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Assessment of Water Resilience Index Due to the Technical Instruction

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Abstract

This research intends to assess the water resilience in Lasolo Watershed that will be as the validation value in building the mathematical model of water resilience performance index based on the scientific study. This research is conducted in the Lasolo Watershed, Southeast Sulawesi. The Lasolo Watershed is in the Lasolo Konawa River region. Lasolo River consists of 18 sub-watersheds. The assessment is carried out based on the 5 aspects that are conservation of water resources (3 indicators and 17 sub-indicators), utilization of water resources (6 indicators and 27 sub-indicators), damage control (3 indicators and 12 sub-indicators), participations of society (4 indicators and 16 sub-indicators), and information system of water resources (3 indicators and 6 sub-indicators). The methodology consists of analyzing the score of each sub-indicators and total scores of each indicator in every dimension, analyzing total of maximum value in every dimension, determining the weight of each dimension, analyzing the end score of dimensions, analyzing the score of Water Resilience Index (IKtA) and the score total, and analyzing the value of water resilience index. The result shows that the 17 sub-watersheds indicate the condition of water resilience are prone (score: 2.1-3.0) and 1 sub-watershed indicates the condition of water resilience is danger (score 0.0-2.1).

Keywords: *Water Resilience, Index, Lasolo Watershed, Indicator, Dimension.*

Introduction

Water resilience has become an urgent global issue (Ingrao et.al, 2023) in the context of sustainable water resources management. However, there is still an obscurity in defining the concept of water resilience itself. So far, there is no consencus that binding about the minimum value of water resilience (Tzanakakis et.al, 2020) which is needed so a region can be developed without influential by drought or flood (Beek and Arriens, 2014; Asmaranto et.al, 2024). The lack of standards causes the difficulty in formulating the comprehensive policy and effective implementation related with water resilience. Whereas, this aspect is very important, remembering that water is a vital component for society health, sustainanility of ecosystem (Langarudi et. al, 2021), and the continuity of economic production.

In Indonesia, water resilience is a complex problem mainly because the water resources management involves many parties, beginning for the centre until regionl government, society and business world. In this context, Indonesia just reached the engaged level in the water resilience classification due to the version of Asian Development Bank (2016), that means that Indonesia is still in the level of starting to be committed in water resources management structurely. The government target to reach the higher water resilience in 2030 shows that there is the seriousness in facing this challenge although the institutional and technical challenges are still very big.

One of the biggest challenges in water resilience management in Indonesia is still low in coordination level between the related institutions. Every sector that is related with water resources is often working sectoral without well coordination (Gain et.al, 2016), which in the end is to hinder the efforts for reaching the maximal water resilience (Tian et.al, 2017; Mason and Calow, 2012). Watershed management is one of the

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examples which the partial management approach is often causing the conflict (Padder and Bashir, 2023; He et.al, 2021) between the various interests like the industry demand and the society base demand.

Especialy in Lasolo Watershed, Southeast Sulawesi, the water resilience problem is very relevant because this region is as the main source of raw water for the local population. In addition, the Lasolo River also supports the various economic activities like industry and pond farming (He and Rosa, 2023) that give the significant contribution to the regional economy. However, the water resources management in Lasolo Watershed has not been optimal because there is still has high potential disaster due to water damage and there has not been available institution regulator that involves the whole aspects of management. Therefore, this research intends to develop the model of water resilience index (Pentewati et.al, 2024 and Sudiarti et.al, 2024) that can be a reference (Grey and Sadoff, 2007; Al-Addous et.al, 2024) for measuring the water resilience level in the Lasolo Watershed by the end aim is to support the sustainable water resources management.

Materials and Methods

Research Location

This research is conducted in Lasolo Watershed, Southeast Sulawesi. The Lasolo Watershed is in the Lasolo Konaweha River Region (Figure 1). However, the Lasolo River consists of 18 sub-watersheds and as the first orde river with the length is ±136.93 km that most of them in the Konawe Utara and Konawe Regencies with the other fraction is in the Morowali Regency-Central Sulawesi and Luwu Timur Regency-South Sulawesi. The area of Lasolo Watershed is ± 6,011.69 km² and the river length with the average width in the downstream is 100 m that is estuaried in Tapunopaka Beach. The average yearly rainfall is Lasolo Watershed that is 2,054 mm per-year. Water availability in Lasolo River has the big enough potency. Based on the data of AWLR Lamonae, the potency of dependable discharge: Q_{80} is 80.93 m³/s. The rezime coefficient of Lasolo River is > 100 and it indicates that the condition of Lasolo River is good enough.

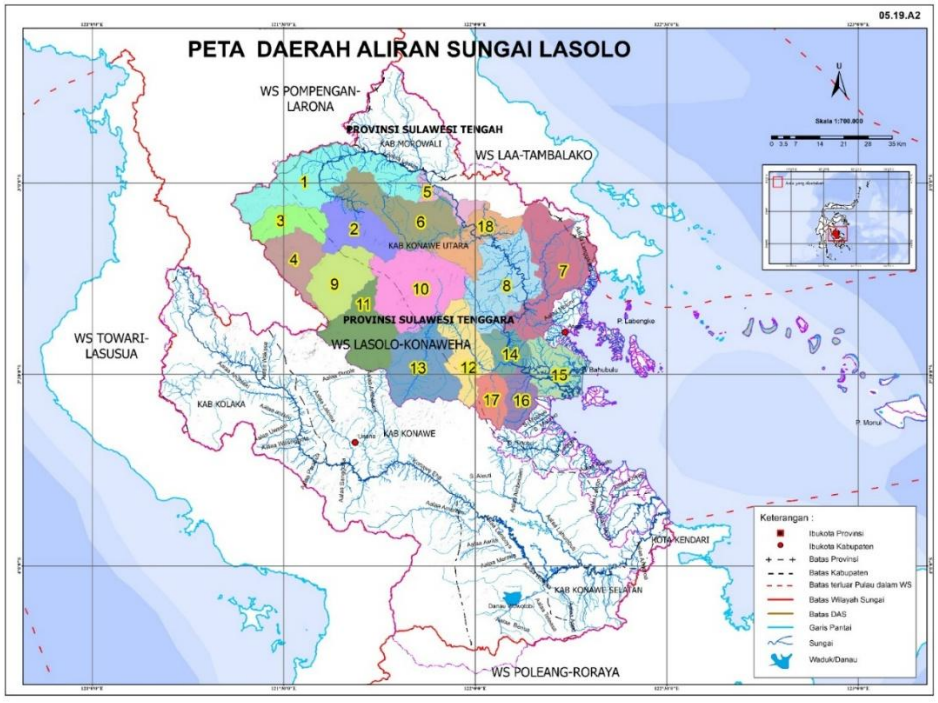

Figure 1. Map of Lasolo Watershed

Source: own study,2025

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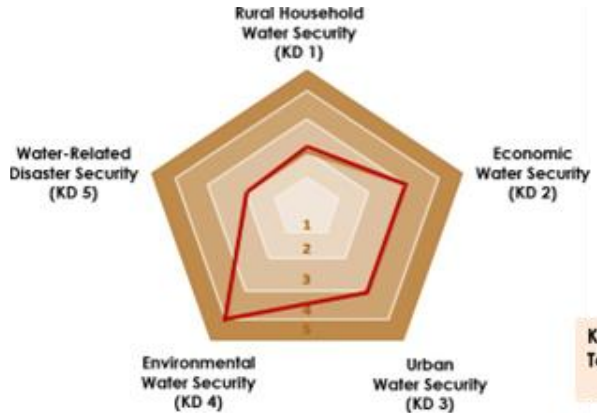
Methodology of Water Resilience Index Analysis

The analysis guidance of National Water Resilience Index is initiated by the Council of National Water Resources since the beginning of 2019. The preparation of Water Resilience Index Guidelines is also as the follow up from the recommendation of water resilience that has been prepared by the council of national water resources which the draft has been confirmed in the pleno session of national water resources council. In the initial step to obtain the illustration, the council of national water resources uses the analysis result of water resilience index in Asia Water Development Outlook (AWDO) that is prepared by Asian Development Bank (ADB). Figure 2 presents the position of Indonesian water resilience based on the AWDO 2020 and the indicators that are used for analyzing.



Index	Score			Range			Stage
5	96	≤	x	4.8	≤	x	Tough
4	78	≤ x <	96	3.9	≤ x <	4.8	Reliable
3	60	≤ x <	78	3	≤ x <	3.9	Moderate
2	42	≤ x <	60	2.1	≤ x <	3	Vulnerable
1	0	≤ x <	42	0	≤ x <	2.1	Danger

KD 1 = 11; KD 2 = 12,2; KD 3 = 11,5; KD 4 = 14,4; KD 5 = 11,9
Total score = 61,0
LEVEL 3 (CAPABLE)

Figure 2. Indonesian Water Resilience Index According to ADB

Source: Asia Water Development Outlook, 2020

The indicators that sre used by ADB as the fund provider bank of development has the aim to see what sectors in a country that needs a development stimulus through the loan funds. Meanwhile, the water resilience index that is prepared by National Water Resources Council will focus to measure the achievement of water resources development and management (in accordance with the water resources laws that consists of 5 water resources pillars) and then becomes as the consideration input in future design. The stage in the water resilience index is prepared by the National Water Resources Council that is tough, reliable, moderate, prone to, and danger. The flow chart of water resilience index analysis is presented in Figure 3.

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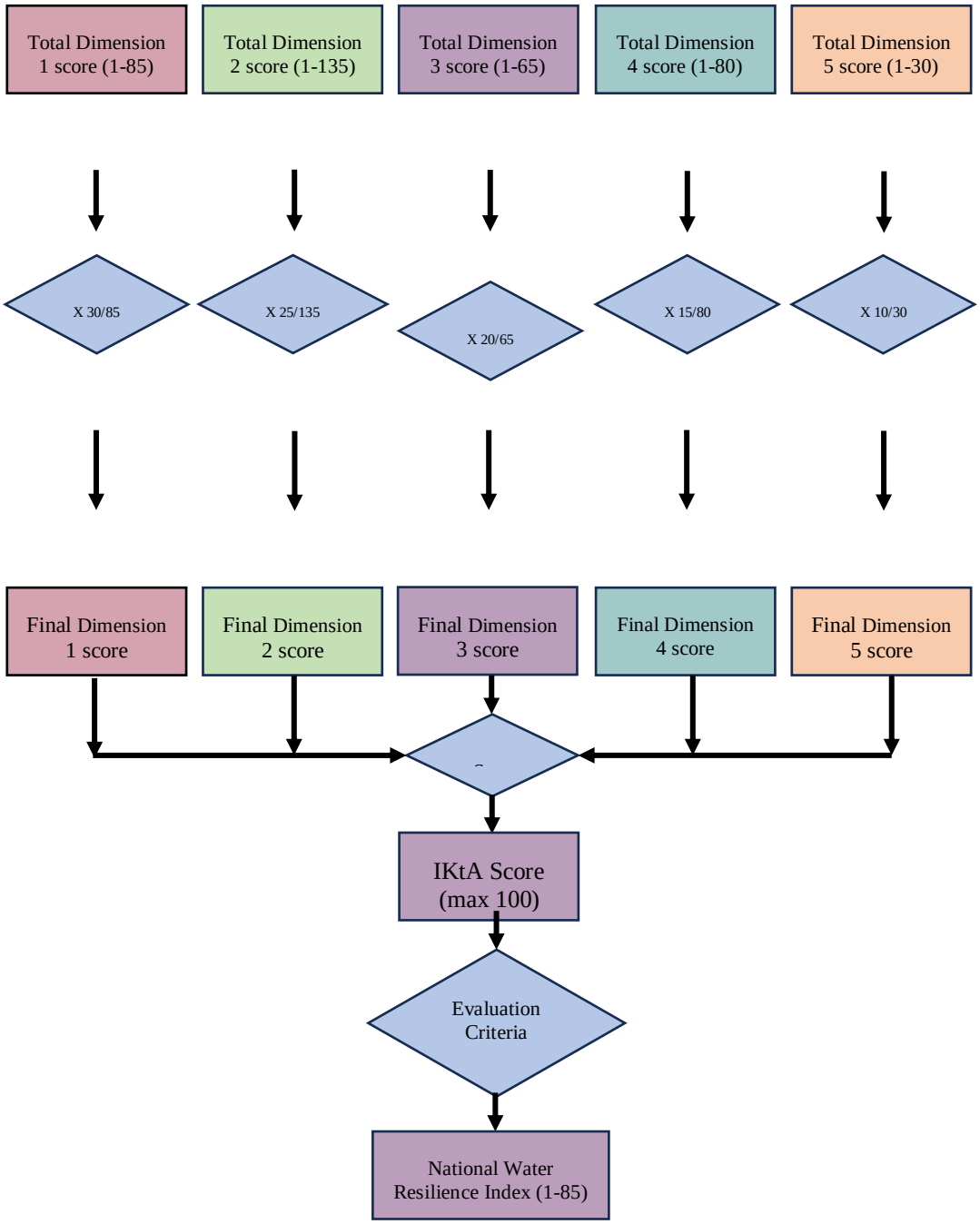

Figure 3. Flow Chart of IKtA Analysis

Source: Analysis Guidelines of National Water Resilience Index, 2021

The Stages to Analyze the Water Resilience Index is As Follows:

- To analyze the score for each sub-indicator.
- To analyze the total score for every dimension by numbering the score in each sub-indicator in every dimension
- To analyze the total of maximum value for every dimension by numbering the maximum value in each sub-indicator in every dimension.

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- To determine the weight of each dimension as follows: conservation of water resources = 30%; utilization of water resources = 25%; damage control = 20%; participation of society = 10%; and information system of water resources = 10%

- To analyze the end score of dimensions by the formula as follows:

  - $weight\ x\ \frac{Total\ of\ score}{Total\ of\ \max value}$ (1)

- To analyze the score of water resilience index (IKtA) by numbering the end score of dimensions (max value: 100).

- To determine the water resilience index (IKtA): end score of dimension-1 + end score of dimension-2 + end score of dimension-3 + end score of dimension-4 + end score of dimension-5 and to be refered to the assessment criteria.

Results and Discussion

Existing Condition of Water Resilience Index in Lasolo Watershed

Analysis of Water resilience Index is carried out by numbering 5 dimensions of water resources. However, the formulation of Water Resilience Index (IKtA) is as follows:

$$IKtA = 0.30\ X_1 + 0.25\ X_2 + 0.2\ X_3 + 0.15\ X_4 + 0.1\ X_5 \quad (2)$$

Note:

X_1= aspect of water resources conservation

X_2= aspect of water resources utilization

X_3= aspect of damage control

X_4= aspect of society participation

X_5= aspect of water resources information system

Aspect of Water Resources Conservation

Aspect of conservation (X_1) has 30% weight that consists of 3 indicators and 17 sub-indicators as follows:

Protection and Preservation of Water Resources

Forest and Land Cover ($X_{1.1}$): the parameter that is used for assessing this sub-indicator is function transfer from forest to non-forest. However, data for measuring this parameter is Land Cover Quality Index (IKTL) and the formulation is as follows: THL = IKTL (%) (3)

Note: THL = forest and land cover and IKTL = Land Cover Quality Index (data is obtained from Ministry of Forest and Life Environment, 2018).

Based on the Land Cover Index analysis that is published by Ministry of Forestry 2024, the formulation of IKTL is as follows:

$$IKTL = \left[(100 - (KTL\ X\ 100)\ X\ \frac{40}{70}\right] \quad (4)$$

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Table 1 presents the scoring analysis for IKTL.

Table 1. Scoring Anaysis for IKTL

No	Name of Sub-watershed	Ratio of Forest towards Sub-watershed Area	IKTL	Score of $X_{1.1}$
1	Sub DAS 1	0.82	46.79	3.00
2	Sub DAS 2	0.96	54.82	4.00
3	Sub DAS 3	0.98	56.04	4.00
4	Sub DAS 4	0.92	52.32	4.00
5	Sub DAS 5	0.96	55.10	4.00
6	Sub DAS 6	0.82	47.07	3.00
7	Sub DAS 7	0.70	40.28	3.00
8	Sub DAS 8	0.61	34.58	3.00
9	Sub DAS 9	0.89	51.07	4.00
10	Sub DAS 10	0.96	54.95	4.00
11	Sub DAS 11	0.96	54.84	4.00
12	Sub DAS 12	0.84	48.21	3.00
13	Sub DAS 13	0.98	55.89	4.00
14	Sub DAS 14	0.48	27.19	2.00
15	Sub DAS 15	0.38	21.72	2.00
16	Sub DAS 16	0.66	37.60	3.00
17	Sub DAS 17	0.88	50.31	4.00
18	Sub DAS 18	0.93	52.89	4.00

Source: own study, 2025

Protected Water Sources (X1.2): the inventory result of secondary data that is sourced from Water Resources Management Pattern in Lasolo Konaweha River Region due to BWS Sulawesi IV, there are no water sources that has not been identified in the study location, so the score of X1.2 is 1.

Karst Area Protection (X1.3): the identification result of morphology in Lasolo Watershed shows that there is no karst area, so in accordance with the guideline of IKtA, the core of X1.3 is 1.

The Change of River Flow Discharge (X1.4): parameter that is used for assessing this sub-indicator is the ratio between Qmax and Qmin (coefficient of flow regime/ KRA). The high value of KRA indicates that the range of run-off and flooding is big, however, in the dry season, water flow is very small (drought). Data that is used is absolute maximum and minimum discharge due to observations. Based on the calculation results, the score for the Lasolo Watershed is 1.

Protected Peatland (X1.5): the identification result of morphology in Lasolo watershed shows that there is no peatland there, so in accordance with the guideline of IKtA, the score for X1.5 is 1

The agricultural cultivation does not follow the conservation standard in a catchment area that is listed in RTRW/RDTR (X1.6): data that is used for measuring this parameter is agricultural area that is managed and does not attend the soil and water conservation, and agricultural cultivation area that is in accordance with RTRW. Based on the analysis results, the sub-watershed with a score of 5 are Sub DAS 16, Sub DAS 17, and Sub DAS 18.

Protected Groundwater Area (X1.7): data that is used for measuring this sub-indicator is as follows: a) number of groundwater (CAT) that has been determined as the conservation area, and b) number of

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available CAT. Based on the analysis result, there is no CAT area in study location, so the score of X1.7 is 1.

Length of Water Source Border that has been determined (X1.8): data that is used for measuring the parameter is a) length of water source border that has been determined, and b) length of water source border that has been planned, based on the inventory result in WS Lasolo Konaweha, there has not been determined the river border in the study location, so the score of X1.8 is 1.

Water Preservation

Availability of Water Storage (X1.9): data that is used for measuring this parameter is as follows: a) capacity of water storage (natural and artificial); b) rainfall in a region; c) potency of groundwater in CAT, and d) target of water storage in 2045.

Protection and recovery the groundwater condition in utilization area of groundwater (X1.10): data that is used for measuring this parameter is as follows: a) number of CAT in damage condition, and b) number of available CAT. Based on the inventory result, there is no CAT in Lasolo Watershed, so the score of X1.10 is 1.

Water Quality and Pollution

Water Quality (X1.11): data that is used for measuring this parameter is National Water Index Quality (IKtA). Based on the identification result by data source of RPJMD-Southeast Sulawesi, 2018-2023, the Water Quality Index (IKtA) with the class-II quality standard is about 56.21%, so the score of water quality in Lasolo watershed is 4.

Solid Waste Degree (X1.12): data that is used for measuring this parameter is number of solid wastes that has been managed. Based on the identification result of secondary data, there is no solid waste data that is managed in Lasolo watershed, so the score of X1.12 is 1.

Communal Liquid Waste (X1.13): data that is used for measuring this parameter is waste data of B3 that is managed and overall waste data of B3. Based on the data inventory, there is still waste of B3 from the test result of water quality in Lasolo watershed.

Ratio of B3-waste that is managed (X1.14): based on the data inventory, there is no B3-waste data that is managed, so the score of X1.14 is 1. Based on the analysis results there has been no control over hazardous waste (B3), therefore the score given is 1.

Liquid Waste Degree of industry (X1.15): based on the data inventory, there is no industry that has had and operated IPAL itself, so the score of X1.15 is 1.

System of fisheries cultivation in lake, reservoir, and swamp (X1.16): based on the inventory result, there is no flosting net cages in Lasolo watershed, so the score of X1.16 is 1.

Biodiversity in water body (X1.17): based on the analysis result, there is no endemic species data in Lasolo watershed, so the score of X1.17 is 1.

Aspect of Water Resources Utilization (X2)

Aspect of water resources utilization (X2) has the 25% weight that consists of 6 indicators and 27 sub-indicators as follows:

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Capacity To Collect the Source of Revenue from Water Resources Utilization Service

The availability of Collecting Institution (X2.1): for this indicator is given the score of 1. The availability of Collecting Institution-BJPSDA and the ability of fund supplying-BPJPSDA that can be collected and utilized right on the target (X2.2): the score for this indicator is 1.

System of Water Resources Stewardship

Zone of water resources utilization (X2.3): based on the analysis, there is zone map of water source utilization in WS Lasolo Konaweha as presented in Table 2 and Figure 5. The score of X2.3 is 5.

Table 2. Zone of Water Resources Utilization in Lasolo Watershed

No	Explanation	Area (ha)	Percentage of Area (%)
1	Very low	8.80	0.002
2	Low	358,397.69	70.138
3	Moderate	134,088.57	26.241
4	High	18,493.78	3.619
5	Very high	0.03	0.00001
	Total	510,988.87	100.000

Source: RPSDA WS Lasolo Konaweha, 2024

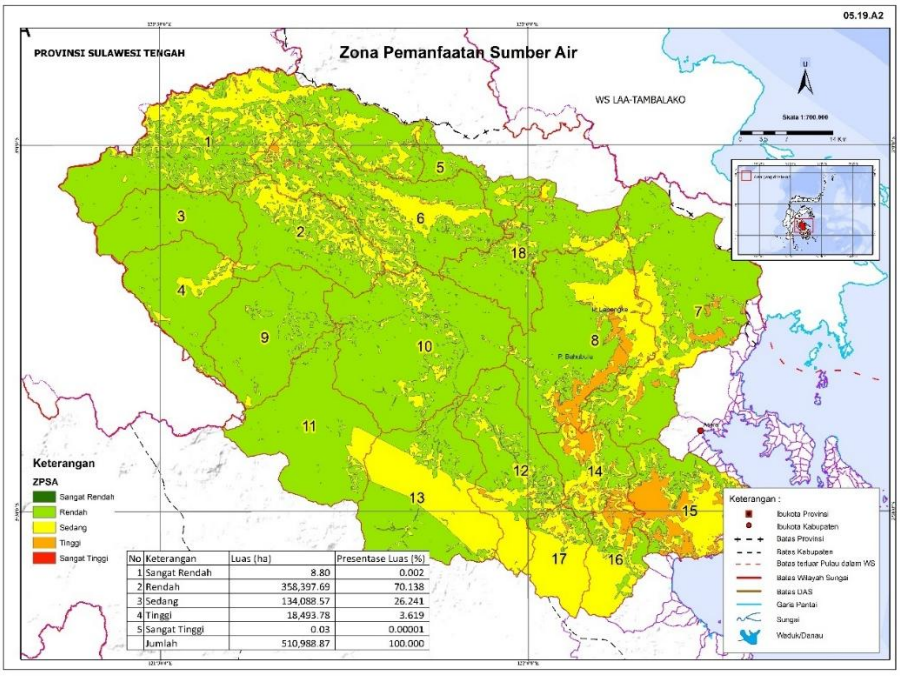

Figure 5. Map of ZPSA in Lasolo Watershed

Source: own study, 2025

The suitability of the quality and quantity of water allocation in water source (X2.4): the score for this indicator is 1.

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Ability of Raw Water Supplying

Feasibility and Safety Degree of Drinking Water (X25): based on the RPJMD 2020-2024 shows that the percentage is 90.84%, so the score of this category is 5.

The ratio of irrigation area that the availability of water is guaranteed by water artificial reservoir/ storage/ groundwater with total area of surface irrigation (X26): the score of sub-watersheds that have irrigation area is 3 that are Sub DAS 8, Sub DAS 14, and Sub DAS 15. Table 3 presents the reliability of irrigation water.

Table 3. Reliability of Irrigation Water

Water allocation		Yearly average				Success times teps	
		Demand	Shortage	Demand	Shortage	number	rate
Node Index and name		(Mem)	(Mem)	(m3/s)	(m3/s)	(-)	(%)
488	DI_Kota_Maju_Kab_Node488	2.203	0.074	0.07	0.002	503	95.3
489	DI_Parudongka_Kab_Node489	0.373	0	0.012	0	528	100
490	DI_Routa_Kab_Node490	0.047	0	0.001	0	528	100
491	DI_Linomulyo_Kab_Node491	0.675	0.005	0.021	0	522	98.9
492	DI_Puuhalu_Kab_Node492	2.264	0.07	0.072	0.002	507	96
493	DI_Lameuru_Kab_Node493	0.084	0.001	0.003	0	518	98.1
494	DI_Andowia_Kab_Node494	0.529	0.01	0.017	0	519	98.3
495	DI_Awila_Kab_Node495	0.37	0.006	0.012	0	517	97.9
496	DI_Belalo_Kab_Node496	0.03	0	0.001	0	524	99.2
497	DI_Lembo_Kab_Node497	0.142	0.004	0.005	0	508	96.2
498	DI_Pakujaya_Kab_Node498	7.407	1.112	0.235	0.035	442	83.7

Source: RPSDA WS Lasolo Konaweha, 2024

The achievement of agriculture indexes every year in the whole irrigation areas in Indonesia (X27): the score for sub-watersheds that have irrigation area is 5.

The reliability of industry water availability (X28): from the analysis result there is obtained that the fulfilment of water demand in Lasolo Watershed for industry, domestic, and urban is > 90%, so the score is 5. Table 4 presents the result of water demand fulfilment in Lasolo Watershed.

Table 4. Result of Water Demand Fulfillment in Lasolo Watershed

Water allocation		Yearly average				Success times teps	
		Demand	Shortage	Demand	Shortage	number	rate
Node Index and name		(Mem)	(Mem)	(m3/s)	(m3/s)	(-)	(%)
270	Inds_Kec_Bangku_Timur_Node270	0.379	0.002	0.012	0	525	99.4
271	Kec_Bangku_Timur_Node271	0.221	0	0.007	0	528	100
272	Kec_Bahodopi_Node272	1.515	0.003	0.048	0	524	99.2
273	Kec_Routa_Node273	0.252	0	0.008	0	528	100
274	Inds_Kec_Molawe_Node274	0.189	0.003	0.006	0	517	97.9
290	Inds_Kec_Lasolo_Node290	0.189	0.001	0.006	0	524	99.2
412	Inds_Kec_Landawe_Node412	0.189	0.001	0.006	0	525	99.4
413	Inds_Kec_Oheo_Node413	0.189	0.001	0.006	0	522	98.9
414	Inds_Kec_Asera_Node414	0.189	0	0.006	0	528	100
415	Inds_Kec_Andowia_Node415	0.189	0.001	0.006	0	525	99.4
417	Inds_Kec_Wawolesea_Node417	0.189	0	0.006	0	527	99.8

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Source: RPSDA WS Lasolo Konaweha, 2024

The reliability of urban water availability (X29): from the analysis result there is obtained that the fulfilment of water demand in Lasolo Watershed for industry, domestic, and urban is > 90%, so the score is 5.

Population that has obtained the water access for reaching the feasible sanitation target (X20): based on the data in population number, Konawe Regency has the access to the feasible sanitation is about 90.5% and Konawe Utara is about 82.74%, so the score for this indicator is 5.

Percentage of villages that have ODF (X2.11): the score for this indicator is 1.

The availability of raw water supplying that prioritizes surface water (X2.12): based on the data inventory result, the average of surface water supplying reaches 58.32%, so the score is 5. Table 5 presents the percentage of water demand fulfillment through surface water.

Table 5. Percentage of Water Demand Fulfillment through Surface Water

No	Regency/ City			Water demand of RKI (m^3/s)	Clean Water Supply (m3/det)	Perecentage of supply (%)	Feasibility of clean water (%)
1	Kolaka Timur			0.210	0.085	40.421	97.610
2	Konawe			0.695	0.306	44.003	86.260
3	Konawe Selatan			0.249	0.203	81.572	89.750
4	Konawe Utara			0.219	0.303	138.633	89.020
5	Kendari			0.459	0.208	45.289	95.270
6	Morowali			0.145	-	-	91.910
Total				1.977	1.105	58.320	91.637

Source: Water Resources Management Plan for the Lasolo Konaweha River Basin, 2024

Efficiency of Water Use

- Efficiency of water use for paddy ($X_{2.13}$): based on the inventory result in analysis of irrigation water reliability in the regency authority, the irrigation water availability reaches > 80%, so the score of sub watersheds that have irrigation area is 5 that are Sub DAS 8, Sub DAS 14, and Sub DAS 15.

- Effectiveness of applying 3 R (Reduce, Reuse, Recycle) in industry and household ($X_{2.14}$): based on the inventory and identification there are no 3 R in industry as well as household, so the score for this indicator is 1.

- The degree of water losses that is reduced ($X_{2.16}$): the average of water losses degree in PDAM Southeast Sulawesi is about 57.99% (PDAM Pohara branch, Kendari, Southeast Sulawesi, 2024), so the score for this indicator is 1.

Development of Water Resources

- The implementation of Water Resources Management Plan into Water Resources Program ($X_{2.17}$): based on the data inventory result, BWS Sulawesi IV has 4 of 5 data that are needed above, so the percentage is 80% and the score is 5.

- Area of swamp irrigation network for agriculture ($X_{2.18}$): based on the inventory result from land cover and irrigation area, there is no swamp in Lasolo watershed, so the score is 1.

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- The usage of alternative irrigation technology ($X_{2.19}$): based on the data inventory and identification, there is no technology for alternative irrigation, so the score for this indicator is 1.

- The availability of water transport mode in river, canal, lake, reservoir, and swamp ($X_{2.20}$): based on the inventory result there is transportation mode in the estuary of Lasolo River (Sub DAS 15), so the score of Sub DAS 15 is 5.

- The utilization of water resources for electrical energy (PLTA) and micro-hydro power (PLTMH) ($X_{2.21}$): based on the data inventory result, there is no PLTMH as well as PLTA in Lasolo Watershed, for the projection there is development plan of Lasolo Dam that has the electric potency of 143 MW, so the score for this indicator is 1.

- The usage of appropriate technology in fulfilling drinking water demand ($X_{2.22}$): based on the inventory result, there has not been the usage of appropriate technology in fulfilling water demand, so the score is 1.

- The effectiveness of the usage of climate modification technology (TMC) ($X_{2.24}$): based on the inventory result, there has not been the usage of climate modification technology, so the score is 1.

- Intensity of the technology application of artificial groundwater ($X_{2.24}$): based on the inventory result, there has not been the technology usage of artificial groundwater, so the score of this indicator is 1.

The Ability of Control to the Utilization of Water Resources for Activity

- The ability of control to the mining minerals activity on water resources ($X_{2.25}$): based on the data that is sourced from Directory of Mining Company, Southeast Sulawesi 2023, there are 71 legal companies of mining minerals that are operated in the region of Konawe Utara Regency. In addition, based on the data from Unit Team of Rekomtek Sulawesi IV Kendari, there are 4 mining business-galian C that have obtained the permission of rekomtek. For the illegal mining data, there is no data information, So, the score of this indicator is 3.

- The ability level of water allocation management for business activity and groundwater licensing ($X_{2.26}$): based on the inventory result, there has been analyzed the water allocation/ RAAT for Lasolo Watershed, with the value of K (factor of water allocation) is > 75%, so the score of this indicator is 5.

- Ratio of the volume of legal groundwater taking to the volume of total groundwater taking ($X_{2.27}$): based on the inventory result for Lasolo watershed, the score of groundwater taking is 1.

Aspect of Water Damage Control (X_3)

Aspect of water damage control (X_3) has 20% weight that consists of 3 indicators and 12 sub-indicators.

Prevention of Water Damage

- Ratio of flooded area to the total of river region area ($X_{3.1}$): based on the inventory result of Sub watershed, flooded area consists of Sub DAS 5, Sub DAS 7, and Sub DAS 8, with the inundation category from moderate until high with the inundation area is > 20%, so the score of this indicator is 5. Figure 6 presents the map of flood prone area in WS Lasolo Konaweha.

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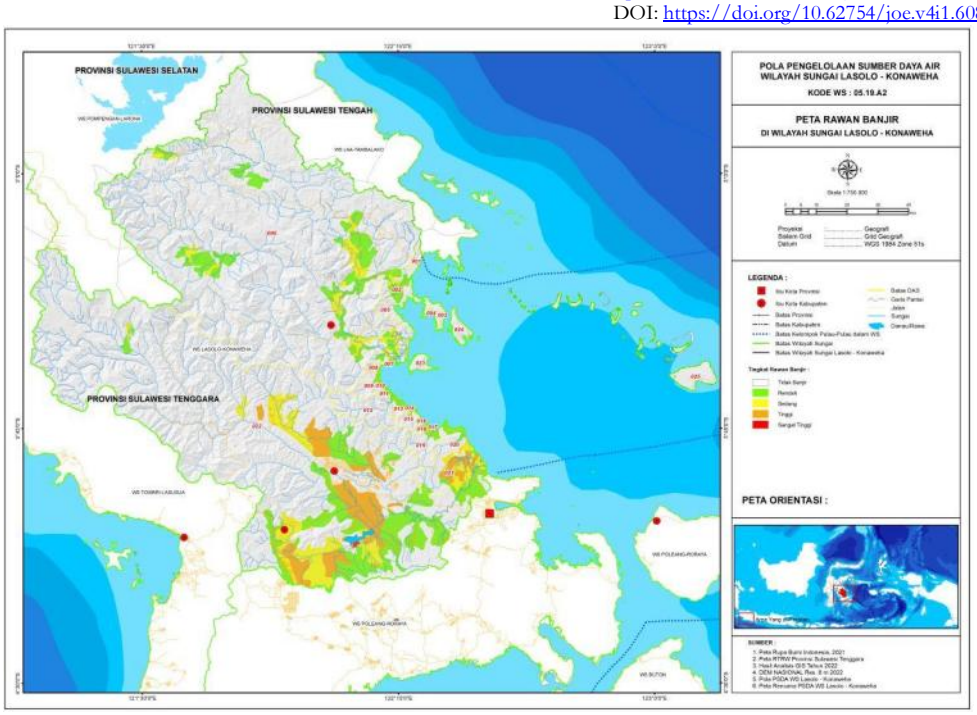

Figure 6. Map of Flood Prone Area in WS Lasolo Konaweha

Source: Water Resource Management Pattern of The Lasolo Konaweha River Basin, 2022

- Ratio of urban drainage control based on the National Standard of Urban Main Drainage Network, there has not been achievement data, so the score is 1.

- Level of society adaptation resilience and ability to flood ($X_{3.3}$): based on the analysis result, there is no data of the number of adaptavie structure to flood, so the score is 1.

- Ratio between irrigated rice area that experiences Puso and irrigated rice area that experiences drought ($X_{3.4}$): data that is used for measuring is irrigated rice area that experiences Puso due to the drought and irrigated rice area that experiences drought. Based on the data inventory results, a score of 1 is given.

- Ratio between irrigated rice area that experiences Puso and irrigated rice area that experiences flooding ($X_{3.5}$): the analysis uses space pattern that is defined by map of vulnerable inundation that has been verified by field condition. Figure 7 presents the overlay between flood prone area and space pattern. Based on the data inventory results, a score of 1 is given.

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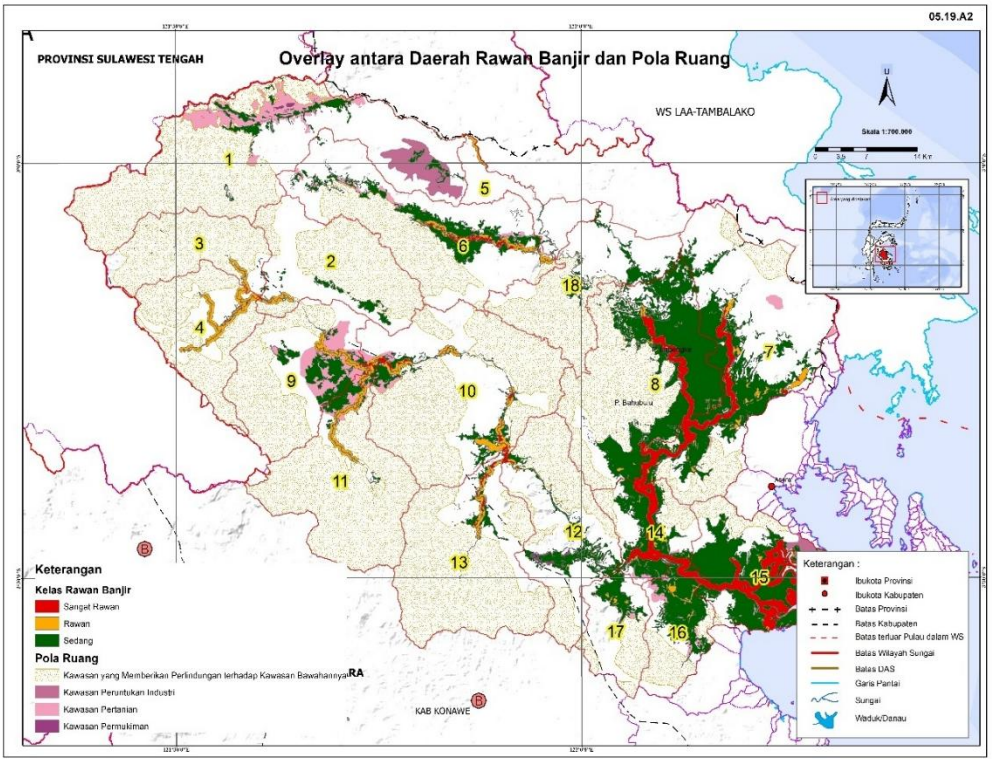

Figure 7. Overlay between Flood Prone Area and Space Pattern

Source: own study, 2025

- The effectiveness of reforestation and greening implementation ($X_{3.6}$): data that is used for measuring this parameter is the increasing of reforestration and greening area and planned area of reforestration and greening. Based on the data inventory results, a score of 1 is given.

- Flood due to the unsuitable between space utilization in area map of vulnerable flood ($X_{3.7}$): data that is used for measuring the sub-indicator is area that is developed in the vulnerable flood area that is not suitable for its designation ($X_{3.7}$): data that is used for measuring the sub-indicator is developed area in vulnerable flood area that is not suitable with its designation, and area that is determined as the vulnerable flood area. Based on the analysis results, a score of 1 is given.

Countermeasures of Water Damage

- The percentage between river that has had the early warning system and total number of rivers ($X_{3.8}$): data that is used for measuring the parameter is number of rivers that has had early warning system and total number of rivers. For the Lasolo Watershed, there is no early warning system in place, so a score of 1 is given.

- Ratio between the budget of emergency countermeasures that is prepared by budget total of demand for disaster countermeasures ($X_{3.9}$): data that is used for measuring the parameter is the available budget of emergency countermeasures and budget total for disaster countermeasures. Based on the data analysis results, a score of 3 is given.

- Level of velocity in giving the rapid response to the flood disaster ($X_{3.10}$): parameters that is used is velopcity in giving response and sending staf and emergency response help to disaster location. In giving a response, a score of 5 is given.

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Ability Level of the Recovery of Water Damage Impact

- Velocity of damage rehabilitation, reconstruction, and recovery of life environment function ($X_{3.11}$): parameter that is used for measuring the sub indicator is ratio between allocation of APBN and proposal of budget. Based on the data analysis results, a score of 1 is given.

- Ability level of the recovery of social and psychology impact ($X_{3.12}$): parameter that is used for assessing this sub indicator is ratio between number of families that obtain the recovery program to the total number of impacted families. Based on the data analysis results, a score of 1 is given.

Aspect of Society Participation (X_4)

Aspect of society empowerment (X_4) has 15% weight that consists of 4 indicators and 16 sub indicators.

Coordination and Intergration in Managing Water Resources and Institution

- Effectiveness of the coordination role and function of national water resources council and TKPSDA ($X_{4.1}$): data that is used for measuring the parameter is the result of evaluation about how far the Jaknas Matrix has been implemented by Ministry/ institution that is as the member of DSDAN such as the average percentage of the programs realization of ministry/ institution that is in accordance with Jaknas. Based on the data analysis results, a score of 3 is given.

- Performance of province water resources council in implementing the coordination role in province level ($X_{4.2}$): data that is used for measuring the parameter is participation level (presence level) of province water resources council member, product, and frequency of meeting that is carried out. Based on the data analysis results from TKPSDA WS Lasolo Konaweha, a score of 1 is given.

- Performance of water resources management institution in river region ($X_{4.3}$): data that is used for measuring the sub indicator is the assessment result of river basin organization performance by team of assessor. Based on the identification results, a score of 3 is given.

- Level of groundwater management service through stance and increasing the CAT institution in CAT priority region ($X_{4.4}$): parameter that is used is number of CAT priority that is managed by CAT institution and number of CAT institutions. Based on the data analysis results, a score of 1 is given.

- Effectiveness of coordination and synchronization in increasing the capacity of water resources and swamp management institution ($X_{4.5}$): data that is used is percentage of programs, activities, and budgets that are planned. Based on the recapitulation results, a score of 3 is given.

Consistance of Stakeholder Role in Managing Water Resources

- The effectiveness of stakeholder role in setting the pattern and plan of water resources management in river region, and in implementing the construction and non-construction, and operation and maintenance of water resources facility ($X_{4.6}$): parameter that is used is the percentage of presence intensity of TKPSDA member in discussing the setting of pattern and plan (frequency of presences, number of presences, and duration of presences). Based on the data analysis results, a score of 5 is given.

- Satisfaction level of the beneficiary of water service (clean water/ drinking water) ($X_{4.7}$): parameter that is used is ratio between SPAM organizer with healthy performance and number of available SPAM organizers. Based on the data analysis results, a score of 4 is given.

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- Activity level of stakeholder in managing groundwater ($X_{4.8}$): parameter that is used is the role of stakeholder through the coordination of groundwater management. Data that is used for measuring the sub-indicator is number of coordination meetings that are carried out in one year. Based on the data inventory results, a score of 1 is given.

- Capacity of the construction and empowerment of water resources management institution ($X_{4.9}$): parameter that is used for assessing this sub indicator is the capacity increasing of the construction and empowerment of water resources management institution. Data that is used for measuring this sub indicator is number of provinces that integrate the construction and empowerment activities of water resources management institution in the regional development plan. Based on the data analysis results, a score of 5 is given.

- Capacity of society and the manager institution of forest and area in rehabiliting forest and area ($X_{4.10}$): parameter that is used is area percentage that integrate the acitivity of society empowerment and institution development in rehabiliting forest and area in the design document of regional development, performance of society and institution in rehabiliting forest and area, area total of group work area that is compared with target area of RHL. Based on the data analysis results, a score of 4 is given.

- Performance of society group in rehabiliting forest and area ($X_{4.11}$): parameter that is used is the assessment to the performance of forest and area rehabilitation by society group that is based on the growth percentage of crop that is planted. Data that is used is total number of life crop and total number of crops that are planted. Based on the data analysis results, a score of 1 is given.

- Ratio of group work area and target area of RHL ($X_{4.12}$): data that is used for measuring the parameter is total area of RHL that is reached by the society group and target area of RHL. Based on the data analysis results, a score of 1 is given.

Activity Intensity of Stakeholder in Supervision of Water Resources Management

- Effectiveness of the coordination role and function of national water resources council, Province water resources council and TKPSDA ($X_{4.13}$): data that is used for measuring the parameter is number of reports/ complaints that have been followed up, and number of reports/ complaints that are entered. Based on the recapitulation results, a score of 1 is given.

Empowerment of Stakeholder and Law Enforcement

- The empowerment of stakeholder in managing water resources ($X_{4.14}$): data that is used for measuring the parameter is number of empowerment activities for managing water resources in one year. Based on the data analysis results, a score of 1 is given.

- Effectiveness of law enforcement related with water resources management ($X_{4.15}$): data that is used for measuring the parameter is number of violation cases that are reported and number of violatin actions in managing water resources. Based on the data analysis results, a score of 1 is given.

- Ratio between number of available PPNS and standard demand of PPNS in every institution ($X_{4.16}$): data that is used is number of available PPNS and number of OONS demand in every institution (BWS/ BWS Sulawesi IV Kendari) which is related with water resources management. Based on the data analysis results, a score of 1 is given.

Information System of Water Resources (SISDA) and Management of SISDA (X_5)

Aspect of information system (X_5) has 10% weight that consists of 3 indicators and 6 sub-indicators.

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Coordination and Intergration in Managing Water Resources and Institution

- The effectiveness of the manager institution of information and data ($X_{5.1}$): data that is used for measuring the parameter is unit number of center/ regional governments and publics as the SISDA data that have been combined in SIH3. Based on the data analysis results, a score of 4 is given.

Network of Sisda

- Effectiveness of SISDA network ($X_{5.2}$): data that is used for measuring the parameter is number of active networks and number of the whole networks. Based on the data analysis results, a score of 4 is given.

- The development of cooperation network ($X_{5.3}$): data that is used for measuring the parameter is affordability of SISDA networks based on the hierarchy of government. Based on the data analysis results, a score of 5 is given.

- The involvement of private sector or society in the SIDA network ($X_{5.4}$): data that is used for measuring the parameter is the involvement of private sector and or society group in data and or information exchange. Percentage of the number of private stations that are enters into coorporation stations is compared with number total of government stations and number of private stations that enter into BMKG stations network. Based on the data analysis results, a score of 1 is given.

Information Technology in the SISDA

- The effectiveness of data exchange and update ($X_{5.5}$): data that is used for measuring the parameter is system of data or information exchange and update. Based on the data analysis results, a score of 1 is given.

- Online information technology related with water resources that is developed and expediency of information technology for increasing the accessibility ($X_{5.6}$): data that is used for measuring the parameter is online information technology that is used. Based on the data analysis results, a score of 5 is given.

Assessment Result Recapitulation of Water Resilience Index in Lasolo Watershed

Recapitulation of the assessment result of water resilience index in Lasolo watershed is presented in Table 6 and Figure 8.

Table 6. Recapitulation of Water Resilience Index Analysis in Lasolo Watershed

NO.	Sub watershed	Conservation of water resources	Utilization of water resources	Damage Control	Participation of society	SISDA	Total of score	Explanation
1	SUB DAS 01	0.44	0.56	0.37	0.34	0.35	2.06	Prone
2	SUB DAS 02	0.41	0.56	0.40	0.34	0.35	2.06	Prone
3	SUB DAS 03	0.41	0.56	0.38	0.34	0.35	2.04	Prone
4	SUB DAS 04	0.41	0.56	0.43	0.34	0.35	2.09	Prone

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NO.	Sub watershed	Conservation of water resources	Utilization of water resources	Damage Control	Participation of society	SISDA	Total of score	Explanation
5	SUB DAS 05	0.46	0.56	0.30	0.34	0.35	2.01	Prone
6	SUB DAS 06	0.44	0.56	0.38	0.34	0.35	2.08	Prone
7	SUB DAS 07	0.39	0.58	0.30	0.34	0.35	1.96	Danger
8	SUB DAS 08	0.41	0.69	0.30	0.34	0.35	2.09	Prone
9	SUB DAS 09	0.41	0.56	0.37	0.34	0.35	2.02	Prone
10	SUB DAS 10	0.41	0.56	0.37	0.34	0.35	2.02	Prone
11	SUB DAS 11	0.41	0.56	0.43	0.34	0.35	2.09	Prone
12	SUB DAS 12	0.39	0.58	0.37	0.34	0.35	2.03	Prone
13	SUB DAS 13	0.41	0.56	0.37	0.34	0.35	2.02	Prone
14	SUB DAS 14	0.48	0.69	0.37	0.34	0.35	2.23	Prone
15	SUB DAS 15	0.42	0.73	0.37	0.34	0.35	2.21	Prone
16	SUB DAS 16	0.46	0.58	0.38	0.34	0.35	2.11	Prone
17	SUB DAS 17	0.48	0.58	0.38	0.34	0.35	2.13.	Prone
18	SUB DAS 18	0.48	0.58	0.43	0.34	0.35	2.18	Prone

Source: own study, 2025

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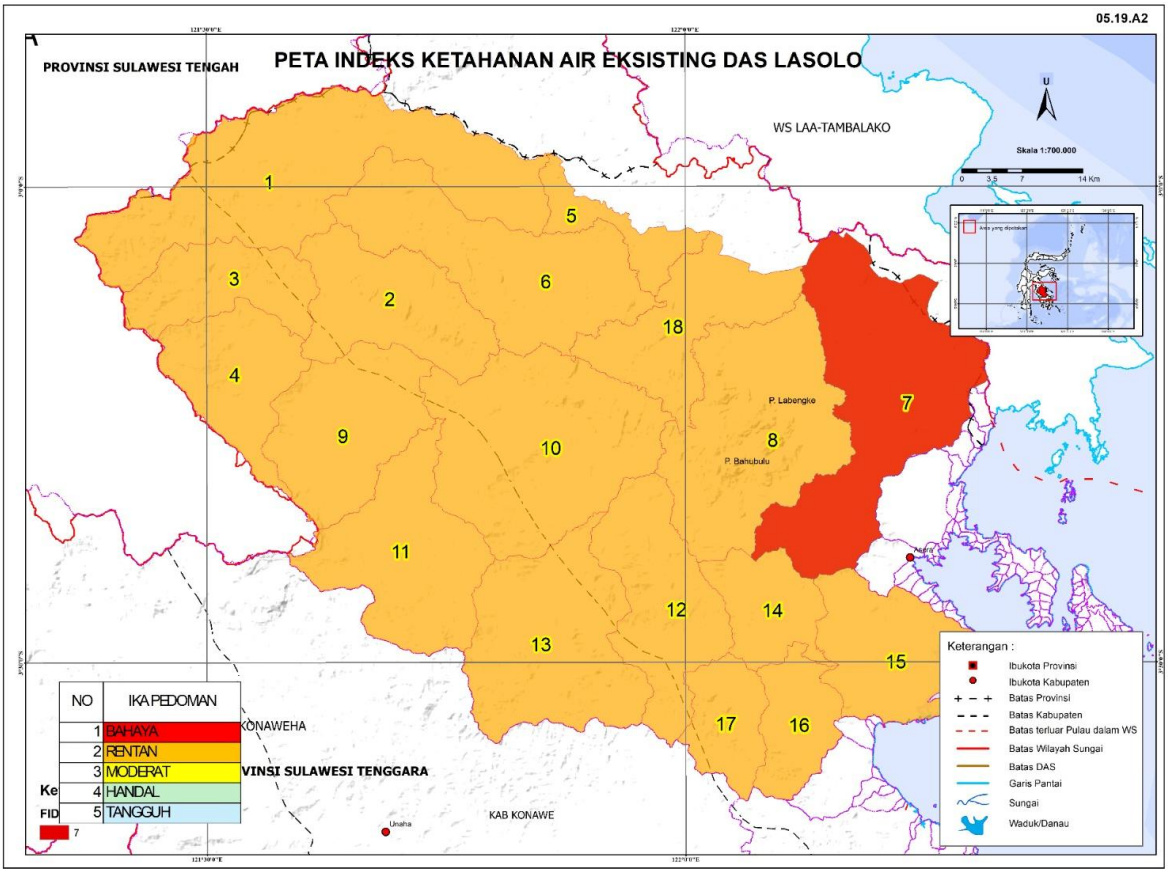

Figure 8. Map of Water Resilinece Index Due to Existing Condition in Lasolo Watershed

Source: own study, 2025

Conclusion

The assessment of water resilience index in Lasolo watershed is based on the assessment of aspects as follows: 1) conservation of water resources (3 indicators and 17 sub-indicators), 2) utilization of water resources (6 indicators and 27 sub-indicators), 3) damage control (3 indicators and 12 sub-indicators), 4) participations of society (4 indicators and 16 sub-indicators), and 5) information system of water resources (3 indicators and 6 sub-indicators). The assessment is carried out in 18 sub-watersheds in Lasolo watershed. The results are as follows: the 17 sub-watersheds inducate the condition of water resilience is prone (score: 2.1-3.0) and 1 sub-watershed indicates the condition of water resilience is danger (score 0.0-2.1).

This assessment is based on the technical guidelines that is applies in Indonesia based on the consensus. Therefore, it is needed to build a performance index model of water resilience based on the scientific study which will be carried out in further research.

References

ADB. (2016). Indonesia Country Water Assessment. Asian Development Bank.

Al-Addous, M., Bdour, M., Rabaiah, S., Boubakri, A., Schweimanns, N., Barbana, N., and Wellmann, J. (2024). Innovations in Solar-powered Desalination: A Comprehensive Review of Sustainable Solutions for Water Scarcity in the Middle East and North Africa (MENA) Region. Water, 16(13), 1877.

Journal of Ecohumanism
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DOI: https://doi.org/10.62754/joe.v4i1.6089

Asmaranto, R., Fidari, J.S., Sari, R.R., and Pramesti, M.Y. (2023). Storm Water Management Model to Evaluate Urban Inundation in Lowokwaru and Blimbing Sub-catchements in the City of Malang. IOP Conference Series: Earth and Environmental Science, 2023, 1311(1).

Beek, E. van, and Arriens, W. L. (2014). Water Security: Putting the Concept into Practice. Global Water Partnership.

Gain, A. K., Giupponi, C., and Wada, Y. (2016). Measuring Global Water Security towards Sustainable Development Goals. Environmental Research Letters, 11(12), 124015. https://doi.org/10.1088/1748-9326/11/12/124015

Grey, D., and Sadoff, C. (2007). Sink or Swim? Water Security for Growth and Development. Water Policy, 9. https://doi.org/10.2166/wp.2007.021

He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J., and Bryan, B. A. (2021). Future Global Urban Water Scarcity and Potential Solutions. Nature Communications, 12(1), 4667.

He, L., and Rosa, L. (2023). Solutions to Agricultural Green Water Scarcity under Climate Change. PNAS nexus, 2(4), pgad117.

Ingrao, C., Strippoli, R., Lagioia, G., and Huisingh, D. (2023). Water Scarcity in Agriculture: An Overview of Causes, Impacts and Approaches for Reducing the Risks. Heliyon.

Langarudi, S. P., Maxwell, C. M., and Fernald, A. G. (2021). Integrated Policy Solutions for Water Scarcity in Agricultural Communities of the American Southwest. Systems, 9(2), 26.

Mason, N., and Calow, R. (2012, October). Water Security: From Absract Concept to Meaningul Metrics. https://media.odi.org/documents/7865.pdf

Padder, F. A., and Bashir, A. (2023). Scarcity of Water in the Twenty-first Century: Problems and Potential Remedies. Medalion Journal: Medical Research, Nursing, Health and Midwife Participation, 4(1), 1-5.

Penetewati, P., Juwono, P.T., Limantara, L.M., and Sholichin, Moh. (2024). Performance Index Model of Smal Dam in Semi-Arid Area. Civil Engineering Journal, 10(8), 2656-2660.

Sudiarti, S.U., Andawayanti, U., Limantara, L.M., and Siswoyo, H. (2024). Performance Index Model of Raw Water Infrastructure. Civil Engineering Journal, 10(6), 1936-1952.

Tian, Y., Hu, H., and Zhang, J. (2017). Solution to Water Resource Scarcity: Water Reclamation and Reuse. Environmental science and pollution research, 24, 5095-5097.

Tzanakakis, V. A., Paranychianakis, N. V., and Angelakis, A. N. (2020). Water Supply and Water Scarcity. Water, 12(9), 2347.