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Overview of the Influence of Land Use Change and Sediment Control Structures on Sedimentation in Lake Sentani

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ABSTRACT

Under Presidential Decree No. 60 of 2021, on National Priority Lakes Rescue, Lake Sentani is one of 15 priority lakes to be rescued. In the annex to the President's regulation, it is mentioned to date about 90 tons or ± 5 m/year of sediment entering Lake Sentani with a total count of 62,0679.78 tonnes/year entering lake Sentani, with a storage capacity of 1,782 billion/m3. The water supply of Lake Sentani is obtained from the supply of 14 large and small rivers. A slope inclination between 0% - 40% of the amount of sediment transported during the rainy season causes a decline in water quality and the high erosion that occurs. This study aims to find out the impact of land-use change and the effect of sediment control buildings on the number of sediments that enter Lake Sentani. From the results of the analysis, the impact of land use change before the construction of the sediment control building based on the analysis carried out by the Papua River Regional Hall, the known potential sedimentation rate is 0.6 mm/th whereas the potential sedimentation rate analyzed after the existence of the building of the Sediment Controller is of 0.012 mm /year. This indicates a change in the rate of potential Sedimentation entering the lake of Sentani affected by the building sediment operator. When it rains with repeated flooding Q20, Q25, Q50, and Q100 years with conditions of one 1 (one) sediment control building it can be judged to be a very heavy erosion class with land loss of more than 280 tons/ha/years with a potential sedimentation rate thickness between 2.55 mm/years to 2.85mm/years.

Introduction

Papua is a province in Indonesia, located in the province of Papua on the western island of New Guinea or West New Guinea. Papua Province is a province that administratively borders directly with the State of Papua New Guinea (Asdak & Supian,

2018). This makes the Government of Indonesia continue to encourage the development of the province of Papua which is the "home terrace" of the Indonesian State. The Regional Government in Papua Province that is directly adjacent to and is the entrance to Indonesia is the Jayapura City Government and the Jayapura Regency Government so the development of Jayapura City and Regency Development continues to be spurred by the Papua Provincial Government (Hidayat et al., 2018).

Papua is the Eastern part of Indonesia and has a huge potential for natural resources. A vast land with dense tropical forests, abundant biodiversity, and biota. The potential of water resources in Papua is also very large, with the number of ± rivers ± 173 or 2% of the number of rivers in Indonesia (8,736). Papua has a coastline of ± 1,882.93 km or ± 1.98% of the coastline in Indonesia. (Rusdiyah, Dahliana, & Maulina, 2016). The potential of swamp land ± 4.89 million hectares or ± 45% (± 10.9 million hectares) of swamp land area in Indonesia. Papua Province has an area of 319,036.05 km2 or 16.7% of the area of Indonesia, (Dawood, 2017).

The development of Jayapura City and Jayapura Regency continues to experience development progress in all sectors. With the increasing development of Jayapura City and Jayapura Regency, the need for housing and transportation facilities has also increased, which has an impact on land use changes and the opening of new land as residential locations. (Nurrochman, Joy, & Asdak, 2018). The land use change that occurred had a dominant influence on the increase in surface flow discharge. Land use change and forest encroachment around the Mount Cyloop buffer forest have resulted in flash floods in Sentani City in 2019. The sediment material caused by flash floods has had an impact on the accumulation of sediment in the estuaries of the river and until now if there is rain with high intensity, the water flowing on the surface will bring sediment into Lake Sentani (RADITYA, 2023). Lake Sentani is one of the largest lakes in Indonesia, which is located just below the slopes of the Cyclops Mountains and stretches between Jayapura City and Jayapura Regency. Lake Sentani also naturally functions as a water reservoir because it receives water from 14 (fourteen) large and small rivers. Since ancient times, Lake Sentani has been directly used by the community as a source of clean water, aquaculture, capture fisheries, crossing transportation, and tourism. (Karim et al., 2023).

The topography around Lake Sentani is mostly plains to undulating hills. Relatively sloping plains are generally located at an altitude of between 50-100 meters above sea level while undulating hills range from 100-500 meters above sea level. The morphology of Lake Sentani includes a slightly rough relief with a slope between 0%-40%. This will cause the problem of high erosion values and discharge fluctuations, so it is very necessary to monitor the estimation of erosion and sedimentation values periodically.

According to BPDAS (Hidayat et al., 2017), the main factor causing flooding in the Sentani watershed is the loss of most of the vegetation/land cover forest, as a result of farming moving in the upstream part of the watershed so that the water absorption into the soil becomes smaller. If land function experts continue to be left untreated and not handled properly and appropriately, it will affect the amount of sediment transportation

that enters Lake Sentani and will eventually cause siltation and the area of Lake Sentani will decrease.

The accumulation of sediment carried by the water flow makes the lake shallower which results in a reduced capacity for water volume. The siltation that occurs causes the water area of Lake Sentani to expand in the rainy season and in the dry season to become shallower. (Huda, Sudarsono, Sasmito, & Kahar, 2014). This exacerbates the widespread flooding around the lake which has an impact on community activities. In addition to siltation, changes in land use in the buffer areas of Lake Sentani will greatly affect the occurrence of pollution.

The objectives to be proven in this study are:

1. Identify the influence of land use change on sediment control buildings.
2. Determine the influence of land use change and the influence of sediment control buildings on the amount of sediment entering Lake Sentani.
3. Determine the strategy that must be carried out to prevent sedimentation that occurs in Lake Sentani.

Method

Research Location

This study is located in Lake Sentani which is located in Jayapura Regency, Papua Province at coordinates 140 23' − 140˚50' LS and 2 31' − 2˚41' E with a water area of 9,630 ha and the Flavouw sub-watershed which is one of the sub-watersheds located in the Sentani-Tami Watershed with a catchment area (DTA) of 28.99 km2 and a river flow length of 12.42 km.

Data Collection Methods

The method that will be carried out in this study uses two methods, namely: field survey and data analysis.

1. The survey method is a method used for research by direct observation of the location to be researched,
2. The data analysis method uses the Universal Soil Loss Equation (USLE) formula assisted by the Geographic Information System.

In the collection of data, primary data is needed regarding the weight of the soil content resulting from erosion in the Flavouw Sub-Basin, as a reference in converting the value of Ton units into m3. Secondary data as inputs in the form of topographic maps, maps of soil types, echo-sounding data, and hydrological data in the form of 10-year daily rainfall data. The data is available from several related agencies, including:

1. Papua River Regional Center,
2. Jayapura Regency Forestry and Environment Service

Research Flow Chart

The flow chart of the stages of this research can be seen in Figure 1.

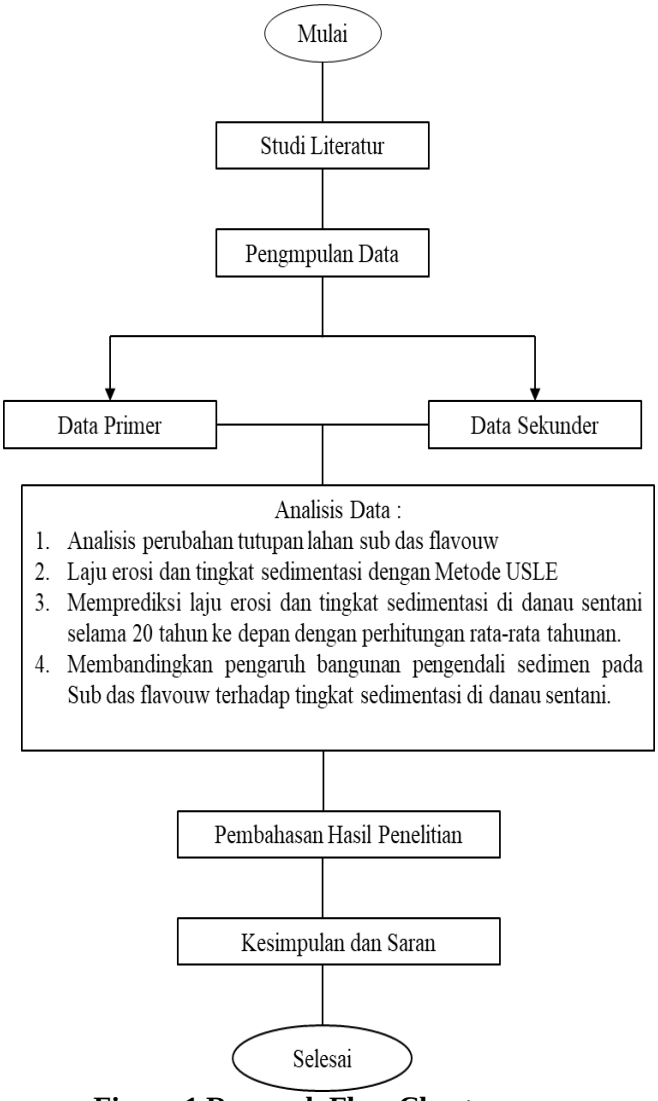

Figure 1 Research Flow Chart

Results and Discussion

Changes in Land Use of the Flavouw Watershed

Land use is an effort to plan land use in an area which includes the division of areas to specialize in certain functions, for example, residential, trade, and industrial functions. Land use change is the increase of land use from one side of use to another accompanied by a decrease in other types of land use from one time to the next. At the Flavouw watershed research location, based on the results of analysis through satellite imagery and ArcGIS applications from 2020 to 2024, it can be found that there have been changes in land use as follows:

Table 1
Land Cover Area in 2020-2024

It	Land Cover	Land Cover Area (Km^2)

		Year 2020	Year 2021	Year 2022	Year 2023	Year 2024
1	Jungle Forest	18,961	18,592	18,247	18,219	18,219
2	Pioneer Airport	1,290	1,290	1,290	1,290	1,290
3	Settlements and Activity Places	4,212	4,259	4,270	4,274	4,274
4	Bush / Alang Alang	2,607	2,929	3,273	3,298	3,298
5	Tegalan / Farm	0,742	0,742	0,732	0,732	0,732
6	Lake Water / Situ	0,003	0,003	0,003	0,003	0,003

Analysis of Sediment Diameter Test Results

To determine the influence of sediment control buildings in the Flavouw River, sediment characteristics of the Flavouw River were tested at the UPTD Testing Center and Laboratory of the Public Works, Spatial Planning, Housing, and Settlement Areas Office of the Papua Provincial Government using filter analysis testing by taking samples from 3 (three) different points on the flavor river which are considered to represent the river and sediment control buildings. The data obtained in this study is primary data. From the results of testing in the laboratory (can be seen in the attachment) it is known that:

1. The results of the test of the flavor river sand material at point-01 which is located upstream of the river, the material is known to be included in the aggregate gradation zone 2.3 and 4 with grain sizes ranging from 0.075 mm to 0.600 mm, which means that the material at point-01 is included in the type of coarse-grained sand, medium-grained sand, fine-grained sand to Silt (mud) material.
2. The results of the test of the Flavouw River sand material at point-02 which is after the sediment control building, the material is included in the aggregate gradation zone 2.3 and 4 with grain sizes ranging from 0.075 mm to 0.600 mm which means that the material at point-02 is included in the type of coarse-grained sand, medium-grained sand, fine-grained sand to silt (mud) material.
3. The results of the Flavouw River sand material test at point-03, the material is included in the aggregate gradation zone 1 and 2 which means that the material at point-03 is included in the type of medium-grained sand, fine-grained sand, and silt (mud) material.

Erosion Hazard Level (TBE)

Erosion calculation using the USLE method is an equation that predicts the average erosion rate of a certain land on a slope with a certain rainfall pattern for each type of soil and the determination of land management/land conservation actions. (Hariati, Taqwa, Alimuddin, Salman, & Sulaeman, 2022). To determine the level of erosion hazard, the classification of erosion levels that have been made by the Ministry of Forestry in 2008 is used.

Table 2
Classification of Erosion Hazard Levels

Kelas Erosi	Kehilangan Tanah	Tingkat
1	<15 ton/ha/tahun	Sangat Ringan
2	15-60 ton/ha/tahun	Ringan
3	60-180 ton/ha/tahun	Sedang
4	180-280 ton/ha/tahun	Berat
5	>480 ton/ha/tahun	Sangat Berat

Sumber : Kementerian Kehutanan, 2008

Based on the results of the analysis conducted by the Papua River Regional Office, it is known that the level of erosion danger in the Flavouw Water Catchment Area is as follows:

Table 3
Flavouw DTA Erosion Hazard Level

TBE (Erosion Hazard Level)	Area (Ha)
Very Light	636.00
Light	352.05
Keep	1234.72
	2222.77

Source: Analysis, 2019

Sediment Yield

Sedimentation is the result of an erosion process, either in the form of surface erosion, trench erosion, or other types of soil erosion. Sediment generally settles at the bottom of hills, in flooded areas, waterways, rivers, and reservoirs. The sediment yield depends on the amount of total erosion in the watershed/sub-watershed and depends on the transport of the eroded soil particles out of the watershed/sub-watershed catchment area. (Andriyani, Wahyuningsih, & Suryaningtias, 2019). The forecast formula for the amount of sediment yield per watershed unit per unit time (in tons/ha/year) can be formulated as follows:

Y = E x SDR

With:

Y: Sediment Transportation

SDR: Sediment Delivery Ratio

Fennel: Watershed area or catchment area (DTA)

The results of the sediment yield analysis on the Flavouw River DTA with river discharge at the time of the study are as follows:

Luas DAS (A)	=	2.222,77	Ha
	=	22,23	km2
Koefesien Kekasaran Manning	=	0,04	
SDR = 0,41 x ($A^{-0,3}$)	=	0,04	dengan A (ha)
	=	0,16	dengan A (km2)
Nilai E	=	286.003,00	(luas ha)
Sedimentasi Petensial (Y) = E x SDR	=	11.616,79	ton/tahun
		31,83	ton/hari
Berat Jenis Tanah	=	2,65	ton/m3
	=	5,23	(ton/ha/th)
	=	5,58	(m3/ha/th)
	=	12.413,24	(m3/th)
Laju Sedimentasi Potensial	=	0,012	(mm/th)

Based on the classification table of sedimentation rate with flow discharge measured at the time of the study, it can be concluded that the sedimentation rate is still classified as a good class because the potential sedimentation rate is < 2 mm/year.

SWOT Analysis

In determining the right and appropriate policy-making, calculations are carried out using tools. The tools or tools used to determine decisions and policies are SWOT. The following is the SWOT (Strength Weakness Opportunity Threat) of the effect of land use change on erosion and sedimentation rate that enters Lake Sentani.

Table 4
Factors Influencing Decision-making

Strength	***Weakness***	***Opportunity***	***Threat***
The existence of the Jayapura Regency RTRW which prohibits deforestation in cyclops-protected areas	There are still stakeholders who are not involved in handling land use change.	Government Attention through the Ministry of Public Works and Housing Regulation No. 19/KPTS/M/2024 concerning the Determination of Lake Boundary Lines in the	Land conversion occurs a lot for agricultural land and residential areas.

Strength	***Weakness***	***Opportunity***	***Threat***
		Mamberamo Tami Apauvar River Area	
Existence of Planning Documents for the Revitalization of Lake Sentani	The Flavouw River provides enough sediment at the time of flash floods, making it possible for a recurrence.	Sedimentation control with sediment control buildings in the inlet rivers of Lake Sentani	Global climate change that results in high-intensity rainfall can occur at any time.
There is a community of nature lovers who care about the destruction of cyclops-protected forests.	The government's program in terms of reforestation of protected forests does not involve the community.	BWS Papua's attention to the maintenance of the Sediment Control Building	Non-participatory policymakers, the bees of rule enforcement
		There are many scientific studies on land use change, erosion, and sedimentation in Lake Sentani.	Land clearing by uncontrolled communities.
			The higher the rainfall, the greater the rate of erosion that occurs in the Flavouw River DTA

After conducting a SWOT analysis, then a recalculation is carried out, namely the score and weight of each SWOT. So after that, there will be which handling and direction of recommendations need to be prioritized first.

Conclusion

From the results of the research and analysis carried out, the following conclusions can be drawn:

1. The effect of land use change conditions that occur on sediment control buildings is that there will be an increase in the rate of sedimentation that is carried by surface flows and is trapped in the sediment control building so that the sediment control building reservoir becomes full so that if maintenance is not carried out, it will cause sediment carried by the flow of sediment-water to enter Lake Sentani.
2. The effect of land use change before the construction of the sediment control building based on the analysis conducted by the Papua River Regional Center is known that the potential sedimentation rate is 0.6 mm/year while the potential sedimentation rate analyzed after the sediment control building is 0.012 mm/year. This shows that there is a change in the potential sedimentation rate that enters Lake Sentani which is influenced by the sediment control building.

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