Engineering and Technology Journal e-ISSN: 2456-3358

Volume 10 Issue 03 March-2025, Page No.- 4041-4051

DOI: 10.47191/etj/v10i03.14, I.F. – 8.482

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Potential Utilization of Water Distribution System Using Iot-Based Energy-Saving Dual Reservoir in Housing

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ABSTRACT: The development of an area requires adequate supporting resources, particularly concerning water availability. High household water consumption is a significant contributor to water scarcity in residential areas, necessitating solutions for water availability that leverage natural reservoirs and the latest efficient, energy-saving, and environmentally friendly technology. This research aims to calculate the water demand of an area and design IoT-based dual reservoir technology for residential areas to support drinking water supply and distribution. The research method includes quantitative analysis of water demand calculations and experimental testing of IoT-based dual reservoirs. The tools required include the HC-SR04 ultrasonic sensor, breadboard, Arduino IDE, Wi-Fi module, transformer, water discharge sensor, plastic box, data cable, mini pump, on-off switch, valve, pipe, ESP8266 module, water flow sensor, and the Blynk and ThingSpeak applications. The reservoir design utilizes IoT technology, allowing the system to operate more efficiently and effectively. The prototype design for clean water distribution employs gravity-fed tanks and sensors to measure water levels in the reservoirs, enabling automatic replenishment. The results indicate that the population's water needs will continue to increase over time. The dual reservoir system functions effectively, displaying water levels in the three reservoirs and water discharge data on a smartphone. Additionally, the screen display and data logging using the ThingSpeak application operate successfully, with an error rate of less than 5%.

KEYWORDS: Water availability, Geoelectric, Epanet, Sensors, Dual reservoir.

I. INTRODUCTION

The development of residential areas requires adequate water availability to meet both domestic and non-domestic needs. Water availability is a primary concern in residential area development, as it is a vital factor for ensuring sustainability. Understanding current and projected future water availability is crucial for determining whether an area is suitable for development.

High household water consumption is a significant contributor to water scarcity in residential areas. Solutions for water availability and distribution must leverage the latest technology to ensure efficiency and environmental sustainability. Technology with high accuracy in identifying water reserves and their locations is essential. Utilizing natural and artificial reservoirs is one potential solution to address water shortages during the dry season, in addition to using deep water wells. However, natural reservoirs are often underutilized, and IoT-based technology is rarely implemented for water resource management in residential areas.

To address these issues, calculating water demand and leveraging IoT-based sensor technology for natural and artificial reservoirs is necessary. This research aims to calculate water demand and design IoT-based dual reservoir technology for drinking water supply and distribution in residential areas.

One example of a developing residential area is the PT TA housing complex in Cisoka, Tangerang Regency, Banten. The Tangerang Regency drinking water company currently serves 124,000 connections [1]. However, the company is unable to meet the full water needs of all residents in the Banten Regency area. To address this, the management of PT TA Housing has constructed a dual reservoir system to fulfill water demand, utilizing both groundwater and rainwater.

PT TA Housing management employs multiple water sources, including upper and lower torens (storage tanks), deep wells, and natural reservoirs for rainwater harvesting during the rainy season as an alternative clean water supply. These storage systems consist of an upper reservoir and a lower reservoir, equipped with pumps, valves, piping, and sensor equipment. The system is integrated through the Internet of Things (IoT) to ensure the efficient and effective operation of water pumps.

II. RESEARCH METHOD

This research was conducted at PT TA Housing in Solear, Tangerang Regency, from late 2022 to early 2023, spanning a duration of six months. Water availability at the location was managed through boreholes and natural reservoirs constructed by the company. The placement of boreholes was determined using geoelectric testing.

The research method involved a quantitative analysis of water demand calculations and experimental testing of IoT-based dual reservoirs. The materials and tools used included 4 HC-SR04 ultrasonic sensors, a breadboard, Arduino IDE, WiFi, a transformer, a water discharge sensor, a plastic box, a data cable, a mini pump, an on-off switch, a valve, pipes, an ESP 8266 microcontroller, a water flow sensor, and the Blynk and ThingSpeak applications.

Geoelectric data was used to identify the potential of underground aquifers to determine the optimal location and depth of the boreholes [2]. Water demand was calculated using the geometric method, with the following formula:

$$P_t = P_0(1+r)^t \ with \ r = \left(\frac{P_t}{P_0}\right)^{\frac{1}{t}} - 1 \qquad (1)$$

Where:

P_t = total population in year t

P_0 = population in the base year

r = population growth rate

t = period between the base year and year t (in years)

The total demand for clean water is calculated by considering domestic and non-domestic water needs, as well as water losses, using the formula [3]:

$$Q_{md} = P_n \ X \ q \ X \ f_{md} \qquad (2)$$

$$Q_t = Q_{md} X \frac{100}{80} \left(20\% \ water \ loss \ factor \right) \quad (3)$$

Where:

Q_{md} = need for clean water

P_n = total population in year n

q = water requirement per person/day

f_{md} = maximum day factor (1.05 – 1.15)

Q_t = total water requirement

To calculate regional rainfall, the Thiessen Polygon method is used with the formula:

$$R = \frac{A1+R1+A2+R2+\cdots+Rn}{A1+A2+\cdots+An} \qquad (4)$$

$$R = W1.R1 + W2.R2 + \ldots + Wn.Rn \qquad (5)$$

$$R = \frac{A1}{A1}.R1 + \frac{A2}{A2}.R\,2 + \ldots + \frac{An}{At}.Rn \qquad (6)$$

$$Wn = \frac{An}{At} \qquad (7)$$

Where:

R = Average rainfall (mm)

$A1, A2, An$ = Area of polygon 1, 2, …, n (km²)

$R1, R2, Rn$ = Maximum rainfall at stations 1,2, …, n (mm)

W = Thiessen coefficient

The research framework is presented in Figure 1.

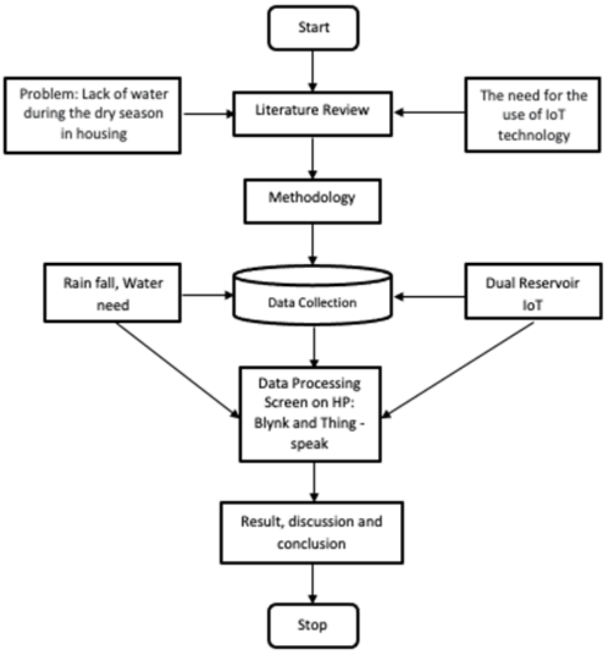


Figure 1. Thinking Framework

Domestic water demand refers to the need for clean water for residents' daily activities. Beyond just food and drink consumption, clean water is required for various basic needs such as bathing, washing, and maintaining environmental hygiene [4].

Domestic water usage encompasses a wide range of activities, including washing clothes, cleaning household appliances, washing vehicles, bathing, brushing teeth, cooking, drinking, mopping floors, personal purification, watering house plants, and caring for livestock or pets (not for commercial livestock purposes). It also includes water for aquariums, which needs to be replaced every few days, and other similar needs [5].

The standard for calculating water demand is based on Indonesian National Standard No. 19-6728.1-2002 (National Standardization Agency, 2002). Additionally, geoelectric analyses and the utilization of dual reservoirs based on IoT technology were conducted using the Blynk and ThingSpeak applications.

III. RESULT AND DISCUSSION

The availability of clean water in the Tangerang Regency area, particularly at the PT TA Housing location, is considerable. This conclusion is supported by the results of geoelectric measurements, which indicate the presence of aquifers in the area. Geoelectric measurements provide information about vertical subsurface conditions. Measurements were conducted at three points: GL1, GL2, and GL3. The maximum measurement length (AB) was 350 meters. With an AB/2 length of 175 meters, it is possible to predict the distribution of rock layers to a depth of 100 meters below the ground surface.

From previous data, the results of geoelectric measurements at the three points, conducted using Vertical Electrical Sounding (VES), are summarized in Table 1.

Table 1. Interpretation of PT TA's Geoelectrical Measurements

Location	Rho ohm. m	Thickness (m)	Depth (m)	Lithological Interpretation
GL-01	142.93	1,4	0 – 1.4	Soil
	18,27	5,32	1.37 – 6.69	Clay Sands
	42,41	10.64	6.69 – 17.33	Rough Sands
	2.76	7,19	17.33 – 24.52	Clay
	22.99	11,16	24.52 – 35.68	Fine-coarse Sands
	8.78	47,11	35.68 – 82.79	Clay
	0.57	37,21	82.79 – 120	Clay
GL-02	20,64	2.38	0 – 2.38	Soil
	19,41	1.07	2.38 – 3.45	Clay Sands
	10.76	8.04	3.45 – 11.49	Clay Sands
	4.77	13,62	11.49 – 25.11	Sands
	22.89	11.85	25.11 – 36.96	Fine-coarse Sands
	13.06	24,41	36.96 – 61.37	Clay Sands
	1.06	58,63	61.37 – 120	Clay
GL-03	13,62	0.83	0 – 0.83	Soil
	6,16	2.68	0.83 – 3.51	Clay
	16,32	3.92	3.51 – 7.43	Clay Sands
	4.86	34,45	7.43 – 42.88	Clay
	27,31	50,61	41.88 – 92.49	Fine-coarse Sands
	4.81	27,51	92.49 – 120	Clay

Table 1 presents the interpretation of geoelectric measurements, showing promising potential for groundwater at the GL-3 location. At the GL-3 point, the rock layer is sandier, with the sand layer's thickness reaching 50.61 meters. Potential groundwater-bearing layers are found at depths of 41.88–92.49 meters below the ground surface.

In addition to the underground aquifers, the PT TA Housing management constructed two natural water reservoirs that function as rainwater collectors. Rainfall data collected from the Tangerang Regency area indicates that the lowest rainfall occurs in August. This is evident from rainfall data in the region spanning 2002–2021. The low rainfall in August highlights the need for PT TA Housing management to optimize the effective and efficient use of both natural and artificial reservoirs. The average rainfall in Tangerang Regency for the 2002–2021 period is summarized in Table 2.

Table 2. Rainfall of Tangerang Regency for the 2002 - 2021 period

Year	Jan	Feb	Mar	Apr	May	June	July	August	Sept	Oct	Nov	Dec
2002	447,35	324,57	255,1	275,73	177,76	111,25	142,99	34,63	30,63	92,52	177,8	231,71
2003	195,67	331,36	259,22	198,65	212,5	208,56	174,43	89,01	213,89	267,83	183,21	192
2004	207,35	268,56	264,85	205,05	200,19	135,43	89,09	23,38	42,87	98,74	196,47	226,82
2005	280,45	295,83	144,11	198,32	242,94	158,44	115,27	33,45	86,54	148,09	163,53	178,52
2006	247,95	344,63	309,37	243,02	207,24	78,89	32,78	50,69	90,98	219,92	133,66	177,05
2007	237,56	382,86	303,89	323,4	230,66	186,27	127,87	69,62	160,88	271,34	203,89	256,64

2008	238,45	364,12	173,04	175,76	101,97	115,65	85,81	48,04	159,95	133,05	187,97	145,12
2009	305,84	203,99	234,17	184,13	132,75	70,96	38,49	18,36	19,29	42,47	147,84	125,04
2010	302,75	183,34	129,62	204,12	123,65	96,35	72,77	44,8	106,82	122,46	98,72	125,21
2011	332,89	242,28	187,17	135,71	171,22	189,19	157,87	103,59	52,28	103,84	205,61	283,22
2012	320,37	227,07	153,65	132,8	158,39	164,53	110,99	98,03	73,2	140,88	177,25	257,18
2013	269,4	424,73	164,22	197,41	190,84	159,99	135,09	265,99	208,33	30,13	236,22	151,96
2014	445,74	303,72	152,11	188,92	157,67	121,43	120,06	236,22	151,96	92,45	137,63	137,63
2015	273,44	219,31	236,11	148,41	77,04	121,43	6,37	13,4	47,53	6,96	201,18	210,66
2016	165,29	287,91	241,7	177,56	154,41	94,12	19,4	6,37	47,53	133,65	154,41	262,65
2017	273,41	340,45	270,48	258,15	103,25	129,83	41,98	41,98	173,3	257,79	212,66	201,27
2018	140,69	236,75	205,94	205,91	120,06	96,51	2,67	4,25	46,84	99,81	197,38	225,29
2019	301,2	230,18	215,51	211,56	108,91	86,19	18,96	17,76	21,14	197,38	225,29	189,56
2020	282,06	327,75	329,62	229,67	61,77	72,35	50,89	69,9	94,44	153,91	186,54	186,54
2021	279,08	434,09	112,01	216,22	225,23	120,22	8,07	16,47	199,45	148,67	299,43	299,43

Rainfall data is highly beneficial for determining the water supply in an area. Water availability in residential areas is critical to ensuring a consistent supply of clean water for current and future residents. The calculation of the mainstay discharge provides information on the minimum flow required to meet predetermined plans, such as irrigation or other water needs [6]. The use of the mainstay discharge as a parameter helps in decision-making regarding water utilization in an area [7].

Groundwater availability is limited, as it depends on factors such as the availability of infiltration areas and soil types in the region. Addressing the issue of limited groundwater availability can be achieved by constructing infiltration wells, bio-pores, and reservoirs, such as those used to maintain groundwater stability [8].
The construction of dual reservoirs aims to meet the clean water needs of PT TA Housing residents both now and in the future. Therefore, it is necessary to calculate the projected water demand in PT TA Housing for the next 20 years to assess whether the clean water supply will be sufficient to meet the needs of housing residents. The prediction of water demand in PT TA Housing, located in Tangerang Regency, based on calculations using the geometric method, is shown in Table 3.

Table 3. Predicted Calculation of Water Demand in PT TA Housing in Tangerang Regency

Year	Total Population People	growth %	Water Need (Liter)
2013	1,732	-	75,861,600
2014	2,044	15.26%	89,527,200
2015	2,346	12.87%	102,754,800
2016	2,655	11.64%	116,289,000
2017	2,946	9.88%	129,034,800
2018	3,249	9.33%	142,306,200
2019	3,546	8.38%	155,314,800
2020	3,827	7.34%	167,622,600
2021	4,111	6.91%	180,061,800
2022	4,396	6.48%	192,544,800

2023	4,840	9.17%	211,992,000
2033	12,668	9.17%	554,858,400
2042	30,116	9.17%	1,319,080,800
	Average	9.33%	

Table 3 illustrates the relationship between population and water demand. It also presents future population projections calculated using a geometric series, with 2022 as the base year, and population estimates for the next 20 years, assuming an average annual growth rate of 9.33%.

Analysis of Water Demand and Availability

Water demand in PT TA Housing is expected to increase as the population in the residential area grows. Designing a multi-source water system and reservoir requires accurate population data and growth predictions to estimate clean water demand effectively.

The population projections for PT TA Housing through 2042, calculated using the geometric method, serve as a basis for estimating water needs over the next 20 years. In addition to domestic water needs for residents, PT TA Housing management must also consider non-domestic water requirements for public facilities and infrastructure within the residential area.

Overall, water demand in PT TA Housing is increasing. In early 2023, the water demand was 5.89 l/s, and by 2042, it is projected to reach 12.45 l/s.

The surface water availability in the Solear area of Tangerang Regency is assessed using climatological data, including rainfall, temperature, sun exposure, and humidity. The regency experiences a favorable rainfall level, averaging up to 3000 mm per year. Between 2002 and 2021, the lowest average rainfall occurred in August, with a reliable discharge ranging between 5.3 liters/second and 11.3 liters/second.

To meet future water needs, the management of PT TA Housing constructed a natural water reservoir designed to collect rainwater. They developed a multi-source water system and reservoirs capable of automatically distributing water to housing residents. The design incorporates ultrasonic sensors to measure water levels, and by utilizing the Internet of Things (IoT), the system operates automatically.

The ultrasonic sensors provide real-time information to managers about water levels in the sources and reservoirs, triggering pumps to distribute water as needed. This automated system aids managers in making informed decisions, ensuring efficient water management and preventing wastage.

Research conducted by Gazza (2020) identified that the water demand in Mutiara Garden Housing is 6.523 l/s, while the water demand in Platinum Regency Housing is 14.04 l/s, bringing the total water demand to 20.57 l/s. The planning incorporates a pump with an output head of 50 meters and a flow rate of 20.57 l/s. The results indicate an average water flow in the pipe of 0.712 l/s, with an average remaining pressure of 54.66 meters .

Clean Water Supply System Analysis

The provision of clean water involves calculating the mainstay discharge for surface water and conducting a geoelectric survey to determine groundwater potential. Meanwhile, the distribution of clean water is analyzed using a water distribution program as a tool. To ensure optimal water supply, managers utilize natural reservoirs to collect rainwater and create boreholes for groundwater extraction. In the water distribution process, PT TA Housing managers prepare two natural tanks as sources of surface water, with groundwater from boreholes serving as a backup water source. Water source management forms the foundation for water balance and distribution management scenarios.

1. **Water Balance**

A water balance is necessary during the projection period to provide an overview of the relationship between water demand and availability at the research site. The water balance includes the availability of water in Reservoir 1, Reservoir 2, and groundwater, as well as the projected water demand from 2023 to 2042. The water balance is presented in Table 4.

Table 4. Water Balance

Water Needs (V/s)			Water Availability (/)			
No	Projection	Total	Month	Reservoir 1	Reservoir 2	Ground Water
1	2023	5.89	January	77	77	2.57
2	2024	6.12	February	87	94	2.57
3	2025	6.36	March	54	59	2.57
4	2026	6.62	April	65	71	2.57
5	2027	6.88	May	26	42	2.57
6	2028	7.15	June	23	25	2.57
7	2029	7.43	July	10	11	2.57
8	2030	7.76	August	5.3	6	2.57
9	2031	8.09	September	6	11	2.57
10	2032	8.41	October	23	25	2.57
11	2033	8.74	November	46	50	2.57
12	2034	9.09	December	50.65	66	2.57
13	2035	9.48				
14	2036	9.87	Noted			
15	2037	10.26	October Total Debit T1		=	23,00 I/sec
16	2038	10.66	Augus Total Debit T-1+ T2		=	11.30 I/sec
17	2039	11.09	August Toral Debit T1+T2+AT		=	13.87 I/sec
18	2040	11.52	Dry Season : April-September			

19	2041	11.98	Rainy Season: October - March
20	2042	12.45	

According to Meteorological, Climatological, and Geophysical Agency, the seasons in Indonesia are divided into two: the dry season and the rainy season [9]. The dry season occurs from April to September, while the rainy season lasts from October to March. Table 4, which analyzes water stability for both water demand and availability, examines conditions during these two seasons as well as the behavior of water usage during holidays. The findings are as follows:

a. First stability: During the rainy season, water availability in Reservoir 1 ranges from 23 l/s to 87 l/s, while water demand from 2023 to 2042 is estimated to be between 5.89 l/s and 12.45 l/s. This indicates that Reservoir 1's water availability is sufficient to meet water demand during the rainy season, demonstrating stability.

b. Second stability: During the dry season, water availability in Reservoir 1 ranges from 5.3 l/s to 65 l/s, while water demand remains at 12.45 l/s. This shows that Reservoir 1 alone cannot meet water demand during the dry season. An additional water source, Reservoir 2, increases total availability to 11.3 l/s, which is still insufficient to meet the demand of 12.45 l/s. Water demand stability can only be achieved by supplementing with groundwater, bringing total water availability to 13.87 l/s.

2. Water Distribution Management Scenarios

To adapt to Indonesia's existing climate, it is necessary to plan several scenarios to ensure that the water needs of the housing complex are adequately met. The scenarios include: (1) Scenario 1, addressing water needs during the rainy season, and (2) Scenario 2, addressing water needs during the dry season. The details of these scenarios are as follows:

1. Scenario 1 during the rainy season

From 2023 to 2042, calculations show that 5.89 l/s to 12.45 l/s of clean water is required. In Reservoir 1, water availability during the rainy season ranges from 23 l/s to 87 l/s, meaning that water needs during the rainy season can be met by Reservoir 1. A sketch illustrating the use of this water source (Reservoir 1) is presented in Figure 2 below:

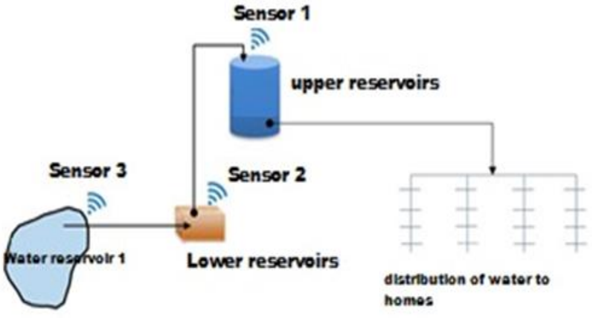


Figure 2. Scenario 1 Rainy season

The stability between water demand and water availability is presented in Table 5 and illustrated graphically in Figure 3:

Table 5. Scenario 1 Water Demand and Availability (l/s)

Year To	Projection Year	Water Needs (I/sec)	Minimal Water Availability (I/se c)
1	2023	5.89	23
2	2024	6.12	
3	2025	6.36	
4	2026	6.62	
5	2027	6.88	
6	2028	7.15	
7	2029	7.43	
8	2030	7.76	
9	2031	8.09	
10	2032	8.41	
11	2033	8.74	
12	2034	9.09	
13	2035	9.48	
14	2036	9.87	
15	2037	10.26	
16	2038	10.66	
17	2039	11.09	
18	2040	11.52	
19	2041	11.98	
20	2042	12.45	

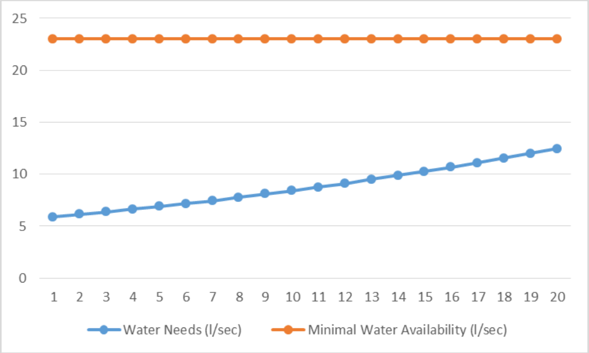


Figure 3. Graph of Scenario 1 Water Demand and Availability

Figure 3 shows that the demand for clean water increased from 5.89 l/s in 2023 to 12.45 l/s in 2042. Meanwhile, the water availability in Reservoir 1 during the rainy season (minimum discharge) is 23 l/s in October. Under these conditions, water demand during the rainy season can be met by Reservoir 1.

2. Scenario 2 during the dry season

From 2033 to 2042, clean water demand is projected to range between 5.89 l/s and 12.45 l/s. During the rainy season, water availability in Reservoir 1 ranges from 23 l/s to 87 l/s, which is sufficient to meet demand. However, during the dry season, the minimum available discharge is only 5.3 l/s, which is insufficient. An additional water source, Reservoir 2, is required to address this. The combined water availability from Reservoir 1 and Reservoir 2 during the dry season totals 11.3 l/s, which still does not fully meet the demand of 12.45 l/s.

To compensate for the shortfall, groundwater is utilized as an additional source. When groundwater is included, the total water availability increases to 13.87 l/s. This condition ensures that water demand during the dry season can be satisfied.

The water sources utilized during the dry season include Reservoir 1, Reservoir 2, and groundwater. A sketch illustrating the use of these water sources is shown in Figure 4.

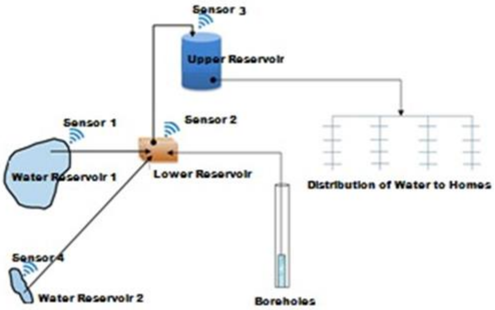


Figure 4. Scenario 2 Dry season

The balance between water demand and water availability is presented in Table 6 and illustrated graphically in Figure 5:

Table 6. Scenario 2 Water Demand and Availability (l/s)

Year To	Projection Year	Water Needs (I/sec)	Minimal Water Availability (I/se c)
1	2023	5.89	13.87
2	2024	6.12	
3	2025	6.36	
4	2026	6.62	
5	2027	6.88	
6	2028	7.15	
7	2029	7.43	
8	2030	7.76	
9	2031	8.09	
10	2032	8.41	
11	2033	8.74	
12	2034	9.09	
13	2035	9.48	
14	2036	9.87	
15	2037	10.26	
16	2038	10.66	
17	2039	11.09	
18	2040	11.52	
19	2041	11.98	
20	2042	12.45	

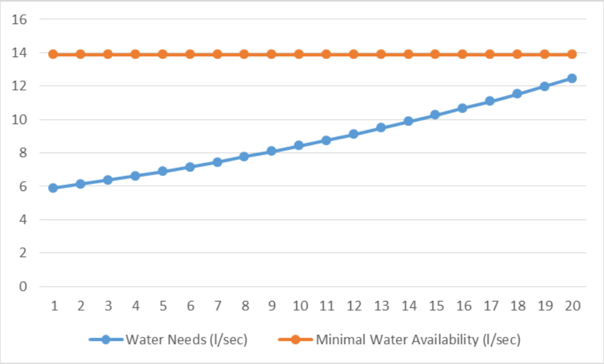


Figure 5. Scenario 2 Graph of Water Demand and Availability

Figure 5 shows that the demand for clean water increases from 5.89 l/s in 2023 to 12.45 l/s in 2042, while the availability of water from Reservoir 1, Reservoir 2, and groundwater during the dry season in August (minimum discharge) is 13.87 l/s. Therefore, water demand during the dry season is safely met.

The distribution network management utilizes multiple reservoirs and gravity tanks to supply clean water to residential areas. The pipe network used for water distribution is analyzed using specialized application software. This software enables the manager to accurately detail each resident's water needs and calculate the required discharge to ensure uninterrupted water flow.

The pipeline application provides a 24-hour overview of water usage, particularly during peak times and periods of maximum daily demand. These calculations are essential for estimating the water discharge required for each house connection (SR) to meet user demands effectively.

The mainstay discharge calculation estimates the amount of water provided by available sources. At PT TA Housing, which consists of 1,908 house connections, Block S14 has the highest peak water demand at 1.80 l/s, while the lowest peak discharge occurs in Blocks S22 and N07, with a total of 0.24 l/s. By using the water distribution application, the manager can also determine the appropriate pipe size for each house connection, ensuring sufficient water discharge to meet user needs.

One of the conclusions from research conducted by Immanuel (2014) is that the total clean water demand for Griya Prima Tebing Tinggi Housing is 330 m³/day. The peak-hour water demand is 0.012963 m³/s. The distribution pipes used in Griya Prima Housing are galvanized iron pipes with diameters of 75 mm and 50 mm. The results of manual pipe network calculations using the Hardy Cross method closely match the analysis provided by the EPANET 2.0 program. This conclusion is based on a comparison between the Hardy Cross method and the EPANET 2.0 program.

In planning the clean water distribution network, gravity tanks serve as water storage facilities in residential areas. The water distribution network in PT TA Housing utilizes sensors that automatically measure the water level in reservoirs and gravity tanks. These sensors improve efficiency and effectiveness in filling the tanks. Water flows into the tanks automatically once the water level reaches a specified point, and the filling process stops when the tanks are full. This system helps the housing management reduce electricity consumption, as no water is wasted.

Calculating clean water demand in housing developments is essential for designing the water distribution pipe network. Proper planning of the distribution pipe network is necessary for both clean and wastewater systems [10]. Combining two sources of clean water, such as Municipal Water Utility (municipal water) and boreholes, is an alternative solution for housing developments to ensure a reliable supply of clean water for homeowners [11]. The design of the dual-reservoir model is shown in Figure 6.

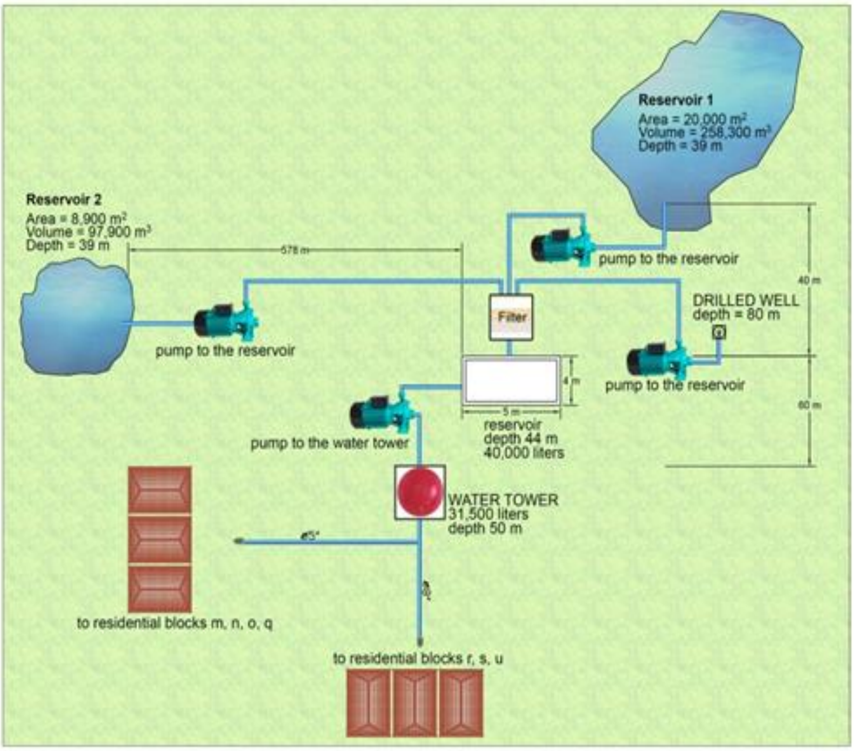


Figure 6. Model of Dual Reservoirs

Based on Figure 6, natural water reservoirs and reservoirs built by PT TA Housing managers are managed to ensure clean water availability for residents' needs. The water distribution system, which was previously handled manually, has been improved by integrating an advanced management system using the Internet of Things (IoT).

The use of water level sensors and flow meters helps regulate reservoir filling, reducing the electrical energy needed to operate water pumps. Test results for the ultrasonic sensors show acceptable performance, with an error value of less than 5%. The sensor test results are presented in Tables 7 and 8.

Table 7. Testing of ultrasonic sensors in Reservoirs 1 and 2

No	Sensors cm	Actual cm	Error %	Sensors 2 cm	actual cm	Error %
1	10.30	10,20	0.98 %	10,20	10.00	2.00 %
2	13.30	13.00	2.31 %	13.00	12.70	2.36 %
3	14,20	14,20	0.00 %	14,20	14.00	1.43 %
4	15.50	15.30	1.31 %	15.70	15.50	1.29 %
5	20.00	19.00	5.26 %	21.00	20.00	5.00 %
6	22.40	22.00	1.82 %	22.00	22.00	0.00 %
7	28.00	27,10	3.32 %	27.00	27.00	0.00 %
8	35.50	35,30	0.57 %	35.80	35.00	2.29 %
9	40.00	39.50	1.27 %	40,70	40.00	1.75 %
10	42,20	42,10	0.24 %	43,20	42.00	2.86 %
	Average		1.71 %			1.90 %

Table 8. Test Results for Ultrasonic Sensors in Reservoirs 3 and 4

No	Sensors 3	actual	Error	Sensors 4	actual	Error
	cm	cm	%	cm	cm	%
1	10.80	10.30	4.85%	10,20	10,10	0.99%
2	13.00	12.90	0.78%	13.30	13,10	1.53%
3	14.30	14,20	0.70%	14.40	14,10	2.13%
4	15.80	15,40	2.60%	15.70	15.00	4.67%
5	20.00	19.30	3.63%	20.80	20.00	4.00%
6	22.90	22.00	4.09%	22.00	22.00	0.00%
7	27.80	27,10	2.58%	27.00	27.00	0.00%
8	35.50	35,20	0.85%	35,70	35.00	2.00%
9	40.00	39.30	1.78%	39,60	38,70	2.33%
10	42,20	42,10	0.24%	42.70	42.00	1.67%
	Average		2.21%			1.93%

A comparison of sensor test results with manual measurements shows that the error rate remains within reasonable limits, ranging from 1.71% to 2.21%, which is below the 5% threshold. The comparison of sensor measurement results is illustrated in Figure 7. The ultrasonic sensor used in this research is installed on the reservoirs to measure water levels. The design of the sensor system for the dual-reservoir model is shown in Figure 8.

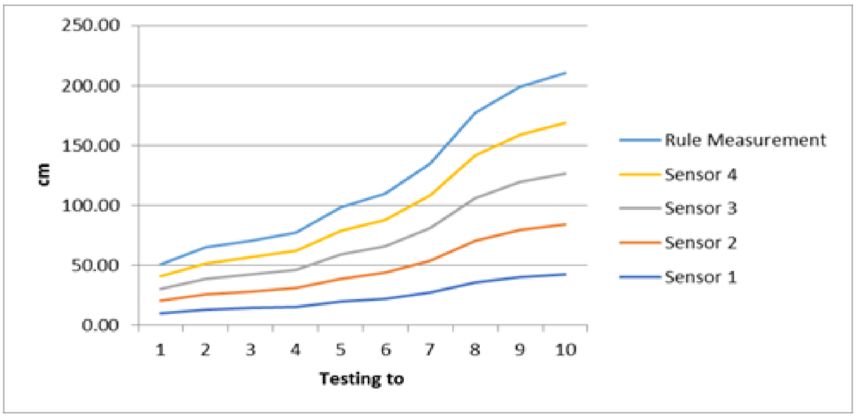


Figure 7. Comparison of Sensor Measurements with Manual

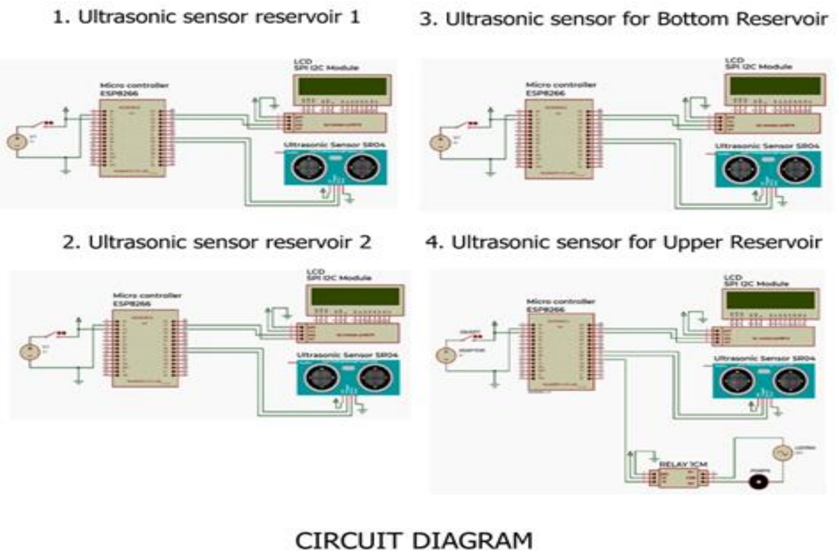
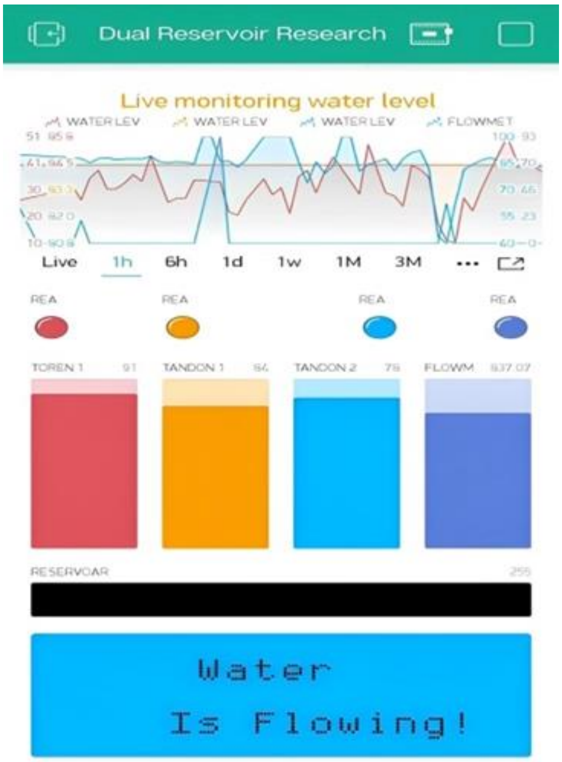


Figure 8. Dual Reservoir (wiring) design

The water level in the tower can be monitored in real-time through the Internet of Things (IoT) by utilizing the Blynk application. The Blynk application interface, which displays the water level condition in the tower, is shown in Figure 9.



Water
Is Flowing!

Figure 9. Blynk application display for 3 ultrasonic sensors and 1 flowmeter sensor

Water level monitoring using ultrasonic sensors based on IoT helps operate water pumps more effectively and efficiently. It also provides real-time water level information for flood early detection systems. Ultrasonic sensors generate real-time updates regarding water levels at floodgates and send the data to users' smartphones [12]. Research on the use of microcontrollers to control water levels in reservoirs, such as the study by Siregar et al. (2021) [13], has been conducted. The study designed an automated reservoir system using Arduino as the software tool to program water level readings. The system can automatically instruct the reservoir to be filled when the water level reaches a specified limit.

In this study, 90% of the mainstay discharge is used for calculation purposes, as the discharge is intended for drinking water needs. The water reservoir managed by PT TA housing serves as a backup water source when municipal water or groundwater cannot meet residents' needs. The use of dual reservoirs is an alternative solution to fulfill the clean water needs of PT TA residents

In this study, the ThingSpeak application is used as a tool to receive sensor readings, store data, and act as a data logger. This application has been utilized in other studies as well. For instance, Diriyana et al. (2019) used the ThingSpeak application to receive data from water level sensors. It provided real-time data and displayed ultrasonic sensor readings. Their research demonstrated that ultrasonic sensor readings were successfully sent to the ThingSpeak web platform, where the results could be viewed [14].

Automatic water management using the ThingSpeak application as a data storage server was implemented in Elhabian's research (2020). This study developed an automatic water quality monitoring system incorporating various sensors, including ultrasonic sensors, temperature and humidity sensors, and oxygen level sensors. The system was applied in residential areas, schools, and other facilities with water tanks [15].

Devi et al. (2020) conducted a study using sensors to measure water levels and water velocity in pipes. Information about the water level and flow speed was updated in a cloud storage system and could be accessed via smartphones connected to the internet. This approach helped maintain water quality [16]. The use of IoT in clean water management systems also aims to minimize operational costs. For example, IoT-based systems can automatically deactivate distribution units experiencing issues such as pipe leaks, valve malfunctions, or pump damage, while simultaneously notifying managers [17]. Additionally, IoT-enabled water distribution systems can optimize water allocation based on user consumption levels and provide historical data to aid macro-level urban planning [18].

Research by Biantoro et al. (2022) demonstrated that the Arduino program integrated with the Blynk application could be used to develop a Flood Early Detection System (FEDS). This tool enables real-time, wireless flood hazard detection in Jakarta rivers using IoT technology [12].

IV. CONCLUSIONS

Water availability is one of the primary resources for area development, particularly residential areas. The presence of water resources is crucial, especially for residential development projects. Therefore, assessing water availability is the first priority for developers.

Geoelectric testing is an alternative method to determine the presence of aquifers at a housing development site. Geoelectric testing conducted in the PT TA housing area at three locations indicates that location GL-03 has the potential to contain aquifers. Boreholes can be drilled at this location to a depth of 41.88–92.49 meters from the ground surface.

In addition to groundwater, the management of PT TA Housing has prepared two water reservoirs as alternative water sources. Water distribution to housing residents is planned using a water distribution application and dual reservoirs. The dual reservoirs consist of an upper reservoir for rainwater harvesting and a lower reservoir for groundwater collection. These reservoirs are managed using IoT-based wireless technology, utilizing the Blynk application for mobile phone display and the ThingSpeak application as a data logger.

Test results from the ultrasonic sensor (water level sensor) show that the readings are accurate within tolerable limits, with an error rate of 1.71% to 2.20%, which is below the 5% threshold.

The clean water distribution network in PT TA Housing is designed with a water level sensor to enable automatic filling of reservoirs or water tanks using the Internet of Things. Automatic water filling reduces electricity consumption by ensuring that the reservoir is filled only when the water level drops to a specified point and stops once it is full.

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