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Analysis of Water Availability and Water Quality for Water Quality Management in Lake Ranau, South OKU Regency

Alda Beby Suhendra[1*], Immroatul Chalimah Juliana[2], Puteri Kusuma Wardhani[3]

Department of Magister Civil Egineering, Universitas Sriwijaya, Indonesia.

***Corresponding Author**

Alda Beby Suhendra

Corresponding Author E-mail: aldabebysuhendraa@gmail.com

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Abstract: Lake Ranau has experienced increasing environmental pressure due to population growth, tourism development, agricultural activities, and floating net cage (FNC) aquaculture within its watershed. Previous studies reported that the lake is moderately polluted, with phosphate concentrations exceeding the Class I water quality standard (Wiata, 2024), while eutrophication, β-mesosaprobic conditions, algal blooms, hypoxia, and periodic fish mortality have also been observed (Efendia et al., 2023; Syahfitri et al., 2025). However, studies integrating water availability, water demand, water balance, and water quality remain limited. Therefore, this study aimed to analyze water availability, water demand, water balance, and water quality as the basis for developing sustainable water quality management strategies for Lake Ranau. A quantitative descriptive-analytical approach was employed using secondary data collected during 2016–2025. Water availability was estimated using the monthly 90% dependable discharge (Q90) based on the Weibull method, while water demand was calculated for the domestic, non-domestic, and irrigation sectors. Water quality was evaluated using 12 physical, chemical, and biological parameters through the STORET and Pollution Index (PI) methods in accordance with Government Regulation No. 22 of 2021 and the Indonesian Ministry of Environment Decree No. 115 of 2003. The results showed that the Q90 dependable discharge ranged from 4.72 to 10.72 m^3/s, while total water demand ranged from 0.041 to 0.328 m^3/s, resulting in a surplus water balance throughout 2025. Although most water quality parameters complied with the Class I water quality standard, phosphate, COD, BOD, DO, nitrite, and TSS exceeded the permissible limits in specific zones and seasons. Both the STORET and PI methods consistently classified Lake Ranau as moderately polluted, with Zone II (Banding Agung) experiencing the highest pollution pressure. These findings indicate that Lake Ranau currently has sufficient water availability to support existing water uses, whereas water quality remains the primary management concern. Therefore, sustainable management should prioritize nutrient input reduction, particularly phosphate, sustainable management of floating net cage aquaculture, improvement of domestic wastewater treatment, runoff control within the catchment area, and continuous water quality monitoring. The novelty of this study lies in integrating water quantity and water quality assessments within a single analytical framework to support evidence-based and sustainable lake management.

Keywords: Water Availability, Water Quality, Water Balance, Water Quality Management, Ranau Lake.

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I. Introduction

Water is a vital natural resource that plays an essential role in maintaining ecosystem sustainability and supporting various socio-economic activities, including domestic water supply, irrigation, fisheries, and tourism (Tecklie et al., 2024). However, the increasing demand for water is often not accompanied by adequate water availability and good water quality (Suhry et al., 2020; Yahya et al., 2019). Surface water quality has become increasingly vulnerable to degradation due to anthropogenic pressures, such as urbanization, settlements, intensive agriculture, fisheries, tourism, and land-use change, which are further exacerbated by climate variability, rainfall fluctuations, and streamflow dynamics (Sapkota et al., 2021; Latron & Gallart, 2018). Therefore, sustainable water resource management requires an integrated approach that simultaneously considers both water quantity and water quality.

Ranau Lake, the second-largest natural lake in Sumatra, Indonesia, covers a surface area of 125.9 km² with a catchment area of approximately 508 km² (BBWS Sumatera VIII, 2025). The lake receives inflow from approximately 40 tributaries, with the Way Warkuk River serving as the largest inflow source (BBWS Sumatera VIII, 2025). It provides multiple ecosystem services and supports domestic water supply, irrigation, floating net cage aquaculture, tourism, and inland water transportation (Naimullah, 2023; el et al., 2023; Agustina & Muliadiasa., 2023). Consequently, the sustainability of Ranau Lake is closely linked to the balance between water availability and environmental quality.

Environmental pressures on Ranau Lake have intensified due to rapid socio-economic development within its surrounding watershed. The population of Banding Agung District increased from 19,088 inhabitants in 2013 to 26,250 inhabitants in 2025 (BPS Banding Agung, 2025). In addition, the lake supports 7 hotels, 26 restaurants, approximately 600 floating net cages (FNCs) in 2023, and livestock consisting of 5,707 animals and 84,434 poultry, all of which potentially contribute organic and nutrient loads to the aquatic environment (BPS Banding Agung, 2025; Fidyandini, 2023). Land-use change has also resulted in an increase of 9.1 ha of built-up land and a decrease of 80.03 ha of open land, accelerating sedimentation and nutrient runoff into the lake (Naimullah, 2025; Haryani et al., 2019; Fadli et al., 2020).

These cumulative pressures have led to a deterioration in the lake's water quality. Recent monitoring indicated that Ranau Lake is classified as moderately polluted, with a Pollution Index (PI) of 6.86, while phosphate concentrations exceeded the water quality standard (Wiata, 2024). Furthermore, the lake has been classified as β-mesosaprobic (Syahfitri et al., 2025) and moderately eutrophic due to elevated ammonia concentrations associated with floating net cage aquaculture (Efendia et al., 2023). These conditions have triggered environmental problems, including algal blooms, upwelling events, hypoxia, and periodic mass fish mortality (Elisdiana & Nontji, 2016). Meanwhile, increasing water demand driven by population growth and socio-economic activities may also affect the balance between water availability and water demand, emphasizing the importance of water balance assessment as a basis for sustainable lake management.

Previous studies on Ranau Lake have primarily focused on individual aspects, such as water quality assessment, the impacts of floating net cage aquaculture, or land-use change. Comprehensive studies integrating water availability based on dependable discharge, multi-sectoral water demand, water balance, and water quality assessment remain limited. Therefore, this study aims to analyze water availability, water demand, water balance, and water quality as a scientific basis for developing sustainable water quality management strategies for Ranau Lake. The novelty of this study lies in integrating water quantity and water quality analyses within a single analytical framework, thereby providing a more comprehensive basis for sustainable lake management.

II. Methods

2.1 Study Area

This study was conducted at Ranau Lake, located in Banding Agung District, Ogan Komering Ulu Selatan Regency, South Sumatra, Indonesia. Ranau Lake is the second-largest natural lake in Sumatra, covering approximately 125.9 km² with a catchment area of 508 km². Water quality analysis was carried out at three monitoring zones representing the inlet, lake utilization area, and outlet according to SNI 9063:2022. Seasonal analyses were performed using data collected during the wet and dry seasons to evaluate seasonal variations in hydrological conditions and water quality.

2.2 Research Design and Data Collection

This research employed a quantitative descriptive-analytical approach using secondary data collected from 2016 to 2025. Hydrological data, including monthly rainfall and lake outflow discharge, were obtained from the Ranau Climatological Station through the River Basin Organization of Sumatra VIII (BBWS Sumatera VIII). Water demand data for domestic, non-domestic, irrigation, and livestock sectors were collected from Statistics Indonesia (BPS), the Department of Agriculture, and related agencies. Water quality data were obtained from the Environmental Agency of South Sumatra Province and consisted of measurements from three monitoring stations during both wet and dry seasons. A total of 56 water quality observations were analyzed using physical, chemical, and biological

parameters, including TSS, TDS, pH, DO, BOD, COD, nitrate, nitrite, ammonia, phosphate, fecal coliform, and total coliform.

2.3 Water Availability Analysis

Water availability was estimated using the 90% dependable discharge (Q90) calculated from monthly outflow discharge records following the Weibull probability method in accordance with SNI 6738:2015. Monthly discharge values were ranked from the highest to the lowest, and the probability of occurrence was calculated using the Weibull equation. The Q90 discharge was selected because it represents a conservative estimate of water availability with a 90% probability of exceedance.

2.4 Water Demand and Water Balance Analysis

Water demand was calculated for four sectors: domestic, non-domestic, irrigation, and livestock. Domestic water demand followed SNI 6728.1:2015, while non-domestic demand was estimated according to the Directorate General of Human Settlements planning criteria. Irrigation demand was determined based on cropping patterns and crop water requirements, whereas livestock demand was estimated from livestock population statistics and standard water consumption rates.

Water balance was subsequently evaluated by comparing water availability (Q90) with total water demand:

$$\Delta S = Q_{ketersediaan} - Q_{kebutuhan}$$

Positive values indicate water surplus, whereas negative values indicate water deficit.

2.5 Water Quality Assessment

Water quality status was evaluated using the STORET and Pollution Index (PI) methods according to the Indonesian Ministry of Environment Decree No. 115 of 2003. All measured parameters were compared with the Class I Water Quality Standards stipulated in Government Regulation No. 22 of 2021. STORET scores were used to determine water quality status, while the Pollution Index classified pollution levels into four categories: good, lightly polluted, moderately polluted, and heavily polluted.

2.6 Development of Water Quality Management Recommendations

Management recommendations were developed by synthesizing the results of water availability, water demand, water balance, and water quality analyses. The synthesis considered seasonal variation, monitoring zones, dominant water-use sectors, critical water quality parameters, and findings from previous studies. The recommendations were formulated to support sustainable water quality management in Ranau Lake.

III. Results and Discussions

3.1 Rainfall and Discharge Analysis

The analysis of rainfall and discharge for the period 2016–2025 reveals a distinct seasonal hydrological pattern in the Lake Ranau area, as shown in the rainfall–discharge graph below.

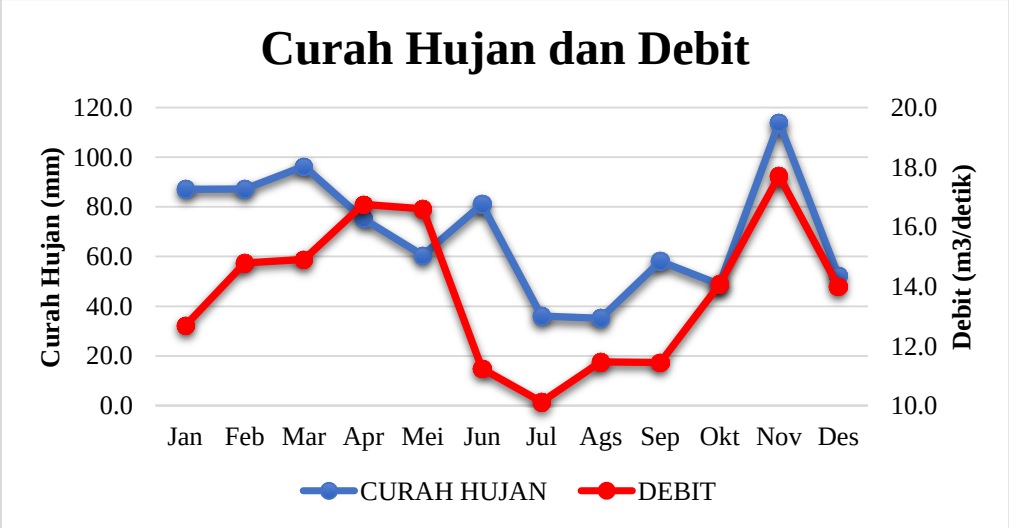


Figure 4.1 Average Monthly Rainfall and Discharge (2016–2025)

The results show that the highest rainfall occurred in November (114.0 mm), with an average discharge of 17.7 m³/s, whereas the lowest rainfall occurred in August (35.2 mm) and the lowest discharge in July (10.1 m³/s). These results indicate differences in hydrological characteristics between the rainy and dry seasons. In some periods, discharge remained relatively high despite declining rainfall, while in other periods, increased rainfall was not immediately followed by increased discharge. This pattern suggests that the discharge of Lake Ranau is influenced not only by rainfall but also by hydrological processes within the *catchment area*, such as infiltration, surface runoff, and subsurface flow, as well as by topography, geology, soil type, and land cover (He et al. 2023).

In this study, the Weibull method was used to estimate the dependable discharge at a 90% reliability level (Q_{90}) as the basis for raw water availability. The dependable discharge analysis used monthly discharge data for the period 2016–2025. The results of the Weibull probability calculation are presented in the following table.

Table 4.1 Discharge Probability

Rank (m)	P (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9.09	17.73	22.40	29.00	30.91	29.66	17.98	17.52	28.90	17.68	21.71	39.73	21.11
2	18.18	17.04	20.81	20.79	20.18	23.76	13.23	11.02	11.02	14.74	20.27	36.51	17.81
3	27.27	14.11	15.97	14.09	19.87	22.65	12.24	11.02	10.67	13.61	17.31	20.39	14.52
4	36.36	12.11	15.91	13.33	17.07	18.13	11.08	10.67	10.57	11.53	15.57	16.45	14.52
5	45.45	12.05	14.95	13.19	16.19	13.96	11.02	10.02	9.80	10.67	14.56	14.89	14.08
6	54.55	11.72	14.39	13.04	15.12	13.17	10.67	9.81	9.61	10.66	14.06	11.02	12.87
7	63.64	11.32	11.88	13.02	14.55	11.93	10.44	8.98	8.98	8.98	10.77	10.61	12.10
8	72.73	11.28	11.03	11.32	13.55	11.08	10.07	8.98	8.98	8.98	9.38	10.54	11.25
9	81.82	10.49	10.83	11.02	11.10	11.02	8.98	8.98	8.70	8.95	8.82	8.93	11.08
10	90.91	8.98	9.70	10.27	8.98	10.67	6.76	4.25	7.42	8.65	8.30	8.01	10.68
Q80%	80.00	10.65	10.87	11.08	11.59	11.04	9.20	8.98	8.76	8.96	8.93	9.25	11.11
Q90%	90.00	9.13	9.81	10.34	9.19	10.71	6.99	4.72	7.55	8.68	8.35	8.10	10.72

The dependable discharge analysis using the Weibull method yielded Q90 values of 4.72–10.72 m³/s, with the highest value in December (10.72 m³/s) and the lowest in July (4.72 m³/s). Q90 was used as the basis for the water availability analysis because it represents a discharge with a 90% probability of being met. The discharge pattern follows seasonal hydrological dynamics, being higher in the rainy season (November–March) and declining in the dry season (June–August). Despite these seasonal fluctuations, the Q90 values indicate that water availability in Lake Ranau remains adequate throughout the year. These results were subsequently used as the basis for the water balance analysis by comparing water availability with total water demand in 2025.

4.2 Water Demand Analysis

Total water demand was calculated from the domestic, non-domestic, and irrigation sectors in Banding Agung Subdistrict in 2025. The results for each sector were summarized as total water demand and used in the water balance analysis through comparison with the Q90 dependable discharge. The water demand summary is presented in Table 4.2.

Table 4.2 Total Water Demand

No	Month	Domestic Water Demand (m^3/s)	Non-Domestic Water Demand (m^3/s)	Irrigation Water Demand (m^3/s)	Total Water Demand (m^3/s)
1	January	0.033	0.007	0,243	0,284
2	February	0.033	0.007	0,180	0,221
3	March	0.033	0.007	0,175	0,216
4	April	0.033	0.007	0,287	0,328
5	May	0.033	0.007	0,219	0,260
6	June	0.033	0.007	0,254	0,295
7	July	0.033	0.007	0,224	0,265
8	August	0.033	0.007	0,204	0,245
9	September	0.033	0.007	0,082	0,123
10	October	0.033	0.007	0,070	0,111
11	November	0.033	0.007	0,017	0,058
12	December	0.033	0.007	0,000	0,041

Based on Table 4.2, the total water demand in Banding Agung Subdistrict during 2025 ranged from 0.041 to 0.328 m^3/s. The highest total water demand occurred in April (0.328 m^3/s), followed by June (0.295 m^3/s) and January (0.284 m^3/s). In contrast, the lowest total water demand was recorded in December (0.041 m^3/s), when no irrigation water demand was required. Domestic and non-domestic water demands remained constant throughout the year at 0.033 m^3/s and 0.007 m^3/s, respectively. Therefore, the monthly variation in total water demand was primarily influenced by fluctuations in irrigation water demand, which reflected changes in the cropping pattern and irrigation requirements during the planting seasons. These total water demand values were subsequently used as the basis for the water balance analysis.

4.3 Water Balance Analysis

The water balance analysis was conducted by comparing the Q90 dependable discharge, representing water availability, with total water demand in Banding Agung Subdistrict in 2025. The comparison shows the surplus or deficit condition of water availability in each month and is presented in the following table.

Table 4.3 Water Balance

No	Month	Water Availability (Q90) (m^3/s)	Total Water Demand (m^3/s)	Water Balance (m^3/s)	Remarks
1	January	9.13	0,284	8,847	Surplus
2	February	9.81	0,221	9,591	Surplus
3	March	10.34	0,216	10,127	Surplus
4	April	9.19	0,328	8,864	Surplus
5	May	10.71	0,260	10,446	Surplus
6	June	6.99	0,295	6,691	Surplus
7	July	4.72	0,265	4,458	Surplus
8	August	7.55	0,245	7,307	Surplus
9	September	8.68	0,123	8,558	Surplus
10	October	8.35	0,111	8,240	Surplus
11	November	8.10	0,058	8,045	Surplus
12	December	10.72	0,041	10,680	Surplus

Based on Table 4.3, the water balance analysis indicates that Lake Ranau maintained a surplus water balance throughout 2025, as the Q90 dependable discharge consistently exceeded the total water demand in every month. The monthly surplus ranged from 4.458 to 10.680 m^3/s, with the highest surplus occurring in December (10.680 m^3/s) and the lowest surplus in July (4.458 m^3/s). Although the Q90 dependable discharge decreased during the dry season, particularly in July, the available water remained sufficient to satisfy domestic, non-domestic, and irrigation water demands. These findings demonstrate that, from a quantitative perspective, Lake Ranau possesses adequate water resources to support existing water uses throughout the year. Therefore, future lake management should prioritize maintaining and improving water quality to ensure the sustainable utilization of the available water resources.

4.4 Water Quality Analysis

The water quality analysis was conducted to evaluate the condition of Lake Ranau waters at three observation stations representing the characteristics of land use in the area. Water quality status was determined from measurements of 12 water quality parameters using the STORET method and the Pollution Index (PI).

Table 4.4 Summary of Average Water Quality Measurements in Lake Ranau by Zone and Season

No	Parameter	Water Quality Standard (Gov. Reg. No. 22 of 2021)		Zone I (Kota Batu)		Zone II (Banding Agung)		Zone III (Rantau Nipis)	
				Rainy	Dry	Rainy	Dry	Rainy	Dry
1	TSS	25	mg/L	**27.39**	21.02	13.41	14.41	13.78	14.80
2	TDS	1,000	mg/L	81.33	87.91	133.86	122.64	101.35	97.45
3	pH	6–9	–	7.20	7.49	7.84	7.48	7.36	7.62
4	COD	10	mg/L	**10.99**	9.20	**11.59**	9.20	**11.09**	9.56
5	BOD	2	mg/L	1.90	**3.83**	1.96	**2.10**	1.99	**2.11**
6	Nitrite	0.06	mg/L	0.01	**0.08**	0.01	**0.24**	0.01	**0.17**
7	DO	6	mg/L	7.05	**5.70**	6.43	**5.21**	6.21	**5.82**
8	Phosphate	0.01	mg/L	**0.20**	**0.21**	**0.19**	**0.20**	**0.19**	**0.21**
9	Nitrate	10	mg/L	0.28	0.38	0.12	0.52	0.27	0.29
10	Ammonia	0.1	mg/L	0.04	0.03	0.04	0.03	0.05	0.04
11	Fecal Coliform	100	MPN/100 mL	47.60	91.98	69.80	57.50	78.81	62.98
12	Total Coliform	1,000	MPN/100 mL	833.90	813.20	790.70	740.50	504.13	301.48

Note: *) Values in **bold** exceed the Class I water quality standard (DO is bold if < 6 mg/L)

Based on the measurement results, most water quality parameters of Lake Ranau still meet the Class I water quality standard under Government Regulation No. 22 of 2021. However, TSS, COD, BOD, DO, nitrite, and phosphate exceeded the standard at certain locations and seasons, indicating the influence of anthropogenic activities and hydrological variation between the rainy and dry seasons. This finding is consistent with Zhang et al. (2023), who stated that water quality is influenced by organic matter and nutrient inputs as well as hydrological dynamics.

The highest TSS value was found in Zone I during the rainy season, which is presumably influenced by runoff from the Way Warkuk River catchment and floating net cage (FNC) activities. In contrast, COD tended to increase in the rainy season, whereas BOD, nitrite, and DO depletion were more pronounced in the dry season owing to reduced dilution and increased accumulation of organic matter. This pattern is consistent with the studies of Silaban et al. (2021) and Nugroho et al. (2024).

Among all parameters, phosphate was the parameter that most consistently exceeded the water quality standard across

all zones and seasons. This condition indicates a continuous nutrient input from FNC activities, domestic wastewater, agriculture, tourism, and catchment runoff. This finding is consistent with Lukman et al. (2021), who stated that FNC activities are one of the main sources of phosphorus in Lake Ranau. Therefore, this parameter was subsequently used as the basis for determining water quality status using the STORET method and the Pollution Index (PI).

Table 4.5 Summary of STORET Scores and Water Pollution Classification of Lake Ranau, 2016–2025

No	Year	Zone I	Classification	Zone II	Classification	Zone III	Classification
1	2016	-20	Moderately Polluted	-27	Moderately Polluted	-	-
2	2017	-22	Moderately Polluted	-35	Heavily Polluted	-27	Moderately Polluted
3	2018	-31	Heavily Polluted	-43	Heavily Polluted	-	-
4	2019	-28	Moderately Polluted	-26	Moderately Polluted	-20	Moderately Polluted
5	2020	-11	Moderately Polluted	-32	Heavily Polluted	-16	Moderately Polluted
6	2021	-16	Moderately Polluted	-10	Lightly Polluted	-12	Moderately Polluted
7	2022	-17	Moderately Polluted	-12	Moderately Polluted	-12	Moderately Polluted
8	2023	-42	Heavily Polluted	-41	Heavily Polluted	-40	Heavily Polluted
9	2024	-33	Heavily Polluted	-44	Heavily Polluted	-25	Moderately Polluted
10	2025	-10	Lightly Polluted	-10	Lightly Polluted	-10	Lightly Polluted
Average		**-23**	Moderately Polluted	**-28**	Moderately Polluted	**-20**	Moderately Polluted
Max		**-10**	Lightly Polluted	**-10**	Lightly Polluted	**-10**	Lightly Polluted
Min		**-42**	Heavily Polluted	**-44**	Heavily Polluted	**-40**	Heavily Polluted

Based on the STORET method, the water quality status of Lake Ranau during 2016–2025 was generally in the moderately polluted category. The average STORET scores for Zone I, Zone II, and Zone III were −23, −28, and −20, respectively, indicating that Zone II had the poorest water quality. Temporally, the worst conditions occurred in 2023–2024, classified as heavily polluted, whereas in 2025 all zones improved to lightly polluted.

The STORET assessment shows that the decline in water quality was mainly driven by high loads of nutrients and organic matter, with the largest contributions from phosphate (40.8%), followed by DO (14.0%), fecal coliform (10.3%), BOD (9.2%), and COD (5.7%). This finding indicates that controlling nutrient inputs, particularly phosphorus from FNC activities, domestic wastewater, and agricultural runoff, should be a priority in the water quality management of Lake Ranau.

Table 4.6 Summary of Pollution Index (PI) Values and Water Pollution Classification of Lake Ranau, 2016–2025

No	Year	Season	Zone I	Classification	Zone II	Classification	Zone III	Classification
1	2016	Rainy	4.15	Lightly Polluted	5.29	Moderately Polluted	-	-
		Dry	5.21	Moderately Polluted	5.27	Moderately Polluted	-	-
2	2017	Rainy	5.27	Moderately Polluted	4.71	Lightly Polluted	4.83	Lightly Polluted
		Dry	4.90	Lightly Polluted	4.19	Lightly Polluted	4.84	Lightly Polluted
3	2018	Rainy	5.05	Moderately Polluted	5.13	Moderately Polluted	-	-
		Dry	4.77	Lightly Polluted	5.23	Moderately Polluted	-	-
4	2019	Rainy	6.93	Moderately Polluted	5.97	Moderately Polluted	5.87	Moderately Polluted
		Dry	6.74	Moderately Polluted	5.99	Moderately Polluted	6.18	Moderately Polluted
5	2020	Rainy	5.34	Moderately Polluted	5.37	Moderately Polluted	5.35	Moderately Polluted
		Dry	5.37	Moderately Polluted	5.36	Moderately Polluted	5.36	Moderately Polluted
6	2021	Rainy	5.38	Moderately Polluted	5.35	Moderately Polluted	5.35	Moderately Polluted
		Dry	5.35	Moderately Polluted	5.35	Moderately Polluted	6.49	Moderately Polluted
7	2022	Rainy	5.44	Moderately Polluted	5.19	Moderately Polluted	4.43	Lightly Polluted
		Dry	5.45	Moderately Polluted	5.35	Moderately Polluted	3.94	Lightly Polluted
8	2023	Rainy	4.73	Lightly Polluted	4.85	Lightly Polluted	4.84	Lightly Polluted
		Dry	6.21	Moderately Polluted	6.40	Moderately Polluted	4.46	Lightly Polluted
9	2024	Rainy	3.97	Lightly Polluted	5.21	Moderately Polluted	3.98	Lightly Polluted
		Dry	4.63	Lightly Polluted	6.28	Moderately Polluted	5.53	Moderately Polluted
10	2025	Rainy	5.57	Moderately Polluted	5.35	Moderately Polluted	6.42	Moderately Polluted
		Dry	5.35	Moderately Polluted	5.35	Moderately Polluted	6.34	Moderately Polluted
Average		Rainy	5.18	Moderately Polluted	5.24	Moderately Polluted	5.13	Moderately Polluted
		Dry	5.40	Moderately Polluted	5.48	Moderately Polluted	5.39	Moderately Polluted
Maximum		Rainy	6.93		6.25		6.41	
		Dry	6.74		6.40		6.50	
Minimum		Rainy	3.97		4.71		3.98	
		Dry	4.63		4.19		3.94	

Based on the Pollution Index (PI) calculation, the water quality status of Lake Ranau during 2016–2025 ranged from lightly polluted to moderately polluted, with PI values ranging from 3.94 to 6.93. The average PI values show that all zones fall into the moderately polluted category, with Zone II having the highest level of pollution.

The PI results show a pattern consistent with the STORET method, namely that the decline in water quality was mainly influenced by phosphate, COD, BOD, nitrite, and DO. The consistency of the two methods indicates that the water quality of Lake Ranau has been polluted, so integrated control of pollution sources is needed to maintain the sustainable use of the lake.

4.5 Water Quality Management Efforts for Lake Ranau

Based on the analysis results, the management of Lake Ranau should focus on pollution control. Although water availability remains in surplus throughout the year, the evaluation using the STORET method and the Pollution Index (PI) indicates a decline in water quality. Therefore, a management strategy focused on controlling pollution sources is required. A summary of the management strategies is presented in the following table.

Table 4.7 Water Quality Management Strategies for Lake Ranau by Zone and Season

Priority	Zone	Dominant Parameters	Management Strategy
1	Zone II (Banding Agung)	Phosphate, COD, BOD, Nitrite, DO	Regulating FNCs according to carrying capacity, improving domestic wastewater management, supervising tourism activities, and conducting periodic water quality monitoring. In the rainy season, the focus is on controlling runoff and waste, whereas in the dry season it is on improving sanitation and reducing the organic matter load.
2	Zone I (Kota Batu)	Phosphate, TSS, COD, BOD, Nitrite, DO	Conserving the Way Warkuk River catchment, controlling erosion and sedimentation, regulating FNCs, improving feed efficiency, and monitoring water quality.
3	Zone III (Rantau Nipis)	Phosphate, COD, BOD, Nitrite, DO	Controlling agricultural runoff and domestic wastewater, adopting environmentally friendly agriculture, rehabilitating riparian vegetation, and conducting periodic water quality monitoring.

IV. Conclusions

The analysis of water availability, water demand, water balance, and water quality in Lake Ranau during the 2016–2025 period indicates that the lake has sufficient water resources to meet domestic, non-domestic, and irrigation demands. The Q90 dependable discharge ranged from 4.72 to 10.72 m^3/s, while the total water demand ranged from 0.041 to 0.328 m^3/s, resulting in a surplus water balance throughout 2025. These findings demonstrate that, from a quantitative perspective, water availability in Lake Ranau remains adequate to support existing water uses, indicating that water quantity is not currently the primary management concern.

Water quality assessment revealed that, although most measured parameters complied with the Class I water quality standards stipulated in Government Regulation No. 22 of 2021, several parameters, including phosphate, COD, BOD, DO, nitrite, and TSS, exceeded the permissible limits at certain locations and during specific seasons. Both the STORET and Pollution Index (PI) methods consistently classified Lake Ranau as moderately polluted, with Zone II (Banding Agung) exhibiting the highest level of pollution pressure due to intensive human activities. Therefore, sustainable lake management should prioritize improving water quality through nutrient input reduction, particularly phosphate, sustainable management of floating net cages (KJA), improved domestic wastewater treatment, runoff control within the catchment area, and continuous water quality monitoring. These measures are essential to maintain the long-term sustainability of Lake Ranau as a vital water resource for the surrounding communities.

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