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Improving the drinking water supply system in the capital of Tomia Timur Subdistrict, Tomia Island, Wakatobi Regency

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Abstract

This research aims to improve the Municipal Drinking Water Supply System (SPAM IKK) in East Tomia, Wakatobi Regency, using a combined method approach and involving 76 participants. The findings indicate that water services in East Tomia adhere to the 4K principles (Quantity, Quality, Continuity, and Accessibility), with an increase in water volume despite some distribution challenges. Water quality remains high due to regular testing, and continuous service is ensured through ongoing maintenance, making the service accessibility for the community. Strategic improvements over the next 5-10 years include the implementation of solar-powered pumps, expansion of storage infrastructure, and enhancement of the distribution system to improve efficiency and sustainability. Recommendations include infrastructure upgrades, adoption of green technology, consistent quality checks, and support from proactive local government policies.

Keywords: *Optimization, SPAM IKK, East Tomia, Wakatobi*

Abstrak

Penelitian ini bertujuan untuk meningkatkan Sistem Penyediaan Air Minum Kota (SPAM IKK) di Tomia Timur, Kabupaten Wakatobi, dengan menggunakan pendekatan metode gabungan dan melibatkan 76 peserta. Temuan menunjukkan bahwa layanan air di Tomia Timur mematuhi prinsip 4K (Kuantitas, Kualitas, Kontinuitas, dan Keterjangkauan), dengan peningkatan volume air meskipun ada beberapa tantangan distribusi. Kualitas air tetap tinggi karena pengujian rutin, dan layanan berkelanjutan dipastikan melalui pemeliharaan berkelanjutan, membuat layanan terjangkau bagi masyarakat. Perbaikan strategis selama 5-10 tahun ke depan termasuk implementasi pompa bertenaga surya, perluasan infrastruktur penyimpanan, dan peningkatan sistem distribusi untuk meningkatkan efisiensi dan keberlanjutan. Rekomendasi

termasuk peningkatan infrastruktur, adopsi teknologi hijau, pemeriksaan kualitas yang konsisten, dan dukungan dari kebijakan pemerintah daerah yang proaktif.

Kata kunci: Optimalisasi, SPAM IKK, Tomia Timur, Wakatobi

Introduction

Water is a crucial resource for all living beings, essential for daily needs and sustaining life naturally (Brown et al., 2015; Hoekstra, 2019; Larsen et al., 2016). Its universal usage in various aspects of life increases its value in terms of both quantity and quality. With rising living standards, the demand for water also increases. Clean water used for daily activities such as washing, bathing, and cooking must meet certain standards to ensure it is safe for health (Exposto et al., 2021; Howard et al., 2020). The Indonesian government, through the Minister of Health Regulation No. 492/MENKES/PER/IV/2010, regulates the quality requirements of drinking water, which must meet physical, microbiological, chemical, and radioactive parameters (Novitasari, 2019; Roza & Andriani, 2023; Susanto et al., 2020).

On the other hand, the provision of clean water is a priority in urban and settlement planning (Cosgrove & Loucks, 2015; Larsen et al., 2016; Tortajada, 2020). Water has become a scarce economic commodity, requiring proper management (Wahyuni, 2017). The Minister of Public Works Regulation No. 13/PRT/M/2013 emphasizes the importance of adequate drinking water availability in terms of quantity, quality, continuity, and accessibility. Good drinking water services help protect the community from water-related diseases and improve their welfare, especially for low-income groups (Emenike et al., 2017; Gonzalez & Carlevaro, 2015; Pal et al., 2018).

Clean water is a fundamental need for human life and is prioritized in urban and settlement planning to support the sustainability and development of a settlement (Tortajada, 2020). According to Kodoatie (2003) safe clean water must meet established quality standards. In the context of drinking water provision, the aspects of quantity, quality, continuity, and accessibility (4K) are crucial to achieving a healthy and prosperous community. Adequate drinking water provision supports regional development success and prevents the spread of diseases caused by unsafe water (Wahyuni, 2017).

In the context of Wakatobi Regency, the need for basic infrastructure such as drinking water provision is crucial, given the rapid growth of the tourism sector. The availability of clean, safe, and adequate drinking water for local residents and tourists is essential to support sustainable tourism (Frone & Frone, 2013; Lee, 2001). Developing an optimal drinking water supply system in East Tomia is part of ensuring that drinking water meets the 4K standards and improves the quality of life for the local community (Wahyuni, 2017).

Various studies have generally examined solutions to address drinking water supply issues. However, there is still a gap between water source capacity and the continuously increasing population growth rate, especially in areas not yet reached by pipeline networks (Coelho & Andrade-Campos, 2014). Previous studies emphasized the importance of proper water management but have not focused much on remote areas with unique geographical conditions like East Tomia (Wahyuni, 2017).

Additionally, many studies have not comprehensively considered the implementation of strategies encompassing the quantity, quality, continuity, and accessibility (4K) aspects simultaneously in one drinking water supply system. Developing holistic and specific strategies tailored to the characteristics of areas like East Tomia is needed to address existing challenges and meet clean water needs sustainably (Sühring, 2021).

East Tomia District on Tomia Island, Wakatobi Regency, is one area facing significant challenges in drinking water provision. This region has great tourism potential, but basic infrastructure, including the drinking water supply system, is inadequate to support this development. Currently, drinking water services in East Tomia are provided by SPAM IKK Kahianga with limited capacity, managed by the PDAM. However, the water source used is often influenced by tidal fluctuations, leading to unstable water quality, especially during the dry season (Wahyuni, 2017).

With increasing demand for drinking water and community development in East Tomia, capacity expansion and optimization of the existing system are needed to meet clean water needs. This study aims to explain the provision of drinking water services that meet the principles of Quantity, Quality, Continuity, and Accessibility based on community perceptions and the optimization of drinking water services in East Tomia, Tomia Island, Wakatobi Regency, based on projections for the next 5-10 years.

Research Method

This study uses a mixed-method approach, combining qualitative descriptive analysis through interviews with quantitative descriptive analysis using questionnaires (Zohrabi, 2013). Our quantitative study sampled 76 people spread across three villages, namely Kahiyanga, Tongano Barat, and Patipelong, to analyze the provision of drinking water services that meet the 4K principles (Quantity, Quality, Continuity, and Accessibility) based on the perceptions of the East Tomia community, Tomia Island, Wakatobi Regency, and conducted interviews with the Head of the SPAM IKK Tomia Unit to analyze the optimization of drinking water services based on projections for the next 5-10 years.

Results and Discussion

The primary water sources on Tomia Island, Wakatobi Regency, are groundwater from hilly areas and karst caves known as Tofa. This water is mostly unsuitable for drinking and is only used for bathing, washing, and sanitation. Drinking water needs are met by collecting rainwater using clay pots and tanks. The construction of the East Tomia SPAM IKK Reservoir is planned in Kahiyanga Village, East Tomia District, with a pump house and Solar Cell installation located in Waha Village, approximately 9 km from the reservoir. The optimization of East Tomia SPAM IKK aims to provide water for the communities in West Tongano, East

Tongano, Kahiyanga, Taemonane, and Patipelong with a total population of around 6,198 people. Currently, the Wakatobi Regency Government has acquired a 1,225 m² land area in Kurukurumai Spring for the construction of a pump house and Solar Cell. This project includes the construction of a 200 m³ steel reservoir, solar cells, 8,920 meters of 100 mm diameter GI transmission pipes, and 3,750 meters of 75 mm diameter GI distribution pipes with an additional 100 SR service units.

Kurukurumai Spring, which serves as the raw water source, has a capacity of 20 liters per second, with an existing installed capacity of 10 liters per second and an uninstalled capacity of 10 liters per second. The transmission pipe from the spring to the reservoir does not involve planting and uses GI SNI pipes. The distribution unit is planned based on peak hour requirements and includes pumping systems, distribution networks, storage buildings, and measurement and monitoring equipment to ensure the quantity, quality, and continuity of water flow. The optimization of the East Tomia IKK SPAM Tomia Island was built with a pumping system. For transmission lines use a pumping system, where water is pumped from the source to the reservoir and for the distribution line the water is flowed by gravity from the reservoir to the service unit.

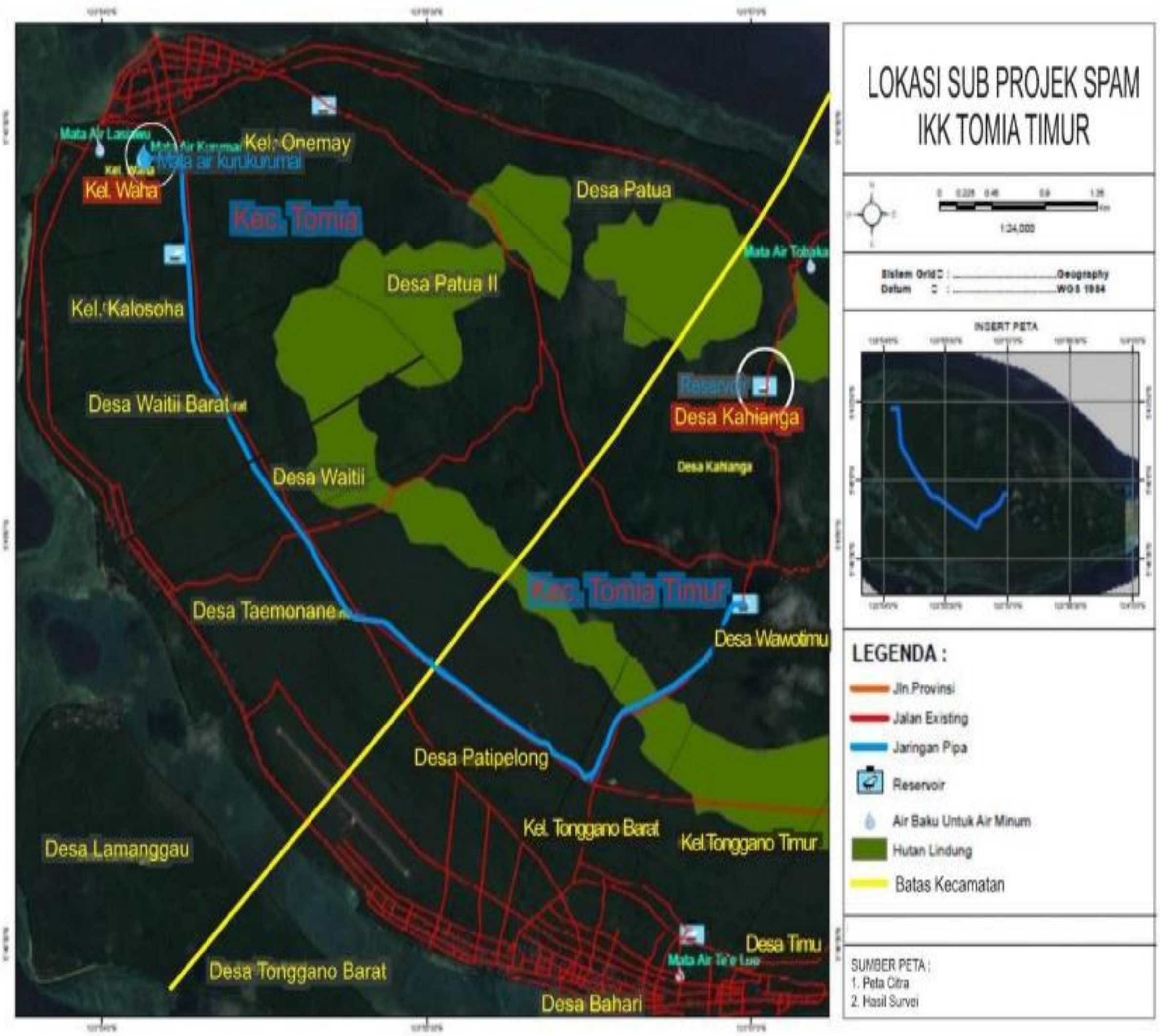

Figure 1. Map of the East Tomia SPAM IKK Development Location

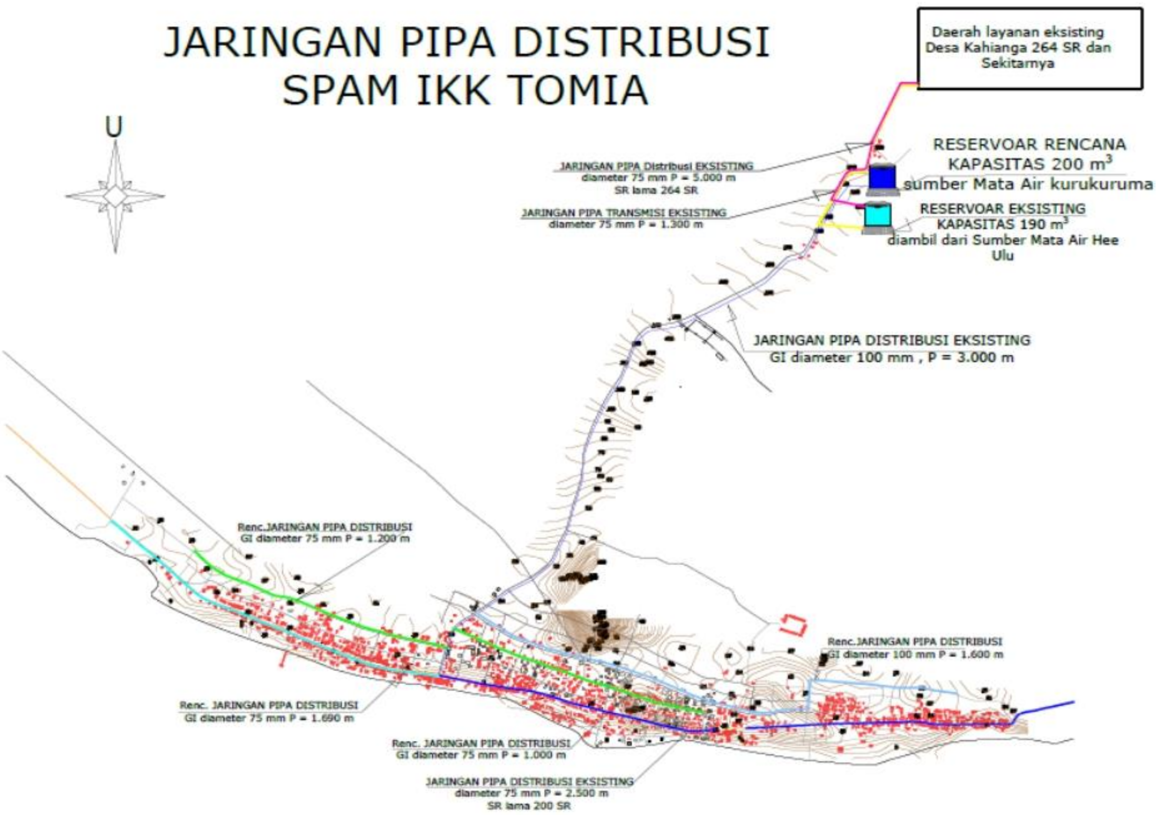

Figure 2. Map of Existing and Planned Pipeline Network on Tomia Island

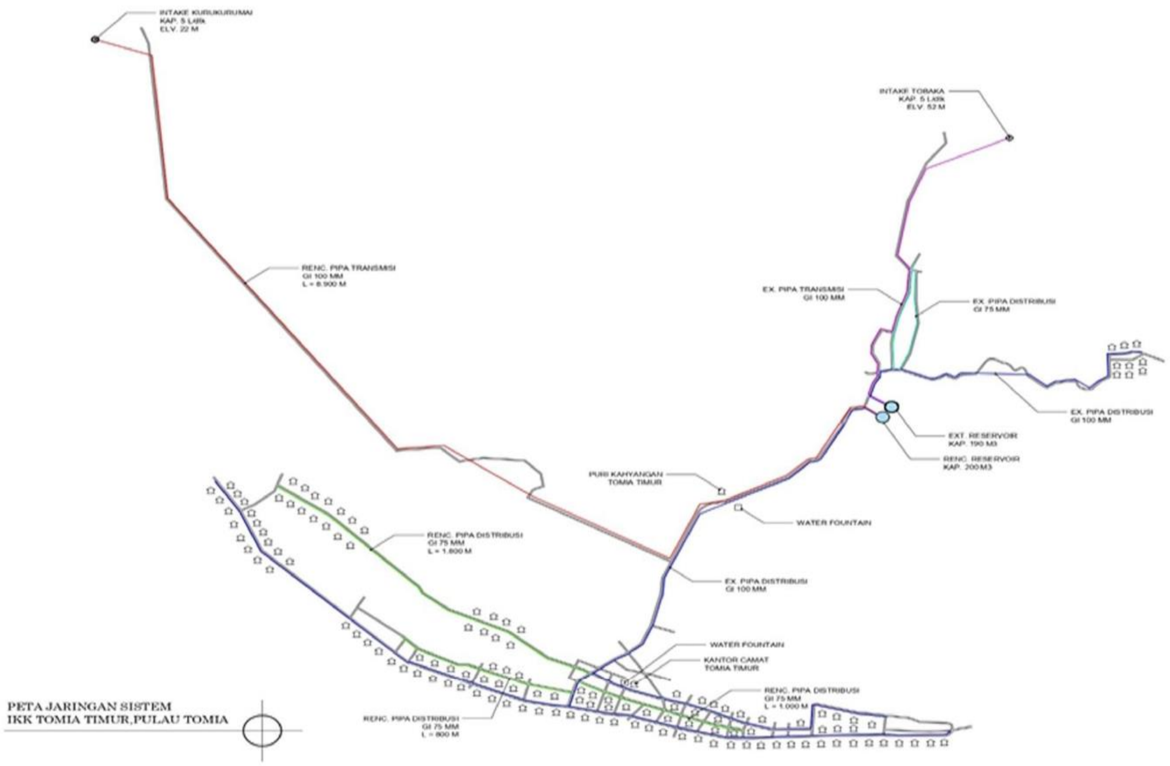

Figure 3. Map of the Optimized SPAM IKK Tomia Pipeline Network

Here is the Epanet Calculation Table for the Transmission Network of SPAM IKK Tomia Timur:

Table 1. Node Network

Node ID	Elevation (m)	Demand (LPS)	Head (m)	Pressure (psi)
M.A	25	0	13	0
Junc T1	20	0	301,64	281,64
Junc T2	18	0	301	283
Junc T3	15	0	300,37	285,37
Junc T4	83	0	282,21	199,21
Junc T5	96	0	261,52	165,52
Junc T6	131	0	254,62	123,62
Res	231	5	241	10

Table 2. Link Network

Link ID	Leght m	Diameter mm	Flow LPS	Velocity m/s	Unit Headlost m/km
Pipe 2	70	100	6,19	0,79	9,08
Pipe 3	70	100	6,19	0,79	9,08
Pipe 4	2000	100	6,19	0,79	9,08
Pipe 5	2280	100	6,19	0,79	9,08
Pipe 6	760	100	6,19	0,79	9,08
Pipe 7	1500	100	6,19	0,79	9,08

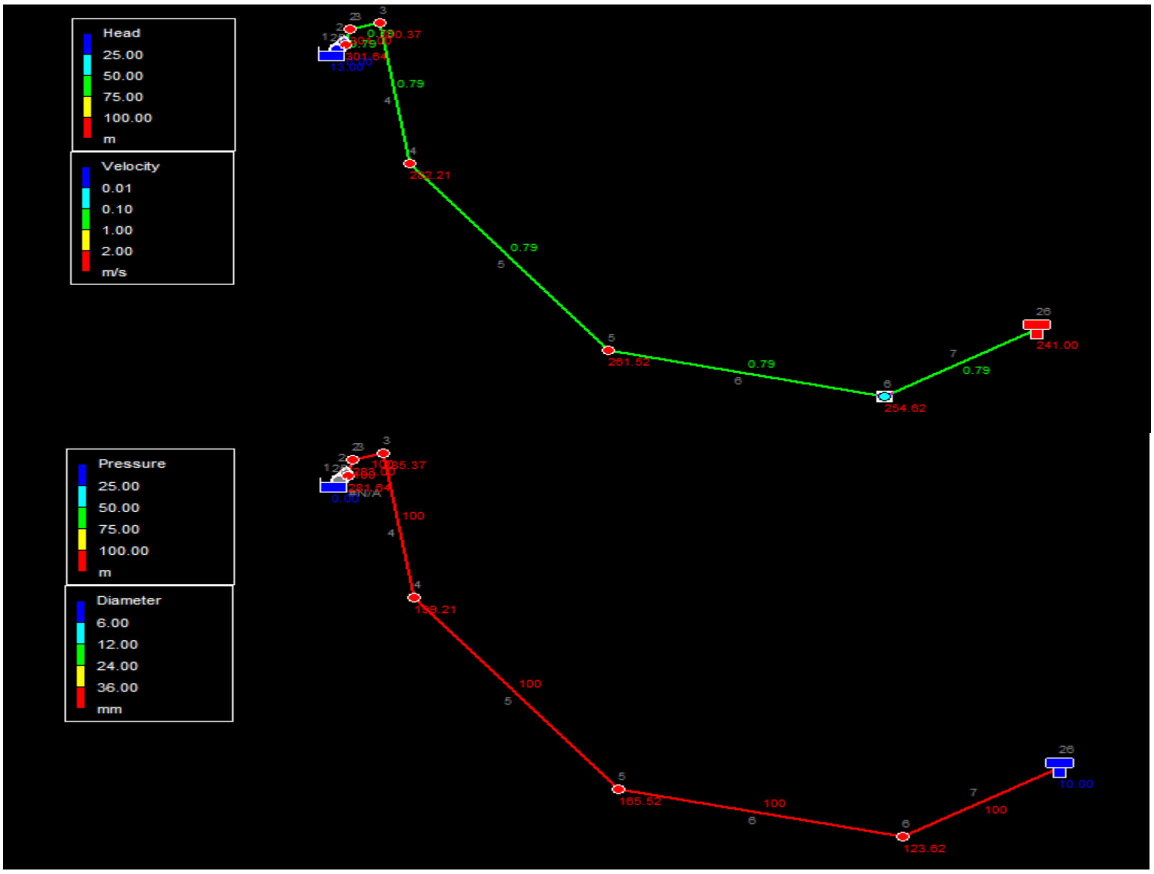

Figure 4. Epanet Transmission Pipe Network SPAM IKK

Below are the key points from the Epanet diagram for the SPAM IKK water transmission pipe network, illustrated using Epanet software, explained as follows:

The diagram is divided into two main sections detailing the characteristics of the pipe network.

1. Top Section of the Diagram:

- Displays information about Head (Pressure Height) and Velocity (Flow Speed).

a. Pressure height is represented with color codes:

- Blue: 25.00 m
- Green: 50.00 m
- Yellow: 75.00 m
- Red: 100.00 m

b. Water flow speed in the pipe is also represented with similar colors:

- Blue: 0.01 m/s
- Green: 0.10 m/s
- Yellow: 1.00 m/s
- Red: 2.00 m/s

c. Numbers along the pipe indicate the flow speed at that location.

d. Numbers near nodes indicate the pressure height at that point, example, 300.37 m at node 3.

2. Bottom Section of the Diagram:

a. Provides information about Pressure and Pipe Diameter.

b. Pressure and pipe diameter are also represented with color codes like the top section:

- Blue: 6.00 mm
- Green: 12.00 mm
- Yellow: 24.00 mm
- Red: 36.00 mm

c. Numbers along the pipe may indicate the length or elevation of the pipe.

d. Numbers near nodes indicate the pressure at that point.

3. General Symbols and Colors:

- Nodes are marked with a white dot circled.
- Special symbols like blue squares for pumps or reservoirs.
- Red lines mark the pipe route within the network.

4. Purpose of the Diagram:

- Provides a detailed overview of aspects such as pressure height, water flow speed, pressure, and pipe diameter in the SPAM IKK Tomia Timur water transmission network.

Below is an explanation of the Epanet Calculation Table for the SPAM IKK Tomia Timur Distribution Network:

Table 3. Network – Node

Node ID	Elevation (m)	Demand (LPS)	Head (m)	Pressure (psi)
Res	226	5,00	226	0,00
Junc T2	155	0,00	225,96	30,75
Junc T3	90	0,00	225,93	58,90
Junc T4	23	0,00	225,91	87,92
Junc T5	21	0,10	225,89	88,78
Junc T6	13	0,10	225,88	92,24
Junc T7	16	3,00	225,88	90,94
Junc T8	13	0,30	225,88	92,24
Junc T9	24	1,00	225,88	87,47
Junc T10	27	0,20	225,88	86,17
Junc T11	17	0,10	225,88	90,51
Junc T12	18	0,20	225,88	90,08
Junc T13	14	0,20	225,88	91,81
Junc T14	16	0,10	225,89	90,94
Junc T15	19	0,10	225,89	89,64
Junc T16	21	0,10	225,89	88,78
Junc T17	26	0,10	225,89	86,61
Junc T18	13	0,30	225,88	92,24
Junc T19	19	0,30	225,88	89,64
Junc T20	21	0,30	225,88	88,77
Junc T21	23	0,20	225,88	87,91
Junc T22	20	0,30	225,89	89,21
Junc T23	21	0,20	225,89	88,78
Junc T24	23	0,30	225,89	87,91
Junc T25	20	0,20	225,88	89,21
Junc T26	21	0,30	225,88	88,78

Table 4. Network Links

Link ID	Leght	Diameter	Flow	Velocity	Unit Headlost
	m	mm	LPS	m/s	m/km
Pipe 1	1000	100	4,4	0,11	0,04
Pipe 2	800	100	4,4	0,11	0,04
Pipe 3	700	100	4,4	0,11	0,04
Pipe 4	500	100	4,4	0,11	0,04
Pipe 5	150	100	3,1	0,08	0,02
Pipe 6	200	100	2,1	0,05	0,01
Pipe 7	800	100	0,9	0,02	0
Pipe 8	800	100	0,8	0,02	0
Pipe 9	800	100	0,3	0,01	0
Pipe 10	800	100	0,2	0,01	0
Pipe 11	800	100	1,1	0,03	0
Pipe 12	800	100	0,8	0,02	0
Pipe 13	800	100	0,5	0,01	0
Pipe 14	800	100	0,2	0,01	0
Pipe 15	800	100	0,8	0,02	0
Pipe 16	800	100	0,5	0,01	0
Pipe 17	800	100	0,3	0,01	0
Pipe 18	600	75	0,4	0,02	0
Pipe 19	600	75	0,3	0,01	0
Pipe 20	600	75	0,2	0,01	0
Pipe 21	600	75	0,1	0	0
Pipe 22	800	75	0,4	0,02	0
Pipe 23	800	75	0,2	0,01	0
Pipe 24	600	75	0,5	0,02	0
Pipe 25	600	75	0,3	0,01	0

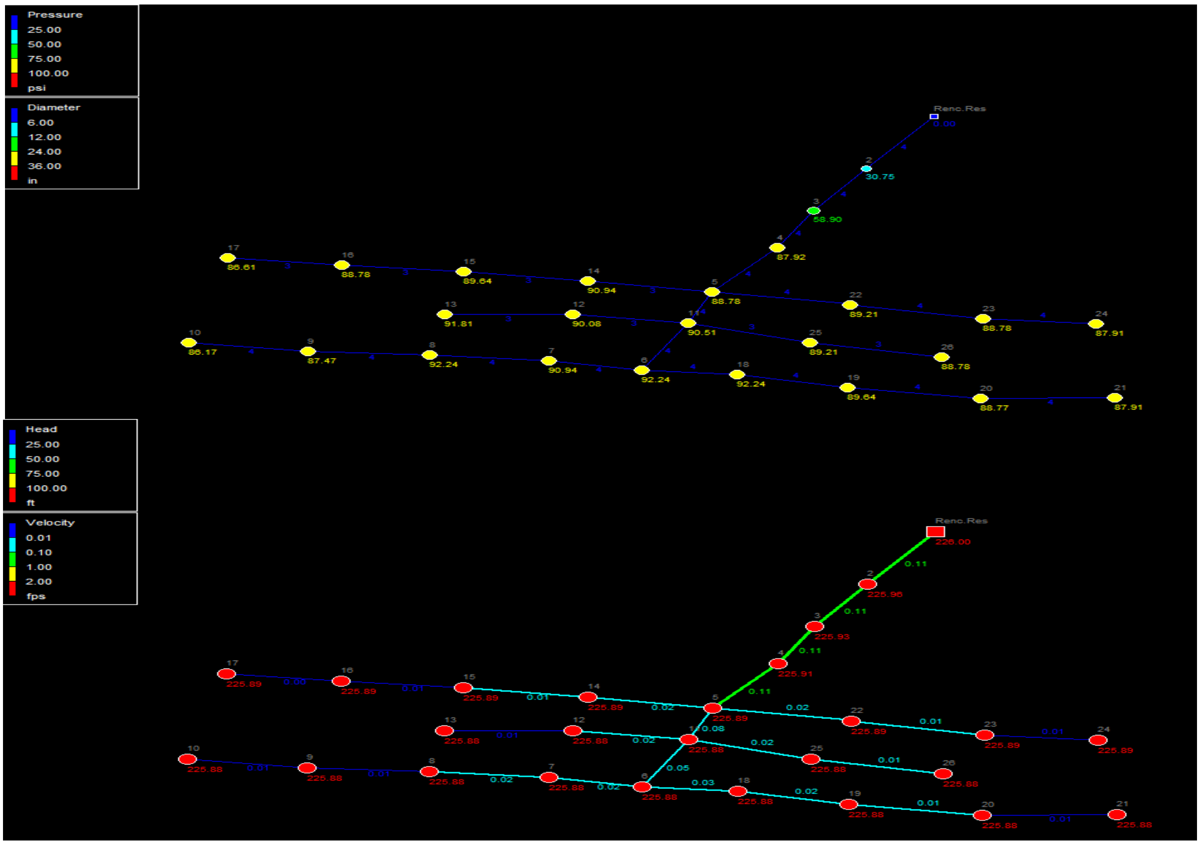

Figure 5. Epanet Distribution Network Calculation SPAM IKK

Here are the main points from the diagram in Figure 5 of the Epanet document for the SPAM IKK water distribution network, explained as follows. The diagram is divided into two main segments detailing the characteristics of the network.

1. Top Part of the Diagram:

a. Focuses on Pressure and Pipe Diameter.

b. Pressure is indicated by color code:

- Blue: 25.00 m

- Green: 50.00 m

- Yellow: 75.00 m

- Red: 100.00 m

c. Pipe diameter is also represented by similar colors:

- Blue: 6.00 mm

- Green: 12.00 mm

- Yellow: 24.00 mm

- Red: 36.00 mm

d. Numbers along the pipes indicate length or elevation.

e. Node numbers indicate that the pressure values range from 87.47 to 98.77 psi, with most nodes showing high pressure (yellow color).

2. Bottom Part of the Diagram:

a. Presents information about Head and Flow Velocity.

b. Head and flow velocity are represented with the same color code as the top part:

- Head is similar to pressure color.
- Flow velocity:
  - Blue: 0.01 m/s
  - Green: 0.10 m/s
  - Yellow: 1.00 m/s
  - Red: 2.00 m/s

c. Numbers along the pipes indicate flow velocity.

d. Numbers near nodes show that the head varies but is generally high, with most nodes indicating a value around 225.88 feet.

3. General Symbols and Colors:

a. Nodes are marked with circled dots.

b. Pumps or reservoirs may be indicated with special symbols, such as a box with a pressure label.

c. Lines indicate the pipe routes within the network.

Table 5. Demographic profile of the respondents

Characteristics	Option	Frequency	Percentage
Age	24-30	10	13,16
	31-37	44	57,89
	38-44	13	17,11
	45-51	6	7,89
	52-58	3	3,94
	Total	76	100
Sex	Male	21	27,63
	Female	55	72,37
	Total	76	100
Occupation	Housewife	48	63,16
	Contract Worker	1	1,32
	Civil Servant	18	23,68
	Police	4	5,26
	Private Sector	4	5,26
	Entrepreneur	1	1,32
	Total	76	100
Villages	Kahiyanga	35	46,05
	Patipelong	17	22,37
	Tongano Barat	24	31,58
	Total	76	100

Table 5 presents the demographic profile of 76 respondents involved in a study on household customers of the Regional Water Company (PDAM) in Tomia Timur Subdistrict, Tomia Island, Wakatobi Regency. Based on age, the respondents are divided as follows: 10 people (13.16%) aged 24-30 years, 44 people (57.89%) aged 31-37 years, 13 people (17.11%) aged 38-44 years, 6 people (7.89%) aged 45-51 years, and 3 people (3.94%) aged 52-58 years. Based on gender, there are 21 male respondents (27.63%) and 55 female respondents (72.37%). In terms of occupation, 48 respondents (63.16%) are housewives, 1 person (1.32%) is a contract worker, 18 people (23.68%) are civil servants, 4 people (5.26%) are police officers, 4 people (5.26%) work in the private sector, and 1 person (1.32%) is an entrepreneur. The respondents also come from three villages, namely Kahiyanga with 35 respondents (46.05%), Patipelong with 17 respondents (22.37%), and Tongano Barat with 24 respondents (31.58%). The total number of respondents is 76 people.

Optimization of Drinking Water Services in Tomia Timur, Tomia Island, Wakatobi Regency Based on 5-10 Year Projections

Table 6. Recapitulation of Answers: Variable Quantity, Quality, Continuity, and Accessibility

Variables	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Average
Water Quantity	4	10	18	44	3.34
Physical Water Quality	3	6	9	58	3.61
Continuity	1	6	8	61	3.70
Accessibility	5	11	8	52	3.41

Table 6 presents the optimization of drinking water services in Tomia Timur, Tomia Island, Wakatobi Regency, based on 5-10 year projections. It evaluates four main variables: water quantity, physical water quality, continuity, and accessibility. Each variable is measured on a scale from "Very Poor" to "Good," reflecting the community's perception of PDAM's drinking water services in the area. For water quantity, the majority of the community (57.9%) rated it as "Good," with an average score of 3.34, indicating sufficient water availability. The physical quality of the water was rated "Good" by 76.3% of respondents, with an average score of 3.61, reflecting potable and healthy drinking water. Continuity of service received the highest rating with an average of 3.70, with 80.3% of respondents rating it "Good," indicating reliable and consistent water service. Accessibility was also rated positively by 68.4% of respondents, with an average score of 3.41, indicating that the service is easily accessible to the community.

Overall, this survey shows a very positive perception from the community of Tomia Timur towards PDAM's drinking water services in terms of quantity, physical quality, continuity, and accessibility. High ratings in each variable reflect PDAM's success in providing adequate services that meet community expectations. The 5-10 year projections suggest that by maintaining and enhancing service standards, PDAM can continue to positively impact the community's well-being in the area.

Optimization of Drinking Water Services in Tomia Timur, Tomia Island, Wakatobi Regency Based on 5-10 Year Projections

Researchers conducted interviews with the Head of the SPAM IKK Tomia Unit, Jufri, to gather information on optimizing drinking water services in Tomia Timur, Tomia Island, Wakatobi Regency, based on 5-10 year projections. This optimization is a long-term investment in the health, economy, environment, and quality of life of the local community.

"Optimization of the Tomia Timur District Capital Water Supply System (SPAM IKK) on Tomia Island, Wakatobi Regency, is an integral part of the local government's efforts to improve the accessibility and quality of drinking water services for residents in this area"

Key steps in this optimization include procuring pumps with solar panel power, constructing a glass-steel water tank with a capacity of 200 m³, building raw water protection facilities, pipe work, procuring household connection meters, and installing two water fountains. According to Jufri, using solar panels for water pumps offers energy efficiency advantages, as it does not rely on conventional electricity, which is limited or unstable.

"By utilizing abundant solar energy in this area, the pump system can operate independently and be more cost-effective in the long run".

The glass-steel water tank construction increases storage capacity, which is essential to meet the growing community needs. Raw water protection facilities safeguard the water quality from external contamination, ensuring that the produced water is safe for consumption. Pipe work and household connection meters help ensure efficient water distribution and accurately monitor water consumption. Properly managed meter usage ensures that water use is regulated efficiently and fairly for all PDAM service users in the area.

This optimization also brings significant social and economic impacts. Adequate drinking water provision improves community health and productivity, reduces water-related diseases, and supports local economic activities such as agriculture and small industries. Good drinking water infrastructure also increases property values and investment attractiveness in the area. Using solar energy and environmentally friendly construction materials like glass-steel reduces the carbon footprint and negative environmental impacts, meeting current needs while protecting natural resources for future generations.

"The sustainability of available water services for 24 hours shows that the raw water supply, optimized from sources, can meet the daily needs of residents"

The local government's role each year allocates a budget for SPAM maintenance, and this year there is a Special Allocation Fund (DAK) for service coverage expansion. Overall, the local government's role is crucial in ensuring that the SPAM IKK system can operate effectively, safely, and sustainably. Through good planning, efficient management, and adequate resource allocation, the local government can meet the community's needs for adequate sanitation and a healthy environment.

Conclusion

The provision of drinking water services in Tomia Timur, Tomia Island, Wakatobi Regency, has been carried out to meet the principles of 4K: Quantity, Quality, Continuity, and Accessibility. Based on community perceptions, the available water quantity has increased, although some areas may still face distribution issues. The water quality is considered good and safe for consumption, especially after routine monitoring and water sampling for testing. The continuity of water services for 24 hours has been maintained through regular maintenance and pump usage rotation. The drinking water service is deemed quite affordable by the community, although there is a need to continuously monitor and adjust rates according to local economic conditions. Overall, PDAM's efforts in providing drinking water services have brought tangible benefits to the community's daily life, with generally positive perceptions of the 4K principles.

Optimizing drinking water services in Tomia Timur, Tomia Island, Wakatobi Regency, over the next 5-10 years involves strategic steps to ensure the community's needs are met. Using solar panels for water pump operations shows a commitment to energy efficiency and environmental sustainability. Infrastructure such as large-capacity water tanks and robust raw water protection systems ensures storage capacity and water quality. Efficient distribution with pipes and household meters ensures evenly distributed and measurable water. Technical capacity improvements and local staff training ensure well-maintained infrastructure, while regular maintenance ensures uninterrupted water service. Improved clean water access enhances community health and supports the local economy. The Special Allocation Fund (DAK) demonstrates the local government's commitment to expanding sustainable sanitation access. These initiatives highlight the crucial role of the government in ensuring optimal SPAM IKK operation for community health and environmental preservation.

Research on the provision of drinking water services in East Tomia faces two main limitations. First, reliance on data derived from community perceptions of service effectiveness can lead to bias and limit the objectivity of results, as qualitative data is difficult to measure accurately. Second, geographical challenges such as difficult terrain and remote areas in East Tomia cause problems in even distribution, affecting the quality and accessibility of services. The implications of this research highlight the need for ongoing support from local government in developing drinking water infrastructure and using environmentally friendly technology. Recommendations based on the findings include advanced infrastructure development, adoption of sustainable technology, and effective community monitoring and education to ensure water quality and efficient use, supporting the improvement of community quality of life through adequate and sustainable access to drinking water.

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