



Design and Analysis of Water Systems for Climate Resilience: A Case Study of Sukareja Village, Sukasari District, Subang

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Abstrak – Perserikatan Bangsa-Bangsa (PBB) mengakui bahwa akses terhadap air dan sanitasi merupakan hak asasi manusia yang mendasar. Namun, dalam menghadapi perubahan iklim dan pembangunan yang tidak merata, menjamin akses air ke seluruh wilayah di Subang masih menjadi sebuah tantangan. Tujuan dari penelitian ini adalah untuk merancang dan menganalisis sistem air yang efektif dan efisien untuk ekstraksi dan distribusi air tanah bagi masyarakat Desa Sukareja. Kombinasi metode kuantitatif dan kualitatif diterapkan untuk mengkaji kebutuhan air, rencana volume waduk, jaringan perpipaan, serta mengevaluasi kondisi sosial ekonomi setempat. Data dikumpulkan melalui observasi lapangan, wawancara, tinjauan literatur dan analisis geolistrik. Pemodelan EPANET digunakan untuk mensimulasikan jaringan distribusi air yang efisien. Hasil analisis menunjukkan bahwa menara air dengan lebar 3 m dan tinggi 8 m, jaringan pipa yang dioptimalkan, dan sumur bor dengan kedalaman ± 120 m diperlukan. Pemilihan material yang tepat untuk desain terbukti sangat penting untuk mengurangi biaya dan meningkatkan ketahanan terhadap iklim. Dapat disimpulkan bahwa mengintegrasikan strategi ketahanan iklim ke dalam desain sistem air berpengaruh dalam menjamin pasokan air yang stabil di Desa Sukareja. Hal ini memiliki implikasi yang signifikan bagi masyarakat pedesaan yang menghadapi kelangkaan air akibat perubahan iklim.

Kata Kunci: EPANET, ketahanan iklim, perubahan iklim, sumur bor, SPAM.

Abstract – The United Nations recognizes access to water and sanitation as a fundamental human right. Nevertheless, in the face of climate change and haphazard development, ensuring water access to all regions in Subang still provides a challenge. The objective of this study was to design and analyze effective and efficient water system for groundwater extraction and distribution of Sukareja Village's community. Combination of quantitative and qualitative methods was carried out to assess water demand, reservoir volume plan, piping network and evaluate local socioeconomic conditions. Data were gathered through field observations, interviews, literature reviews and geoelectric analysis. EPANET modeling was used to simulate the efficient water distribution network. The analysis showed that a 3 m wide by 8 m tall water tower, an optimized pipe network, and a drilled well with ± 120 m depth was required. Selecting appropriate materials for designs was found to be critical to reduce costs and increase climate resilience. The study concludes that incorporating climate resilience strategies into water system design is essential to guarantee a steady water supply in Sukareja Village. This has significant implications for similar rural communities facing water scarcity due to environmental change.

Keywords: EPANET, climate resilience, climate change, boring well, SPAM.

I. INTRODUCTION

Water is a vital element for human survival and plays a critical role in addressing key sustainable development concerns, such as human welfare, food and energy security, industrial growth, urban management and climate change mitigation (UNESCO 2015). The United Nations recognizes the ability to access water and sanitation as a basic human right that plays a critical role in advancing health, dignity, and prosperity. However, a substantial population, numbering in the billions, still lacks access to water and sanitation services that are effectively and securely administered.

Water scarcity is largely affected by socio-economic and climate change (Wang et. al. 2024). Socio economic factors such as poverty, education and the place to live (rural or urban) have a significant impact on access to safe water and sanitation (Azeez et. al. 2023). Moreover, while the recognition of water access rights exists, there is a tendency to oversimplify the socio-technical difficulties linked to it (Kozikis and Winkler 2020). The historical underinvestment in marginalized communities and the existence of environmental racism have led to disparities in water accessibility to the public (Mohai & Bryant 2019).

The other factors, such as climate change, severe droughts, population growth, increased water demand and

inadequate management in recent years has further caused the water shortage for billions of people worldwide (Salehi 2021). Climate change affects multiple aspects of the environment, encompassing temperature, sea level, precipitation, and water resources which significantly impacts agricultural productivity, crop yields, and food security (FAO 2015). Thus, securing a good water supply system (WSS), or *Sistem Penyediaan Air Minum* (SPAM) that can withstand climate change and readily accessed by the public is crucial.

Sustainable Development Goals (SDGs) number 6 is to ensure availability and sustainable management of water and sanitation for all (United Nations 2015). In line with the goals, Indonesia had devised a number of national programs to increase access to clean water over the past ten years. Although, there are still many areas suffering from water shortage caused by lack of infrastructure, for instance Sukareja Village, in Subang.

A significant number of the population of Sukareja Village, located in Sukasari District within Subang Regency relies on dug wells to meet their daily water needs. However, during periods of drought, these wells dried up, causing the villagers to suffer from water shortage. They had to rely on water depots to buy water. Because of this, Sukareja Village was chosen as the designated site for the

study.

In order to build sustainability of water supply, a good water system and management, especially one that can withstand climate change, is needed. This journal provides an in-depth analysis of the water distribution system in Sukareja Village. The objective of this journal is to design and analyze an effective and efficient water system for groundwater extraction and distribution, and to ensure the sustainability and resiliency of Sukareja Village's community in order to face challenges due to climate changes.

II. RESEARCH METHODS

The study used a combination of quantitative and qualitative methodologies to obtain a comprehensive understanding of the current conditions, water requirements, and essential infrastructure for the Drinking Water Supply System (*Sistem penyediaan Air Minum, SPAM*) in Sukareja Village, Sukasari District, Subang Regency. Qualitative methods offered a deeper understanding of the local context and socio-economic conditions, while quantitative methods quantified water demand, reservoir volume, and piping network analysis.

The research concentrated on the topography, aquifers, piping networks, and supporting infrastructure, including reservoirs and water towers. Primary data were obtained through field observations that employed GPS and topographic measuring instruments, while secondary data were obtained from literature reviews and geoelectric analysis reports to ascertain the depth of the aquifer (Drew 2023; Alfadli & Natasia 2017). Data collection methodologies presented structured interviews with village officials and residents, field observations, and reviews of existing literature and service area maps.

Representation was chosen by a randomly selected sample (Martínez-Mesa 2016), which was 50 respondents. Data analysis evaluated location's feasibility using topographic data, the calculation of water demand, the design of infrastructure, and the estimation of costs. The planning process was conducted in three stages: the analysis of water flow and structural strength for water towers, the selection of components and the determination of drilling depth for boring wells, and the planning of pipe routes using Google Maps, EPANET program, and direct surveys for precise and durable results.

III. RESULTS AND DISCUSSION

Location Overview

The proposed project is designated in Northern Subang area (Pantai utara, Pantura), specifically in Sukareja Village, Sukasari Subdistrict, Subang Regency, West Java. The site, situated at approximately 2 meters above sea level with coordinates of 6°18'03.7"S 107°47'31.3"E, falls within a "shallow groundwater zone" with saline water tendency (Revisi RTRW Kabupaten Subang 2021). This location (Figure 1) was selected based on the critical need for a reliable water supply system.

Historical data of Northern Subang, as shown in Table 1, indicates frequent droughts causing wells to dry up, forcing residents to buy water from nearby depots. This location selection aligns with the urgent need for sustainable water solutions in areas with limited access, as mentioned by He *et al.* (2021). Notably, the topography of this area is relatively flat, as evidenced by the Morphological Map of Subang Regency (2022). Efficiently distributing water

without using excessive energy and ensuring cost-effectiveness is a challenge. Therefore, a thorough investigation is necessary to evaluate the most suitable infrastructure and facilities for efficiently distributing water within the proposed area.



Figure 1. Project Location

Table 1. Northern Subang Drought Histories

Year	Occurrences/ Impact	Reference(s)
2023	18	BNPB (2023)
2019	25/ decrease of productive field area	BPBD (2019); Andri (2020)
2018	18-15	Maemun & Wati (2019)

Interviews and surveys conducted with residents and village officials have revealed the socio-economic difficulties associated with accessing water. Most residents are apprehensive about the financial onus of acquiring water during periods of drought. Typically, 85% of the participants require a daily intake of 130 liters of water for drinking and sanitation, whereas the remaining individuals need 100-120 liters. The survey indicates that all participant (100%) agrees that there is water scarcity during the arid season. In severe drought, 84% of the participants purchase water, which is priced between 10,000 and 15,000 IDR per cartload and can be used for 2-3 days. In addition, 78% of respondents perceive the current water quality as subpar, specifically mentioning a mildly brackish flavor. As a result, all participants are willing to pay a monthly fee ranging from 5,000 to 15,000 IDR in order to obtain higher quality water.

This qualitative data corroborated the quantitative findings and emphasizes the substantial socio-economic consequences of water scarcity. The socio-economic data supports the findings of Oskam *et al.* (2021), indicating that households with lower socio-economic status frequently depend on inferior drinking water sources. However, specific associations on the source of water and income group need further examination.

Climate Resilience in Water System

Access to clean water and sanitation is recognized as a fundamental human right (United Nations, 2015). However, global disparities in water accessibility persist, exacerbated by socio-economic and climatic factors (Azeez *et al.*, 2023). Previous studies have highlighted the critical role of

effective water management systems in ensuring sustainable water supply (Kozikis & Winkler, 2020; Mohai & Bryant, 2019). Despite numerous national initiatives, regions like Sukareja Village still face significant challenges in water accessibility (Wang et al., 2024). This study was constructed from the work of Gorelick et al. (2022) and Amin et al. (2021) to propose a climate-resilient water distribution system tailored to local conditions.

Grosso et al. (2019) argued that the key determinants comprise climatic variables like temperature, precipitation, and relative humidity; population magnitude; water pressure; system losses; pricing structure; supply and water metering systems; household income; and the extent of outdoor area. Thus, when designing a WDS, it is crucial to carefully plan the supporting infrastructure in terms of water pressure (head) and potential water loss (head loss) to guarantee optimal and efficient system performance.

Climate change from global warming is indicated by high climate variability, early seasons, and extreme weather. Cruz et al. (2007) stated that air temperature and rainfall affect food production and water availability. Subang is vulnerable to disasters, especially floods and droughts, due to its agricultural land (BNPB 2011). Pramudia's (2002) study links El Niño to drought, decreased rainfall, and decreased rice production in West Java regions such as Karawang, Subang, and Indramayu.

Groundwater is stored in soil or rock layers below the surface, with formations including aquifers, aquitards, and aquicludes. Aquifers are geological formations capable of storing and conveying water in economically sufficient quantities. They are characterized by being porous, permeable, and saturated, allowing them to both drain and store water. The depth of groundwater zones can be investigated by using the geoelectrical resistivity technique.

The geoelectrical resistivity technique is one of the geophysical methods that studies the nature of electrical current in the earth and depends on the electrical resistivity (the reciprocal of conductivity), which is a fundamental property of all the earth's materials (El-Dayem et al. 2023). The electrical resistivity method is easy to use and doesn't cost much.

The geoelectric analysis, as shown in Table 2, provides a comprehensive understanding of the depth and properties of aquifers in Sukareja Village. The analysis reveals that the material resistivity ranges from 0.72 to 5 Ωm . This discovery is consistent with geological surveys carried out in comparable regions (Suyanto 2016; Setiadi & Pratama 2018; Sholihuddin et al. 2020). Based on the analysis, it seems that the primary aquifer is located at a depth of 68.73-120 meters, and it has enough capacity to fulfill the water requirements of the village.

Table 2. Result of Geoelectrical Estimations

Measurement Point	Depth (m)	Resistivity Value (Ωm)	Soil layer	Remark
GL-1	0.00 - 2.54	5.22	Top Soil	Brackish
	2.54 - 6.78	2.10	Clay	
	6.78 - 21.63	1.34	Loam	
	21.63 - 42.18	5.12	Clay	
	42.18 - ~	0.72	Loam	Aquifer (saline)

Source: Team Geophysic 2022

Thus, the suggested boring depth is 120 m deep to avoid saline aquifer and to do well logging investigation to predict future position of screen for the extracted aquifer. Nonetheless, it is imperative to conduct a comprehensive examination to evaluate the water quality and verify that the levels of contaminants are within acceptable limits for utilizing this aquifer as a source of drinking water.

The topography of Sukareja Village is relatively flat, which leads to a low water pressure, or known as *head* (H). This had been shown through modelling in EPANET program. EPANET is a software application used throughout the world to model water distribution systems. It was developed as a tool for understanding the movement and fate of drinking water constituents within distribution systems, and can be used for many different types of applications in distribution systems analysis (EPA 2024).

Establishing a water system that can withstand the impacts of climate change necessitates assistance from the government and policymakers (Khaniya et al. 2021). Water resources sector on Java Island is currently in a precarious state Aldyan (2023), and the government dedicated to promote sustainable development in addressing the consequences of climate change Bappenas (2021). Accurate, data-driven policies based on climate scenarios are essential to mitigate these impacts effectively.

Projects focused on enhancing climate resilience must be designed, built, and operated to endure the potential impacts of climate change and associated natural calamities (International Hydropower Association 2015). Climate resilience is the ability of a system to predict, get ready for, and react to problems caused by climate change. For water management to work well, systems need to be able to handle changes in the water supply and extreme weather.

The water distribution network system in Sukareja Village, Sukasari Sub-district, is being conducted as a part of the rural Drinking Water Supply System (WSS/SPAM) developments in Subang Regency. The development of SPAM aims to provide facilities and infrastructure for the reliable and continuous availability of drinking water. By ensuring both sufficient quantity and high quality, these activities guided by the implementation of new construction, enhancement, and enlargement, as required by Permen PUPR No. 27 of 2016.

The EPANET modelling technique was employed to analyze the quantity, quality, and continuity aspects of this distribution network system. The results included the pressure analysis, water velocity through pipes, head loss, and flow direction within the distribution network. These analyses conform to the established criteria for drinking water distribution network systems.

The pressure analysis in Figure 2 shows that the existing energy is inadequate to transport water from the source to the households without the assistance of supplementary pumps. The experiment was done using EPANET with a water reservoir model without a water tower. The elevation assumed to be the same as the ground elevation and the house connection (*Sambungan Rumah*/ SR) that connected the main pipes with household tapping water. The results showed that the remaining pressure will fail to distribute water to the resident houses due to the flat topography of the area. Sukasari Village is a low plain with a completely flat surface, unlike the plateau with higher ground elevation in which water can be directly flowed by gravity. Thus, the water systems require a water tower.

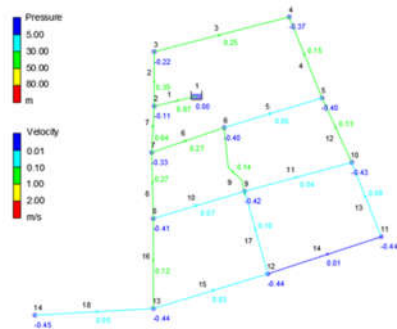


Figure 2. Initial Pressure (Without Water Tower)

However, employing additional pumps beyond the necessary amount for extracting groundwater would result in increased expenses for electricity and maintenance. Hence, it is imperative to elevate the reservoir structure, which is commonly situated directly on the ground. This modification guarantees that the water from the reservoir will possess sufficient pressure to reach the designated households.

Modification of height in the reservoir through EPANET showed that the most optimal height is 8 meters high. Considering the daily water demand of Sukareja community, which is 130 liters per household per day, the optimum capacity of the reservoir to be build was 18 m³. Input demand was based on the water capacity in the water tower of 2 liters/second. Input demand refers to Figure 3 in the water distribution network system scheme in Sukareja Village, Sukasari Sub-district. Assuming that the raw water source comes from a protected deep well, it flows into an 8 m high reservoir using a submersible pump. Water distribution flows directly from the reservoir to the collector pipe (1) to the main junction (2). Furthermore, water is distributed evenly to each branch junction. Subsequently, the height input in Figure 4 refers to the sum of the ground elevation and tower elevation, then the elevation at each junction follows the elevation of the pipe installation.

The choice of pipe material in water distribution systems significantly impacts efficiency. Different materials react differently to climate changes, affecting fragility and failure rates (Suribabu 2017). Optimal design strategies consider pipe material to enhance resilience and minimize costs (Fan et al. 2023). For instance, climate change can lead to varying failure rates based on pipe material, age, and maintenance strategies (Yoo et al. 2016). Robustness in water distribution systems is also influenced by the choice of pipe material, aiming to simultaneously minimize costs and maximize system reliability (Amin et al. 2021). Therefore, selecting the right pipe material is crucial for ensuring efficient water distribution while considering factors like climate, seismic events, and overall system robustness.

Different pipe materials have varying impacts on the environment, especially in the context of climate change. Climate change can influence the fragility of water pipes, with factors like geographic location, pipe material, age, and maintenance strategies affecting the system's resilience (Suribabu 2017). Optimal design of water distribution networks should not only focus on minimizing capital costs but also on maximizing resilience to withstand failure scenarios, which is a key environmental consideration (Fan et al. 2023). Therefore, it is essential to consider the long-term environmental implications of pipe material selection,

as climate change can lead to different failure rates and impacts on water systems based on geographic regions and weather patterns. Using the trial-and-error method in EPANET, it is found that the most optimal pipe size is 63 mm in diameter and the material uses PVC with a roughness coefficient of 120.

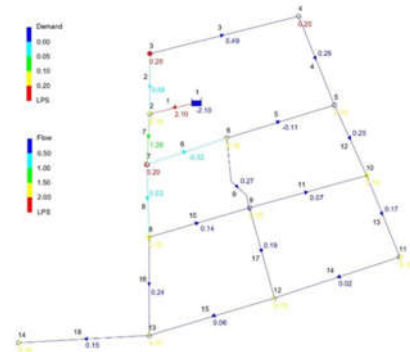


Figure 3. Demand and Flow

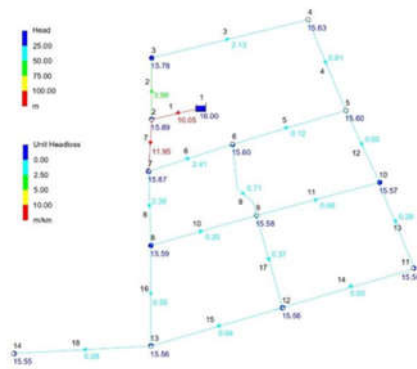


Figure 4. Height

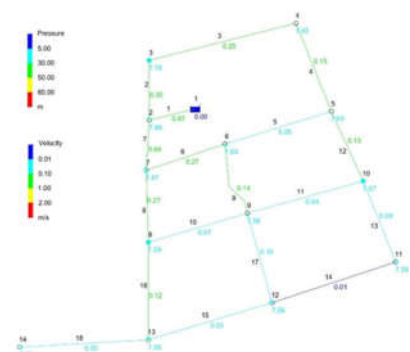


Figure 5. Pressure and Velocity

The results of the residual pressure and velocity analysis using the Hazen-Williams formulation in the EPANET program are shown in Figure 5. The analysis indicated that the residual pressure meets the standard criteria set by the Ministry of Public Works and Housing (PUPR) Technical Guidelines, maintaining levels below 10 mPa. The velocity analysis results, presented in Table 4 and Table 5, reveal that while most pipe sections meet the standard velocity range of 0.25-2.5 m/s, eight pipe sections fall below this standard.

Despite this, the overall water distribution analysis confirmed that water is successfully delivered to all points in the system. Thus, it showed the effectiveness of the design. In the loop system, water flow remained consistent and evenly distributed, which means the planned water system would be running effectively. The head loss analysis indicated that some pipes experience head loss slightly higher than the standard of 10 m/km. Specifically, pipes 1 and 7, located near the reservoir, exhibit head losses of 10.05 m/km and 11.95 m/km, respectively, which are only marginally above the specified standard.

Table 4. Nodes Analysis

Node ID	Demand	Head.	Pressure
	LPS	m	m
Junc 2	0.15	15.89	7.89
Junc 3	0.20	15.78	7.78
Junc 4	0.20	15.63	7.63
Junc 5	0.15	15.60	7.60
Junc 6	0.15	15.67	7.60
Junc 7	0.20	15.59	7.67
Junc 8	0.15	15.58	7.59
Junc 9	0.15	15.57	7.58
Junc 10	0.15	15.56	7.57
Junc 11	0.15	15.56	7.56
Junc12	0.15	15.56	7.56
Junc 13	0.15	15.56	7.56
Junc 14	0.15	15.55	7.55
Resvr 1	-2.10	16.00	0.00

Source: Analysis results, 2024

Table 5. Velocity Analysis

LinkID	Flow	Velocity	Unit Headloss
	LPS	m/s	m/km
Pipe2	0.69	0.35	3.99
Pipe 3	0.49	0.25	2.13
Pipe 4	0.29	0.15	0.81
Pipe 5	-0.11	0.05	0.12
Pipe 6	-0.53	0.27	2.41
Pipe 7	1.26	0.64	11.95
Pipe 8	0.53	0.27	2.39
Pipe 9	0.27	0.14	0.71
Pipe10	0.14	0.07	0.20
Pipe 11	0.07	0.04	0.06
Pipe12	0.25	0.13	0.60
Pipe 13	0.17	0.09	0.29
Pipe 14	0.02	0.01	0.00
Pipe 15	0.06	0.03	0.04
Pipe 16	0.24	0.12	0.55
Pipe 17	0.19	0.10	0.3
Pipe 1	2.10	0.67	10.05
Pipe 18	0.15	0.05	0.08

Source: Analysis results, 2024

Reservoir Design

Subang Regency is located in north coast West Java, and consists of four coastal districts, namely Blanakan, Sukasari, Legon Kulon, and Pusakanagara. The coastal line of this regency is up to 48 km² and experiences rapid and advantageous economic growth due to its strategic location. However, this is also parallel with environmental destruction and may lead to significant damage to

properties and infrastructures, along with considerable loss of coastal ecosystem in the area. The climate of Subang district classified as monsoon, tropical. It receives annual rainfall range from 1500 – 3000 mm based on the location with an occurrence of 70-80% of the total rainfall in the monsoon during November to April. The average temperature varies between 23 °C and 34 °C. (Subang Statistic Agency 2021; Handiani et al. 2018; Putu 2018).

Concrete is widely recognized as the most commonly used construction material worldwide due to its exceptional performance, cost-effectiveness, and local availability of raw materials in different regions. Concrete has been widely utilized in the construction of a wide range of infrastructures, including transportation systems, health facilities, residential and commercial buildings, water systems, and more. Nevertheless, according to Adesina & Zhang (2024), the extensive production and utilization of concrete have been discovered to have detrimental effects on the environment. This is primarily due to its significant contribution to greenhouse gas (GHG) emissions and its consumption of natural resources.

However, unlike other construction materials such as steel and glass, concrete has a lower unit embodied carbon. This is evident in Figure 6, which depicts the embodied carbon emissions of each material per kilogram. The production of primary binder in concrete and other cementitious materials, the Portland Cement (PC), contributes significantly to high greenhouse gas emissions. The biggest usage of concrete among all cementitious materials is PC which accounting for approximately 70% of its usage. The remaining 30% is allocated to other cementitious materials like mortar and grout.

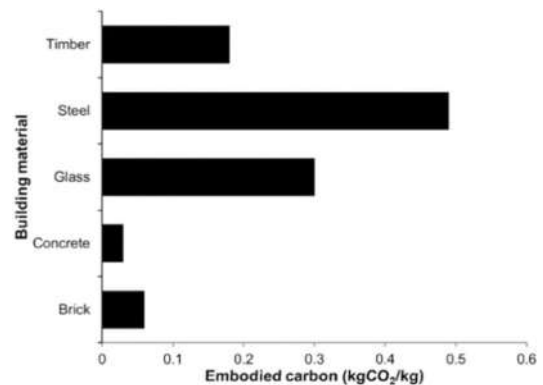


Figure 6. Materials Carbon Usage

Source: Adesina (2020)

The high consumption of concrete for different applications can be associated with its outstanding performance and versatility coupled with the local availability of raw materials which makes it suitable for various construction applications (Adesina 2020). Concrete is well known for its attributes of strength, durability, resilience and safety, making it the ideal material for resilient communities. Its strength and durability mean it has an important role to play in strengthening the resiliency and adaptive capacity of communities to climate-related and nature disasters as concrete construction is better able to survive extreme weather and other catastrophic events than other building materials (Global Cement and Concrete Association 2024). Owing to this reason, concrete was then

chosen as the main material for the water tower in this study.

Based on overall analysis, the optimal flow rate to ensure secure and sustainable clean water access for 75-100 households in Sukareja Village is between 1-1.5 liters per second (lps). Considering the daily water usage of 130 liters per household, it is necessary for the reservoir to have a volume of 18 m³ in order to effectively store water prior to distribution. In order to meet the needs of potential future customers with higher consumption, the flow rate had been determined to be 2 liters per second.

The water tower was designed using concrete with compressive strength (f'_c) of K300-K350, depends on where the types of the structure components. For safety reasons, the water tower consisted of four floors: the ground floor, first deck floor, second deck floor and the third deck floor, with a total height of 800 cm and a width of 300 cm to 300 cm. The water tower plans are shown in Figures 7 and 8. Based on EPANET analysis, this dimension was the most suitable for the targeted communities, along with its potential development, i.e. additional costumers.

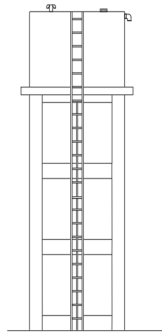


Figure 7. Water Tower Plan

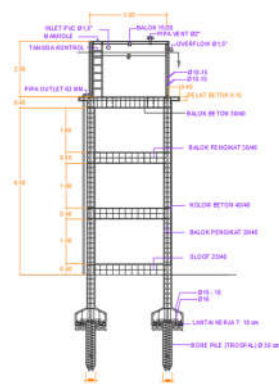


Figure 8. Section A: Detailed Steel Reinforcement

Generally, the raw water quality produced by deep wells is good and can be further treated for drinking water by adding chlorination (SIMANTU PU 2024). The technical design of the water infrastructure, including water towers and piping networks, was informed by topographic data and direct field observations. The design, as shown in Figure 2, ensures efficient water distribution with minimal loss.

Beside water tower, the most important infrastructure is a boring well. A deep well is a man-made water source in the form of a concentric hole from the surface of the ground to

a certain depth. Typically, this hole penetrates a relatively impermeable layer of soil, allowing it to reach depths of up to 100 meters. An ideal deep well can collect groundwater from high-transmissivity sand layers. These sand layers are sandwiched between clay layers with high storativity. However, the capacity of a deep well to supply water is not very large. In addition, the productivity of a deep well tends to decrease as the storage capacity (storativity) of the supporting clay layer diminishes (SIMANTU PU 2024).

The deep well should be constructed with a depth of 120 meters and a width of 10 inches. The recommended materials to be used in the construction of the deep well are grouting, PVC suction pipe AW Ø1.5", gravel pack, PVC casing pipe type AW Ø5", low carbon screen, and a cover. A submersible pump is used to pump water from the deep well to the reservoir. The drilled well design is shown in Figure 9.

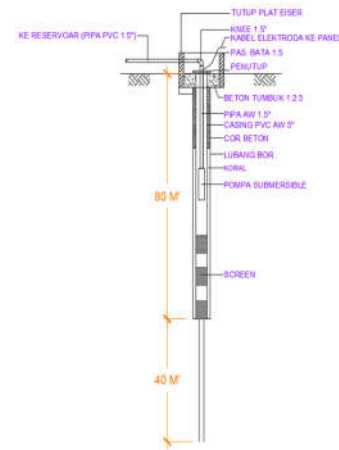


Figure 9. Drilled Well Design

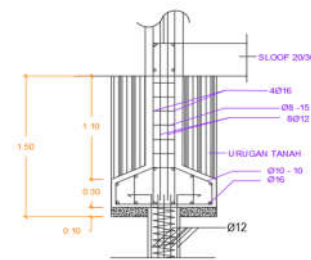


Figure 10. Section A: Detailed Foundation Plan

Foundation design is a crucial step in the construction process, establishing the basis for the structural stability of buildings. The foundation employed in this design was a footplate foundation measuring 100 x 100 cm. At the top of the tower, a concrete water tank (with a storage capacity of 18 m³) will be installed. Section A and the foundation plan of the tower are illustrated in Figures 10 and 11. The rendered image of the water tower is shown in Figures 12.

The estimated construction and operational costs, presented in Table 6. This financial planning was being made by considering to cost effective water supply systems in rural areas i.e. the cost of local materials and local manpower salary. For similar cases, such as Malawi, Mwangomba and Tilley (2021) stated that based on Ministry of Irrigation &

Water Development 2010, it is common for communities to contribute around 25% of the total project cost through their own labor and resources. However, the specific percentage may vary depending on the availability of these resources and labor.

Table 6. Estimated Cost

No	Work Description	Total (Rp)
1	2	3
I	PREPARATION	2.750.000,00
II	CONSTRUCTION WORK SAFETY	7.507.350,00
III	PIPING AND ACCESSORIES WORKS	33.687.807,67
IV	SAMBUNGAN RUMAH 75 UNIT	84.723.750,00
V	BORING WELL AND PUMP INSTALATION	132.782.233,72
VI	WATER TOWER	185.614.857,31
VII	ELECTRICAL ENGINEERING	5.636.704,00
	TOTAL CONSTRUCTION	452.702.702,70
	TAX 11%	49.797.297,30
	TOTAL COST	502.500.000,00

Source: Analysis results, 2024

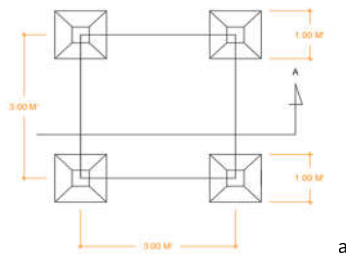


Figure 11. Foundation Plan



Figure 12. Rendered Image of Water Tower

Mwagomba & Tilley (2021) also argue that it can be challenging for communities to show their ownership and satisfaction with a community water supply system by contributing local resources. However, it is crucial to identify clear indicators of user satisfaction in the community and take action to manage them early on during project implementation.

In this study, another focus was on the financial participation of the local community in the operational and management activities of the rural SPAM. The community is anticipated to come together and create a self-governing

collective to manage the distribution of water from the source to consumers' homes and establish their own organizational structure. In addition, establishing a well-defined organizational structure will promote ongoing oversight, thus improving the efficiency of the bureaucratic system. Each customer will be charged a subscription fee based on an agreement or a cross-subsidy system as a way to provide incentives. In most cases, the cost of subscribing to SPAM is determined by how much the community is willing to pay. Based on the survey results, the range of willingness to pay per month is from Rp. 5000 to Rp. 15,000. The financial management is focused on benefiting the local community, with the aim of turning it into a source of regional income. This could be done with the help and supervision of relevant agencies or the local government. This principle is in line with the local residence empowerment stipulated in Peraturan Bupati No. 101 of 2020.

The design and analysis used in this study are consistent with previous research on rural water supply system. For instance, a study by Bartlett & Dedekorkut-Howes (2023) on climate resilience in water management highlights the importance of integrating local socio-economic conditions into the planning process. The designated findings demonstrate the necessity of considering both quantitative data and qualitative insights to create a comprehensive SPAM.

Discussion of Future Development for SPAM

Incorporating climate resilience strategies into project design is essential. Efficient water distribution networks should provide uninterrupted clean water at sufficient pressure, especially for urban areas, as highlighted by Amin et al. (2021). For areas with intermittent supply, a tank holding a week's water supply are recommended, with water pumped to upper tanks.

Water distribution system (WDS) optimization is vital for efficient water supply management, aiming to minimize costs and maximize robustness. Techniques like Optimal Power Use Surface (OPUS) reduce costs and improve hydraulic efficiency (Suribabu 2017) and can be used for future research. Moreover, considering unknown flow directions and operational costs can lead to more cost-effective network designs (Saldarriaga et al. 2020). Other methods that can be used like differential evolution and simulation-based iterated local search metaheuristic (Amin et al. 2021; Gustavo et al. 2022) can help achieve optimal designs balancing cost and resilience.

Maximizing WDS robustness involves optimizing design to handle uncertainties (Yoo et al. 2016), along with multi-objective optimization techniques by balancing cost minimization and resilience under demand uncertainty (Zheng et al. 2022). A data-based methodology for stochastic optimal water flow problems can aid in making optimal decisions for network components (Boindala & Ostfeld 2022).

Adhering to ecosystem constraints while meeting the growing needs of population become challenges for regulatory redundancies and a compartmentalized mindset. The focus has been on infrastructure development, land restoration, and community involvement, often prioritizing human needs over hydrological factors (Pambudi and Kusumanto 2023). Effective water management policies, as emphasized by UNEP (2024), are crucial for Integrated

Water Resources Management (IWRM) and should prioritize sustainable practices.

Subang Regency's water resource management is guided by local regulation Peraturan Bupati Subang Nomor 101 Tahun 2020 (RAD AMPL 2020-2024), aligned with IWRM principles. This policy emphasizes community-based strategies, clear objectives, and consistent monitoring. The key aspects are empowerment of local residents and involvement of both government and private sectors in water management. The other aspect is the goals for clean water and sanitation access, coordinating local and national efforts. The last is monitoring and evaluation to ensure effective and sustainable water management.

Community engagement is essential, involving stakeholder participation, education, skill development, local projects, and feedback mechanisms. Implementation of RAD AMPL in Sukareja Village help to build a reliable water supply system. Substantial community engagement and education will ensure long-term sustainability and effective water resource management despite environmental challenges.

IV. CONCLUSION

The study concludes that a 3 m wide by 8 m tall water tower, an optimized pipe network, and a drilled well with ± 120 m depth was required to fulfil water demand in Sukareja Village. Selecting appropriate materials for designs also was found to be critical to reduce costs and increase efficiency of water distribution. Climate resilience strategies incorporated into water system design was essential to guarantee a steady water supply in Sukareja Village. Future research should concentrate on long-term system performance, advanced monitoring technologies, alternative water sources, community involvement, and detailed economic analyses to enhance the system's sustainability and adaptability to climate change.

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