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DETERMINING THE STATUS OF THE SETIAMANAH RESERVOIR ECOSYSTEM IN CIMAHI CITY OF WEST JAVA PROVINCE

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ABSTRACT: Water availability in Cimahi City is increasingly threatened, so efforts are needed to increase the number of water sources to meet the increasing needs of the population. One of the efforts is to find a reservoir that can be used as a water source. Setiamanah Reservoir is one of the reservoirs that will be utilized. This research aims to evaluate the reservoir ecosystem according to the assessment guidelines issued by the Ministry of Environment of the Republic of Indonesia. The assessment uses parameters grouped into aquatic, border, and terrestrial ecosystems. Based on the research results, Setiamanah Reservoir Ecosystem has been damaged. Aquatic ecosystems categorized as damaged are trophic status, biodiversity, and food web. The bordering ecosystem is categorized as damaged, especially for land use conditions at the border and waste disposal. Terrestrial ecosystems are categorized as threatened for vegetation cover on catchment area land and are included in the damaged category for the impact of the siltation of reservoirs and dumps. The cause of the damage is mainly the settlements in the riparian areas and water catchment areas, which continue to experience an increase. In 2022, 68.19% of the reservoir boundaries will be residential. The settlement is not equipped with a domestic wastewater management system, so the accumulated wastewater enters the reservoir. This causes the aquatic ecosystem to be disrupted. Improvements are made in managing domestic wastewater, especially in the riparian and water catchment areas.

Keywords: Cimahi, Setiamanah Reservoir, Ecosystem, Aquatic, Terrestrial

1. INTRODUCTION

Cimahi City is one of the cities in West Java Province experiencing rapid development. In 2020 the population will be 553,755 people, with an average growth of 2.32% annually. Population growth increases the need for clean water. Cimahi City's raw water is experiencing a decline in quality and quantity, especially from river water [1]. The quality of river water in Cimahi City is heavily polluted due to domestic and agricultural activities [1]. While the quantity of river water in Cimahi City decreases during the dry season, during the rainy season, it can cause flooding in several areas due to a lack of water absorption and changes in land use. Groundwater has experienced a decrease in water quality due to excessive exploitation for domestic and industrial needs, which is exacerbated by the conversion of catchment areas into concrete areas [2]. Steps to anticipate this, the Cimahi City Environmental Service plans to revitalize the reservoir or lake, which is used as an addition to raw water reserves.

According to [3], reservoirs are water conservation buildings in the form of reservoirs. During the rainy season, the reservoir is used for rainwater, runoff water, and others. While during the dry season, the reservoir is used to meet the needs of the surrounding community. The reservoir in Cimahi City consists of eight reservoirs, one of which is the Setiamanah Reservoir. The Setiamanah Reservoir is in Setiamanah Village, Central Cimahi District, West Java. Based on the Cimahi City Regional Environmental Management Performance Information Document for 2020, Setiamanah Reservoir has an area of 0.04 ha with a volume of 1,204.5 m^3 used for residential areas. Currently, the Setiamanah Reservoir is only used as a water reservoir. Setiamanah Reservoir needs to be revitalized for the short term to the long term for the infrastructure that has been built to be used as well as possible. The stages in carrying out revitalization or improvement efforts are to determine the ecosystem status of each of these reservoirs. Ecosystem types include aquatic, border and terrestrial ecosystems in the water catchment area. This research aims to determine the quality status of the Setiamanah Reservoir ecosystem. The quality status criteria analyzed were aquatic, border and terrestrial ecosystems.

Research on reservoir studies has been carried out in various regions. Research on the water quality of the Saguling reservoir as the main water source in West Java Province concluded that heavy metal contamination had occurred in the water body. Cr, Cd, Cu, and Pb contamination loads were detected in large quantities. This study did not review the boundary and terrestrial conditions, so the potential pollution load is unknown [4,5]. Another study was conducted at Lake Rawa Besar, Depok, West Java. This study examines the relationship between water quality and land use in catchment areas [6]. Research conducted at Lake Rawa Besar linked lake water quality to land use in the catchment area. The research did not analyze the aquatic ecosystem parameters completely. Research is carried out to analyze water quality, water conditions, and calculation of pollution loads, as we can see in [7,8]. The research conducted for Setiamanah Reservoir was carried out based on guidelines issued by the Indonesian Ministry of Environment. The assessment parameters cover three aspects: waters represented by aquatic ecosystems and pollution that occurs in the water catchment area represented by the assessment of border and terrestrial ecosystems.

The benefits of research are determining the condition of the Setiamanah Reservoir ecosystem, including aquatic, border and terrestrial ecosystems. The information obtained can be used as basic data for better reservoir management.

2. RESEARCH SIGNIFICANCE

Setiamanah Reservoir has an important role in the daily life of the people around its catchment area. The current condition is experiencing serious degradation due to anthropogenic activities. Each reservoir has its own characteristics, morphogenesis, morphology, and socio-economic. Therefore, the problems that occur in each reservoir also vary, depending on the physical, social, and economic characteristics of each. This research is very important to help decision-makers and increase public awareness about the importance of lake ecosystem management that focuses on an ecological approach to water resource management to provide sustainable water for the community.

3. RESEARCH METHODS

To determine the status of the reservoir ecosystem, an assessment was carried out on 3 locations, namely the status of the aquatic, border and terrestrial ecosystems. Each ecosystem assessment is further detailed in the form of several parameters. The assessment criteria are divided into three levels for each ecosystem status parameter: good, threatened, and damaged [9].

3.1 Determination of Aquatic Ecosystem Status

Reservoir parameter criteria for aquatic ecosystems consist of trophic status, water quality status, biodiversity, food web, a cover of aquatic plants, algae/blue algae (microcytic), and aquaculture feed waste are seen in Table 1. Data on biodiversity, food web, aquatic plant cover, and aquaculture feed waste were obtained by observing the field while determining the presence of algae/blue algae [9].

Determination of water quality status in the Setiamanah Reservoir uses the Pollutant Index Method referring to [10] concerning Guidelines for Determining Water Quality Status. The water quality standard used is in [7] for lake water and the like. The data comes from the Cimahi City Environment Service in October 2021 and April 2022. The pollutant index calculation results are compared with a value of $0 \leq PIj \leq 1.0$, including the category of meeting quality standards (good condition); $1.0 < PIj \leq 5.0$ mildly polluted; $5.0 < PIj \leq 10$ moderately polluted; and $PIj > 10$ severely polluted [10].

The trophic status shows the impact of the load of nutrient waste that enters the Setiamanah Reservoir water. This trophic status is determined using the parameters Total N, Total P, Chlorophyll-a and brightness. The steps for determining the trophic status of the reservoir using the UNEP-ILEC method are presented in Table 2.

3.2 Boundary Ecosystem Status Determination

The assessment of the riparian ecosystem is seen from the presence or absence of water structures at the riparian location, the presence of land management at the tidal border, the presence of wastewater disposal, and the utilization of lake water for hydroelectric power and raw water.

The criteria for assessing the status of the bordering ecosystem can be seen in Table 3. Data collection was carried out using field conservation and aerial photography. This aerial photography activity was carried out on Monday, July 4, 2022. The research method was based on the DJI Phantom 4 Pro drone mapping survey. The first stage in the field is preparing the shooting equipment.

Tools such as Unmanned Aerial Vehicles (UAV), smartphones, spare batteries and drone applications deploy to determine the flight path and altitude. The flight distance used when shooting aerial photos is 70 meters above sea level. The object under study is the boundary area of the reservoir with a distance of 100 meters from the point of the reservoir, based on the Regulation of the Minister of Public Works and Public Housing No. 28 of 2015 concerning the Stipulation of River Boundary Lines and Lake Boundary. Lake border lines are determined to encircle reservoirs at least fifty meters from the edge of the highest water level that has ever occurred (the boundary of the body of the lake/reservoir/reservoir) and cover land vegetation in the catchment area [11,12].

3.3 Terrestrial Ecosystem Status Determination

The criteria for reservoir parameters for terrestrial ecosystems consist of vegetation cover in the catchment area, river regime coefficients, land erosion in the catchment area, the impact of siltation of the reservoir, and waste disposal, as in Table 4. Land vegetation cover uses Digital Elevation Model (DEM) data for 2018 compared to 2022 aerial photo data. Based on [13] concerning monitoring and evaluation of watershed management.

Table 1 Aquatic ecosystem status criteria

Lake Parameters	Lake Ecosystem Status		
	Good	Threatened	Damaged
Aquatic Ecosystem			
Trophic status	Oligotrophs-Mesotrophs	Eutrophic	Hypereutrof
Water quality status	Unpolluted	Moderately polluted	Heavily polluted
Quality status of water biodiversity	There are still endemic and native species of fauna/flora	Reduction of endemic and native fauna/flora species	Loss of endemic and original fauna/flora species, many introduced/invasive species were found
Food web	Balanced trophic levels	The trophic levels are unbalanced	There are no trophic levels
Aquatic plant cover	Controlled does not spread and does not interfere with the function of the lake	Less controlled and disrupted the function of the lake	It spreads uncontrollably, seriously disrupting the function of the lake
Algae/blue algae	A slight	Moderate	Lively
Aquaculture feed waste	The amount of fish production and use of feed is following the capacity of the lake and permits	The amount of fish production and use of feed exceeds the capacity of funds but fulfills permits	Cultivation activities and use of feed are out of control, do not fulfill permits and do not meet the capacity of the lake

Source: [9].

Table 2 Classification of lake water trophic status UNEP-ILEC Method

Trophic Status	Average Content of Total N (μg/l)	Average Level of Total P (μg/l)	Average Level of Chlorophyll-a (μg/l)	Average Brightness(m)
Oligotrophic	≤ 650	< 10	< 2.00	≥ 10
Mesotrophic	≤ 750	< 30	< 5.00	≥ 4
Eutrophic	≤ 1,900	< 100	< 15	≥ 2.50
Hyperetrofik	> 1,900	≥ 100	≥ 200	< 2.50

Source: [10].

Table 3 Boundary ecosystem status criteria

Lake Parameters	Lake Ecosystem Status		
	Good	Threatened	Damaged
Boundary Ecosystem			
Lake border	No buildings	There is been a bit of development going on	Lots of buildings
Tidal border	No buildings There is no land management, and there are no plantations and rice fields with fertilization	There is land processing for plantations and rice fields, such as fertilization	There is a building There is land processing, and there are plantations and rice fields with fertilization
Waste disposal	There is no land management, and there are no plantations and rice fields with fertilization	There is waste disposal, and there is no water pollutant control system, but it does not exceed the capacity of pollutant	There is sewage disposal, and water pollutant control systems do not exist or are inadequate and have exceeded lake water
Utilization of lake water			
Utilization of hydropower to generate hydroelectric power	It does not change the tidal characteristics of the water level and does not disturb aquatic ecosystems	Changing the tidal characteristics of the water level but not disturbing the aquatic ecosystem	Changing hydrology and water balance so that lake water recedes drastically and disrupts aquatic ecosystems
Raw water intake	It does not change the tidal characteristics of the water level and disturb aquatic ecosystems	Changing the tidal characteristics of the water level but not disturbing the aquatic ecosystem	Changing hydrology and water balance so the lake water recedes and disrupts aquatic ecosystems

Source: [9].

Vegetation cover by land was obtained from data on the area of Permanently Vegetated Land (PVL) and the area of the water catchment area found on the land cover map (land use). Processing data using Eq. (1).

$$\boldsymbol{VCA = \frac{PVL}{Wide\ of\ DTA}\ x\ 100\%} \tag{1}$$

Where IPL is the land cover index (%), PVL is the area of permanently vegetated land (Ha), and the catchment area is the catchment area (Ha). According to [11], the river regime coefficient (RRC) is the ratio between the maximum discharge (Q_{max}) with a minimum discharge (Q_{min}) in a river flow area. The calculation to determine the river regime coefficient is presented in Eq. (2).

$$RRC = \frac{Q_{max}}{Q_{min}} \tag{2}$$

Where RRC is the coefficient of the river regime, namely the highest annual average daily discharge (Q) (m3/second), and that is the lowest annual average daily discharge (Q) (m^3/s). The Universal Soil Loss Equation (USLE) method is predicted using an erosion prediction model. This method is obtained from the relationship between several factors causing erosion based on the Wischemeier and Smith formula (1978) presented in Eq. (3).

$$A = R.K.LS.C.P \tag{3}$$

Where A is the amount of eroded soil (tons/ha/year), R is the erosivity of rain (cm), K is the erodibility of the soil, L is the length of the slope (m), S is the slope of the slope (%), C is the vegetation cover and management plants, and P is a special action factor for soil conservation [14].

4. ANALYSIS AND DISCUSSION

Setiamanah Reservoir has an area of 0.04 Ha with a depth of 3 m and a volume of 1,204.5 m^3, which the Cisangkan River functions pass as a reservoir for river water and rainwater. The reservoir is planned as a source of raw water for daily needs. The Cisangkan River is a tributary of the Citarum River in Cimahi City with a length of 4.50 km and a width of 3-7m. The Setiamanah Reservoir is in Setiamanah Village, Central Cimahi District, as shown in Figure 1.

4.1 Aquatic Ecosystem Conditions

Determination of aquatic ecosystems consists of trophic status, water quality status, biodiversity, feeding networks (food web), the cover of aquatic plants, algae/blue algae, and aquaculture feed waste. Research to determine aquatic conditions was carried out by direct observation in the field and laboratory. The results are compared with the criteria presented in Table 1.

1. Trophic status can be assessed by laboratory analysis, namely analyzing Total N, Total P, and chlorophyll-a levels, while field analysis measures the brightness.
2. Biodiversity in Setiamanah Reservoir cannot be assessed because there are no longer typical endemic flora and fauna in that environment, and the area is densely populated urban, making it impossible to have unique endemic flora and fauna still.
3. The water quality status can be determined from the reservoir water quality obtained from secondary of City Environment Service Cimahi in October and April 2022.

Table 4 Terrestrial ecosystem status criteria

Lake Parameters	Lake Ecosystem Status		
	Good	Threatened	Damaged
	Catchment Area Terrestrial Ecosystem		
Vegetation Coverage on Catchment Area Land	< 75%	30 - 75%	< 30%
Lake Entrance River Regime Coefficients	50	50 - 120%	120
Watershed Erosion	The erosion rate is still below the erosion tolerance limit	The erosion rate has matched the erosion tolerance limit	The erosion rate has exceeded the erosion tolerance limit
The Impact of Fundraising	There was no siltation	Shallowing average per year < 2% of lake depth	Silting average per year ≥ 2% of the depth of the lake Siltation causes a very shallow lake-type ecosystem to turn into a swamp ecosystem
Waste disposal	There is waste disposal, and there is a water pollution control system, and it is following the capacity to accommodate lake water pollution	There is waste disposal, and there is no water pollution control system, but it does not exceed the capacity of the lake water pollution	There is waste disposal, and the water pollution control system is not bad and has exceeded the capacity to accommodate lake water pollution

Source: [9].

Fig. 1 Location of Setiamanah Reservoir

4. Food webs, biodiversity, and aquatic plant habitats were analyzed by observing the food chains in the study area.
5. Algae/blue algae research was conducted by determining the type of algae that can be observed in the laboratory using a microscope.
6. Setiamanah Reservoir is only used as a water reservoir and is usually used for fishing ponds for residents, but these fish are not raised and bred. So, it does not result in fish production and feed use. Based on this, there is no aquaculture feed waste in the reservoir.

4.1.1 Trophic status analysis

Analysis of the trophic status of water is needed as information on the condition of the lentic ecosystem (waters that retain or have no water flow) in their utilization, such as for clean water, recreation, aesthetics, and efforts to control blooming algae [15]. Data were obtained through direct measurements in the field. Brightness parameters using tools disk buckets, Total N, Total P, and chlorophyll-a of water sampling were analyzed in Bandung Institute of Technology and Padjadjaran University laboratories. The study showed that the total P concentration was 0.17 mg/L, total N was 8.19 mg/L, chlorophyll-a was 2.19 mg/L, and brightness was 0.44 m. Based on the analysis results using Table 2, the trophic status of Setiamanah Reservoir using the UNEP/ILEC method is hypereutrophic.

Setiamanah Reservoir is hypereutrophic because it is indicated that the brightness is less than 2.50 meters. The poor brightness is affected by the shallow depth, which is caused by a large amount of water Total Suspended Matter (TSM) at the bottom of the water [15,16]. The silting that occurs in this reservoir is related to activity in the catchment area. Pollution of organic materials from domestic activities and the occurrence of erosion and sedimentation in the catchment area are the drivers of siltation in the reservoir [17,18]. Trophic status at each station based on the average content of total N is included in the eutrophic classification (a surface, mid, bottom). At each station, it shows that the waters of the Koto Panjang Reservoir have experienced eutrophication to a hypereutrophic level [17,18].

4.1.2 Water quality parameters

Based on the measurement results of 10 parameters that did not meet quality standards, including free chlorine, its dissolved Mn, Total Phosphate, Sulfide, MBAS, DO, BOD, COD, Oil and Fat, and Phenol. The quality standard refers to [19] Quality Standards for Lake Water and the Like. The quality standard used for the Setiamanah Reservoir is the class I lake water quality standard. The determination of the water quality status of the Setiamanah Reservoir uses the Pollution Index method based on [10]. The water quality status of the Setiamanah Reservoir is included in the category of moderately polluted, with a value of 8.32. The quality status of the Setiamanah Reservoir is the same as the water pollution status in Padang, Brantas, Miass, and Inklong U-Tapao Rivers [20-23].

4.1.3 Feeding network parameters (food web) and aquatic plant cover

Food chains and food webs in an aquatic lake/reservoir/reservoir play an important role in determining trophic levels. Based on observations and field interviews, the Setiamanah Reservoir did not find any fish in the reservoir because the reservoir is only used as a reservoir to store rainwater and river water from the Cisangkan River [24-25]. The cover of disturbing aquatic plants, called aquatic weeds, is an indicator in determining water fertility. The abundance of aquatic plants on the surface will cause eutrophication due to the abundance of nutrients or nutrients from nitrogen and phosphorus [26]. The existing conditions in the Setiamanah Reservoir are not covered by aquatic plants such as water hyacinth, Kiambang and other types that can disturb the reservoir's waters. This is because routine management is carried out every month on the surface of the Setiamanah Reservoir, such as cleaning leaves or trash.

4.1.4 Parameters of algae/blue algae

The plankton analysis used for this parameter is phytoplankton or microalgae with a type of blue algae because these algae can disrupt the aesthetics of lakes/reservoirs and exacerbate eutrophication [17,18]. The assessment of the status of this parameter is determined by laboratory analysis after obtaining samples obtained in the field. Based on the observations, it was found that various types of phytoplankton were in the water of the Setiamanah Reservoir. Based on the observations of phytoplankton, the classification of the Setiamanah Reservoir phytoplankton division is Euglenophyta, Cyanophyta, Bacillariophyta, Chlorophyta, and Cyanobacteria. Chlorophyta, Bacillariophyta, and Cyanophyta generally dominate Lake or reservoir waters. Chlorophyta is a green alga which, if there is a lot of water, will make the waters green.

Meanwhile, Bacillariophyta is phytoplankton better known as diatoms. The most dominant type of phytoplankton in the waters of Setiamanah Reservoir is Phormidium, Synedra, and Euglena. Phormidium was included in the division Cyanobacteria, whereas Synedra was included in the division Bacillariophyta, and Euglena was included in the division Euglenophyta. Polluted lake areas are usually found in Chlamydomonas, Euglena, Boats, Oscillatoria, Phormidium and Synedra, which can tolerate much organic matter [17,18].

Type Synedraable to survive in low nutrient or oligotrophic environmental conditions with low levels of nitrogen and phosphate as nutrients. This is because Synedra can accumulate nutrients and store them as food reserves in insoluble polymers [17,18]. This is related to the laboratory research results, which proved that Setiamanah Reservoir has a low nutrient value for Total P (0.17 mg/L) and Total N (8.19 mg/L). The results of determining trophic status using the UNEP-ILEC method for Total N and Total P indicate that the Setiamanah Reservoir waters have an oligotrophic status, and the determination of trophic status using the TSI calculation method is oligotrophic. Type Euglena is one type of phytoplankton from the division Euglenophyta which is usually found in freshwater or brackish water. Type Euglena is usually abundant in ponds or shallow waters where organic matter is indicated from animals [17,18]. Based on the research results, the Setiamanah Reservoir has a shallow depth of 3 m and is sometimes used for fishing and fish feed. This fish feed is one of the causes of high levels of Total N in the Setiamanah Reservoir, so the amount of Total N in the waters is in harmony with the number of phytoplankton species Euglena in the water. Phytoplankton types Phormidium is a division of Cyanophyta or Cyanobacteria. Cyanobacteria (blue-green algae) is included kingdom eubacteria (prokaryotes) because they can fix atmospheric nitrogen into organic nitrogen, have cell walls like gram-negative bacteria and have the main pigment, namely chlorophyll-a, and are composite or able to live in a variety of fresh, brackish and saltwater conditions with hot or cold temperatures, where other algae are unable to grow and survive [17,18]. Phytoplankton type Phormidium is the most abundant species in the waters of the Setiamanah Reservoir because it can survive in any condition and is one division of phytoplankton with microcystic.

The relationship between the existence of all types of phytoplankton and chlorophyll-a is because chlorophyll-a is the main pigment of phytoplankton growth in photosynthesis. The abundance of phytoplankton and the amount of chlorophyll-a concentration are directly proportional; the more abundant phytoplankton in the water, the greater the concentration of chlorophyll-a in the water, or vice versa. In addition to chlorophyll-a as an indicator of the abundance of phytoplankton, the water brightness parameter also affects the abundance of phytoplankton in the Setiamanah Reservoir water because brightness is very influential in the photosynthesis process of phytoplankton. Based on the results in the field at the time of sampling, the water condition of Setiamanah Reservoir is very turbid due to the amount of TSS in the waters, so there is an inhibition of the penetration of light entering the waters and inhibiting the growth of phytoplankton. Based on the analysis results that have been obtained in the determination of blue-green algae, but in the waters of Setiamanah Reservoir, this type of algae was not found, so to determine the criteria for aquatic ecosystem status for the parameters of algae/blue algae status is good. Based on the assessment results referring to Table 1, the recapitulation of the criteria for the status of aquatic ecosystems is presented in Table 5. Based on Table 5, it can be seen that the conditions of the tropics and food webs are in the damaged category, the water quality status is in the threatened category, and the cover of aquatic plants and the presence of algae/blue algae is not detected so that it is included in the good category.

4.2 Boundary Ecosystem Determination

The determination of the boundary ecosystem consists of the parameters of the lake boundary, tidal boundary, waste disposal, utilization of hydropower, and water extraction. Parameters of the bordering ecosystem that can be assessed are only the condition of the border and waste disposal around the border. The Setiamanah Reservoir boundary is in the middle of a residential area, filling the reservoir with residents' buildings. There are pipes/channels for domestic wastewater disposal that enter the Setiamanah Reservoir. Setiamanah Reservoir is a small reservoir with no tidal boundaries and no raw water intake and is not used as a hydroelectric power plant.

4.2.1 Boundary of Setiamanah Reservoir

Based on [12] concerning "Determination of River Boundary Lines and Lake Boundary Lines," lake border lines are determined to encircle the lake/reservoir at least 50 meters from the edge of the highest water level that has ever occurred (the boundary of the body of the lake/reservoir/reservoir). The Setiamanah Reservoir boundary is 100 m from each edge of the highest water level. Monitoring of the reservoir border is carried out to determine the utilization of the border used. Monitoring in this study is a qualitative descriptive method using spatial analysis techniques software ArcGIS to analyze land conversion and land area changes from 2018 (secondary data by DEMNAS) and 2022 (primary data by drones). Regional development greatly influences related aspects, one of which is land use which results in land conversion, one of the triggers for land conversion is buildings in border areas. The determination of the area of land conversion from 2018 to 2022 is listed in Table 6.

Based on Table 6, The land in the Setiamanah Reservoir border area consists of settlements, cultivation, ponds, cemeteries, gardens, and cemeteries. Based on the mapping results, there has been an increase in the area of settlements from 2018 to 2022 from 2.57 ha to 2.83 ha or 0.26 ha. The cultivated area increased from 0.37 Ha to 0.38 Ha or 0.01 Ha. The burial area decreased from 1.01 Ha to 0.82 Ha or by 0.19 Ha, and the gardens decreased by 0.08 Ha from 0.16 Ha to 0.08 Ha. Based on the identification of the use of the Setiamanah Reservoir riparian land in 2018 and 2022, there has been an increase in land use for settlements of 6.26%. Based on Table 2, the status of the bordering ecosystem is damaged if the percentage of buildings on the border is > 25%. In the existing condition, the percentage of buildings or settlements on the banks of Setiamanah Reservoir in 2018 was 61.93%, and in 2022 it was 68.19%. This shows that there are a lot of buildings in the border area, so to determine the criteria for the status of the bordering ecosystem, the status is categorized as damaged.

Table 5 Recapitulation of aquatic ecosystem status criteria

No	Aquatic Ecosystem Parameters	Research Result	Ecosystem Status
1	Trophic status	The tropical condition of Setiamanah Reservoir is in the hypereutrophic category	Damaged
2	Water quality status	The water quality status of the Setiamanah Reservoir is in the moderately polluted category	Threatened
3	Biodiversity	Loss of endemic and original fauna/flora species, many introduced/invasive species were found	Damaged
4	Food Web	There is no food web	Damaged
5	Aquatic plant cover	There is no aquatic plant	Good
6	Algae/blue algae	There are no algae/blue algae, based on observations of the classification of the Setiamanah Reservoir phytoplankton division, namely Euglenophyta, Cyanophyta, Bacillariophyta, Chlorophyta, and Cyanobacteria.	Good

Source: Results Analysis, 2022.

4.2.2 Parameters of waste disposal at Setiamanah Reservoir

The waste disposal parameters are used to identify whether or not there are sewerage channels for waste from both industrial and domestic activities that enter the Setiamanah Reservoir. This parameter is closely related to the quality of the pond's aquatic ecosystem. Based on the results of observations in the field, there is an inlet (inlet) to the Setiamanah Reservoir, which originates from the Cisangkan River, and there is a water outlet from Setiamanah Reservoir which enters the Cisangkan River. Based on the results of the interviews that have been conducted, the use of the channel aims to accommodate the water of the Cisangkan River when the water discharge is abundant and to prevent river water from overflowing, which can cause flooding.

The water quality of the Cisangkan River has been polluted. Parameters that did not meet quality standards were color, DO, total phosphate, zinc, free chlorine, fecal coliform, total coliform, oil and grease, phenol, and detergents such as MBAS, BOD, and COD. The water quality of the Cisangkan River is based on calculations using a pollutant index ranging from 7.76-8.86 with moderately polluted river quality [24,25]. The poor quality of river water causes the reservoir water to be contaminated with river water and affects the quality of the reservoir water. The results of the recapitulation of the criteria for the status of the bordering ecosystem are presented in Table 7.

4.3 Terrestrial Ecosystem Determination

Table 4 explains that the parameters used in the assessment of terrestrial ecosystems are vegetation cover in water catchment areas, river regime coefficients which explain the comparison between the river that enters the reservoir during the rainy season with during the dry season, erosion of water catchment areas, the impact of silting lakes, and waste disposal. This study cannot analyze the river regime coefficients because this research was only conducted in one season, so the average discharge for the dry and rainy seasons cannot be determined. Another parameter that cannot be calculated is the erosion of the water catchment area because the condition of the catchment area is already closed by settlements, so calculations with Eq (3) cannot be calculated.

Land vegetation cover can be determined by calculating the area of vegetation land cover based on data from the Digital Elevation Model (DEM) and aerial photography via drones. The occurrence of siltation in the Setiamanah Reservoir is determined by comparing the water depth data at the beginning of construction with the current water depth. Waste disposal in the catchment area is determined based on field observations.

4.3.1 Vegetation cover on water catchment land

The water catchment area is determined based on the lowest elevation in the area. The vegetation land in the catchment area serves attachment area for rainwater that will gather into the reservoir or seep into the ground. Land vegetation cover in the water catchment area is determined by comparing the area in 2018 using maps sourced from DEM data and in 2022 using maps from aerial photo mapping with drones.

Identification of changes in land use is very important to study because it can provide an understanding of environmental management [26]. Land use change that occurs in the water catchment area is presented in Table 8.

Table 6 Transfer of land functions from 2018 to 2022

No	Year					
	2018			2022		
	Land Use Type	Wide (ha)	Percentage (%)	Land Use Type	Wide (ha)	Percentage (%)
1	Settlement	2.57	61.93	Settlement	2.83	68.19
2	Cultivation	0.37	8.92	Cultivation	0.38	9.16
3	Reservoir	0.04	0.96	Reservoir	0.04	0.96
4	Burial	1.01	24.34	Burial	0.82	19.76
5	Garden	0.16	3.86	Garden	0.08	1.93
	Total	4.15	100		4.15	100

Source: Results Analysis, 2022.

Table 7 Parameters of waste disposal at Setiamanah Reservoir

No	Aquatic Ecosystem Parameters	Research Result	Ecosystem Status
1	Boundary pond	In the existing condition, the percentage of buildings or settlements on the boundary of Setiamanah Reservoir in 2018 was 61.93%, and in 2022 it was 68.19%. Based on Table 2, the status of the bordering ecosystem is damaged if the percentage of buildings on the border is > 25%.	Damaged
2	Disposal of waste in ponds	There is the indirect discharge of domestic wastewater to the Setiamanah Reservoir via the Cisangkan River	Damaged

Based on the calculation of the area of closed land in the form of cultivated land and settlements, vegetated land includes ponds, cemeteries and gardens. In 2018 the area of covered land was 1.06 Ha or 54.64% of the total area of the catchment area. In 2022 it will be 1.16 or 59.79%. There was an increase in the covered land area of 1 Ha or 5.15%. The percentage of vegetated land in 2018 was 45.36%; in 2022, it decreased to 40.21%. The land use change that occurred. Namely, cemeteries into settlements are presented in Table 8. Based on Table 3 regarding the criteria for terrestrial ecosystem status, if the percentage of the vegetated land area is 30-75%, then the status of terrestrial ecosystems is included in the threatened category.

4.3.2 The impact of silting ponds

Setiamanah Reservoir has a very shallow depth of less than 10 m. Based on the results of interviews with the manager, this reservoir was built in 2011 with a depth of 3 m. Based on the results of measurements in 2022, the depth is only 96 cm. The depth of the reservoir decreased by 2.04 m in 11 years from 2011-2022, or around 18.50 cm/year. Siltation occurs due to sedimentation that settles at the bottom of the reservoir. Sediment consists of suspended solids such as particles or living (biotic) components, namely phytoplankton, zooplankton, bacteria, and fungi [27]. In addition to the biotic components, TSS also consists of dead (abiotic) components such as detritus and solids (sand, silt and clay) suspended in the water [16]. The determination of criteria for the status of aquatic ecosystems for parameters of the impact of silting ponds is based on Table 3. Each year, the status is damaged because the average annual percentage yield is more than 2%.

4.3.3 Parameters of waste disposal in river bodies

Disposal of waste to Setiamanah Reservoir via the Cisangkan River first. This river is located in Kelurahan Setiamanah, where the central part of the watershed is dominated by the educational, domestic and community home activities industry [24,25]. Each of these activities will generate waste. This waste is not managed properly but is discharged directly into the Cisangkan River water body without any prior processing [26]. Disposing of this waste directly without prior processing will affect the river water quality. Water quality status of the middle part of the Cisangkan River during the transition season (moderately polluted), dry season (heavily polluted), and the rainy season (heavily polluted) [24,25]. The Cisangkan River, which is polluted due to the disposal of domestic and industrial waste, will affect the water quality of Setiamanah Reservoir because the river water enters the river inlet pond. There is a connection with the water quality status of the Setiamanah Reservoir, which has been discussed previously.

The water quality status of the reservoir is moderately polluted during the rainy and dry seasons; the contamination load from the Cisangkan River influences this. Determination of criteria for the status of aquatic ecosystems for parameters of waste disposal in river water based on Table 3 is damaged because, in the Cisangkan River, there are waste discharges from the domestic and industrial aspects.

The water quality status of the reservoir is moderately polluted during the rainy and dry seasons; the contamination load from the Cisangkan River influences this. Determination of criteria for the status of aquatic ecosystems for parameters of waste disposal in river water based on Table 3 is damaged because in the Cisangkan River, there are waste discharges from the domestic and industrial sectors, and there is no pollution control system.

Based on the analysis results for each terrestrial parameter can be carried out based on the existing conditions, namely the parameters of vegetation cover in the water catchment area, the impact of siltation, and waste disposal. The results of the recapitulation of criteria for terrestrial ecosystem status are listed in Table 9.

The recapitulation of the Setiamanah Reservoir ecosystem assessment is presented in Table 10. Based on the analysis results in Table 10, of the 17 parameters determined by the Ministry of Environment of the Republic of Indonesia in 2008, only 11 parameters could be assessed. Due to reservoir conditions, research time, and data limitations, six parameters cannot be assessed.

Table 8 Land function transfer in the Setiamanah Reservoir catchment area

No	Year					
	2018			2022		
	Land use	Wide (ha)	Percentage (%)	Land use	Wide (ha)	Percentage (%)
1	Settlement	0.04	2.06	Settlement	0.04	2.06
2	Cultivation	0.28	14.43	Cultivation	0.28	14.43
3	Reservoir	0.78	40.21	Reservoir	0.88	45.36
4	Burial	0.79	40.72	Burial	0.74	38.14
5	Garden	0.05	2.58	Garden	0.00	0.00
	Total	1.94	100.00		1.94	100.00

Source: Results Analysis, 2022.

Due to reservoir conditions, research time, and data limitations, six parameters cannot be assessed. Based on the analysis results, it was concluded that the condition of the Setiamanah Reservoir ecosystem was categorized as endangered. Management efforts are needed in aquatic ecosystems, borders and water catchment areas so that the condition of the reservoir improves.

5. CONCLUSIONS

The city of Cimahi is currently looking for a source of raw water for the fulfillment of clean water that continues to increase along with population growth that continues to increase. Setiamanah Reservoir is one of the potential water sources to be developed as a new raw water storage source. Based on the research results, the Setiamanah Reservoir Ecosystem has experienced damage due to the settlement of residents in the border and water catchment areas that continue to increase.

The pond's aquatic ecosystem is damaged for tropic status, biodiversity, and food web. The tropical condition of Setiamanah Reservoir is in the hypereutrophic category. The parameter status of polluted water quality is moderate.

The decline in water quality has resulted in the loss of food webs and biodiversity. Aquatic plant cover and algae/blue algae are in a good category because the conditions at the study site are clean of aquatic plants. Based on observations of the classification of the Setiamanah Reservoir phytoplankton division, namely Euglenophyta, Cyanophyta, Bacillariophyta, Chlorophyta, and Cyanobacteria. Damage to the Setiamanah Reservoir ecosystem is also affected by the condition of the Cisangkan River, which is the water supplier for the reservoir. Watershed management is needed to improve the quality of the reservoir ecosystem.

The condition of the reservoir border ecosystem is in the damaged category.

Table 9 Recapitulation of boundary ecosystem status criteria

No	Aquatic Ecosystem Parameters	Research Result	Ecosystem Status
1	Vegetation cover in the catchment area	There was an increase in the covered land area of 1 Ha or 5.15%. The percentage of vegetated land in 2018 was 45.36%; in 2022, it decreased to 40.21%. Based on Table 3 regarding the criteria for terrestrial ecosystem status, if the percentage of the vegetated land area is 30 - 75%, then the terrestrial ecosystem status is included in the threatened category.	Threatened
2	The impact of silting ponds	There was a decrease in the depth of the reservoir by 2.04 m in 11 years from 2011-2022, or around 18.5 cm/year.	Damaged
3	Disposal of waste in river bodies	Disposal of waste to Setiamanah Reservoir via the Cisangkan River first. This river is located in Kelurahan Setiamanah, where educational, domestic and home industry activities dominate the central part of the watershed.	Damaged

Source: Results Analysis, 2022.

Table 10 Recapitulation of Setiamanah Reservoir Ecosystem Determination

No	Parameter	Status
	Aquatic Ecosystem	
1	Trophic status	Damaged
2	Water quality status	Threatened
3	Biodiversity	Damaged
4	Food Web	Damaged
5	Aquatic plant cover	Good
6	Algae/blue algae	Good
7	Aquaculture feed waste	-
	Boundary Ecosystem	
1	Boundary pond	Damaged
2	Tidal border	-
3	Tidal order sequential waste disposal	Damaged
4	Utilization of hydropower to generate hydroelectric power	-
5	Raw water intake	-
	Terrestrial Ecosystem	
1	Vegetation cover in the catchment area	Threatened
2	River-to-lake regime coefficient	-
3	Erosion of catchments	-
4	The impact of silting ponds	Damaged
5	Waste disposal	Damaged

Source: Results Analysis, 2022.

In 2022, 68.19% of the reservoir boundaries will be settlements. There was an increase in the covered land area of 1 Ha or 5.15%. The percentage of vegetated land in 2018 was 45.36%; in 2022, it decreased to 40.21%. The settlement is not equipped with a domestic wastewater management system, so the accumulated wastewater enters the reservoir.

Terrestrial ecosystem conditions are categorized as threatened and damaged. Vegetation cover in the water catchment area is included in the endangered category. There was an increase in the covered land area of 1 Ha or 5.15%. The percentage of vegetated land in 2018 was 45.36%, and in 2022 it decreased to 40.21%. Based on Table 3 regarding the criteria for terrestrial ecosystem status, if the percentage of the vegetated land area is 30-75%, then the terrestrial ecosystem status is included in the threatened category. The depth of the reservoir decreased by 2.04 m in 11 years from 2011-2022, or around 18.5 cm/year. Disposal of waste to Setiamanah Reservoir via the Cisangkan River first. This river is located in Kelurahan Setiamanah, where educational, domestic and home industry activities dominate the central part of the watershed.

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7. REFERENCES

[1] Wardhani E. and Primalaksono Y., Pollutant Index Method in Determining the Water Quality Status of the Cimahi River in West Bandung Regency. IOP Conference Series: Earth and Environmental Science, Vol. 999, Issue 1, 2022, p. 012025.

[2] Putri L. O. L. and Wardhani E., Analysis of Groundwater Quality in Cimahi City of West Java Province. IOP Conference Series: Earth and Environmental Science, Vol. 894, Issue 1, 2021, p. 012037.

[3] Circular of the Minister of Public Works and Public Housing Number 07/SE/M/2018 of 2018 Concerning the Development of Small Ponds and Other Water Storage Structures in Villages.

[4] Wardhani E., Roosmini D., and Notodarmojo S., Calculation of Heavy Metals Pollution Load Enters to Saguling Dam West Java Province. IOP Conference Series: Earth and Environmental Science, Vol. 802, Issue 1, 2021, p. 012032.

[5] Wardhani E., Suprihanto N, and Dwina R., Assessment of Heavy Metal Contamination in Saguling Reservoir Water West Java Province Indonesia. E3S Web of Conference, Vol. 73, 2018, p. 06009.

[6] Lukiyansah E., Tambunan M. P., and Marko K., Water Quality Index Analysis of Lake Rawa Besar, Depok, West Java, and Its Relationship with Land Use. IOP Conference Series: Earth and Environmental Science, Vol. 561, Issue 1, 2019, p. 012025.

[7] Covarrubia J., C., Rayburg S., and Neave M., The Influence of Local Land Use on the Water Quality of Urban Rivers. International Journal of GEOMATE, Vol. 11, Issue 23, 2016, pp. 2155-2161.

[8] Sanjoto T. B., Sidiq W. A. B. N., and Nugraha S. B., Land Cover Change Analysis to Sedimentation Rate of Rawapening Lake. International Journal of GEOMATE, Vol. 18, Issue 70, 2020, pp. 294-301.

[9] State Ministry of Environmental Indonesia Republic in 2008 on Guidelines for Management of Lake Ecosystems in Indonesia.

[10] Decree of the State Minister for the Environment Number 115 of 2003: Determination of Water Quality Status.

[11] Brookes J. D., Antenucci J., Hipsey M., Burch M. D., Ashbolt N. J., and Ferguson C. Fate and Transport of Pathogens in Lakes and Reservoirs. Environment International, Vol. 30, Issue 5, 2004, pp. 741-759.

[12] Regulation of the Minister of Public Works and Public Housing Number 28 PRT/M/2015 Concerning the Establishment of River Boundary Lines and Lake Boundary Lines.

[13] Regulation of the Minister of Forestry Number P. 61/Menhut-II/2014 Concerning Monitoring and Evaluation of Watershed Management.

[14] Wischmeier W. H. and Smith D. D. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Department of Agriculture, Science and Education Administration, 1978, pp. 1-58.

[15] Zhu K., Wu T., Li C., Xu J., and Zhang M., Ecosistem-Based Restoration to Mitigate Eutrophication: A Case Study in a Shallow Lake. Water. Vol. 12, Issue 8, 2020, p. 2141.

[16] Koue J. Study on the Analysis of the Controlling Factors Ofhypoxia in the Bottom of Lake Biwa, Japan. International Journal of GEOMATE, Vol. 24, Issue 102, 2023, pp.101-108.

[17] Carlson R. E., A Trophic State Index for Lakes. Limnology and Oceanography, Vol. 22, Issue 2, 1977, pp. 361-369.

[18] Nojavan F., Kreakie B. J., Hollister J. W., and Qian S. S., Rethinking the Lake Trophic State Index. PeerJ, Vol. 7, 2019, p. e7936.

[19] Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning

Implementation and Management of the Environment.

[20] Dewata I. Water Quality Assessment of Rivers in Padang Using Water Pollution Index And Nsf-Wqi Method. International Journal of GEOMATE, Vol. 17, Issue 64, 2019, pp. 192-200.

[21] Kustamar, Kustamar, and Wulandari L. K. The Pollution Index and Carrying Capacity of the Upstream Brantas River. International Journal of GEOMATE, Vol. 19, Issue 73, 2020, pp. 26-32.

[22] Kostryukova A., Mashkova I., Shchelkanova E., Trofimenko V., and Maslova J. Time-Space Assessment of Water Qualityof Miass River. International Journal of GEOMATE, Vol. 19, Issue 74, 2020, pp. 145-152.

[23] Maprasit S., Darnsawasdi R., Rangpan V., and Suksaroj C. Spatial Variations of Surface Water Quality and Pollution Sources Inkhlong U-Tapao River Basin. International Journal of GEOMATE, Vol. 14, Issue 43, 2018, pp. 98-103.

[24] Rosmeiliyana and Wardhani E., Calculation of the Water Quality Status of the Cisangkan River, Cimahi City, West Java Province. The 21st Century Infrastructure Technology National Symposium, 2021.

[25] Rosmeiliyana and Wardhani E., Analysis of Cisangkan River Water Quality, Cimahi City, West Java Province. Jungkung Journal of Environmental Engineering, Vol. 7, Issue 1, 2021, pp. 01-119.

[26] Thongdonphum B. and Meksumpun S. Assessment of Pollution Carrying Capacity in the Lower Part of Mae Klong River, Thailand. International Journal of GEOMATE, Vol. 19, Issue 71, 2020, pp. 84-89.

[27] Medallon M. C. and Garcia E. Physical and Chemical Properties of Water: Case of Taal Lake, Philippines. International Journal of GEOMATE, Vol. 21, Issue 83, 2021, pp. 11-19.