Habitat quality assessment in the Royal Belum rainforest, Malaysia using spatial analysis

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Abstract. Royal Belum rainforest contains various flora and fauna species, however, the assessment of habitat quality is still lacking. This study aims to develop the habitat quality zone in the Royal Belum rainforest. The downloaded Landsat 8 OLI/TIRS CI satellite images in the year 2020 from the United States Geological Survey (USGS) were processed using supervised classification and exported into vector data in ArcGis 10.8. Land use, normalized difference vegetation index (NDVI), buffer, and land structure were then analyzed. The result shows that the highest percentage and density of the land use of the Royal Belum rainforest is vegetation. Buffer zone analysis identifies the risky area for habitat in the range of 1km and 5km from the built-up area. The area within the buffer ring should be protected from building and construction to ensure habitat quality in that area can be maintained. This study will give a better understanding of land use and vegetation index assessment for future planning in the Royal Belum rainforest. Therefore, habitat quality assessment is an important tool that can help to identify areas of high-quality habitat that are crucial for the survival and reproduction of target species and to prioritize these areas for conservation and management.

1 Introduction

Habitat quality is a crucial indicator of the health and efficiency of ecosystem services [1]. Vegetation has a major role in the stabilization of habitat quality. The provision of numerous ecosystem services and products by vegetation is essential for adaptation to and the reduction of the effects of global climate change. It is crucial to have empirical information on the current situation of the vegetation using a variety of techniques. Spectral vegetation index data have been used to analyze how climate and vegetation interact at the landscape level, which is important for land management and the sustainable use of forest and other vegetation resources [2].

The Normalized Density Vegetation Index (NDVI) is a popular technique that aids in evaluating density in vegetation cover [3]. With the aid of remote sensing and geographic information systems (GIS), NDVI can evaluate the vegetation. The quality of a habitat, however, is determined by the proximity and intensity of human land usage [1]. In the unprotected regions surrounding many of the protected zones, land usage is increasing and becoming more intensive. Prioritizing the area for the conservation and maintenance of animal habitat and its ecosystem will be made easier with the aid of an assessment of the land use types, its surrounding zone, and its structure [4]. Therefore, this study aims to i) classify the land use land cover types ii) identify the habitat quality factor and iii) develop the habitat quality zone in the Royal Belum rainforest in the year 2020. The Royal Belum rainforest is a rainforest that has existed for more than 130 million years old and making it the oldest rainforest in the world even older than the Amazon rainforests. Belum rainforest size is estimated to be 15,200 hectares. There

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are many endangered animal species that live there such as the Malaysian sun bear, Asiatic elephant, and Malayan tapir. Belum rainforest is not only known as a home for plants and animals but also a home for orang asli or aboriginal people who have lived there for millions of years [5]. Belum rainforest was shortlisted as a UNESCO World Heritage site in 2019.

2 Methods

2.1 Study area

The Malaysian state of Perak is home to the Royal Belum rainforest, a protected region (Figure 1). It occupies a space of over 121,000 hectares and is located in Peninsular Malaysia's northern region. The park is well-known for its abundant biodiversity, which includes a wide range of plant and animal species, many of which are unique to the region. Several threatened and endangered species, such as the Malayan tiger, Asian elephant, and Malayan tapir, can be found in the Royal Belum rainforest. The forest is also well known for having a wide range of plants, including a number of indigenous tree species that are significant to the regional lumber industry [5].

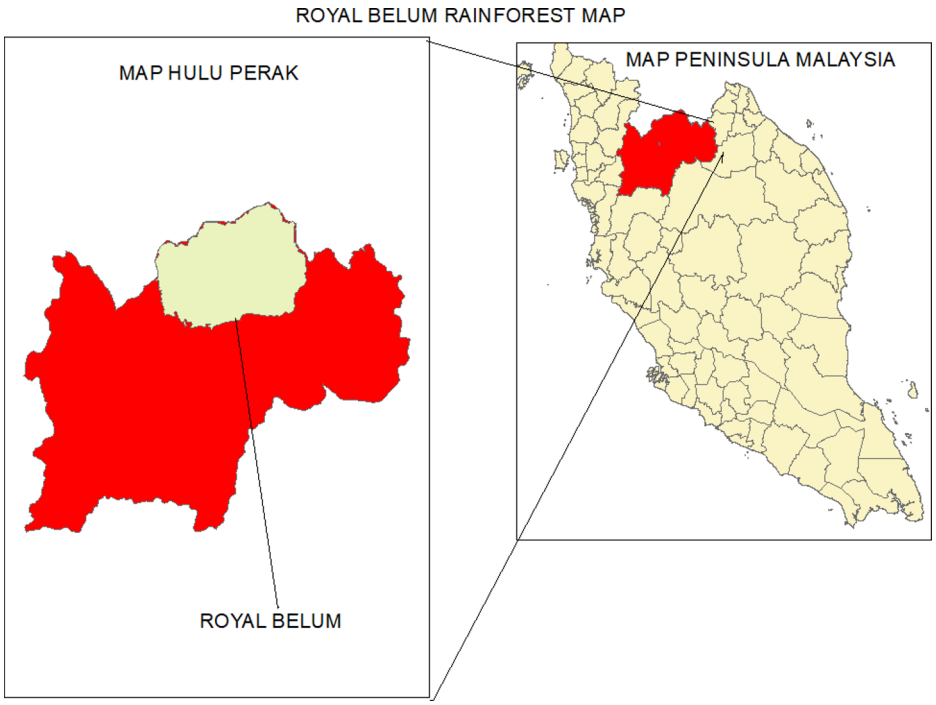

Fig. 1. Map of Royal Belum rainforest

2.2 Habitat Quality Factors

The type of land uses, NDVI, buffer analysis, and landscape structure analysis were used as habitat quality factors to determine the habitat quality level of the Royal Belum rainforest (Table 1). In order to identify the land use and land cover types, two Landsat 8 OLI/TIRS CI satellite images were downloaded from the United States Geological Survey (USGS). The land use/land cover types such as bare land, water bodies, vegetation, built-up areas, and agricultural land were classified using supervised classification in ArcGIS 10.8. NDVI analysis determines the vegetation density of the landscape. The dense vegetation creates a suitable habitat for wildlife and ecosystem. The percentage of area and edge density were determined by analyzing the landscape structure.

Table 1. Habitat quality factor

INPUT DATA	DESCRIPTION
Land use/land cover type	Land use classification of Royal Belum rainforest consist of five classes, water body vegetation, agriculture, built-up area, and bare land.
Vegetation density	Vegetation density refers to the amount of plant cover present in a given area. It is often measured as a percentage or a ratio, and can be determined by counting the number of individual plants or measuring the amount of foliage per unit area. Vegetation density can vary greatly depending on factors such as climate, soil type, and human activity. For example, a dense forest will have a high vegetation density, while a desert will have a low vegetation density.
Landscape metric	A landscape metric is a numerical assessment used to identify certain features of a landscape. Patch density is the quantity of patches in a given region. Patch size refers to the typical size of a patch in a landscape. Shape index: an indicator of how intricate patches' shapes. Degree to which several patches are connected to one another is known as connectivity. Diversity: the quantity of several kinds of patches in a landscape.
Buffer Zone	An area of land known as a "buffer zone" surrounds and borders a protected area, such as a national park or wildlife reserve, and is intended to shield it from the damaging effects of human activity. By establishing a zone of lower human activity around protected locations, buffer zones can be used to lessen the effects of human activity on those regions. They can also act as a transitional space between the protected area and the surrounding environment and offer extra wildlife habitat. In order to preserve or restore natural habitats, biodiversity, water supplies, and other ecological benefits, buffer zones are frequently managed.

2.3 Buffer Analysis for Habitat Quality Zoning

Buffer analysis is a technique used to locate and map areas of high-quality habitat. The size of the buffer zone is defined by the species' habitat needs and dispersing abilities. Buffer zones are typically circular areas with a fixed distance surrounding each occurrence. The study area's map is then overlaid with the buffer zones, and the overlapped areas are noted as areas of high-quality habitat.

2.4 Landscape Structure Analysis

Landscape structure analysis was calculated using FRAGSTAT software [6] at the patch level analysis. PLAND and ED were calculated in this analysis. The extension of Fragstat allows users to analyze changes in land use and land cover over time [7]. It can be used to detect, quantify, and analyze changes in patch-level patterns of land use and land cover. The software can be used to calculate a variety of landscape change metrics, such as changes in patch size, shape, and connectivity, as well as to produce maps and graphs that display the results of the analysis [6].

3 Results and discussion

3.1 Land Use Classification and Normalized Density Vegetation Index

Land use land cover percentage area shows that vegetation is the highest percentage of 89% followed by built-up area, waterbody, and agriculture (Table 2, Figure 2a). Normalize Density Vegetation Index (NDVI) measures the density and greenest of vegetation that includes near red infrared and red-light spectrum. NDVI values consist from -1 to 1, where the negative values are from water and snow then the value that is close to 0 indicates non-forest, and a value close to 1 indicates a tropical forest (Figure 2b and Figure 2c).

Table 2. The land use area and percentage of Royal Belum rainforest

Water Body		**Vegetation**		**Agriculture**		**Built-up area**		**Agriculture**	
Area	%	Area	%	Area	%	Area	%	Area	%
30405	1.975	1380489	89.689	3692	0.239	37035	2.406	91251	5.928

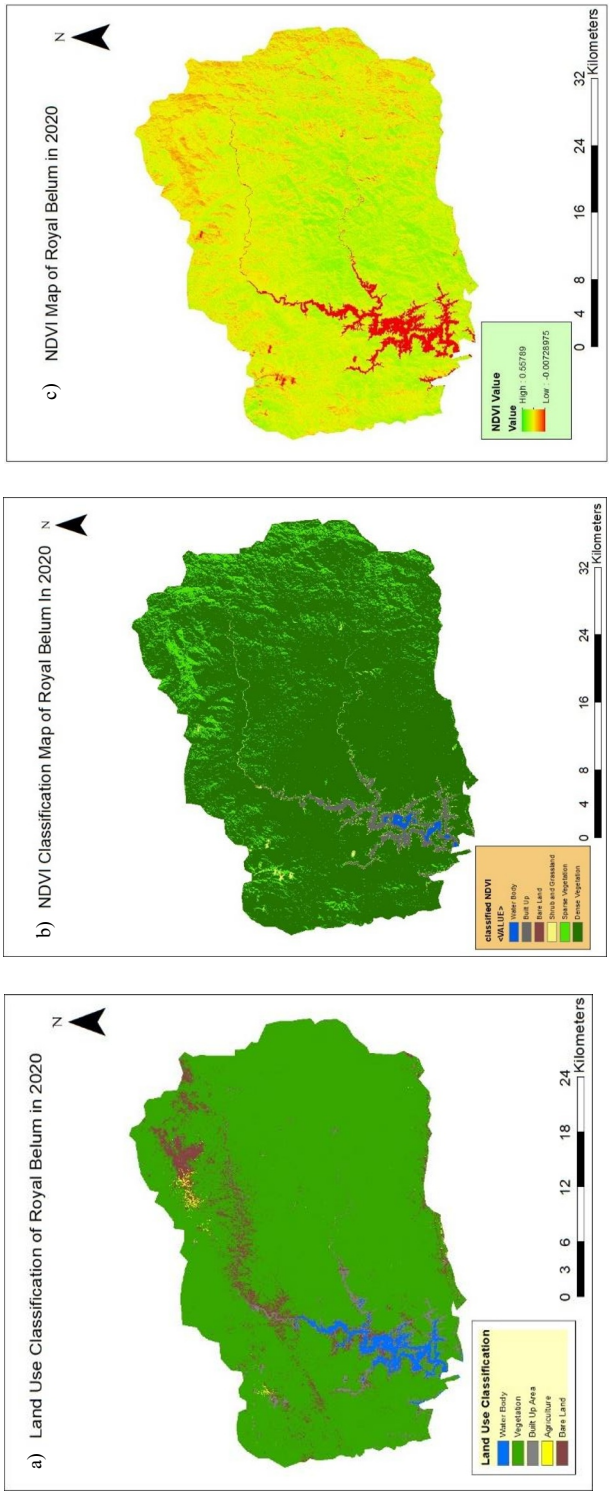

Fig. 2. a) Land use classification map of Royal Belum rainforest in 2020, b) NDVI classified map of Belum Rainforest in 2020 and c) NDVI (Normalize Density Vegetation Index) value Map of Belum Rainforest

3.2 Habitat quality zoning using buffer analysis

The buffer zone of 1km and 5 km was developed in the study area that focuses on the built-up area zone where inside the ring zone is the high-risk area for animals in Royal Belum rainforest. According to [8], a 1 km distance was considered to create buffer areas surrounding the built-up area in order to understand the impact of settlements on the wildlife habitat. Animals should avoid 1 kilometer from the built-up area because the built-up area has no proper ecosystem to support animal's needs such as food, water, and shelter [9]. Starvation and the risk of human conflict are high if animals roam around in that 1km- 5km zone. On the other hand, the 5km buffer zone of the built-up area is also important to see how crucial the zone is if the place becomes the habitat of various animals in the future. [9] found that 18% of forest decreased in the protected area of the 5 km zone. Therefore 1- 5 km buffer zone area is also important to protect and preserve wildlife habitat.

The 1 km zoning buffer can be used to create a protective zone around sensitive areas, such as wildlife habitats, wetlands, or cultural sites, to buffer them from negative impacts of human activities. This zoning buffer also can be used to guide land use planning and development by identifying areas that are suitable or not suitable for certain types of land use, such as urban development, agriculture, or resource extraction [10]. The 5km zoning buffer can be used to capture a larger scale of land use and land cover patterns that would not be captured by a smaller buffer size, providing a more comprehensive analysis of the area of interest. A 5 km zoning buffer also can be used to identify larger-scale impacts of human activities, such as urbanization or deforestation, on the surrounding environment and biodiversity (Figure 3).

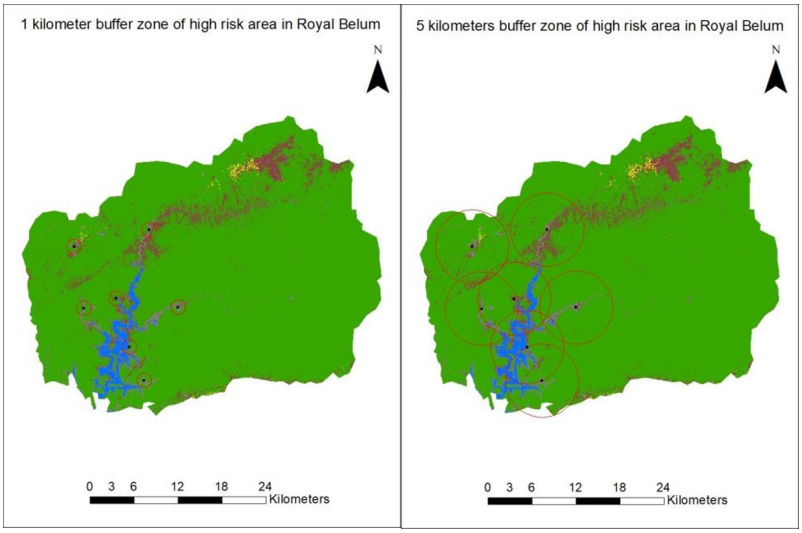

Fig 3. 1 km and 5 km buffer zone of high-risk area in Belum Rainforest

3.2 Landscape structure analysis

Landscape structure analysis shows that the highest percentage of the area is vegetation (89.4%). It is followed by bare land, built-up area, and waterbody with percentages of 5.9, 2.4, and 1.9 respectively. The lowest percentage of the area is agriculture with only 0.2 %. The ED (Edge Density) shows the two highest data which are vegetation and bare land with values of 34.3 and 33.9 respectively (Table 2). It is followed by a built-up area with a value of 11.5. The lowest edge density is waterbody and agriculture with values of 2.2 and 2.0 respectively. The more fragmented the terrain is, the higher the ED value, and the more connected the landscape is, the lower the ED value. The term "ED" (Edge Density) refers to a metric that quantifies the number of edges present in a landscape, more precisely the proportion between the length of all edges and the area of the landscape. Edge density is a measure of fragmentation since landscapes with high edge densities tend to be more fractured because they have a higher proportion of edges compared to core sections [11]. Edge density is frequently employed as a measure of habitat fragmentation and can be used to pinpoint regions that are especially susceptible to habitat degradation and loss. The entire edge length of a landscape is divided by the total area of the landscape to determine the ED measure. The outcome is a ratio that can be used to compare fragmentation across various landscapes or across time. Therefore, although the vegetation shows the highest percentage in the area, it has potentially fragmented and land management and conservation of the area is really important in order to protect the area for wildlife habitat and ecosystem.

Table 2. Landscape change matric of Land use classification

TYPE	PLAND	ED
Vegetation	89.4	34.3
Built-Up Area	2.4	11.5
Bare Land	5.9	33.9
Agriculture	0.2	2.0
Water Body	1.9	2.2

Note: PLAND (Percentage of Landscape); ED (Edge Density)

4 Conclusion

The result shows that the land use of Royal Belum rainforest is mostly covered by vegetation and water bodies. The NDVI map shows that the vegetation index is near value 1 indicating healthy vegetation. Buffer zone analysis identifies the risky area for habitat in the range of 1km and 5km from the built-up area. The area within the ring should be protected from building and construction to ensure habitat quality in that area can be maintained. The landscape structure analysis shows the edge density and landscape structure is dominated by vegetation at the patch level analysis. Habitat quality assessment is an important tool for conservation biology and landscape ecology that can help to identify areas of high-quality habitat that are crucial for the survival and reproduction of target species and to prioritize these areas for conservation and management. This study will be the indicator for future

planning by the government to avoid the deterioration of habitat quality in Royal Belum rainforest.

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