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Normalization of Way Ruhu River in Hative Kecil, Galala and Aster Villages in Sirimau District, Ambon City

Rudi Serang

Ambon State Polytechnic, Indonesia

Abstract**—***Way Ruhu River is one of the watersheds in Sirimau District, Ambon City. The limited handling of the city government and the awareness of the local community to expand residential areas in the Way Ruhu watershed resulted in floods and landslides that brought sedimentation and garbage, this caused shallowness that occurred on the riverbed, thereby overflowing river water into the residential area of Hative Kecil, Galala. and Aster. To overcome this problem, an intensive study and periodic handling of sedimentation and garbage on the riverbed is required by periodically backfilling the Way Ruhu river area. Therefore, the analysis of sedimentation and garbage in the Way Ruhu river needs special handlers to deal with the overflows of water that occur every rainy season in the villages of Hative Kecil, Galala and Aster. This study aims to overcome water overflow caused by the accumulation of sedimentation on the riverbed so that there is no flooding, by backfilling the riverbed. The results of the analysis of this study indicate that most of the Way Ruhu river area has been damaged by water-fed land which has been turned into residential land which has resulted in flooding and landslides in the Way Ruhu watershed area. The sedimentation rate that occurs in the Way Ruhu river watershed averages every year of: 3,599 m^3 / day or 1,313,635 m^3 / year. So that the sedimentation that is carried out of the river is as much:32,386m^3/ dayi atau 11.954.078 m^3/ year*

Keywords**— *Watershed, Sedimentation, River Normalization.***

I. INTRODUCTION

Climate change is a global phenomenon, experiencing an increase as a result of human activities such as the use of fossil fuels and changes in land use. One of the global climate changes is the increasing frequency and incidence of climate extremes such as storms, floods and drought.

The development of Ambon City from year to year with a sufficiently increasing population so that the problem of settlements is the main problem of the city government to overcome the existence of flooding that occurs in every river and settlement, especially the Way Ruhu river area, so that from observations in the area it must be a concern. by the local community and the city government. Observing the results of observations, most of the Way Ruhu river area has been damaged by water-fed land which has been turned into residential land which has resulted in flooding and landslides in the Way RuhuWatershedarea.

Way Ruhu is one of the watersheds in Sirimau District, Ambon City. The limited handling of the city government and the awareness of the local community to expand the residential area in the Way Ruhu watershed resulted in floods and landslides that brought sedimentation and garbage made shallowness that occurred on the riverbed, thus overflowing the Way Ruhu river water resulting in flooding in the residential area of Hative Kecil, Galala and Aster.

To overcome this problem, it is necessary to periodically study and handle intensive sedimentation and garbage and the characteristics of the river bed by periodically backfilling the Way Ruhu river area. Therefore, the analysis of sedimentation and garbage in the Way Ruhu river is felt to be done by special handlers to deal with the water overflows that occur every rainy season in the villages of Hative Kecil, Galala and Aster, from problems that occur in fact in the study area, the authors raise the title : "Normalization of Way Ruhu River in Hative Kecil, Galala and AsterVillage in Sirimau District, Ambon City".

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The purpose ofThis research is to overcome water overflow so that there is no flooding in the villages of Hative Kecil, Galala and Aster by backfilling the riverbed of Way Ruhu.

II. LITERATURE REVIEW

2.1. General purpose

Flood control is a relative term, because it is not economical to provide protection against the largest possible flood. Since the beginning of human civilization, flooding is a natural occurrence that is well documented after describing a series of past floods. Hoye and Langbein (1955) concluded that the concept of flood control is generally understood. Nature will let go of all the burdens it carries. Year-round floods cause immeasurable damage and terrible loss of life. Climatologists believe that the current flood rains are caused by a combination of metrological and hydrological conditions that will only occur once a million years. Reservoir,

2.2. Hydrology

Meteorology is part of a broader hydrological science, which includes observing the occurrence of water in the atmosphere and water on the ground and below the earth's surface. One presentation of the hydrological cycle as shown in Figure 1 which shows the formation of rain (in the form of rain, snow, drizzle or hail)

Rain usually occurs in many forms and can change shape during the process. The form of rain in the form of falling water droplets can be classified as drizzle or rain. Drizzle consists of rain with a grain size of <0.5 mm. While larger raindrops are scattered in the air, droplets> 5 mm in diameter are generally unstable. Part of the rain will evaporate partially or completely before it reaches the ground surface. Rain on the soil can be captured by vegetation, infiltrated into the soil to evaporate or become surface runoff. Evaporation can come from the soil surface, free water surface, or from plant leaves through the process of transpiration. Some of the rain will move on the ground as runoff, some of it will enter the soil used by plants, can become a deep supply of groundwater,

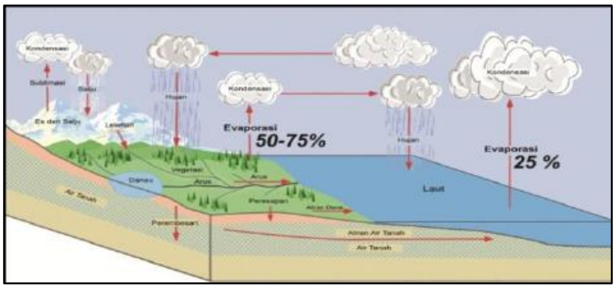

Fig. 1: Hydrological Cycle

2.3. Surface Water Runoff

Runoff is the portion of rainfall that flows towards a channel, lake, river or sea as surface or underground flow. Runoff will only occur when the rate of rain exceeds the infiltration rate into the soil. After the infiltration rate is met, water begins to fill small or large depressions on the soil surface. After the basin is filled, runoff begins. So a rain in a short time may not produce runoff, while rain with the same intensity for a long time will produce runoff, in other words, rainwater that falls to the ground will flow to the ground if the soil infiltration capacity is less than the intensity of rain. The destructive force of water flowing on the ground is greater in proportion to the steeper and longer the slope. Plants that live above the soil surface will increase the ability of the soil to absorb water and reduce the destructive force of falling raindrops, the dispersion power, and the carrying capacity of surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain. and surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain. and surface runoff. The rate and volume of runoff from a catchment area is influenced by the distribution of rainfall in the area, however heavy rainfall in a particular part of the catchment area can produce more runoff than moderate rainfall above the catchment. The amount of water that constitutes this layer is highly dependent on the amount of rainwater per unit time (intensity), soil conditions (especially the slope), soil type, and the presence or absence of previous rain.For the magnitude of the surface flow coefficient value can be seen in Table 1 as follows:

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Table .1: Flow Coefficients for the Rational Method

Land description / surface character	Flow coefficient, C
Business	
Urban	0.70 - 0.95
Fringe	0.50 - 0.70
Housing	0.30 - 0.50
Single house	
Multiunit, separate	0.40 - 0.60
Multiunit, incorporated	0.60 - 0.75
Village	0.25 - 0.40
Apartment	0.50 - 0.70
Industry	
Light	0.50 - 0.80
Weight	0.60 - 0.90
Pavement	
Asphalt and concrete	0.70 - 0.95
Bricks, paving	0.50 - 0.70
Roof	0.75 - 0.95
Yard, sandy soil	
Flat, 2%	0.05 - 0.10
Average, 2-7%	0.10 - 0.15
Steep, 7%	0.15 - 0.20
Yard, heavy soil	
Flat, 2%	0.13 - 0.17
Average, 2-7%	0.18 - 0.22
Steep, 7%	0.25 - 0.35
Railroad yard	0.10 - 0.35
Playground	0.20 - 0.35
Garden, cemetery	0.10 - 0.25
Forest	
Flat, 0-5%	0.10 - 0.40
Wavy, 5-10%	0.25 - 0.50
Hilly, 10-30%	0.30 - 0.60

(Source: McGuen, 1989 in Suripin, 2004)

2.4. Soil Structure

Soil structure is defined as the mutually binding arrangement of soil particles, the bonding of soil particles aims as the soil aggregate that forms itself, this aggregate (Soil Survey Staff, 1975). Slopes can be grouped as shown in Table 2 below,

Table 2: Slope Classification

Symbols	Slope Class	Land Shape
L_O`	0 - 3	Flat
L_1	3 - 8	Slopes / waves
L_2	8 - 1	Slightly sloping / wavy
L_3	15 - 30	Sloping / hilly
L_4	30-45	Somewhat cheating
L_5	45 - 60	Steep
L_6	> 65	Very steep

(Source: Asdak, 2002)

The effectiveness of the soil as a means of removing water depends largely on the size and resistance of the channel in the soil. The physical properties of the soil change the infiltration capacity and how large the particles can be separated and transported. Soil properties that explain how easily soil particles can be eroded are their separation and transportability. The properties that renew erosion include soil structure, texture, organic matter, and chemical and biological properties of soil.

2.5. Vegetation and Land Use

Vegetation is one part of the land system that provides benefits for the survival of creatures, especially humans. The existence of vegetation varies from place to place, because it is influenced by different land conditions. Vegetation plays an important role in maintaining soil sustainability because it can inhibit surface runoff and erosion, including: (1) interception of rain by plant canopy; (2) reduce surface runoff speed and water-destroying force; (3) the influence of roots and biological activities related to vegetative activities and their influence on the stability of the structure and soil porosity; and (4) transmiration which results in reduced groundwater content. Thick ground cover vegetation such as grass or jungle will eliminate the influence of rain and topography on erosion.

Land use (Land use) according to Aryad (1989; 207) can be interpreted as any form of human intervention (intervention) on land in order to meet their needs. Land use is a dynamic process. Therefore, information on land use becomes out-of-date relatively quickly when compared with geological, geomorphological and soil information.

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Land use can be grouped into two major groups, namely agricultural land use and non-agricultural land use.

2.6. Erosion

Erosion is the event of removing or transporting material in the form of a solution or suspension from the original site by flowing water (runoff flow), erosion is the loss or erosion of soil or parts of land in one place that are transported by water and wind to another place (Arsyad, 1989).

The damage experienced to the soil where erosion occurs takes the form of a deterioration of the physical and chemical properties of the soil such as loss of nutrients and organic matter, poor infiltration, the ability of the soil to retain water, reduced stability of soil structure which ultimately leads to worsening plant growth. (Arsyad, 1989)

The classification of the level of soil damage by erosion according to (Arsyad) is presented in Table 3.

Table 3: Classification of Soil Damage and Erosion Levels

Symbol	Erosion Rate	Information
E_0	No erosion	Fixed soil layer
e_1	Light	Less than 25% of the top layer is lost
e_2	Moderate	25-27% of topsoil is lost
e_3	It's a bit heavy	More than 75% of the topsoil up
e_4	Weight	More than 25% of that layer is gone
e_5	Very heavy	Same with trench erosion

(Source: Asyad, 1989)

2.7. Land Erosion Factors

The factors that influence the amount of erosion in a watershed include:

- Rain Erosion
- Soil sensitivity to rain
- Drought and slope length and tillage factors are closely related to soil cover or vegetation
- Rain Erosion (REI)

The amount of rain erosivity can be calculated based on the maximum rainfall data for each rainy day every month (from monthly rainfall data)

- Soil Erodibility (K)

The soil erodibility factor is closely related to the condition and physical soil.

- Slope (LS)

The slope factor can be calculated based on the empirical formula developed by Wischmeies, namely:

- For the slope (S) <20%, take:

LS = Lo 0.5 x (0.0138+0.00965 S + 0.00138 S^2) ... (1)

- For a slope (S)> 20%, is taken;

$Ls_S^{0,61,4}$ .... (2)

Where :

Ls = slope factor
Lo = Length of flow over the ground
S = Slope / slope

- Factors on Plant Types and Soil Processing (CP)

This CP factor has a huge effect on sediment production and the amount of erosion in an area. The size of the CP value can be adjusted based on soil processing activities and by planting certain types of plants on the land

- Erosion Rate

The estimated magnitude of the permissible erosion rate for a watershed is approximated by the following formula (Achlil, 1982):

A = 4 + 1,226 (10 D - K- 2) .... (3)

Where :

A = Permissible rate of erosion (tonnes / ha)
K = soil erodibility factor
D = depth of soil layer, (m)

Table 4: Classification of Erosion Hazards

Erosion Rate ton/ha/ year	Classification
0.0 - 12.5	Very small
12.5 - 17.5	Small
17.5 - 25.0	Medium
25.0 - 30.0	Weight
> 30.0	Very Heavy

2.8. Stream Erosion

In the analysis of river channel erosion, the stability of the grains on the river bed and the volume of sediment transport will be reviewed.

In a gloomy river channel, in general, sediment transport seen from the way it moves can be divided into two, namely;

- Suspended load where the sediment particles move floating in the water and carried along with the flow
- Bed load, which moves from the particles not far from the river bed and moves, shifts, rolls and jumps individually.

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If there is a change in the river either artificially or naturally, the riverbed will change accordingly. Over time an adequate relationship will re-form between the hydraulic properties of the irrigation and the sediment that flows downward and eventually a stable channel will be formed.

Therefore, in making a review / planning of a river, the cross section must be selected not only based on the flood discharge but also taking into account the condition of the river repair work.

The stable condition of the channel means the conditions along the channel where there is no streak and deposition. This means that the amount of sediment flowing in each cross section of the river must be kept stable.

2.9. Riverbed Stability Calculations

From the results of research on riverbed stability analysis, some basic equations can be used as follows:

- Fiber force and critical shear speed according to the Two Boys:

  To = …………………………………………….. (4)

  U * = V (Ton / fw) …………………................... (5)

  Where :

  To = fiber force (ton / m^2)

  U * = Sliding speed (m / sec)

  R = Hydraulic radius (m)

  ∫w = Water mass density (ton / m^3)

  g = Acceleration of gravity (m / sec^2)

  I = The slope of the base of the riveri

2.10. Rainfall Intensity Analysis

To find out the intensity of rainfall, it is analyzed using the Gumbel method with the formula:

$Xt = X + K. S_X$ .... (6)

Where :

Xt = The amount expected to occur t year (mm)

t = Return period in this case t = 10 years

X = Average daily rain during observation (mm)

Yt = The relationship between times and the reduction factor ($Y_t$and n)

Sn = Reduced standard deposit (relationship between Yn and n)

S_X = Standard deviation

The value of Sn, Yn, and YTr can be seen in Table 5; 6; 7 as follows:

Table 5: Reduced mean (Yn)

N	0	1	2	3	4	5	6	7	8	9
10	0.4952	0.4996	0.5035	0.5070	0.5100	0.5128	0.5157	0.5181	0.5202	0.5220
20	0.5236	0.5252	0.5268	0.5283	0.5296	0.5309	0.5320	0.5332	0.5343	0.5353
30	0.5362	0.5371	0.5380	0.5388	0.5396	0.5403	0.5410	0.5418	0.5424	0.5436
40	0.5436	0.5442	0.5448	0.5453	0.5458	0.5463	0.5468	0.5473	0.5477	0.5481
50	0.5485	0.5489	0.5493	0.5497	0.5501	0.5504	0.5508	0.5511	0.5515	0.5518
60	0.5521	0.5524	0.5527	0.5530	0.5533	0.5535	0.5538	0.5540	0.5543	0.5545
70	0.5548	0.5550	0.5552	0.5555	0.5557	0.5559	0.5561	0.5563	0.5565	0.5567
80	0.5569	0.5570	0.5572	0.5574	0.5576	0.5578	0.5580	0.5581	0.5583	0.5585
90	0.5586	0.5587	0.5589	0.5591	0.5592	0.5593	0.5595	0.5596	0.5598	0.5599
100	0.5600	0.5602	0.5603	0.5604	0.5606	0.5607	0.5608	0.5609	0.5610	0.5611

(source, Suripin, 2004)

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Table 6: Reduced standard deviation (Sn)

N	0	1	2	3	4	5	6	7	8	9
10	0.9496	0.9676	0.9833	0.9971	10,095	10,206	10,316	10,411	10,493	10,565
20	10,628	10,696	10,754	10,811	10,864	10,915	10,961	11,004	11,047	11,080
30	11,124	11,159	11,193	11,226	11,255	11,285	11,313	11,339	11,363	11,388
40	11,413	11,436	11,458	11,480	11,499	11,519	11,538	11,557	11,574	11,590
50	11,607	11,623	11,638	11,658	11,667	11,681	11,696	11,708	11,721	11,734
60	11,747	11,759	11,770	11,782	11,793	11,803	11,814	11,824	11,834	11,844
70	11,854	11,863	11,873	11,881	11,890	11,898	11,906	11,915	11,923	11,930
80	11,938	11,945	11,953	11,959	11,967	11,973	11,980	11,987	11,994	12,001
90	12,007	12,013	12,020	12,026	12,032	12,038	12,044	12,049	12,055	12,060
100	12,065	12,069	12,073	12,077	12,081	12,084	12,087	12,090	12,093	12,096

(Source: Suripin, 2004)

Table 7: Reduced Variate (YTr)

Reset Period Tr (year)	Reduced Variate YTr	Reset Period Tr(year)	Reduced Variate YTr
2	0.3668	100	46,012
5	15,004	200	52,969
10	22,510	250	55,206
20	29,709	500	62,149
25	31,993	1000	69,087
50	39,028	5000	85,188
75	43,117	10000	92,121

(Source, Suripin, 2004)

2.11. Calculation of Flood Plan

Design flood is a large annual flow rate caused by rain with a certain return period.

Calculation of the flood discharge plan using the Der Weduwen Method:

Formula: Q = α .β .qn. A .... (7)

Where :

Q = Discharge (m^3 / sec)
α = Flow coefficient (run off coefficient)
β = Reduction coefficient
qn = Maximum rain (mm)
A = Area of flow

1. The run off coefficient is the ratio between run off and rain: α = 1 - 4.1 / (β.qn + 7) .... (8)
2. Concentration Time (t)
   t = 0.25. L .A -0,126.I-0,26 .... (9)
   Where :
   t = Concentration time (hours)
   L = Length of river (km)
   I = Slope of 0.001
   A = Area of watershed (km^2)
3. Redux Coefficient (β)
   This figure is used to get the average rainfall from the maximum rainfall.
   $$\beta = \frac{120+\frac{t+1}{t+9}A}{120+A} \text{ .... (10)}$$
   Where :
   β = Reduction coefficient
   t = Concentration time(hours)
   A = Area of the watershed(km^2)
4. The relationship between q and R
   $$q_n = \frac{Rn}{240} + \frac{67,65}{t+1,45} \text{ ....(11)}$$

2.12. Analysis River Discharge

This analysis was carried out to determine the river discharge that occurred in the Way Ruhu river using the following formula:

River Water Flow Discharge (DLAS) uses the general equation DLSA (Chow), namely;

Q = V. A .... (12)

Where :

Q = River flow rate (m^3 / sec)

V = River water layer velocity (m / sec)

A = Wet cross-sectional area of river water layer (m^3)

2.13. Analysis Average Sediment Discharge

To calculate the annual average sediment discharge, the planned annual return time discharge using the DER WIDUWEN method is used as follows:

Q = a * β * g * A .... (13)

Where :

Q = Return flood discharge (m^3 / sec)

A = Area of flow area (Km^2)

S = slope of the river bed

t = Kosenttimeconstellation (hour)

β = Reduction coefficient

g = Intensity of rain yang is calculated (m^3 / km^2 / sec)

2.14. Sedimentation Rate

Sedimentation rate prediction is done using the equation:

Qs = Q. S .... (14)

Where :

Q_S = River water sediment discharge (gram / second)

Q = River flow rate (m^3 / sec)

Cs = Weight of filter paper (mg)

V = Sediment concentration (mg / liter)

2.15. Sedimentation Transport

Many methods for estimating the capacity for sediment transport have been developed based on the hydraulic shear rate, flow velocity and sediment properties.

V = P * Q .... (15)

Where :

V = volume of sedimentation (m^3)

P = length of river (m)

Q = amount of sedimentation (m^2)

The process of erosion between grooves is used in several computer models to estimate erosion, including CREAMS (Kniel, 1980).

III. METHODOLOGY

3.1. Analysis Technique

In general, the sedimentation rate analysis of this study can be seen in the following diagram:

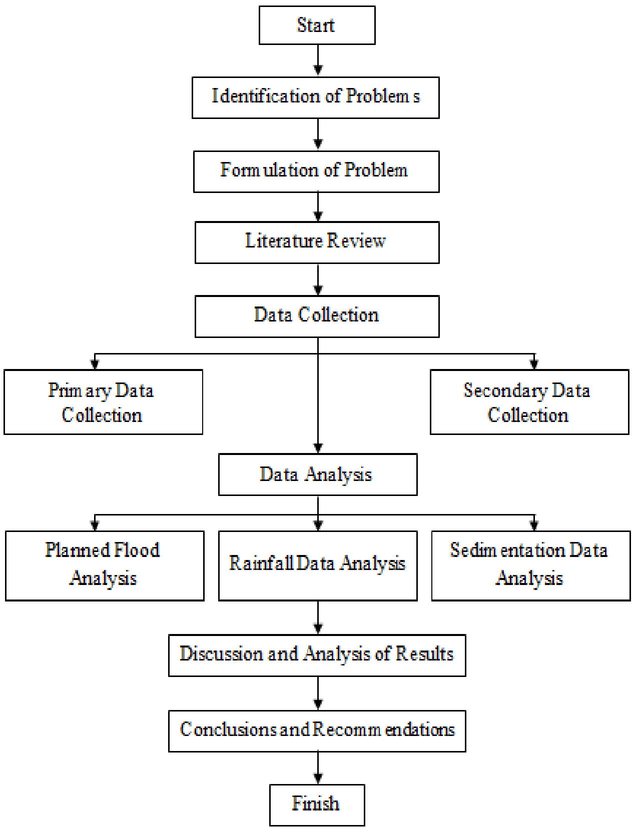

Fig.4: Research Flowchart

3.2. Location and Time

The location or object of the analysis was taken based on the sediment transport plan that occurred in the Way Ruhu River (NegeriGalala), in the last 10 years the rainfall data at the Ambon Pattimura Airport Meteorological Station.

Fig.3: Map of Research Location

3.3. Materials and Analysis Tools

The materials needed in conducting this analysis are a permit and data, both in the form of analysis data and planning data from the object being analyzed, and so on. Meanwhile, the tools used are digital cameras, heavy equipment to support the implementation, meters and other supporting tools.

3.4. Analysis Variable

The analysis variables required in the analysis of sedimentation transport on the Way Ruhu River are specified based on the following problem formulations:

1) Map of the Way Ruhu River
2) Research Location Map

3.5. Data Collection Technique

The data collection stages from the sedimentation transport analysis are as follows:

1) Preparation phase
2) Data Collection Stage
3) Problem Formulation Stage
4) Problem Analysis Stage
5) Implementation of Activities

IV. ANALYSIS AND DISCUSSION

4.1. The Mechanism of Erosion

So erosion can occur at least in one step, namely dispersion by granules or runoff. The erosion stages include:

1. Raindrops collide with the ground;
2. Splash the ground by raindrops with soil.
3. Destruction of a lump of soil by raindrops;
4. Transport of splashed particles / soil mass dispersed by runoff during rain.

To find out the relationship between erosion and hydrology, we must study the effects of land and vegetation management in the upper watershed areas, including its effects on erosion, water quality, flooding and climate in the upstream and downstream areas. And the influencing factors in this calculation are rain erosivity, slope slope, soil sensitivity to erosion, and river length. And soil management factors are closely related to land cover or vegetation.

4.2. Hydrological Data Analysis

To find out how much erosion has occurred in the Way Ruhu watershed, it is necessary to know the planned flood discharge which will be used to calculate the amount of erosion rate that occurs in the Way RuhuWatershed.

Rainfall data required is maximum daily rainfall data with a minimum number of observations of 10 years. Rainfall data for this analysis were taken from the Pattimura - Ambon Meteorological Station

4.3. Rainfall Calculation

Rainfall calculation analysis, selected the Pattimura Airport Meteorological Station Observation Post - Ambon.

Table 8: Data of Way Ruhu River Maximum Daily Rainfall 2003 - 2012

No.	Observation Year	Rainfall (mm)
1	2003	94.47
2	2004	135.65
3	2005	237.82
4	2006	262.05
5	2007	284.66
6	2008	476.31
7	2009	167.32
8	2010	325.68
9	2011	384.17
10	2012	420.09

(Source: Pattimura-Ambon Airport Meteorological Station)

a) Calculation of Algebraic Average Rainfall

$R = \frac{1}{n}\left(R^1 + R^2 + R \ldots \ldots R^n\right)$ .... (16)

b) Calculation of Standard Deviation, Coefficient of Variation and Coefficient of Skewness

1. Σ Year (n) = 10
2. On average, Rr

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$$\mathrm{Rr} = \sum \frac{\mathrm{Ri}}{\mathrm{n}}$$
$$= \frac{2788{,}29}{10}$$
$$= 278{,}82$$

3. Standard Deviation, Std

$$\mathbf{Std} = \sqrt{\sum_{i-1}^{n} \frac{(\mathbf{R} - \mathbf{Rr})^2}{\mathbf{n} - \mathbf{1}}}$$
$$= \sqrt{\frac{3411{,}03}{9}}$$
$$= 19{,}46$$

4. Coefficient of Variation, Cv

$$\mathbf{Cv} = \frac{\mathbf{Std}}{\mathbf{Rr}}$$
$$= \frac{19{,}46}{278{,}82}$$
$$= 0{,}06$$

5. Skewness Coefficient, Cs

$$\mathbf{Cs} = \frac{\mathbf{n}\sum(\mathbf{R} - \mathbf{r})^3}{(\mathbf{n} - \mathbf{1})(\mathbf{n} - \mathbf{2})(\mathbf{Std})^3}$$
$$= \frac{10\, x 7047794{,}66}{(9)(8)(19{,}46)^3}$$
$$= 132.82$$

Table 9: Rainfall Recapitulation

Year	*R*	*R - Rr*	*(R - Rr)²*	*(R - Rr)³*
2003	94.47	-184.35	-33984.92	-6265.12
2004	135.65	-143.17	-20497.64	-2934648.34
2005	237.82	-41	-1681	-68921
2006	262.05	-16.77	-281.23	-4716.27
2007	284.66	5.84	34.10	199.17
2008	476.31	197.49	39002.3	7356848.77
2009	167.32	-111.5	-12432.25	-1386195.87
2010	325.68	46.86	2195.84	102897.98
2011	384.17	105.35	11098.62	1169239.88
2012	420.09	141.27	19957,21	2819355.46
Σ	**2788.29**		**3411.03**	**7047794.66**

(Source: Analysis Results)

4.4. Calculation of Flood Plan

Design flood is a large annual flow rate caused by rain with a certain return period.

To calculate the planned flood discharge, the Der Weduwen method can be used:

- Calculation of flood discharge plans using the Haspers Method:

The formula Q = α .β .qn .A

Where :

Q = Debit
α = Flow coefficient (run off coefficient)
β = Reduction coefficient
qn = Maximum rain (mm)
A = Area of flow = 0.0216 km^2

1) Calculation of the length of rain (hours)

t = 0.25. L .A -0,126.I-0,26

Where :

t = Concentration time (hours)
L = Length of river (km)
I = Slope of 0.01
A = Area of watershed (km^2)

t = 0.25. L .A -0,126.I-0,26
= 0.25. 9.10. 0.0216-0.126. 0.01-0.26
= 12 hours

2) $\beta = \frac{120 + \frac{t+1}{t+9} A}{120 + A}$

Where :

β = Reduction coefficient
t = Concentration time (hours)
A = Area of watershed (km^2)

$$\beta = \frac{120 + \frac{12+1}{12+9} 0{,}0216}{120 + 0{,}0216} = 1.02$$

3) Calculation of rainfall area (m^3 / sec. km^2) with a return period

$$qn = \frac{Rn}{240} + \frac{67{,}65}{t + 1{,}45}$$

Where :

Rn = Maximum daily rainfall (mm / day) with return period (n) years. = 278.8 mm / day
t = Time (hour)

$$qn = \frac{278{,}8}{240} + \frac{67{,}65}{12 + 1{,}45}$$
= 6.2 m^3 / sec.km^2

4) The run off coefficient is the ratio between run off and rain:

α = 1 - 4,1 / (β qn + 7)

Where :

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β = Reduction coefficient
qn = area of rainfall (m^3 / sec.km^2)

α = 1 - 4,1 / (1,02 6,2+ 7)
= 0.7

5) Flood discharge calculation
Q = α .β .qn. A

Where :

Q = Discharge (m^3 / s)
α = Flow coefficient = 0.7
β = Reduction coefficient = 1.02
qn = Maximum rain (mm) = 6.2 m^3 / sec.km
A = Area of flow = 0.0216 km^2

Q = α .β .qn. A
= 0.7. 1.02. 6.2. 0.0216 = 0.0956 m^2 / sec

4.5. Slope (Ls)

As an example of calculating the slope, the Way Ruhu Watershed was chosen

Known :

River length, L = 9.10 km

Watershed area = 0.0216 km^2

Drainage Density, d = 9.10 / 0.0216 = 421.29 km^2

4.6. Calculation of potential and actual land erosion on the Way Ruhu river

From the data it is known:

1. For land slopes of 0 - 3%, value of K = 0.120
2. For land slopes of 3 - 8%, value of K = 0.120
3. For land slopes of 8 - 15%, value of K = 0.260
4. For land slopes of 15 - 40%, value of K = 0.230
5. For land slopes> 40%, value of K = 0.210

4.7. Calculation of Average Slope

(for average slope S = 4%)

D = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 4 + 2. 80

= 572,581

Lo $=\frac{1}{2\ .\ D}$

$=\frac{1}{2\ .\ 572{,}581}$

= 285.79 m

Ls $=Lo^{0.5}$ (0.0138 + 0.00965. S + 0.00138. S2)

= 285,790.5 (0.0138 + 0.00965.4 + 0.00138.42)

= 1,259

(for the average slope S = 11.50%)

D = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 11.50 + 2.80

= 574,531

Lo $=\frac{1}{2\ .\ D}$

$= =\frac{1}{2\ .\ 574{,}531}$287,265 m

Ls $=Lo^{0.5}$ (0.0138 + 0.00965. S + 0.00138. S2)

= 287.2650.5 (0.0138 + 0.00965.11.50 + 0.00138.11.502)

= 5,211

(for average slope S = 20%)

D = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29+ 0, 26. 20 + 2.80 = 576,741

Lo $=\frac{1}{2\ .\ D}$

$= =\frac{1}{2\ .576{,}741}$288,370 m

Ls =. $= 14{,}283\left(\frac{Lo}{22{,}1}\right)^{0{,}6}\left(\frac{20}{9}\right)^{1{,}4}$

(for average slope S = 35%)

D = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0, 26. 30 + 2.80 = 579,341

Lo $=\frac{1}{2\ .\ D}$

$= =\frac{1}{2\ .579{,}341}$289,670 m

Ls $=\left(\frac{Lo}{22{,}1}\right)^{0{,}6}. = 31{,}351\left(\frac{35}{9}\right)^{1{,}4}$

(for average slope S = 40%)

D = 1, 35. d + 0, 26. S + 2, 80

= 1, 35. 421.29 + 0.26 .40 + 2.80 = 581,941

Lo $=\frac{1}{2\ .\ D}$

$= =\frac{1}{2\ .\ 581{,}941}$290,970 m

Ls =. $= 37{,}898\left(\frac{Lo}{22{,}1}\right)^{0{,}6}\left(\frac{40}{9}\right)^{1{,}4}$

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Table 10: Calculation of Slope Slope (Ls)

No.	Long River	Large Watershed	Drainage Density (d)	Slope Land%	Slope is average	D	Lo (m)	Ls
	Way RuhuWatershed							
	9,10	0.0216	421.29	0 - 3	4.00	572,581	285.79	1,259
	9,10	0.0216	421.29	3 - 8	11.50	574,531	287,265	5,211
	9,10	0.0216	421.29	8 - 15	20.00	576,741	288,370	14,283
	9,10	0.0216	421.29	15 - 40	35.00	579,341	289,670	31,351
	9,10	0.0216	421.29	> 40	40.00	581,941	290,970	37,898

(Source: Analysis Results)

Thus:

1. For land slope 0 - 30%
   Formula: A = 4 + 1.226 (10 D - K- 2)
   A = 4 + 1.266 (10. 572,581 - 0.120 - 2)
   = 7250,191 ton / ha / year
2. For land slope 3 - 8%
   A = 4 + 1.266 (10. 574,531 - 0.120 - 2)
   = 7274,878 ton / ha / year
3. For land slope 8 - 15%
   A = 4 + 1.266 (10. 576,541 - 0.260 - 2)
   = 7300,147ton / ha / year
4. For land slope 15 - 40%
   A = 4 + 1,266 (10,579,341 - 0,230 - 2)
   = 7335,633 ton / ha / year
5. For slopes> 40%
   A = 4 + 1.266 (10.581,941 - 0.210 - 2)
   = 7368,575 ton / ha / year

The average allowable rate of erosion rates for the Way Ruhu river basin are:

So the formula that I derive is:

$$\overline{Ar} = \frac{1A + 2A + 3A + 4A + 5A}{5}$$

$$\overline{Ar} = \frac{7250{,}191 + 7274{,}878 + 7300{,}147 + 7335{,}633 + 7368{,}575}{5}$$

$$= 7305{,}884 \ \text{ton/ha/year}$$

Table 11: Calculation of Erosion Rate

Watershed Name	Slope Land (%)	ThicknessHumus (D)(M)	Erodibility(K)	Erosion Rate(A) ton / ha / year	A Average (ton / ha / hr)
Way Ruhu	0 - 3	3.00	0.120	7250,191	7,305,884
	3 - 8	3.00	0.120	7274,878	
	8 - 15	3.00	0.260	7300,147	
	15 - 40	3.00	0.230	7335,633	
	> 40	3.00	0.210	7368,575	

(Source: Analysis Results)

The calculation of erosion can be seen in Table 11. Based on the calculation results, it can be seen that the rate of erosion in the Way Ruhu watershed is classified as very heavy, so it needs immediate treatment.

4.8. Annual Average Sediment Discharge Calculation

To calculate the annual average sediment discharge, the annual discharge plan for the return period using the Der Widuwen method is used as follows

Q = α * β * q * A

Where :

A = Flow area (km^2) = 0.0216 km^2

t = Concentration time (hours) = 4.65 hours

β =The reduction coefficient = 1.26

q = The calculated rainfall intensity (m3 / km^2 / sec) = 314,130 m^3 / km^2 / second

α = Flow coefficient = 0.421

Thus, the annual average sediment discharge can be calculated as follows:

Q = 0.421 * 1.26 * 314,130 * 0.0216

= 3,559 m3 / day

Q year = 365 * 3,599 = 1,313,635 m^3 / year

4.9. Sedimentation Transport

River length : 9100 m

Lots of sedimentation : 3,599 m^3 / day

: 1,313,635 m^3 / year

Sedimentation Transport (V) = P * Q

Sedimentation Transport / day = 9100 m * 3,559 m^3 / day

= 32,386m^3 / day

Sedimentation Transport / yr = 9100 m * 1,313,635 m^3 / yr

= 11,954,078 m^3 / year

V. CONCLUSIONS AND SUGGESTION

5.1. Conclusion

Based on the results of calculations and analysis, the following conclusions can be drawn:

The sedimentation rate that occurs in the Way Ruhu river basin annually is: 3,599 m^3 / day or 1,313,635 m^3 / year.

So that the sedimentation that is carried out of the river is as much: 32,386m^3 / day or 11,954,078 m^3 / year

5.2. Suggestion

In this study, several suggestions are presented as follows:

1. For the Government of Galala Village and Hative Kecil Village and the communities of the two villages to be able to participate and work together to maintain environmental sustainability by replanting shade trees, providing formative counseling so that the people around the Watershed area realize their responsibility to keep maintaining and protecting existing forests from damage.
2. For people who live around the watershed, they should maintain and preserve a clean culture by not throwing garbage into the river.

REFERENCES

[1] Arsyad, 1989. S Soil and Water Conservation. Faculty of Agriculture, Institute of Agriculture: Bogor

[2] Bennet, HH, 1939. Soil Conservation, Mc.Graw-Hill, New York.

[3] Choy Asdak, MSc, PhD, 2002. Hydrology and Watershed Management, Gajah Mada.

[4] Ministry of Public Works Standard SK SMI – 18–1989 – F, 1989. Flood Discharge Calculation Method. LPMB Foundation: Bandung.

[5] Ministry of Public Works, Directorate of Irrigation I, 1986. Handbook of Irrigation Planning, Bandung: cv. Galang Persada.

[6] Rahim.SE 2002. Soil Erosion Control in the Context of Environmental Conservation, Bandung: Earth Literacy.

[7] Vanoni, V, A. 1975. Sedimentatioan Engineering, New York.