INVESTIGATION OF SOIL EROSION IN AGRO-TOURISM AREA: GUIDELINE FOR ENVIRONMENTAL CONSERVATION PLANNING

Ni Made TRIGUNASIH [1*] and Moh SAIFULLOH [2]

DOI: 10.21163/GT_2023.181.02

ABSTRACT:
Most agro-tourism areas are located in the upstream area of the watershed, in the highlands, steep slopes, and the air temperature is peaceful and calm. One of them is in the tourism area in the Penet upstream watershed, Bali, Indonesia. Agro-tourism, in addition to providing economic benefits to agricultural products, also from tourist visits to the panorama and landscape of agricultural land. Land use that is not wise and not following conservation rules can cause erosion. This study aims to investigate soil erosion rate and plans for environmental-based conservation. The method used to quantify erosion uses Universal Soil Loss Equation (USLE) with a geographic information system (GIS) approach. This research integrates field surveys and soil analysis in the laboratory. The result showed that the erosion rate in agro-tourism areas ranges from 0.32 t ha^{-1} yr^{-1} (very light) to 1,535.34 t ha^{-1} yr^{-1} (very heavy). The agro-tourism areas affected by erosion with heavy to very heavy categories are the villages of Antapan, Bangli, Apuan, Angseri, and Candikuning. Conservation actions can be taken, including improving plant management factors with dense vegetation, increasing land management actions by constructing bench terraces, and planting parallel to contour lines. It is recommended for further researchers to model erosion by integrating remote sensing data and geographic information systems in order to complement data that cannot be obtained in the field or the laboratory.

Key-words: *Erosion, USLE, Agro-tourism, Conservation, Geographic Information System (GIS)*

1. INTRODUCTION

The island of Bali has been known by many tourists worldwide as a famous tourist destination (Rideng et al., 2020). Natural tourism objects such as beaches, lakes, mountains, cultural tourism objects, and agro-tourism are all found on the island of Bali (Utama, 2020). Many researchers have studied the agro-tourism sector regarding marketing, development concepts, and economic benefits . Agro-tourism is an activity that seeks to develop the natural resources of an area with the potential for agriculture to be used as a tourist area. Plantation areas, specific vegetable-producing centers, and rural areas have great potential to become agro-tourism objects (Mahanani et al., 2021; Marin, 2015; Rosardi et al., 2021). The contained potential must be viewed in terms of the natural environment, geographical location, types of products, agricultural commodities produced, facilities, and infrastructure (Satriawan et al., 2015). In this study, we examine from a different perspective, namely, the impact of agro-tourism activities in the upstream area of the river on the environment. Apart from lowland rice, horticultural crops such as vegetables are one of the commodities cultivated in this upstream of agrotourism area. Characteristics of horticultural cultivation are intensive soil cultivation. Intensive tillage can cause the stability of soil aggregates to be disturbed. The upstream area of this agro-tourism area has an average annual rainfall of 3,110 mm/year. Cultivation of horticultural crops in areas with steep slopes, intensive tillage, and high rainfall can cause erosion.

Another problem with agricultural activities on steep slopes is that they are prone to landslides (Diara et al., 2022; Trigunasih & Saifulloh, 2022). Therefore, using sloping land to meet human

[1*] *Soil Sciences and Environment, Faculty of Agriculture Udayana University, 80234 Denpasar, Indonesia, Corresponding author*, trigunasih@unud.ac.id*

[2] *Spatial Data Infrastructure Development Center Udayana University, 80234 Denpasar, Indonesia, moh9saifulloh@gmail.com*

interests requires the application of soil and water conservation. Soil and water conservation are efforts to maintain and increase soil productivity, quantity, and water quality. Applying soil and water conservation techniques is the primary strategy in efforts to preserve and utilize the environment and natural resources (Narendra et al., 2021; Nugroho et al., 2022). Soil and water conservation is beneficial in mitigating climate change and land degradation in the long term. Therefore, it is essential always to pay attention to conservation rules so that the land is not susceptibility to erosion.

Based on the abovementioned problems, the authors assume it is necessary to research erosion mapping and determine appropriate conservation plans in agro-tourism areas. This study aims to quantify the amount of erosion and its spatial distribution and to plan environmental-based conservation measures.

2. STUDY AREA

This research was conducted in the upstream area of agro-tourism on the island of Bali (**Fig 1a)**. Hydrologically this area is included in the upstream Penet and Beratan watersheds. The slope of the slope is dominated by steep, with altitudes ranging from 334 - 2142 masl (**Fig 1b**). This area is located in Baturiti District, Tabanan Regency, Bali Province. Several villages use the land for agro-tourism activities, such as Candikuning, Angseri, Baturiti, and Antapan villages. The main tourist attraction is Lake Batur, with superior commodities on the surrounding agricultural land: strawberries, peppers, carrots, etc. Geographically, is located at 08° 14'30"-08° 38'07" latitude and 114° 59'00"-115° 02'57" east longitude.

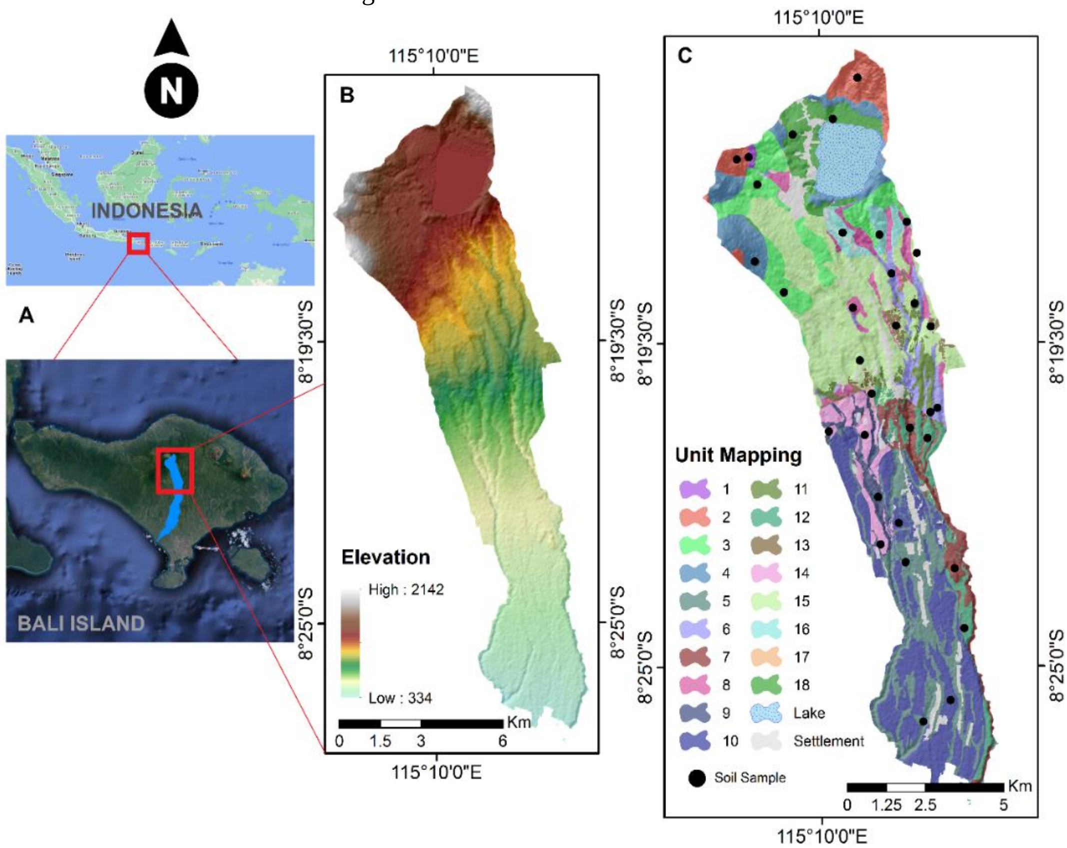

Fig. 1. The research location is viewed from a global scale in Indonesia and the island of Bali (a), a regional scale and shows the altitude of the research area (b), mapping units and the location of soil samples in the field (c).

3. DATA AND METHODS

3.1. Tools and Materials

The materials needed for our reserch include (1) chemical compounds (Calgon 5%, H_2O_2 30%, H_2O, $K_2Cr_2O_7$, concentrated H_2SO_4, concentrated H_3PO_4, DPA, $FeSO_4$); (2) soil samples obtained from field observations; (3) rainfall data for the last ten years from Meteorological, Climatological, and Geophysical Agency (BMKG); (4) soil type maps ; (5) land use maps, and slope class maps derived from Alos Palsar Digital Elevation Model (DEM), and Google Earth Satellite Imagery. The tools used include (1) Belgy drill; (2) sample ring; (3) field knife; (4) Abney levels; (5) ArcGIS 10.8 software; (6) laboratory analysis equipment, such as permeability determination apparatus, mug or glass beaker, pipette, tin, Erlenmeyer, burette, Petri dish, texture sieve, measuring cup, oven, and scale.

3.2 Data Analysis

The method used in this research is a field survey method by taking soil samples using the purposive sampling technique and then the soil samples analysis at the Laboratory. The stages of research implementation are (1) preparation (library study, determination of homogeneous land units, and preliminary survey); (2) field survey and soil sampling; (3) soil analysis in the Laboratory; (4) erosion calculations; (5) Tolerable erosion (EDP) calculation; (6) soil and water conservation planning; and (7) erosion mapping. This research mapping unit is based on thematic map overlays (soil type, land use, and slope). Eighteen mapping units were obtained, which were then used to take soil samples in the field. Soil sampling was carried out by purposive sampling and compositely, referring to the mapping unit that had been made previously. The map of the mapping unit and the soil sampling point is presented in **Fig. 1c**.Two parameters are observed, namely those observed in the field and those observed in the Laboratory. The parameters observed in the field include:

1. the length of the slope (L) measured using a meter,
2. the slope (S) measured or observed with the Abney level,
3. visually observed soil structure based on the shape and type of soil structure,
4. adequate depth measured with a Belgy Drill,
5. visually observed type and density of vegetation (C), and
6. visually observed land management (P).

Meanwhile, the parameters observed in the Laboratory include

1. soil texture using the pipette method,
2. organic materials using the Walkey and Black method,
3. permeability using the De Booth method based on Darcy's law, and
4. soil volume weight using the ring sample method.

Parameter criteria through field observations and laboratory analysis adopted from previous researchers, which were carried out in the Galunggung Watershed, Bali Province (Trigunasih et al., 2018). We adopted the previous researchers because our area's biophysical characteristics are similar to those of previous researchers. The difference is in the research area and the recommended conservation output, that this research is specific for conserving the upstream watershed area for ago-tourism activities.

a. Calculation of soil Erosion

The method used for calculating erosion is the USLE method proposed by (Wischmeier & Smith, 1978) with the following Eq. 1

$$A = R \times K \times LS \times C \times P \quad (1)$$

where A is the weight of soil lost ($t\ ha^{-1}\ yr^{-1}$), R is the rain erosivity factor ($kj\ ha^{-1}\ cm^{-1}$), K is the soil erodibility factor ($t\ kj^{-1}$), LS is the factor of slope length and slope, C is the factor of vegetation cover and plant management, and P is the factor of land management.

b. Rainfall Erosivity (R)

Rain erosivity (R) is the ability of rainwater to cause erosion which is calculated using the Bols methode (Wischmeier & Smith, 1978) with the Eq. 2

$$EI_{30} = 6.119(RAIN)^{1.21} \times DAYS^{-0.47} \times MAXP^{0.53} \quad (2)$$

where EI_{30} is the monthly rainfall erosivity, RAIN is the average monthly rainfall (cm), DAYS is the average rainy day in one month, and MAXP is the maximum rainy day in the month concerned (cm).

c. Soil Erodibility (K)

Soil erodibility (K) is the ease with which the soil erodes, which can be calculated using the following (Wischmeier & Smith, 1978) Eq. 3

$$100K = 1.292\,[2.1\,M^{1.14}\,(10^{-4})\,(12-a) + 3.25\,(b-2) + 2.5\,(c-3)] \quad (3)$$

where K is the soil erodibility value. M is the percentage of very fine sand fraction (0.1 – 0.05 mm diameter) and dust fraction (0.05 – 0.002 mm diameter) × (100 – clay fraction percentage), *a* is the percentage of organic matter, *b* is the soil structure code, and *c* is the soil profile, permeability class.

d. Slope Length (LS)

Length and slope (LS) is the ratio between the amount of erosion from a plot of land with a certain slope length and steepness, which can be calculated using the (Renard et al., 1991) Eq. 4

$$LS = \sqrt{x(0{,}0138 + 0{,}00965s + 0{,}00138s^2)} \quad (4)$$

where x is the length of the slope (m) and s is the steepness of the slope (%).

e. Ground Cover Vegetation and Plant Management and Land Management (CP)

Ground cover vegetation and plant management (C) is the ratio between the amounts of erosion from planted soils with certain management to the amount of soil erosion that is not planted and processed cleanly, whose value is obtained by observing visually at the field survey stage.

Land management (P) is the ratio of the amount of soil erosion with a certain conservation measure to the amount of erosion from soil that is processed according to the direction of the slope, whose value is also obtained by direct observation at the field survey stage. The C and P values are then calculated by multiplying the two factors to get the combined CP value.

f. Permissible Erosion (Edp)

Setting the maximum allowable erosion rate (Edp) is essential because it is impossible to reduce the erosion rate to zero on agricultural land, especially in sloping areas. The Edp value was obtained using the (Renard et al., 1991) Eq. 5

$$Edp\ (t\ ha^{-1}\ yr^{-1}) = Edp\ (mm\ yr^{-1}.) \times Bulk\ Density \times 10\ (t\ ha^{-1}\ yr^{-1}.) \quad (5)$$

Where Edp is the allowable erosion rate (t ha^{-1} yr^{-1}.), the equivalent depth is the effective depth × value of the depth factor (mm), the useful life of the soil is 400 years, and Bulk Density is the weight of the soil volume.

4. RESULTS AND DISCUSSIONS

4.1. Parameters Causing Erosion

The rain erosivity values obtained each month are then added together to get the annual erosivity value. The results show that the annual rainfall erosivity at Pos Luwus is 2,414.18 t ha^{-1} cm^{-1}; the annual rainfall erosivity at Baturiti Post is 2,443.00 t ha^{-1} cm^{-1}, and rain erosivity at Candikuning Post has a value of 2,807.23 t ha^{-1} cm^{-1} (**Fig 2a**). Soil erodibility in the study area ranges from 0.08-0.51 (very low to high). Very low soil erodibility is found in Unit 2, with a value of 0.08. Low soil erodibility was found in Units 3, 7, 12, 13, 17 and 18. Medium soil erodibility was found in Units 4, 5, 8, 9, 10, and 11. Slightly high soil erodibility was found in Unit 14. High soil erodibility was found in Units 1, 6, 15, and 16 (**Fig 2b**). Calculating the length and slope of the slopes produce LS values between 0.39 to 6.06. The lowest LS value of 0.39 is found in Unit 5, with a length and slope of 50 m and 3%, respectively. While the highest LS value, which is 6.06, is found in Unit 2, with a slope length of 3.5 m and a slope of 45% (**Fig 2c**). The CP value obtained starts from the lowest, which is 0.001, and the highest is 0.28. The lowest CP values were found in Units 1, 2, 3, and 4 with forest land use and no land management or conservation action. In comparison, the CP with the highest value can be found in Units 15, 16, 17, and 18 with the use of dry land and land management actions in the form of traditional terraces (**Fig 2d**). Statistical data regarding the parameters that cause erosion are presented in **Table 1**.

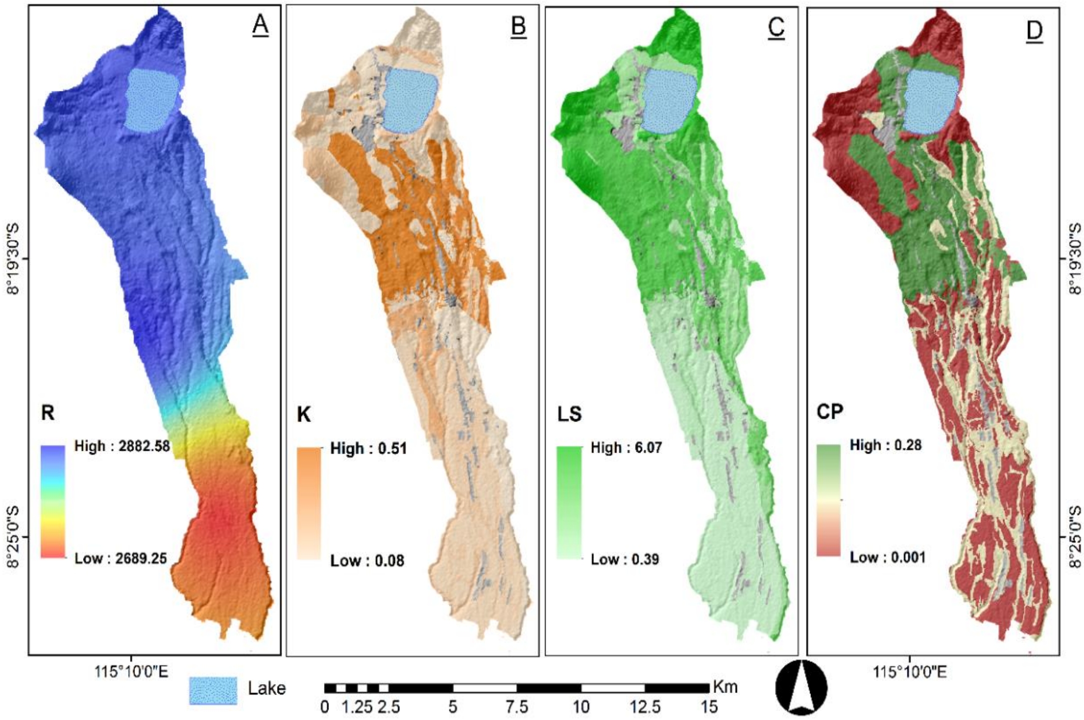

Fig 2. The thematic map that we use to calculate the amount of erosion i.e. Erosivity (R) is derived from data on rainfall (a), erodibility (K) (b), slope length (LS) (c), and land management (CP) (d).

4.2. Spatial Distribution of Soil Erosion and Conservation Effort

The amount of erosion (A) calculation shows that the study area experienced erosion from 0.32 to 1535.34 t ha^{-1} yr^{-1}. Based on the classification of erosion levels according to (Morgan et al., 1984), the amount of erosion in the study area is very light to very heavy. Very light erosion was found in Units 1, 2, 3, 4, 10, 11, 12, 13, and 14 (4,848.31 ha). Mild erosion was found in Unit 5 (971.88 ha). Moderate erosion was found in Units 7, 8, 9, and 17 (989.61 ha). Heavy erosion occurred in Units 6 and 18 (599.70 ha). Very heavy erosion was found in Units 15 and 16 (2,516.77 ha) (**Fig 3a**).

Table 1.

Statistical data on the parameters that cause erosion calculation results and conservation efforts.

Land Unit	Landuse	Area (ha)	R	K	LS	CP	A (t ha^{-1} yr^{-1})	Categories	EDP	Conservation
1	Primary dry land forest	266.26	2443	0.47	5.76	0.001	6.68	Very Light	28.2	Maintenance effort
2	Primary dryland forest	722.13	2443	0.08	6.07	0.001	1.25	Very Light	24.03	Maintenance effort
3	Secondary dryland forest	897.32	2443	0.21	4.89	0.001	2.49	Very Light	33.3	Maintenance effort
4	Secondary dryland forest	661.25	2443	0.27	5.48	0.001	3.63	Very Light	35.1	Maintenance effort
5	Mixed Dryland Farming	971.88	2414.18	0.25	0.39	0.08	19.04	Light	27.79	Maintenance effort
6	Mixed Dryland Farming	243.31	2443	0.46	3.22	0.08	290.78	Heavy	24.75	Mixed dryland farming (high density) and bench terraces of good construction
7	Mixed Dryland Farming	358.58	2414.18	0.19	3.79	0.08	139.5	Moderate	25.65	Mixed dryland farming (high density) and bench terraces of good construction
8	Mixed Dryland Farming	280.58	2443	0.22	1.8	0.08	76.09	Moderate	19.6	Mixed dryland farming (medium-high density) and bench terraces of medium-fine construction
9	Mixed Dryland Farming	255.31	2443	0.27	1.4	0.08	74.85	Moderate	24.7	Mixed dryland farming (medium-high density) and bench terraces of medium-fine construction
10	Ricefield	1652.35	2414.18	0.22	0.4	0.0015	0.32	Very Light	17.1	Maintenance effort
11	Ricefield	169.81	2443	0.26	1.79	0.0015	1.71	Very Light	14.55	Maintenance effort
12	Ricefield	305.26	2414.18	0.19	2.01	0.0015	1.38	Very Light	19.95	Maintenance effort
13	Ricefield	103.12	2443	0.19	0.82	0.0015	0.58	Very Light	16.5	Maintenance effort
14	Ricefield	337.07	2807.23	0.34	1.01	0.0015	1.43	Very Light	18.53	Maintenance effort
15	Dryland Farming	2208.66	2443	0.49	4.61	0.28	1535.3	Very heavy	22.27	Peanuts with straw mulch 4 t h^{-1} and bench terraces of good construction
16	Dryland Farming	308.11	2443	0.51	4.32	0.28	1505.6	Very heavy	22.73	Peanuts with straw mulch 4 t h^{-1} and bench terraces of good construction
17	Dryland Farming	95.14	2443	0.14	1.54	0.28	147.36	Moderate	23.75	Dryland farming and terrace benches are of good construction
18	Dryland Farming	356.39	2443	0.2	2.1	0.28	289.56	Heavy	26.33	Mixed dryland farming (high density) and bench terraces of medium construction

Source: Researcher Analysis in 2022.

Very light erosion was spread in the villages of Angseri, Antapan, Apuan, Bangli, Batunya, Baturiti, Candikuning, Mekarsari, Perean, Perean Kangin, and Perean Tengah (Units 1, 2, 3, 4, 10, 11, 12, 13, and 14). The K factor that causes very mild to mild erosion in Units 2, 3, 5, 12, and 13 indicates that the soil in the area is not easily eroded. Meanwhile, the CP factor causes very mild erosion in Units 1, 2, 3, 4, 10, 11, 12, 13, and 14. Units 1, 2, 3, and 4 have land use in the form of forests with a lot of litter. Forests have a high density between plants to reduce the impact of rainwater because it is blocked by plant canopies that touch each other. In addition, a lot of litter also plays a role in increasing infiltration so that it can reduce the surface runoff velocity. Units 10, 11, 12, 13, and 14 have land use in the form of rice fields with bench terraces of medium construction.

Irrigated rice has a dense plant density to reduce runoff and block the soil surface from the impact of rainwater. In addition, the fibrous roots in rice can control erosion because the fine threads in the fibrous roots can bind the primary soil grains so that the stability of soil aggregates becomes stable (Trigunasih et al., 2018; Trigunasih et al., 2017). Using rice fields with terraces also contributes to reducing the CP value. Bench terraces reduce the length and slope of the slope to minimize the amount and speed of runoff (Gao et al., 2020; Lowe et al., 2021; Ma et al., 2019).

Light erosion was spread in the villages of Angseri, Antapan, Apuan, Bangli, Baturiti, Luwus, Mekarsari, Perean, Perean Kangin, and Perean Tengah (Unit 5). The area has the lowest LS value with a slope classified as sloping. The gentle slope can increase infiltration, reducing the amount and speed of runoff. Erosion is spreading in the villages of Angseri, Antapan, Apuan, Bangli, Batunya, Baturiti, Candikuning, Luwus, Mekarsari, and Perean Kangin (Units 7, 8, 9, and 17). The slope in this area is classified as slightly sloping to sloping, allowing surface runoff. Units 7, 8, 9 (**Fig 3a)** have medium density mixed dryland farming with traditional terraces.

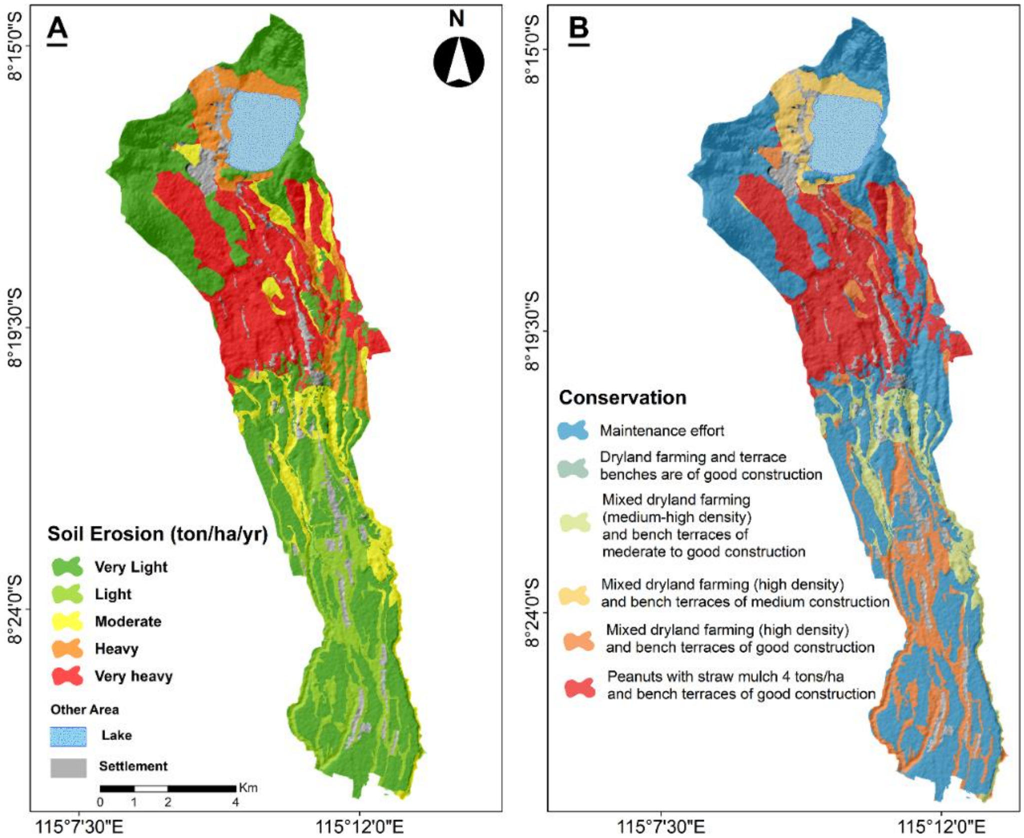

Fig. 3. Map of spatial distribution of erosion magnitude in agro-tourism areas (a), spatial distribution of environmental-based conservation action plans (b).

Raindrops will easily destroy soil particles because the plant density is less dense, so the plant canopy does not completely cover the soil. In addition, the ability of traditional terraces will not be as good as that of bench terraces of moderate to good quality in reducing the amount and speed of runoff (Chen et al., 2022; Deng et al., 2021; Khelifa et al., 2017).

Heavy erosion was spread in the villages of Antapan, Bangli, Batunya, Baturiti, and Candikuning (Units 6 and 18). The K factor is the cause of heavy erosion in Unit 6 with a high category, indicating that the soil in the area is easily eroded. The slope in this area is classified as slightly sloping to slightly steep so that it can cause surface runoff. Land Unit 6 has a land use of medium density mixed dryland farming of medium density and dry fields can increase the erosion value because it has a density between less dense plants. So that the soil is easily destroyed by the destructive power of rain and traditional terraces that do not have as good quality as bench terraces of medium and good construction.

Very heavy erosion was spread in the villages of Angseri, Antapan, Apuan, Bangli, Batunya, Baturiti, Candikuning, Luwus, and Mekarsari (Units 15 and 16). The high value of soil erodibility (K) indicates that the soil in the area is easily eroded. The LS value in the unit is high which can increase the amount and speed of runoff. CP with the use of dry land can increase the erosion value because it has a loose plant density, causing soil aggregates to be easily destroyed when it rains with high intensity and traditional terraces do not have the ability as well as bench terraces in reducing the amount and speed of runoff (Gao et al., 2020; Khelifa et al., 2017).

Recent research conducted by (Jemai et al., 2021), estimating soil erosion using GIS and remote sensing in South-Eastern Tunisia. The average soil loss rate is about 0.2 t ha^{-1} yr^{-1}. The maximum soil loss in the study area is 17 t ha^{-1} yr^{-1} in the Matmata mountain area. Further research by (Pham et al., 2018) in Sap Watershed, Central Vietnam. The results showed that forest land experienced the most soil erosion at around 19 t ha−1 year−1, plantation forests at 7 t ha^{-1} yr^{-1}, and other agricultural lands at 3.70 and 1.45 t ha^{-1} yr^{-1} for annual crops and lowland rice.

Comparing the two previous researchers in different regions of the country shows that our findings regarding the erosion rate are drastically different, namely for the maximum erosion rate reaching 1,535.3 t ha^{-1} yr^{-1} on dry land farming land use. This condition is caused by the characteristics of the regions in the different research areas, causing different results for each parameter built using the USLE model. We assume that the findings of our study should be evaluated by conducting further research with a different approach.

This research is not based on raster/pixel but the based data from vector/polygon. The uncertainty and weakness are that the resulting erosion model is general. Other researchers analyzed the erosive factor with remote sensing data such as the Global Precipitation Measurement Mission (GPM) and Tropical Rainfall Measuring Mission (TRMM) (Chen et al., 2021; Das et al., 2022). Land use and vegetation density through remote sensing spectral index approach (e.g., Normalized Difference Vegetation Index) (Ayalew et al., 2020), and use of detailed scale soil type to analyze erodibility (Ayalew et al., 2020). The effects of land use change must also be considered in quantifying erosion. The study investigates the impact of land use change on the rate of soil erosion, and informs that the rate of soil erosion is increasing along with changes in forest land to crop with lowest vegetation density and bare land (Eskandari Damaneh et al., 2022; Mariye et al., 2022; Sourn et al., 2022).

The conservation actions are determined after comparing the amount of erosion that occurs (A) with the tolerable erosion (EDP). If the value of (A) is greater than (EDP) then conservation action is required. Meanwhile, if the value of A is less than Edp, then there is no need to take conservation measures and only implement maintenance efforts. Units with an A value lower than the Edp value are Units 1, 2, 3, and 4 with forest land use, Unit 5 with mixed dryland farming, and Units 10, 11, 12, 13, and 14 with paddy field use. The unit does not require soil and water conservation measures and requires only maintenance efforts. Meanwhile, Units 6, 7, 8, and 9 with mixed dryland farming and 15, 16, 17, and 18 with dry land use require soil and water conservation measures because these eight units have A values greater than EDP. Conservation data based on allowable erosion conditions are presented in **Table 1**, and their spatial distribution is shown in **Fig. 3b.**

5. CONCLUSIONS

The erosion rate in agro-tourism areas ranges from 0.32 t ha^{-1} yr^{-1} (very light) to 1,535.34 t ha^{-1} yr^{-1} (very heavy). The spatial distribution of erosion rates in the heavy to very heavy categories, respectively, is 599.70 and 2,516.77 ha. The agro-tourism areas affected by the erosion rate in this category are the villages of Antapan, Bangli, Apuan, Angseri, and Candikuning. Conservation actions can be taken, including improving plant management factors with dense vegetation, increasing land management actions by constructing bench terraces, and planting parallel to contour lines. It is recommended for further researchers to model erosion by integrating remote sensing data and geographic information systems in order to complement data that cannot be obtained in the field or the laboratory.

REFERENCES

Ayalew, D. A., Deumlich, D., Šarapatka, B., & Doktor, D. (2020). Quantifying the sensitivity of NDVI-based C Factor Estimation and Potential Soil Erosion Prediction using Spaceborne Earth Observation Data. Remote Sensing, 12(7). https://doi.org/10.3390/rs12071136

Chen, Y., Xu, M., Wang, Z., Gao, P., & Lai, C. (2021). Applicability of two satellite-based precipitation products for assessing rainfall erosivity in China. Science of the Total Environment, 757. https://doi.org/10.1016/j.scitotenv.2020.143975

Chen, Y., Jian, S., Wu, Q., Hu, C., & Soomro, S. e. hyde. (2022). Identify runoff generation patterns of check dams and terraces and the effects on runoff: a case study. Acta Geophysica, 70(2). https://doi.org/10.1007/s11600-022-00728-4

Das, S., Jain, M. K., & Gupta, V. (2022). A step towards mapping rainfall erosivity for India using high-resolution GPM satellite rainfall products. Catena, 212. https://doi.org/10.1016/j.catena.2022.106067

Deng, C., Zhang, G., Liu, Y., Nie, X., Li, Z., Liu, J., & Zhu, D. (2021). Advantages and disadvantages of terracing: A comprehensive review. In *International Soil and Water Conservation Research* (Vol. 9, Issue 3). https://doi.org/10.1016/j.iswcr.2021.03.002

Diara, I. W., Suyarto, R., & Saifulloh, M. (2022). Spatial Distribution Of Landslide Susceptibility In New Road Construction Mengwitani-Singaraja, Bali-Indonesia: Based On Geospatial Data. *GEOMATE Journal*, *23*(96), 95–103. https://doi.org/https://doi.org/10.21660/2022.96.3320

Eskandari Damaneh, H., Khosravi, H., Habashi, K., Eskandari Damaneh, H., & Tiefenbacher, J. P. (2022). The impact of land use and land cover changes on soil erosion in western Iran. Natural Hazards, 110(3). https://doi.org/10.1007/s11069-021-05032-w

Gao, J., Bai, Y., Cui, H., & Zhang, Y. (2020). The effect of different crops and slopes on runoff and soil erosion. *Water Practice and Technology*, *15*(3). https://doi.org/10.2166/wpt.2020.061

Jemai, S., Kallel, A., Agoubi, B., & Abida, H. (2021). Soil Erosion Estimation in Arid Area by USLE Model Applying GIS and RS: Case of Oued El Hamma Catchment, South-Eastern Tunisia. Journal of the Indian Society of Remote Sensing, 49(6). https://doi.org/10.1007/s12524-021-01320-x

Khelifa, W. Ben, Hermassi, T., Strohmeier, S., Zucca, C., Ziadat, F., Boufaroua, M., & Habaieb, H. (2017). Parameterization of the Effect of Bench Terraces on Runoff and Sediment Yield by Swat Modeling in a Small Semi-arid Watershed in Northern Tunisia. *Land Degradation and Development*, *28*(5). https://doi.org/10.1002/ldr.2685

Lowe, M. A., McGrath, G., & Leopold, M. (2021). The Impact of Soil Water Repellency and Slope upon Runoff and Erosion. *Soil and Tillage Research*, *205*. https://doi.org/10.1016/j.still.2020.104756

Ma, B., Liu, G., Ma, F., Li, Z., & Wu, F. (2019). Effects of crop-slope interaction on slope runoff and erosion in the Loess Plateau. *Acta Agriculturae Scandinavica Section B: Soil and Plant Science*, *69*(1). https://doi.org/10.1080/09064710.2018.1488988

Mahanani, R. S., Hidayat, T., Wardatic, I., Galushasti, A., & Wiyono, L. C. (2021). Local economic development strategies to increase economic growth in agrotourism areas. *Tourism(Poland)*, *31*(2). https://doi.org/10.18778/0867-5856.31.2.07

Marin, D. (2015). Study on the Economic Impact of Tourism and of Agrotourism on Local Communities. *Research Journal of Agricultural Science*, *47*(4).

Mariye, M., Mariyo, M., Changming, Y., Teffera, Z. L., & Weldegebrial, B. (2022). Effects of land use and land cover change on soil erosion potential in Berhe district: a case study of Legedadi watershed, Ethiopia. International Journal of River Basin Management, 20(1). https://doi.org/10.1080/15715124.2020.1767636

Morgan, R. P. C., Morgan, D. D. V., & Finney, H. J. (1984). A predictive model for the assessment of soil erosion risk. *Journal of Agricultural Engineering Research*, *30*(C). https://doi.org/10.1016/S0021-8634(84)80025-6

Narendra, B. H., Siregar, C. A., Dharmawan, I. W. S., Sukmana, A., Pratiwi, Pramono, I. B., Basuki, T. M., Nugroho, H. Y. S. H., Supangat, A. B., Purwanto, Setiawan, O., Nandini, R., Ulya, N. A., Arifanti, V. B., & Yuwati, T. W. (2021). A review on sustainability of watershed management in Indonesia. In *Sustainability (Switzerland)* (Vol. 13, Issue 19). https://doi.org/10.3390/su131911125

Nugroho, H. Y. S. H., Basuki, T. M., Pramono, I. B., Savitri, E., Purwanto, Indrawati, D. R., Wahyuningrum, N., Adi, R. N., Indrajaya, Y., Supangat, A. B., Putra, P. B., Auliyani, D., Priyanto, E., Yuwati, T. W., Pratiwi, Narendra, B. H., Sukmana, A., Handayani, W., Setiawan, O., & Nandini, R. (2022). Forty Years of Soil and Water Conservation Policy, Implementation, Research and Development in Indonesia: A Review. In *Sustainability (Switzerland)* (Vol. 14, Issue 5). https://doi.org/10.3390/su14052972

Pham, T. G., Degener, J., & Kappas, M. (2018). Integrated universal soil loss equation (USLE) and Geographical Information System (GIS) for soil erosion estimation in A Sap basin: Central Vietnam. International Soil and Water Conservation Research, 6(2). https://doi.org/10.1016/j.iswcr.2018.01.001

Renard, K. G., Foster, G. R., Weesies, G. A., & Porter, J. P. (1991). RUSLE: revised universal soil loss equation. *Journal of Soil & Water Conservation*, *46*(1).

Rideng, I. W., Budiartha, I. N. P., & Sukandia, I. N. (2020). The development of bali tourism through cultural and local wisdom of customary village. *International Journal of Entrepreneurship*, *24*(5).

Rosardi, R. G., Prajanti, S. D. W., Atmaja, H. T., & Juhadi. (2021). Sustainable tourism model in pagilaran tea plantation agrotourism, in Indonesia. *International Journal of Sustainable Development and Planning*, *16*(5). https://doi.org/10.18280/ijsdp.160519

Satriawan, I. K., Pujaastawa, I. B. G., & Sarjana, I. M. (2015). Development of small-scale agro-tourism in the Province of Bali, Indonesia. *Advances in Environmental Biology*, *9*(21).

Sourn, T., Pok, S., Chou, P., Nut, N., Theng, D., & Vara Prasad, P. V. (2022). Assessment of Land Use and Land Cover Changes on Soil Erosion Using Remote Sensing, GIS and RUSLE Model: A Case Study of Battambang Province, Cambodia. Sustainability (Switzerland), 14(7). https://doi.org/10.3390/su14074066

Trigunasih & Saifulloh. (2022). Spatial Distribution of Landslide Potential and Soil Fertility: A Case Study in Baturiti District, Tabanan, Bali, Indonesia. *Journal of Hunan University Natural Sciences*, *49*(2). https://doi.org/https://doi.org/10.55463/issn.1674-2974.49.2.23

Trigunasih, N. M., Kusmawati, T., & Yuli Lestari, N. W. (2018). Erosion Prediction Analysis and Landuse Planning in Gunggung Watershed, Bali, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *123*(1). https://doi.org/10.1088/1755-1315/123/1/012025

Trigunasih, Ni Made, Merit, I. N., Wiyanti, W., Narka, I. W., & Dibia, I. N. (2017). Evaluation Of Land Suitability For Increasing Productivity In Degraded Unda Watershed, District Of Karangasem, Bali. *International Journal of Biosciences and Biotechnology*, *5*(1). https://doi.org/10.24843/ijbb.2017.v05.i01.p03

Utama, I. G. B. R. (2020). Tourism Visitor Center Flowchart As Recommendation for Bali Tourism Destination. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3669739

Wischmeier, W., & Smith, D. (1978). Predicting rainfall erosion losses: a guide to conservation planning. In *U.S. Department of Agriculture Handbook No. 537*. https://doi.org/10.1029/TR039i002p00285