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Monitoring and Evaluation of Water System as a Performance Indicator in Laeya Watershed Management, Southeast Sulawesi

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Abstract—This research aimed to monitor and evaluate the performance of the Laeya Watershed, South Konawe Regency, Southeast Sulawesi Province. The method used a survey with a scoring technique using the flow regime coefficient, annual flow coefficient, sediment load, flood, and eater use index parameters based on the Regulation of the Minister of Forestry of the Republic of Indonesia Number 61 of 2014. The results showed that the performance assessment of the Laeya Watershed based on the aspect of water management was classified into a good class with a value of 73.05, with each of the sub-criteria flow regime coefficient (4.24 or very low class), annual flow coefficient (0.31 or medium class), sediment load (7.73 or low class), flooding (flood frequency 1 time/year or high class) and water use index (4,228.60 or moderate class). The conclusion was that the performance of Laeya watershed management is quite good.

Keywords—Watershed, Water Management, Indicators, Monitoring, Evaluation.

I. INTRODUCTION

A watershed is an area that is limited by topography (Wang et al 2016), where rainwater is channeled into a flow system called an outlet (Narendra et al 2021). Watersheds are not only limited by hydrological units, but also by economic, social, and political units in managing natural resources (Ready et al 2017).

The watershed is a very important unit of analysis in the planning and management of natural resources to regulate the interaction between natural resources and humans to achieve economic and ecological balance and sustainability.

Indonesia integrated watershed management efforts have long been introduced since the Dutch era by carrying out various cross-sectoral and multidisciplinary activities, but because of the complexity of the problems that must be faced, and the large number of watersheds handled, many watersheds have not been handled even watershed degradation is getting higher every time (Sudaryono, 2002).

Watershed degradation can be identified through monitoring aspects of water management. Water is the main element in human life (Tuwu and Kete, 2017). Water resources used by humans come from surface water and groundwater (Santosa and Adji, 2010; Kete et al 2020). Both sources have an important role in supporting human life. Therefore, in its utilization, conservation efforts are needed (Kete, 2021).

Law No. 7 of 2014 states that water resource conservation is an effort to maintain the existence and sustainability of the condition, nature, and function of water resources so that they are available both in quantity and quality both now and in the future. The watershed ecosystem functions as a protection for the watershed system (Asdak, 2010). Therefore, to ensure the availability and sustainability of water resources in the future, it is important to carry out monitoring and evaluation as a performance indicator for watershed management. This research is in the Laeya Watershed because it is classified as a priority watershed that must be restored in Southeast Sulawesi Province.

II. RESEARCH METHODS

This research was in the Laeya Watershed, Southeast Sulawesi Province. The data source was obtained from a combination of primary data in the form of field observations and secondary data from the River Flow Observation Station. Data-based analysis Regulation of the Minister of Forestry of the Republic of Indonesia Number 61 of 2014 concerning Monitoring and Evaluation of Watershed Management (Sudia et al, 2023). One aspect of the assessment is the water system includes Flow Regime Coefficient, Annual Flow Coefficient, Sediment Load, Flood and Water Use Index.

The flow regime coefficient is the ratio between the maximum discharge (Q max) and the minimum discharge (Q min) in a watershed. Analysis of the flow regime coefficients uses Equation (1), while the criteria, values and weights of the flow regime coefficients are presented in Table 1.

$$\text{Flow Regime Coefficient} = Q\text{max}/Q\text{min}. \quad (1)$$

The annual flow coefficient is the ratio between the annual flow thickness (Q, mm) and the annual rainfall thickness (P, mm) in the watershed or it can be said how many percent of rainfall becomes runoff in the watershed. The data used in the KAT analysis in the DAS is using Rainfall data sourced from the River Basin Office.

Analysis of the annual flow coefficient using Equation (2).

$$\text{Annual Flow Coefficient} = \text{Q Annual}/\text{P Annual}. \quad (2)$$

Sediment Load is the amount of soil material resulting from erosion. Sediment load analysis uses Equation (3), while the criteria, values , and weights of sediment loads are presented in Table 1.

$$\text{Sediment Load} = \text{A x SDR}. \quad (3)$$

A flood is a natural disaster caused by the volume of water sourced from rainfall that has increased and submerged the land. Flood data was obtained from interviews with stakeholders and supported by disaster incident reports in this area.

The Water Use Index is carried out to describe the amount of water demand compared to the quantity of water availability in the watershed by using the following equation (4).

$$\text{Water Use Index} = \frac{\text{Number of Water}}{\text{Number of Population}}. \quad (4)$$

The calculation method is to measure the performance level of the Laeya watershed. Table 1 shows detailed criteria, values, and weights of the annual flow coefficient are presented.

Table 1. Criteria, value and weight of critical land in the Laeya watershed

Sub Criteria	Weigh t	Mark	Class	Score
Flow Regime Coeficient	5	KRA ≤ 20	Very low	0.5
		20<KRA≤50	Low	0.75
		50<KRA≤80	Currently	1
		80<KRA≤110	Tall	1.25
		KRA > 110	Very high	1.50
Annual Flow Coefficien t	5	KAT ≤ 0.2	Very low	0.5
		0.2 <KAT≤0.3	Low	0.75
		0.3 <KAT≤0.4	Currently	1
		0.4 <KAT≤0.5	Tall	1.25
		KAT> 0.5	Very high	1.50
Sediment Load	4	MS ≤ 5	Very low	0.5
		5<MS≤10	Low	0.75
		10<MS≤15	Currently	1
		15<MS≤20	Tall	1.25
		MS > 20	Very high	1.50
Flood	2	Never	Very low	0.5
		1 time in 5 years	Low	0.75
		1 time in 2 years	Currently	1
		1 time per year	Tall	1.25
		More than 1 time per year	Very high	1.50
Water Use Index	4	IPA > 6,800	Very good	0.5
		5.100<IPA≤6.800	Good	0.75
		3,400 <IPA≤5,100	Currently	1
		1,700<IPA≤3,400	Bad	1.25
		IPA ≤ 1,700	Very ugly	1.50

Table 2 shows the criteria for Laeya Watershed Performance Determination shows in.

Table 2. Determination of Laeya Watershed Performance

Criteria	Mark
Good	50-83
Currently	84-117
Bad	118-150

III. RESEARCH AND DISCUSSION

A. Laeya Watershed Overview

The Laeya Watershed is in South Konawe Regency and has an area of± 68,978.79 ha (Sudia, et al. 2023). Administratively, the Laeya watershed flows through several districts. Laeya District dominates 28% of the total watershed area of Wolasi District (19.99%), Baito District (15.56%), Lainea District (14.31%), Palangga District (14.27%), Kolono District (5 .62%) and Palangga Selatan District (0.57%) (Sudia et al. 2023).

B. Flow Regime Coefficient

The flow rate flowing in the Laeya watershed shows that the highest average discharge occurred in June at 2.16 m^3/second and the lowest in September at 0.51 m3/d. The total discharge for one year of the Laeya River is 12.96 m^3/second so the monthly average discharge is 1.08 m^3/second. Table 3 shows the detail of the average monthly discharge in Laeya Watershed.

Table 3. Average monthly discharge in the Laeya Watershed

#	Subdistrict	Debt (m^3/second)
1	January	0.50
2	February	1.02
3	March	1.45
4	April	1.42
5	May	1.55
6	June	2,16
7	July	1.24
8	August	0.72
9	September	0.51
10	October	0.52
11	November	0.70
12	December	1.17
	Amount	12.96

Based on the results of calculating the criteria in Table 3, values, and weights, it shows that the Flow Regime Coefficient value is 4.24. Therefore, the value of the Flow Regime Coefficient Laeya Watershed belongs to the very low class with a score of 0.5.

C. Annual Flow Coefficient

Determination of the Annual Flow Coefficient of the Laeya Watershed of South Konawe Regency is carried out by first determining the annual discharge (Q annual) with annual rainfall (Annual). The results of the analysis show that this watershed has annual Q and annual P values of 34,033,824 m3 and 108,262,211 m3, respectively.

Based on the results of calculating the criteria, scores, and weights, it shows that the KAT value is 0.31 or belongs to the middle class with a score of 1.

D. Sediment Load

The sediment load was analyzed using the sediment delivery ratio (SDR) approach. The approach uses the average erosion value and the area of the watershed. Table 4 shows the SDR value is greatly influenced by the area of the watershed.

Table 4. SDR values for various watershed areas

#	Watershed area (ha)	SDR
1	10	0.53
2	50	0.39
3	100	0.35
4	500	0.27
5	1,000	0.24
6	5,000	0.15
7	10,000	0.13
8	20,000	0.11
9	50,000	0.085
10	2,600,000	0.049

The SDR value for the Laeya watershed is determined by determining the area of each watershed (in hectares). The Laeya watershed has an area of 68,978.80 ha. This shows that the Laeya Watershed SDR value ranges from 0.085-0.049 or an average of 0.062. while the average erosion is 125.54 tons/ha/year. Thus, it can be obtained that the sediment load value in this watershed is 7.73 tons/ha/year.

The results of the evaluation of the criteria, weight, value, class, and score of sediment load are in the 5-10 range with a weight of 0.75. This value belongs to the low class.

E. Flood

Identification of flood events is carried out by calculating the frequency of occurrence of floods during a year in the watershed area obtained from the results of community interviews and supported by disaster reports at the study locations.

From this information was obtained that this watershed area has experienced floods during the annual period, namely once a year. This shows that the Laeya watershed belongs to the high category and has a score of 1.25.

F. Water Use Index

Calculation of the water use index uses the domestic water demand approach with water availability. This approach uses population data and average discharge data for the Laeya River.

The total population in the Laeya Watershed in 2021 includes the Baito, Kolono, Laeya, Lainea, Moramo, Palangga, South Palangga, and Wolaso Districts with a growth rate of 1.34% per year. Table 5 shows the number and rate of population in the Laeya Watershed.

Table 5. The Number and Rate of Population in the Laeya Watershed

#	Subdistrict	Number of Population (Person)	Growth rate (%)
1	Baito	9.125	1.34
2	Colono	11,550	1.34
3	Laeya	21,747	1.35
4	Another	10.173	1.34
5	Moramo	15,844	1.34
6	Palangga	14,991	1.35
7	South Palanga	7,491	1.34
8	Wolasi	5,732	1.34
	Amount	96,653	1.34

Source: Statistics Center of Konawe Selatan (2022)

The calculation results show that the average amount of water available in the Laeya Watershed is 408,706,560 m3 to meet the needs of the population of 96,653 people so a water use index of 4,228.60 is obtained. Thus, the water use index in this watershed area belongs to the moderate class and gets a score of 1.

G. Laeya Watershed Performance Evaluation

The results of monitoring and evaluation of the Laeya Watershed based on water management aspects were 73.05, so the watershed was in the good criteria because it was in the range of 50-83. Table 6 shows the data of the performance evaluation of Laeya Watershed.

Table 6. Laeya Watershed Performance Evaluation

Parameter	Score	Weigh t	Mark
Flow Regime Coefficient	4,24	5	21,2
Annual Flow Coefficient	0.31	5	1.55
Sediment Load	7,73	4	30,92
Flood	1.25	2	2,5
Water use index	4,22	4	16.88
Total	17.75	20	73.05

IV. CONCLUSION

The results showed that the performance assessment of the Laeya watershed based on aspects of water management was classified into a good class with a value of 73.05, with each sub-criterion flow regiment coefficient (4.24 or very low class), annual flow coefficient (0.31 or medium class), sediment load (7 .73 or low class), flooding (flood frequency 1 time/year or high class) and water use index (4,228.60 or medium class).

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