EVALUATING THE IMPACT OF HAZARDS ON ECOSYSTEM CHANGES IN THE AREA OF PUMAT NATIONAL PARK, NGHEAN, VIETNAM

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Abstract

Planning for the protection of ecosystems is a difficult task that incorporates a variety of different problems and requires an integrated assessment. In addition to managing a considerable amount of data used to characterize ecosystem aspects, these problems also involve selecting the right methods for assessing risks and dangers. This paper focuses on the basic fundamentals of analyzing the distribution of ecosystem evolution and the impact of hazards (such as landslides and erosion) in order to determine how these hazards have impacted the ecosystem evolution. GIS and the AHP method were used to create the hazards map and its component maps (the erosion map with 5 input maps and the landslide map with 9 input maps), as well as to undertake evaluations of ecosystem change in 2010 and 2020. The area of Pu Mat National Park, which is located in Vietnam's Nghean province and has significant biological characteristics, is the subject of the case study. The results are indicating the magnitude and strength of hazard's influence on ecosystem change. Following that, they will support the planning of socioeconomic development in the research region and diversity conservation.

Keywords: Ecosystem changes, hazard, Pumat National Park, Vietnam

ОЦЕНКА ВОЗДЕЙСТВИЯ ОПАСНОСТЕЙ НА ИЗМЕНЕНИЯ ЭКОСИСТЕМЫ В РАЙОНЕ НАЦИОНАЛЬНОГО ПАРКА ПУМАТ, НГЕАН, ВЬЕТНАМ

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Аннотация

Планирование защиты экосистем представляет собой сложную задачу, которая включает в себя множество различных проблем и требует комплексной оценки. В дополнение к управлению значительным объемом данных, используемых для характеристики аспектов лекосистемы, эти проблемы также связаны с выбором правильных методов оценки рисков и опасностей. В этом документе основное внимание уделяется основным принципам анализа распределения эволюции экосистемы и воздействия опасностей (таких как оползни и эрозия), чтобы определить, как эти опасности повлияли на эволюцию экосистемы. ГИС и метод анализа иерархий использовались для создания карты опасностей и карт ее компонентов (карта эрозии с 5 входными картами и карта оползней с 9 входными картами), а также для проведения оценок изменения экосистемы в 2010 и 2020 годах. Национального парка Пумат, расположенного во вьетнамской провинции Нгеан и обладающего значительными биологическими характеристиками, является предметом тематического исследования. результаты, указывающие на величину и силу воздействия опасности на изменение экосистемы. После этого он будет поддерживать планирование социально-экономического развития в регионе исследований и сохранение разнообразия.

1. Introduction

1.1. Introduction

Hazards are influenced by four factors: time, space, society type, and event type. Hazards have reportedly caused the extinction of civilization in certain circumstances, while they have also allegedly inspired advancements and created cultures that are more resilient. Our contemporary culture shouldn't be seduced by technology and globalization in the face of ecosystem change since these factors may end up being more causes of susceptibility than of prevention and mitigation. Transformations are usually expensive [7].

The expansion of human society has improved social well-being and economic prosperity, but these benefits have come at a growing ecological cost, as shown by the deterioration of ecosystems and habitats [4] and have made people more susceptible to environmental hazards. The deltaic habitats present additional challenges to human well-being due to significant exposure to numerous environmental and social risks, in addition to the rapid deterioration of natural ecosystems and habitat loss brought on by intensive human activities ([6]; [9]).

Natural ecosystem degradation and growing risks from climate change are putting deltas' long-term viability in threat. As a result, it is essential for ecosystem conservation and climate adaptation to prioritize the placement of green infrastructure (GI) in space [8]. There is no organized way to take the level of vulnerability and danger into account in the deltaic regions' current GI priority processes.

When an ecosystem is determined to be relevant for the provision of a regulating ecosystem function, it is crucial to understand what ecosystem components are essential. Using forests as an example, controlling water flows is associated with ecosystem services that are positively correlated with biomass and forest quality ([2], [6]). Forest habitat fragmentation threatens biodiversity and, as a result, the supply of related ecosystem services [1].

It is essential information to identify which ecosystem services should be managed or changed in order to operationalize and preserve the conservation value. Individual ecosystem services for managing and conserving biodiversity are produced by ecosystems themselves over the course of their existence. This method comprises assisting in the long-term decision-making process for investments that are focused on natural ecosystems, land and ecosystem management, and strategic land use planning. Combining data on hazards and how they affect ecosystem change to support targeted conservation and restoration initiatives meant to keep or enhance the delivery of ecosystem services that regulate human activity [3].

1.2. Research area

About 130 kilometers from Vinh City, Pumat National Park is located in three districts of Anh Son, Con Cuong Tuong Duong, in the Western Nghean Biosphere Reserve. The Pumat

National Park, formerly known as the Pumat National Reserve, is made up of 194,804 hectares. 100,000ha of that are in the buffer zone and 94,804 ha are in the core zone. Pumat National Park contains 2,500 plant species from 160 groups and about 1,000 animal species. Additionally, it safeguards rare and untamed genetic sources.

Purpose of the research

Indicate the impact of hazards (erosion and landslide) on ecosystem change in the research area

Contents of the research:

- Create maps of landslides and erosion in the study area;
- Create a change matrix and an ecosystem change map for the research area for the years 2010 to 2020;
- Assessing the effect of hazards on ecosystem change in the research area.

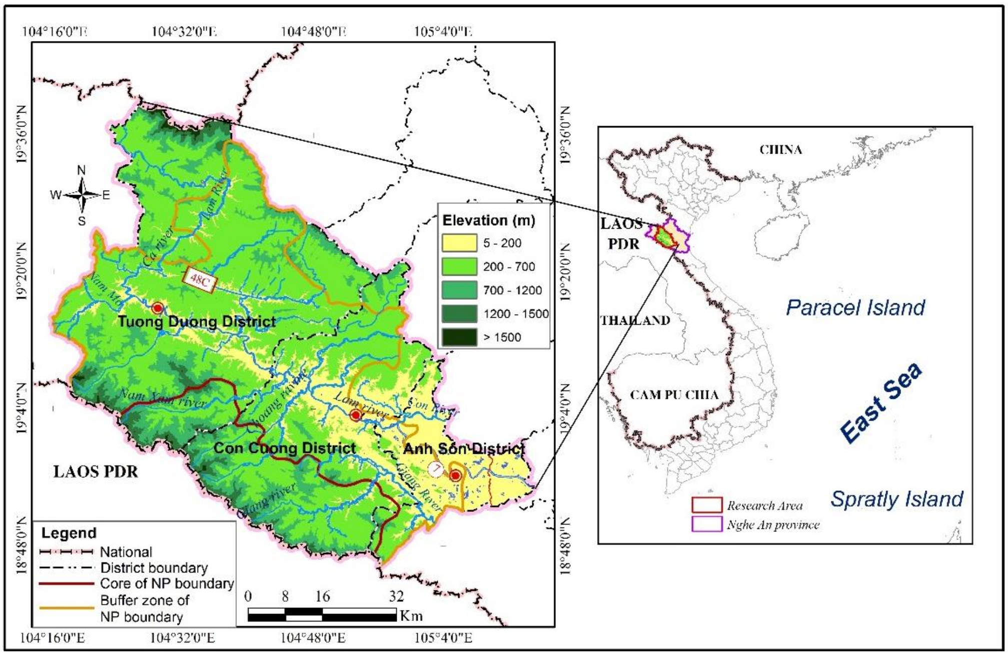


Figure 1. Map of the research area

2. Material and Methods

2.1. Material

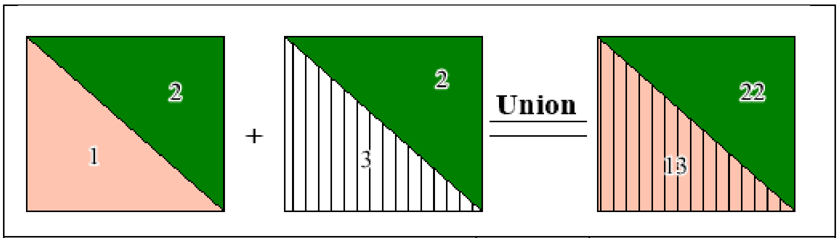
The following input maps were used to create the erosion map: R = rainfall-runoff erosivity factor;K = soil erodibility factor; L = slope length factor; S = slope steepness factor; C = cover-management factor; P = support practice factor.

Elevation, Aspect, Slope, Lineament(Fault), StreamDensity, Rock, Landuse Landcover, Soil, Max Precipitation are the variables used in landslide input maps. Maps used as input for landslide maps The digital elevation model (DEM) is used to interpolate height, slope direction, and slope; Rock types and fault density are interpolated from the fault system on the 1:50,000 scale geological map of the study region; The topographic map of the research area at a scale of 1:50,000 is used to interpolate the river and stream system, and the current map of land use and forest status is used to synthesize the cover. The soil types are taken from the General Department of Land's 1:50,000 scale land map; The eco-climate map in the research area is merged with the Max precipitation that is extrapolated from meteorological station data.

The input maps for the ecosystem change map and change matrix between the ecosystems in 2010 and 2020 are the ecosystem maps from 2010 and 2020. These input maps were gathered from the districts of the research area's Department of Resources and Environment.

2.2. Methods

Making an ecosystem change map from the 2010 and 2020 data using ArcGIS 10.5's overlay tool. To accomplish this, a tool called union can be applied.



INPUT		OUTPUT
- *Ecosystem map in 2010* - *Ecosystem map in 2020*	**Union**	- Ecosystem change map.

Figure 2. Translation method of creating landscape ecology map Union Tool

Soil erosion modulus was calculated by using the revised universal soil loss equation (RUSLE) [5].

$$A = \underline{R} * \underline{K} * \underline{LS} * \underline{C} * \underline{P} \qquad (1)$$

Where

A = estimated average soil loss in tons per acre per year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

L = slope length factor

S = slope steepness factor

C = cover-management factor

P = support practice factor

AHP-based weight calculations are used to build a land-slide map using a mix of input data. These components are Elevation, Aspect, Slope, Lineament(Fault), StreamDensity, Rock, Landuse landcover, Soil, Max precipitation

*Landslide = "Elevation.tif" * 0.020 + "Aspect.tif" * 0.021 + "slope3.tif" * 0.036 + "Faults_Density.tif" * 0.152 + "RiverDensity.tif" * 0.035 + "Rock.tif" * 0.144 + "LULC.tif" * 0.067 + "Soil.tif" * 0.097 + "Rainfall4.tif" * 0.158 (2)*

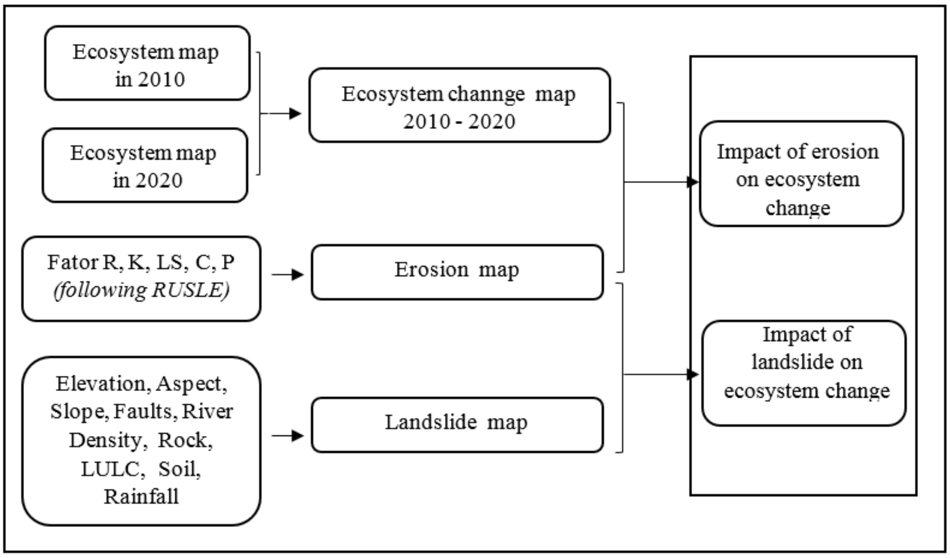


Figure 3. Outline of the methodology in the paper

3. Results and Discussion

3.1. Ecosystem change

Pu Mat National Park's ecosystem is diverse in both type and distribution, with seven distinct ecosystems including evergreen broadleaf forest, mixed bamboo and wood ecosystem, planted forest ecosystem, glade ecosystem, shrubs, agricultural ecosystem, and aquatic ecosystem.

Table 1: Matrix of cosystem change in the area of Pumat National Park

	1	2	3	4	5	6	7	**Tổng**
1	212739,61	2174,66	2559,74	31050,22	603,16	5605,82	601,81	***255335,02***
2	9219,14	5218,91	1178,04	1081,16	9,65	252,12	0,87	***16959,89***
3	3170,08	706,68	19434,12	4647,46	18,91	2764,24	66,44	***30807,93***
4	482,85	84,63	112,22	3119,39	11,56	1421,07	276,25	***5507,97***
5	27842,32	419,53	4558,02	95829,32	3085,27	36340,13	2561,58	***170636,17***
6	2376,90	65,74	641,49	9478,20	431,83	19008,88	321,25	***32324,29***

7	7,41	0,23	1,76	28,54	0,19	66,46	2824,18	***2928,77***
Total	***255838,31***	***8670,38***	***28485,39***	***145234,29***	***4160,57***	***65458,72***	***6652,38***	**514500,04**

(Note: 1) The evergreen broadleaf forest ecosystem, 2) The mixed bamboo and wood ecosystem, 3) The bamboo ecosystem, 4) The planted forest ecosystem, 5) The shrub ecosystem, 6) The agricultural ecosystem, and 7) The aquatic ecosystem.

The evergreen broadleaf forest ecosystem's area hasn't altered much; 83.32% of it (or 212739.61 hectares) is still in existence. 2559.4 hectares, or 12.16 percent, underwent conversion to a mixed-bamboo and wooded ecosystem. In spite of a rate of barely 1%, the evergreen broadleaf forest ecosystem had minor alterations in ecosystems 2, 5, 6, and 7 between 2010 and 2020.

Between 2010 and 2020, the mixed bamboo and wood ecosystem saw a considerable amount of change, with only 30.77% (or 5218.91 ha) of its original area remaining. An ecosystem of evergreen broadleaf forests was created on up to 54.36% of the area, or 9219,141 ha. The ecosystem of mixed bamboo and wood was also changed into ecosystems 3 and 4, at a rate of around 6.5%, and into ecosystems 5, 6, and 7, at a rate of just about 1.5%.

The bamboo ecosystem had significant fluctuations from 2010 to 2020, with only 63.08% of its original area (or 19434.12 hectares) remaining. Up to 15.09% of the land area (4647.46 ha) was converted to a planted forest ecosystem. The evergreen broadleaf forest ecosystem (10.29%, or 3170.08 ha), followed by the agroecosystem (8.97%, or 2764.24 ha), is the next significant area of change. Additionally, the mixed bamboo and wood ecosystem is transformed into ecosystems 2 (2.29%, or 706.68 hectares), and ecosystems 5 and 7 with a minor amount of less than 1%.

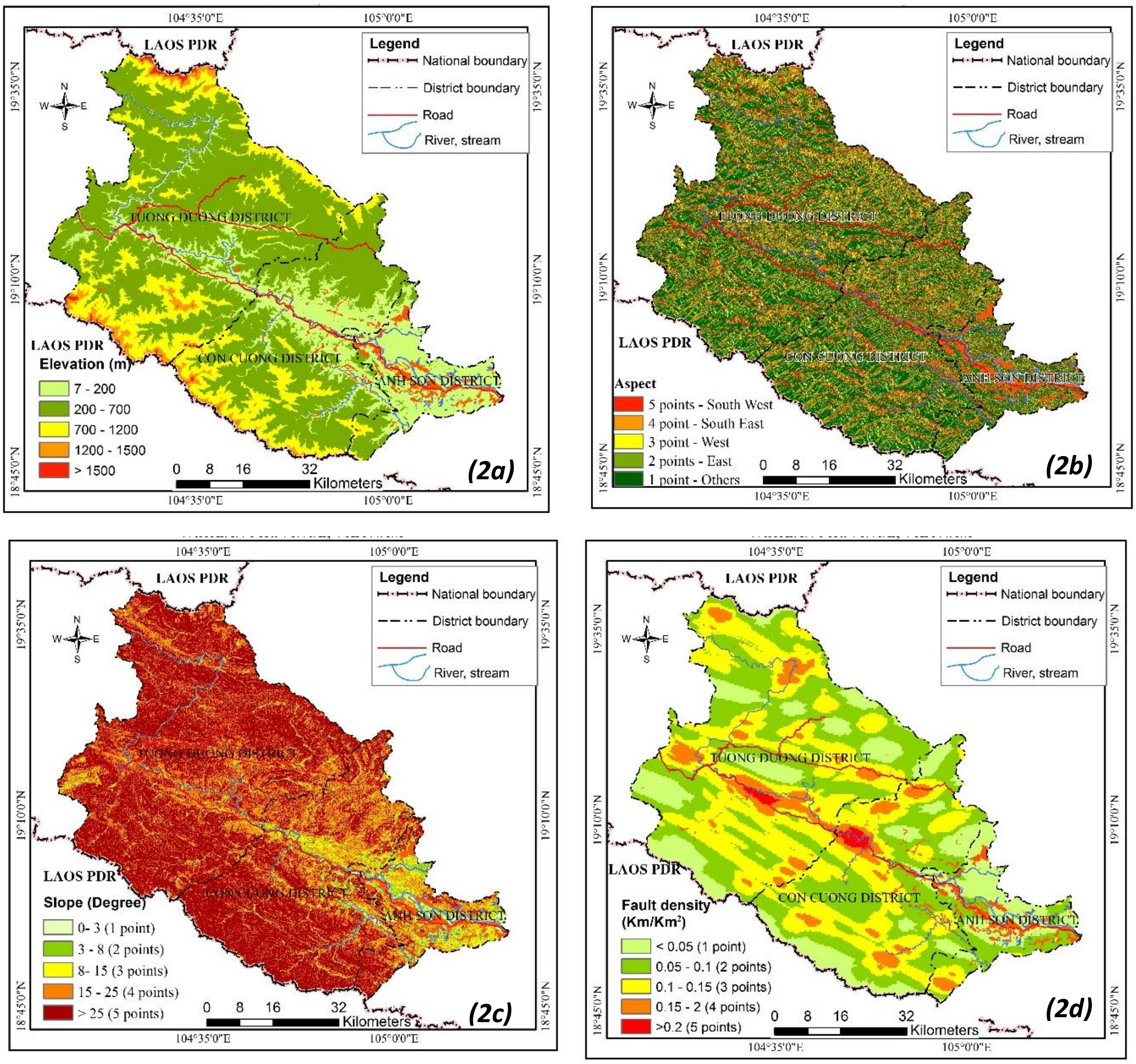
Between 2010 and 2020, the ecosystem of grasses and shrubs had considerable oscillations as a result of the conversion of land to plantations (56.16%, or 95829.32 ha), an evergreen broadleaf forest ecosystem (with 16.32%, or 27842.32 ha), and an agro-ecosystem (with 21.30%, or 2561.58 ha). During the computation period, just 1.50 ha of this type of ecosystem's area stayed constant. The difference between one ecosystem and the one above is too great since in the first half of 2010, space for this type of ecosystem was created as a result of logging, temporary deforestation, or new planting, so is still regarded as a shrubland. This means that by 2020, when the existing ecosystem replaces the temporary one, a considerable change will have taken place.

Between 2010 and 2020, the agro-ecosystem saw major changes, with just 58.81% of the total area remaining in the same status (corresponding to 19008.88ha). With planted forests covering 29.32% of the area, this ecosystem suffered major change (corresponding to 9478.20ha). According to the estimations, the area of agro-ecosystems today comprises 7.35 percent evergreen broad-leaved forest ecosystem. The research indicates that this transformation is the antithesis of ecological succession. Depending on the input data, different classification techniques and generalization rates are used for these items (forest status, land use status).

3.2. Landslide distribution

3.2.1. Landslide distribution map and its component map

Nine landslide component maps have been produced on the basis of an analysis of the features, functions, and effects of components impacting landslides in the research area. These maps include elevation, aspect, slope, fault density, river density, petrology, rock, soil, and maximum rainfall.



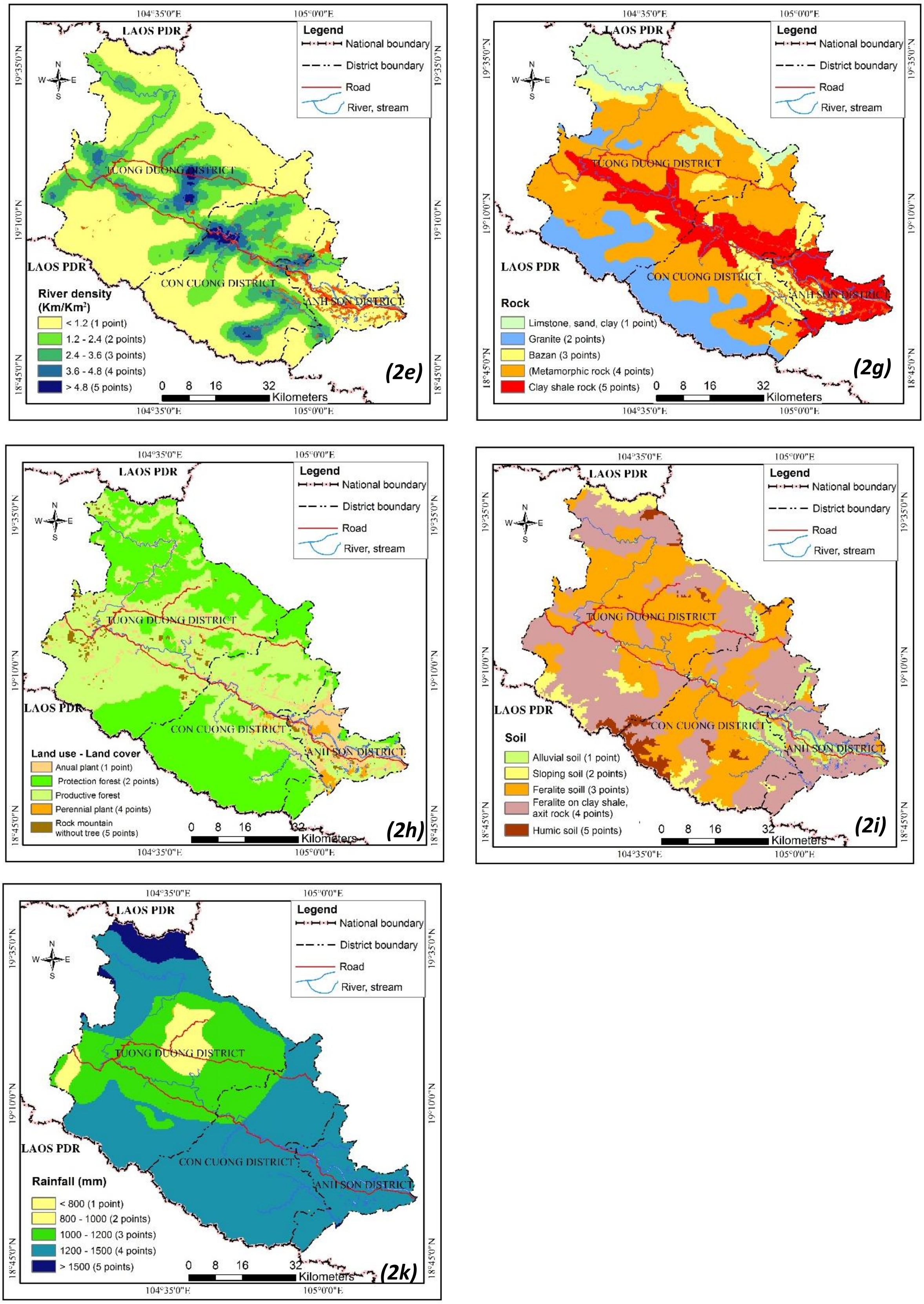

(2e)
LAOS PDR
TUONG DUONG DISTRICT
CON CUONG DISTRICT
ANH SON DISTRICT
Legend
National boundary
District boundary
Road
River, stream
River density (Km/Km2)
< 1.2 (1 point)
1.2 - 2.4 (2 points)
2.4 - 3.6 (3 points)
3.6 - 4.8 (4 points)
> 4.8 (5 points)
0 8 16 32 Kilometers
104°35'0"E
105°0'0"E
19°35'0"N
19°10'0"N
18°45'0"N
(2g)
Rock
Limstone, sand, clay (1 point)
Granite (2 points)
Bazan (3 points)
(Metamorphic rock (4 points)
Clay shale rock (5 points)
(2h)
Land use - Land cover
Anual plant (1 point)
Protection forest (2 points)
Productive forest
Perennial plant (4 points)
Rock mountain without tree (5 points)
(2i)
Soil
Alluvial soil (1 point)
Sloping soil (2 points)
Feralite soill (3 points)
Feralite on clay shale, axit rock (4 points)
Humic soil (5 points)
(2k)
Rainfall (mm)
< 800 (1 point)
800 - 1000 (2 points)
1000 - 1200 (3 points)
1200 - 1500 (4 points)
> 1500 (5 points)

Figure 2: Component maps for landslide map in the research area

(2a: Elevation ; 2b: Aspect; 2c: Slope; 2d: Faults density; 2e: Rivers density; 2g: Landuse – Land cover; 2h: Soil; 2k: Max Rainfall)

Then, The weights of the contributing components for the landslide process in the research area should then be calculated using these data along with the AHP approach.

Table 2: Weight of component effected on landslide calculated by AHP method

	1	2	3	4	5	6	7	8	9	Weight
1		1	1/9	1/8	1/2	1/7	1/4	1/6	1/7	0.020
2			1/8	1/9	1/2	1/8	1/4	1/5	1/7	0.021
3				3	7	3	5	4	2	0.036
4					3	1	3	2	1	0.152
5						1/4	1/3	1/4	1/5	0.035
6							2	2	1	0.144
7								1/2	1/2	0.067
8									1/2	0.097
9										0.158

1	*Elevation*	6	*Rock*
2	*Aspect*	7	*Landuse – Land cover*
3	*Slope*	8	*Soil*
4	*Faults density*	9	*Max Rainfall*
5	*Rivers density*		

Landslide map at Pu Mat National Park are categorized into 5 levels: Very High, High, Medium, Low, and Very Low. This map is made up of the nice elements in equation 1.

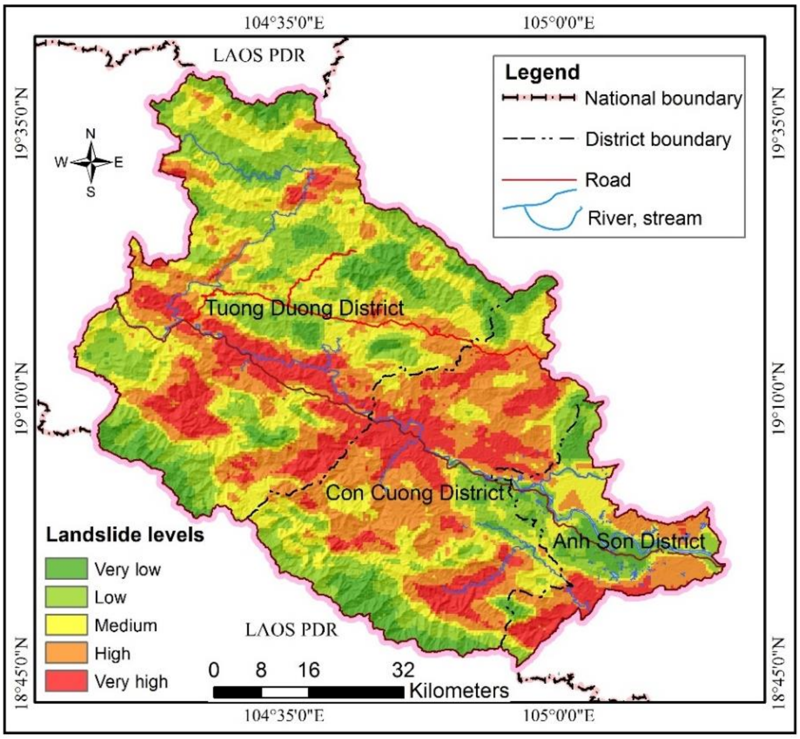


Figure 3: Landslide map in the research area

According to the map above, valleys near rivers, major roads, and highways are where landslides occur most frequently. In mountainous and hilly places where production forests and agroforestry types are created, landslides also happen. Low landslides are found in places with special-use forests and protection forests, which are mostly found in the core and buffer zones of the National Park as well as locations with a relatively high elevation.

3.2.2. Relationship between ecosystem change and landslide levels

The connection between the rate of landslides and ecosystem change can be seen when the landslide map and the ecosystem change map are combined (Figure 4).

The transition to a bamboo ecosystem, which had a mean erosion value of 2.31, was responsible for the evergreen broadleaf forest ecosystem (1). Average landslide level values over 2 are also present for transitions 11, 12, 14, 16, and 17. The transitional value between this ecosystem and the shrub ecosystem is 1.97, which is the lowest value.

The transition from the mixed-wood and bamboo forest ecosystem (2) to the plantation and bamboo forest ecosystem has significant landslide level values, 2.36 and 2.35, respectively. The remaining conversions have values ranging from 2.21 to 2.29 and 2.26 for 21, 22, and 26, respectively; 25 has the lowest value at 2.01.

The change from a bamboo ecosystem (3) to a mixed wood and bamboo forest ecosystem was responsible for the greatest mean landslide value, 2.45. Other conversions have values between 2.30 and 2.31, including 31, 33, 34, and 36. Transformation 37 has a mean landslide value of 2.19, which is less.

The transformation of 42,43,44 has a high value of landslide severity, corresponding to 2.42, 2.48, and 2.41, for the plantation forest ecosystem (4). Smaller values, 2.39, 2.29, and 1.97, respectively, are present in the remaining conversions 41 and 46.47.

The changes 51, 52, 53, 54, 56, and 57 for the shrub ecosystem (5) have landslide magnitude values that range from 2.19 to 2.27. This ecosystem's unconverted area is located in a region with a lower landslide magnitude value of 1.95.

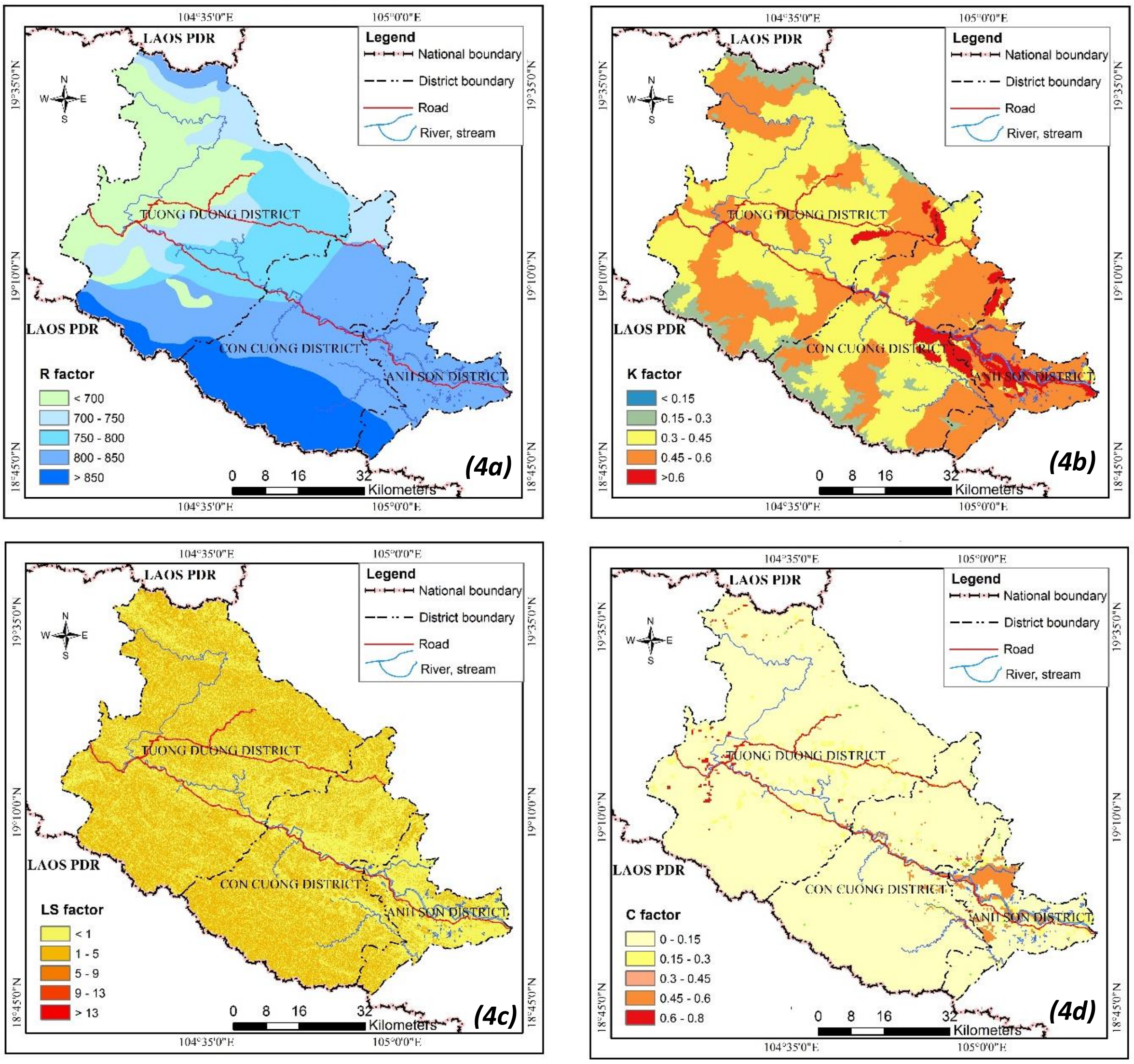
The 63 and 64 transition for agricultural ecosystems (6) has a higher mean landslide value of 2.33 and 2.30. The average landslide magnitude in the transition between 61, 62, 66, and 67 is between 2.14 and 2.28. The least valuable transformation is 65, with a value of 1.99.

Figure 4: The connection between ecological change and landslide levels

3.3. Erosion distribution

3.3.1. Erosion distribution map and its component map

Five erosion component maps have been created using the RULSE equation and an investigation of the characteristics, purposes, and outcomes of the components that affect erosion in the study area. These maps comprise rainfall-runoff erosivity factor (R), soil erodibility factor (K); slope length factor (L); slope steepness factor (S); cover-management factor (C) and support practice factor (P).



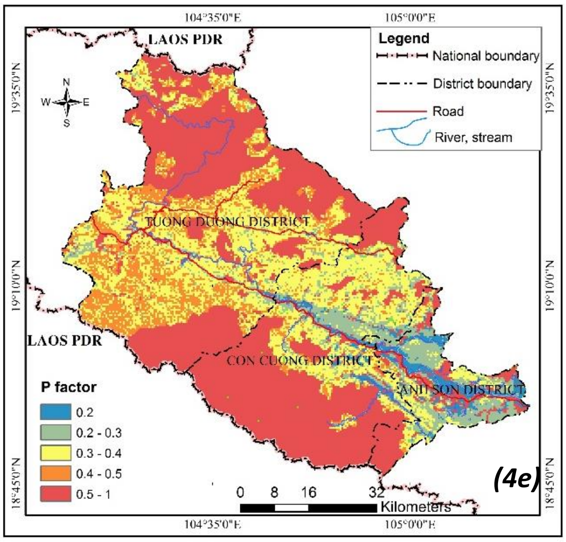


Figure 5: Component maps for landslide map in the research area

Erosion maps at Pu Mat National Park and its component maps are categorized into 5 levels: Very High, High, Medium, Low, and Very Low. This map is made up of the five elements in equation 2.

Based on the findings of the soil erosion map shown above, it is clear that only a small portion of the study area, specifically in the rocky areas northeast of the study area and along the Con River in the core zone of the National Park (Con Cuong and Anh Son districts), perspectives high levels of erosion. Most mountainous and hilly terrain have areas with moderate erosion; these areas are found where there is a steep slope or where perennial trees have grown in the research area. Low, extremely low erosion is seen in the remaining valleys and low slopes around the Con river and highway 7.

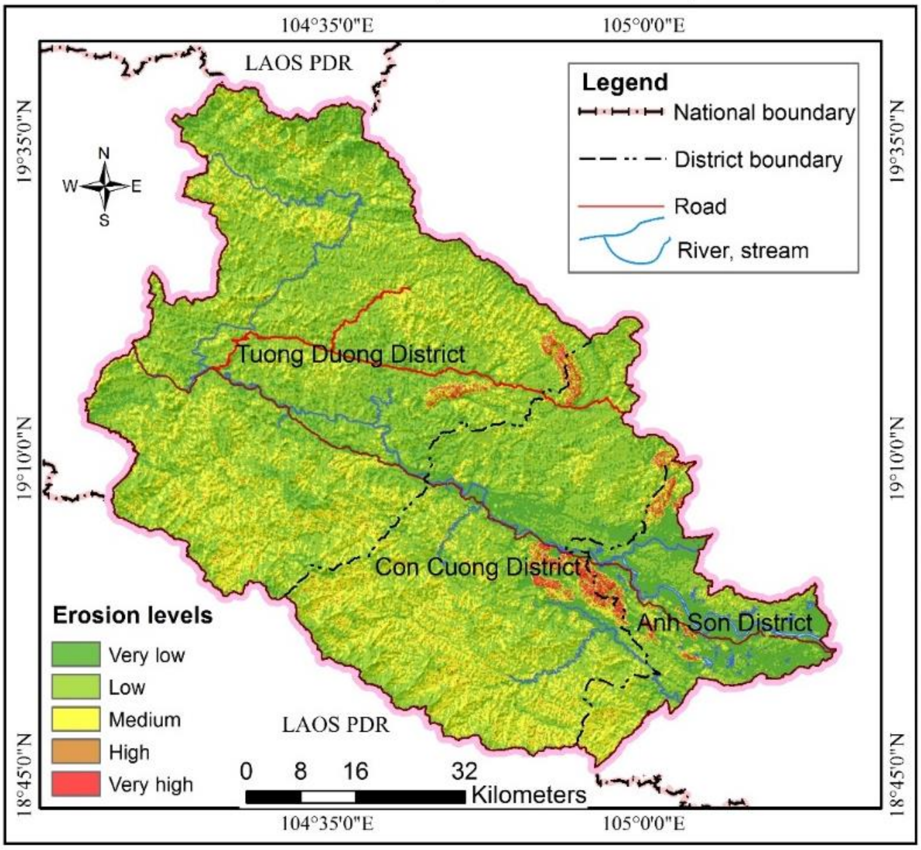
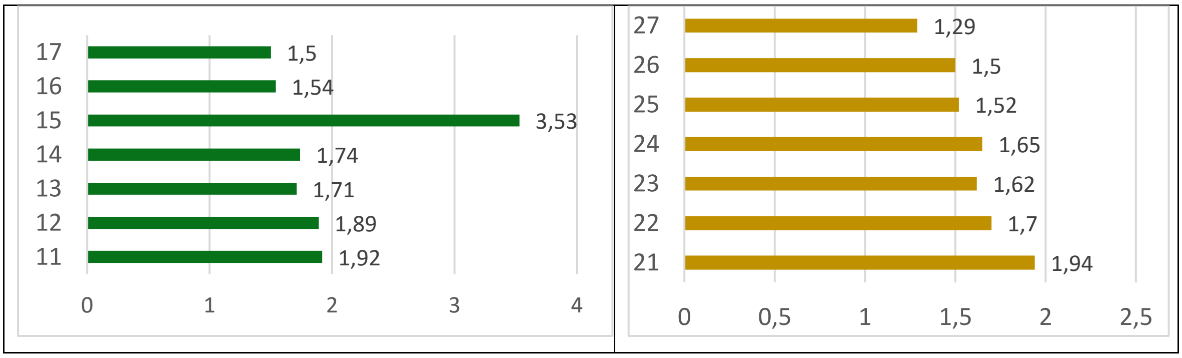
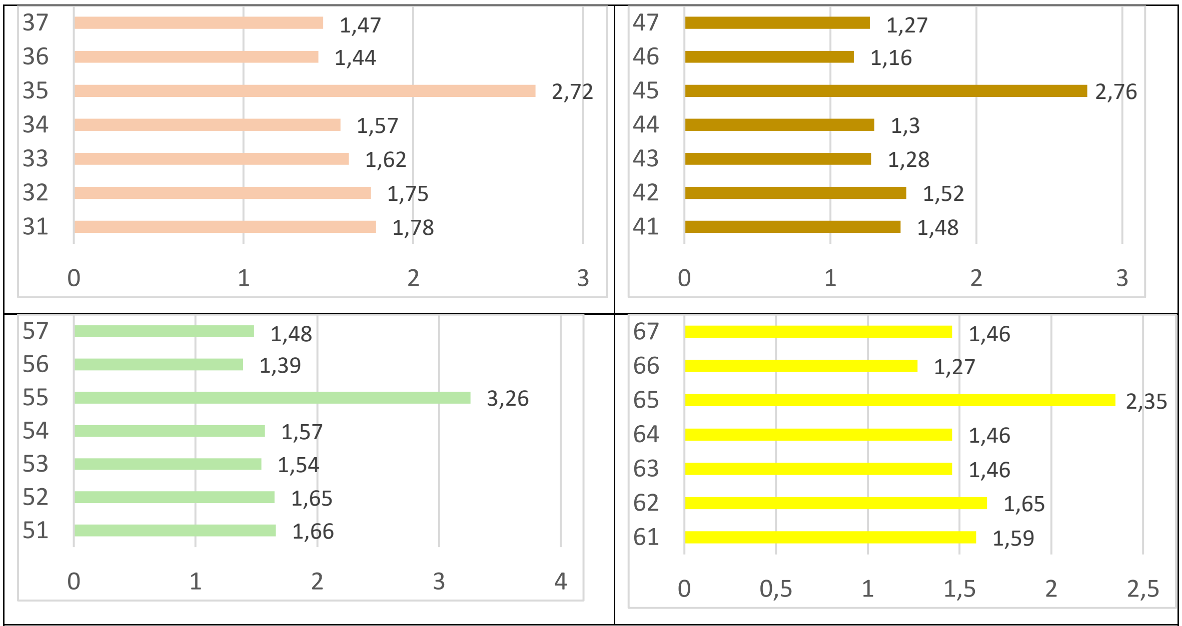


Figure 6: Erosrion map in the research area

3.3.2. Relationship between ecosystem change and erosion levels

Combining the soil erosion map and the ecosystem change map reveals a relationship between the rate of erosion and ecosystem change (Figure 6). With an average score of 3.53, the transition from the evergreen broadleaf ecosystem to the grassland and shrub ecosystem is situated in the area with the greatest risk of landslides. The following ecosystems differ on the lower landslide area: 11, 12, which correlate to 1.92 and 1.89; 13, 14, which corresponds to 1.71 and 1.74; and 16, 17, which relates to 1.54 and 1.5.





Note: 1) The evergreen broadleaf forest ecosytem, 2) The mixed bamboo and wood ecosystem, 3) The bamboo ecosystem, 4) The planted forest ecosystem, 5) The shrub ecosystem, 6) The agricultural ecosystem, and 7) The aquatic ecosystem.

Figure 7: Relationship between ecosystem change and erosion level

For the mixed ecosystem of wood and bamboo (2), the variation in erosion level is less than 2, and the erosion effect average values for variations 21, 22, 23, and 24 range from 1.94 to 1.65. Variations 25 and 26 and 27 have erosion effect everage values that range from 1.52 to 1.29.

The transition from the bamboo ecosystem (3) to the shrub ecosystem (5), which is situated in a region with a high landslide risk, has an average value of 2.72. The remaining variations 31, 32, 33, and 34 have an average erosion level value ranging from 1.78 to 1.57; variations 36 and 37 have an erosion level value less than 1.5.

The planted forest ecosystem (4) to scrub ecosystem (5), which is also situated in a region with a high landslide risk, has an average value of 2.76. The subsequent modifications (the transformation of ecosystem 4 into ecosystems 2, 3, , 6, and 7) have erosion values that range from 1.52 to 1.27 on average.

The unaltered area for shrub ecosystems (5) is situated on the high erosion risk area with an average value of 3.26. The remaining alterations (ecosystem 5 transformed into ecosystems 1, 2, 3, 4, 6, and 7) had an erosion value on average that was the same, 1.66 to 1.39.

The transition from an agricultural ecosystem (6) to a shrub ecosystem (5), which is similarly situated in a region with a high risk of landslides, has an average score of 2.35. The average erosion value ranges from 1.65 to 1.27 for the remaining transitions (ecosystem 1 becoming ecosystems 1, 2, 3, 4, and 7).

Conclusion

Numerous factors that impact natural, social, and environmental characteristics cause ecosystem changes. However, natural hazards, particularly landslides and soil erosion, can cause large-scale variations in the research area. The article's research findings are centered on delineating each connection and effect of this natural hazard on ecosystem fluctuations with regard to seven ecosystem units. Through the volatility matrix and the ecosystem change map for the years 2010 to 2020, the distribution of ecological fluctuations is made more concrete. By doing so, it is feasible to comprehend the extent and scope of ecosystem changes in the research area. GIS technology and the AHP approach were used to construct the landslide map from 9 component maps (elevation, slope, slope direction, fault density, density of rivers and streams, petrology, mantle, soil, maximum rainfall). The RULSE formula was used to construct the soil erosion map from 5 component indices (R, K, LS, C, P). The results illustrate the connection between these hazards and ecological changes, combine ecosystem changes, landslide maps, and erosion maps. From a scientific and practical standpoint, these studies are essential for the planning of the conservation of biodiversity in the research area and prudent resource use.

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