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Landscape assessment - a comprehensive approach to conservation on Phu Quoc island, Vietnam

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Abstract This study delves into the theoretical foundations of landscape science, examining its intrinsic relationship with natural resource management and conservation efforts. It underscores the role of the landscape as a fundamental unit of analysis and intervention, formed through the dynamic interaction of geographical, climatic, and ecological factors. However, in recent decades, landscapes have undergone profound transformations, driven by both natural environmental changes and intensified human activities. These changes have significantly impacted landscape quality, posing substantial risks to ecological integrity and cultural heritage. Phu Quoc Island, the largest island located in the Gulf of Thailand, exemplifies these challenges as it experiences rapid urbanization and economic development. Such processes have led to the degradation of both natural and cultural landscapes, heightening the urgency for comprehensive conservation strategies. In this context, a weighted comprehensive evaluation method was employed to classify and assess the landscape units across Phu Quoc Island using a robust set of 16 criteria. The findings of the study reveal notable spatial disparities in conservation levels. Certain areas, due to their exceptional biodiversity and ecological value, require stringent protection measures to mitigate the risks of degradation. Conversely, other areas, which exhibit medium to low conservation levels, reflect the consequences of ongoing human-induced activities and developmental pressures. To address these findings, the study presents a detailed spatial distribution of conservation levels, providing a clear and systematic framework for identifying priority areas for intervention. This spatial assessment serves as a critical foundation for formulating targeted and sustainable management strategies. The proposed measures aim to reconcile economic development with environmental preservation, safeguarding the ecological integrity, biodiversity, and cultural significance of Phu Quoc Island for future generations. By advancing the understanding of landscape assessment methodologies and their applications, this research contributes to the broader discourse on sustainable landscape management and conservation. It highlights the need for integrated, evidence-based approaches to balance development with preservation in rapidly urbanizing regions, offering insights that are applicable not only to Phu Quoc Island but also to similar landscapes facing comparable challenges globally.

Keywords: natural resource management, natural resources, landscape units, cultural landscapes

1. Introduction

The division of the Earth's surface leads to the formation of the theory of territorial differentiation laws of the geographical crust; the landscape is identified as a basic unit on the basis of the unity of zonal and azonal differentiation laws (A.G., Ixatsenko, 1969). The landscape is understood as a homogeneous natural territorial complex in terms of origin, dynamically interconnected and regularly repeated in space by geological, topographical, and climatic components. The landscape can also be understood as a separate origin of any regional unit, characterized by homogeneity in zonal and azonal aspects, with its own structural and morphological composition (A.G, Ixatrenko, 1985). Alternatively, the landscape is a geographical entity, differentiated within a plain zone and a high belt in mountainous areas, with a vertically integrated structure of geological foundation, topographical type, climatic type, hydrological type, soil complex, and vegetation complex and includes a regular set of geographical forms and smaller structural units in a homogeneous horizontal structure (Lap, 1976). Although landscapes can be understood in many different ways, landscape is a unified geographical entity in terms of vertical structure and is homogeneous in terms of the horizontal structure of inorganic and organic components, and each landscape unit is a complete ecosystem that can be repeated in space (Figure 1). In each landscape unit, there coexist components related to the solid material foundation (soil, rock) and the thermal–moisture foundation (rivers, streams, forests, grasslands), which are closely interconnected, and each element plays an essential role in the entire ecosystem.

The landscape has a high degree of complexity in terms of its ecological structure and function as well as its dynamic behavior (Valentín et al., 2014). The complex differentiation of landscape-forming components creates ecological niche

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diversity within the landscape structure, generating biodiversity. However, the landscape is constantly changing due to natural (lawful) and human (abrupt) impacts.

When one of the landscape components is impacted, it will change the structure, function, and properties of the landscape, altering biodiversity. This explains why the main purpose of landscape research is to support the rational use of natural resources, conservation, and sustainable development. In reality, landscape characteristics affect ecological processes and species distributions, especially in fragmented landscapes, where landscape structure is related to the resilience of ecosystems to environmental changes, including climate change and economic development pressures (Metzger et al., 2009).

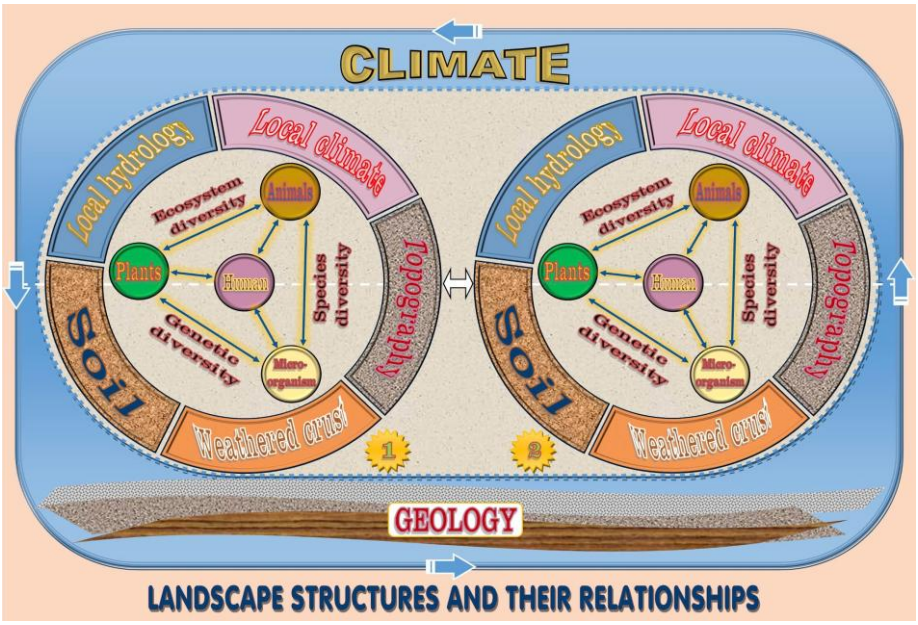

Figure 1 Landscape structures.

Landscape assessment is based on landscape units. These units contain the full characteristics of landscape components (ecological, social, economic) (Rogers et al., 2012). Landscape assessment serves not only as a process to understand and evaluate the complex picture of the environment in which humans live but also as an integrated approach that combines ecological sustainability, community needs, and strategic planning. Landscape assessment is the process of determining the suitability between the subject and the object of the assessment, where the subject is the landscape unit and the object is the selected entity. Landscape assessment is the process of evaluating the characteristics, values, and potential of a landscape. This process typically includes analyzing the visual, ecological, cultural, and functional aspects of a specific area to understand its current state and future management needs. This assessment can be used for various purposes, most commonly land use planning, conservation, development, and tourism. Among these, landscape assessment for conservation is highly regarded in the context of increasing climate change and ecosystem degradation. The difference between landscape assessment for conservation and regular landscape assessment lies in the values that need to be preserved and maintained when they are selected for evaluation. Landscape assessment for conservation includes evaluating ecological, social, and economic factors in a specific geographical area to enhance biodiversity and ecosystem services. The main factors considered in landscape assessment for conservation include the following: (1) Ecological value: Assessing biodiversity and ecosystems in the area, including endemic plant and animal species, as well as the ecological services they provide (Filyushkina et al., 2022) (Willis et al., 2012); (2) Ecological connectivity: Assessing the connectivity between ecological areas for wildlife, helping maintain species transfer and mating (Braaker et al., 2014) (Kirk et al., 2023); (3) Human impact: Assessing the influence of economic activities such as agriculture, tourism and urban development on the natural landscape, thereby proposing measures to mitigate negative impacts (An, 2024) (Pham et al., 2014); and (4) Resilience and adaptability: Assessing the resilience of ecosystems to environmental changes, including climate change and economic development pressures (Baho et al., 2017) (Dakos & Kéfi, 2022) (Liu et al., 2014). In this study, our landscape assessment is approached through a comprehensive scientific approach to allow for more informed decisions on conservation initiatives on the basis of the assessment results of landscape components and their relationships. Additionally, landscape assessment for conservation is an important task in human efforts to protect the environment agains the increasing challenges of climate change and urbanization. Through landscape assessment, we gain a better understanding of soil quality, ecological corridors for organisms, and the impact of human economic development activities. This approach is also important for evaluating the interactions between organisms and the environment, habitat disturbance and biodiversity (Palang et al., 2007). With the accelerating pace of climate change, some habitats may migrate or transform. Proactive landscape assessments will help predict these changes and plan adaptive measures, thereby ensuring that

ecosystems remain resilient under changing conditions. Therefore, landscape assessment for conservation goes beyond merely analyzing natural factors; it requires an integrated approach that acknowledges the complex interactions among ecology, society and culture. By fostering this multidimensional vision, we can truly aim to conserve our planet.

Conversely, the success of conservation and natural restoration activities heavily depends on the landscape context, as the processes that create and maintain restored areas are influenced by ecological and cultural dynamics on a larger landscape scale (Naveh, 2006). From a comprehensive perspective, biodiversity information is linked with agricultural and forestry activities and cannot be separated from landscapes (Schroth et al., 2004). Furthermore, studies aimed at researching the potential for biodiversity conservation from a landscape perspective, as well as discussing the benefits related to biodiversity, can increase the support of individuals and communities in conservation policies, highlighting some political, socioeconomic and ecological pressures on biodiversity (Schroth et al., 2004). Engaging local communities in this process is crucial, as they often possess invaluable traditional knowledge about the local landscape and sustainable resource use. The combination of local wisdom and modern scientific methods enriches landscape assessment while promoting community participation in conservation initiatives. Moreover, it is important to view the landscape as both a physical space and a place of cultural and spiritual significance. For example, sacred landscapes hold special meaning for certain communities, indicating that their protection goes beyond ecological considerations.

Phu Quoc is the largest island in an archipelago of 14 small islands (Figure 2). Phu Quoc Island is located in the Gulf of Thailand, approximately 40 km west of mainland Vietnam. The island is undergoing a significant transformation with impressive development and urbanization. From pristine land with beautiful beaches and rich ecosystems, the Phu Quoc has become an international-class economic, commercial and tourism center. This transformation involves not only building modern infrastructure but also reshaping the cultural identity and living environment of its residents. However, this development is not smooth, especially when facing environmental challenges. The rapid development of infrastructure and construction projects has increased pressure on Phu Quoc's natural ecosystem. Many areas that were once mangrove forests, home to many rare plant and animal species, have now been encroached upon for urbanization projects. Flooding due to river and stream encroachment is one of the severe consequences of uncontrolled development. This not only degrades the living environment but also affects the lives of residents. Additionally, climate change and rising sea levels have had noticeable impacts on the island known as Vietnam's Pearl Island.

Figure 2 Study area map.

The objective of this study is to conduct a comprehensive landscape assessment to evaluate the ecological, cultural, and socio-economic characteristics of Phu Quoc Island for the purpose of conservation and sustainable development. Through a scientific and integrated approach, this study aims to identify and classify landscape units, assess their current conservation values, and propose strategies to mitigate human impacts while enhancing biodiversity and ecosystem resilience. The findings

of this research are expected to provide critical insights into the landscape dynamics of Phu Quoc Island. By integrating scientific methodologies with local knowledge, this study aims to inform policy decisions and propose practical measures to preserve the island's ecological integrity, cultural identity, and socio-economic potential in the face of growing development pressures and environmental changes.

2. Data and Research Methods

The weighted scoring landscape assessment method is used to determine the level of conservation needed. This method reflects the nature of the assessment process, which involves the relationship between the subject and the object. The natural and social conditions of Phu Quoc Island, the assessment subject, are considered and selected, while the assessment object is the conservation target used to determine the level of conservation needed (high, medium, low) for the natural and social conditions of Phu Quoc Island. This method is implemented through the 4-step process presented in Table 1.

Table 1 Process for landscape assessment for conservation on Phu Quoc Island.

	Steps	Description
Step 1	Establish a 1/50,000-scale landscape map of Phu Quoc Island	The 1/50,000 scale landscape map of Phu Quoc Island is established based on the integration of geographical component maps of the same scale: topographic map, geomorphological map, soil map, and vegetation map. The integration of geographical component maps is completed based on cartographic and GIS technology. The landscape layerification system of Phu Quoc Island includes 6 levels: landscape system, sublandscape system, landscape layer, landscape type, landscape genus, and landscape category. Among them, the landscape category is the basic unit selected for landscape assessment for conservation on Phu Quoc Island.
Step 2	Select and rank assessment criteria	Determining specific criteria for each level is essential, with quantitative characteristics to compare assessment results. To ensure accurate determination of each level's indicators, assessment criteria are selected based on the combination of Phu Quoc Island's actual conditions and the research results of Rita et al. (2017). In this study, 16 criteria were selected to evaluate the landscape for conservation on Phu Quoc Island. Each criterion is divided into 03 levels with specific parameters (table 2), corresponding to assessment scores of 3, 2, and 1 points. These criteria are compared with the natural and social conditions of Phu Quoc Island to initially determine the scores of each landscape type for conservation. Alternatively, this step can be understood as determining the scores of the natural and social conditions of Phu Quoc Island for conservation purposes. This serves as the basis for determining the overall assessment score.
Step 3	Carry out a comprehensive assessment using a weighted scoring	Determining the weights (W) of the assessment criteria is also very important in this research step. In reality, each criterion identified in step 2 will have different significance and importance for conservation on Phu Quoc Island. The weights of each criterion in this study are determined by the expert method. Criteria that play a very important role in conservation are assigned a weight of 3. Criteria that play a less important role are assigned weights of 2 and 1. The overall assessment results in this study use the method of summing individual assessment scores: $Dt = X_1W_1 + X_2W_2 + ...+ X_nW_n$ Where: Dt: Total assessment score $X_{1...n}$: Individual assessment scores of factors 1 to n $W_{1...n}$: Weights of factors 1 to n
Step 4	Classify conservation levels	To rank the conservation levels based on the landscape assessment results, the Natural Break method is used. $\delta = \frac{Dx - Dm}{n}$ Where: δ: Distance between the levels Dx: Maximum total assessment score Dm: Minimum total assessment score n: Number of assessment levels

The weighted comprehensive evaluation method has the advantage of being relatively objective and easy to implement, allowing for a quick and comprehensive assessment of territorial potential through quantified values.

3. Results and Discussion

3.1. Landscape characteristics of Phu Quoc Island

Phu Quoc Island is located in the tropical monsoon landscape system. Phu Quoc Island is situated in the Gulf of Thailand, guarding the southwestern part of Vietnam's territory, 115 km from Rach Gia and 46 km from Ha Tien, forming a subsystem of

tropical monsoon–humid marine landscapes. The strong differentiation of geology and topography combined with the impact of hydrological factors on climatic conditions has differentiated the landscape of Phu Quoc Island into 2 landscape layers, 3 landscape types, 9 landscape genera and 36 landscape categories (Figure 3).

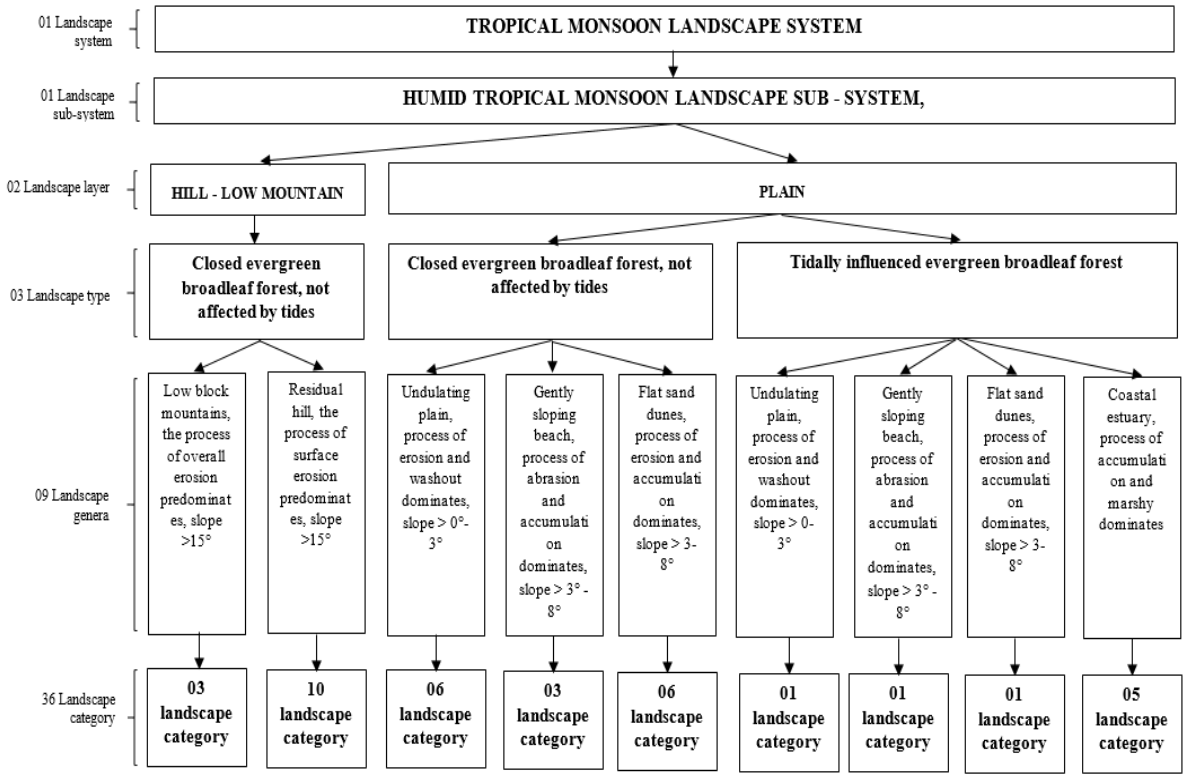

Figure 3 Landscape verification system of Phu Quoc Island.

The low hill-mountain landscape layer accounts for 70% of the island's total area, including 01 landscape types, 2 landscape genera and 13 landscape categories, which are distributed mainly in East China and partly in North China and South China. These landscapes are formed by sedimentary rocks such as sandstone, siltstone, and conglomerate, with a gentle dip toward the southwest. They feature narrow ridge surfaces extending along the mountain ridge, often exposing bedrock or covered with a thin layer of gravel. Gravity slopes are distributed in the high parts of the low mountain terrain surrounding the ridge surfaces, with fairly steep slopes > 30°, exposing bedrock or covered with gravelly sand material. Erosion-wash slopes are very common on the western slopes of residual hills, with slopes > 8° composed of gravelly materials. The accumulation slopes are not commonly distributed, with some foot slopes from Bai Vong to Vo Huong, with slopes ranging from 8–15°, which are composed of 1–2 m thick gravel. Currently, these landscape units are not affected by tides and are covered by evergreen broadleaf forests in Phu Quoc National Park and shrub grasslands. Some landscapes have been exploited for settlement development and agricultural production (Figure 4).

The plain landscape layer occupies the remaining area of the island, including 2 landscape types, 07 landscape genera, and 23 landscape categories concentrated in the west and southwest of the island, with some being scattered in the south. These landscapes are formed by Quaternary sediments aged from Q12--3 to Q2. They feature marine terraces of the third level, 20–30 m high, gently sloping, wavy, distributed in wide strips, composed of dark yellow, reddish–yellow sand and gravel (4–5 m thick); second-level marine terraces with fairly wide surfaces, composed of pebbles, gravel mixed with gray clay; and first-level marine terraces with gentle slopes, composed of light gray sand mixed with a little clay, kaolin clay. Erosion-accumulation beaches, such as Sao Beach, Thom Beach, Ganh Dau Beach, Rach Tram Beach, etc.,, are widely distributed across the island and cover the bedrock surface with thin gravel and sand. Flats and wavy dunes are distributed along the southern coast of the island and are altered by human activities. Swamps are distributed at river mouths such as Cua Cai Lap, Ham Ninh, Rach Tram, and Cua Cạn; lagoon formation is due to the strong development of marine formations, and wind-formed barriers outside river mouths create waterlogged depressions that accumulate silt and organic matter. Although these landscapes are still affected by tides, owing to scientific and technological advancements, many areas have been converted for urban and agricultural development, while some small areas retain coastal shrublands, grasslands and mangrove forests (Figure 4).

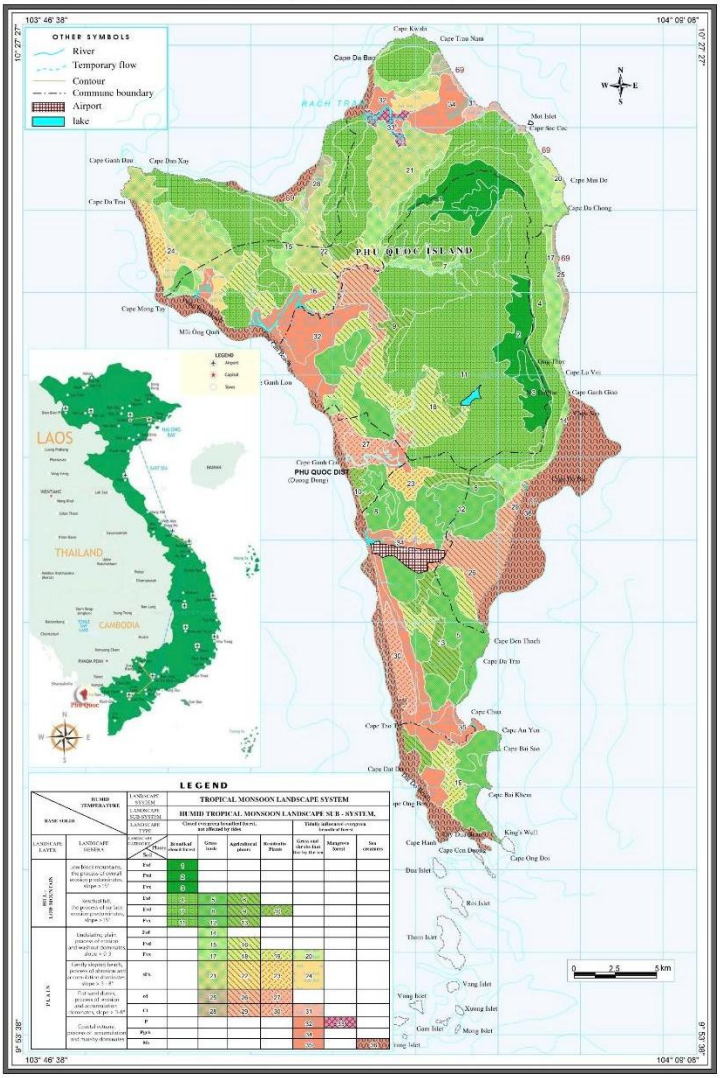

Figure 4 Landscape map of Phu Quoc Island.

3.2. Landscape assessment for conservation on Phu Quoc Island

Each landscape unit contains comprehensive data on biodiversity, land use, and socioeconomic factors. Therefore, landscape assessment is a comprehensive approach to conservation. The results of the landscape assessment serve as the basis for identifying key areas for conservation, restoration, and sustainable use by considering the connectivity between ecosystems and human activities. However, to ensure the reliability of the assessment results, the criteria selected for landscape assessment are crucial, especially in the effort to conserve natural areas, particularly on Phu Quoc Island, which is undergoing rapid urbanization. The main goal of conservation on Phu Quoc Island is to preserve biodiversity and sociocultural values. On the basis of the characteristics of each landscape unit on Phu Quoc Island and referencing the conservation criteria of El-Hajj Rita et al. (2017), we selected 16 assessment criteria. These criteria are used to determine the conservation levels of different landscape units, highlighting areas of high, medium, and low conservation needs. However, the discussion of the article's results presents an insufficient theoretical framework, which suggests a lack of theoretical basis and impairs the credibility of the argument presented. A robust discussion should situate the study's results in the context of previous work, comparing and contrasting the findings with existing literature on landscape science and conservation practices. This comparison helps validate the significance of the results, highlight similarities or discrepancies with prior studies, and contribute to advancing theoretical understanding in the field. Without such a foundation, the discussion risks appearing incomplete and disconnected from broader academic discourse. To address this issue, future studies should include a more extensive engagement with the theoretical frameworks of landscape assessment and conservation science. By situating findings within a broader academic context, researchers can better articulate how their results contribute to existing knowledge and guide practical applications for conservation management. This approach not only strengthens the validity of the conclusions but also provides a clearer understanding of the ecological and socio-economic implications of landscape assessment in rapidly urbanizing regions like Phu Quoc Island.

Table 2 Criteria for Landscape Assessment for Conservation.

No	Criteria	Description
1	Diversity of Habitats and Species	Diversity of habitats and species refers to the richness and variety of different types of habitats (living environments) and species (plants and animals) within a landscape unit. Species diversity is the presence of many different species within the same ecological community, including differences within populations of a species and populations of different species. This criterion estimates the impact of habitat loss, degradation and fragmentation on biodiversity conservation.
2	Rarity of Habitats and Species	The rarity of habitats and species refers to the limited distribution of species or ecosystems within landscape units. Rare species may only appear in isolated geographic areas. The habitats of rare species often have stringent conditions for survival and development; ecosystems such as mangroves and coral reefs are typical examples of rich habitats that can become rare due to environmental changes. This criterion relates to species diversity and abundance. It helps determine the integrity and suitability of habitats for species.
3	Replaceability or Irreplaceability	Replaceability in nature refers to biological resources that can be replaced or restored over time, usually at a rate fast enough for humans to continue using them. For example, water, plants and animals can regenerate if properly managed. Conversely, irreplaceability occurs with resources that regenerate very slowly or cannot be regenerated, such as minerals or fossil fuels. This criterion is a comprehensive measure of species dependence on conservation areas, calculated from the distribution overlap of each species within and outside conservation boundaries.
4	Endemism/Rarity	Endemic species are those that naturally occur in a specific geographic area with limited distribution. Endemic plants and animals, with high vulnerability due to small populations, are key components of ecosystems and serve as indicators when assessing the health of a territory. Endemism or rarity refers to species with limited distribution, often existing only in a specific geographic area. Endemic species often arise due to geographic isolation, leading to the distinct development of these species in characteristic habitats.
5	Habitat Space	Habitat is the part of the environment surrounding an organism where environmental factors directly or indirectly affect its growth, development and activities. Habitat space is the area where organisms (plants, animals, humans) exist and interact with each other; it is the living space that provides all natural resources and is subject to human impacts from production and living activities. It includes physical, chemical and biological factors that can directly or indirectly affect the life, growth and development of species.
6	Typicality	Used to describe common characteristics that can represent a group of landscapes with the same nature, rules and prominent features, making it easier to recognize and understand this group of landscapes.
7	Unique Representativeness	Related to the special, distinct and unique characteristics of a landscape; representativeness often does not depend on time and space, allowing the assessment of unique features in various cases.
8	Spatial Connectivity	Refers to the ability to create interactive environments such as corridors and belts to optimize connectivity between landscapes.
9	Wildlife Stock Potential	To assess the ability and extent to which wildlife can exist and be exploited within a certain space.
10	Vegetation Structure	Refers to how plants within a landscape unit are arranged and distributed by height and canopy. Vegetation often has multiple layers, each with its own coverage and characteristics, such as tall trees, shrubs and ground vegetation. Additionally, vegetation structure relates to assessing the integrity of plants within each landscape unit.
11	Conservation Status	Refers to the ability of a landscape unit to exist in nature and assesses the risk of its loss in the future.
12	Ecological Integrity	To evaluate whether a landscape unit can maintain multiple species, provide suitable living spaces and contribute to the resilience and maintenance of the entire ecosystem. Ecological integrity also refers to the undivided and undiminished state of the ecosystem within each landscape unit.
13	Threats and Human Interference	Often related to harmful human actions toward each landscape unit. These actions can create risks of resource degradation within each landscape unit.
14	Vulnerability	The tendency of natural systems to be negatively affected by climate change, natural disasters, or other catastrophes; is reflected in the level of resource loss or degradation and the resilience, recovery and response capacity of each landscape unit.
15	Biodiversity Value	Includes economic value, educational value, utility value and scientific value. Used to indicate the value and richness of genes, species and ecosystems within each landscape unit.
16	Accessibility	The ways in which communities and stakeholders can participate in the natural conservation process; include ensuring representation, full and effective participation of the socioeconomic sector to achieve biodiversity conservation and sustainable development goals.

Source: El-Hajj Rita et al.

3.2.1. The assessment results show the following:

Landscape units 1, 2 and 3 belong to the low mountain block landscape genus, with dominant erosion processes; landscape units 4, 7 and 11 belong to the residual hill landscape genus, with dominant surface erosion processes; and landscape units 33 and 36 belong to the coastal estuary landscape genus, with dominant swamp accumulation processes, identified as having high conservation levels (strict protection areas). These landscapes are part of the core area of Phu Quoc National Park and coastal mangrove forests, with high biodiversity. These landscapes are home to 1,164 vascular plant species and 490 animal species, including 12 endemic plant species, such as Croton phuquocensis Groiz, Phyllanthus phuquocianus Beille, Trigonostemon phuquocensis Gogn, Salavia quocensis Tard, Aglaia phuquocensis Pierre, Xinenia americana Willd, Archidendron queens Pierre, Dioxylum Cyrtophylum miqvar quocensis, Tarenna queens Pierre, Xamtonnea quocas Pierre, Connarus Semidecandras Jack and Hedyotis quocensis Pierre, and 09 endangered forest plant and animal species listed in the Vietnam Red Book, such as Pinus echinata, agarwood, Dalbergia tonkinensis, Diospyros mun, Nageia fleury, and Cycas pectinata. Additionally, this area is the main habitat for blue crabs, coral reefs and seagrass beds. Therefore, strict protection of these landscape units is essential to preserve their integrity, authenticity and natural environment. This creates the best conditions for the conservation and development of endemic plant and animal species, as well as the characteristic ecosystems of Phu Quoc Island. Moreover, their landscape service values are the foundation for developing a green economy and green growth on the island. These landscape units also act as green lungs, geochemical barriers, carbon storage, water storage for renewable energy, clean energy, wind energy and solar energy on southwestern islands.

Landscape units No. 5, 8 and 12 belong to the low mountain landscape category, where the comprehensive erosion process predominates; landscape units No. 14, 15, 17 and 20 belong to the gently sloping plain landscape category, where the erosion process predominates; landscape units No. 21 and 24 belong to the gently sloping beach landscape category, where the accumulation erosion process predominates; landscape units No. 25, 28 and 31 belong to the flat, undulating dune landscape category, where the wind erosion process predominates; and landscape units No. 32, 34 and 35 belong to the coastal estuary landscape category, where the marsh accumulation process predominates, are evaluated to have a medium conservation level (restoration and conservation area). These landscapes are often found in high terrain, with steep slopes and relatively strong fragmentation, and are located in the buffer zone of Phu Quoc National Park and the estuary area. Although the vegetation here mainly consists of shrubland (myrtle) and grass (beach morning glory), with coastal shrubs (pineapple, casuarina) having low biodiversity, if managed and conserved properly, they will form natural corridors that help protect and mitigate negative impacts on sensitive areas that need strict protection. Additionally, these landscapes are destinations for beach tourism activities due to the attractive beauty of beaches such as Sao Beach, Dai Beach, Khem Beach, Ong Lang Beach, Ganh Dau Beach, etc. These beaches are formed from fine, pristine white sand, attracting millions of tourists each year for sightseeing and relaxing. Although there are many economic benefits from tourism development, it also creates significant environmental pressure, such as an increase in tourism waste on beaches. Therefore, to achieve sustainable development for the tourism industry and maintain the brand of beaches, protecting these landscapes is essential.

Landscape units No. 6, 9, 10 and 13 belong to the residual hill landscape category, where the surface erosion process predominates; landscape units No. 16, 18 and 19 belong to the gently sloping, undulating landscape category, where the erosion process predominates; landscape units No. 22 and 23 belong to the gently sloping beach landscape category, where the accumulation erosion process predominates; and landscape units No. 29 and 30 belong to the flat, undulating dune landscape category, where the wind erosion process predominates, are identified to have a low conservation level. These landscape types not only constitute the habitat of Phu Quoc residents but are also covered by crops such as pepper and various fruit trees such as coconut and custard apple. Although biodiversity here is not high, this area contains a rich culture and history with many unique elements, typical of tangible heritage as well as intangible values such as customs, festivals, language and traditional art forms. With a long development history, they have become the residences of different ethnic groups, such as Khmer, Cham and Vietnamese, creating notable cultural exchanges among ethnic groups. The distinctive cultural features related to the sea and agricultural production in the Phu Quoc have created uniqueness in terms of tourism and local economic development. For this reason, these landscape types need to be reasonably conserved to maintain the national cultural identity while creating a rich living environment for generations.

4. Discussion

The results of this study highlight significant insights into landscape conservation. Strict protection areas, particularly within Phu Quoc National Park, underscore the importance of preserving biodiversity hotspots. This finding aligns with El-Hajj Rita et al. (2017), emphasizing the necessity of conserving rare endemic species, such as Croton phuquocensis and Pinus echinata, which are critical to global biodiversity. Additionally, the ecological value of carbon storage and renewable energy potential in these areas reinforces the argument for prioritizing their conservation, as supported by Schroth et al. (2013).

Medium-priority areas, often located in buffer zones, provide essential natural corridors that enhance ecosystem connectivity. This is consistent with Metzger et al. (2009), who documented the delayed effects of connectivity loss on biodiversity. However, these areas also face challenges from tourism and urbanization, requiring proper management to balance development and conservation. The economic and aesthetic value of such landscapes is notable, particularly in tourism, but waste management concerns, as noted by Gómez-Sanz et al. (2014), highlight the need for sustainable practices.

Low-priority areas, while less significant in terms of biodiversity, hold substantial cultural and historical value. These landscapes reflect the heritage of ethnic groups such as Khmer and Cham, showcasing unique cultural identities crucial for national identity. This aligns with Palang et al. (2007), who advocate for the inclusion of cultural landscapes in conservation planning. Leveraging these areas for sustainable agro-tourism initiatives complements the integrated conservation and production models proposed by Liu et al. (2014).

The study contributes to advancing theoretical frameworks in landscape conservation by situating the findings within broader academic contexts. The weighted scoring method provides a replicable framework for rapidly urbanizing regions, addressing gaps in quantitative methodologies noted by Dakos and Kéfi (2022). Furthermore, the spatial distribution of conservation levels offers practical insights for policymakers, enabling targeted interventions. For instance, strict protection areas can serve as core conservation zones, as recommended by Willis et al. (2012), while medium-priority areas can enhance ecological networks to improve resilience.

5. Conclusion

The discussion underscores the interconnectedness of ecological, cultural, and socio-economic factors in landscape conservation. By grounding the findings in established theories and previous research, the study offers a credible and comprehensive perspective on sustainable management strategies for Phu Quoc Island.

Ethical Consideration

This study strictly adhered to ethical research practices. The research design ensured no adverse impact on the environment, culture, or society of Phu Quoc Island. The data collection and analysis processes respected local communities, their traditions, and ecological integrity. Stakeholder participation was conducted with full consent and transparency, aligning with ethical guidelines in conservation and landscape management research.

Conflict of Interest

The authors declare that they have no conflict of interest regarding the publication of this article. All findings and recommendations presented in this research are independent and unbiased.

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