Assessment of Challenges and Potential of Urban Water Supply

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Abstract
Many Ethiopian urban communities continue to suffer from a lack of safe drinking water. Sekela town has faced a potable water supply problem; however, a large number of people do not have access to an adequate amount of potable water, and frequent water interruption is a common problem. The study's goal was to assess the challenge and potential of urban water demand and supply. The following data were used to achieve this goal: primary data such as field visits and interviews, secondary data such as population density, water supply data, and water demand estimation.The demand for water in a given town was proportional to the population to be provided. The population of Sekela town was estimated to be 21,538 in 2016 by the Sekela town administration office, and this figure was used as the basis for the current estimate. According to the CSA, the annual growth rate for urban population at the regional level in 2016 was 4.14 percent. In 2030, the total predicted water demand is 1,488,461 m3/year. Water production is currently expected to be 466,560 m3/year. This means that in fourteen years, the water supply should be increased by 1021,901 m3/year. As a result, the present water supply will be supplemented, and water loss in the distribution system will be reduced.
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1. INTRODUCTION

"Water is essential to life and health. The human right to water is essential for living a healthy and dignified life. It is a necessary condition for the realization of all other human rights."

Many of the challenges that many countries face today in their quest for economic and social development are increasingly related to water. One of the international goals set for 2015 in the United Nations Millennium Declaration and the World Summit on Sustainable Development Implementation Plan is to cut in half the proportion of people who do not have adequate access to water and basic sanitation. While access to sufficient and clean drinking water may be taken for granted in the developed world, problems with access are most severe in the developing world, where more than 5 million people die each year from water-related diseases, and more than 1 billion people suffer from water-related illnesses.

Concerns are growing in Sub-Saharan Africa (SSA) about the distribution and allocation of water resources, water pollution, poor institutions, ineffective governance, and a lack of political will to address growing water scarcity.

Water scarcity and deterioration in quality are two of the issues that require more attention and action. Diverse strategies are constantly being developed to make water accessible to all residents. However, due to insufficient infrastructure, rapid population growth, and urbanization, the gap between water demand and supply continues to widen.

1.1 Statement of problem

According to a 2006 report by Water Partner International, the number of people without access to improved water supply could reach 2.3 billion by 2025. According to the Global Water Supply and Sanitation Assessment 2000 Report, Africa and Asia are home to the majority of the world's population without access to improved water supply or sanitation services [1]. According to this report's findings, nearly 250 million water and sanitation-related diseases are reported each year, with more than 3 million deaths. This equates to approximately 10,000 deaths per day. Furthermore, diarrheal diseases have the greatest impact on children, killing more than 2 million young children each year in developing countries. Many more are left underweight, stunted mentally and physically, and vulnerable to other deadly diseases. Many more are left underweight, stunted mentally and physically, and vulnerable to other deadly diseases.

Water supply and sanitation conditions in Ethiopia are similar to those found in developing countries as a whole. In 2004, Ethiopia's national water service coverage was estimated to be only 37% (24 percent rural coverage and 76% urban coverage) [2]. Only 6,698,000 people lived in rural areas. As a result, in Ethiopia, 87 percent of the rural population lacks access to potable water (WHO, 2000). Two reports, one by Water Supply Hygiene and Sanitation [3] and the other by [4], show that the consequences of the country's poor water supply coverage are severe. Inadequate access to safe drinking water leads to higher infant mortality rates, lower economic productivity, and lower female enrollment in school. These consequences are more serious in the rural populations that have virtually no sanitation facilities, though only eight percent of the total population has access to sanitation.

The construction of potable water projects in rural areas is the first step toward increasing community access and contributing to its members' health. However, this would not achieve all of the intended goals. According to an African Development Fund [2] report, 33 percent of rural water services in Ethiopia are inoperable due to a lack of funds for operation and maintenance, insufficient community mobilization and commitment, and a lack of spare parts.

Water supply system aspects that promote sustainability but require improvement include better planning and follow-up, as well as better operation, maintenance, and management. As international and national organizations increase their investment in RWS, more specific information on water supply systems is required. Furthermore, both during the planning and implementation phases, it is necessary to investigate challenges that jeopardize the long-term viability of rural water supply projects.

An assessment of the challenges and potential of urban potable water use in Ethiopia, particularly in Horro Bulluq Woreda, Sekela town, is critical.

1.2 Objectives of the study

The research's general goal is to assess the challenge and potential of urban water demand and supply, and its specific goals are as follows: To determine how well the water supply meets the towns' water demands and compare it to the World Health Organization's (WHO) standards; Identifying issues with potable water supply and management systems in the study area. To ascertain the nature and extent of community involvement in the development of a water supply system.

2. MATERIAL AND METHODS

2.1. Description of study Area

The town of Sekela is located in the Oromia regional state, Horro Guduru Wollega Zone, 333 kilometers and 370 kilometers respectively from Finfinne, the capital city. The average annual rainfall in the area is around 1350 mm, with 85 percent falling during the three-month rainy season from mid-June to mid-September [5].

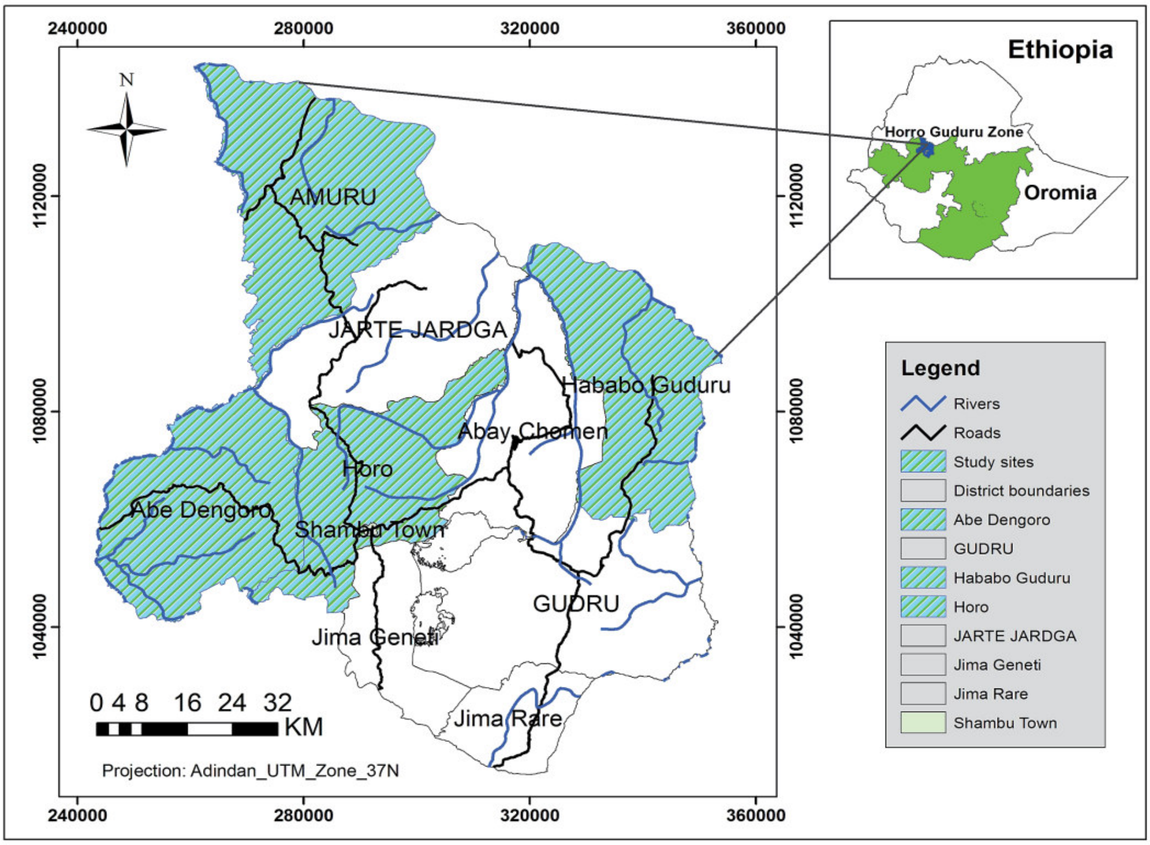

Figure 1: **Map of study area, Horro Guduru Wollega Zone by districts. (Source: Adapted Finance and Economic Development Bureau of Oromia, 2016).**

2.2. Data type and source

To answer the research questions, both qualitative and quantitative data were used in the study. Data sources include both primary and secondary sources. The primary data was gathered from residents and included socio-demographic information, the frequency of water availability in their respective areas of residence, and household water consumption patterns, among other things. Secondary data sources included reports, journals, books, and district development plans from government agencies such as the Puntland State Agency for Water, Energy, and Natural Resources (PSAWEN).Certain observations were made during the field investigation, and it was decided to use them as vital information for future studies, as discussed in the following sections.

2.2.1. Primary Data

Primary data such as saving habits, scarcity of water sources, repairing and maintaining water supply services, and the like were collected from sample households, water office experts, kebele heads, and health office heads. The primary data collection methods were interviews and field observations.

2.2.2. Secondary Data

The primary source of secondary data came from governmental and non-governmental publications about how to solve the problem, which included maintaining the old pipe line and building a new water pipe line for the community. The annual report indicated the amount of water supply and demand in relation to the population in order to adjust the potable water sustainability.

2.3. Method of Data Analysis

The primary data was gathered from residents and included socio-demographic information, the frequency of water availability in their respective areas of residence, and household water consumption patterns, among other things. Secondary data sources included reports, journals, books, and district development plans from government agencies such as the Puntland State Agency for Water, Energy, and Natural Resources (PSAWEN). Certain observations were made during the field investigation, and it was decided to use them as vital information for future studies, as discussed in the following sections.

2.4. Water production of the Town

The water supply for the town comes from a deep well. The water is pumped from a deep well and delivered to the consumer's home via a pump and gravity flow. The daily, monthly, and yearly water production were calculated using the following relationship based on the aggregate operating time and actual discharges of deep wells:

$$Vprod(L) = DW(Dischsrge)\left(\frac{L}{S}\right) * DWworking\ time(s) \quad \text{..................................3.1}$$

Where V_{prod} is the total volume produced by the well in liters, DW discharge is the borehole discharge in liters per second, and DW working time is the aggregate working time of the well in seconds.

2.4.1. Population forecasting

Exponential population forecasting method is used to forecast the current Sekela town population.

$$p = po * e^{rm} \quad \text{..3.2}$$

Where:

P = Estimated population

Po = Base population

r = Growth rate and,

n = Number of year

The population project is projected over the design period as an entry point into the detail design. Population growth is not a linear phenomenon; it is determined by the interaction of the population and the environment.

Table 1: Population rate, Oromia regional state

Description	Unit	2007	2010	2016	2020	2026	2030	2036
Average growth rate	%	-	4.33	4.14	3.93	3.68	3.68	3.27

(Source: CSA, 2007 national statistical census document, Oromia region)

2.5. Water supply coverage

2.5.1. Mode of services

According to town water service office reports, there are four major modes of service for Sekela town's domestic water consumers. These are house connections, private yard connections, shared yard connections, and public fountains.

2.5.2 Population distribution by mode of services

The proportion of the population served by each mode of service varies over time. This variation is caused by changes in living standards, service level improvements, building standards, and the capacity of the water supply service to expand. The majority of the population was served by the public fountain, while the remainder obtained their water from both shared yard taps and house connections found throughout the town. Domestic demand is typically distributed by taking into account the community's socioeconomic conditions, population density, and the extent of services provided to the population. Based on these considerations, the supply connection pattern is divided into three categories, namely the house connection, Yard connection, and Public fountains.

SWSSE has been using these demand categories for a number of years. The division is based on the level of consumption and socioeconomic status of the community living in each kebele. At the end of 2016, per-capita consumption levels for house, yard, and public fountain users were in the order of 100, 25, and 12 l/cap/day, respectively, according to table-2. Though the logic behind categorizing the level of consumptions per connection pattern is acceptable, the per-capita demand indicated for each category does not accurately reflect the area's current consumption pattern.

Table 2: Summarized Sekela town domestic water demand pattern by level of consumption

Mode of service	Demand L/C-day
HC	100
YC	25
PF	12

(Source: Town Category standard under category 5)

2.5.3. Water demand Assessment

Non-domestic water demand, firefighting water demand, non-revenue water demand, and industrial water demand are among these water demands. For all cases of percentage water demand in this study, the standard established by the Ministry of Water Resources in 2006 was used to calculate the percentage of each demand category from domestic demand.

Water demand forecasting is component-based, which means that demand is broken down into different components and a baseline demand in each component is assessed from a base year to a future date. Water demand assessment is the amount of water required to supply the population, which necessitates data collection on existing water consumption patterns, the number and types of facilities and levels of service in use, potential demand for future upgrades, and operation and maintenance arrangements. This strategy is based on current water consumption, projected population growth, service delivery mode or customer types, and demand types. Water demand assessment necessitates planning changes in terms of levels and trends in past and current water consumption.

2.5.4. Water demand projection

2.6. Water consumption

Water consumption is typically quantified using billing records. Billing records are equivalent to consumption, which can be used to calculate water balances [6]. The annual water consumption has been calculated using data from private connected, public taps, in-house connected, institutional, and commercial center meters.

While reviewing water consumption data, differences in some consecutive months were discovered. This difference could be due to irregular meter readings. In such cases, the water company has designed a checking mechanism as well as new meter installation procedures. Monthly individual water consumption revealed large consumption on the one hand and small consumption on the other. Despite this variation, the aggregated values were not significantly affected because the lower and higher individual values can be balanced against each other. To compute daily water consumption, annual water consumption was converted to average daily per capita consumption and population data were used [6].

$$W_{Cons}(liter/person/day) = \frac{Annual\ consumption(m^3)X1000L/m^3}{population\ numberoftheTownX\ 365} \quad \ldots\ldots\ldots\ldots..3.2$$

Where, W cons = per capita water consumption in liter/person/day. The average daily per capita consumption was used to indicate the water supply coverage of the Town.

3. RESULTS AND DISCUSSION

3.1 .Population and water demand projection

The water demand was calculated by taking into account the various categories and the WHO per capita demand standard [8].

3.1.1. Population projection

The water demand of a specific town was proportional to the population to be served. The population of Sekela town was 21538 according to the Sekela town administration office in 2016, and this was used as the base population for current estimation. According to the CSA, the regional annual growth rate for urban population in 2016 was 4.14 percent.

Table 3: Population growth, projected, Oromia regional state

Description	Unit	2007	2010	2016	2020	2026	2030
Average growth rate	%	-	4.33	4.14	3.93	3.68	3.68
Population	-	-		21538	25200	31248	36185

Using the exponential population forecasting method, the estimated total population figure of Sekela town was 21,538 during 2016 [9].

3.1.2. Water demand projection

The city's water supply coverage has been assessed based on average per capita consumption. The average water consumption per capita was calculated by aggregating the city's annual consumption from individual water meters and public taps. As a result, using the town's population data, the annual water consumption data was converted to average daily per capita consumption.

$$percapital\ consumption\left(\frac{\frac{l}{c}}{d}\right) = annual\ consumption(m3) * \frac{1000l}{m3}/(Total\ po * 360d)$$

Using this formula, the aggregated per capita water consumption in 2016, 2020, 2026, and 2030 can be calculated and tabulated in the table below.

Table 4: Total average water demand

Year	**Unit**	**2016**	**2020**	**2026**	**2030**
Adjusted average per capita domestic demand	L/C/Day	16.9	18.8	21.5	22.2
Population	Number	21538	25200	31248	36185
Domestic demand	L/day	366060	473407	671145	804573
Public demand (10%)	L/day	36606	47340.7	67114.5	80457.3
Losses in the system (25%)	L/day	91515	118352	167786	201143
Firefighting water demand (5%)	L/day	183030	236704	335572	402287
Total average demand	L/day	677211	875803	1241617	1488461

In 2030, the total projected water demand is 1,488,461m3/year. The current water output is estimated to be 466,560 m3/year. This means that the water supply should be increased by 1,021,901 m3/year over the next fourteen years. As a result, supplementing existing water supplies and reducing water loss in the distribution system are critical activities.

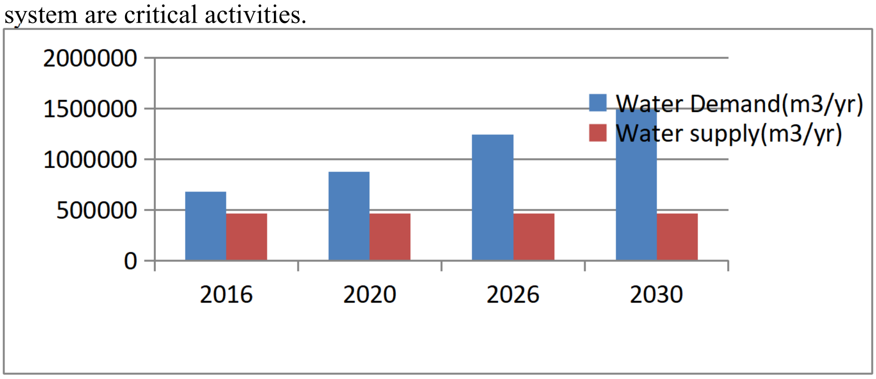

Figure 2: Gap between Water demand and supply (2030).

Water production for supply from 2016 to 2030 appears to have been constant, but water consumption has significantly increased. This means that no improvements were made to increase water production.

Table 5: Gap between supply and demand of water.

Year	2016	2020	2026	2030
Total Water Demand(L/s)	16.9	18.8	21.5	22.2
Total Water Supply(L/s)	15	15	15	15
Gap(L/s)	1.9	3.8	6.5	7.2

Table 5 revealed a significant difference in water demand and supply of water delivered to the Sekela town community. A slew of water supply issues will arise by 2030 unless some problem-solving mechanisms are devised.

3.2. Challenges of Water supply

3.2.1. Challenges related to potable water supply services

According to Figure-2, 200(66.4 percent) of respondents said the challenges of potable water supply were high, while 45(15 percent) said medium, 40(13.3 percent) said very high, 6(2 percent) said low, and 10(3.3 percent) said very low.

More than half of those polled said that the challenges of potable water supply were significant. As shown in the table, the level of challenges associated with potable water supply services was high in order to obtain potable water suitable for drinking, cooking, and domestic hygiene.

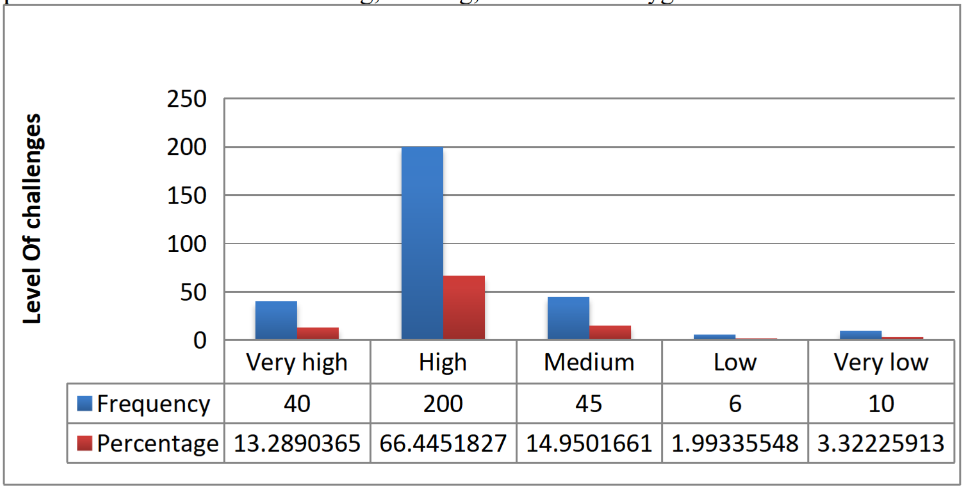

Figure 3: Level of challenges related to potable water supply services

3.2.2. Cause of shortage of Water supply and consumption

Access to safe drinking water is a basic human right. However, water supply and distribution are hampered by a number of socioeconomic (population growth, a lack of technological capacity, and financial issues), institutional (a lack of institutional capacity and weak sector coordination), and environmental factors (topography of the area and insufficient water resource).

Table 6: The main challenges of water supply distribution

No.	Possible reasons	Alternatives			
		Yes		No	
		No.	Percent	No.	Percent
1	Population growth and urbanization	42	33	23	22.1
2	Lack of institutional capacity	-	-	12	11.5
3	Lack of technological capacity	10	7.9	2	1.9
4	Insufficient financial resource	5	3.9	24	23.1
5	Insufficient water resources	3	2.4	12	11.5
6	Weak sector coordination	25	19.7	10	9.6
7	Lack of community participation	42	33.1	21	20.2
Total		127	100	104	100

Source: Sampled household survey, 2021

According to the results of a sample household survey, the problems with water supply in Sekela town were multifaceted and stemmed from a variety of sources. These are primarily due to population growth and urbanization, a lack of technological capacity, insufficient financial resources, insufficient water resources, weak sector coordination, and the area's topography.

3.3. Community participation in water supply and distribution

As previously stated, participation entails the concept of contributing, influencing, sharing, or redistributing power of control, resources, benefits, knowledge, and skill gained through beneficiaries' participation in decision making. Water supply project activities are unlikely to succeed without the active and ongoing participation of users. Users would have to be involved in the development, planning, implementation, operation, and maintenance, either directly or indirectly. It is a critical component of the long-term viability of water supply schemes. Water supply agencies must take proactive measures such as raising awareness, mobilizing communities, establishing community-based institutions such as water user associations and water committees, strengthening democratic processes within them, and broadening community participation by transferring responsibility and authority to them in all aspects of water supply development and operation.

In other words, the knowledge gained by local communities through their experiences is not taken into account during the planning stages, which can have an impact on sustainability. Concerning the need for communities to participate in site selection, [7] stated that if social aspects are not taken into account during planning, the risk is high that the water supply system will not be used or will be misused. As a result, community participation is required at all stages of water supply projects, as well as the existence of alternative traditional water sources.

Table 7: Identification of level of community participation

No.	Question	Type, nature and level of Participation	Response	
			Frequency	Percentage
1.	What was your contribution in development of the water supply schemes?	Local materials (stone, sand, wood) support	89	33.33
		Labor, money and local material support	23	8.62
		Information provision in site selection	57	21.35
		Support on site clearance, excavation and project mobilization.	98	36.7
	Total		**267**	**100**
2.	Who had participated in the development of water supply schemes?	Husbands	18	40
		Adult males and females	13	28.9
		Women	6	13.3
		All people collaboration	8	17.8
	Total		45	100

Source: Sampled household survey, 2021

Since active community participation is a key component in the provision of urban infrastructure such as water supply, the sample households reported that they contributed to construction activities by providing free labor, money, and local material supports. Furthermore, they stated that the town's water service office should pay close attention to the issue and develop strategies to increase service provision and raise awareness among urban dwellers in order to increase participation, which in turn helps to improve water supply and distribution provisions.

4. CONCLUSION AND RECCOMENDATION

4.1. Conclusion

Water supply and consumption were both assessed using data from the town's population as well as annual water production and consumption. The current water supply for the town was discovered to be 466,560 m3/year. In addition, the current water consumption of various customer groups was calculated. Private yard connections, public tap users, in-house connections, and the town's average per capital per day were found to be 16.918, 21.5, and 22.2, respectively. The Town's water supply target was 15 L/c/d in comparison to the Universal Access Plan. This water supply coverage value did not indicate whether or not the population had enough water, but it was compared to WHO minimum survival and local per capita per day water use standards. This indicated that the current supply of water was insufficient to meet demand.

Based on the findings of this paper, one can conclude that the water supply in the study area, Sekela town, is insufficient for a number of reasons. The study elicited the primary causes of the area's water supply systems becoming insufficient. These are primarily due to population growth and urbanization, a lack of technological capacity, a lack of financial resources, a lack of water resources, a lack of sector coordination, and the topography of the area.

Local communities are heavily involved in decisions related to the development of rural water supply in the study areas. According to the findings of the study, the participation of local people during the project's initiation and development phases was significant. The society's willingness to participate in and contribute to the development and management of water supply projects was found to be promising for future project planning and implementation in the area.

4.2. Recommendation

The following recommendations have been made to improve the existing Sekela town water supply system in terms of water loss, water quantity, customer satisfaction, and operation and maintenance.

- Even though community participation alone is insufficient, knowing the community's need, initiation, and participation in the area is promising, sector participants should design and implement additional water schemes to improve water supply in the area by mobilizing resources and finance.
- Ensure effective coordination and collaboration with various stakeholders in the water supply sector in accordance with government legislation and policies.
- The undermining weakness for not identifying the necessary steps to overcome these barriers was a lack of active involvement of responsible authorities, NGOs, and the public.
- Finally, further detailed research into the hydro-geological aspects of the area's water supply sources, particularly in the drier parts for additional wells, is highly recommended

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