RESEARCH ARTICLE OPEN ACCESS

Study of Sediment Mass Flow in the Sumbawa River Basin

Ida Nyoman Gaotama[1], Eko Pradjoko, ST., M.Eng.,Ph.D[2], Dr. Eng. Hartana, ST.,MT[2]

[1]*Civil Engineering-Master Program, University of Mataram, Mataram, Indonesia*
[2]*Civil Engineering, University of Mataram, Mataram, Indonesia*
Corresponding Author: Ida Nyoman Gaotama

ABSTRACT:
Sumbawa River Basin consists of hills with the center of Mount Tambora, located in the middle of the Sumbawa River Basin, and mountain ranges located in the North and South. Due to the active volcano, Sumbawa River Basin is vulnerable to debris danger. The work of Sediment Mass Flow Studies in the Sumbawa River Basin has been carried out with the application of the Model Builder System with the Inverse Distance Weighted (IDW) interpolation method, namely the interpolation process by using a weighted average between the value and distance of the closest point to the interpolated cell, and the Complex Model type with using 5 (five) indicators of spatial and tabular data including: gradient of debris flowing relationship with river slope, slope, hydrology, regional geology, and land use. From the model work, it is obtained the classification of the potential distribution zones of sediment flow in the Sumbawa River Region as follows: Zone 1 (High Debris Potential) of 3,480.69 Km^2 = 23%, Zone 2 (Middle Debris Flow Potential) of 4,464.99 Km^2 = 30%, Zone 3 (Potential Low Debris Flow) area of 5,084.33 Km^2 = 34%, and Zone 4 (No Potential Debris Flow) of 2,055.46 Km^2 = 14%. The average volume of sediment transported (Vec) in the Sumbawa River Region is 941,436.79 m^3. Regency / City Region with a percentage value of Zone 1 (zone of potential for High debris flow) ≥ 20% is Sumbawa Regency and Bima City.

Keyword:Debris,Sumbawa River Basin, Flow Coefficient

Date of Submission: 02-11-2019 Date Of Acceptance: 20-11-2019

I. INTRODUCTION

Administratively, Sumbawa River Basin Have 4 (four) Regencies and 1 (one) City, namely: Sumbawa Regency, West Sumbawa Regency, Dompu Regency, Bima Regency, and Bima City.

Sumbawa River Basin has a very diverse topography, ranging from flat, sloping to hilly and mountainous. Productive plains for cultivation are generally located along the north coast of the island (RPSDA Sumbawa River Basin, 2018). Sumbawa River Basin has an area of approximately 15,414.50 km², and land cover according to data from the Ministry of Forestry is around 42.50% for forest area (6,553 km²) Land cover outside that is in the cultivation area, and in general it is still Shrubs / Thicket (5,111 km², 33.16%). The land use in the Sumbawa River Basin includes paddy fields and dry land (gardens, swamps, ponds, ponds, forests, settlements and plantations) (RPSDA Lombok River Basin, 2018).

The Sumbawa River Basin consists of hills with the center of Mount Tambora, located in the middle of the Sumbawa River Basin, and mountain ranges located in the North and South. Due to the active volcano, Sumbawa River Basin is vulnerable to debris danger.

The natural disasters of flash floods that occurred in the Belanting watershed and in the Segara watershed (Bentek Village) in the Lombok River Basin were unexpected, so the vigilance of similar disasters in other areas in the Sumbawa Island region needs to be prioritized. Since Sumbawa Island includes rivers that have steep cliff conditions and landslides often occur, a survey of potential flood sediments is needed in this area.

II. STUDY AREA

The location of the activity is in the watersheds in the Sumbawa River Basin which in analysis maps allows debris to occur administratively covering the Sumbawa Regency and part of Dompu Regency.

Map of The Sumbawa River Basin

Map of the Hydrological Postal Network

III. METHOD

3.1 Results of Rainfall data analysis

Rainfall data used in this hydrological analysis are: ARR Gapit, ARR Kadindi, ARR Parado, ARR Pungkit atas, ARR Rea Atas, ARR Semongkat, ARR Sumi, and ARR Utan Rhee.And then for further analysis, from the 8 (eight) stations Polygon Isohyet was made with the aim of obtaining the percentage of the cathedral area that influences each of the rain stations for a 100-year design rain.

3.2 Results of Rainfall Analysis design of each Automatic Rainfall Recorder (ARR) Station

Design rainfall is the largest annual rainfall with a certain probability of occurrence in a certain return period. Design rainfall is needed as input data for design flood discharge analysis, drainage modulus analysis and other analyzes.

3.3 Analysis of Flow Control

Normative Reference: SNI No. 03-1724-1989, Sni No. 03-2415-1991, SNI 03-2851-1991, Pd T-18-2004-A.

Control,(Tg Ø) $tg\theta_c = \frac{C_*(\rho_s-\rho_w)}{C_*(\rho_s-\rho_w)+\rho_w\left(1+\frac{1}{K}\right)} tg\varphi$

Sediment Concentration (Cd) $C_d = \frac{11{,}85\times tg^2\theta}{1+11{,}85\times tg^2\theta} tg\varphi$

Total Flow Discharge (Qt) $Q_t = \frac{2}{3{,}6}\left(f_2\times A_2+f_1\frac{C_d}{C_*-C_d}A_1\right)I_{30}$

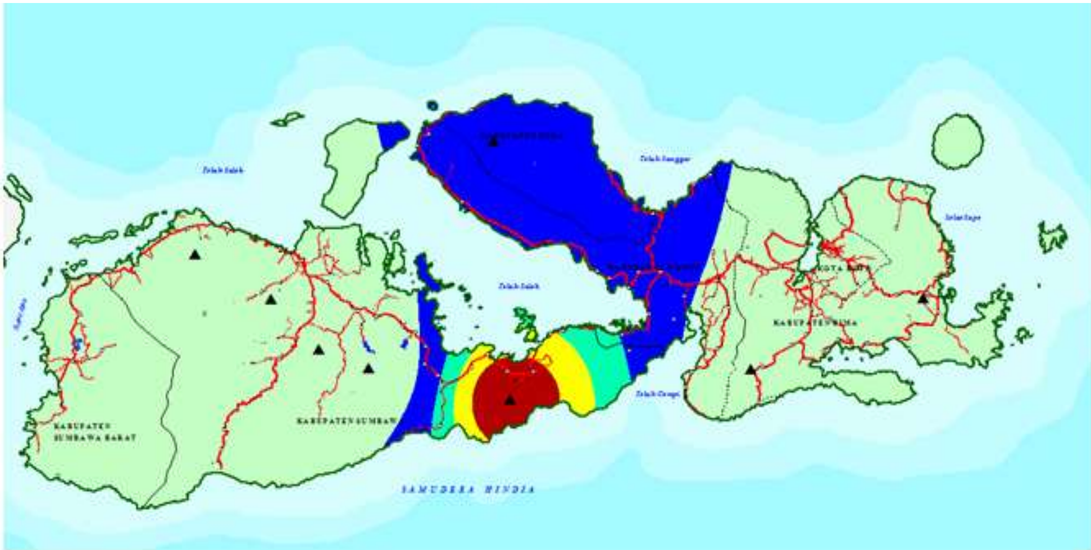
Flow Volume Sediments Transported(Vec)

$$V_{ec} = \frac{R_{24}\times A\times 10^3}{1-\lambda}\left(\frac{C_d}{1-C_d}\right)f_r$$

IV. RESULT AND DISCUSSION

Rainfall analysis uses the Thiesen Polygon method. Sumbawa River Basin. Here are the results of the analysis of the Polygon Thiesen.

4.1 Rainfall



Map of Polygon Isohyet Rain Design 100 Years Sumbawa River Basin

4.2 Results of Rainfall Analysis Design of Each Automatic Rainfall Recorder (ARR) Station

Design rainfall is the largest annual rainfall with a certain probability of occurrence in a certain return period. Design rainfall is needed as input data for design flood discharge analysis, drainage modulus analysis and other analyzes.

Table 4.1. Recapitulation of Rainfall Design of Each ARR in Sumbawa River Basin

No	Probability	Return Period (Years)	ARR Gapit	ARR Kandidi	ARR Parado	ARR Pungkit Atas	ARR Rea Atas	ARR Semongkat	ARR Sumi	ARR Utan Ree
			Manual (mm)	Manual (mm)	Manual (mm)	Manual (mm)	Manual (mm)	Manual (mm)	Manual (mm)	Manual (mm)
1	0.5	2	952.367	1466.63	301.359	242.738	200.924	295.901	221.468	147.652
2	0.8	5	798.416	567.932	248.5	203.809	171.216	256.518	182.659	138.8
3	0.9	10	731.289	472.063	225.681	187.004	158.391	217.172	165.905	134.831
4	0.96	25	662.984	385.216	202.778	170.137	145.519	195.498	149.09	129.751
5	0.98	50	592.604	306.148	179.705	153.144	132.551	174.428	132.15	123.208
6	0.99	100	495.174	213.113	148.603	130.239	115.071	147.196	109.315	111.27
7	0.995	200	415.654	150.765	123.988	112.111	101.237	126.422	91.242	98.434
8	0.999	1000	291.726	76.262	86.809	84.73	80.341	96.243	63.945	71.546

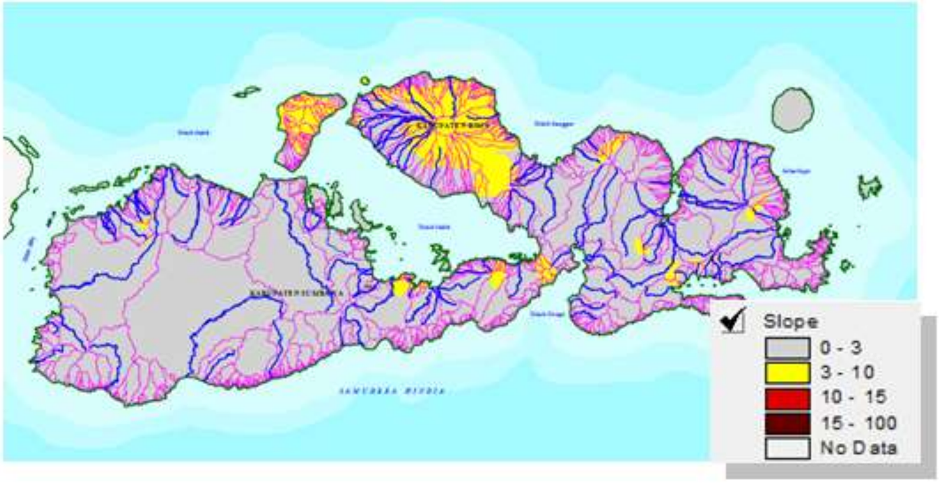
4.3 Potential / Simulation Results of Sediment Potential Based on Geographic Information Systems (GIS)

The mass formed from the material of debris (debris) called debris and media mixing water, flows down the valley from the upstream to the downstream with very high speed and strength of damage.Some of the characteristics of the debris flow disaster are:

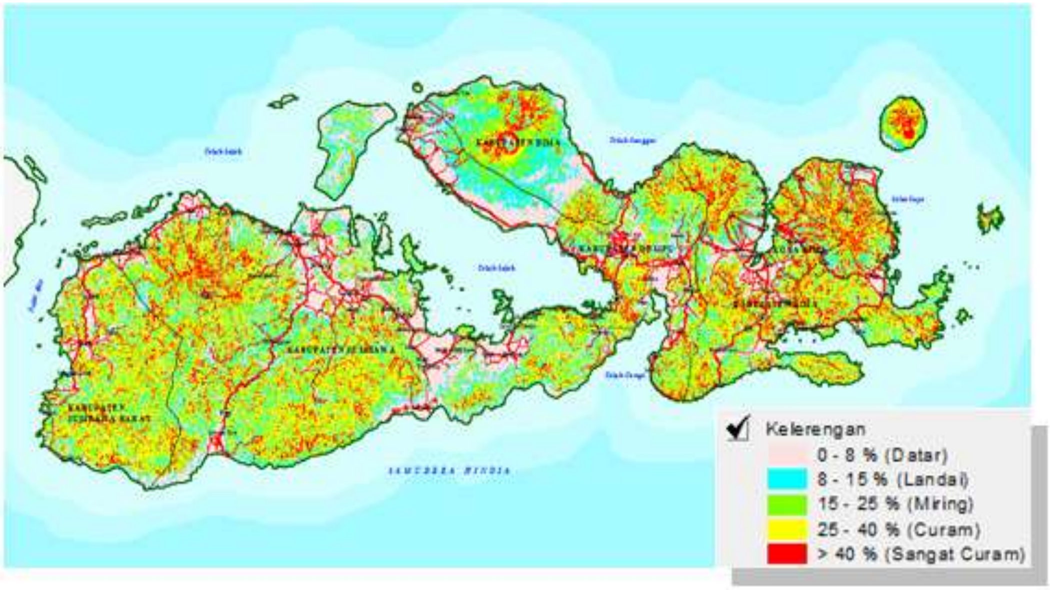
- There were many casualties
- Many houses and public facilities were damanged by debris flow attacks.

Large time and funds are needed to reconstruct areas damaged by debris flooding.

Making simulation models of potential sediment flooding in the WS. This Sumbawa will apply the ModelBuilder System with the Inverse Distance Weighted (IDW) interpolation method, the interpolation process using the weighted average between the value and distance of the closest point to the interpolated cell, and the Complex Model type using 5 (five) indicators of spatial and tabular data . The technique of this indicator's theme grid process with 3 (three) forms of the Process Grid Model are the slope, point, and vector model

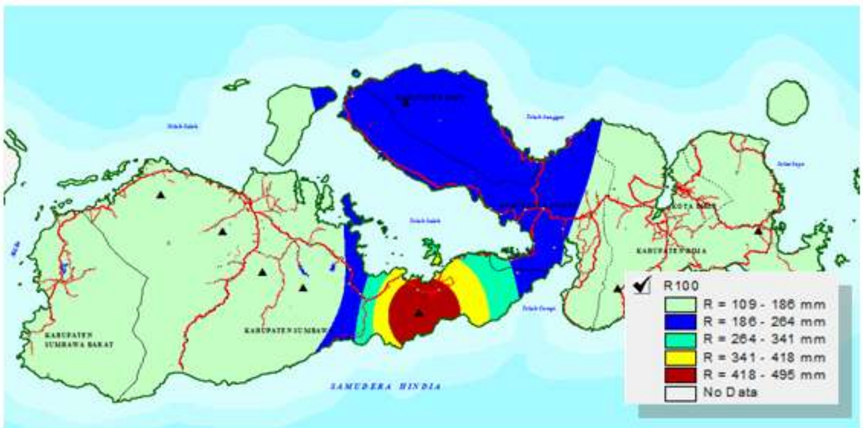


Display Results / Output Model Theme Grid Indicator Gradient Event Flow of Debris with River Slope in Sumbawa River Basin

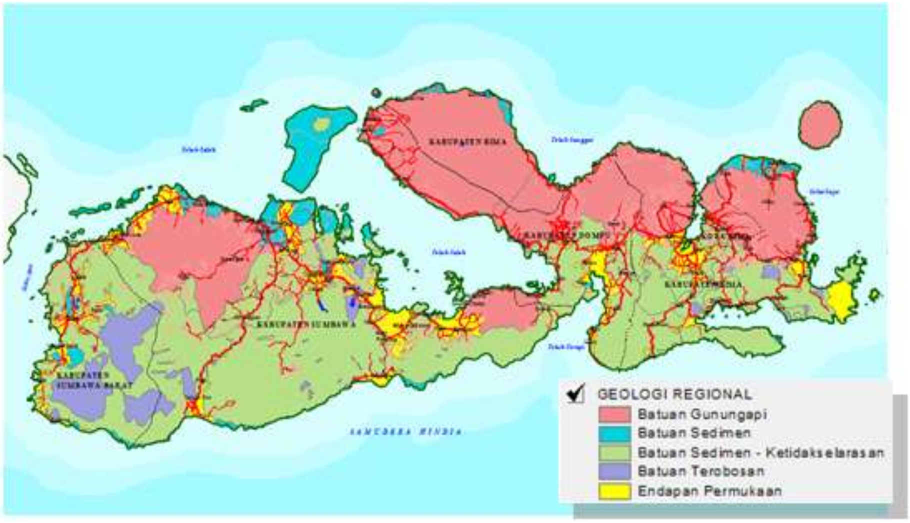


Display Results / Output Model Theme Grid Indicator Slope Slope

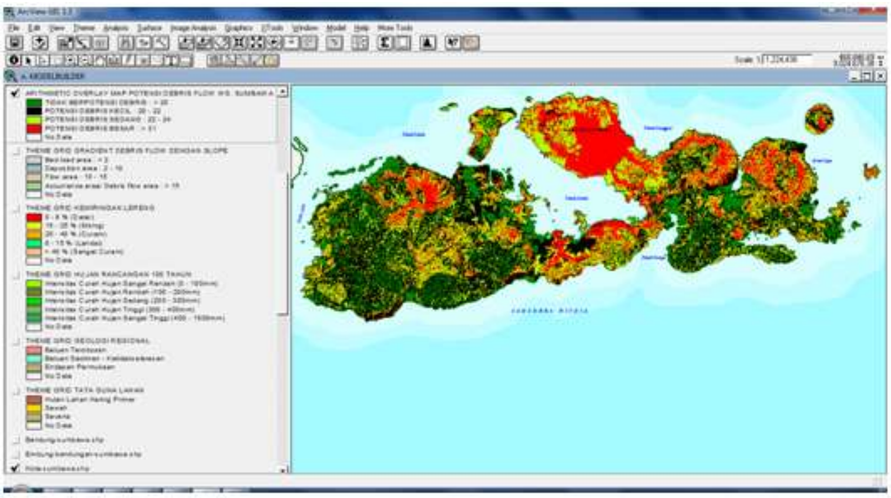
Display Results / Output Model Theme Grid Hydrological Indicator



Result/output model Theme Grid Display Land Use Indicator



Display of Output model Theme Grid Regional Geological Indicator



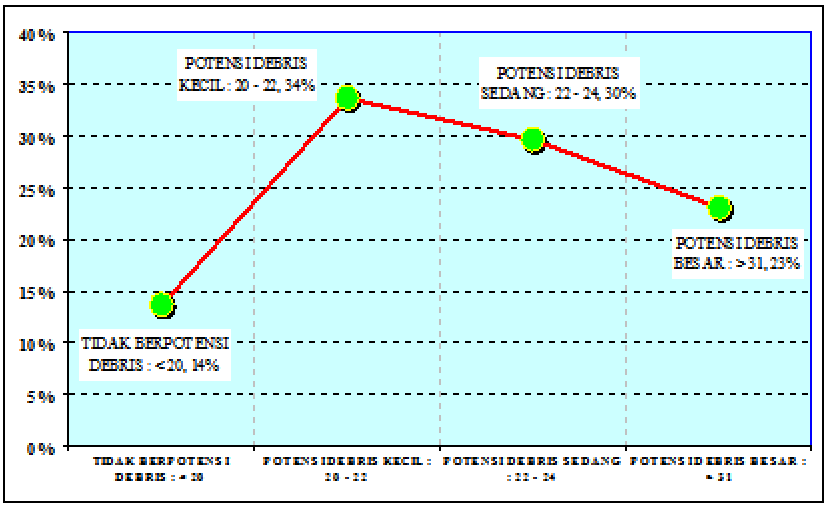
Potential Distribution of Sediment Floods in Sumbawa River Basin

4.4 Determination of Sediment Control Priorities

Handling sediment floods is a complex task involving various data systems. Ideally, anticipation of sediment flood hazards includes natural disasters and should be an important consideration and be allocated in the product planning pattern and the Water Resources Master Plan.From the work of a study model of potential sediment flow in the Sumbawa River Basin by using these 5 (five) classifications of spatial and tabular sediment flow potentials are obtained as follows:

Classification of Study Results of Sediment Mass Flowing in the Sumbawa River Basin

No	Gridcode	Area (Km^2)	Percentage (%)
1	Doesn't Potentially Debris : < 20	2,055.46	14%
2	Potentials of Low Debris : 20 - 22	5,084.33	34%
3	Potentials of Middle Debris : 22 - 24	4,464.99	30%
4	Potentials of High Debris : > 31	3,480.69	23%
	Total	**15,085.47**	**100%**



Graph of Classification Results of Sediment Mass Flow Studies in the Sumbawa River Basin

4.5 Results of Flow Coefficient Analysis (C)

Flow Coefficient (C) is a number that shows the ratio of the amount of surface runoff that occurs to rainfall. The classification used in assessing the flow coefficient after adjusting for studies (Anonymous, 1986) is as follows:

Table 4.3 Flow Coefficient Value (C) in Sumbawa River Basin

No	Land Use	Area (Km^2)	Percentage (%)	C^{table}	C^{choose}	$C^{Calculation}$
1	Primary Dry Land Forest	3,766.21	24.43%	0.05 - 0.25	0.25	0.06
2	Secondary Dry Land Forest	2,703.59	17.54%	0.05 - 0.25	0.25	0.04
3	Primary Mangrove Forests	31.88	0.21%	0.05 - 0.25	0.25	0
4	Secondary Mangrove Forests	40.86	0.27%	0.05 - 0.25	0.25	0
5	Industrial Plantation Forest (HTI)	9.53	0.06%	0.05 - 0.25	0.25	0
6	Settlement	46.48	0.30%	0.50 - 0.70	0.7	0
7	Mining	15.73	0.10%	0.50 - 0.70	0.7	0
8	Dryland farming	644.32	4.18%	0.30 - 0.60	0.6	0.03
9	Dry Land Agriculture with Shrubs	2,051.14	13.30%	0.30 - 0.60	0.6	0.08
10	Savana	35.23	0.23%	0.15 - 0.45	0.45	0
11	Rice fields	686.35	4.45%	0.30 - 0.60	0.6	0.03
12	Shrubs	5,112.87	33.16%	0.50 - 0.70	0.7	0.23
13	Swamp / Thicket Swamp	6.94	0.05%	0.50 - 0.70	0.7	0
14	Pond	111.42	0.72%	0,70 – 0,80	0.7	0.01
15	Open Land	152.05	0.99%	0.50 - 0.70	0.7	0.01
16	Transmigration	1.9	0.01%	0.50 - 0.70	0.7	0
	Total	**15,416.50**	**100.00%**	**0**	**8.4**	**0.49**

Flow coefficient in Sumbawa River Basin : 0.49 or 49%, so it is included in the classification of the flow coefficient (C) : Medium (25% - 50%).

4.6 Flow Control Analysis Results

Following is the flow control result table in Sumbawa River Basin

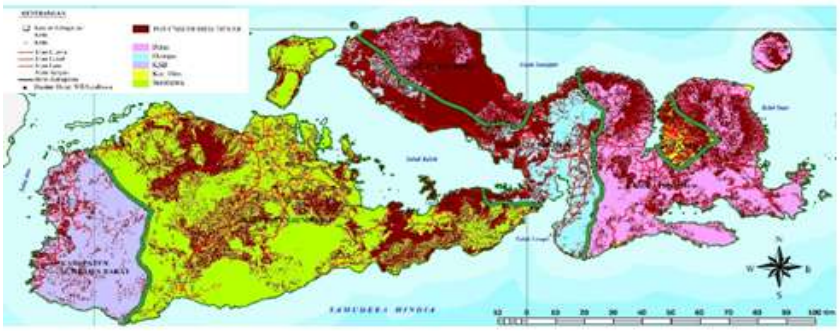
Table 4.2. Results of Analysis of Flow Control of Debris Sumbawa River Basin (The Five Largest Sedimentary Watersheds)

Rank	Watershed	Watershed Area (Km2)	ZONA 1 {(High Debris) (Km^2)}	ZONA 2 {(Middle Debris) (Km^2)}	ZONA 3 {(Low Debris) (Km^2)}	ZONA 4 {(Secure) (Km^2)}	R (mm)	Flow Coefficient (f1,f2)	Control *Tgq*	Sedimen Concentration (Cd) [Mizuyama]	Total Flow Discharge (Q_t) [m^3/dtk]	Volume of Sediment Stated By Flow (Vec) [m^3]
1	Sori Tengatebe, Sori Tempo Watershed	203.92	158.82	40.4	3.48	-	250	0.586	0.153	0.22	24,108.05	1,868,492.24
2	Sori Lebelela Watershed	115.69	320.42	181.11	73.14	-	100	0.591	0.153	0.22	9,890.70	1,507,876.30
3	Sori Kambu Watershed	247.96	84.98	115.63	38.31	6.97	250	0.579	0.153	0.22	23,906.65	999,776.29
4	Brang Nangagali Watershed	202.49	56.42	57.12	70.35	14.63	350	0.58	0.153	0.22	26,541.46	929,281.36
5	Brang Beh Watershed	1,532.69	160.9	557.25	619.94	192.95	100	0.451	0.153	0.22	40,700.66	757,185.25

Figure 4.1. Map of Potential Sediment Flood Distribution in Sumbawa River Basin

Table 4.3. Results of Analysis of Sediment / Debris Flow Potential Zones in Administrative Areas

No	District / Region	Percentage (%)			
		Potential of High Debris	Potential of Midlle Debris	Potential of Low Debris	Not Potentially Debris
1	Sumbawa Region	49.05%	48.63%	43.32%	31.66%
2	Bima Region	20.96%	21.65%	28.56%	43.28%
3	West Sumbawa Region	19.23%	18.72%	9.70%	2.07%
4	Dompu Region	9.74%	9.92%	15.80%	19.91%
5	Bima City	1.02%	1.08%	2.62%	3.08%



Map of Outcome Distribution of Potential Sediment Floods in Sumbawa River Basin in the Administrative Region

V.

VI. CONCLUSION

The conclusions of the above study are as follows:

1. The Study of Sediment Mass Flow Studies in the Sumbawa River Basin has been carried out with the application of the Model Builder System with the Inverse Distance Weighted (IDW) interpolation method, namely the interpolation process by using a weighted average between the value and distance of the closest point to the interpolated cell, and of the Model type Complex using 5 (five) indicators of spatial and tabular data including: gradient of debris flowing relationship with river slope, slope, hydrology, regional geology, and land use.
2. From the model work, it is obtained the classification of potential distribution zones of sediment flow in the Sumbawa River Region as follows:

- Zone 1 (Potential High Debris Flow) area of 3,480.69 Km^2 =23%,
- Zone 2 (Potential middle Debris Flow) area of4,464.99 Km^2 = 30%,
- Zone 3 (Potential Low debris flow) area of5,084.33 Km^2 = 34%,
- Zone 4 (No Potential Debris flow) area of2,055.46 Km^2 = 14%.

3. The average value of sediment transported (V_{ec}) volume in the Sumbawa River Basin is 941,436.79 m^3.
4. Regency / City Areas with a percentage value of Zone 1 (zone of potential for High debris flow) ≥20% are Sumbawa Regency and Bima City.

REFERENCE

[1]. PERMEN PU No.11 A/PRT/M/2006m, Kriteria dan Penetapan Wilayah Sungai
[2]. PERMEN PU No.63/PRT/1993, tentang garis sempadan sungai, daerah manfaat sungai, daerah penguasaan sungai dan bekas sungai, daerah penguasaan sungai adalah dataran banjir, daerah retensi, bantaran atau daerah sempadan.
[3]. Peraturan Menteri Dalam Negeri Nomor 33 Tahun 2006 Tentang Pedoman Umum Mitigasi Bencana
[4]. KepMen PU No. 458/KPTS/1986, tentang Ketentuan Pengamanan Sungai Dalam Hubungan dengan Penambangan Bahan Galian Golongan C
[5]. PP Nomor 35 Tahun 1991, tentang pemberdayaan sungai, pemeliharaan sungai.
[6]. PP Nomor 42 Tahun 2008, tentang Pengelolaan Sumber Daya Air.
[7]. Seminar Nasional Penanganan Bencana Sedimen, "Menyikapi Problematika Kejadian Bencana Sedimen di Indonesia", Magelang November 2009.
[8]. Perencanaan Detail Desain Normalisasi sungai Pemenang di Kabupaten Lombok Barat, CV. Fiscon Total Consultant 2007

Ida Nyoman Gaotama" Study of Sediment Mass Flow in the Sumbawa River Basin" International Journal of Engineering Research and Applications (IJERA), vol. 9, no. 11, 2019, pp 24-31