

Land Use Scenario Simulation for Erosion Control Using the Universal Soil Loss Equation (USLE) Method in Nagari Lawang, Agam Regency

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Article History:

Received : 28 October 2024
Revised : 30 November 2024
Accepted : 05 December 2024

Keywords:

Erosion,
Simulation,
Land Use,
USLE.

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ABSTRACT

Nagari Lawang is located in Agam Regency, West Sumatra, which is a nagari situated in the highlands with a slightly steep to very steep slope with the most types of land use in moors/fields. This can directly encourage erosion. This study aims to analyze the optimal land use pattern for reducing the rate of erosion in Nagari Lawang. The method used to calculate the erosion rate is the Universal Soil Loss Equation (USLE) and to obtain the optimal land use in reducing the erosion rate is a simulation with three scenarios. The results of the study showed that 47.29% of the Nagari Lawang land area was at an erosion rate above the tolerance erosion with the category of light to very heavy. Based on land use simulations, planning scenario III by allocating the use of shrubland into mixed gardens with planting according to contour lines and the use of shrub land into mixed forests is the best scenario because it can reduce erosion by 39.05% of the total erosion of Nagari Lawang. The reduction of erosion on the diverted land (moors/fields and shrubs) reached 45.83% of the existing condition, which was 2105.928 tons/ha/year. The best scenario land use can be used as a reference by policy makers and the community in determining appropriate land management actions in Nagari Lawang.

1. INTRODUCTION

A significant increase in population can increase the need for life, both in quantity and quality, while the availability of land resources will decrease and be very limited (Yanti & Arlius, 2014). This can trigger an increase in land resources to produce as much as possible without considering the consequences, resulting in changes in land function. Land use pressure that exceeds land capacity can cause land damage, one of which is erosion (Arifin, 2010).

Erosion is one of the causes of land damage in Indonesia. Erosion is an event of transporting or moving soil or parts of the soil from one place to another caused by natural factors such as water and wind. In the event of erosion, the soil or top layer will be eroded and transported which is then deposited elsewhere (Andriyani *et al.*, 2019). There are two causes of erosion, namely erosion that occurs naturally and due to human activities. Erosion that occurs naturally can occur to maintain soil balance and still provide adequate media for plant life to continue. The impact of natural erosion is not always significant because the erosion process is very slow. Meanwhile, erosion caused by human activities is caused by the peeling of soil or topsoil due to agricultural activities that are not in accordance with conservation principles, land conversion that changes land use and development activities that damage the physical condition of the land. The impact of erosion caused by human activities can damage ecosystems, the environment, reduce land productivity and others (Alie, 2015). Specific solutions to overcome the impacts of these two erosion

factors are to optimize land use by considering proper land use and the application of soil and water conservation techniques.

Changes in land use can cause uncontrolled erosion, where land cover is converted into agricultural land or dry fields (Yanti *et al.*, 2015). Land that does not have good vegetation cover will be susceptible to erosion caused by rain, especially on land located on steep slopes (Yanti, 2018). High erosion causes the soil to lose its topsoil and nutrients, this can reduce soil productivity (Munzir *et al.*, 2019). Plants or vegetation indirectly protect the soil from physical damage caused by surface flow. The presence of soil plants will be protected from rainwater that hits the surface of the soil, because the amount of rain interception will be blocked by the number and density of plant canopies (Wulandari *et al.*, 2013).

The method that can be used to obtain the value of land use changes is to compare land use with other land uses. The Universal Soil Loss Equation (USLE) method is used to estimate the amount of erosion. The USLE method uses the parameters R, K, LS, C, P which can predict the impact of land use changes on the level of erosion. The amount of erosion is determined by topographic factors (slope gradient/LS) followed by supporting factors for conservation practices (P), soil erodibility (K), plant management (C) and rain erosivity factors (R) (Wulandari *et al.*, 2013).

Nagari Lawang located in Agam Regency, West Sumatra is an area located at an altitude of ± 825 -1357 meters above sea level and an area dominated by slope topography in class III, namely a slope of 15-25% (Slightly Steep) with an average erosion rate of 127.85 tons/ha/year in 2023. Slope gradient is a factor in erosion, where the steeper the slope, the greater the surface flow velocity, thereby increasing the water transport energy (Arlius *et al.*, 2017). A major study of erosion based on the influence of land use changes needs to be carried out in Nagari Lawang to maintain land sustainability and avoid land degradation in Nagari Lawang. This study aims to analyze the optimal land use pattern to reduce erosion in Nagari Lawang.

2. MATERIALS AND METHODS

This research is a case study of changes in land use regarding the rate of erosion that occurred in Nagari Lawang. Geographically, Nagari Lawang is located at 0°15.56'49.56" South Latitude-100°16.21'16" East Longitude, with an area of 1379.19 ha, while administratively Nagari Lawang is directly adjacent to Nagari Sungai Puar to the north, to the south to Nagari Matua Mudiak, to the west to Nagari Bayua and to the east to Nagari Tigo Balai. Nagari Lawang has a local rainfall pattern because it is located in a highland area where the mass and air pressure are different from those in the lowlands, this will affect rainfall in Nagari Lawang. Rainfall is one of the causes of erosion. The higher the rainfall intensity, the higher the erosion that occurs (Arsyad, 2010).

The methodology in this study includes erosion prediction using the USLE (Universal Soil Loss Equation) method to determine the level of erosion hazard that occurs. Then, a land use simulation was conducted with 3 scenarios based on existing land use conditions to reduce the rate of erosion in Nagari Lawang. The research stages include:

2.1. Data Collection

- a. Primary data collection by taking soil samples to be tested in the Laboratory to determine the physical properties of the soil, which will later be used to determine the soil erodibility value. Soil samples are taken based on sample points that are determined intentionally (purposive sampling) by considering land use conditions and slope gradients based on land use units (SPL). The results of the laboratory analysis are then processed using Microsoft Excel 2021 to obtain soil erodibility values.
- b. Collection of secondary data such as (1) slope gradient maps obtained from the Digital Elevation Model (DEM), (2) land use maps obtained from Ina-Geoportal and (3) rainfall data for the last 10 years obtained from the Water Resources Management Service (DPSDA).

2.2. Data Processing

Analysis of primary and secondary data was carried out to obtain the values of factors that affect erosion such as:

Erosivity. The value of rainfall erosivity was determined by rainfall data obtained from 5 (five) rainfall observation stations, namely Koto Tingi Station, Manggopoh Station, Paraman Talang Station, BMKG Padang Panjang and Gumarang Station. After analyzing the distribution of rainfall stations from the five rainfall observation stations using the Thiessen Method, the results showed that Nagari Lawang was included in the Gumarang Station zone. The data used to determine erosivity was 10 years of rainfall data (2013-2022), then calculated using the Bols equation.

$$R = 6.119 (CH)^{1.21} \times (HH)^{-0.47} \times (H_{24})^{0.53} \quad (1)$$

where R is rainfall erosivity, CH is average monthly rainfall (cm), HH is average number of rainy days per month (days), H_{24} is maximum daily rainfall (cm).

Erodibility. The soil type map of Nagari Lawang was analyzed to determine the type of soil in Nagari Lawang, then soil samples were taken to determine the physical properties of the soil. The samples taken were 8 soil samples based on the condition of the land units in Nagari Lawang. Soil samples were tested in the laboratory and processed using the Wischmeier and Smith equation, 1978 to obtain soil erodibility values.

$$100K = 1.292[2.1M^{1.149}(10^{-4}) \times (12 - a) + 3.25(b - 2) + 2.5(c - 3)] \quad (2)$$

$$M \text{ is } (\% \text{ dust} + \% \text{ very fine sand}) \times (100 - \% \text{ clay}) \quad (3)$$

where K is erodibility factor, *a* is % organic matter, *b* is soil structure and texture code, *c* is soil permeability code.

Slope length. The length and slope of Nagari Lawang slopes were obtained based on GIS analysis on maps sourced from DEM (Digital Elevation Model) by determining 5 slope slope classes. Table 1 presents the values of slope length and slope based on slope class.

Table 1. Slope Length and Slope Factors

Slope Class	Slope Gradient (%)	LS Value
I	0-8	0.40
II	8-15	1.40
III	15-25	3.10
IV	25-40	6.80
V	>40	9.50

Source: (Kironoto *et al.*, 2021)

Management. The values of plant management (C) and conservation actions (P) are obtained from the analysis of land use maps. Table 2 presents the value of factor C and Table 3 presents the value of factor P.

Table 2. Plant Management Factor (C)

Types of Plants	C-Factor	Types of Plants	C-Factor
Rice paddy	0.01	Permanent imperata	0.4
Sugarcane	0.2-0.3	Undisturbed bushes	0.01
Corn	0.64	Undisturbed forest, little litter	0.005
Peanuts	0.4	Undisturbed forest, lots of litter	0.001
Cassava	0.7	Rice + corn	0.5
Sweet potato	0.4	Corn + nuts	0.4
Chilies, onions, other vegetables	0.8	Rice-corn-peanuts	0.45
Coffee	0.5	Mixed garden, dense	0.1
Good (permanent) grassland	0.1	Mixed garden, cassava + soybeans	0.2
Poor (permanent) grassland	0.04	Mixed garden, pigeon pea + peanut	0.4
(+) overlap; (-) crop rotation			

Source: (Kironoto *et al.*, 2021)

2.3. Existing Condition Erosion Analysis

Erosion analysis was conducted using ArcGIS 10.8 software to calculate the erosion rate using the USLE method based on existing condition data. Erosion mapping was conducted using the GIS method to perform analysis and

Table 3. Conservation Practices (CP)

Conservation Practices	P Factor	Conservation Practices	P Factor
Bench terrace, good	0.04	Contour cropping with >25% slope	0.9
Bench terrace, moderate	0.15	Permanent grass strips, good, dense, and aligned	0.04
Bench terrace, poor	0.4	Permanent grass strips, poor	0.4
Traditional terrace	0.35	Straw mulch at 6 t/ha/year	0.15
Ridge terrace, good	0.15	Straw mulch at 3 t/ha/year	0.25
Contour cropping with 1-3% slope	0.4	Straw mulch at 1 t/ha/year	0.6
Contour cropping with 3-8% slope	0.5	Corn mulch at 3 t/ha/year	0.35
Contour cropping with 8-15% slope	0.6	Peanut mulch	0.75
Contour cropping with 15-25% slope	0.8	Contour cropping with >25% slope	0.9

Source: Kironoto *et al.* (2021)

visualization. The erosion rate class is presented in Table 4 and the USLE equation to calculate the erosion rate is presented as follows (Arsyad, 2010):

$$A = R \times K \times LS \times CP \quad (3)$$

Table 4. Erosion Rate Classes

Class	Erosion Rate (ton/ha/year)	Description
I	<15	Very light
II	15-60	Light
III	60-180	Moderate
IV	180-480	Heavy
V	>480	Very heavy

Source: (Arsyad, 2010)

2.4. Preparation of Land Use Scenarios

Land use scenarios were prepared to reduce the rate of erosion, with the following scenario preparation rules:

- Land use that change the C and P values that is categorized as moderate to very severe erosion levels.
- Land use changes are carried out on land designated for agriculture and in each scenario land use recommendations are taken based on land conditions in each land unit.
- Based on conservation action directions, government policies and regulations in Law No. 26/2007 which regulates land use for land sustainability including natural resource conservation and prevention of environmental damage.

The planning scenarios prepared are as follows:

- Planning Scenario I: changing the use of dry land/fields to plantation crops with bench terraces and the use of shrub land to selective logging production forests.
- Planning Scenario II: changing the use of dry land/fields to sugar cane crops with good ridge terraces and the use of shrub land to selective logging production forests.
- Planning Scenario III: changing the use of dry land/fields into mixed gardens with planting according to contour lines and the use of shrub land into mixed forests.

2.5. Erosion Analysis Based on Land Use Scenarios

The erosion rate was re-analyzed using ArcGIS 10.8 software using the USLE method based on land management planning data based on each scenario.

2.6. Formulation of Recommendations

Based on the results of the study, the best scenario was chosen, namely the right land use to reduce erosion. The right land use is used as a recommendation for land management, because it is in accordance with conservation actions.

3. RESULTS AND DISCUSSION

Nagari Lawang is administratively located in Agam Regency, West Sumatra Province. Geographically, Nagari Lawang is located at 0°15.56'49.56" South Latitude-100°16.21'16" East Longitude, with an area of 1379.19 ha at an altitude of ±850-1,450 meters above sea level. The soil type of Nagari Lawang is dominated by andosol and cambisol. The use of dry land or fields is a very large land use in Nagari Lawang. The value of rain erosivity (R) of Nagari Lawang is calculated based on rainfall intensity, number of rainy days and maximum rainfall at the Gumarang rain observation station. The erosivity value of Nagari Lawang ranges from 50.98 to 247.08 kJ/ha (Table 5). According to [Lestari *et al.* \(2022\)](#), the greater the R factor value, the greater the ability of rain to cause erosion.

The erodibility value of Nagari Lawang soil is presented in Table 6. The difference in K values in Nagari Lawang is caused by the physical and chemical properties of the soil, where the permeability and organic matter values can change over time along with changes in land management and use. The erodibility value of soil in Nagari Lawang ranges from 0.13-0.67. This erodibility value is influenced by soil texture such as dust, very fine sand and clay, where the higher the dust content, the more susceptible the soil is to erosion. A fine soil texture will be more easily washed away than soil with a coarse texture. According to [Andriyani *et al.* \(2019\)](#), the higher the soil erodibility value, the more susceptible it is to erosion.

Table 5. Rain erosivity factor (R) of Nagari Lawang.

Month	Rainfall R (cm)	Rainy Days (days)	Maximum Rainfall (cm)	Rain Erosivity (kJ/ha)
January	9.34	9.2	2.38	50.98
February	8.82	7.1	2.21	51.66
March	15.06	10.4	3.32	102.34
April	14.51	10.8	3.13	93.16
May	14.01	12.4	3.23	85.08
June	13.19	8.7	3.44	96.60
July	12.96	8.0	3.50	99.27
August	13.43	9.8	3.10	88.35
September	18.17	11.4	4.11	137.75
October	22.91	14.9	4.50	168.70
November	30.06	16.9	5.56	247.08
December	22.42	17.3	3.89	141.82

Table 6. Erodibility value of Nagari Lawang lands

Land Unit	%dust	%very fine sand	%clay	a	b	c	K-value
LW 01	58.1	33.84	6.89	4.52	2	3	0.62
LW 02	63.13	6.00	18.75	5.65	3	3	0.37
LW 03	41.91	19.22	0.42	9.24	2	3	0.15
LW 04	53.26	8.95	28.88	9.7	3	3	0.13
LW 05	40.49	28.74	0.29	8.12	2	3	0.25
LW 06	48.19	11.78	16.47	8.98	3	2	0.14
LW 07	58.96	21.58	9.3	9.64	3	2	0.17
LW 08	58.58	13.08	0.24	7.11	3	3	0.37

Table 7 shows the results of the analysis of the slope data of Nagari Lawang. The LS value represents the effect of the length and slope of the slope on the amount of erosion by water ([Kardhana *et al.*, 2024](#)). The most dominant LS value in Nagari Lawang is in class 3 (three) with a value of 3.1 which is in an area with a rather steep terrain of 350.61 ha or 25.42% of the land area of Nagari Lawang.

The type of conservation action needed to determine the P value and the C value is determined based on the type of land cover. Based on the analysis of land use maps, 6 types of land use were obtained in Nagari Lawang (Table 8). The CP value of Nagari Lawang ranges from 0.001-0.28 with the highest CP value in dry land use of 0.28, which is 45.53% of the land area of Nagari Lawang. The high management and conservation action (CP) value is caused by the plants planted not having good roots and not being strong enough to withstand rain erosivity ([Alewell *et al.*, 2019](#)).

Table 7. Slope length and slope (LS) values of Nagari Lawang

Slope Gradient (%)	Symbol	Criteria	LS Value	Area (ha)	Percentage (%)
0-8	1	Flat	0.4	179.08	12.98
8-15	2	Gentle	1.4	300.30	21.77
15-25	3	Moderately Steep	3.1	350.61	25.42
25-40	4	Steep	6.8	227.66	16.51
>40	5	Very Steep	9.5	321.55	23.31
Total				1379.19	100

Table 8. Land use and CP values in Nagari Lawang

Land Use	CP Value	Area (ha)	Percentage (%)
Fishpond	0.001	0.51	0.04
Virgin Forest	0.001	577.80	41.89
Settlement & Activity Areas	0.05	17.47	1.27
Rice Fields	0.01	144.26	10.46
Shrubland	0.1	11.24	0.81
Dry Fields/Plantations	0.28	627.91	45.53
Total		1379.181	100

Rain Erosivity (Factor R), Soil Erodibility (Factor K), Length and Slope Gradient (Factor LS) and Plant Management and Conservation Actions (Factor CP), are factors that affect the erosion rate (A). The magnitude of the erosion rate (A) in Nagari Lawang is presented in Table 9 and spatially presented in Figure 1. The spatial classification of erosion in Nagari Lawang in tons/ha/year. Areas with the same color mean they are in the same erosion rate classification. The erosion rate in Nagari Lawang is classified into five erosion criteria, class I criteria is very light (erosion rate below 15 tons/ha/year) to class V criteria is very heavy (erosion rate more than 480 tons/ha/year). The results of the analysis show that the erosion rate that occurs in Nagari Lawang is dominated by class I (52.71%), class III (15.74%), class V (13.14%), class II (9.56%), and class IV (8.84%).

Based on Table 9, several land units in Nagari Lawang experienced erosion with very heavy criteria. These land units are IV.Sb.1, IV.T.1 and V.T.5 with a percentage area of 13.14% (181.26 ha) with an average erosion rate of 1029.85 tons/ha/year. As much as 47.29% of the total area of Nagari Lawang, erosion rates with moderate, severe and very severe criteria occur. Land use in these land units is shrubs and fields/fields. According to [Pham *et al.* \(2018\)](#), land use affects the results and characteristics of soil erosion and severe erosion often occurs in agricultural land.

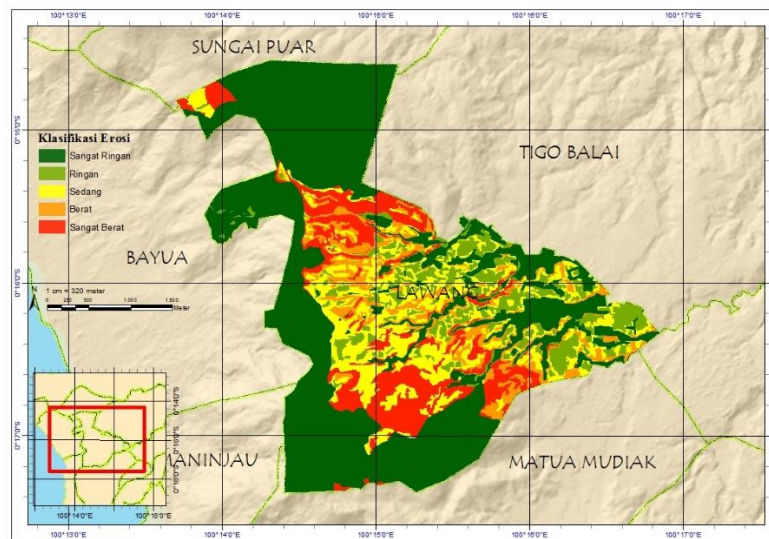
Figure 1. Large map of existing erosion rates of Nagari Lawang (Source: [Zawiyah *et al.*, 2024](#))

Table 9. Existing erosion rate (A) in Nagari Lawang

No.	Land Unit	R (ton/ha/yr)	K	LS	CP	A (ton/ha/yr)	Erosion Rate Criteria	Land Area (ha)	Total Erosion (ton/yr)
1	I.Hr.7	1362.79	0.17	0.4	0.001	0.093	Very Light	9.2912	0.010
2	IP7	1362.79	0.17	0.4	0.05	4.633	Very Light	8.6723	0.534
3	IS2	1362.79	0.37	0.4	0.01	2.017	Very Light	41.4057	0.049
4	I.Sb.2	1362.79	0.37	0.4	0.1	20.169	Light	0.0511	394.973
5	IT2	1362.79	0.37	0.4	0.28	56.474	Light	119.649	0.472
6	II.E.6	1362.79	0.14	1.4	0.001	0.267	Very Light	0.0748	3.570
7	II.E.5	1362.79	0.25	1.4	0.001	0.477	Very Light	0.1377	3.463
8	II.Hr.6	1362.79	0.14	1.4	0.001	0.267	Very Light	54.6477	0.005
9	II.Hr.5	1362.79	0.25	1.4	0.001	0.477	Very Light	26.2436	0.018
10	II.P.6	1362.79	0.14	1.4	0.05	13.355	Very Light	6.9218	1.929
11	II.P.5	1362.79	0.25	1.4	0.05	23.849	Light	0.3051	78.162
12	II.S.6	1362.79	0.14	1.4	0.01	2.671	Very Light	45.0832	0.059
13	II.S.5	1362.79	0.25	1.4	0.01	4.770	Very Light	2.7453	1.737
14	II.Sb.6	1362.79	0.14	1.4	0.1	26.711	Light	0.2208	120.947
15	II.Sb.5	1362.79	0.25	1.4	0.1	47.698	Light	0.3858	123.642
16	II.T.6	1362.79	0.14	1.4	0.28	74.790	Moderate	132.209	0.566
17	II.T.5	1362.79	0.25	1.4	0.28	133.55	Moderate	31.3255	4.263
18	III.E.4	1362.79	0.12	3.1	0.001	0.507	Very Light	0.0581	8.725
19	III.E.3	1362.79	0.15	3.1	0.001	0.634	Very Light	0.1707	3.712
20	III.Hr.4	1362.79	0.12	3.1	0.001	0.507	Very Light	88.5609	0.006
21	III.Hr.3	1362.79	0.15	3.1	0.001	0.634	Very Light	53.1997	0.012
22	III.P.8	1362.79	0.37	3.1	0.05	78.156	Moderate	1.3280	58.853
23	III.P.3	1362.79	0.15	3.1	0.05	31.685	Light	0.1458	217.341
24	III.S.4	1362.79	0.12	3.1	0.01	5.070	Very Light	38.4331	0.132
25	III.Sb.8	1362.79	0.37	3.1	0.1	156.312	Moderate	1.9475	80.264
26	III.Sb.3	1362.79	0.15	3.1	0.1	63.370	Moderate	1.2712	49.852
27	III.T.8	1362.79	0.37	3.1	0.28	437.674	Heavy	116.509	3.757
28	III.T.3	1362.79	0.15	3.1	0.28	177.435	Moderate	48.9808	3.623
29	IV.E.1	1362.79	0.62	6.8	0.001	5.746	Very Light	0.0688	83.526
30	IV.Hr.1	1362.79	0.62	6.8	0.001	5.746	Very Light	55.1700	0.104
31	IV.Hr.3	1362.79	0.15	6.8	0.001	1.390	Very Light	54.3911	0.026
32	IV.P.1	1362.79	0.62	6.8	0.05	287.276	Heavy	0.0991	2898.76
33	IV.P.3	1362.79	0.15	6.8	0.05	69.502	Moderate	0.0008	84966.1
34	IV.S.1	1362.79	0.62	6.8	0.01	57.455	Light	7.7969	7.369
35	IV.S.3	1362.79	0.15	6.8	0.01	13.900	Very Light	5.4353	2.557
36	IV.Sb.1	1362.79	0.62	6.8	0.1	574.552	Very Heavy	2.0293	283.133
37	IV.Sb.3	1362.79	0.15	6.8	0.1	139.005	Moderate	0.0393	3532.97
38	IV.T.1	1362.79	0.62	6.8	0.28	1608.746	Very Heavy	102.629	15.675
39	V.Hr.5	1362.79	0.25	9.5	0.001	3.237	Very Light	236.291	0.014
40	V.S.5	1362.79	0.25	9.5	0.01	32.366	Light	3.3603	9.632
41	V.Sb.5	1362.79	0.25	9.5	0.1	323.663	Heavy	5.2903	61.180
42	V.T.5	1362.79	0.25	9.5	0.28	906.255	Very Heavy	76.6056	11.830

Source: Zawiyah *et al.*, 2024

Land use is an important factor that affects the value of the erosion rate that occurs in each land unit. When compared to jungle forest land cover, fields/fields have a greater potential for erosion. This is because fields/fields do not have a good root system and vegetation that is unable to withstand the destructive power of rain (Apriani *et al.*, 2021). In this case, land conditioning efforts need to be made through agroforestry or reforestation to help stabilize the soil and increase land cover (Kardhana *et al.*, 2024).

Based on the erosion rate values in Table 9, land units with moderate to very severe erosion rates require effective land management measures to reduce their erosion rates because of their significant impact on soil productivity and the environment. Erosion rates that exceed tolerance limits are very concerning because they have long-term negative effects on land productivity (Andriyani *et al.*, 2019). Some erosion control methods that can be carried out include

land management according to contour lines, intercropping, cover crops, mulch, terraces and strip cultivation and the use of organic materials are types of conservation practices used to control erosion (Liu *et al.*, 2011). Table 10-12 shows changes in C and P values with land use simulations based on land use and conservation systems for land units that require erosion control measures or land units that are in the criteria for moderate to very severe erosion rates. The simulated land is land with the use of dry fields/fields and bushes. Spatially, it can be seen in Figure 2.

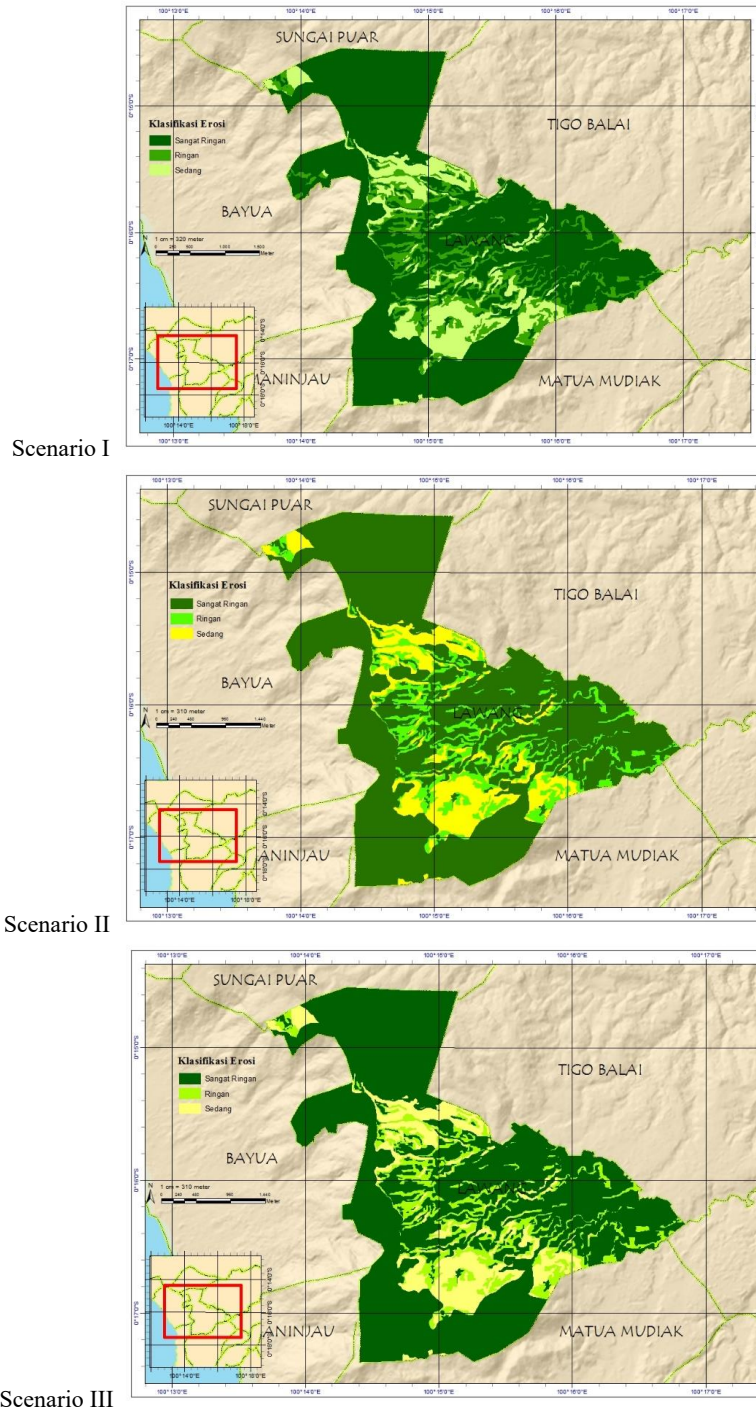


Figure 2. Erosion rate map based on Scenario I (top), Scenario II (middle), Scenario III (bottom).

Table 10. Analysis results of Scenario Planning I

No.	Land Unit	Land Use Scenario	C	P	CP	A (ton/ha/yr)
1	II.T.6	Plantation crops with bench terraces	0.5	0.15	0.075	20.033
2	II.T.5	Plantation crops with bench terraces	0.5	0.15	0.075	35.773
3	III.Sb.8	Selective logging production forest	0.2	1	0.2	312.624
4	III.Sb.3	Selective logging production forest	0.2	1	0.2	126.739
5	III.T.8	Plantation crops with bench terraces	0.5	0.15	0.075	117.234
6	III.T.3	Plantation crops with bench terraces	0.5	0.15	0.075	47.527
7	IV.Sb.1	Selective logging production forest	0.2	1	0.2	1149.105
8	IV.Sb.3	Selective logging production forest	0.2	1	0.2	278.009
9	IV.T.1	Plantation crops with bench terraces	0.5	0.15	0.075	430.914
10	V.Sb.5	Selective logging production forest	0.2	1	0.2	647.325
11	V.T.5	Plantation crops with bench terraces	0.5	0.15	0.075	242.747
Total						3408.03

Table 11. Analysis Results of Scenario Planning II

No.	Land Unit	Land Use Scenario	C	P	CP	A (ton/ha/yr)
1	II.T.6	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	8.013
2	II.T.5	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	14.309
3	III.Sb.8	Selective logging production forest	0.2	1	0.2	312.624
4	III.Sb.3	Selective logging production forest	0.2	1	0.2	126.739
5	III.T.8	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	46.894
6	III.T.3	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	19.011
7	IV.Sb.1	Selective logging production forest	0.2	1	0.2	1149.105
8	IV.Sb.3	Selective logging production forest	0.2	1	0.2	278.009
9	IV.T.1	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	172.366
10	V.Sb.5	Selective logging production forest	0.2	1	0.2	647.325
11	V.T.5	Sugarcane crops with good ridge terraces	0.2	0.15	0.03	97.099
Total						2871.49

Table 12. Analysis Results of Scenario Planning III

No.	Land Unit	Land Use Scenario	C	P	CP	A (ton/ha/yr)
1	II.T.6	Mixed gardens with contour planting	0.2	0.5	0.100	26.711
2	II.T.5	Mixed gardens with contour planting	0.2	0.5	0.100	47.698
3	III.Sb.8	Mixed forest	0.24	0.43	0.103	161.314
4	III.Sb.3	Mixed forest	0.24	0.43	0.103	65.398
5	III.T.8	Mixed gardens with contour planting	0.2	0.5	0.100	156.312
6	III.T.3	Mixed gardens with contour planting	0.2	0.5	0.100	63.370
7	IV.Sb.1	Mixed forest	0.24	0.43	0.103	592.938
8	IV.Sb.3	Mixed forest	0.24	0.43	0.103	143.453
9	IV.T.1	Mixed gardens with contour planting	0.2	0.5	0.100	574.552
10	V.Sb.5	Mixed forest	0.24	0.43	0.103	334.020
11	V.T.5	Mixed gardens with contour planting	0.2	0.5	0.100	323.663
Total						2489.43

Table 13. Total accumulation of erosion of existing conditions and land use scenarios in Nagari Lawang

Analysis Conditions	Erosion (ton/ha/year)						Total Erosion
	Forest	Fields/Farms	Shrubs	Paddy Fields	Settlements	Pond	
Existing	12.350	3394.928	1351.479	118.249	508.457	7.630	5393.093
Scenario I*	12.350	950.703	2608.380	118.249	508.457	7.630	4205.769
Scenario II**	12.350	414.166	2608.380	118.249	508.457	7.630	3669.232
Scenario III***	12.350	1248.779	1391.700	118.249	508.457	7.630	3287.165

*Fields/farms are converted into plantation crops with bench terraces, and shrubland is converted into selective logging production forest.

**Fields/farms are converted into sugarcane with well-maintained ridged terraces, and shrubland is converted into selective logging production forest.

***Fields/farms are converted into mixed gardens with contour planting, and shrubland is converted into mixed forests.

Table 14. Erosion reduction on land with scenario use

Analysis Conditions	Erosion (ton/ha/year)			Erosion Reduction (%)
	Fields/Farms	Shrubs	Total Erosion	
Existing	3338.454	1256.901	4595.355	
Scenario I	894.229	2513.802	3408.031	25.84
Scenario II	357.691	2513.802	2871.494	37.51
Scenario III	1192.305	1297.122	2489.427	45.83

The total erosion rate in Nagari Lawang in the moderate-very severe class calculated using the USLE (Universal Soil Loss Equation) method is 5393.093 tons/ha/year. The erosion rate can be reduced if land use simulation is carried out by changing the C and P values in land use in Nagari Lawang. Changes in the C and P values in each land unit are carried out on agricultural land experiencing moderate, severe and very severe erosion rates. There are 11 land units that were simulated for land use with three planning scenarios, namely dry fields/fields and bushes located on slopes of class II to class V. The amount of erosion reduction on the scenario land (converted) is presented in Table 14.

From Table 13 and Table 14, it can be seen that the largest erosion reduction is scenario III, which reduces erosion from 5393.093 tons/ha/year to 3287.165 tons/ha/year. In scenario I, the erosion rate decreases by 25.84% with an erosion rate of 4205.769 tons/ha/year and in scenario II, the erosion rate decreases by 37.51% with an erosion rate of 3669.232 tons/ha/year due to changes in C and P factors on the converted land. Scenario III is an optimal land use scenario compared to other land use scenarios because in scenario III there is a decrease in erosion of around 39.05% of the total erosion of Nagari Lawang in existing conditions. In scenario III, the use of dry land/fields is changed into mixed gardens with planting according to contour lines and the use of shrub land into mixed forests. From Table 14, it can be seen that the decrease in erosion on converted land (dry fields/fields and bushes) reached 45.83% of the existing condition, which is 2105.928 tons/ha/year.

Based on Table 9, there are 11 land units for agriculture experiencing erosion that can affect agricultural productivity, by implementing land use planning scenarios on these land units, the amount of erosion can be reduced. The land use scenario simulation that was prepared recommends the implementation of terracing, planting of ground cover vegetation and conservation-based land management that can reduce surface flow that can cause erosion. With this simulation-based approach, it can not only reduce the rate of erosion that occurs, but also contribute to sustainable agriculture with land management based on conservation actions.

4. CONCLUSION

Based on the land use simulation conducted in Nagari Lawang, the optimal land use pattern to reduce erosion in Nagari Lawang is planning scenario III by allocating the use of dry land/fields into mixed gardens with planting according to contour lines and the use of shrub land into mixed forests. Land with steep slopes can be managed based on scenario III, namely planting according to contour lines and implementing terracing. The reduction in erosion on converted land (dry land/fields and shrubs) reached 45.83% of the existing condition, which was 2105.928 tons/ha/year. This study is limited only to determine the optimal land use allocation to reduce the amount of erosion on land units used for agriculture in Nagari Lawang.

ACKNOWLEDGEMENTS

The researcher would like to thank all parties who have assisted in the implementation of the research. The research was funded by ANDALAS UNIVERSITY in accordance with the Research Contract for Undergraduate Thesis Research (PSS) Batch I Number: 201/UN16.19/PT.01.03/PSS/2024 Fiscal Year 2024.

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