as it determines whether WCSA has sufficient funds to cover total operating, maintenance, and investment costs. In the case of Shankarnagar WCSA, the total operating expenses are fully covered by revenue collected from water users. Assessing the extent to which water revenue meets total O&M expenses is therefore essential. Poor financial performance can lead to low-quality water service delivery and threaten the overall sustainability of the system.

In this study, the financial performance of WCSA was analyzed using three key indicators: Cost Recovery Ratio (CRR), the proportion of the budget allocated to maintenance relative to total operating costs, and the Water Revenue Collection Ratio (RCR).

3.3.1 Cost Recovery Ratio (CRR)

Table 3.8. Cost Recovery Ratio (CRR)

Fiscal Year	**2080/81**	**2081/82**
Total water revenue billed (NRs.)	31,560,557.37	32,494,574.4
Total operational expenses (NRs.)	53,22,913	61,89,090
CRR	5.93	5.25

3.3.2 Maintenance Cost as a Proportion of Operation Cost

Table 3.9. Maintenance Cost as a Proportion of Operating Costs

Fiscal Year	**2080/81**	**2081/82**
Total maintenance cost (NRs.)	24,26,346	12,54,006.00
Total operational expenses (NRs.)	53,22,913	61,89,090
Maintenance cost Vs. operating costs (%)	45.55	20.26

3.3.3 Revenue Collection Ratio (RCR)

Table 3.10. Revenue Collection Ratio (RCR)

Fiscal Year	**2079/80**	**2080/81**
Total water revenue collected	30,781,829.07	31,735,176.8
Total water revenue billed (NRs.)	31,560,557.37	32,494,574.4
RCR (%)	97.53	97.66

3.3 Functionality Status and Physical Structure Index of Water Supply System

3.3.1 Functionality Status of Water Supply System

Table 3.11. Calculation of functionality Index of Water Service Provider

S.N.	Indicators	Weightage (As per NMIP)	Status	Marks Obtained
1	WUSC Registration	Yes (10), No (0)	Yes	` 10
2	Having own staffs with maintenance workers	Yes (10), No (0)	Yes	10
3	O & M Fund	Sufficient (10), Less (5), No (0)	Sufficient	10
4	WSUC Meetings	RegularYes (10), Irregular (5), No (0)	Regular	10
5	Efficient water tariff collection	Yes (10), Partial (5), No (0)	Yes	5
6	Record keeping	Proper (10), Random (5), No (0)	Proper	10
7	Tools and fittings reserve	Sufficient (10), Inadequate (5), No (0)	Sufficient	10
8	Water safety plan	Functional (10), Partial Functional (5), Non functional (0)	Partial Functional	5
9	Reliability (whole year supply)	Yes (10), Nine month (5), Six month (0)	Whole year	10
10	Accessibility	15 minutes (10), 30 minutes (5), More than 30 minutes (0)	Less than 15 minutes	10
	Total	**100**		**90**

3.3.2 Physical Structure Index of Water Supply System

Table 3.12. Condition of Physical Structures of Water Supply System

S.N.	Physical Structure	Overall condition	Full Marks	Marks Obtained
1	Air valve chamber	Good	10	10
2	Motor pump	Good	10	10
3	Chlorination chamber	Good	10	10
4	Generator	Good	10	10
5	Overhead Reservoir	Good	10	10
6	Valve fittings and valve chamber	Satisfactory	10	8
7	Distribution pipelines	Satisfactory	10	7
8	Transmission pipelines	Satisfactory	10	8
	Total		**60**	**56**
	Efficiency (%)			**91.25%**

3.4 Discussion

Water samples were collected from eight different locations to represent the overall supply system, and all samples complied with the required water quality standards. A household survey of 382 respondents indicated that most users were satisfied with the water supply, with 92% expressing satisfaction and only 8% reporting

dissatisfaction. Furthermore, the majority of households (91.9%) consumed the supplied water directly without any treatment, while 6.57% boiled their water and 1.55% used filtration before drinking.

The water affordability indicators of the water supply system were calculated as 0.24% and 0.22% of GNI for the fiscal years 2080/81 and 2081/82, respectively. These values indicate that the water supply service was highly affordable in both fiscal years. The existing water tariff was therefore considered appropriate for the project, contributing to strong water revenue generation and a high Cost Recovery Ratio (CRR). Furthermore, household perceptions of the current tariff showed that 85.08% of households felt the tariff was low, 3.93% considered it reasonable, while 7.85% and 3.14% perceived it as high and very high, respectively.

A 100% metering ratio in both fiscal years 2080/81 and 2081/82 reflects the strong management practices adopted by WCSA in effectively controlling water production, consumption, losses, billed water, and non-revenue water (NRW). This complete metering practice has enabled WCSA to implement a well-structured water tariff system, resulting in high revenue generation and the ability to fully cover operational expenditures, including operation and maintenance (O&M) costs.

The total number of registered water connections in fiscal years 2080/81 and 2081/82 were 8,061 and 8,331, respectively. During both fiscal years, WCSA employed a total of 21 staff members. The Staff Productivity Index (SPI) of the water supply system was calculated as 2.6 for fiscal year 2080/81 and 2.52 for fiscal year 2081/82. These values are lower than the benchmark recommended by Tynan and Kingdom (Bajracharya, 2014). This indicates that WCSA does not face an overstaffing issue and that available human resources are being utilized efficiently.

The proportion of maintenance costs relative to total operating costs was 45.55% in fiscal year 2080/81 and 20.26% in 2081/82, both exceeding the benchmark of 20% suggested by [12]. This indicates that a substantial portion of the budget was allocated to maintenance in both years. Such funding levels are sufficient to support WCSA in properly maintaining its assets, ensuring the delivery of efficient, effective, and sustainable water services.

4 CONCLUSIONS

All water samples from eight locations met the required quality standards, but not all users were completely satisfied 92% were happy with the water quality, while 8% were not. The system provides 203 liters of water per person per day, fully meeting the needs of 96.9% of households, though 3.1% still experienced some shortage. The water tariff is very affordable, accounting for only 0.24% and 0.22% of GNI in fiscal years 2080/81 and 2081/82, which helps WCSA generate strong revenue and maintain a high Cost Recovery Ratio. Still, about 11% of users felt the tariff was high, indicating that a little more attention to pricing or communication with users could help improve satisfaction. The practice of 100% metering has allowed WCSA to implement a structured tariff system, ensuring full coverage of operational and maintenance costs. Staffs are being used efficiently, with no overstaffing issues, and the system performs well in terms of energy consumption. Non-Revenue Water (NRW) is already lower than the national average of 21.6%, but further improvements are possible by repairing leaks in the distribution network and replacing faulty meters promptly. Overall, WCSA has established an efficient, reliable, and financially sustainable water supply system, though continued attention to user satisfaction, minor losses, and maintenance will help sustain and improve service in the future.

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