Sedimentation Study at Batang Lampasi River

Studi Sedimentasi di Sungai Batang Lampasi

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ABSTRACT

Batang Lampasi River was located in Talawi village, Nagari Koto Nan GadangPayakumbuh, about 30 km from Bukittinggi, with 48.19 km river length and around 226 km2 Cathment Area. The river flow carries a lot of sediment material, causing siltation on the riverbed which causes the river to overflow in the surrounding area. Sediment transport was triggered by Lampasi watershed erosion, that especially in the upstream section and settling on the riverbed. Prediction of depth decrease caused by sedimentation was conducted. Theoretical flood discharge determined used Nakayasu method. Sediment yield caused by land erosion determined by USLE equation and will compared with total sediment transport that calculated for 5 years return period with Yang's, Engelund Hansen, Ackers and White's methods. HEC-RASS 4.0 was used to find the high of flood water level and also as input hydraulics term to calculating transport sediment. The equivalent value approaching sediment yield was Yang's method where the sediment transport value is 21294,763 tons / year with sediment thickness of 27.24 cm / year. With these deposits thickness we can see from HEC-RASS 4.0 modeling the elevation of high flood water during normal conditions and the presence of thick sediment deposits.

Keywords : Sedimentation, Flood , HEC RAS, Batang Lampasi

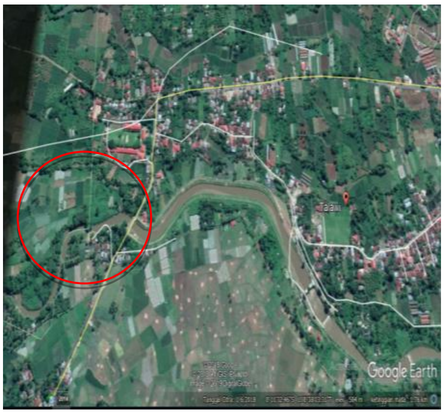
INTRODUCTION

Batang Lampasi River was located in Talawi village, Nagari Koto Nan Gadang Payakumbuh, about 30 km from Bukittinggi, with 48.19 km river length and around 226 km^2Cathment Area. The river flow carries a lot of sediment material, causing siltation on the riverbed which causes the river to overflow in the surrounding area. Sediment transport was triggered by Lampasi watershederosion, that especially in the upstream sectionand settling on the riverbed. Sedimentation was material that resulted from the erosion process, either in the form of surface erosion, trench erosion, or other types of soil erosion that settles at the bottom of the foothills, in areas of inundation, waterways, rivers, and lakes. Whereas sedimentation is the process of depositing fragmental material by water as a result of erosion. In general, erosion and sedimentation is the process of removing soil grains from the parent somewhere and transporting the material by wind or water movement then followed by the deposition of the material transported (Asdak.C., 2002). Erosion is a process in which the land is detached and then moved to another place by the forces of water, wind, and gravity [Haerdjowigeno, S. 1995]. Erosion is the result of interactions of climate, soil, topography, vegetation, and human activities on natural resources. The eroded material then settles to a certain location and becomes the ultimate material destination of the material deposited into sedimentation [Arsyad, S. 2000.]. Transport sediment and sedimentation during floods was studied. (4), (5). Study to investigating the retrogressive erosion that was often impacts on both the reservoir capacity and

the sedimentation in the downstream river channel was conducted (6). Sediment continuity through a regulated upland valley fluvial system in response to the extreme Storm flood event was quantified (7). Study addressed to discussing relationships between luminescence dating, sediments, and reach-scale geomorphology was performed (8). Hydraulic model tests for propagation of flow and sediment in floods due to breaking of a natural landslide dam during a mountainous torrent and also flood risk analysis for flood control
and sediment transportation was conducted (9), (10), (11), (12). A scale model to measure the impact forces of fluviatile flood events on buildings was performed (13). The intense flooding and sediment movement were investigated in order to better understand the drivers and functioning of composite alluvial system (14). Study to improving sediment load estimations was conducted (15). Modelling of hyperconcentrated flood and channel evolution with 1D morphodynamic model was developed for the braided reach (16). The use of mathematical modeling with HEC RAS, RMA2 and SED2D in analyzing flow and sediment transport patterns has been carried out [17], [18]. Application of GIS was used to predicting the potency of sediment at river caused by erosion that triggered of land used character [19], [20].

METHODOLOGY

Research was conducted in BatangLampasi which is located in Talawi Village, Nagari Koto Nan Gadang, NorthPayakumbuh District which is 7 km from Payakumbuh city. Depth decreasing of the river that caused by siltation and sedimentation was indicated as factor that triggered flooding with inundation area as shown at Figure 1.



Research area

The source of the sediment simulation comes from land erosion that flow into the river which was predicted previously using the USLE equation. Of the several methods for estimating the amount of surface erosion, the Universal Soil Loss Equation (USLE) method is the most commonly used method [21]. Universal Soil Loss Equation (USLE) equation can be write as :

$$A = R.K.L.S.C.P$$

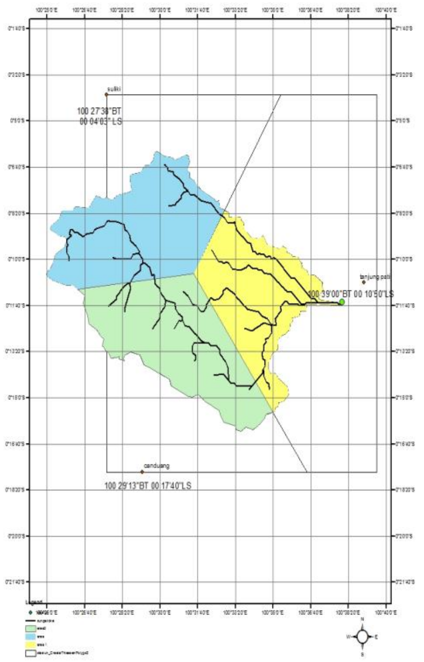
Where ; A is the amount of land eroded in t/ha/year ; R is Rainfall factor, i.e. the number of rain erosion index units, which is the multiplication of total rain energy (E) with a maximum rainfall intensity of 30 minutes (I30) ; K is soil erodibilities factor, i.e. erosion rate per unit of erosion index for a soil obtained from a standard homogeneous experimental plot, with a length of 72.6 feet (22 m) located on a slope of 9% without plants ; L is slope length factor is 9%, namely the erosion ratio of the soil with a certain slope length and the erosion of the soil with a slope length of 72.6 feet (22 m) under identical conditions ; S is slope steepness factor, which is the ratio between the amount of erosion from a slope to the steepness of a particular slope, to the amount of erosion from the soil with a slope of 9% under identical conditions ; C is factors of vegetation cover and plant management, namely the ratio between the amount of erosion from an area with vegetation cover and management of certain plants to the amount of erosion from identical soils without plants and P is factor of soil conservation measures, ie the ratio between the amount of erosion from soils treated by soil conservation measures such as contour management, planting in strips or terraces to the amount of erosion from soils treated in the same direction in the same slope. Rainfall data used 10 (ten) years data record with 3 (three) stations namely Tanjung Pati, Suliki, and Canduang (Figure 2). From theses rainfall analysis then theoretical flood discharge could be determined used Nakayasu method with :

$$Qp = C * \frac{1}{36} * A * \frac{Ro}{(0.3 * Tp + T_{0.3})}$$

Sediment sampling material was putting at 3 points to obtain the grain diameter. Calculation of profile and flow character using HECRAS by applying the standard step method for steady flow [22] as shown in Figure 3 with the energy equations as follow ;

$$y_1 + \frac{V^2}{2g} + z_1 = y_2 + \frac{V^2}{2g} + z_2 + h_L$$

$$y_1 + \frac{V^2}{2g} + z_1 = y_2 + \frac{V^2}{2g} + z_2 + S_e \Delta L$$



Batang Lampasi Watershed

RESULT AND DISCUSSION

With watershed area is 226 km2, the suitable method used was the algebraic method. However, the method has a weakness caused the assumption that the watershed is uniformly and very simple. Whereas the Lampasi watershed has a variety of rain areas, to consider such conditions, the Thiesen polygon method was considered more appropriate for calculating regional rainfall because the method involves the area factor represented by each rain station. Rainfall average for BatangLampasi watershed resulting with Thiesen polygon method as seen in Table 1. The theoretical flood discharge analysis was performed using the Nakayasu, Hasper and Melchior method to obtain some value of flood discharge with some return periods variations as shown in table 2. Validation is done by comparing the results of theoretical flood discharge calculations to observations of flood water levels in the field with the assumption that flood was occurred at a 10-year return period (Q10). Result showed that Nakayasu method was more closed to field condition value.

Table 1. Rainfall Average for BatangLampasi Watershed (Thiesen Polygon Method)

NO	CANDUANG	TANJUNG PATI	SULIKI	HUJAN RATA2 KAWASAN
1	27.25	35.84	33.28	35.84
2	37.07	42.50	36.22	42.50
3	37.33	27.06	66.98	66.98
4	38.50	34.00	31.11	38.50
5	28.02	33.98	25.71	33.98
6	31.50	48.50	27.41	48.50
7	39.60	34.18	30.85	39.60
8	40.97	29.17	40.21	40.97
9	43.58	20.50	36.06	43.58
10	40.27	19.42	19.42	40.27

Table 2. Flood Discharge With Some Return Period Variations

Periode Ulang (Tahun)	Debit Rencana Berdasarkan Data Hujan		
	Nakayasu (m^3/dt)	Hasper (m^3/dt)	Melchior (m^3/dt)
0	0	0	0
2	136.12	85.356	115.873
5	159.60	100.075	135.855
10	173.47	108.772	147.662
25	188.04	117.912	160.069
50	200.70	125.850	170.845
100	211.63	132.704	180.150

Sedimentation that transported to the river was determined from land erosion that was calculated with USLE equation. This needed the value of Rainfall Erosoivity Index (R) that was calculated with Bols equation. Table 3 was showed the Rainfall Erosoivity Index (R). However, not all of these land erosion that deposited to the river body. Some of them was deposited into the storage or basin in the land that reduced the total value of land erosion into as sediment to the river. The ratio of these was described as Sediment Delivery Ratio (SDR) of sediment transport that was calculated using the AUERSWALD equation. Transport sediment in the river, with discharge at some return periods were calculated with Yang's, Ackers and White, and Engelund and Handsen equation as shown in Table 4. These results then compared with sediment yield that calculated from SDR and getting that Yang's equation are more closed to sediment yield from SDR. This was incated that sediment thickness could be determined with Yang's equation to simulating the depth decreased of river cross caused by sedimentation. Sediment weight then could be calculated from the value that resulted from transport sediment, and then converted into the thickness of sediment to getting the depth decrease.

Table 3. Rainfall Erosoivity Index (R)

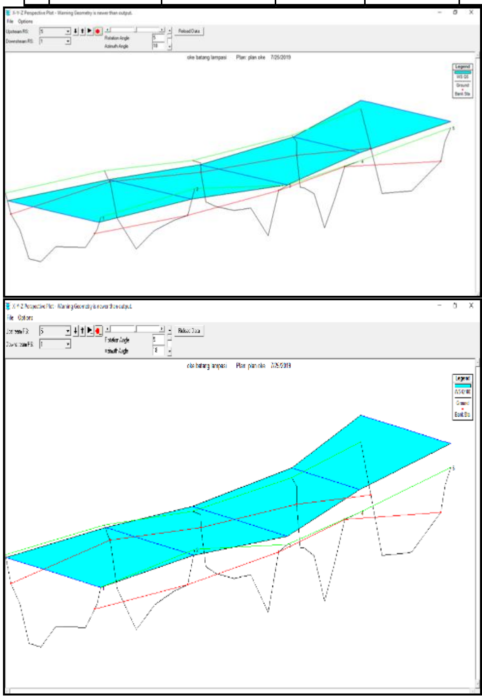
No	Tahun	Rm
1	2009	108.91
2	2010	123.66
3	2011	134.65
4	2012	193.41
5	2013	135.74
6	2014	118.25
7	2015	150.18
8	2016	72.54
9	2017	101.24
10	2018	111.41
JUMLAH		1249.00
Rm RATA2		125.00

Table 4. Total Sediment Transport

Periode	Metode Angkutan Sedimen Total (ton/tahun)		
Ulang	Yang's	Ackers and White	Engelund and Hansen
2	20753.283	353.900	30502.533
5	21294.763	348.987	33943.926
10	21557.630	344.900	35869.715
25	21822.385	341.899	37854.549
50	22051.341	340.722	39561.370
100	22253.107	340.962	41032.223

Table 5. Sediment Weight

No.	Metode	Volume Air Sungai (lt)	Berat Sedimen (mg/lt)	Berat Sedimen (mg)	Berat Sedimen (ton/tahun)
1	Yangs	2901038000.00	7340.394	2.12948E+13	21294.763
2	Ackers danWhite's	2901038000.00	120.297	3.48987E+11	348.987
3	Engelund dan Hansen	2901038000.00	11700.614	3.39439E+13	33943.926



Flood Water Level Simulations (Q5 dan Q100)

CONCLUSION

Sediment material deposition at the riverbed of Batang Lampasi River is very influential on the potential for flooding that occurredaround the river, which causes siltation of the river bed, thereby reducing the capacity of the river cross section. Calculation for total sediment transport was carried out by three methods, Yang's, Ackers & White and Engelund& Hansen methods with resulting the sediment transports about 21294,763 tons / year, 348,987 tons / year and 33943,926 tons / year, using 5-year return period discharges as 159 , 60 m3 / sec. Land erosion using the USLE equation shows that soil losses was 192804.68 tons / year and the SDR (sediment delivery ratio) value is 0.110208, so that the amount of erosion expected to enter the Y river (yield) is 21248.70 tons / year. This value approaches the calculation of sediment transport in the river using the Yang method, so the method chosen to determine the thickness of the sediment so Method with the thickness of the sediment obtained 27.24 cm / year.

The results of 5 year return period discharge are 159.60 m3 / sec thetmodeled with HEC-RASS 4.0, where during normal river conditions flooding occurred in some river cross sections, with the thickness of sediment deposits 27.24 cm / year the water level becomes increasingly higher and at this condition also occurs flooding. Because flooding usually occurs in rivers during the 25 year return period, then for HEC-RASS 4.0 modeling, it is modeled with a 100 year return discharge period which results in flooding in all cross sections of the river point being reviewed. To reducing sediments that occurred by land erosion needs to be controlling by building sediment control structures such as sabodam, chekdam and also planting vegetation or plants to prevent damage, so that surface erosion can be suppressed.

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