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# Water Demand and Availability in the Tarutung District, North Tapanuli Regency, Indonesia

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

This comprehensive study addresses the intricate dynamics of population growth, water demand, and availability in the Tarutung District. Employing a geometric approach, we projected the population growth from 2018 to 2032, estimating a 0.74% annual increase. Subsequently, a meticulous water demand analysis encompassed domestic sectors, including household connections and public hydrants, and non-domestic sectors such as educational, religious, market, health, and commercial facilities. The calculated total water demand, encompassing both domestic and non-domestic needs, reached 6,034,026.38 liters per hour and 123,552,000 liters per hour, respectively. In parallel, we investigated the water availability through an examination of spring sources and rainfall data, revealing a substantial surplus. As of now, Tarutung District boasts a surplus water availability of 183,326,289.18 cubic meters per year. In conclusion, the findings

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indicate that, under current conditions, the Tarutung District is well-equipped to manage its water resources until 2032. However, the study underscores the importance of implementing sustainable environmental policies to safeguard water sources and optimize resource management. The proposed recommendations advocate for local government interventions, community awareness initiatives, water use efficiency enhancements, infrastructure improvements, and stringent forest area management. This research contributes valuable insights to water resource management, emphasizing the need for proactive measures to sustain the water abundance in the Tarutung District. The conclusions drawn and recommendations presented serve as a foundation for informed decision-making, aligning with the broader goals of environmental sustainability and community resilience.

*Keywords: Water resource management; population growth projection; geometric model; sustainable environmental policies; Tarutung District.*

## 1. INTRODUCTION

As human demand for water continues to increase, alternative water resources besides surface water are needed. One such alternative is groundwater. Groundwater is water located in the saturated zone beneath the earth's surface that can flow to the surface naturally or artificially. More than 98 percent of all inland water is hidden beneath the earth's surface, with the remaining 2 percent found in rivers, lakes, and reservoirs. Groundwater, based on its depth, is divided into two types: shallow groundwater (phreatic) and deep groundwater (Geology and Hydrogeology Module, 2017).

Water, an indispensable element for life, underscores the delicate balance between human survival and environmental sustainability. While Earth boasts an abundant supply of water, the fraction that is readily usable by humans is surprisingly limited. About 97.5% of the Earth's water is saline, found in oceans, and only 2.5% is freshwater. Of this freshwater, the majority is locked away in polar ice caps and glaciers, rendering it inaccessible for immediate human use [1]. The presence of water in solid, liquid, and gas forms across the Earth's surface, characterized by its colorlessness, tastelessness, and odorlessness, is a testament to its vital role in both human life and the broader ecosystem (Ikhtiar, 2017).

The interconnection between water sources and clean water supply systems is critical; these systems rely on the availability of uncontaminated sources to provide water that meets health standards for human consumption [2]. The necessity for clean and accessible water links directly to human needs and the environmental consequences of fulfilling these needs through development. Satia (2021) emphasizes the distinction between essential human needs and desires, suggesting that while development is often driven by the latter, it should be guided by the former to avoid detrimental impacts on the ecosystem. Arga (2024) specifically connects this concept to water demand by arguing that unchecked development, often resulting from extensive land use changes like deforestation, directly affects water availability and quality. Such activities not only disrupt ecosystem balance but also reduce the capacity of natural environments to replenish water sources, ultimately impacting water supply systems. This dynamic underscores the critical need for sustainable development practices that prioritize ecological preservation to ensure the continued availability of clean water, essential for both human consumption and maintaining biodiversity.

Various sources contribute to the water present on Earth, each playing a pivotal role in addressing the planet's diverse water needs:

a. **Spring Water:** Spring water refers to points or small areas where groundwater emerges or is released from an aquifer (a subsurface layer containing water).
b. **Rainwater:** Rainwater is a seasonal water source, readily available during rainy seasons, and has the potential to alleviate pressure on the use of clean water sources. Rainwater harvesting systems typically consist of catchment areas, collection channels, or pipes directing rainwater to storage tanks [3].
c. **Surface Water:** Surface water originates from rivers, lakes, and ponds. According to the Research and Development Center for Settlements, Ministry of Public Works (2012), surface water can also come from

irrigation channels, swamps, reservoirs, and rainwater. Surface water is often contaminated and should not be used for drinking unless properly treated.

d. **Groundwater:** Groundwater is water collected within the ground and emerges as springs or wells. Groundwater is usually free from bacteria as it filters through sand and soil. However, it can be contaminated by natural minerals like fluoride or arsenic, through leaking waste, septic tanks, family latrines, waste disposal sites, or toxic chemicals from industries or agriculture.

Each region has its unique water needs, influenced by factors such as population growth, improved living standards, urban development, and socio-economic advancements, resulting in an increased per capita water demand.

To meet the water needs in the Tarutung District of North Tapanuli Regency, 11 spring sources are utilized. Notable among them are Ugan spring with a capacity of 15 liters per second and Sitakka spring with a capacity of 5 liters per second. Other sources include Horsik (10 lt/s), Nagatimbul (5 lt/s), Bintang Pinur (10 lt/s), Aek Nasia (5 lt/s), Goti (1.5 lt/s), Tampang (2 lt/s), Gorat (10 lt/s), Sioma (10 lt/s), and Golat (3 lt/s).

The studies by Nofrizal and Robi Agung Saputra [4] in the Tigo Nagari District and Verrdy Chrisna Primandani's [5] analysis of the South Purwokerto SPAM area offer valuable insights into local water needs. However, my article delves into the distinct geographical context of the Tarutung District, providing a comprehensive overview of water management considerations. While each study contributes to localized knowledge, a more holistic perspective can emerge by combining findings from multiple regions. This approach allows for a nuanced understanding of the diverse challenges and solutions in water resource management.

### 1.1 Temporal Variations

Nofrizal and Robi Agung Saputra [4] project water needs until 2030, while Verrdy Chrisna Primandani [5] extends the analysis to 2045. Bridging this temporal gap, my article addresses water needs in the Tarutung District until 2032. By aligning these temporal scopes, a more continuous and connected narrative emerges, providing insights into the evolving patterns of water demand. This correlation across timelines enhances our ability to anticipate and adapt to changing water requirements over the coming years.

### 1.2 Water Source Dynamics, Population Growth, and Resilience

The studies primarily focus on river and reservoir capacities, with my article introducing a broader spectrum of water sources such as springs and rainfall in the Tarutung District. A comparative analysis can uncover the dynamics of different water sources and their collective impact on overall water availability. Moreover, my article emphasizes the crucial role of population growth in driving water demands, offering a more integrated understanding of demographic trends. Additionally, while the existing studies touch on infrastructure capacities, my article provides recommendations for enhancing resilience and sustainability, contributing to a more comprehensive approach in addressing future water challenges. This multifaceted exploration aims to enrich the existing body of knowledge and guide effective water resource management strategies.

In the upcoming years, the rapid growth of the population will inevitably impact the escalating demand for water resources. However, the available water supply may not suffice to meet the increasing demand for clean water. Hence, an analysis of the demand and availability of clean water in the Tarutung District of North Tapanuli Regency is essential. This research aims to project and plan the situation and conditions, serving as the foundation for water supply planning strategies for the residents in the Tarutung District of North Tapanuli Regency. Therefore, it is imperative to conduct a comprehensive study, culminating in a thesis entitled "Water Demand and Availability in the Tarutung District of North Tapanuli Regency." This research endeavors to provide alternative solutions to water-related issues, particularly in the Tarutung District of North Tapanuli Regency [6].

## 2. METHODS

This research employs a qualitative descriptive approach, utilizing necessary data and direct surveys of water sources to assess their availability in the Tarutung District, North Tapanuli Regency, North Sumatra Province. Tarutung District is situated at an

elevation between 900-1200 meters above sea level, positioned at N. 2.020702, E. 98.962758.

## 2.1 Types and Sources of Data

### 2.1.1 Primary Data

Primary data encompass the potential water sources in Tarutung District, the existing conditions of these sources, and their viability. This includes topographical measurements and field survey documentation.

### 2.1.2 Secondary Data

Secondary data are obtained from external sources or intermediaries, such as maps of Tarutung District, population figures, agricultural land data, and rainfall data acquired from relevant authorities in North Tapanuli Regency [7].

## 2.2 Data Analysis Method

### 2.2.1 Analysis of water demand based on population

To calculate the water consumption per capita, the following analyses are conducted:

1. Calculation of the average population growth in the Tarutung District until the planned year, based on population density in the region.
2. Prediction/projection of the population in the Tarutung District until the planned year using a method with the highest correlation coefficient among the chosen methods:

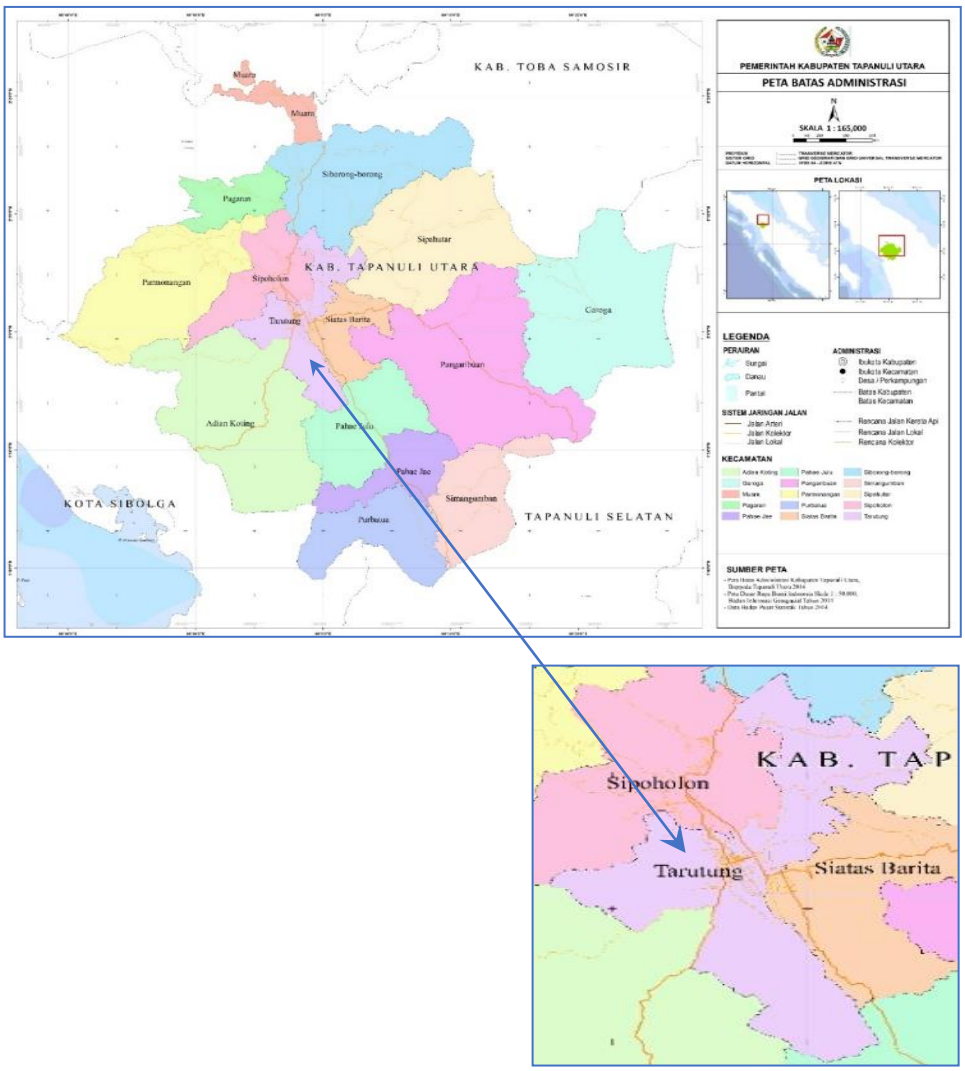


**Fig. 1. Research Location**

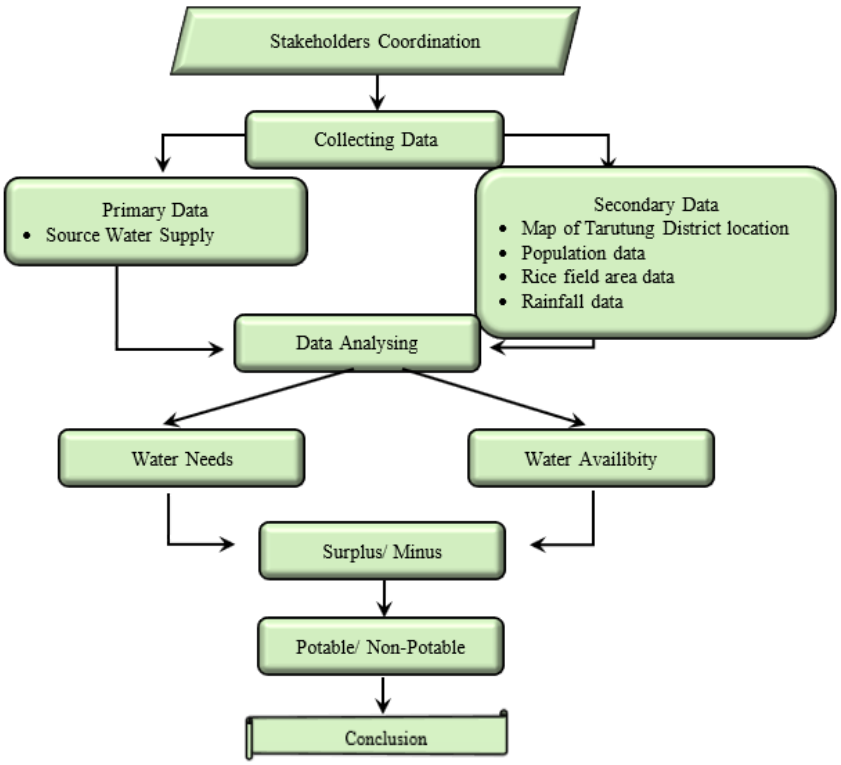


**Fig. 2. Research flow stages**

a. Geometric Method

$P_n = {}_0 (1 + r)$

Where:

Pn = population in year n
P0 = population in the base year
r = population growth rate
n = time period between the base year and year n (in years)

b. Arithmetic Method

$P_n = P_0 (1 - rn)$

Where:

Pn = population in year n
P0 = population in the base year
r = population growth rate
n = time period between the base year and year n (in years)

### 2.2.2 Analysis of clean water demand

Estimating the quantity of clean water required for domestic and other purposes involves approximating the daily water needs based on population conditions and development. The analysis calculates water needs according to the Planning Criteria of the Directorate General of Human Settlements, Ministry of Public Works, for both urban and rural categories (Pratama, 2016).

Steps for calculating clean water demand are as follows:

1. Identify the fundamentals for calculation: a. Population in the research area b. Number of clean water users
2. Calculate the Total Clean Water Demand: a. Domestic demand b. Non-domestic demand

## 3. RESULTS AND DISCUSSION

## 3.1 Geographic Analysis of Tarutung District

### 3.1.1 Population Data

The population of Tarutung District has consistently increased over the years, in line with recorded observations. In 2020, the population reached 42,831 people, showing a growth rate of

0.33% compared to the previous year's 42,689 people. The rise in Tarutung District's population is influenced by factors such as birth, death, migration, and the arrival of new residents, expanding activities in the region in 2020. There has been an increase in both deaths and births, as well as migration and arrivals from 2018 to 2022 [8].

Based on the Population Data of Tarutung District, the population figures for the past 5 years are presented in Table 1:

**Table 1. Population Data of Tarutung District 2018 – 2022 (People)**

| No | Year | Population |
|---|---|---|
| 1 | 2018 | 42.419 |
| 2 | 2019 | 42.689 |
| 3 | 2020 | 42.831 |
| 4 | 2021 | 43.212 |
| 5 | 2022 | 43.694 |

*Source: Central Statistics Agency of North Tapanuli Regency 2023*

### 3.1.2 Spring Sources

To fulfill the demand for clean water in Tarutung District, North Tapanuli Regency, 11 spring sources are utilized:

**Table 2. Spring source data**

| No | Spring Name | Source Capacity (lt/s) |
|---|---|---|
| 1 | Ugan | 15 |
| 2 | Sitakka | 5 |
| 3 | Horsik | 10 |
| 4 | Naga Timbul | 5 |
| 5 | Bintang Pinur | 10 |
| 6 | Aek Nasia | 5 |
| 7 | Goti | 1,5 |
| 8 | Tampang | 2 |
| 9 | Gorat | 10 |
| 10 | Sioma | 10 |
| 11 | Golat | 3 |

*Source: Central Statistics Agency of North Tapanuli Regency 2023*

The utilization of these spring sources underscores the importance of sustainable water management in meeting the increasing demands of the growing population in Tarutung District. Further analysis and discussion will delve into the implications of these findings on water resource planning and potential challenges in ensuring an adequate supply of clean water for the community.

### 3.1.3 Facility conditions

Economic and social facility data obtained from the Central Statistics Agency (BPS) of North Tapanuli Regency are utilized to estimate non-domestic water needs. The economic and social facility data for Tarutung District in 2022 are presented in Table 3

### 3.1.4 Rainfall Conditions

Rainfall data obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) of North Tapanuli Regency is used to determine the rainfall in Tarutung District during the period from 2018 to 2022. This information is crucial for assessing water availability in the district. The rainfall data for Tarutung District can be observed in Table 4.

## 3.2 Water Demand Calculation in Tarutung District

### 3.2.1 Population Growth Calculation

Population analysis is crucial for detecting and understanding population characteristics, such as the number of people residing in a specific area and the patterns of growth and distribution. The demographic situation significantly impacts the overall conditions of a region, influencing major activities and development trends. Population aspects serve as a measure or criterion in determining the growth trends of a place, as observed in the case of Tarutung District. The projected growth of Tarutung District can be examined by understanding these demographic features, which can further be explored in terms of the expected demand for water resources in the future.

The Geometric approach is employed to assess the estimated population of Tarutung District. The Geometric model is chosen due to its common usage and simplicity compared to the exponential model. The Population Projection Formula using the Geometric Model is:

$$Pn = Po\ (1 + r)^n$$

Percentage increase in the population:

$$r = 2,97 / 4$$
$$r = 0,74\ \%$$

The population increase from 2022 to 2032 is calculated as:

$$P2032 = P2022\ (1 + r)^n$$

$$= 43.694\ (1 + (0{,}0074))^{10}$$

$$= 47.053{,}66 \approx 47.054 \text{ jiwa}$$

Based on the calculation above, the population growth is projected to increase by 0.74%. The population of Tarutung District in 2032 is estimated to be 47,054 people.

In Table 6, the estimated population figures indicate a consistent but not overly significant population growth from year to year. Based on

**Table 3. Economic and social facility data of Tarutung District 2022**

| No | Facility Type | | Description | |
|---|---|---|---|---|
| | | | Number of units | Number of people |
| 1 | Educational Facilities | TK/RA | 42 | 491 |
| | | SD | 39 | 5550 |
| | | SMP/MTS | 10 | 3414 |
| | | SMA/SMK/MA | 8 | 4155 |
| 2 | Place of worship | Mosque | 3 | - |
| | | Church | 87 | - |
| 3 | Health Facilities | Health Center | 1 | - |
| | | Small Health Center | 5 | - |
| 4 | Market Facilities | Village Market | 2 | - |
| 5 | Hotel Facilities | Hotel | 10 | - |
| 6 | Restaurant Facilities | Restaurant | 33 | - |
| 7 | Office Facilities | Office | 15 | - |

*Source: Central Statistics Agency of North Tapanuli Regency 2023*

**Table 4. Rainfall Data of Tarutung District 2018 - 2022 (mm)**

| | Year | 2018 (mm) | 2019 (mm) | 2020 (mm) | 2021 (mm) | 2022 (mm) |
|---|---|---|---|---|---|---|
| **Month** | January | 321 | 242 | 312 | 312 | 209 |
| | February | 264 | 241 | 73 | 73 | 228 |
| | March | 304 | 183 | 121 | 121 | 280 |
| | April | 518 | 322 | 353 | 353 | 150 |
| | May | 370 | 147 | 197 | 197 | 0 |
| | June | 146 | 155 | 146 | 146 | 170 |
| | July | 24 | 103 | 151 | 151 | 22 |
| | August | 70 | 62 | 82 | 82 | 220 |
| | September | 529 | 39 | 215 | 215 | 101 |
| | October | 474 | 273 | 262 | 262 | 162 |
| | November | 267 | 215 | 372 | 372 | 215 |
| | December | 272 | 306 | 437 | 437 | 200 |

*Source: BMKG of North Tapanuli Regency 2023*

**Table 5. Population growth of Tarutung District 2018-2022**

| Year | Population | Growth | |
|---|---|---|---|
| | | Increase | % |
| 2018 | 42.419 | | |
| 2019 | 42.689 | 270 | 0,64 |
| 2020 | 42.831 | 142 | 0,33 |
| 2021 | 43.212 | 381 | 0,89 |
| 2022 | 43.694 | 482 | 1,12 |
| Jumlah | | 1.275 | 2,97 |

*Source: Analysis Result, 2023*

the projections, the average population growth in Tarutung District is anticipated to be 0.74%between 2022 and 2032. Natural factors such as births and deaths impact population increase, considering both inbound and outbound migration. Regarding population growth, the data show that despite fluctuations in population figures, the population growth rate in Tarutung District tends to increase on average each year.

**Table. 6 Population of Tarutung District 2022-2032**

| No | Year | Population (People) |
|---|---|---|
| 1 | 2.022 | 43.694 |
| 2 | 2.023 | 44.019 |
| 3 | 2.024 | 44.346 |
| 4 | 2.025 | 44.676 |
| 5 | 2.026 | 45.008 |
| 6 | 2.027 | 45.343 |
| 7 | 2.028 | 45.680 |
| 8 | 2.029 | 46.020 |
| 9 | 2.030 | 46.362 |
| 10 | 2.031 | 46.706 |
| 11 | 2.032 | 47.054 |

*Source: Analysis Result, 2023*

### 3.2.2 Water demand calculation

To balance usage and availability, it is essential to determine the input values, including the amount of water available and the amount needed in water resource management. Domestic, urban, industrial, agricultural, irrigation, and other uses all contribute to water demand. According to Article 29, paragraph (2) and (3) of Law No. 7 of 2004 regarding Water Resources, "the provision of water resources in each river basin is carried out in accordance with the arrangement of water resources set to meet basic needs, environmental sanitation, agriculture, energy, industry, mining, transportation, forestry, biodiversity, sports, recreation and tourism, ecosystems, aesthetics, as well as other needs." Meanwhile, the primary goal is to provide water for daily basic needs (domestic) and irrigation for community agriculture in the current irrigation system.

**a) Domestic Water Demand**

The formula presented in the literature review can be utilized to determine domestic water demand in Tarutung District. The domestic water demand in Tarutung District from 2022 to 2032 is calculated as follows. The assumptions used are as follows (according to the standard set by the Directorate General of Spatial Planning, Ministry of Public Works, 1997):

- The population of Tarutung District is classified as moderate based on the estimated population until 2032.
- Household connection consumption: 130 gallons per person per day.
- Average daily consumption of public hydrant connections is 30 liters per person.
- The ratio of HR (household connection) to PU (public hydrant) is 70:30.
- According to MDGs, the service coverage is 80%, with a water loss factor of 20%.

**b) Household Connection (HC)**

Table 7 presents the water demand for various family categories in Tarutung District:

**c) Public Hydrant (HU)**

Table 8 presents the water demand for public hydrants in Tarutung District:

**d) Non-Domestic Water Demand**

The assessment of the non-domestic sector is conducted using the latest growth statistics for socio-economic facilities in the planning area.

### 3.2.3 Education facilities

Educational facilities serve the community, and the growth of students is considered equivalent to the population growth rate in Tarutung District. According to the rules of the Directorate General of Spatial Planning, Ministry of Public Works, the number of students with a daily water requirement of 10 liters is taken into consideration.

The majority of water is provided in educational facilities for students and teachers working in formal educational institutions, both public and private. Based on the data recapitulation obtained, in 2022, there will be 491 students and teachers at the RA and TK levels, 5550 at the SD and Madrasah levels, 3414 at the SMP and Madrasah Tsanawiyah levels, and 4153 at the SMA and SMK levels, with a total of 13,610 students and teachers. The estimated total water demand until 2032, based on a population growth rate of 0.74 percent, is shown in Table 9:

**Table 7 Household connection water demand in Tarutung District**

| Year | Population | Service Level (%) | Served Population (people) | Average Consumption (lt/person/day) | Total Usage (lt/hour) | Water Loss (lt/hour) | Total Water Demand (lt/hour) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|---|---|
| 2022 | 43.694 | 65 | 28.401 | 130 | 3.692.143 | 738.429 | 4.430.572 | 1.617.158,63 |
| 2023 | 44.019 | 65 | 28.612 | 130 | 3.719.595 | 743.919 | 4.463.514 | 1.629.182,69 |
| 2024 | 44.346 | 65 | 28.825 | 130 | 3.747.251 | 749.450 | 4.496.702 | 1.641.296,15 |
| 2025 | 44.676 | 65 | 29.039 | 130 | 3.775.113 | 755.023 | 4.530.136 | 1.653.499,67 |
| 2026 | 45.008 | 65 | 29.255 | 130 | 3.803.183 | 760.637 | 4.563.819 | 1.665.793,94 |
| 2027 | 45.343 | 70 | 31.740 | 130 | 4.126.188 | 825.238 | 4.951.426 | 1.807.270,35 |
| 2028 | 45.680 | 70 | 31.976 | 130 | 4.156.867 | 831.373 | 4.988.241 | 1.820.707,94 |
| 2029 | 46.020 | 70 | 32.214 | 130 | 4.187.775 | 837.555 | 5.025.330 | 1.834.245,45 |
| 2030 | 46.362 | 70 | 32.453 | 130 | 4.218.912 | 843.782 | 5.062.695 | 1.847.883,61 |
| 2031 | 46.706 | 70 | 32.694 | 130 | 4.250.281 | 850.056 | 5.100.337 | 1.861.623,18 |
| 2032 | 47.054 | 70 | 32.938 | 130 | 4.281.883 | 856.377 | 5.138.260 | 1.875.464,90 |

*Source: Analysis Result, 2023*

**Table 8. Public hydrant water demand in Tarutung District**

| Year | Population | Service Level (%) | Served Population (people) | Average Consumption (lt/person/hour) | Total Usage (lt/hour) | Water Loss (lt/hour) | Total Water Demand (lt/hour) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|---|---|
| 2022 | 43.694 | 35 | 15.293 | 30 | 458.787 | 91.757 | 550.544 | 200.948,71 |
| 2023 | 44.019 | 35 | 15.407 | 30 | 462.198 | 92.440 | 554.638 | 202.442,82 |
| 2024 | 44.346 | 35 | 15.521 | 30 | 465.635 | 93.127 | 558.762 | 203.948,04 |
| 2025 | 44.676 | 35 | 15.637 | 30 | 469.097 | 93.819 | 562.916 | 205.464,46 |
| 2026 | 45.008 | 35 | 15.753 | 30 | 472.585 | 94.517 | 567.102 | 206.992,15 |
| 2027 | 45.343 | 30 | 13.603 | 30 | 408.085 | 81.617 | 489.701 | 178.741,02 |
| 2028 | 45.680 | 30 | 13.704 | 30 | 411.119 | 82.224 | 493.343 | 180.070,02 |
| 2029 | 46.020 | 30 | 13.806 | 30 | 414.176 | 82.835 | 497.011 | 181.408,89 |
| 2030 | 46.362 | 30 | 13.909 | 30 | 417.255 | 83.451 | 500.706 | 182.757,72 |
| 2031 | 46.706 | 30 | 14.012 | 30 | 420.357 | 84.071 | 504.429 | 184.116,58 |
| 2032 | 47.054 | 30 | 14.116 | 30 | 423.483 | 84.697 | 508.180 | 185.485,54 |

*Source: Analysis Result, 2023*

**Table 9. Water demand for educational facilities in Tarutung District**

| Year | Students and Teachers (people) | Standard Water Demand (lt/person/hour) | Water Demand (lt/hour) | Water Demand (lt/day) | Water Demand ($m^3$/year) |
|---|---|---|---|---|---|
| 2022 | 13.610 | 10 | 136.100 | 1,58 | 49.676,50 |
| 2023 | 13.711 | 10 | 137.112 | 1,59 | 50.045,86 |
| 2024 | 13.813 | 10 | 138.131 | 1,60 | 50.417,97 |
| 2025 | 13.916 | 10 | 139.158 | 1,61 | 50.792,84 |
| 2026 | 14.019 | 10 | 140.193 | 1,62 | 51.170,50 |
| 2027 | 14.124 | 10 | 141.236 | 1,63 | 51.550,97 |
| 2028 | 14.229 | 10 | 142.286 | 1,65 | 51.934,26 |
| 2029 | 14.334 | 10 | 143.344 | 1,66 | 52.320,41 |
| 2030 | 14.441 | 10 | 144.409 | 1,67 | 52.709,43 |
| 2031 | 14.548 | 10 | 145.483 | 1,68 | 53.101,34 |
| 2032 | 14.656 | 10 | 146.565 | 1,70 | 53.496,16 |

*Source: Analysis Result 2023*

**Table 10. Water Demand for Religious Facilities in Tarutung District**

| Year | ∑Population | Mosques | Protestant Churches | Water Demand for Mosques (lt/hr) | Water Demand for Churches (lt/hr) | Total Water Demand (lt/hr) | Total Water Demand (lt/day) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|---|---|
| | Jiwa | unit | unit | 3000 lt/hr | 1000 lt/hr | (lt/hr) | (lt/dt) | ($m^3$/th) |
| 2022 | 43.694 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2023 | 44.019 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2024 | 44.346 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2025 | 44.676 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2026 | 45.008 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2027 | 45.343 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2028 | 45.680 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2029 | 46.020 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2030 | 46.362 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2031 | 46.706 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |
| 2032 | 47.054 | 3 | 87 | 9.000 | 87.000 | 96.000 | 1,11 | 35.040,00 |

*Source: Analysis Result, 2023*

**Table 11. Water Demand for Market Facilities in Tarutung District**

| Year | ∑Population | Estimated Market Units | Water Demand per Market (lt/hr) | Total Water Demand (lt/hr) | Total Water Demand (lt/day) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|
| 2022 | 43.694 | 2 | 12.000 | 24.000 | 0,28 | 8.760,00 |
| 2023 | 44.019 | 2 | 12.000 | 24.000 | 0,28 | 8.760,00 |
| 2024 | 44.346 | 2 | 12.000 | 24.000 | 0,28 | 8.760,00 |
| 2025 | 44.676 | 2 | 12.000 | 24.000 | 0,28 | 8.760,00 |
| 2026 | 45.008 | 2 | 12.000 | 24.000 | 0,28 | 8.760,00 |
| 2027 | 45.343 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |
| 2028 | 45.680 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |
| 2029 | 46.020 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |
| 2030 | 46.362 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |
| 2031 | 46.706 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |
| 2032 | 47.054 | 3 | 12.000 | 36.000 | 0,42 | 13.140,00 |

*Source: Analysis Result 2023*

## 3.3 Religious Facilities

Religious facilities are utilized by the community for worship, and it is expected that the number of religious facilities will increase with the growing population. The Directorate General of Spatial Planning, Ministry of Public Works, guarantees the need for clean water for mosques at 3,000 liters/unit/day and Protestant churches at 1,000 liters/unit/day, following the regulations set by the Directorate General of Spatial Planning, Ministry of Public Works (Table 10). Assume the use of water for prayer rooms (mushola) is 1,000 liters per unit per day. For the year 2022, there are 3 units of mosques, 85 units of Protestant churches, and 2 units of Catholic churches.

## 3.4 Market Facilities

There are markets that cater to the most basic daily needs, and the availability of clean water is crucial for these markets. Table 11 shows the basic assessment of the need for clean water for market facilities. The water consumption for market facilities is calculated using the following assumptions:

- A minimum of 30,000 people supporting one market unit.
- 12,000 liters per day is the average daily usage.
- Every five years, a new market unit is added.

In Table 11, the calculation of water needs for market facilities is as follows.

## 3.5 Health Facilities

Water is typically used for cleaning medical equipment and other hygiene needs in healthcare institutions, such as restrooms, patient washing, and room cleaning. Hospitals, community health centers (Puskesmas), and Sub-district Health Centers (Pustu) are among the facilities to be considered (Pustu). According to BPS statistics, there is 1 unit of Puskesmas and 4 units of Pustu health facilities. The underlying assumptions are as follows:

- Hospitals require 20,000 liters/unit/day.
- Community health centers (Puskesmas) require 2,000 liters/unit/day.
- Sub-district Health Centers (Pustu) require 100 liters/bed/day.
- Puskesmas has a patient capacity.
- Pustu can accommodate 11 patients.

Table 12 shows the estimated water consumption for healthcare facilities in the Tarutung District until 2032, based on the assumptions.

## 3.6 Hotel, Restaurant, and Office Facilities

Water needs are typically used to support operational activities. Clean water needs for commercial establishments include the water requirements for hotels, restaurants, and offices. The underlying assumptions are as follows:

- Hotels require 3,750 liters/unit/day.
- Restaurants require 2,000 liters/unit/day.
- Offices require 750 liters/bed/day.

## 3.7 Agricultural Needs

In the study of domestic and non-domestic water requirements, the demand for water is not exempted from the agricultural sector. According to the latest data, the Tarutung district has an agricultural area covering 993.80 hectares (Source: BPS 2023). The analysis of the agricultural sector involves the use of a water requirement calculation balance for the most recent 1000 hectares of paddy fields, requiring a maximum of 1.43 cubic meters per second for irrigation. Here is the recapitulation of the water requirements.

Domestic water needs include the requirements for House Connections (HC) and also the requirements for Public Hydrants (PH). To meet the non-domestic water needs, including the requirements for educational facilities, places of worship, markets, health facilities, hotels, restaurants, offices, and agricultural areas, the level of requirement is presented in Table 14.

## 3.8 Water Avalibility Calculation

### 3.8.1 Data on spring sources

Currently, the Tarutung District has several spring sources to meet its water needs. The capacity of these water sources is outlined in Table 15.

**Table 12. Water demand for health facilities in Tarutung District**

| Year | Total Population (People) | Hospitals (Unit) | Community Health Centers (Puskesmas) (Unit) | Sub-district Health Centers (Pustu) (Unit) | Total Water Demand (lt/hr) | Total Water Demand (lt/day) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|---|
| 2022 | 43.694 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2023 | 44.019 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2024 | 44.346 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2025 | 44.676 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2026 | 45.008 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2027 | 45.343 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2028 | 45.680 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2029 | 46.020 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2030 | 46.362 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2031 | 46.706 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |
| 2032 | 47.054 | 1 | 1 | 5 | 22.500 | 0,260 | 8.212,50 |

*Source: Analysis Result, 2023*

**Table 13. Water Demand for Hotel, Restaurant, and Office Facilities**

| Year | Hotels (Unit) | Restaurants (Unit) | Offices (Unit) | Total Water Demand (lt/hr) | Total Water Demand (lt/day) | Total Water Demand ($m^3$/year) |
|---|---|---|---|---|---|---|
| 2022 | 10 | 33 | 15 | 81.010 | 0,938 | 29.568,65 |
| 2023 | 10 | 33 | 15 | 81.010 | 0,938 | 29.568,65 |
| 2024 | 10 | 33 | 15 | 81.010 | 0,938 | 29.568,65 |
| 2025 | 10 | 33 | 15 | 81.010 | 0,938 | 29.568,65 |
| 2026 | 10 | 33 | 15 | 81.010 | 0,938 | 29.568,65 |
| 2027 | 12 | 35 | 17 | 86.512 | 1,001 | 31.576,88 |
| 2028 | 14 | 35 | 17 | 86.514 | 1,001 | 31.577,61 |
| 2029 | 16 | 35 | 17 | 86.516 | 1,001 | 31.578,34 |
| 2030 | 18 | 35 | 17 | 86.518 | 1,001 | 31.579,07 |
| 2031 | 20 | 35 | 17 | 86.520 | 1,001 | 31.579,80 |
| 2032 | 22 | 35 | 17 | 86.522 | 1,001 | 31.580,53 |

*Source: Analysis Result, 2023*

**Table 14. Recapitulation of Water Needs in the Tarutung District**

| Water Needs | ∑Water Needs (lt/hr) | ∑Water Needs (lt/dt) | ∑Water Needs ($m^3$/th) |
|---|---|---|---|
| **Domestic Water Needs** | | | |
| 1. Household Connections (HC) | 5.138.260 | 59,47 | 1.875.464,90 |
| 2. Public Hydrants (HU) | 508.180 | 5,88 | 185.485,54 |
| **Non-Domestic Water Needs** | | | |
| 1. Educational Facilities | 146.565 | 1,70 | 53.496,16 |
| 2. Regilious Facilities | 96.000 | 1,11 | 35.040,00 |
| 3. Market Facilities | 36.000 | 0,42 | 13.140,00 |
| 4. Health Facilities | 22.500 | 0,26 | 8.212,50 |
| 5. Hotel, Restaurant, and Office Facilities | 86.522 | 1,00 | 31.580,53 |
| **Agricultiral Needs** | | | |
| 1. Agricultural Sector | 123.552.000 | 1.430,00 | 45.096.480,00 |
| TOTAL Potable Water Needs | 6.034.026,38 | 69,84 | 2.202.419,63 |
| TOTAL Non-Potable Water Needs | 123.552.000,00 | 1.430,00 | 45.096.480,00 |

*Source: Analysis Result 2023*

**Table 15. Capacity of water sources in the Tarutung District**

| No | Spring Name | Water Source Capacity (lt/hr) | Water Source Capacity (lt/dtk) | ∑Total Water Needs (m³/th) |
|---|---|---|---|---|
| 1 | Ugan | 1.296.000 | 15,00 | 473.040,00 |
| 2 | Sitakka | 432.000 | 5,00 | 157.680,00 |
| 3 | Horsik | 864.000 | 10,00 | 315.360,00 |
| 4 | Naga Timbul | 432.000 | 5,00 | 157.680,00 |
| 5 | Bintang Pinur | 864.000 | 10,00 | 315.360,00 |
| 6 | Aek Nasia | 432.000 | 5,00 | 157.680,00 |
| 7 | Goti | 129.600 | 1,50 | 47.304,00 |
| 8 | Tampang | 172.800 | 2,00 | 63.072,00 |
| 9 | Gorat | 864.000 | 10,00 | 315.360,00 |
| 10 | Sioma | 864.000 | 10,00 | 315.360,00 |
| 11 | Golat | 259.200 | 3,00 | 94.608,00 |
| Source Capacity | | 6.609.600,000 | 76,500 | 2.412.504,000 |

*Source: Perkim Instituion, 2023*

**Table 16. Rainfall Data in Kecamatan Tarutung**

| | 2018 (mm) | 2019 (mm) | 2020 (mm) | 2021 (mm) | 2022 (mm) | Jumlah | Rata-rata |
|---|---|---|---|---|---|---|---|
| Januariy | 321 | 242 | 312 | 312 | 209 | 1.396 | 279 |
| February | 264 | 241 | 73 | 73 | 228 | 879 | 176 |
| March | 304 | 183 | 121 | 121 | 280 | 1.009 | 202 |
| April | 518 | 322 | 353 | 353 | 150 | 1.696 | 339 |
| May | 370 | 147 | 197 | 197 | - | 911 | 182 |
| June | 146 | 155 | 146 | 146 | 170 | 763 | 153 |
| July | 24 | 103 | 151 | 151 | 22 | 451 | 90 |
| August | 70 | 62 | 82 | 82 | 220 | 516 | 103 |
| September | 529 | 39 | 215 | 215 | 101 | 1.099 | 220 |
| October | 474 | 273 | 262 | 262 | 162 | 1.433 | 287 |
| November | 267 | 215 | 372 | 372 | 215 | 1.441 | 288 |
| December | 272 | 306 | 437 | 437 | 200 | 1.652 | 330 |
| Total Rainfall (mm) | | | | | | | 2.649,20 |
| Effective Annual Rainfall (mm) P.80% | | | | | | | 2.119,36 |
| Annual Rainfall (m) | | | | | | | 2,12 |
| Tarutung District Area (Km2) | | | | | | | 107,68 |
| Tarutung District Area (m2) | | | | | | | 107.680.000,00 |
| Annual Water volume (m³/th) | | | | | | | 228.212.684,80 |

*Source: Analysis Result, 2023*

### 3.8.2 Rainfall data

In addition to spring sources, rainfall data is a crucial component in ensuring water availability for daily needs. Kecamatan Tarutung possesses abundant rainfall data, which serves as a vital stock of water supply for the region. The rainfall data is presented in Table 16:

From the analysis of water demand and availability in the Tarutung District, the total water demand is estimated at 47,298,899.62 m³/th, while water availability is projected to be 230,625,188.80 m³/th. Therefore, the current water condition shows a surplus of 183,326,289.18 m³/th, with potable water amounting to 2,412,504,000 m³/th.

## 4. CONCLUSION AND RECOMMENDATIONS

From this research, it can be concluded that the Tarutung District is expected to manage its water needs wisely until 2032. The total estimated water demand is 47,298,899.62 m³ per year, while the water availability is projected to be 230,625,188.80 m³ per year. Currently, the Tarutung District has a water surplus of 183,326,289.18 m³ per year. Although this condition indicates water abundance, it is crucial to implement sustainable environmental policies to protect water sources and ensure efficient resource management by the community.

To address water demand and availability in the Tarutung District, several recommendations can be considered. Firstly, local governments need to issue environmentally friendly policies, such as Regent Regulations (Perbup), to regulate sustainable water source protection. This can also include water usage management by the community to increase awareness of the importance of natural resource management. Additionally, efforts should be made to reduce water loss rates to enhance water use efficiency. Improvement of water storage facilities is also essential to accommodate water needs in the Tarutung District. Lastly, regulation in forest area management is necessary to maintain the sustainability of water availability, prevent misuse by certain parties, and protect the ecosystem as a whole.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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