American Journal of Water Science and Engineering
2023; 9(2): 36-40
http://www.sciencepublishinggroup.com/j/ajwse
doi: 10.11648/j.ajwse.20230902.12
ISSN: 2575-1867 (Print); ISSN: 2575-1875 (Online)

Assessing Challenges of Potable Water Supply, Demand and Enhancing Sustainability

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To cite this article:
Ebissa Gadissa Kedir. Assessing Challenges of Potable Water Supply, Demand and Enhancing Sustainability. *American Journal of Water Science and Engineering*. Vol. 9, No. 2, 2023, pp. 36-40. doi: 10.11648/j.ajwse.20230902.12

Received: February 4, 2023; **Accepted**: April 25, 2023; **Published**: May 10, 2023

Abstract: This paper presents the challenges of water supply demand and enhancing water sustainability in rural areas. Data collected from field observation, regional water offices and officials, questionnaires and community responses were conducted. Data from the selected districts of the study area was discussed and analyzed. Two hundred seventeen water supply points (one hundred thirty hand-dug wells, thirty-five rope pumps, forty-eight spring development, and five shallow wells) are constructed in the study area. Among these water points, one hundred ninety-four were functional during the study time, and twenty-three were non-functional. Developed spring and rope pumps account for 22.11% and 16.12% of the total, respectively. In contrast, the hand-dug well and shallow wells as a source of water account for 59.9 % and 2.3%, respectively. The communities in the study area also use rivers and unprotected springs as water sources. This study found that the water supply in the study area is far less adequate for multiple reasons. The rural water supply system fails due to inappropriate design and underestimating population growth while designing water supply by considering only the existing population. The social and economic importance of providing a potable water supply is widely recognized. The study elicited why water supply systems have become inadequate in the area. This study may be helpful to have sufficient information before launching significant investments in rural water supply works.

Keywords: Potable Water Supply, Water Demand, Challenges, Sustainability, Ethiopia

1. Introduction

Water is fundamental for life. Water is necessary for leading a healthy life with human dignity. Consequently, water and sanitation-related diseases are widespread [1–3]. When humans do not have access to water, they may suffer physical, emotional, and socio-economic problems. The main health problems, especially in developing countries like Ethiopia and others, are due to poor access to potable water and sanitation practices [4–6]. For this, supplying safe drinking water is of critical importance. Ethiopia has the lowest secure water coverage in sub-Saharan Africa, estimated at only 42%, with 31% rural coverage. By realizing the crucial significance of supplying potable water, national and regional governments and local and international NGOs invest millions of capital annually in developing countries to tackle the problem by implementing water supply projects [7, 8].

Growing populations and a lack of available cost-effective supply augmentation options make reliable estimates of residential water demand important for policymaking [5, 9, 10]. Problems of providing a safe water supply to developing cities and poor urban increase as the population increases. Thus, the demand for additional water sources and infrastructure is growing. Ethiopia's population surpasses 100 million and is the second country in Africa, next to Nigeria by population. For this case, reliable estimates of residential water demand, water source choice decisions and effects have become more critical for policymaking in the water supply sector [5, 10, 11].

Ethiopia has the potential for water resources with 12 river basins with an annual runoff volume of 122 billion m^3 and an estimated 2.6 - 6.5 billion m^3 of groundwater. However, the distribution and availability of water are not satisfactory within time and space. Thus, despite the abundance, the country is highly water-scarce. Of the total water resources available to Ethiopia, only 9% remains; the bulk flows downstream to neighbouring countries and is particularly important for Egypt, Sudan, Kenya and Somalia.

The water supply system in Ethiopia is failed due to inappropriate design and underestimation of population growth or projection while designing the water supply. The projects are designed and implemented considering only the existing population [4, 9, 10, 12, 13]. The pipe installations also did not feel the population pressure. Constructing water supply systems alone would not eliminate all problems, especially in rural areas. Hence, functionality intended for beneficiary utilization and water project resilience must be considered and integrated to achieve maximum benefits [14, 15]. The integration between beneficiaries and project suppliers in contributions and management must be addressed in all phases [5]. Therefore, the scope of this research is limited to water supply distribution and demand prediction. In addition, it is necessary to examine challenges that undermine the long-term sustainability of rural water supply projects. Assessing the challenges of sustainable rural potable water use at both pre-and post-construction stages is critical for Ethiopia and the present study area. Having sufficient information before launching significant investments in rural water supply works will be helpful.

2. Study Area Description

The present study area, Farta woreda/district, is located in the northern part of Ethiopia in the Amhara region, approximately between the projected coordinate system of 1291463.66 m and 1332190.77 m'N, and between 373998.97m and 422988.61 m'E. The Woreda includes thirty-five Kebeles and is about 660 km away from the capital city of Ethiopia, Addis Ababa, and is 100 km from the Regional Capital of Bahir Dar to the east direction, as shown in Figure 1. The total area of the watershed is about 1099.25 km^2. Topographically, it is characterized by undulating terrain with a significant altitudinal variation.

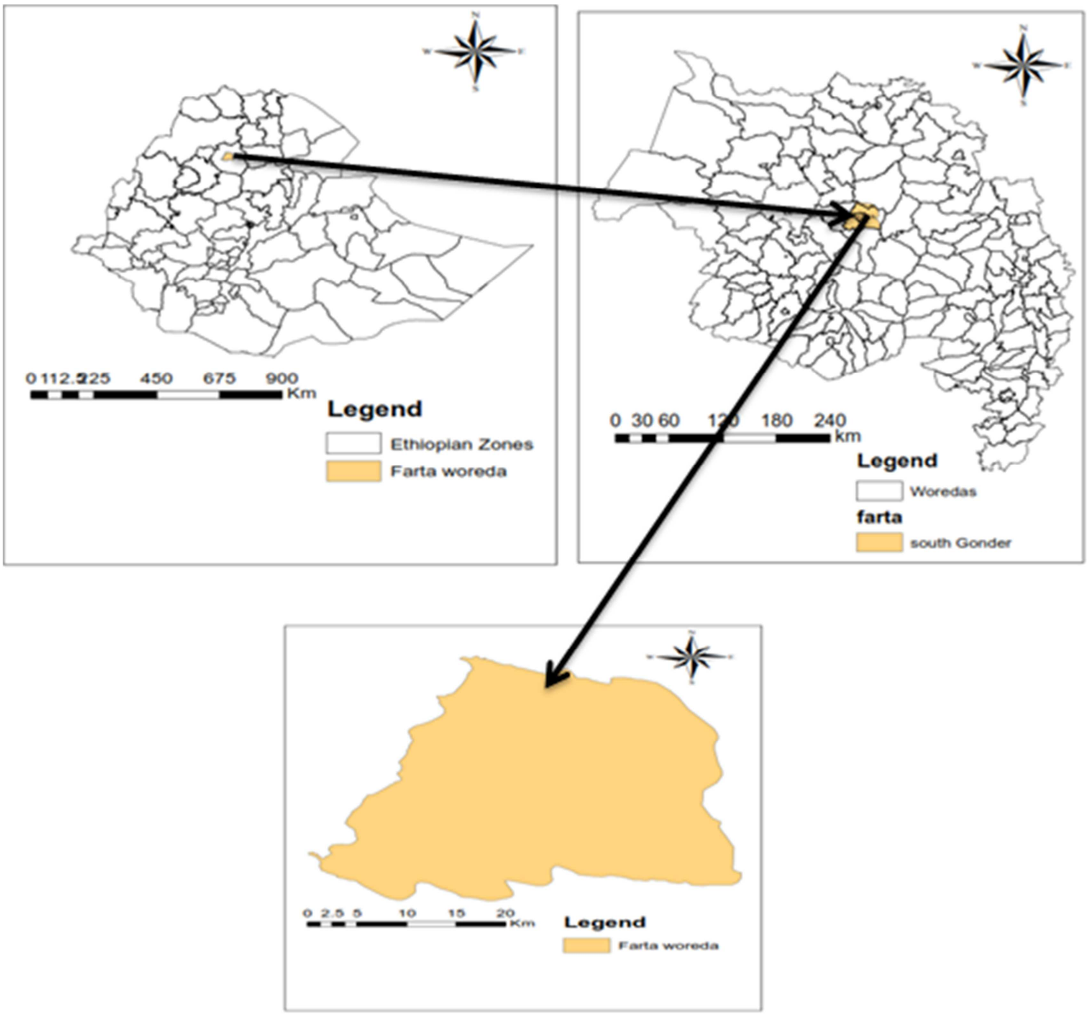

Figure 1. *Location of the study area.*

The climate is under the traditional classification of the agro-climatic zone of Ethiopia as hot lowlands (<500 m), lowlands (500 - 1,500 m), midlands (1,500 - 2,300 m), highlands (2,300 - 3,700 m), and highland (>3,700 m elevation variation. The average annual rainfall is 1553.7 mm, and the maximum precipitation occurs from July to August. About 78% of the rainfall of Debre Tabor is during this season. During summer, rain is heavy. The temperature of the

Woreda is moderate, with the annual average temperature of the study area being 15°C. It is quite favourable for life. Tropical diseases are prevalent in the lowlands and are practically non-existent in Farta Woreda. Farta Woreda is geologically part of the Trappean series of volcanic deposits dating from the Tertiary. The volcanic and associated sedimentary rocks are subdivided into various formations.

The geology of the study area belongs to different formations. Tarmaber basalts cover most parts of the entire study area. The geological map of the study area is shown in Figure 2.

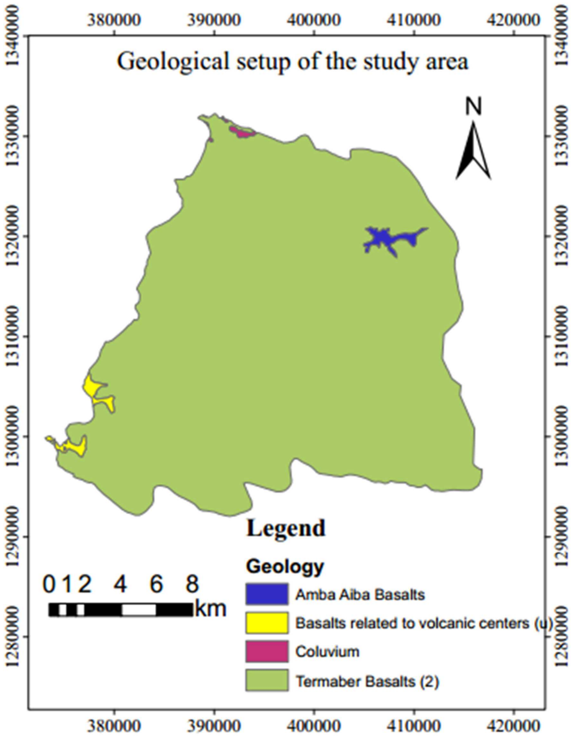

Figure 2. *Geological map of the study area.*

3. Materials and Methods

3.1. Research Design

In this study, a mixed approach with a central premise of quantitative and qualitative approaches provides a better understanding of research problems. Thus, the hybrid method used in this research employs strategies of inquiry that involve collecting qualitative and quantitative data simultaneously for a better understanding of the research problem under study. This study was guided by multiple sources and subsequent cross-checking of information and applying various data collection.

3.2. Data Sources

The preliminary data is collected from the sample area's community and the study area's officials. To supplement the primary data and to make this research work more worthy and valid, the relevant secondary sources applicable to the study were consulted and analyzed. In addition, different written documents, published and unpublished books, journals, research work concerning the issue under consideration, and government policy and strategy are reviewed to supplement the study.

3.3. Method of Data Collection

The data was collected for multiple cases. The primary data was collected from households and concerned offices using questionnaires, interviews and an observation checklist. Before the actual data collection began, a pilot test was conducted to check the workability of the household survey questionnaires. Thus, the household survey was conducted from September to March 2018/19. An open and close-ended questionnaire was employed to collect primary household data about water service provision, community participation, scheme function, level of consumer satisfaction for the service provided, institutional support, maintenance phases etc. Thus, interviews with experts and project coordinators regarding community awareness. Also, field observation was conducted to identify the standard of construction of the water schemes, the status or functionality of the available water supplies, and how to protect the water schemes.

3.4. Sampling

Still, no study has yet been conducted to identify the causes of the area's failing an adequate and sustainable water supply system. The Woreda has one town and 35 rural kebeles with a rural population of 218,502 (male =109,721 and female =108,780) and an urban population of 3,718 (male =1625 and female =1097) as per the data collected from the South Gondar Zone water, Irrigation and Energy office.

4. Results and discussion

4.1. Water Sustainability

Sustainable development meets the needs of the present generations without compromising future generations to meet their own needs [16]. Being this case, different organizations produced their definition to address their intended objective. Thus, various studies conducted about water supply services have made scores of reports concerning sustainability in the context of water supply projects [8, 15, 16]. The achievement of sustainability engrosses the realization of enduring the beneficial changes in rural water supply services for the community. The flow chart needed for sustainability is shown in Figure 3.

4.2. Frameworks of Sustainability in Rural Water Supply System

Several conceptual frameworks have been produced to better understand the essential rural water supply sustainability. Researchers have divided frameworks into five key categories, i.e., institutional, social, environmental, technical, and financial [6, 9]. As a result, the success of lasting sustainable water supply services depends on the interaction of factors that emphasize community participation, external collaboration, and technical support to ensure the operation and maintenance of the system. To closely look at the interplay of these factors, the researcher presents below the recently produced conceptual framework of sustainable water services [17].

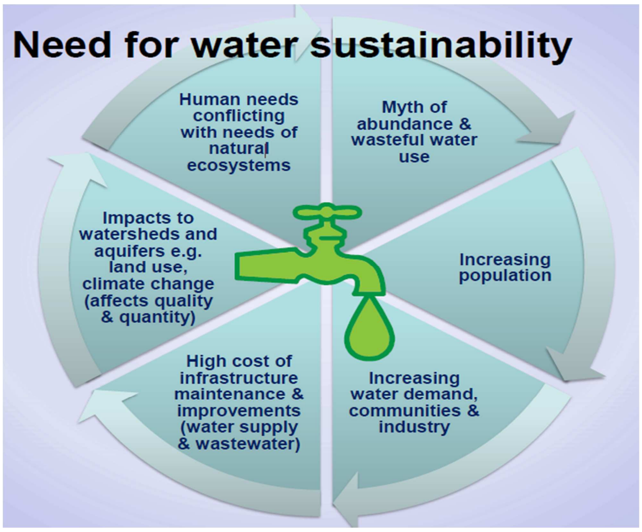

Figure 3. *Flowchart for the need for water suitability.*

4.3. Current Major Water Sources, status and Practices in a Sample Area

The regional government undertook a detailed study on the depth at which water could be accessed, water flow level, and water sustainability. Thus, experts of the region participate in the project from site selection up to project establishment and providing technical support after the launching of projects. According to the District water resource Bureau, 2016, the study sample of the selected four Kebele's number of schemes and status is presented in Table 1.

Table 1. *Type and status of water supply schemes in the study area.*

No/name of District	Number of water scheme types and status							
	Hand-dug well	Rope well	Spring development	Shallow well	Deep well	functional	Non-functional	total
Kebele 1	77	14	4	2	-	93	4	97
Kebele 2	2	2	22	2	-	18	9	27
Kebele 3	29	11	16	1	-	53	4	57
Kebele 4	22	8	6	-	-	30	6	36
Total	130	35	48	5		194	23	217

The survey findings on the current water source show that hand-dug well, progressive springs, rope pumps, and shallow wells are the significant sources in the sample districts. The developed spring and rope pumps account for 22.11% and 16.12% of the total, respectively. In contrast, those currently using the hand-dug well and shallow wells as a source of water account for 59.9 % and 2.3%, respectively. Note that the study area's society also uses rivers and unprotected springs as water sources. However, the community indicated the area's inadequacy of the water supply. Respondents also asked about the estimated distance of the current water source from their homes. The estimated average time is taken for a single trip and the average waiting time at the water source to fetch water.

Like other rural parts of the country, fetching water is usually women's and children's responsibility in the sample District. Thus, the total respondents for 62% and 18% of the sample households fetching are the responsibility of women and children, respectively. In addition, the remaining 20% of fetching is the responsibility of others relatives or cowboys. However, Men/husbands fetch water only when children and women cannot. In almost all sample kebeles (study area), women and children travel, on average, two times per day using a 20 litre of jerry can or traditional clay pot with a capacity of 25 litres to fetch water from the water source. The average distance of the water source from home, as observed and responses from the community estimated distance, is from 200 to 2000 or more meters.

Thus, the average time taken for a single trip to fetch water from the current water source is 30 to 60 minutes, as 40% of respondents report. About 20% of the respondents reported needing more than an hour. In addition to the long hour for the trip, they are forced to wait longer at the water source. Thus, 60% of the respondents spend an average of 30 to 60 minutes at the water source to secure water needs. The respondents also explained that the waiting time is sometimes higher for hand pumps than the protected springs due to the single get-valve, required labour, and time to pump water. They further state that the time necessary increases during the dry season as the water volume decreases and may even be dried up. The amount of water consumed per day was also the other issue and area of interest. Hence, the average amount of water the community uses daily for domestic consumption is like drinking, cooking, bathing, and washing clothes and dishes. Accordingly, the statistical finding indicates that 42% of the respondents consume 18 or fewer litres of water per household per day which is below WHO's standard.

4.4. Challenges of Water Supply and Management Approaches

The longer distance the majorities travel, the more extended travel and waiting time to fetch, the existence of non-functional schemes, the dissatisfaction of the majority with the water amount of water they get, and the inadequacy of water supply and management in the sample area.

In addition, the dominant challenges are the lack of adequate technical and financial support from zonal and regional water resource bureaus. This highly discourages Woreda's water resource bureau from performing well in water supply and management activities in the District.

5. Conclusion

The present study assesses the challenges of potable water supply, sustainability and management approach for the selected study area. Water projects impact people's lives, extending far beyond the expected improvements to health and reducing time spent collecting water. The water supply in the present study area is far less adequate for multiple reasons. The study elicited why water supply systems have become inadequate in the area. As a result, there are dominant challenges to the potable water supply. The community needed technical, financial and material support for the weak Woreda water bureau, which highly deterred the bureau's capacity. This inadequate institutional capacity was due to a shortage of skilled human resources, a lack of logistics, and a sufficient budget for monitoring maintenance and operation. In some water schemes, as observed and discussed, partial and complete non-functionality were observed, which can be limited to adequate coverage in the sample area. Therefore, water sustainability can be achieved by maintaining or replacing the system when it cannot function.

The active participation and willingness of the community and contribute to the development and management of water supply projects were promising for further project planning and implementation in the area.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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