e-ISSN: 2637-0395

Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

Built Environment Journal 22(1) 2025, 29 - 42.

Built Environment Journal

GIS based Analytical Hierarchical Process for Ecotourism Site Suitability Assessment

Ainon Nisa Othman[1*], Muhammad Ajmal A'imullah Idris[1], Nurhanisah Hashim[1], Abdul Rauf Abdul Rasam[1], Akhbaarudin Abd Hamid[2]

[1]*School of Geomatic Science and Natural Resources, College of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[2]*Department of Survey and Mapping Pahang, Malaysia, Jalan Tengku Mohamed, Taman Pelindung Aman, 2505 Kuantan, Pahang*

ARTICLE INFO

Article history:
Received 17 March 2024
Revised 11 June 2024
Accepted 02 July 2024
Online first
Published 01 January 2024

Keywords:
Ecotourism
Geographical Information System (GIS)
Analytical Hierarchical Process (AHP)

DOI:
10.24191/bej.v22i1.1032

ABSTRACT

Ecotourism grounded in environmental conservation and cultural sensitivity and emerges as a powerful tool for promoting tourism while preserving natural and cultural heritage. Lipis district located in Pahang have faces challenges such as illegal logging, thus pushing the needs and necessitating strategic planning for ecotourism sites. The study aims to derive a site suitability map for ecotourism in Lipis district using Geographic Information System (GIS) and Analytic Hierarchy Process (AHP). The objectives are to identifying key criteria influencing site suitability, developing an ecotourism model using GIS (AHP), and analysing the suitability of existing ecotourism areas. The criteria used were land use, slope, elevation, roads and proximity to infrastructure, are validated through expert opinions and past studies. The AHP calculation were done and the scoring of the criteria based on expert's opinion. Results from the weightage shows the highest values are Land Use, Slope, Elevation, Roads and Infrastructure Proximity. The study concludes by developed a Site Suitability for Ecotourism Model (SSEM) and assessing existing ecotourism sites against the model. Results indicate that the SSEM successfully categorise areas into classes of suitability with Natural Breaks and Equal Interval classification. Overall, the district has a coverage of 9% Very High Suitability, 30% High Suitability, 33% Moderate Suitability, 22% Low Suitability, and 6% Not Suitable. Finally, the existing ecotourism sites in Lipis district align with the model's suitability classes, which mostly located around Very High Suitability and High Suitability rating area with a total value of 39% suitable area thus validating the effectiveness of the approach in site suitability assessment for ecotourism.

[1*] Corresponding author. *E-mail address*: ainonnisa6941@uitm.edu.my
https://doi.org/10.24191/bej.v22i1.1032

INTRODUCTION

Ecotourism has a strong connection with sustainable tourism. Ecotourism is a type of tourism that involves visiting natural areas, such as forests, mountains, and wildlife reserves, with a focus on experiencing and learning about the environment and supporting conservation efforts. The aim of ecotourism is to minimise the impact on the environment, promote conservation, and contribute to the well-being of local communities. The goal of ecotourism is to provide a positive experience for both the visitors and the host communities while promoting environmental and cultural awareness and conservation. Thus, this form of tourism is based on purposeful travel coupled with cultural and spiritual understanding of a variety of natural phenomena (Ahmadi et al, 2015). Unplanned development is a significant issue that can have severe consequences for the environment, the economy, and people's lives. It refers to the development that takes place without proper planning, regulation, or consideration of its impacts on the environment and society. The problems arose when the unplanned development has disturbed the natural area where need to be preserves. Ecotourism relies on an involvement with nature which has a minimal impact on people and also for the environment. Accessibility also plays an important role in ecotourism which is a site's accessibility is crucial in determining its suitability for ecotourism area. It should be easy to reach and have proper transportation facilities such as roads, airports and train stations. Other infrastructure such as accommodation, restaurants, and medical facilities are critical in making a site suitable for ecotourism (Boˇzi´c et. al., 2018). Site suitability assessment involves conducting a feasibility study, environmental impact assessment and stakeholder consultation and also helps to identify the potential for ecotourism in a particular area and assess the infrastructure and services required for its development. An environmental impact assessment helps to evaluate the impact of ecotourism on the environment and identify measures to mitigate the negative effects (Boˇzi´c et. al., 2018). This study is aimed in deriving the potential site suitability map for ecotourism in Pahang by using GIS and AHP method by taking an important criterion as the main information in the study.

Ecotourism in Malaysia takes place in the country's protected areas system The growth of the tourism industry in Malaysia has resulted in an increase in the number of both foreign and domestic tourists visiting natural areas. Malaysia’s ecotourism park is abundant in tropical forests, marine ecosystems, and wetland ecosystems. The Malaysian government has been actively promoting ecotourism by developing and conserving natural areas, encouraging community involvement in tourism development, and promoting sustainable tourism practices. Pahang is a state in Malaysia that is known for its ecotourism attractions, including national parks, wildlife reserves, and cultural sites. According to a report by the Pahang State Tourism and Culture Office, ecotourism activities in Pahang continued to grow in 2018, with a total of 4.4 million tourist arrivals, an increase of 2.4% from the previous year (Sahoo et al., 2023).

In recent years, researchers have combined GIS with Multi-Criteria Decision Analysis (MCDA) which are also known as spatial MCDM for many decision-making planning (Bali et al, 2015). Multiple Criteria Decision Analysis (MCDA) methods offer a systematic framework to tackle decision problems involving multiple objectives, diverse criteria, and varying preferences (Ananda et. al, 2009). The importance of MCDA techniques comes from its ability to handle the complexity involved in decision-making procedures involving several stakeholders, criteria, and objectives. This approach guarantees transparency, minimises uncertainty, and promotes consistent decision-making (Sahoo et al, 2023).

The AHP is a decision-making method that can be applied in GIS for site selection purposes. The method helps in evaluating and prioritising criteria and alternatives based on their relative importance and performance. This method has steps including specifying the hierarchical structure, determining the relative important weights of the criteria and sub-criteria, assigning preferred weights of each alternative and determining the final score (Mazaher M., 2010). The AHP, an eigenvalue technique, uses pairwise judgement comparisons to assess intangible aspects by depicting the dominance of one factor over another with respect to a shared feature. One of the most popular techniques for multiple criteria decision-making

https://doi.org/10.24191/bej.v22i1.1032

today is AHP (Hassan Zabihi et. al, 2020). GIS in the recent years have proved to be vital tool in environmental planning and management, particularly in site suitability analysis for ecotourism development. A study done by Hu et, al, in 2024 has applied GIS to ecotourism suitability based on AHP-GIS technique at the area of the Giant Panda National Park. The study took into consideration factors including acceptance by society, accessibility, and the health of coral reefs. The selection of appropriate locations for the development of low-impact ecotourism and the visualisation of spatial connections were made possible by GIS. Overall, the capabilities of GIS produced a perfect and workable for spatial analysis environment in term of site suitability selection which further elevates the visualisation of the model and aiding in decision-making process.

STUDY AREA

Lipis district, Pahang was chosen as the primary study area due to its diverse range of flora and fauna as well as its cultural attractions, making it an ideal location for ecotourism. It is located approximately 4°25'14.53"N, 101°55'47.35"E and with a total area of 5,198 km². Lipis district is bordered by Cameron Highlands and Perak on the west, Jerantut on the east, Kelantan and Raub on the north and south, respectively. Lipis district has a rich history and is renowned for its colonial charm and natural beauty. It is situated within lush vegetation and surrounded by hills which makes it suitable for ecotourism site. Pahang state also host several other ecotourism sites that are listed at the Table 1 and Figure 1 below.

Table 1. Existing Ecotourism site in Pahang

No	Name
1.	Taman Negara
2.	Taman Negeri Rompin
3.	Tasik Chini
4.	Benus Bird Camp
5.	Taman Eko Rimba Bukit Pelindung
6.	Fraser's Hill
7.	Bukit Gambang Resort City
8.	Sungai Pandan Waterfall
9.	Cameron Highlands

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i1.1032

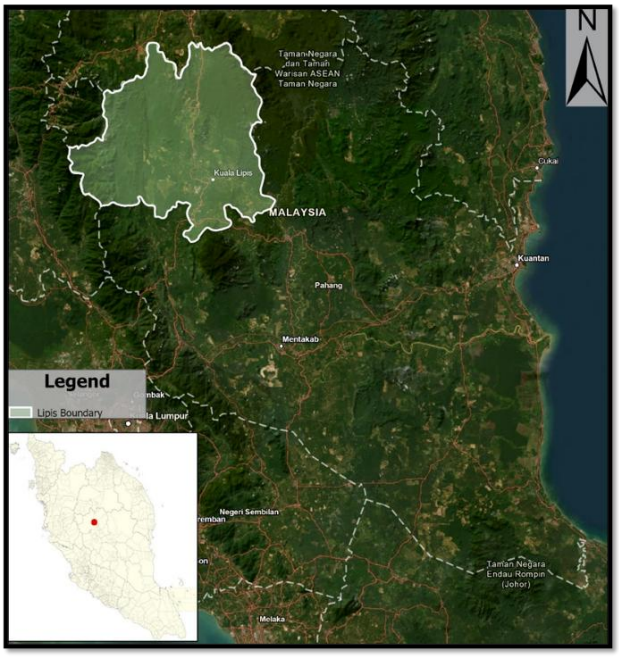

Fig 1. The location of the study area

Source: Authors (2024)

Fig 2. Location of existing ecotourism site at Pahang

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i1.1032

METHODOLOGY

Figure 3 shows the methodology of this study where it involves multiple stages which is preliminary study, data collection, data processing, data analysis, and result analysis to determine the most optimal location for the ecotourism site at the study area. After the study area selection, which is Lipis district, core criteria for site suitability are identified, which includes factors such as land use, slope, elevation, roads and proximity to infrastructure. These were the finalised core criteria verified by experts. For data processing, AHP technique is used to determine the relative importance of the identified core criteria. The AHP involves pairwise comparisons where each criterion is compared to every other criterion. These values are used to generate weights for each criterion, representing their importance in the overall site suitability assessment

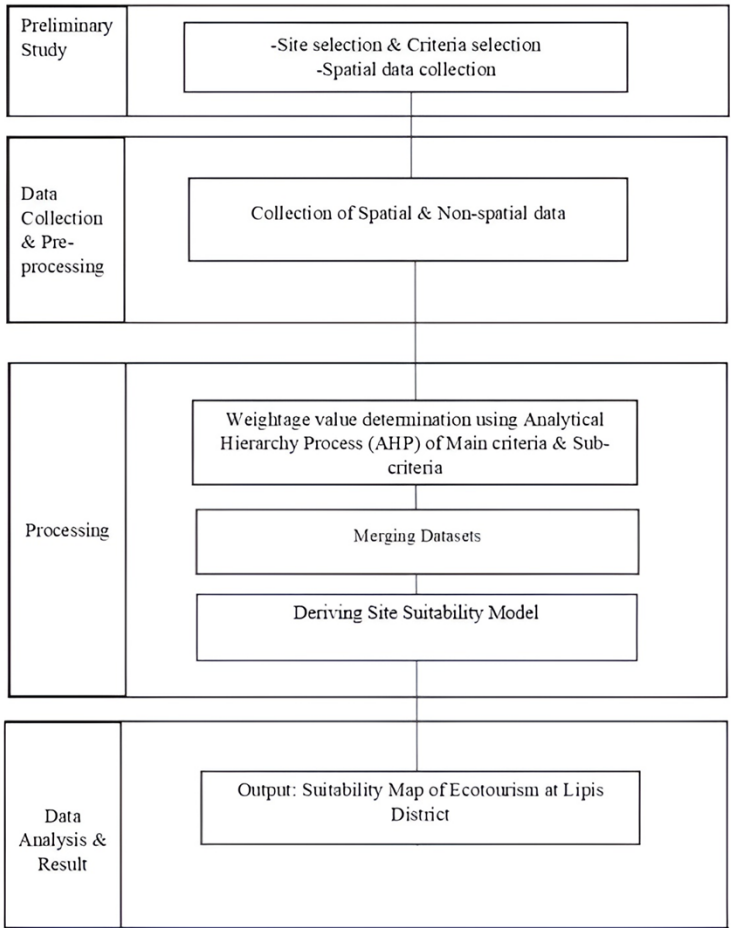

Fig 3. Workflow of Methodology

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i1.1032

Table 2 shows the five (5) main criteria selected along with each of its own respective sub-criteria selected and used in this study. The main criteria were Land use, elevation, slope, roads, and infrastructure. Each of the main criteria has its own sub-criteria based on the expert opinions.

Table 2. Main criteria & Sub-criteria

Main Criteria	Sub-Criteria
Land Use	Forest
	Forest Reserve (Kekal)
	Forest Reserve (Negeri)
	Water bodies
	Bare Land
	Vegetation
	Beach
	Residential
Elevation (m)	0 - 30
	31 - 150
	151 - 300
	301 - 1000
	1001 - 2180
Slope	0 -15
	16-25
	26-45
	>45
Roads (m)	0 - 1000
	1001 - 2000
	2001 - 5000
	5001 - 10000
Infrastructure Proximity (Hotel)	0 - 15km
	15 – 30km
	30 - 45km
	> 45km

Source: Authors (2024)

RESULT AND ANALYSIS

Main Criteria & Sub-criteria Weightage

Table 3 finalised the calculation of weightage for each of the main criteria and the sub-criteria. Overall, the weightage value of the main criteria and sub-criteria are relevant and parallel to the response of the expert's opinion. It can be seen from the Land Use category especially the forestry part of the criteria where it holds the highest overall weightage score and Bare Land category which is devoid of any plants interpreted as the lowest score of 0 where it holds no significant at all. After that, for the Elevation and Slope, it is classified according to the guidelines provided by the Malaysian Government for ecotourism purposes and the result of the sub weightage were direct with high value slope and elevation were deemed to be unsuitable for ecotourism. Finally, for the Roads and Infrastructure Proximity, both were scored according to its distance from the subject. Both of these calculations were also direct in terms of ranking and evaluation. The weightage calculation for main criteria used AHP technique and involves pairwise comparisons where each criterion is compared to every other criterion. The score given by the expert's interview were noted and will be used for further calculation of the weightage calculation. The value of sub criteria was calculated using the Linear Scale Transformation method. This method assigns the normal weight to each of the sub-criteria listed according to the preference. In this case, the preference used were according to expert's view. The scoring starts with a range from the lowest value of zero (0) to highest number of seven (7). The value zero (0) in this scoring scheme represents the sub-criteria that has no

https://doi.org/10.24191/bej.v22i1.1032

influence or deemed to be not suitable at all in this study. The highest scoring in the sub-criteria which belongs to the Land Use category has a value of seven (7). which shows its utmost importance in this study. The weight assigned were then calculated using the normalise formula.

Table 3. Main criteria & sub-criteria weightage

Main Criteria	Sub-Criteria	Main Weightage	Sub Weightage
Land Use	Forest	0.423	0.1209
	Forest Reserve (Kekal)		0.1007
	Forest Reserve (Negeri)		0.0806
	Water bodies		0.0604
	Vegetation		0.0403
	Residential		0.0201
	Bare Land		0.0
Elevation (m)	0 - 30	0.169	0.0676
	31 - 150		0.0507
	151 - 300		0.0338
	301 - 1000		0.0169
	1001 - 2180		0.0
Slope	0 -15	0.257	0.1285
	16-25		0.0848
	26-45		0.0437
	>45		0.0
Roads (m)	0 - 1000	0.088	0.044
	1001 - 2000		0.02904
	2001 - 5000		0.0150
	5001 - 10000		0.0
Infrastructure Proximity	0 - 15km	0.063	0.0315
	15 – 30km		0.0208
	30 - 45km		0.0107
	> 45km		0.0

Source: Authors (2024)

Map Site Suitability Area (Equal Interval)

The Equal Interval classification method divides Lipis District into five classes namely Not Suitable, Low Suitability, Moderate Suitability, High Suitability and Very High Suitability based on equal value intervals. The disparity is evident in areas such as Batu Yon, where the Equal Interval classification shows minimal coverage of Very High Suitability classification. Observing the map, distinct areas classified as Not Suitable, depicted in red, highlight regions where criteria for ecotourism suitability are not met. These areas are predominantly urbanized, exhibiting unsuitability for ecotourism activities due to factors such as high elevation and steep slopes. Notably, along the main expressway and at the northern borders of Hulu Jelai and Batu Yon, red patches signify areas deemed unsuitable for ecotourism ventures due to elevation and slope considerations. Additionally, vegetation areas in Hulu Jelai are unsuitable for ecotourism due to their agricultural nature, although certain vegetation types could be repurposed for ecotourism attractions. Conversely, subdistricts like Hulu Jelai, Batu Yon, Kechau, and Telang exhibit high suitability for establishing new ecotourism sites, primarily due to abundant reserve forests. These areas offer promising opportunities for ecotourism development, given their natural features and potential for sustainable tourism ventures.

https://doi.org/10.24191/bej.v22i1.1032

Table 4. Area and Percentage of Equal Interval

Classes	Area (km^2)	Percentage (%)
Not Suitable	128.5669	2.487750
Low Suitability	1103.507	21.35268
Moderate Suitability	2849.406	55.13557
High Suitability	1051.379	20.34402
Very High Suitability	35.14144	0.679981

Source: Authors (2024)

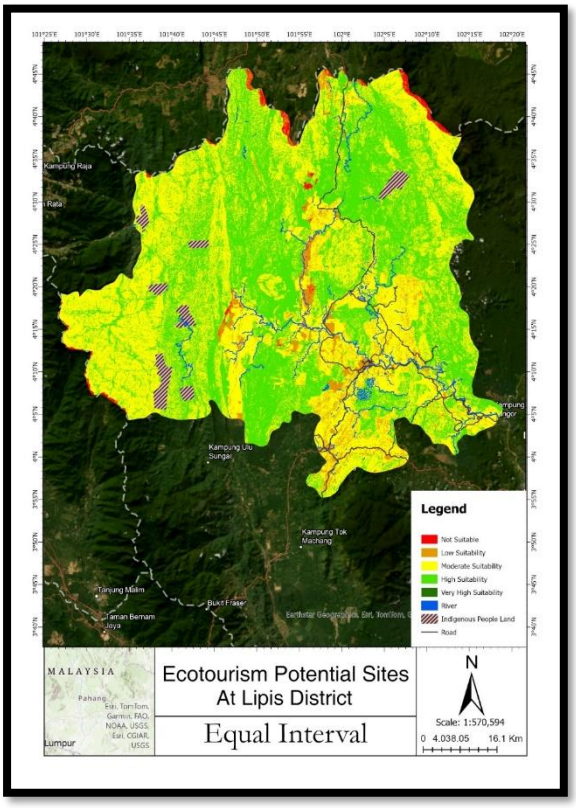

Fig 4. Equal Interval Classification map

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i1.1032

Map Site Suitability Area (Natural Break Jenks)

The Natural Break (Jenks) classification method utilise an optimisation process to categorise Lipis District into five distinct classes namely Not Suitable, Low Suitability, Moderate Suitability, High Suitability, and Very High Suitability by minimise the intra-class variance and maximise the inter-class variance. This method is particularly adept at identifying clusters or patterns within the dataset which resulting in a map with visually discernible class distributions. When compared to Equal Interval, the Natural Break classification yields a map with pronounced visual contrasts, demonstrating a more even distribution of class categories across the study area. This characteristic is attributed to the algorithm's ability to detect underlying data patterns and clusters, providing a more natural representation of the terrain.

Moderate Suitability emerges as the most prevalent class, covering 33% of the district and primarily concentrated around Kuala Lipis. This classification is influenced by surrounding urbanisation and infrastructure accessibility, particularly evident in areas adjacent to main roads connecting to Gua Musang, Kelantan. High Suitability ranks as the second-highest class which comprising 30% of the area and distributed evenly throughout the map, especially along the western border of Hulu Jelai. However, patches of Moderate and Low Suitability adjacent to High Suitability areas indicate the influence of steep slopes exceeding 45 degrees, despite higher elevations not necessarily impeding ecotourism development.

For Not Suitable and Low Suitability categories cover 6% and 22% of the district, respectively, primarily concentrated around urban centers like Pekan Kechau Tui and Bandar Padang Tengku. These areas are deemed unsuitable for ecotourism ventures due to intense urbanisation and higher elevations. Very High Suitability areas constitute 9% of the district, mainly found bordering Batu Yon and Telang subdistricts, benefiting from strategic locations near cities and existing infrastructure. This classification underscores the potential for ecotourism or plantation development in these regions.

The Natural Break classification is selected for its ability to provide a more natural grouping of class intervals, accurately reflecting suitability criteria such as vegetation cover, urbanisation, roads, and elevation. This classification aligns well with existing ecotourism sites in High and Very High Suitability areas, highlighting its effectiveness in site suitability assessment for ecotourism in Lipis District.

Classification methods are used for classifying numerical fields for graduated symbology. Both techniques which are Equal Interval and Natural Break have their own characteristic. Equal interval divide the range of attribute values into equal-sized subranges and allow to specify the number of intervals, and the class breaks based on the value range are automatically determined. Meanwhile, Natural breaks classification classes are based on groupings inherent in the data. (ESRI, 2023).

Table 5. Area and Percentage of Natural Break (Jenks)

Classes	Area (km^2)	Percentage (%)
Not Suitable	288.5321	5.583052
Low Suitability	1159.928	22.44443
Moderate Suitability	1720.619	33.29372
High Suitability	1560.678	30.19889
Very High Suitability	438.2417	8.52000

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i1.1032

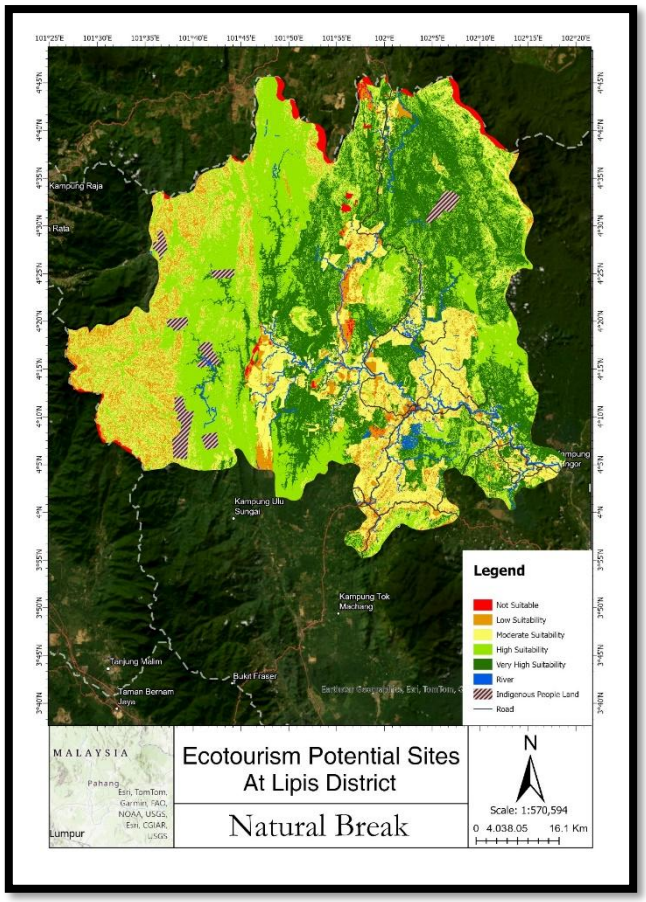

Fig 5. Natural Break (Jenks) Classification map

Source: Authors (2024)

Existing Site of Ecotourism at Lipis District

Figure 6 shows the location of existing ecotourism sites. Table 6 highlights that existing ecoparks predominantly fall within the Moderate Suitability to Very High Suitability range. Among these, Kenong Eco Camp and Kenong Rimba Park stand out as noteworthy examples. Situated in close proximity to each other, Kenong Rimba Park slightly north of Kenong Eco Camp, both offer campsite areas adjacent to caves such as Gua Batu Tangga, Gua Batu Tangkup, and Gua Batu Telahup. This provision of campsites likely contributes to their Moderate Suitability classification, while their location near the fringe of Taman Negara earns them an overall High Suitability rating.

https://doi.org/10.24191/bej.v22i1.1032

Table 6. List of existing Eco Park

No	Site Name	Equal Interval	Natural break
1.	Kenong Eco Camp	High Suitability	Moderate Suitability
2.	Kenong Rimba Park	High Suitability	High Suitability
3.	Lata Orik	High Suitability	Very High Suitability
4.	Sungai Yu Recreation Centre	High Suitability	Very High Suitability
5.	Taman Negara Sungai Relau	High Suitability	Very High Suitability

Source: Authors (2024)

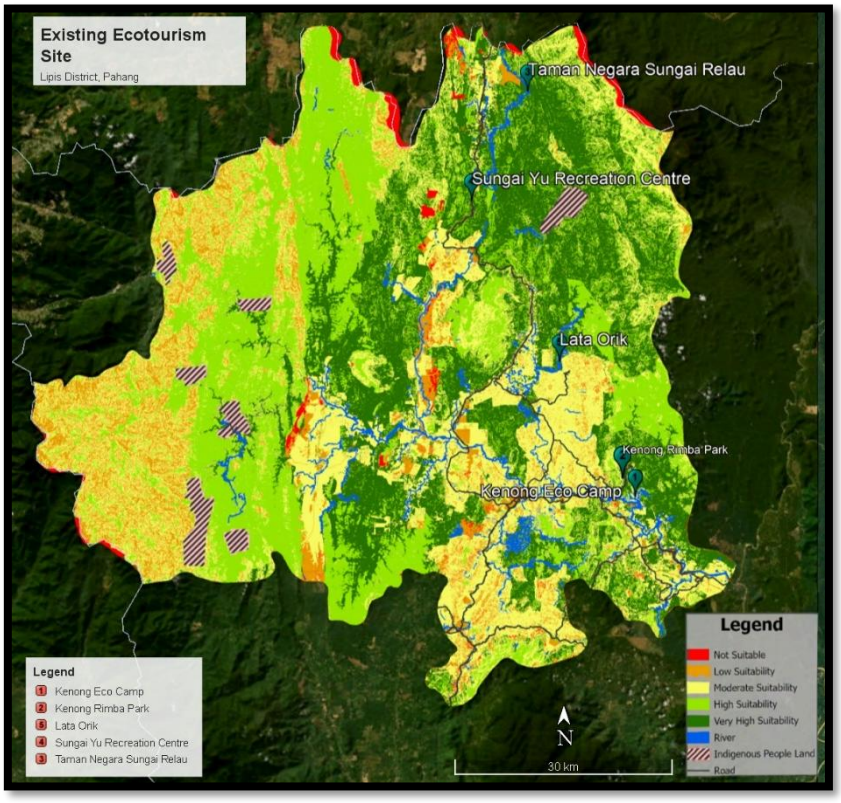

Fig 6. Existing Eco Park map

Source: Authors (2024)

Lata Orik, located approximately 5.8 km from Bandar Kuala Lipis, is renowned for its picturesque waterfall and lush green surroundings, making it a popular destination for recreational activities. With a consistently high weightage value, Lata Orik scores an average of Very High Suitability due to its abundant forest cover, river, and nearby infrastructure.

Similarly, Sungai Yu Recreation Park, nestled amidst the hills surrounding Kuala Lipis, offers captivating river and forest landscapes, attracting ecotourists with its stunning scenery. With an average

weightage class of Very High Suitability, Sungai Yu Recreation Park benefits from its strategic location near Kuala Lipis town, enhancing accessibility for visitors.

Lastly, Taman Negara Sungai Relau, situated in Lipis District, is a renowned destination for jungle trekking and mountain climbing, particularly to Gunung Tahan. Accessible via a 14-km jeep trail from Sungai Relau to Kuala Juram, this site boasts lush greenery and a protected state forest reserve. With an average rating of Very High Suitability, Taman Negara Sungai Relau benefits from its pristine environment and nearby infrastructure, including expressways connecting Kuala Lipis to Gua Musang, ensuring convenience for tourists. Overall, these existing ecotourism sites demonstrate varying levels of suitability, with Taman Negara Sungai Relau emerging as the most strategically located and environmentally conducive destination for ecotourism in Lipis District.

CONCLUSION

In conclusion, the study conducted a comprehensive site suitability assessment for ecotourism in Lipis district, achieving several key objectives. Firstly, the study successfully identified the criteria and indicators influencing site selection, encompassing Land Use, Elevation, Slope, Roads, and Infrastructure. These criteria, validated by previous studies and ecotourism experts, revealed Land Use as the most influential factor, followed by Slope, Elevation, Roads, and Infrastructure Proximity.

Secondly, an ecotourism model utilising GIS and AHP was developed, assigning weightage values to each criterion through pairwise comparisons. The model, validated by Consistency Ratio analysis, effectively visualized suitability levels across the study area, with Natural Break classification deemed the most suitable for its logical representation of site suitability.

Lastly, the study analysed the suitability of existing ecotourism areas, confirming the accuracy of the Natural Break model through comparison with known ecotourism sites. Notably, three out of five existing sites were located within areas classified as Very High Suitability, validating the efficacy of the model in identifying suitable ecotourism locations. In summary, the findings provide valuable insights for ecotourism planning and management in Lipis district, laying the groundwork for sustainable development and conservation efforts in the region.

ACKNOWLEDGEMENTS/FUNDING

The authors would like to acknowledge the support of Universiti Teknologi Mara (UiTM), Kampus Shah Alam and College of Built Environment, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for providing the facilities and support on this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Muhammad Ajmal A'imullah carried out the research together with Ainon Nisa Othman. Ainon Nisa Othman providing the idea, wrote, revised the article, supervised the research progress and approved the arcticle submission. Ainon Nisa Othman and Nurhanisah Hashim designed the research and also monitor the progress of the research. Abd Rauf Abd Rasam support on providing the ideas on writing the article and the methodology used for this research. Akhbaaruddin Abd Hamid are together with Ainon Nisa Othman on providing and do the collection of the data used for the research.

References

Ahmadi, M., Asgari, S., Ghanavati, E., (2015). Land capability evaluation for ecotourism development in Ilam Province, a gis approach. Bol. Ciencias Geodesicas 21, 107–125. https://doi.org/10.1590/S1982-21702015000100008

Ananda, J., & Herath, G. (2009). A critical review of multi-criteria decision-making methods with special reference to forest management and planning. Ecological Economics, 68(10), 2535-2548. https://doi.org/10.1016/j.ecolecon.2009.05.010

Bali, A., Monavari, S. M., Riazi, B., Khorasani, N., & Zarkesh Kheirkhah, M. M. (2015). A spatial decision support system for ecotourism development in Caspian Hyrcanian mixed forests ecoregion. Boletim de Ciˆencias Geod´esicas, 21(2), 340–353. https://doi.org/10.1590/S1982-21702015000200001

Boˇzi´c, S., Vujiˇci´c, M.D., Kennell, J., Besermenji, S., Solarevi´c, M. (2018). Sun, sea and shrines: application of analytic hierarchy process (AHP) to assess the attractiveness of six cultural heritage sites in Phuket: Thailand. Geographica Pannonica, 22, 121–138. https://doi.org/10.5937/22-16983

Çetinkaya, C., Kabak, M., Erbas¸, M., Ozceylan, E. (2018). Evaluation of ecotourism sites: a GIS-based multi-criteria decision analysis. *Kybernetes*, Vol. 47 No. 8, pp. 1664-1686. https://doi.org/10.1108/K-10-2017-0392

Hu JY, Liu LY, Dai QL, Yang B, Zhou WJ. Evaluation of ecotourism suitability based on AHP-GIS: Taking Xiaoxiangling area of the Giant Panda National Park and the surrounding communities as an example. Ying Yong Sheng Tai Xue Bao. 2024 Mar 18;35(3):780-788. English. doi: 10.13287/j.1001-9332.202403.020. PMID: 38646766.

ESRI (2023). Data classification Methods. Retrieved from website https://pro.arcgis.com/en/pro-app/latest/help/mapping/layer-properties/data-classification-methods.htm

Hasan Zabihi, Mohsen Alizadeh, Isabelle D. Wolf, Mohammadreza Karami, Anuar Ahmad, Hasan Salamian. (2020). A GIS-based fuzzy-analytic hierarchy process (F-AHP) for ecotourism suitability decision making: A case study of Babol in Iran. https://doi.org/10.1016/j.tmp.2020.100726

Mazaher M. (2010). Sitting MSW landfill using weighted linear combination and analytical hierarchy process (AHP) methodology in GIS environment (case study: Karaj). Physica B: Waste Manage 2010; 30:912-920. https://doi.org/10.1016/j.wasman.2010.01.015

Pahang State Tourism and Culture Office, (2018) Ministry of Tourism, Arts, and Culture. Retrieved from website https://pahangtourism.org.my

Sahoo, Sushil Kumar & Goswami, Shankha. (2023). A Comprehensive Review of Multiple Criteria Decision-Making (MCDM) Methods: Advancements, Applications, and Future Directions. Decision Making Advances, 1, 25-48. https://doi.org/10.31181/dma1120237