Watershed Management Performance Assessment Based on Land Condition Indicators
(Laeya Watershed Case, Southeast Sulawesi Province

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ABSTRACT

Laeya Watershed is one of the three Priority Watersheds in Southeast Sulawesi. Therefore, monitoring and evaluating watershed performance is very important to ensure that watershed management is sustainable. This study aims to assess the performance of watershed management based on indicators of land conditions in the Laeya Watershed, Southeast Sulawesi Province. The method used is a survey with a scoring technique using the parameters index of the percentage of critical land, vegetation cover, and erosion index to determine the carrying capacity of the watershed. The results showed that the carrying capacity of the Laeya Watershed was classified as very good with a score of 35 (<70), with each sub-criterion of critical land classified as very low with a score of 0.5, sub-criteria for vegetation cover classified as good with a score of 0.75 and sub-criteria the erosion index criteria are classified as very high with a score of 0.75. It can be concluded that the management performance of the Laeya watershed is very good.

Keywords: watershed management; carrying capacity; land criticality; land cover and erosion.

INTRODUCTION

Watershed management is a human effort to regulate the interaction between natural resources and humans in a watershed and all its activities to achieve ecosystem sustainability and harmony and increase the sustainable use of natural resources for humans. Watershed management aims to coordinate, integrate, synchronize, and synergize watershed management to increase the carrying capacity of the watershed. Under Government Regulation Number 37 of 2012, the stages of watershed management include planning, implementation, monitoring, and evaluation as well as guidance and supervision. This study focuses more on the evaluation and monitoring stages through watershed performance indicators.

Determination of management performance is an important step to determine the status or carrying capacity of a watershed. The results of the performance review are used as a reference for evaluating the success of watershed management. This monitoring and evaluation stage is very crucial because the success of watershed management can be assessed so that follow-up management can be formulated properly.

Watershed management performance is prepared based on the criteria of land conditions, water system, socio-economic, investment in water structures, and regional spatial use (Government Regulation Number 37 of 2012). This study uses criteria for land conditions including indicators of the percentage of critical land, the percentage of vegetation cover, and the erosion index or land management.

Geographically, the region of Southeast Sulawesi Province is divided into 1,877 watersheds according to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 304 of 2018 concerning the Determination of River Basin Area Maps and based on Government Regulation Number 37 of 2012 classified into the restored watersheds and the watersheds which have maintained their carrying capacity. This categorization depends on the critical level of the land because it can affect the hydrological conditions of a watershed (Auliana et al., 2018).

Human activities contribute greatly to watershed environmental degradation (Kometa & Ebot, 2012; RN et al., 2016), such as the rate of land change, reduced vegetation cover, and land use principles that do not consider the carrying capacity of land in the development process (Adegboyega, 2021). This causes floods and landslides (Gebretsadik, 2014). This condition also occurs at the end of each rainy season in this region, including in the South Konawe district as the coverage area of the Laeya Watershed with an area of 68,978.79 ha. Therefore, efforts are needed to overcome environmental damage in the future. One way to do this is to evaluate the management performance of the Laeya Watershed which is guided by the Regulation of the Minister of Forestry of the Republic of Indonesia Number 61 of 2014 concerning Monitoring and Evaluation of Watershed Management. This study aims to analyze indicators of land conditions that affect the carrying capacity of the Laeya Watershed to create a balanced and harmonious watershed environment.

RESEARCH METHODS

This research was conducted in the Laeya River Basin, Southeast Sulawesi (Figure 1), in July-December 2022. The data used in this research is in the form of primary data from field measurements and secondary data in the form of Indonesian Topographical Maps, administrative maps, land use, and land use maps. Land cover, and critical land maps obtained from related agencies. The tools used in the form of laptops, GIS software, Geographical Position System (GPS), digital camera, and stationery.
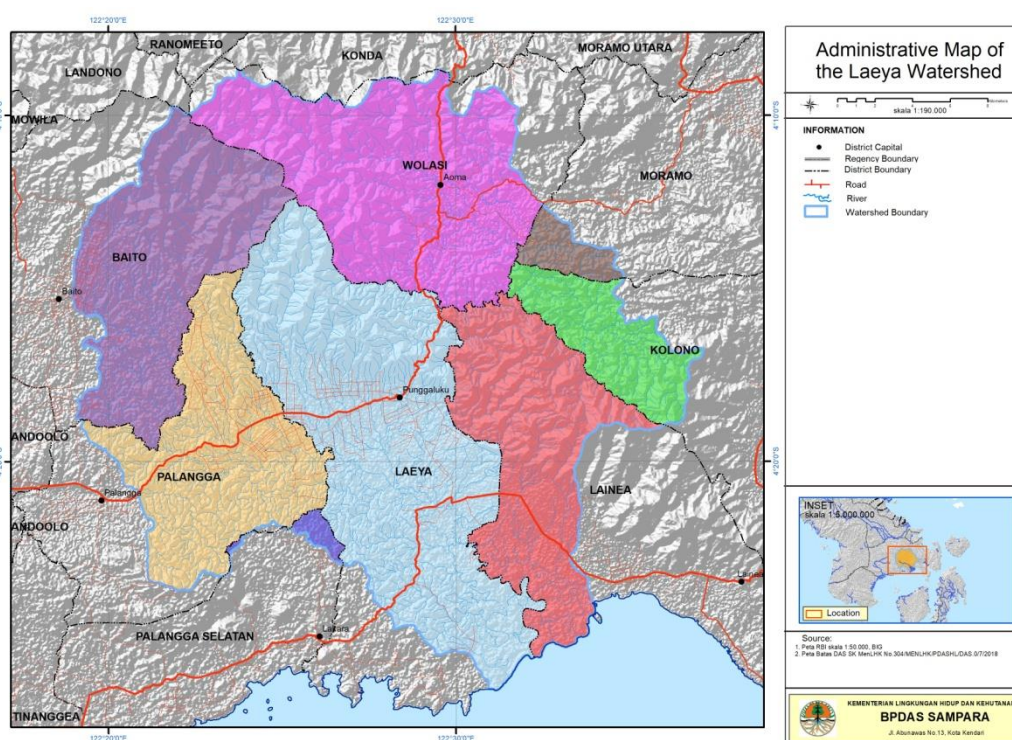

Figure 1. Laeya Watershed Research Location Map

Data Analysis

Data analysis The evaluation of Laeya watershed management performance is based on the Regulation of the Minister of Forestry of the Republic of Indonesia Number 61 of 2014 concerning Monitoring and Evaluation of Watershed Management. Performance evaluation is seen from various aspects, namely land conditions, water management, social, economic, and institutional. In this study, the assessment of watershed performance is based on indicators of land conditions. Land criteria consist of the percentage of critical land, the percentage of vegetation cover, and the erosion index or land management. Analysis of each land criterion is calculated by comparing it with the

area of the watershed. The calculation of watershed management performance for each parameter consists of criteria, weights, and values presented in Table 1.

Tabel 1. Criteria, Value, and Weight of Laeya Watershed Critical Land

Sub Criteria	Weight	Parameter	Mark	Class	Score
Percentage of Critical Land	20	PCL = (Critical Land Area / Watershed Area) x 100 %	PCL ≤ 5	Very Low	0,5
			5 ≤PCL≤10	Low	0,75
			10 ≤PCL≤15	Moderate	1
			15 ≤PCL≤20	High	1,25
			PCL≥ 20	Very High	1,50
Percentage of Vegetation Cover	10	PVC = (Area of Vegetation Cover / Area of Watershed) x 100 %	PPV > 80	Very Good	0,5
			60 <PPV≤80	Good	0,75
			40 <PPV≤60	Moderate	1
			20 <PPV≤40	Bad	1,25
			PPV≤ 20	Very Bad	1,50
Erosion Index (EI)	10	EI = (A/ETOL)	EI > 0,5	Very Low	0,5
			0,5 <EI≤1,0	Low	0,75
			1,0 <EI≤1,5	Moderate	1
			1,5 <EI≤2,0	High	1,25
			EI> 2,0	Very high	1,50
Land Management (PL)	10	LM= C x P = CP	CP ≤ 0,10	Very Low	0,5
			0,1 <CP≤0,3	Low	0,75
			0,3 <CP≤0,5	Moderate	1
			0,5 <CP≤0,7	High	1,25
			CP> 0,7	Very high	1,50

Analysis of the carrying capacity of the watershed was obtained from the results of an analysis of the weight values and scores for each land condition parameter. The classification of the carrying capacity of the watershed is presented in Table 2.

Table 2. Classification of Watershed Carrying Capacity (DDD)

Value	Category
DDD ≤ 70	Very Good
70 < DDD ≤ 90	Good
90 < DDD ≤ 110	Moderate
110 < DDD ≤ 130	Bad
DDD > 130	Very Bad

RESULT AND DISCUSSION
The general condition of the Laeya watershed

Administratively, the Laeya Watershed is located in South Konawe Regency with an area of ± 68,978.79 ha across eight sub-districts namely Baito, Kolono, Laeya, Lainea, Moramo, Palangga, South Palangga, and Wolasi sub-districts. The widest administrative area of the sub-district in the

Laeya Watershed is Laeya District with an area of 19,315.46 ha or 28%, while the smallest is South Palangga District with 396.29 ha or 0.57% (Table 3).

Table 3. Laeya watershed administrative area

Sub-district	Area	
	ha	**%**
Baito	10.735,62	15,56
Kolono	3.874,55	5,62
Laeya	19.315,46	28,00
Lainea	9.873,16	14,31
Moramo	1.149,61	1,67
Palangga	9.844,57	14,27
South Palangga	396,29	0,57
Wolasi	13.789,52	19,99

Critical land

Critical land is land that has experienced a decline in function (Mey et al., 2020), as a means of production (Syaf et al., 2022) as well as a medium for water management. The increase in critical land area was caused by a decrease in vegetation cover, slope conditions, erosion rates, crop productivity, and community land management (Yulianto et al., 2013). The results of the analysis show that the area of critical land in the other watershed is dominated by the moderately critical class, reaching 38,119.78 ha or 55.36%. Furthermore, land with critical potential is 18,140.22 ha or 26.30%, non-critical land is 11,328.45 ha or 16.42% and critical land is 1,390.34 ha or 2.02% (table 4). This reflected that the critical land in the Laeya watershed is relatively good, but if the management does not consider the carrying capacity of the land, then in the future it has the potential to experience land degradation and reduction of biodiversity (Sewnet & Abebe, 2018; Wang, 2022).

Table 4. Laeya watershed critical land area

Critical Land	Area	
	ha	**%**
Moderately Critical	38,119,78	55,26
Critical	1,390,34	2,02
Critical Potential	18,140,22	26,30
Non-Critical	11,328,45	16,42
Total	**68,978,80**	**100**

Based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 61 of 2014 concerning monitoring and evaluation of watershed management, the criteria for the percentage of critical land assessed are in the critical and very critical categories. A critical land analysis is a comparison of critical land with the Laeya watershed area. The condition of critical land in the Laeya watershed is 1,390.34 ha the total area of the Laeya watershed is 68,978.79 ha. Based on the criteria for determining the critical level of land in the Laeya Watershed, it is classified as very low with a PCL value of ≤ 5 with a score of 0.5, and a weight of 10. This condition illustrates that the Laeya Watershed needs to maintain vegetation cover to improve its performance of the Laeya Watershed.

Vegetation Cover

Vegetation cover is a very important component in ecosystems (Gadiga, 2015), as a regulator of water management both in terms of quality and quantity (Tundisi et al., 2015). The condition of the Laeya watershed vegetation cover is presented in Table 5.

Based on Table 4, shows that there are 13 types of vegetation cover in the Laeya watershed, dominated by secondary dry land forest types of 21,152.73 ha or 30.67%, while the lowest is plantation forest of 44.35 ha or 0.06%. Lately, the problem of deforestation has continued to increase so it has an impact on the hydrological system of a watershed. Changing vegetation land into built-

up areas can increase the rate *run off* and the change of forest area to agricultural land causes soil erosion (Salim et al., 2019).

Table 5. Area and Type of Vegetation Cover in Laeya Watershed

Land Cover	Area	
	ha	**%**
Primary Dry land Forest	5.036,36	7,30
Secondary Dry land Forest	21.152,73	30,67
Secondary Mangrove Forest	1.704,01	2,47
Plantation Forest	44,35	0,06
Settlement	1.097,16	1,59
Plantation	3.448,47	5,00
Dry land farming	1.829,29	2,65
Mixed Dry Land Agriculture	15.890,41	23,04
Richfield	3.577,54	5,19
Shrub	12.953,26	18,78
Pond	1.399,28	2,03
Dry Land farming	237,28	0,34
Open Land	608,66	0,88
Water Body	5.036,36	7,30
Total	**68.978,80**	**100**

Based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 61 of 2014 concerning the Monitoring and Evaluation of Watershed Management, the criteria for the percentage of vegetation cover (PPV) assessed is the category of permanent vegetation cover. Based on this, land cover that belongs to the category of permanent vegetation in the Laeya Watershed is Secondary Dry land Forest, Secondary Mangrove Forest, Mixed Dry land Agriculture and shrubs with an area of 21,152.73 ha, 1,704.01 ha, 15,890.41 ha respectively and 12,953.26 ha so that the area of vegetation cover in the Laeya Watershed is 51,700.41 ha.

The calculation results show that the parameter value of the percentage of vegetation cover in the Laeya watershed is 74.95%. Based on the criteria for assessing the percentage of vegetation cover in the Laeya watershed range from 60 <PPV≤80 and are categorized as good with a score of 0.75 with a weight of 10.

Land Erosion/Management Index

Soil erosion by water is a problem in watershed management ((Bewket & Teferi, 2009). The erosion index/land management is approximated by the erosion index value in the watershed which is the ratio of actual erosion to allowable erosion. Determination of the erosion index value is done through analysis of erosion levels average (A) which is calculated using the general equation of soil loss (*Universal Soil Loss Equation,* USLE) compared with erosion tolerable (ETOL). The results of the data analysis on the erosion hazard level of the Laeya Watershed show that there are 5 classes of erosion hazard levels (Table 6) which are dominated by the moderate erosion hazard class with an area of 45,250.97 ha or 65.60%, then a light hazard of 15,327.36 ha or 22.22%, Heavy hazard 6,660.89 ha or 9.66%, very veavy hazard 939.08 ha or 1.36% and very light hazard 800.50 ha or 1.16%.

Table 6. Erosion hazard level and weighted area in Laeya watershed

Erosion Rate (tons/ha/year)	Erosion Hazard Class	Area		Weighted Area (tons/ha/year)
		ha	**%**	
7,5	Very Light	800,50	1,16	6.003,75
37,5	Light	15.327,36	22,22	574.776,00
120	Moderate	45.250,97	65,60	5.430.116,40
330	Heavy	6.660,89	9,66	2.198.093,70
480	Very heavy	939,08	1,36	450.758,40
Total		**68.978,80**	**100**	**125,54**

The calculation of the average erosion in each watershed is carried out using the weighted average value approach for each erosion class. The calculation results show that the average erosion value in the Laeya Watershed of South Konawe Regency is 125.54 tons/hectare/year. The average erosion value in the Laeya watershed is used to determine the value of the erosion index criteria. In this context, the erosion value of each watershed is compared with the tolerated erosion value (ETOL). The ETOL value is determined by the effective depth factor, the depth factor value (determined by the soil type), the minimum soil depth that can be penetrated by plant roots, and the service life of the soil. The ETOL value uses the results of previous studies in the Laeya watershed. The results showed that the average ETOL value of deep solum tropical soils ranged from 25-40 tonnes/ha/year (Arsyad, 2010). Thus the average ETOL value in the Laeya watershed is 32.5 tons/ha/year.

The ETOL value in the Laeya watershed is used to calculate the erosion index value in the watershed. The result of the calculation is that the Laeya watershed erosion index is 3.86. This value is classified as very high (EI> 2.0) with a score of 1.50 so the EI value of DAS Laeya is 15.

Determination of erosion index criteria can also be approached by analyzing land management factors. Land management factors are determined through the value approach of plant/vegetation management and soil management or the CP factor. The CP value is determined based on the land use of each watershed and then the value is determined based on the results of previous studies regarding various CP values (Table 7).

Table 7. Area and Type of Vegetation Cover in Laeya Watershed

Type of Land Cover/Land Use	Area (ha)	CP	Weighted CP
Primary Dry Land Forest	5.036,36	0,01	0,0007301
Secondary Dry Land Forest	21.152,73	0,05	0,0153328
Secondary Mangrove Forest	1.704,01	0,01	0,0002470
Plantation Forest	44,35	0,05	0,0000321
Settlement	1.097,16	0,80	0,0127246
Plantation	3.448,47	0,50	0,0249966
Dry Land farming	1.829,29	0,70	0,0185637
Mixed Dryland Agriculture	15.890,41	0,60	0,1382200
RicefEIld	3.577,54	0,01	0,0005186
Check	12.953,26	0,30	0,0563358
Pond	1.399,28	0,01	0,0002029
Dryland farming	237,28	1,00	0,0034399
Open Land	608,66	0,00	0,0000000
Water Body	5.036,36	0,01	0,0007301
Total	**68.978,80**		**0,27**

The calculation results show that the weighted average CP value of the Laeya DAS is 0.27. The results of the evaluation of criteria, weights, parameters, values, classes, and land management scores for the Laeya Watershed were 0.27. this value is in a low category with a value of 0.1<CP<0.3 thus the score obtained is 0.75, so the value of land management in the Laeya Watershed is 7.5.

Carrying Capacity of the Laeya Watershed

The carrying capacity of the watershed is the ability of the watershed to realize the sustainability and harmony of ecosystems and the benefits of natural resources for humans and other living things in a sustainable manner (Government Regulation No. 37 of 2012). The carrying capacity of the watershed is an important factor that must be considered in the development process, because uncontrolled changes in the carrying capacity of the watershed have an impact on increasing erosion, sedimentation, decreasing vegetation cover, and land degradation (Krishna, 2009). The results of the analysis of the carrying capacity of the Laeya watershed based on indicators of Land conditions show that this watershed has a score of 35 or belongs to the very good category (≤ 70). This indicates that the carrying capacity of the Laeya watershed needs to be maintained and improved.

Table 8. Carrying Capacity of the Laeya Watershed

Description	Class	Weight	Score	Weight x Score	DDD
Critical Land	Low	0,50	10	5	35
vegetation Cover	Good	0,75	10	7,5	
Erosion Index	Very High	1,50	15	22,5	

CONCLUSION

The evaluation of the management performance of the Laeya Watershed, based on the critical land sub-criteria is classified as very low with a score of 0.5, the vegetation cover sub-criteria is classified as good with a score of 0.75, and the erosion index sub-criteria is classified as very high with a score of 0.75. Laeya watershed carrying capacity based on indicators of the condition of the land is included in the very good category because it has a value of ≤ 70, namely 35. It can be concluded that the management performance of the Laeya Watershed is very good.

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