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Management of erosion hazard with the agro technology in watershed aie limau kambiung on the upper watershed tarusan

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Abstract. One of the hazards of the erosion is soil infiltration capacity is decreased in the place of occurrence of erosion and increasing the volume of surface flow. It will also lead to the occurrence of the superficiality of the river due to the deposition of materials of soil erosion. These hazards need alternative agrotechnology which could reduce the rate of soil erosion. This research is to know the hazard of soil erosion in the upper watershed of the Aie Limau Kambiung and find out the alternative agrotechnology for reducing the soil erosion. This research was conducted. Soil samples collected was taken in purposive random sampling based on a unit of land. The data were analyzed using the universal soil loss equation. The research results of the largest erosion threat come from the land use of traditional gardens and plant density is low. The highest erosion 151,012.00 ton/ha/year was founded on the plantation blended that have a steep slope over 35% LS value of 9.5. The better of agrotechnology with increasing plant density, that could reduce erosion to 503.40 ton/ha/year. This means that the hazard of soil erosion could be controlled with land management and selected of the better agrotechnology.

1 Introduction

Upstream river basin area based on its function is a conservation area or water catchment area. This is because the upstream area has a steeper slope. However, due to the high pressure of the population, this area is targeted as a farming area, such as gardens that generally do not pay attention to soil conservation methods so that the surface flow and erosion are high [1]. Erosion occurs due to the process of destruction of soil aggregates by the kinetic energy of rainfall. The soil will experience fractionation into clay, dust and sand and soil organic matter. Then the ground was washed away by the strength of the surface flow to the lower slope and kept partway into the stream and deposited on the quiet and flat part [2].

The eruption is actually a natural process that is easily recognizable, but in most places, it is exacerbated by human activities in poor land use, deforestation, mining, plantation, and cultivation. Utilization of soil to produce agricultural crops typically has much greater erosion of soil with forest vegetation. The conversion of forests into agricultural fields increases erosion because the strong root structure of forest plants binds the soil is replaced by weaker crop root structures. To suppress small erosion or equal to erosion which permits should find alternative agrotechnology appropriate to this area such as contour cropping system integrated with gulud terrace [3].

The Tarusan watershed is one of the priority watersheds according to BPDAS Agam Kuantan Office.

The Tarusan watershed is one of the watersheds located in Koto XI Tarusan Subdistrict of Pesisir Selatan Regency. The Tarusan watershed covers 51,740 ha with a stream length of 52.47 Km Batang Tarusan stretches in Pesisir Selatan Regency in West Sumatera Province. This river comes in the vicinity of the hill line between Solok District and Pesisir Selatan Regency. The area of the Batang Tarusan flow covers an area of 508.34 km², which empties into the Indian Ocean with an average discharge of 1.826 m³ / sec. [4].

The land use is generally dominated by Tarusan river basin (2,038 Ha), gambier (9,064 Ha), brown (1,096 Ha), protected forest (13,187 Ha). Land used by the community in Tarusan watershed is a land that has hilly topography or slope and steep. One of the sub-watersheds of this Tarusan watershed is the attention of Aie Batu Kambiung sub-watershed because in this sub-watershed has also a lot of lands including steep is utilized by the community. This will have an impact on rising surface flows and erosion as well as silt of streams in the lower reaches of the Tarusan watershed so that rapid river floods occur. The results of the study [5] show that the surface runoff, erosion and sedimentation found in the Masang Besar sub-basin in Agam district are found in the use of cultivated lands or gardens especially those with steeper slopes.

To predict erosion and small erosion planning, or equal to the permissible erosion of the universal soil loss equation (USLE) models; the most commonly used method. The USLE method can be used to predict the magnitude of erosion for different land-use conditions

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and different climatic conditions. USLE allows planners to predict the average erosion rate of a certain land on a slope with a specific rain pattern for each soil type and land management (land conservation). USLE is designed to predict long-term erosion of sheet erosion and flow erosion under certain conditions. The equation can also predict erosion on non-agricultural lands, but not to predict sediment [6].

Calculation of erosion damage is highly influenced by rainfall factor, slope length, slope, soil, and land cover and management action. The main factors causing erosion are rainfall and the presence of surface flows [7]. The research objectives predict soil erosion in the Aie Limau Kambiang sub-basin on the Tarusan basin and look for appropriate agrotechnology to suppress it as small or equal to the permissible erosion.

2 Research methodology

2.1. Research location

This research was conducted in October 2017 - January 2018 on the various land area of land in sub-basin Aie Limau Kambiang, Pesisir Selatan, West Sumatra province, Indonesia. The soil analysis will be carried out at Soil Physics Laboratory, University of Andalas, Padang.

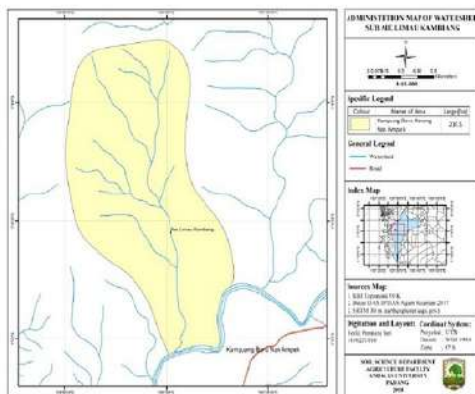


Fig. 1 Map of Aie Batu Kambiang Sub-watershed Administration on the Tarusan Watershed.

2.2 Tools and materials

The tools used in research are GPS (Global Positioning System), Belgian drill, command knife, ring sample. Peroxide acid materials, aquades, Na-hexametaphosphate, hydrochloric acid and working maps of Batu Kambiang sub-basin.

2.3 Research methodology

Field research was conducted by survey method. The research was conducted in several stages (1) preparation,

(2) main survey and sampling (3) soil analysis in laboratory (4) data processing.

2.3.1 Rainfall data

Rainfall data were obtained from the Meteorology Climatology and Geophysics Agency (BMKG) Sicincin from 2011-2016. Rainfall data is processed by using the Bolds formula to obtain rain erosivitas. The formula put forward by Bolds (1978) cit Arsyad (2010) as follows:

$$EI30 = 6,119(RAIN)^{1,21}(DAYS)^{-0,47}(MAXP)^{0,53} \quad (1)$$

EI30 is the monthly rainfall erosion index, RAIN is the monthly average rainfall in centimeters, DAYS is the number of days of average rainfall per month, and MAXP is the maximum rainfall for 24 hours in a cyclical month.

2.3.2 Determining the soil erodibility value

Soil erodibility value can be calculated by the following formula:

$$100 K = 1,292 [M,14 (10^{-4}) (12-a) + 3,25 (b-2) + 2,5 (c-3)] \quad (2)$$

Annotation:

K = Soil erodibility factor

M = (% dust +% very fine sand) x (100 - % clay) 10

a = Percentage of organic matter

b = Class of soil structure

c = Soil permeability grade

2.3.3 Mapping

Topographic maps, slopes, land use, obtained from SRTM (Shuttle Radar Topography Mission) data analysis into DEM (Digital Elevation Model) data in Global Mapper 16 and contour data using Arc GIS 10.2.1 software using counters in the arc toolbox.

2.3.4 Determining the slope

The estimated slope factor value is based on the slope percentage. The magnitude of the slope is predicted with a slope class map.

Table 1. How to grade gradients to determine the value of (LS).

Slope Class	Slope (%)	LS
A	0 - 5	0.25
B	5 - 15	1.20
C	15 - 35	4.25
D	35 - 50	9.50
E	> 50	12.00

Source: Standard Operation Procedure RTL-RLKT Jakarta (1986)

2.4. Main survey

In the main survey, soil sampling was done according to the point specified on the map. The samples taken were determined by purposive random sampling, i.e. the samples were taken based on the land units in the Aie Batu Kambiing of Tarusan Sub-watershed. Samples taken are disturbed soil samples and soil samples intact. Disturbed soil samples are captured using a Belgian drill or hoe. Samples were taken 3 replicates on each unit of land. Whole ground samples were taken using a sample ring, samples were taken on each unit of land.

2.5. Soil analysis in the laboratory

Samples taken in the main survey were analyzed in the laboratory. Analysis of disturbed soil samples to be performed in the laboratory is the determination of texture by the method of pipettes and sieves, Groundwater Level Determination method Gravimetry, and C-organic methods Wakley and Black. While for the analysis of intact soil sample is Determination Permeability De Boodt method.

2.6. Calculating soil erosion value

To predict the magnitude of soil erosion in USLE formulas from Wischmeier and Smith (1978). The USLE formulation is as follows.

$$A = R \times K \times L \times S \times C \times P \quad (3)$$

Annotation :

A = The rate of soil erosion (ton/ha/year)

R = Rainfall erosivity index

K = Index of soil erodibility

L = Index of slope length

S = slope inclination index

C = Index of vegetation cover

P = Index of land treatment or action of soil conservation

To determine the values of C and P are based on Table 2.

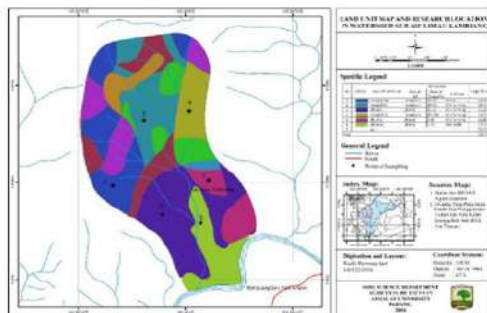


Fig. 2 The use of a sub-watershed area of Batu Kambiing in Tarusan watershed

Table 2. The value of C X P on some land use

No.	Land Use Type	CP
1.	The undisturbed forest	0.01
2.	Forest without plants	0.01
3.	Forests with no plants and litter	0.50
4.	Shrubs/groves partially overgrown with grass	0.10
5.	The undisturbed underbrush	0.01
6.	A mixed garden	0.07
7.	Hardwood plantations with partial ground cover	0.01
8.	The yard	0.20
9.	Plantation of hard plants with some plants ground cover	0.07
10.	Grass cover grass	0.02
11.	Reed grass is burned every year	0.06
12.	Lemongrass	0.65
13.	Grass ground cover well	0.01
14.	Plant tubers	0.63
15.	Plant moor beans	0.36
16.	General agriculture with:	0.14
-	use mulch	0.04
-	patio benches	0.14
-	bunds	0.258
17.	Sorghum Crotalaria strip	0.345
18.	Sorghum strip grass	0.438
19.	Sorghum strip beans	0.380
20.	Peanut strip Brachiaria	0.205
21.	Cowpea strip Brachiaria	0.200
22.	Single Crotalaria strips	0.880
23.	Upland rice stripe grass	0.890
24.	Patio bench + sorghum	0.890
25.	Patio bench + corn	0.012
26.	Patio bench + peanuts	0.070
27.	Patio bench + corn	0.025
28.	Patio bench + peanuts	0.050
29.	Patio bench + peanut + corn	0.060
30.	Patio bench + corn + manure	0.040
31.	Patio bench + maize + peanut + manure	0.008
32.	Patio bench + upland rice	0.020
33.	Patio bench + beans + bitumen	0.035
34.	Patio bench terrace + beans	0.003
35.	Teracce bunds + beans	0.020
36.	Teracce bunds + single beans	0.008
37.	Teracce bunds + corn	0.114
38.	Teracce width + beans	

Source : Weischmeier, 1980

According to [8] proposes an acceptable rate of erosion calculation based on the depth of the soil equivalent and the duration of preservation of expected soil resources by equation:

$$T = KE * FK / UGT \quad (4)$$

Q : Erosion allowed (ton / ha / year)

KE: Effective depth of soil (mm)

FK: Depth factor of the land sub-order

UGT: Ground age (for preservation use 100 years)

3 Results and discussion

3.1. Rain erosivity

Based on the analysis of rainfall data with Bolds 1978 formula, rainfall erosivity value is found in Aie Batu Kambiang sub-waters as in Table 2. The average erosivity during the last six years is 246,112. This erosiveness demonstrates the ability of the destructive force of rain to crush aggregate soil into clay fraction, dust and sand. This is closely related to the maximum amount of rainfall, the amount of rain that occurs in each rainy month. According to [9] states that the most important character of the rain on the occurrence of soil erosion is precipitation, intensity, and distribution. The important properties of this rain together will determine the ability of rain to crush the grains of the soil as well as the amount and velocity of runoff. According to [10] states that the energy from falling rain falling leads to the release of soil particles from the soil structure. The higher the intensity of rainfall will produce higher the more soil particles that are detached from the clods of soil. This loose soil will be thrown along with a splash of water.

3.2 Soil erodibility

Soil erodibility is the sensitivity of the soil to the easiness of the soil eroded by rain. To determine the sensitivity of this soil first in the analysis of soil physical properties such as texture, organic matter, permeability, and soil structure. Each unit of land has different soil erodibility values and this is closely related to differences from organic materials, texture, and soil structure due to different land uses. According to [2] explains that in the event of erosion, the subtle fraction of the soil will be raised first and more of the coarse fraction. This is related to the carrying capacity of the surface flow to different grains of soil.

3.3 Soil erosion

Based on the calculation of erosion prediction in sub-Aie Batu Kambiang Tarusan, the largest erosion was found in mixed garden land use (Incept D Kc). The cause of high erosion in this unit of land is caused by the steeper slope of the land, ie 30-45% with the value of LS 9.5. Thus the flow of the surface flows faster and the energy is greater to carry the ground grains. According to [2] also states that the steeper the slope increases the greater the erosion occurs. According to [11] states, some of the physical characteristics that greatly affect the erosion process in the watershed are the slope of the land, soil type, and land cover. According to [12] steep slopes (with slopes between 15-40%) more easily eroded. If coffee plants are young and still slightly canopy, erosion may exceed tolerable limits.

Besides, the use of land with a mixture of people's garden with low intensity. This causes the rainfall granules to easily enter through the canopy escaping to

the soil surface and destroying the aggregate of the soil. Based on the results of the research [5] in the Masang Basin sub-districts indicate that the land used for mooring and mixed gardens having rare canopy cover has an actual erosion higher than erosion tolerance.

3.4 Allowable erosion

The amount of soil erosion tolerated in the two land orders in the subwatershed is ultisol and inceptisol (Table III). According to [2] The value of erosion tolerance is sought by the formula.

Table 3. The value of erosion that can be tolerated in two types of soil in Aie Batu Kambiang Tarusan Sub-watershed.

No	Soil Order	Allowable Erosion t/ha/year
1	Ultisol	150
2	Inceptisol	112

3.5 Agrotechnology to suppress erosion rate

To reduce the high rate of erosion, a more appropriate agrotechnology option is needed, ie plant canopy can protect the soil surface. Rarely, mixed community gardens need to be increased intensity with productive crops and can increase farmers' acceptance. Productive plants and have aspects of conservation are durian, jengkol, petai, jackfruit and mangosteen. Thus soil erosion can be suppressed equally with permissible erosion.

To suppress the rate of erosion equal to the tolerable erosion, the multiplication between plant coefficients (C) and conservation measures (P) or CP must have values ranging from 0.001 to 0.0058. Based on the calculation of the CP value of conservation management result, erosion value in the mixed garden (incept D Kc) can be reduced to 503,4 ton / h / year. Similarly, other land units have lower erosion values.

4 Conclusions

Based on the results of research on the sub-waters Aie Batu Kambiang, it can be concluded that:

1. Highest erosion in sub-watershed of Batu Kambiang was 151,012 ton/ ha/year in Incept D Kc land unit or in the mixed garden with a steep slope
2. The erosion can be reduced to 503,40 ton/ ha/year by using agrotechnology.

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Table 4. Erosivity of rainfall from 2011 to 2016 in Aie Batu Kambiang of Tarusan Sub-watershed

Month	2011	2012	2013	2014	2015	2016	Average
January	23,509	4,081	17,628	4,081	10,119	17,844	12,877
February	8,668	4,725	21,643	8,569	16,706	8,368	11,447
March	8,182	10,516	4,958	18,891	34,016	19,656	16,037
April	37,149	2,234	26,440	15,890	22,417	37,775	23,651
May	5,740	18,715	5,275	11,823	26,390	32,992	16,823
June	39,337	4,168	10,164	27,083	28,964	26,436	22,692
July	19,260	4,484	13,962	9,486	6,001	23,610	12,801
August	24,032	20,757	29,989	23,447	20,016	8,278	21,087
September	9,498	3,336	10,918	9,479	15,282	15,067	10,597
October	21,815	31,942	8,041	29,949	9,849	55,747	26,224
November	63,936	12,827	29,778	47,896	30,067	20,214	34,120
December	20,373	76,890	90,651	14,161	13,288	16,828	38,699
						R	246,112

Table 5. Physical Characteristics of the Soil in the Sub-watershed Aie Batu Kambiang of Tarusan

No	Code	Land Unit	% Sand	% Silt	% Clay	BV(g/cm ³)	Hydraulic Conductivity (cm/hour)	Structure
1	SPL 1	Incept.B.Hp	1	84	15	0.9	135.7	Granular Crude
2	SPL 2	Incept.B.Kc	34	44	22	1.04	11.5	Angular Blocky
3	SPL 3	Ult.B.Kc	6	29	65	0.79	56.4	Angular Blocky
4	SPL 9	Incept.D.Kc	8	33	59	1.01	54.8	Angular Blocky
5	SPL 12	Ult.A.Kc	4	39	57	0.89	7.9	Angular Blocky
6	SPL 14	Ult.A.Sw	9	6	87	0.79	22	Angular Blocky

Table 6. Land Sensitivity Value at Aie Batu Kambiang in Tarusan Sub-watershed

% Very fine sand	Silt	Clay	M	M (1.14)	a	b	c	Erodibility
0.07	84	15	7146.1	24753.7	7.49	3	6	0.28
0.69	44	22	3486.1	10921.2	4.74	4	4	0.22
0.05	29	65	1016.8	2680.6	7.95	4	6	0.19
0.1	33	59	1357.1	3725.4	4.85	4	6	0.22
0.04	41	57	1764.9	1764.9	6.9	4	4	0.15
0.05	6	87	78.7	78.7	3.54	4	3	0.09

Table 7. The slope on some land units and the value of LS at Air Batu Kambiang in Tarusan sub-watershed

No	SPL Code	Land Unit	Slope (%)	LS Value
1	SPL 1	Incept.B.Hp	15-30	1.2
2	SPL 2	Incept.B.Kc	15-30	1.2
3	SPL 3	Ult.B.Kc	15-30	1.2
4	SPL 9	Incept.D.Kc	30-45	9,50
5	SPL 12	Ult.A.Kc	0-15	0.25
6	SPL 14	Ult.A.Sw	0-15	0.25

Table 8. The value of erosion factor and soil erosion in Aie Batu Kambing of Tarusan sub-watershed

No	SPL Code	Land Unit	Erosivity R (KJ/ha/year)	Erodibility K	Slope (%)	LS	C	P	A t/ha/year
1	SPL 1	Incept.B.Hp	246112.0	0.3	15-30	1,2	0,005	1	83,6
2	SPL 2	Incept.B.Kc	246112.0	0.2	15-30	1,2	0,3	1	19.378,7
3	SPL 3	Ult.B.Kc	246112.0	0.2	15-30	1,2	0,3	1	17.268,8
4	SPL 9	Incept.D.Kc	246112.0	0.2	30-45	9,50	0,3	1	151.012,0
5	SPL 12	Ult.A.Kc	246112.0	0.1	0-15	0,25	0,3	1	2.757,7
6	SPL 14	Ult.A.Sw	246112.0	0.1	0-15	0,25	0,05	0,04	10,5

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