

## Policy Priority Model for Management of Lake Sentani Waters Degradation After Flash Floods Using the A'WOTMIC Method

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### ABSTRACT

Most of the pollution levels of Lake Sentani waters in the Expo watershed (92%) have been mildly and moderately polluted, while only a small proportion (8%) still meet quality standards. The condition of the level of heavy pollution will be dangerous for the life of living things, especially fish and have an impact on humans. This study aims to analyze the priorities of the Sentani Lake pollution management policy in the strength-opportunity (SO), strength-threat (ST), weakness-opportunity (WO), and weakness-threat (WT) strategies with the A'WOT method. The results showed that the policy priorities that first needed to be implemented immediately in the SO strategy were to Improve Enforcement of Environmental Law with an eigen value of 0.196. The priority of the policy strategy that first needs to be immediately implemented in the WO strategy is to make regional regulations by utilizing Government and community support with an eigen value of 0.267. The first policy priority that needs to be immediately implemented in the ST strategy is to use government authority in the environment to control environmental pollution and damage with an eigenvalue of 0.494. The first policy priority needs to be immediately implemented in the WT strategy is to improve environmental law enforcement so that lake water is not polluted with an eigen value of 0.202.

**Keywords:** policy priority, management, pollution, Lake Sentani, A'WOTMIC.

### INTRODUCTION

The level of pollution of Lake Sentani waters in the Expo watershed is largely (92%) mild and moderate, while 8% still meets quality standards (DLHK, 2019). This is caused by the weak enforcement of regulations that ultimately cause damage in the upstream, middle and downstream of the Sentani River Basin. Activities that increase pollution in the upper reaches of the watershed are land use changes that cause increased erosion. Activities in the middle of the Sentani River Basin are settlements, and disposal of domestic waste into the river. So Lake Sentani became a waste collection place for the city of Jayapura

and Jayapura Regency. While the activity in the downstream of the Sentani watershed is the existence of settlements and floating net cages.

There are many cases of water pollution that occur in the Lake such as cases of heavy metal pollution in Lake Chad caused by run off from agricultural activities around the lake, where the concentration of heavy metals in sediment samples is higher than the WHO determined value, this shows that Lake Chad has been contaminated with heavy metals (Joseph., et al., 2012). Lake Mjøsa is known to be contaminated by polybrominated diphenyl ethers (PBDE) from local industry activities. Polychlorinated biphenyls (PCB), dichlorodiphenyltrichloroe (DDTs)

and PBDE contaminated fish in Lake Mjøsa. The results of this study indicate that the high level of contamination in Lake Mjøsa has a negative impact on the health status of wild fish that inhabit the lake (Berg., Et al., 2013). (Allinger., et al. 2013) have examined the quality of Erie Lake water due to phytoplankton-based eutrophication, which based on the latest phytoplankton collection, the abundance of summer blue-green algae has increased, which is likely due to changes in input and nutrient dynamics, and the dreissenid effect. Eutrophication in Lake Erie is caused by agricultural activities that have contributed to the increase in phosphorus to the lake (Watson, et al., 2016). Similarly, studies of phosphorus and nitrogen pollution in Baiyangdian Lake in northern China are caused by nutrition (Ying, et al., 2010). (Walukow, A.F., 2016), has researched about Phosphate and Copper pollution in Lake Sentani. The results of the study concluded that Lake Sentani was polluted by the Cu parameter of 1.57 tons/year. Pb pollution in the sediments of Lake Sentani has also been investigated, where the results showed that the Pb concentration in sediments was around 28 mg/kg to 40 mg/kg. Walukow, A.F. (2021) has examined the constraints that have caused the decline in the status of water quality in Lake Sentani such as population behavior constraints, forest degradation, and the need for development of land conversion in activities in upstream watersheds. The waters in the Sentani watershed (Simporo Strait, Tlaga Ria watershed, Glanggang Expo waters, Bridge II of river) have been lightly polluted by the parameters TSS, BOD, COD and  $PO_4$ , so that the waters in the Sentani watershed are unfit for use as a source of drinking water (Class I) and for allotment of places for recreation, tourism and fish farming (Class II) (Walukow, A.F., 2022).

However, in the previous research, the above-mentioned has not yet reviewed the priorities of lake pollution management policies using the A'WOTMIC method. In this research the Sentani Lake management policy priorities will be examined by combining Analytical Hierarchy Process (AHP) analysis, Strength Weakness Opportunity and Threats (SWOT) analysis and dynamic models. The combination of the two analyzes is known as A'WOTMIC. Analysis of Lake Sentani's pollution management policy priorities with the A'WOTMIC method applied in the waters analysis is expected to be a gap research and research novelty. The superiority of A'WOTMIC technique

is that it can be identified the most appropriate priority in the management of Lake Sentani pollution, so that the lake remains sustainable (Marimin, 2004). The study of research on the priorities of the Sentani Lake waters pollution management policy is very important to be implemented because it is in line with the Main Scientific Pattern of Cenderawasih University namely Anthropology, Natural Resources and the Environment. Likewise, this research study is in line with the mission of the 3 (three) Regional Medium-Term Development Plans of Jayapura City in 2013–2033, which is controlling environmental pollution and protection of conservation areas, and this research is in line with the general strategy of the 4 (four) Jayapura City government the year 2013–2033 is environmentally friendly development.

## MATERIAL AND METHODS

As for the locations of the study are: Expo Lake Sentani watersheds, as in Figure 1.

Steps for the A'WOTMIC method:

1. Identifying the problem: Determine the main goal or what is to be realized / achieved.
2. Arrange the hierarchical structure.
3. Make a Pairwise Comparative Judgment Matrix, based on the Saaty scale.

The expert will answer in Table 1 by comparing the attributes in the row and column. The expert fills in the white box, then the researcher will make an inverse of the numbers. The fields of expert respondent science are Environmental Biology, Ecology, Chemistry, natural resource management and the environment.

4. Calculate the eigenvector value for each matrix by: Converts matrices to decimal numbers, performs multiple squares multiplications, adds matrix rows and normalizes.
5. Calculating the Consistency Index, using the formula:

$$Ci = \frac{\lambda_{max} - n}{n - 1} \quad (1)$$

6. Calculate CR (Consistency Ratio), where Consistent if  $CR < 0.1$ , with the formula:

$$CR = \frac{Ci}{\bar{Ci}} \quad (2)$$

7. Perform dynamic modeling on SWOT strategy factors that can be quantified.

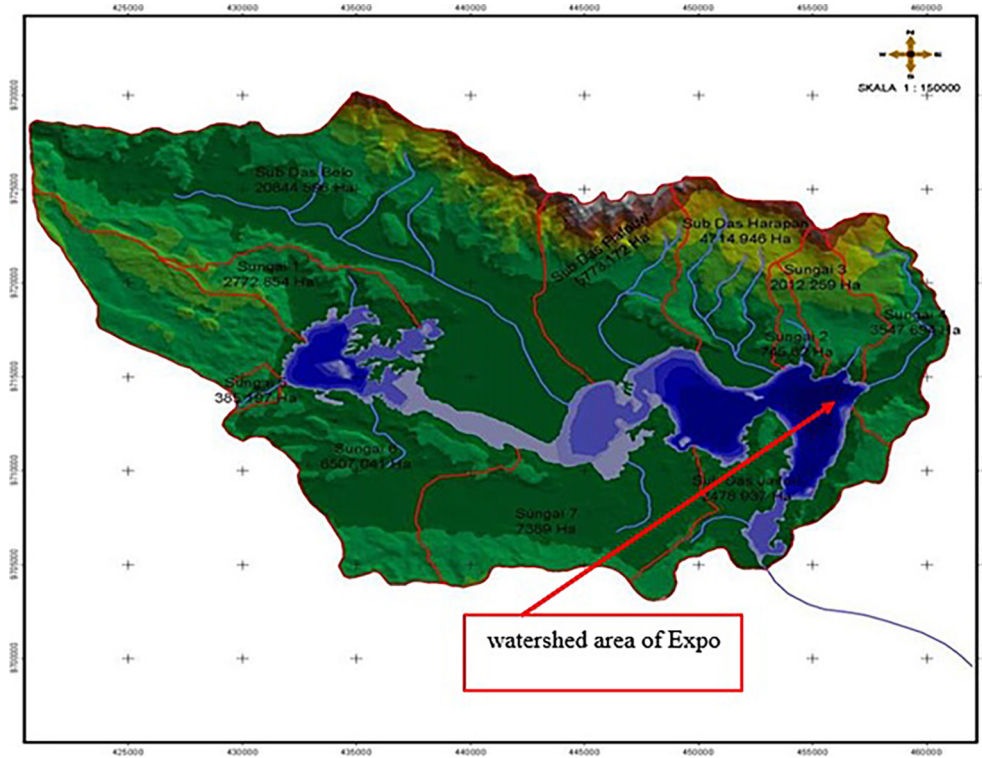


Figure 1. Research location

Table 1. Pairwise Comparative Judgment Matrix (Marimin, 2004)

Attribute	A	B	C	D
A	1	...	3	...
B		1	...	...
C			1	...
D				1

Table 2. Saaty Number Scale (Marimin, 2004)

Intensity importance (value)	Definition
1	Both elements are equally important
3	One element is slightly more important than the other
5	One element is essential or very important than the other
7	One element is clearly more important than the other elements
9	One absolute element is more important than the other
2,4,6,8	Values when in doubt between two contiguous considerations

## RESULTS AND DISCUSSION

This research study uses four strategies, namely: Strength-Opportunity (SO), Strength-Threat (ST), Weakness-Opportunity (WO), and Weakness-Threat (WT) which are analyzed using

A’WOTMIC analysis. A’WOTMIC analysis results are presented in Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, and Figure 7.

The components of the strength – opportunities strategy is (Walukow, A.F., 2022):

1. Improve enforcement of Environmental Law (SO1).
2. Increasing the commitment of leaders and the role of government institutions in handling pollution and mainstreaming sustainable development (SO2).
3. Making the lake as an ecotourism area by keeping the lake from being polluted (SO3).
4. Carry out socialization and training on waste management (Wiriani, E.R.E., et al. 2018) (SO4).
5. Analyze and determine the capacity of the pollution load (SO5).
6. Improve guidance and supervision of waste water disposal (Wiriani, E.R.E., et al. 2018) (SO6).
7. Increasing socialization, guidance and supervision of environmental destruction (SO7).
8. Making Communal Wastewater Treatment Plants and Business Wastewater Treatment Plants (SO8).
9. Involving the community in pollution planning and control (Wiriani, E.R.E., et al. 2018) (SO9).
10. Increase the number of environmental documents of the type of business (SO10).

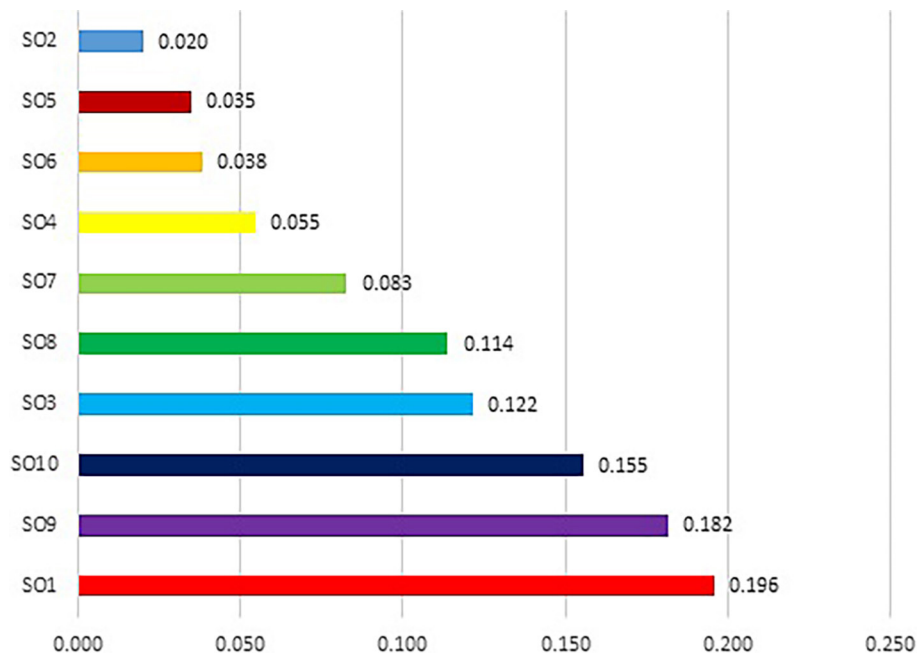


Figure 2. Eigen value of SO strategy

Based on Figure 2 the first policy strategy priority that needs to be immediately implemented in SO strategies is to Improve Enforcement of Environmental Law with an eigen value of 0.196. This means that the first priority that needs to be upheld in the management of Lake Sentani pollution is to improve the enforcement of Environmental Law. Jazuli (2015) also mentioned that weak law enforcement causes excessive pressure on environmental functions. The authority to control environmental management is still distorted, not yet in the direction of its legal political objectives. Law enforcement is difficult because of the difficulty in proving and determining the standard criteria for environmental damage. For this reason, dedication and professionalism of law enforcement officers and public awareness are needed in implementing the provisions of environmental law (Sutrisno, 2011). In deed the role of the Department of the Environment in the prevention and control of water pollution is very important. However, the obstacle until now is the weak enforcement of environmental law (administrative, civil and criminal) due to the process of pre-investigation and prosecution carried out by various different agencies not only done by the Department of Environment (Syaputri, 2017). The second priority that must be considered in handling lake degradation is to involve the community in the planning and control of pollution. The community that needs to be involved are traditional leaders, community leaders, religious

leaders and local government. The results of this study are in line with the opinion of Agustiniingsih, et al. (2012) which states that the institutional social aspect becomes a priority aspect in controlling water pollution due to the use of natural resources and environmental quality related to the behavior of the surrounding community. If the community's behavior is anthropocentric and egocentric then the surrounding community tends to damage the environment in order to fulfill their own interests, but if the community's behavior is ecocentric then the community will tend to preserve the environment so that it does not have a negative impact on the surrounding community in general. Therefore the community needs to be involved in planning so that the negative impacts of the destruction of natural resources can be minimized. The community needs to be involved so that the community understands the importance of protecting forest resources, land resources, lake resources and river resources. The community also needs to be involved in planning in terms of not littering and liquid waste, and the community must be given knowledge about the use of waste with the concept of reduce, reuse, recycle, and participation (3R + P). A'WOTMIC analysis results obtained priority order of Lake Sentani pollution management policies in the SO strategy are:

1. Improve enforcement of Environmental Law (SO1) (Walukow, A.F, et al. 2022).
2. Involving the community in pollution planning and control (Wiriani, E.R.E., et al. 2018) (SO9).



3. Increase the number of environmental documents of the type of business (SO10).
4. Making the lake as an ecotourism area by keeping the lake from being polluted (SO3).
5. Making communal wastewater treatment plants and business type treatment plants (SO8).
6. Increasing socialization, guidance and supervision of environmental destruction (SO7).
7. Carry out socialization and training in waste management (Wiriani, E.R.E., et al. 2018) (SO4).
8. Improving guidance and supervision of waste water disposal (Wiriani, E.R.E., et al. 2018) (SO6).
9. Analyzing and determining the capacity of the pollution load (SO5).
10. Increasing the commitment of leaders and the role of government institutions in handling pollution and mainstreaming sustainable development (SO2).

The components of the weaknesses-opportunities (WO) strategy are:

1. Increase the number of environmental quality monitoring tools and infrastructure and funds to improve the quality of lake water or uncontaminated water (WO1).
2. Optimizing government support, to increase the quantity of apparatus and conduct formal activities in order to improve the quality of human resources of the apparatus, so as to create optimal work effectiveness (WO2).
3. Optimizing the coordination function between agencies, in the context of lake management (WO3).
4. Making local regulations using government and community support (WO4).

5. Increase business owner support through Corporate Social Responsibility (CSR) (WO5).
6. Improve coordination and management of cooperation between government agencies so that they have the same Vision in the management of upstream to downstream watersheds (WO6).
7. Develop a plan that is in accordance with the local competitiveness of the community around the Lake through the support of the Business Owner (WO7).
8. Through socialization of the importance of protecting the environment (WO8).

Based on Figure 3 the priority of the first policy strategy that needs to be implemented immediately in the WO strategy is to make local regulations by utilizing Government and community support of an eigen value of 0.267. This means that the first priority that needs to be upheld in the management of Lake Sentani pollution is making regional regulations by utilizing government and community support. The results of this study are in line with research by Ntiba et al., (2008) which states that the governments of Kenya, Uganda and Tanzania have implemented regional regulations to address problems in Lake Victoria by establishing a regional international institution called the Lake Victoria Fisheries Organization. The three countries agreed to enforce laws and regulations that prohibit the introduction of alien species into lakes and enforce regulations on fisheries on Lake Victoria. The regulations on Lake Victoria include land use management, tree planting in water catchments, fisheries research

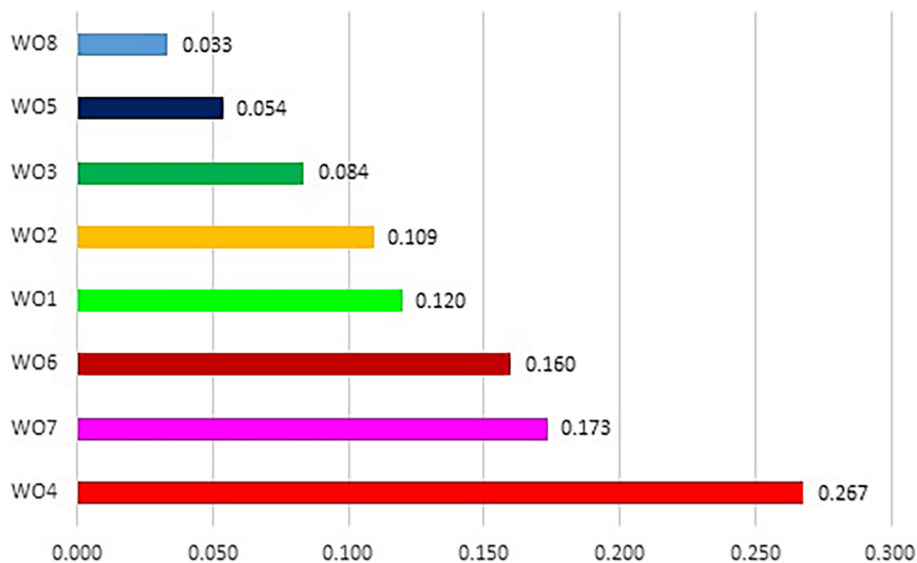


Figure 3. Eigen value of WO strategy

and management, water hyacinth control, industrial waste management, and municipal waste treatment. A'WOTMIC analysis results obtained priority order of Lake Sentani pollution management policies in the WO strategy are:

1. Making local regulations by utilizing government and community support (WO4).
2. Developing a plan that is in accordance with the local competitiveness of the communities around the Lake through the support of the business owner (WO7).
3. Improve coordination and management of cooperation between government agencies so that they have the same Vision in the management of upstream to downstream watersheds (WO6).
4. Increase the number of environmental quality monitoring tools and infrastructure and funds to improve the quality of lake water or uncontaminated water (WO1).
5. Optimizing government support, to increase the quantity of apparatus and conduct formal activities in order to improve the quality of human resources of the apparatus, so as to create optimal work effectiveness (WO2).
6. Optimizing the coordination function between agencies, in the context of lake management (WO3).
7. Increase business owner support through CSR (WO5).
8. Through socialization of the importance of protecting the environment (WO8).

Components of the strength-threats strategy are:

1. Using the government's authority in the environment to control environmental pollution and damage (ST1).

2. Increasing the role of the community in the protection / conservation of Sentani Lake (ST2).
3. Increase community knowledge, through social training by related fields (ST3).
4. Optimizing the coordination function between agencies (ST4).
5. Optimizing leadership policies that support lake protection activities (ST5).

Based on Figure 4 the priority of the first policy strategy that needs to be immediately implemented in the ST strategy is to use government authority in the environment to control environmental pollution and damage with an eigen value of 0.494. This means that the main priority that needs to be upheld in the management of Lake Sentani pollution is to use government authority in the environmental field to control environmental pollution and damage. The results of this study are in line with the opinion of Asnil (2013) which states that government agencies involved in the utilization of natural resources are the central government, regional governments and the Lake Management Agency. The lake management agency in question is the Office of Environment and Cleanliness, while the Central Government in question is the Ministry of Environment and Forestry. Nusantari (2010) also mentioned that efforts to control lake damage need to improve water quality from pollution. A'WOTMIC analysis results obtained priority order of Lake Sentani pollution management policies in the ST strategy are:

1. Using the government's authority in the environment to control environmental pollution and damage (ST1).
2. Optimizing the coordination function between agencies (ST4).

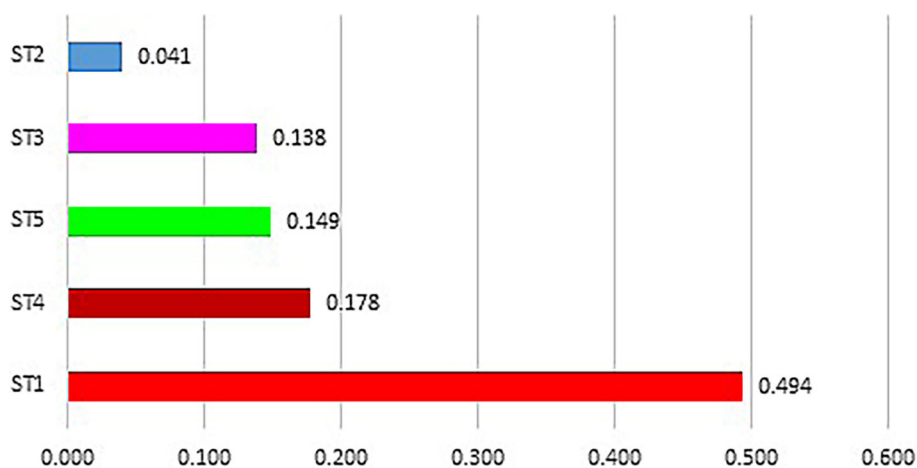


Figure 4. Eigen value of ST strategy

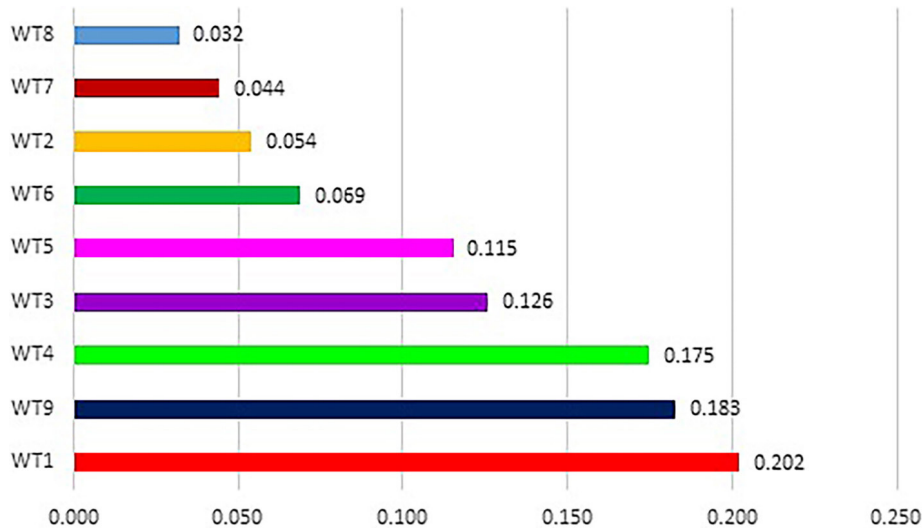


Figure 5. Eigen value of WT strategy

3. Optimizing leadership policies that support lake protection activities (ST5).
4. Increase community knowledge, through social training by related fields (ST3).
5. Increasing the role of the community in the protection / conservation of Sentani Lake (ST2).

The components of the Weaknesses – threats strategy is:

1. Improve environmental law enforcement so that lake water is not polluted (WT1).
2. Increase the quantity and quality of human resources in the relevant department (WT2).
3. Improve the coordination function between agencies, to conduct pollution handling activities (WT3).
4. Making local regulations, to minimize the level of pollution (WT4).
5. Increase research funds for rivers and lakes (WT5).
6. Developing Communal Wastewater Treatment Plants and Wastewater Treatment Plants (WT6).
7. Enhancing the environmental education program (WT7).
8. Increasing climate change socialization and disaster mitigation (WT8).
9. Increase the number of types of businesses that have an environmental permit.

Based on Figure 5 the first policy strategy priority that needs to be immediately implemented in the WT strategy is to improve environmental law enforcement so that lake water is not polluted with an eigen value of 0.202. This means that the main priority that needs to be upheld in

the management of Lake Sentani pollution is to improve environmental law enforcement so that lake water is not polluted. Enforcement of environmental law and enhancement of environmental management capacity are in line with the direction of the National Medium-Term Development Plan (KLHK, 2014). Asnil (2013) also mentioned that in the use of lakes it is necessary to have clear regulations and the main obstacles in preserving the natural resources of the lake due to weak enforcement of regulations. A WOTMIC analysis results obtained priority order of Lake Sentani pollution management policies in the WT strategy are:

1. Improve environmental law enforcement so that lake water is not polluted (WT1).
2. Increase the number of types of businesses that have an environmental permit.
3. Making local regulations, to minimize the level of pollution (WT4).
4. Improve the coordination function between agencies, to conduct pollution handling activities (WT3).
5. Increase research funds for rivers and lakes (WT5).
6. Developing communal wastewater treatment plants and business type wastewater treatment plants (WT6) (Haerati, 2022).
7. Increase the quantity and quality of human resources in the relevant department (WT2).
8. Enhancing the environmental education program (WT7).
9. Enhancing climate change socialization and disaster mitigation (WT8).

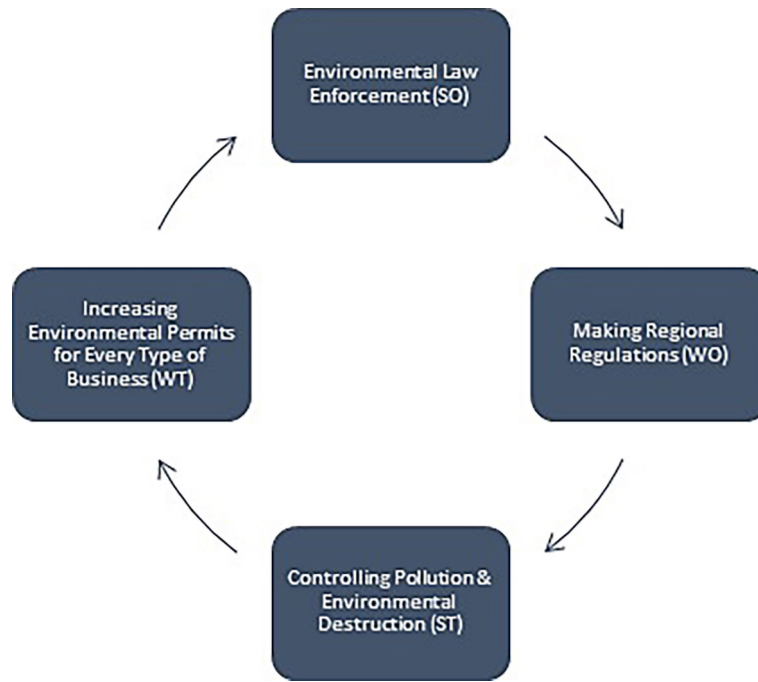


Figure 6. Policy priority model for Lake Sentani degradation management after flash floods

Table 3. Amount of communal WWTP needs in districts around Lake Sentani

Year	Sentani District	Ebungfau District	Waibu District	Sentani Timur District	Heram District
2022	73.93	3.00	21.22	9.69	66.79
2024	76.46	3.10	21.95	10.03	68.94
2026	79.08	3.21	22.70	10.37	71.17
2028	81.80	3.32	23.48	10.73	73.46
2030	84.60	3.43	24.28	11.09	75.83
2032	87.50	3.55	25.11	11.47	78.28
2034	90.50	3.67	25.98	11.87	80.80
2036	93.60	3.80	26.87	12.27	83.41
2038	96.81	3.93	27.79	12.70	86.10
2040	100.13	4.06	28.74	13.13	88.88
2042	103.57	4.20	29.73	13.58	91.74

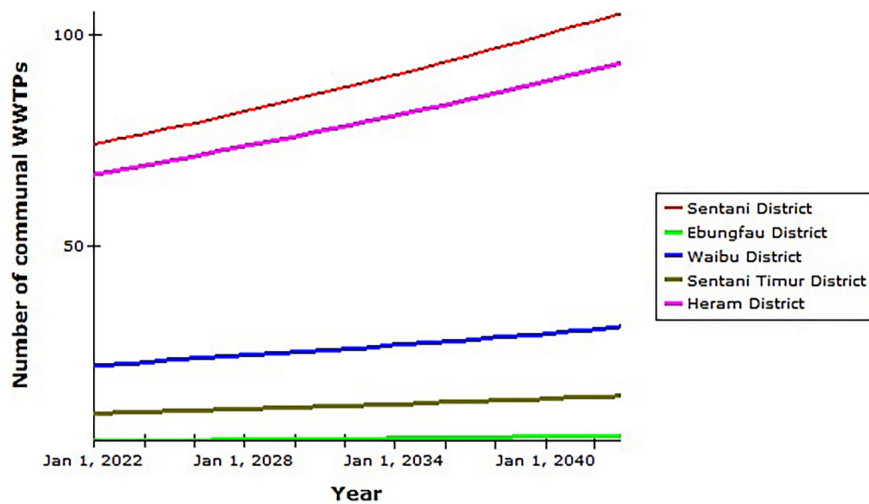


Figure 7. Amount of communal WWTP Needs in districts around Lake Sentani



Based on the analysis above, the policy priority model is a combination of policy priorities in the four SWOT strategies as shown in Figure 6.

The sixth sequence in the WT strategy above is the need to develop a Communal Wastewater Treatment Plant and a Business Type Wastewater Treatment Plant (WT6), so this WT strategy needs to be dynamically modeled. Residents around Lake Sentani must have a Communal WWTP. Lake Sentani borders the Sentani District, Ebungfau District, Waibu District, East Sentani District and Heram District (Jayapura City Area). According to BPS (2022), the population of Sentani District is 73927 people, Ebungfau District is 3000 people, Waibu District is 21218 people, East Sentani District is 9694 people and Heram District is 66788 people. According to SNI 8455:2017, WWTP can serve 5 families-200 families.

Based on Table 3 and Figure 7 above, the Sentani District requires the largest number of Communal WWTPs. The need for the Sentani District Communal WWTP will increase from 73.93 to 103.57 in 2022–2042. Ebungfau District requires Communal WWTP from 3 units to 4.20 units in 2022–2042. Likewise, the Waibu District needs for Communal WWTPs increased from 21.22 to 29.73 units. East Sentani District requires Communal WWTP from 9.69 units to 13.58 units in 2022–2042. Likewise, the Heram District's need for Communal WWTPs has increased from 66.79 units to 91.74 units in 2022–2042.

## CONCLUSIONS

The first policy priority that needs to be immediately implemented in the strengths-opportunities (SO) strategy is to Improve Enforcement of Environmental Law, with an eigen value of 0.196. The first policy priority needs to be immediately implemented in the weaknesses-opportunities (WO) strategy is to make local regulations using Government and community support, with an eigen value of 0.267. The first priority policy needs to be immediately implemented in the strengths-threats (ST) strategy is to use government authority in the environmental field to control environmental pollution and damage, with an eigenvalue of 0.494. The first policy priority needs to be immediately implemented in the Weaknesses-Threats (WT) strategy is to Improve environmental law enforcement so that lake water is not polluted, with an eigenvalue of 0.202. Policy priority

models for Lake Sentani Post-Flood Flood Degradation Management are Environmental Law Enforcement (SO), Making Local Regulations (WO), Controlling Environmental Pollution & Destruction (ST), and Increasing Environmental Permits for Each Type of Business (WT). The most needed IPAL for Communal is Sentani District, which is 73.93 units and the lowest is the Ebungfau District with 3 WWTP units in 2022.

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