RISK ASSESSMENT AND FLOOD MANAGEMENT OF SELUANG RIVER IN MAHAKAM RIVER BASIN

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ABSTRACT

Seluang River is located in Suka Raja and Tengin Baru villages, Sepaku sub-district, Penajam Paser Utara district, East Kalimantan Province. Seluang River experienced floods from 2021 to 2023, which claimed the lives of approximately 500 families and 350 houses, not including public facilities. For this reason, a study is needed related to the risk and handling of flooding on the Seluang River in the Mahakam River Basin. The length of Seluang River is 29,181 km and the watershed area is 22,386 km^2.

The design flood discharge analysis uses Q100 because the location is the State Capital, obtained a Q100 discharge of 98.84 m^3/s then run using hecras and produce flood inundation with a total area of 1.16 km^2 spread across 2 (two) villages, Suka Raja Village and Tengin Baru Village.

The results of the threat analysis in the area were obtained as high class, the results of the social vulnerability analysis were obtained as medium class, the results of the economic vulnerability analysis for Suka Raja Village were high class and Tengin Baru Village were medium class, the results of the physical vulnerability analysis were obtained as high class, the results of the environmental vulnerability analysis were obtained high class, the results of the flood vulnerability analysis show that the high class area is flood prone. Meanwhile, for the capacity of this area, a medium class analysis or level 3 resilience was obtained and the results of the risk analysis at that location were high class or very at risk of flood disasters.

To reduce the risk of flooding in this area, disaster mitigation efforts need to be carried out, in order to improve flood-resistant infrastructure, good river management, forest conservation, creation of land use, and public awareness about flood risks and how to choose alternative flood control methods. This research aims to obtain a Flood Risk and Management Study on the Seluang River. The method used is the case study analysis method and literature study.

Efforts to deal with floods are divided into 2 types, structural and non-structural, structural, namely building embankments, normalizing rivers, creating green open spaces, building early warning systems. Non-structural policy enforcement and study preparation. These efforts can reduce flooding in the study area.

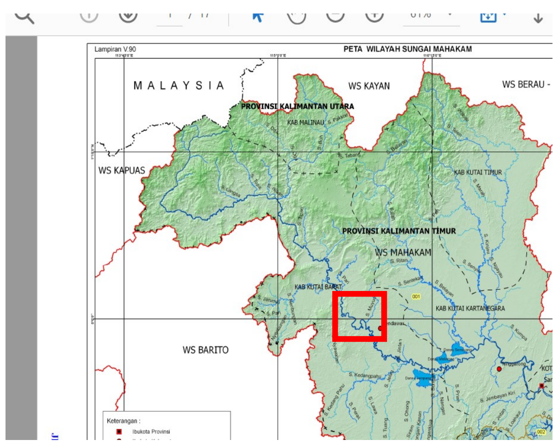
Keywords: *Seluang, Mahakam River Basin, Risk Assessment, Flood Management*

1. INTRODUCTION

Seluang River is located in Suka Raja and Tengin Baru villages, Sepaku sub-district, Penajam Paser Utara district, East Kalimantan Province. Seluang River experienced floods from 2021 to 2023, which claimed the lives of approximately 500 families and 350 houses, not including public facilities. For this reason, a study is needed related to the risk and handling of flooding on the Seluang River in the Mahakam River Basin. The length of Seluang River is 29,181 km and the watershed area is 22.386 km^2.

To identify in a participatory manner the possible hazards and vulnerabilities of community groups to flood events in Sungai Seluang, analyze these and estimate and assess the likelihood of occurrence and potential damage that may be caused by such flood events, and identify and study possible weaknesses and gaps in existing protective and adaptive strategies. To formulate realistic recommendations for actions to address the weaknesses and reduce disaster risks that have been identified and assessed, and agree them with the affected parties. Here it is particularly important to identify and enhance existing capacities and protection strategies. And to ensure and improve the feasibility, effect and efficiency of protective measures by working on the basis of risk analysis to a) balance various interests, b) consider the feasibility of measures and c) make possible social agreements on strategies and measures to reduce disaster risks.The purpose of this research is in the Risk Assessment and Flood Management of Seluang River in Mahakam River Basin is an overall study of the behavior of the middle part of the river that causes overtopping / overflow / inundation and riverbed degradation / aggradation problems, in terms of hydrology and hydraulics for environmental influences on the Seluang River channel, and planning the type of construction that is in accordance with the current river conditions, in order to control further Water Destruction.

Hence the objective is to obtain a Flood Risk and Management Study on the Seluang River. The target to be achieved is to obtain alternatives and handling plans caused by the Seluang River system. The location of the Seluang River watershed is shown in the following figure.



Source: PERMEN PUPR No. 4/PRT/M/2015 tentang Kriteria dan penetapan Wilayah Sungai

Figure 1: Research Location

2. METHODOLOGY

The method used in this research is divided into several parts, namely watershed characteristics analysis, hydrological analysis, hydraulics analysis flood modeling (hecras), risk analysis and risk assessment and flood management.

A. Watershed Characteristics Analysis

Watershed characteristics are influenced by 1) geological conditions, namely (stratification type and porosity / permeability of soil / rock) which affects the absorption capacity of soil, infiltration, percolation, groundwater and the percentage of rainwater that directly into surface flow; 2) the shape of the earth's surface in the form of basins, flat, hilly and so on that affect the fast / slow surface water runoff; 3) land slope, which affects the magnitude of the speed of propagation of surface flow to the river; 4) land use, which affects the permeability of surface soil, the magnitude of evaporation, surface soil moisture, air temperature, surface soil water resistance and stability of the physical condition of the watershed; and 5) geographical location that determines the size of the influence of solar radiation and regional weather.

B. Hydrological Analysis

1) Plan Rain Frequency Analysis Method

Based on the condition of the available data, the methods in the calculation of flood discharge can be classified and described as follows:

a. Availability of observation flood discharge data (gauged catchment):

Availability of instantaneous maximum discharge data for a period of > 20 years, rain data was tested using the outlier test, trend test, independence test and stability test methods.

a) Outlier Test

A rainfall data series needs to be checked for outliers. Checking for outliers in the annual maximum daily rainfall data series, both upper outliers and lower outliers, is done using the method developed by the Water Resource Council (1981). According to the Water Resource Council, if:

- The skewness coefficient of the sample data > +0.4, it is necessary to check for upper outliers,
- The skewness coefficient of the sample data < -0.4, it is necessary to check for lower outliers,
- And -0.4 < skewness coefficient < +0.4, it is necessary to check for upper outliers and lower outliers.

b) Trend Test

Before being used for analysis, a hydrological data series must first be confirmed to be free of trend, which is the correlation between the sequence of data and the increase (or decrease) in the magnitude of the data values. In general, the trend test is performed for the entire data period, although it can also be performed only on data periods where a trend is suspected.

c) Independence Test

To check the independence of a data series, the serial-correlation coefficient is used. If the data series is perfectly random, then the auto-correlation function of the population will be equal to zero for all lags, except zero. To check for independence, it is sufficient to calculate the serial-correlation coefficient, which is the correlation between adjacent observations in the data series.

d) Stability Test

In this stability test, it is carried out to determine whether the data is stationary or not. In general, there are two tests carried out on variance and mean in the form of F and T tests, where the F test distribution of the variance ratio follows a normal distribution and indicates the stability of the variance. The F test is described by the equation:

$$F_t = \frac{\sigma^2 1}{\sigma^2 2} = \frac{s^2 1}{s^2 2}$$

Description:

Ft : stability for which indications are acceptable

σ : population scale standard deviation

s : sample scale standard deviation

b. Availability of maximum instantaneous discharge data for a period of time < 20 years, rain data was tested using the outlier test, trend test, independence test and stability test methods. The methods that can be used are:
    a) Regional analysis method, if the maximum instantaneous discharge observation discharge data available is less than 20 years and greater than 10 years then it can be used with the addition of synthetic discharge from the regional analysis of neighboring watersheds (which is calculated using frequency analysis of observed discharge that has observations > 20 years or from the relationship between rain and discharge at the maximum rainfall event where the relationship parameters are obtained from the results of calibration). The results of this regional analysis can be used if the characteristics of the watershed and neighboring rainfall homogeneous. Testing the homogeneity can be done with a correlation approach between the two watersheds;
    b) Threshold method, if the available instantaneous flood discharge data is between 3 years to 10 years. This method is based on taking the flood peak in one year (several events) above a certain threshold and is only suitable for data obtained from the automatic water estimation post (PDAO);

c. Satellite Data Rainfall Plan Analysis
Satellite rain data can be used in conditions of limited rain station data in terms of spatial and temporal. Spatial limitations here in the sense that the location of the rain station is far from the watershed being studied, while temporal limitations mean that the length of the available rain data is too short or has a lot of empty data. Based on previous studies, it is known that satellite rain data has errors when compared to rain station/groundstation data. Therefore, before being used for further analysis, satellite rain data needs to be corrected first.
Examination of rain data results in that the rain data series at each station is suitable for further analysis. Results of frequency analysis with GEV probability distribution. In general, each rainfall station has a similar amount of rainfall with a similar family curve. This shows that the results of the analysis using the GEV probability distribution are reasonable and acceptable.

2) Flood Discharge Calculation Method
The flow hydrograph describes a time distribution of flow (in this case discharge) in a river within a watershed at a certain location. The flow hydrograph of a watershed is an important part needed in various planning in the field of Water Resources. There is a close relationship between the hydrograph and the characteristics of a watershed, where the flood hydrograph can show the response of the watershed to the rainfall input.
a. Definition
By definition, a unit hydrograph is a hydrograph of direct runoff (without base flow) recorded at the downstream end of a watershed generated by one unit of effective rainfall (1 mm, 1 cm, or 1 inch) that occurs evenly throughout the watershed with a fixed intensity in a certain unit of time (e.g. 1 hour).

C. Hydraulics Analysis

In conducting hydraulic analysis using HEC-RAS softwre which is an application program for modeling flow in rivers, River Analysis System (RAS), created by the Hydraulic Engineering Center (HEC) which is a work unit under the US Army Corps of Engineers (USACE). Basically, HEC-RAS was developed to accommodate 4 types of hydraulic analysis, namely:
1) Water level profile analysis for steady flow
2) Water level profile analysis for unsteady flow
3) Water quality modelling (pollutant distribution and temperature)

D. Risk Analysis

Flood hazards were created based on flood-prone area data by taking into account the depth of inundation in accordance with Regulation No. 2 of BNPB Year 2012. Flood prone areas were created using DEM raster data based on the method developed by Manfreda et al (2009) through a modified topographic index with the equation:

$$TI_{m} = log\left(\frac{a_d^n}{tan(\beta)}\right)$$

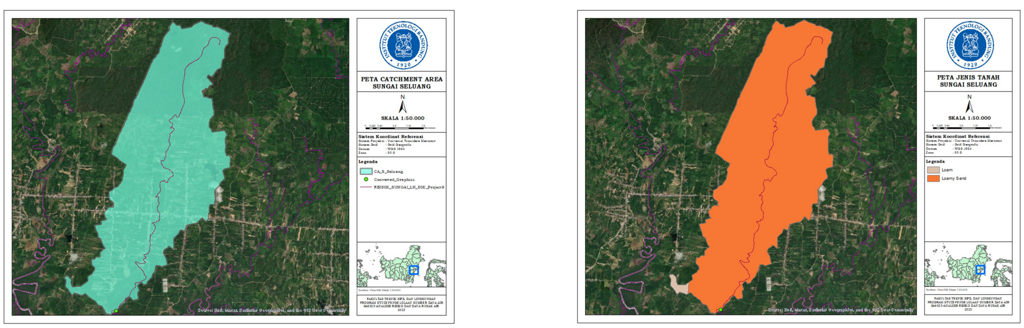
Where TIm is the modified topographic index, ad is the flow area per unit contour length (or accumulated flow value based on DEM data analysis; value depends on DEM resolution), tan (β) is the slope (based on DEM data analysis), and n is an exponential value. The n value is calculated by the formula n = 0.016x0.46, where x is the DEM resolution. After the topographic index map is produced, flood-prone areas can be identified through the use of a threshold value (τ) where a flood-prone area is if the topographic index value is greater than the threshold value (TIm > τ). The value of τ is τ = 10.89n + 2.282. The flood hazard index is estimated based on the slope and distance from the sun in the flood-prone area using the fuzzy logic method.

3. ILLUSTRATION

A. Watershed Characteristics Analysis

1) Catchment Area

The shape of the earth's surface in the form of basins are variative. The height difference between upstream and downstream has a slope of 0.03186%. The catchment area of the Seluang River has an area is 22.386 km^2 and the length of Seluang River is 29,181 km. The catchment area of Seluang River is shown in the figure below.



Source: Analysis Result, 2023

Figure 2 Catchment Area of Seluang River and Soil Type Map of Seluang River Catchment Area

2) Geological Condition

Geological Conditions in the Seluang River catchment area obtained from the Harmonized World Soil Database are divided into 2 types of soil, namely loamy sand soil type with Hydrologic Soil Group "A" spread in the upstream to middle area and loam soil type with Hydrologic Soil Group "B" spread in the downstream catcment area. The soil type map of the Seluang River catchment area is shown in the figure 3 and table below.

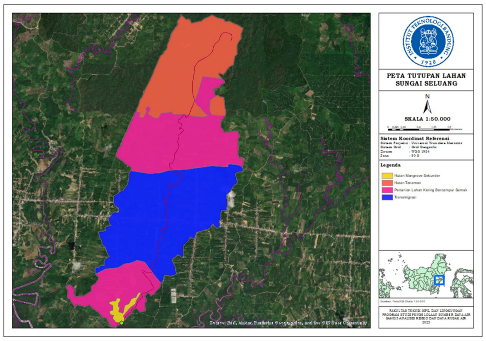
Table 1 Soil Type Map of Seluang River Catchment Area

SNUM	Texture class (USDA conventions)	HSG	D1_Topsoil (0-30 cm)		
			% Sand	% Silt	% Clay
4563	Loamy sand	A	87	6	7
3749	Loam	B	49	28	23
SNUM	Texture class (USDA conventions)	HSG	D2_Subsoil (30-100 cm)		
			% Sand	% Silt	% Clay
4563	Loamy sand	A	87	6	7
3749	Loam	B	49	26	25
SNUM	Texture class (USDA conventions)	HSG	(Combine (30% Top Soil + 70% Sub Soil)		
			% Sand	% Silt	% Clay
4563	Loamy sand	A	87	6	7
3749	Loam	B	49	26.6	24.4

Source: Analysis Result, 2023

3) Land Use

In the Seluang River catchment area analyzed based on data from the Ministry of Environment and Forestry related to Land Cover, 4 types of land cover were obtained in the catchment area. Among others, Secondary Mangrove Forest with an area of 0.26 Km^2, Plantation Forest with an area of 5.50 Km^2, Dry Land Agriculture Mixed with Shrubs with an area of 8.11 Km^2 and Transmigration with an area of 8.42 Km^2. The Land Use Map of the Seluang River Catchment Area is shown in the figure and table below.



Source: Analysis Result, 2023

Figure 3 The Land Use Map of the Seluang River Catchment Area

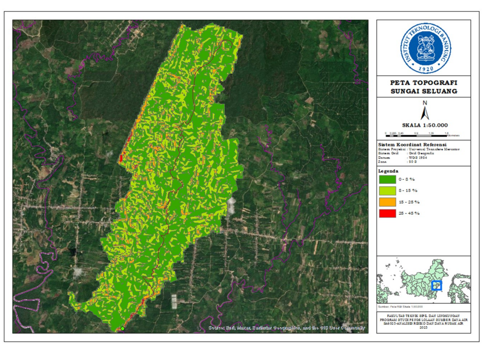
Table 2 The Land Use Map of the Seluang River Catchment Area

FID *	pl2020_id	Jenis_Tu_1	Luas_Tupl (Km^2)
1	20041	Hutan Mangrove Sekunder	0.26
2	2006	Hutan Tanaman	5.50
3	20092	Pertanian Lahan Kering Bercampur Semak	8.11
4	20122	Transmigrasi	8.42
		Jumlah	22.29

Source: Analysis Result, 2023

4) Land Slope

The slope of the Seluang River catchment area is divided into 4 (four) classes, namely the flat class with a slope of 0%-8%, the gentle class with a slope of 8%-15%, the moderately steep class with a slope of 15%-25% and the steep class with a slope of 25%-45%. The Seluang River Catchment Area Slope Map is shown in the figure and table below.



Source: Analysis Result, 2023

Figure 4 The Seluang River Catchment Area Slope Map

Table 3 The Seluang River Catchment Area Slope

KERELRENGAN	KLAS
0 – 8 %	Datar
8 – 15 %	Landai
15 – 25 %	Agak Curam
25 – 45 %	Curam

Source: Analysis Result, 2023

B. Hydrological Analysist

1) Rainfall Plan Analysis

Rainfall data based on satellite data processing using Global Precipitation Measurement (GPM). GPM provides 0.1º spatial rainfall data (about 10-11 km at the equator) in the range of 0.5 - hourly, daily, or monthly. This data is then corrected with the nearest ground-based rain station data. The rain station data used for GPM satellite data correction comes from the Samboja Karya Tunggal Rain Station with coordinate 1 02' 06" LS-117 02' 48" BT from 2012 to 2021. With the results of several rain data tests as follows.

The results of the outlier test show that the rain data to be used is accepted, the results of the trend test on rain data obtained the results are accepted, the results of the rain data independence test obtained independent data series. The results of the rain data stability test show that the mean and variance data are stable. Next is to look for gpm data from each grid in the catchment area, the Seluang River catchment area is divided into 4 (four) grid sections. And obtained the annual maximum regional rainfall as follows.

Table 4 Annual Maximum Rainfall

Tahun	Max of GPM Koreksi_S1	Max of GPM Koreksi_S2	Max of GPM Koreksi_S3	Max of GPM Koreksi_S4	Hujan Wilayah
2012	143.68	131.15	95.60	95.60	116.26
2013	103.98	124.94	77.19	77.19	93.93
2014	74.86	86.82	177.08	177.08	130.41
2015	103.17	87.91	108.77	108.77	103.23
2016	67.43	72.85	87.26	87.26	78.79
2017	98.62	254.55	167.43	167.43	163.70
2018	171.45	176.86	229.57	229.57	202.77
2019	131.65	129.95	164.85	164.85	148.65
2020	71.47	90.70	105.19	105.19	92.66
2021	106.68	106.67	127.39	127.39	117.48

Source: Analysis Result, 2023

2) Rain Frequency Analysis

From the maximum area rainfall, the design rainfall with return period 2, 5, 10, 25, 50, 100, 200 and 1000 can be analyzed. Analyzing the design rainfall using several methods including the gumbel method, the normal method and the log pearson type III method. The results of the calculation are shown in the table below. Of the three methods, the results of the gumbel method passed The Chi Square distribution test and The Smirnov Kolmogorov distribution test. A comparison of the fit test results is shown in the table below.

Table 5 Fit Test Resume

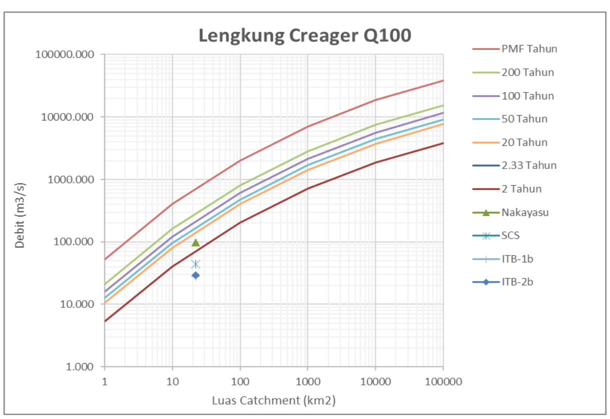
Resume Uji Kecocokan

No.	Jenis Distribusi	Jenis Uji Kecocokan	
		Rata-rata % Error	Deviasi
1	Normal	5.97	12.32
2	Gumbel	4.19	5.80
3	Log Pearson III	18.12	27.00
Maksimum		21.30	27.24
Minimum		4.19	5.80

Source: Analysis Result, 2023

3) Effective Rainfall Analysis

Therefore, it is necessary to transform point rainfall into areal rainfall. Areal rainfall that uses catchment area as its boundary of influence is often referred to as basin rainfall. After obtaining the HSS Q100, then test the planned flood discharge with the creager curve. The closest HSS Nakayasu with Q100 of 98,84 m3/s is obtained, shown in the figure and table below.



Source: Analysis Result, 2023

Figure 5 Creager Q100 arch

Table 6 Creager Q100

	Nakayasu	SCS	ITB-1b	ITB-2b	Q creager	T	a
Qp100 (m3/s)	98.84	43.73	28.06	29.51	147.75	20	0.80625

Source: Analysis Result, 2023

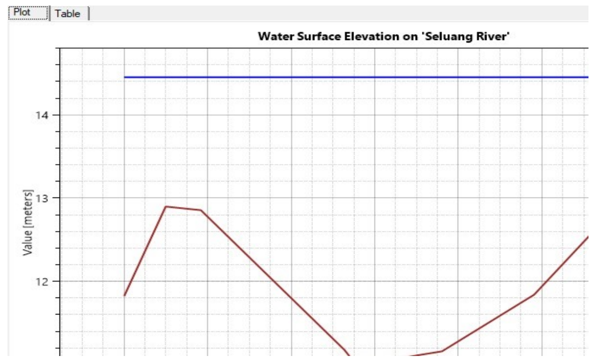
C. Hydraulics Analysis

The data needed to analyze the hydraulics of the Seluang River catchment area are DEM Data, Land Cover, Slope, Q100 Plan Flood Discharge. By using the HEC-RAS software application. The flood inundation area in Suka Raja Village is 0,84 Km^2 and the flood inundation area in Tengin Baru Village is 0,32 km^2. With a total inundation area in the catchment area of 1.16 km^2. With flood inundation depth as shown below. Percentage of Flood Inundation to Village Area is 0,11 for Sukaraja Village and 0,07% for Tengin Baru Village.

Table 7 Flood Inundation Area

Sum of Genangan			
DESA	gridcode	Total	Ha
SUKA RAJA	1	0.1650	16.50
	2	0.1552	15.52
	3	0.5233	52.33
SUKA RAJA Total		**0.8435**	
TENGIN BARU	1	0.0915	9.15
	2	0.0632	6.32
	3	0.1685	16.85
TENGIN BARU Total		**0.3232**	
Grand Total		**1.1668**	**116.68**

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 6 Flood Depth

D. Risk Analysis

For the calculation of the Provincial level, the whole process was carried out following cartographic rules, namely with a minimum analysis using input data available at a scale of 1 : 250.000. The results produced will also follow the scale of the analysis used. This also refers to the general guidelines for disaster risk assessment established by BNPB in 2012.

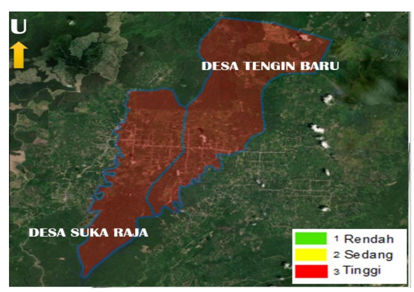
1) Hazard Analysis

Flood Hazard Index component, using the Prone Class field, there is only one type of class, namely flood prone. Overlaying the flood prone class with SRTM to get the inundation height. Using the scoring class is high grade. The table above shows that Suka Raja Village and Tengin Baru Village are in the high hazard index class. The hazard index map can be seen in the figure below.

Table 8 Flood Hazard Index Results

Kedalaman (m)	Nilai	Luas Genangan (km²)	Skor	Luas Genangan x Skor	Ancaman Banjir	Kelas
SUKA RAJA						
< 0.76	1	0.165	0.333	0.055	0.808	Tinggi
0.76 - 1.50	2	0.155	0.667	0.104		
> 1.50	3	0.523	1.000	0.523		
	Jumlah	**0.844**		**0.682**		
TENGIN BARU						
< 0.76	1	0.091	0.333	0.030	0.746	Tinggi
0.76 - 1.50	2	0.063	0.667	0.042		
> 1.50	3	0.169	1.000	0.169		
	Jumlah	**0.323**		**0.241**		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 7 Flood Hazard Map

2) Social Vulnerability

Social vulnerability consists of population density parameters and vulnerable groups. Vulnerable groups consist of sex ratio, vulnerable age group ratio, poor population ratio, and disabled population ratio. Spatially, each parameter value is distributed in the settlement area per village/hamlet in the form of a raster grid (pixels) based on WorldPop data references or developed dasymetric methods. Each pixel represents a social parameter value (number of people) in the entire settlement area. The parameters of social vulnerability shown middle grade. The results of the analysis of social vulnerability calculations obtained a medium class in each village. Shown in the figure below.

Table 9 Social Vulnerability Score

Parameter	Bobot (%)	Nilai	Skor	Kerentanan Sosial	Kelas
Suka Raja					
Kepadatan Penduduk (jiwa/km²)	60	50	0.333	0.462	Sedang
Rasio Jenis Kelamin (%)	10	107%	1.000		
Rasio Kemiskinan (%)	10	32%	0.333		
Rasio Orang Cacat (%)	10	155%	0.333		
Rasio Kelompok Umur (%)	10	261%	0.667		
Tengin Baru					
Kepadatan Penduduk (jiwa/km²)	60	90	0.333	0.462	Sedang
Rasio Jenis Kelamin (%)	10	103%	1.000		
Rasio Kemiskinan (%)	10	40%	0.333		
Rasio Orang Cacat (%)	10	128%	0.333		
Rasio Kelompok Umur (%)	10	251%	0.667		

Source: Analysis Result, 2023

Source: Analysis Result, 2023

Figure 8 Social Vulnerability Map Medium Score

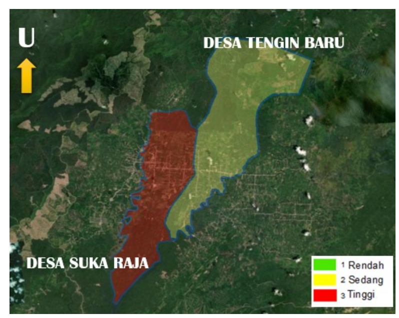
3) **Economic Vulnerability**

Economic vulnerability consists of the parameters of GRDP contribution and productive land. The dollar value of productive land is calculated based on the value of GRDP contributions to sectors related to productive land (such as agriculture) that can be classified based on land use data. The parameters of economic vulnerability analysis shown below. Results of the economic vulnerability analysis in each village. The difference between the two villages is that Suka Raja Village obtained high economic vulnerability results, while Tengin Baru Village obtained moderate economic vulnerability results.

Table 10 Results of Economic Vulnerability Analysis

Parameter	Bobot (%)	Besaran (juta)	Skor	Kerentanan Ekonomi	Kelas
Suka Raja					
Lahan Produktif	60	Rp 60,186.22	0.667	0.800	Tinggi
PDRB	40	Rp 5,654,589.69	1.000		
Tengin Baru					
Lahan Produktif	60	Rp 33,818.77	0.333	0.600	Sedang
PDRB	40	Rp 5,654,589.69	1.000		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 9 Economic Vulnerability Analysis Map

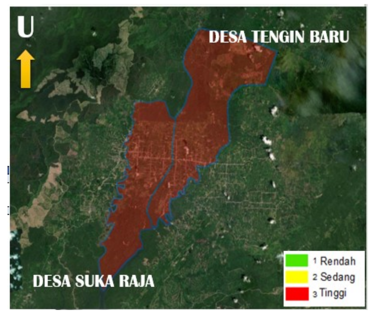
4) **Physical Vulnerability**

Physical vulnerability consists of the parameters of houses, public facilities and critical facilities. The total dollar value of houses, public facilities and critical facilities was calculated based on the hazard class in the affected area. The spatial distribution of the value of rupiah for the parameters of houses and public facilities was analyzed based on the distribution of residential areas as was done for the analysis of social vulnerability. Each parameter was analyzed using a scoring method in accordance with BNPB Regulation No. 2/2012 to obtain a physical vulnerability score. The parameters of physical vulnerability shown below are. The results of the Physical Vulnerability Analysis of the two villages are high vulnerability. So it is displayed on a red map shown below.

Table 11 Results of Physical Vulnerability Analysis

Parameter	Bobot (%)	Juta Rupiah	Skor	Kerentanan Fisik	Kelas
Suka Raja					
Rumah	40	Rp 16,860.00	1.000	1.000	Tinggi
Fasilitas umum	30	Rp 35,250.00	1.000		
Fasilitas Kritis	30	Rp 6,700.00	1.000		
Tengin Baru					
Rumah	40	Rp 17,550.00	1.000	1.000	Tinggi
Fasilitas umum	30	Rp 34,500.00	1.000		
Fasilitas Kritis	30	Rp 6,450.00	1.000		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 10 Physical Vulnerability Analysis Map

5) **Environmental Vulnerability**

The results of the environmental vulnerability analysis in each village location obtained high-class environmental vulnerability results, which means that both villages are very vulnerable to flood disasters. The map of the results of the environmental vulnerability analysis is shown in the figure below.

Table 12 Results of Environmental Vulnerability Analysis

Parameter	Bobot (%)	Luas (Ha)	Skor	Kerentanan Lingkungan	Kelas
Suka Raja					
Hutan Lindung	30	2060	1.000	0.9333	Tinggi
Hutan Alam	30	3500	1.000		
Hutan Bakau/ Mangrove	10	150	0.333		
Semak Belukar	10	1500	1.000		
Rawa	20	54	1.000		
Tengin Baru					
Hutan Lindung	30	1642	1.000	0.9333	Tinggi
Hutan Alam	30	5700	1.000		
Hutan Bakau/ Mangrove	10	150	0.333		
Semak Belukar	10	2000	1.000		
Rawa	20	30	1.000		

Source: Analysis Result, 2023

Source: Analysis Result, 2023

Figure 11 Environmental Vulnerability Analysis Map

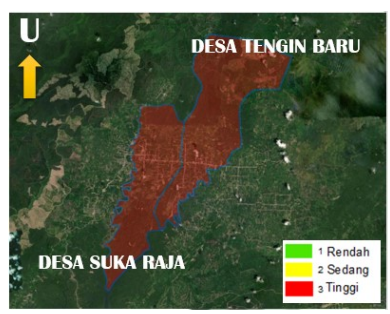
6) **Flood Vulnerability**

The vulnerability index of each threat is obtained from the results of combining the social, physical and economic vulnerability scores using the weight of each vulnerability component as follows flood : IKB=(IKS x 40%)+(IKF x 25%)+(IKE x 25%)+(IKL x 10%). The results of flood vulnerability shown below. The map of the flood vulnerability analysis results is shown in the figure below.

Table 13 Results of Flood Vulnerability

Parameter	Skor	Kerentanan Banjir	Kelas
SUKA RAJA			
Kerentanan Sosial	0.462	0.728	Tinggi
Kerentanan Ekonomi	0.800		
Kerentanan Fisik	1.000		
Kerentanan Lingkungan	0.933		
TENGIN BARU			
Kerentanan Sosial	0.462	0.678	Tinggi
Kerentanan Ekonomi	0.600		
Kerentanan Fisik	1.000		
Kerentanan Lingkungan	0.933		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 12 Flood Vulnerability Analysis Map

7) **Capacity Analysis**

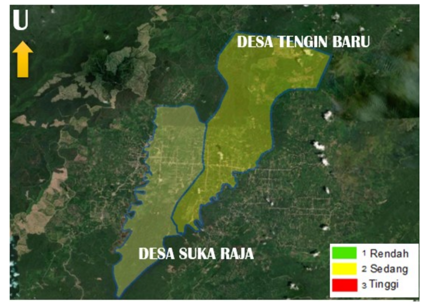
Regional capacity in the implementation of disaster management is an important parameter to determine the success of disaster risk reduction. Regional capacity in disaster management must refer to the National Disaster Management System contained in Law No. 24/2007 on Disaster Management and its derivatives.

The capacity analysis parameters refer to the Head of BNPB Regulation No. 2/2012 on General Guidelines for Disaster Risk Assessment, shown in the table below. The results of the Capacity Analysis show that the capacity of the 2 (two) areas or villages is in the medium class or resilience level 3.

Table 14 Capacity Analysis Results 1

No	Komponen/ Indikator	Bobot (%)	Skor	Kapasitas	Kelas
Suka Raja					
1	Aturan dan Kelembagaan Penanggulangan Bencana	100	0.667	0.400	Sedang
2	Peringatan Dini dan Kajian Risiko Bencana		0.333		
3	Pendidikan Kebencanaan		0.333		
4	Pengurangan Faktor Risiko Dasar		0.333		
5	Pembangunan Kesiapsiagaan pada seluruh ini		0.333		
Tengin Baru					
1	Aturan dan Kelembagaan Penanggulangan Bencana	100	0.667	0.400	Sedang
2	Peringatan Dini dan Kajian Risiko Bencana		0.333		
3	Pendidikan Kebencanaan		0.333		
4	Pengurangan Faktor Risiko Dasar		0.333		
5	Pembangunan Kesiapsiagaan pada seluruh ini		0.333		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 13 Regional Capacity Analysis Map

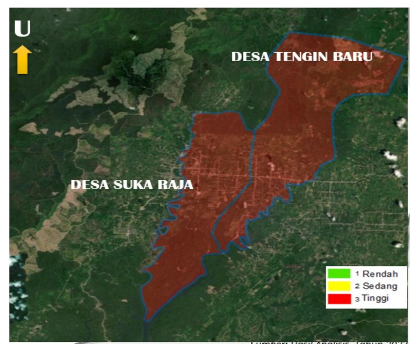
8) Flood Risk Analysis

The results of the flood disaster risk analysis show that both areas are at high risk. Shown in the figure and table below.

Table 15 Risk Analysis Results

No	Parameter	Skor	Risiko Banjir	Kelas
Suka Raja				
1	Indeks Ancaman (Hazard)	0.808	0.707	Tinggi
2	Indeks Kerentanan (Vulnerability)	0.728		
3	Indeks Kapasitas (Capacity)	0.400		
Tengin Baru				
1	Indeks Ancaman (Hazard)	0.746	0.671	Tinggi
2	Indeks Kerentanan (Vulnerability)	0.676		
3	Indeks Kapasitas (Capacity)	0.400		

Source: Analysis Result, 2023



Source: Analysis Result, 2023

Figure 14 Flood Risk Analysis Map

9) Flood Risk Assessment and Management

From the results of flood modeling analysis and risk analysis in the research watershed, to reduce flood inundation and reduce all material and non-material losses, handling and risk management efforts in water destructive power are carried out.

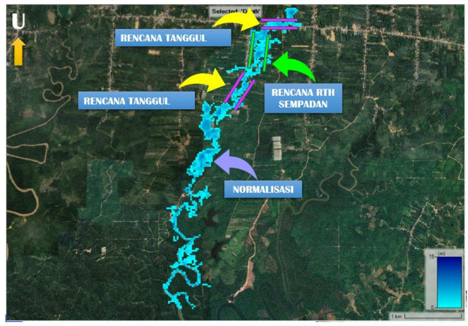
Alternative handling is divided into 2 (two), namely structural and non-structural.

Structural:

- Embankment Construction
- River Normalization
- Creation of Riverbanks Green Open Space
- Construction of Early Warning System

Non-Structural Early Warning System:

- Policy Enforcement
- Preparation of flood-related Studies/Research/Detail Engineering Design.



Source: Analysis Result, 2023

Figure 15 Flood Management Efforts

With the efforts made, it can reduce flooding and reduce losses due to flood disasters in the form of casualties or material.

4. CONCLUSIONS

The conclusion of this research is that the Seluang River catchment area has an area of 22,386 Km^2 and a river length of 29.181 km, has 2 (two) types of soil, namely loam and loamy sand, with land cover which is divided into 4 (four) namely secondary mangrove forest, plantation forest, dry land agriculture mixed with shrubs and transmigration. The slope of the catchment area varies with 0 - 8% flat class, 8 - 15% sloping class, 15 - 25% slightly steep class, 25 - 45% steep class.

In the hydrological analysis of rain data from the Samboja Karya Tunggal station passed the outlier, trend independence and stability tests, after which correcting the GPM data downloaded from Giovanni with the rain data shown in Table 10. After that, analyze the rain frequency with the Gumbel method, the normal method and the log Pearson type III method, by testing the suitability using the CHI Square and Smirnov Kolmogorov methods and the one that passes is the Gumbel Method.

The design flood discharge analysis uses Q100 because the location is the State Capital, obtained a Q100 discharge of 98.84 m^3/s then run using hecras and produce flood inundation with a total area of 1.16 km^2 spread across 2 (two) villages, Suka Raja Village and Tengin Baru Village.

The results of the threat analysis in the area were obtained as high class, the results of the social vulnerability analysis were obtained as medium class, the results of the economic vulnerability analysis for Suka Raja Village were high class and Tengin Baru Village were medium class, the results of the physical vulnerability analysis were obtained as high class, the results of the environmental vulnerability analysis were obtained high class, the results of the flood vulnerability analysis show that the high class area is flood prone. Meanwhile, for the capacity of this area, a medium class analysis or level 3 resilience was obtained and the results of the risk analysis at that location were high class or very at risk of flood disasters.

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