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Analysis of Clean Water Demand in Watudiran Village, Sikka Regency

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Abstract

The study examines a semi-arid area experiencing limited access to clean water due to the absence of an adequate piped water network. To develop an effective and sustainable clean water pipeline project, various baseline data are required to support technical planning and guide appropriate investment decisions. This study aims to analyze clean water demand based on projected population growth and domestic water consumption standards. The method involves population projection using a geometric growth model and water demand estimation based on government standards, assuming a daily per capita consumption of 60 liters per person. The analysis covers the period from 2024 to 2039. The results show that the population of Watudiran Village is projected to increase from 1,871 people in 2024 to 2,559 people in 2039. Based on this assumption, the average daily water demand will reach 153,522 liters by the end of the projection period. The peak flow is estimated at 3.56 liters per second, using a peak factor of 2.0. These findings provide a quantitative foundation for designing the village's clean water distribution system and serve as an important reference for rural infrastructure development planning.

Keywords : *Clean Water Demand, Population Projection, Watudiran Village*

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Introduction

Clean water is a fundamental need essential for supporting public health, productivity, and overall community well-being (Akhai & Taneja, 2025; Bandari & Sadhukhan, 2021; Exposto et al., 2021; Ghozali & Yanti, 2017; Harmans et al., 2022; Setyari et al., 2022). According to the World Health Organization (2022), access to safe and affordable drinking water is a basic human right that must be fulfilled by governments (Jha et al., 2020; Organization, 2021; Rahman et al., 2023). In Indonesia—particularly in regions with arid geographic conditions such as Watudiran Village in Sikka Regency—access to clean water remains a significant challenge (Umami et al., 2022). Based on the report by Bappenas (2021), eastern Indonesia still faces major

obstacles in providing clean water services, mainly due to limited infrastructure and uneven distribution of water resources.

Watudiran Village is situated in a semi-arid zone and relies on rainwater and shallow wells as its primary sources of clean water. However, the capacity of these sources is inadequate to meet long-term water demand, especially as the population continues to grow (Brown et al., 2019; Cosgrove & Loucks, 2015). Previous studies have shown that planning water distribution systems based on projected clean water demand and population growth can significantly enhance service efficiency. Therefore, a data-driven approach using projection models is crucial for designing adequate clean water distribution infrastructure in rural areas.

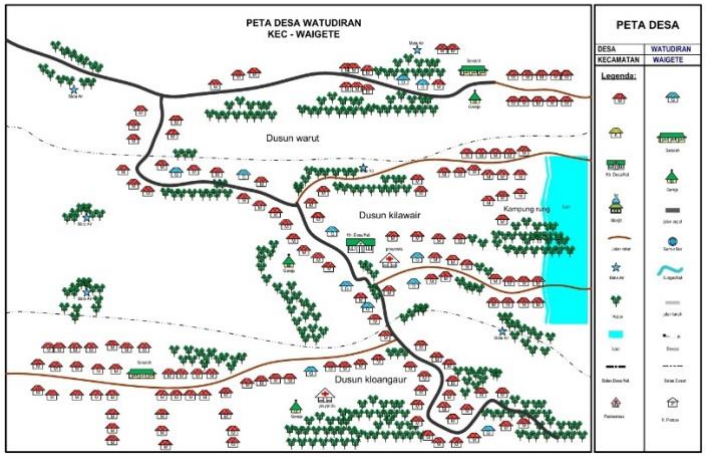

Figure 1. Layout map of Watudiran Village
Source: Watudiran Village Documentation, 2025

Previous studies have examined the issue of clean water supply and demand projections, particularly in rural areas, which share similar characteristics with Watudiran Village. For instance, a study by Ariantana et al. (2023) highlighted the importance of planning water distribution systems based on projected demand and population growth, emphasizing the use of data-driven approaches to enhance service efficiency. This aligns with the need for effective water management systems in areas facing challenges such as limited infrastructure and insufficient water resources. Ariantana's research, however, did not delve into specific regional characteristics such as semi-arid zones, which are a unique feature of Watudiran Village. This study addresses this gap by focusing on the specific needs of Watudiran and employing a tailored projection model for clean water demand.

Another relevant study by Mauliana et al. (2023) focused on the use of projection models in rural water distribution planning. Mauliana's research also utilized population-based projections to estimate water demand but lacked a focus on practical, localized planning for specific rural villages facing semi-arid conditions. While their

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work provides a broad framework for water demand analysis, it does not consider the unique challenges of water scarcity in such regions. This study fills this gap by applying a geometric model tailored to the water demands of Watudiran Village, considering both population growth and national consumption standards.

This study aims to analyze clean water demand in Watudiran Village as the basis for the technical planning of a piped water supply system. The water demand projection is calculated based on population growth using a geometric model and domestic water consumption standards set by national regulations, namely 60 liters per capita per day (Regulation of the Minister of Public Works and Public Housing No. 27/PRT/M/2016). The results of this analysis are expected to serve as a quantitative reference for designing the village's clean water network and to support investment decision-making for water infrastructure in remote areas.

Method

This research was conducted in Watudiran Village, Talibura Subdistrict, Sikka Regency, East Nusa Tenggara Province, which is geographically categorized as a semi-arid region. The location was chosen due to the absence of a centralized clean water piping system, with the community relying primarily on local water sources such as springs and rainwater. The study employed a quantitative descriptive approach using a field-based case study method and secondary analysis of demographic and technical planning data. Primary data were obtained through field surveys, including elevation measurements using a Garmin eTrex 10 GPS device with an accuracy of ±3 meters, and interviews with village officials regarding water needs and distribution conditions. Secondary data were sourced from the Civil Registry Office of Sikka Regency and technical documents from the Ministry of Public Works and Public Housing (PUPR). Population projections were calculated using the geometric growth method, which assumes a constant annual growth rate. The formula applied is as follows:

$$P_n = P_0 \times (1 + r)^n$$

Where:
P_n = Projected population in year n
P_0 = Current population
r = Annual population growth rate
n = Number of years ahead
Subsequently, clean water demand (Q) was calculated using the following formula :

$$Q = P_n \times K$$

Where:
Q = Clean water demand (liters/day)
K = Per capita daily water consumption

The clean water demand was calculated based on the domestic consumption standard of 60 liters per capita per day, in accordance with the Regulation of the Minister

of Public Works and Public Housing (PUPR) No. 27/PRT/M/2016. The total annual water demand was determined by multiplying the projected population for each year by the daily consumption rate and the number of days in a year. The peak flow was estimated by applying a peak factor of 2.0 to the average daily water demand. Data analysis was conducted using spreadsheet software (Microsoft Excel) to develop projections of population growth, average water demand, and peak flow. These projections serve as the basis for designing the initial capacity of the clean water distribution system and as a foundation for further hydraulic planning

Results and Discussion

Historical population data for Watudiran Village from 2018 to 2023 indicate a positive growth trend, as shown in Table 1. This steady growth reflects natural population increase, with no significant out-migration from the village. The trend is consistent with the findings of Mauliana et al. (2023), who reported that villages in East Nusa Tenggara (NTT) Province generally exhibit gradual yet consistent annual population growth.

Table 1. Population of Watudiran Village from 2018 to 2023

Year	Population (People)	Annual Growth Rate	Average Annual Growth
2018	1.650		0,0211
2019	1.690	0,02424	
2020	1.724	0,02012	
2021	1.759	0,02030	
2022	1.795	0,02047	
2023	1.832	0,02061	

Source: Watudiran Village Office, 2024

Based on this trend, a population projection was carried out using the geometric growth method for the period 2024–2039. The results indicate that the population will increase to 2,559 people by the year 2039 (Table 2). This increase reflects a growing demand for clean water each year.

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Table 2. Projected Population Growth in Watudiran Village (2024–2039)

Year	Population (People)	Year	Population (People)
2024	1.871	2032	2.211
2025	1.910	2033	2.257
2026	1.950	2034	2.305
2027	1.992	2035	2.354
2028	2.034	2036	2.403
2029	2.077	2037	2.454
2030	2.120	2038	2.506
2031	2.165	2039	2.559

Source: Authors' Analysis, 2025

The projected population figures presented in Table 2 were then used to calculate daily drinking water demand by multiplying each projected population value by the per capita water consumption rate of 60 liters per person per day. This calculation produced the results shown below.

Table 3. Projected Drinking Water Demand in Watudiran Village (Up to 2039)

Year	Population (People)	Drinking Water Demand (liters)
2024	1.871	112.239,30
2025	1.910	114.607,60
2026	1.950	117.025,80
2027	1.992	119.495,00
2028	2.034	122.016,40
2029	2.077	124.590,90
2030	2.120	127.219,80
2031	2.165	129.904,10
2032	2.211	132.645,10
2033	2.257	135.443,90
2034	2.305	138.301,80
2035	2.354	141.219,90
2036	2.403	144.199,70
2037	2.454	147.242,30
2038	2.506	150.349,10
2039	2.559	153.521,50

Source: Authors' Analysis, 2025

The results in Table 3 show an increase in water demand from 112,260 liters per day in 2024 to 153,540 liters per day in 2039. This represents a 36.7% increase over a 15-year period, entirely attributed to population growth. This trend aligns with the findings

of Ariantana et al. (2023), who emphasized that population variables are the primary determinants in planning clean water infrastructure in rural areas of Indonesia.

Conclusion

This study was conducted to estimate the clean water demand in Watudiran Village as a foundation for measurable and sustainable water infrastructure planning. The findings indicate that the village's population will grow from 1,871 people in 2024 to 2,559 people in 2039, with an annual growth rate of 2.11%. Based on the national domestic water consumption standard of 60 liters per capita per day, the total daily clean water demand will increase from 112,260 liters in 2024 to 153,540 liters in 2039. Using a peak factor of 2.0, this translates to a peak flow requirement of 3.56 liters per second, which will serve as the design basis for the village's clean water distribution system. This study contributes valuable insights for the development of water infrastructure in semi-arid rural areas, particularly in regions facing challenges in water resource management. Future research could expand on this by incorporating additional factors such as seasonal variations in water demand, climate change impacts, and the integration of renewable water sources to further enhance the sustainability and resilience of water systems in similar regions.

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