Multicriteria potential mapping for Mangrove ecotourism in Batu Ampar, West Kalimantan

S Sisriany¹, B Sulistyantara², and T Budiarti²

¹ Graduate School of IPB University, Department of Landscape Architecture, IPB University, Bogor, Indonesia
² Department of Landscape Architecture, IPB University, Bogor, Indonesia
E-mail: bambang_sulistyantara@apps.ipb.ac.id

Abstract. Mangrove ecosystems provide a wide variety of vital ecological and economic ecosystem services to coastal communities, including ecotourism. Batu Ampar, where one of the most extensive mangrove forests lies, is encouraged to develop mangrove ecotourism. This study aims to determine the priority for ecotourism development in Batu Ampar districts by using the potential map based on the multiple aspects from tourism, environment, legal, and landscape value. This research's multicriteria use includes Natural Tourism Attraction, Mangrove Tourism Suitability, Biophysical Vulnerability, Landscape Values, and Spatial Policy, and weight overlay based on Analytic Hierarchy Process (AHP) score. The results indicate that by using multicriteria for the mangrove ecotourism potential, 18% is the high potential area, 30% is moderate potential, 22.6%, and the rest are not potential. The high potential area should become the priority of ecotourism development in Batu Ampar, situated in five villages: Batu Ampar, Telok Nibong, Nipah Panjang, Tanjung Harapan, and Sungai Kerawang.

Keywords: AHP, Ecotourism, GIS, Mangrove, Potential Mapping

1. Introduction
Mangrove ecosystems provide ecological benefits, as nutrition supplier, a place for spawning and foraging for aquatic biotas, protecting shorelines from erosion, providing nurseries for many species of fish and crustaceans, preventing intrusion of seawater and strong winds, and blocking sea waves, as well as an economic benefit, among others, as a provider of various timber forest products and ecosystem services, and providing a place for mangrove nursery areas [1–3]. The mangrove ecosystem in the ecological landscape structure is in the ecotone area, an intermediate area between two different ecosystems. It has high biodiversity due to the combination of the two ecosystems and has a very high vulnerability.

Indonesia, as a tropical archipelago, has the largest area of mangrove forests in the world, with a total area of $4.25 \times 10^4$ km² (26% of world total), followed by Brazil ($1.34 \times 10^4$ km²), Nigeria ($1.05 \times 10^4$ km²) and Australia ($1.00 \times 10^4$ km²) [4]. One of the largest is the Batu Ampar Mangrove Biosphere, located in West Kalimantan, with a total area of 655.85 km². Batu Ampar mangrove forest has been claimed as one of the most extensive mangrove forests in Asia and has the most comprehensive mangrove species in the world.

Batu Ampar district is located in Kubu Raya Regency. This regency has claimed that mangrove is their identity, especially one particular species of mangrove name *Kandelia candel*. The local government concern with the ecotourism development in this area to support tourism. Unfortunately, these potentials have not affected the local community's social economy, and existing tourism has consistently not attracted tourists. Ecologically, the mangrove protected forest in Batu Ampar is good. Still, however, its sustainability is
considered insufficient from the social and economic aspects [5]. An area is designated as a conservation area to provide three dimensions of benefits: ecological benefits, economic benefits, and social benefits.

Ecotourism is one of the activities in the Batu Ampar mangrove area. Ecotourism has been believed to encourage regional and local economic growth for the improvement of community welfare and preserve the natural resources and biodiversity as tourist objects and attractions. Quality ecotourism in the mangrove area of Batu Ampar has the potential to be sustainable tourism by maintaining the quality of objects and natural attractions. Also, its activities can impact community life values, such as providing income, welfare, and social life of local peoples. Spatial assessment is needed to study this large area properly, and integrated with multiple factors for sustainability, including ecological aspects, policy aspects, to social and economic aspects, otherwise a sustainable tourism will not be adequately actualized.

The mangrove ecosystem in Batu Ampar well distribute almost in every village in Batu Ampar, and every village is encouraged to develop ecotourism in their area. An assessment of mangroves’ potential needs to be carried out, especially in the protected forest area of Batu Ampar, West Kalimantan, to determine the priority of ecotourism areas developed with a spatial approach. The primary purpose of this research is to model the potential map of mangrove ecotourism with an appropriate combination of multiple aspects from tourism, environment, legal, and landscape value. The appropriate combination is obtained by assign the weight calculated from Analytic Hierarchy Process (AHP) methods.

2. Methods
This research was conducted in the Mangrove Landscape of Batu Ampar District, Kubu Raya Regency, West Kalimantan Province (Figure 1), located at 0°43'06.1 S and 09° 42'34.0" E, in a total area of 2,002.00 km². This district consisted of 15 villages, as follows: Ambarawa, Batu Ampar, Muara Tiga, Nipah Panjang, Medan Mas, Padang Tikar I, Padang Tikar II, Sumber Agung, Sungai Besar, Sungai Jawi, Sungai Kerawang, Tanjung Beringin, Tanjung Harapan, Tasik Malaya dan Teluk Nibung.

![Figure 1 Case Study Location](image)

The field survey was carried during August 2019 to collect primary and secondary data and carry out the questioner including the interview towards the local people and stakeholders such as local government and NGOs. The datasets used in this research include the SRTM-DEM for elevation and slope map, Indonesia’s geospatial portal, and
the multispectral satellite images from Landsat 8 OLI from March 20, 2017 (for low tide, $z=-0.102m$), and July 30, 2018 (for high tide, $z=0.6m$). The year 2017 and 2018 was purposely chosen to match the collected secondary data related to this study such as mangrove forest from LAPAN (Indonesia’s Aeronautics and Space Institute), and mangrove species, biota, village forest policy and document from SAMPAN (NGO) and LPHD Batu Ampar (Forest Management Group). The mapping and analysis processes are mostly conducted in ArcGIS Desktop 10.5, and the rest in other software such as QGIS 3.8 and Microsoft Excel.

Identification and mapping of mangrove ecotourism parameters in this study consist of multiple criteria from the four main aspects: mangrove ecotourism, biophysics vulnerability, legal aspects, and local people value, see Table 1. The criteria used in this study are as follows: 1) Natural Tourism Attraction [6] and Mangrove Tourism Suitability [7] for tourism aspects, 2) Mangrove Biophysical Vulnerability Index [8] for vulnerability aspects, 3) Landscape Value [9], for local people perceptions, and 4) Village Forest and Consensus Forest Use for the policy aspects.

Potential maps are generated by using weighted overlay analysis towards those multiple criteria. The weight score assigned to each map of the criteria are obtained by using the AHP methods [10] from the selected expert respondent, with Consistency Ratio (CR) = 2.3%, and principal eigenvalue = 4.062, see Table 1.

### Table 1 Multicriteria parameters for mangrove ecotourism potential mapping

| No | Aspects                                | Weight | Categories                      | Datasets                                                                 |
|----|----------------------------------------|--------|---------------------------------|--------------------------------------------------------------------------|
| 1  | Ecotourism                             |        |                                 |                                                                          |
|    | a. Natural Tourism Attraction [6]      | 4      | Feasible for Development - 3     | Scenery, Natural Resource, Tourism Activity, Hygiene, Condition, Distance, Distance from City Centre, Road type, Accommodation and Room, Existing Facilities in the Area |
|    |                                         |        | Moderately Feasible - 2         |                                                                          |
|    |                                         |        | Not Feasible - 1                 |                                                                          |
|    | b. Mangrove Tourism Suitability [7]   | 17     | High Suitability -3             | Mangrove Density (NDVI), Mangrove Species, Biota Species                 |
|    |                                         |        | Moderate Suitability -2         |                                                                          |
|    |                                         |        | Low Suitability -1               |                                                                          |
| 2  | Biophysical Vulnerability Index [8]    | 46     | Low Vulnerability – 3            | Geology, Elevation and Slope (SRTM-DEM), Mangrove, Water Vegetation, Marsh |
|    | (Inundation & Erosion)                |        | Moderate Vulnerability – 2       |                                                                          |
|    |                                         |        | High Vulnerability - 1           |                                                                          |
| 3  | Landscape Value [9]                    | 5      | High Value - 3                   | Land use base map, and Questionnaire for Sociocultural Value, Economy Value, Environment Value, and Aesthetic Value. |
|    |                                         |        | Moderate Value -2                |                                                                          |
|    |                                         |        | Low Value - 1                    |                                                                          |
| 4  | Legal Aspects – Spatial Policy         | 28     | Village Forest – 3               | Village Forest, and Consensus Forest Use Map                             |
|    |                                         |        | Protected Forest, Other Usages -2|                                                                          |
|    |                                         |        | Production Forest - 1            |                                                                          |
3. Result and Discussion

3.1 Ecotourism Aspects

Natural Tourism Attraction criteria are widely used for the ecotourism potential assessment, especially in Indonesia. Although these criteria have been handy and cover multiple ecosystems such as coastal areas and mountain areas, it still requires some adjustment and modification, particularly for this study on the mangrove ecosystem. Therefore, for ecotourism aspects is also used other criteria for Mangrove Tourism Suitability [7]. Contrary to the Natural Tourism Attraction criteria, this Mangrove Tourism index is specifically focused on the mangrove as the attraction. The combination of these two criteria expected to represent most of the tourism aspects.

3.1.1. Natural Tourism Attraction

For Natural Tourism Attractions assessments, the results show four villages are feasible to develop: Telok Nibong, Tanjung Harapan, Nipah Panjang, and Medan Mas. Meanwhile, two villages are not feasible to develop: Muara Tiga and Tanjung Beringin. And the rest are classified as moderately feasible (Figure 2d).

3.1.2. Mangrove Tourism Suitability

For Mangrove Tourism Suitability, there are three parameters, mangrove density, number of mangrove species, and the number of biotas (Figure 2a, 2b, 2c). Based on these criteria, the area with mangrove covers has high suitability, although some of the mangrove covers moderate suitability (Figure 2d). Mangrove density maps were generated from NDVI, and only High, Moderate, and Low Density include in the calculation. Non-vegetation and Over High-Density mangrove areas are considered not suitable for ecotourism.

Figure 2 Ecotourism Aspects
Table 2 List of Mangrove in Batu Ampar Districts

| Classification          | Conservation Status Category | Mangrove Species                                                                 |
|-------------------------|------------------------------|----------------------------------------------------------------------------------|
| True Mangrove           | Least Concern                | Acanthus ebracateatus, Acanthus ilicifolius, Aegiceras corniculatum, Avicennia officinalis, Barringtonia racemosa Bruguiera cylindrica, Bruguiera gymnorrhiza, Bruguiera parviflora, Bruguiera gymnorrhiza, Ceriops tagal, Kandelia candel, Lumnitzera littorea, Nypa fruticans, Rhizophora mucronata, Rhizophora apiculata, Sonneratia alba |
|                         | Near Threatened              | Brownlowia tersa, Ceriops decandra, Sonneratia ovata                            |
|                         | Critically Endangered        | Bruguiera hainessii,                                                             |
| Mangrove Associated     | Least Concern                | Barringtonia asiatica, Cerbera manghas, Excoecaria agallocha, Dolichandrone spathacea, Cryptocoryne ciliata, Hibiscus tiliaceus, Pandanus tectorius, Pongamia pinnata, Terminalia catappa, Thespesia populnea |
| Unclassified            |                              | Allophylus cobbe, Ardisia elliptica, Clerodendrum inerme, Dalbergia canadenatensis, Derris trifoliata, Finlaysonia obovata, Ipomoea pescaprae, Melastoma malabathricum, Merope angulata, Morinda citrifolia, Morinda citrifolia, Passiflora foetida, Pluchea indicia, Planchnella obovata, Sarcolobus globosus, Scaevola taccada, Sesuvium portulacastrum |

Mangrove species in Batu Ampar are recorded around 46 species and distributed almost entirely in the mangrove forest. There is consist of true mangrove species and mangrove associates, see Table 2. Biota in Batu Ampar includes Channa striata, Channa micropeltes, Trichopus Trichopterus, Anabas testudineus, Helostoma temminckii, Macrobrachium rosenbergi, Scylla serrata, Apis Cerana, Trigona sp, and Orcaella brevirostris.
3.2 Mangrove Biophysical Vulnerability Index

Despite their high potential for ecotourism, mangroves have a very high risk of destruction and very vulnerable to changes, moreover to climate changes [13,14]. Therefore, it's essential to identify areas of mangrove that are prone to damage and vulnerable. The ecotourism activities will not disturb the vulnerable ecosystems and, alternatively, manage to conserve the high vulnerability areas.

Identification of the mangrove vulnerability in this research is divided into two effects, Inundation and Erosion (see Figure 3d & 3e), each consist of three parameters Elevation, Geology, and Vegetation [15] (see Figure 3a, 3b, and 3c). The map for these aspects is generated from multispectral satellite images (vegetation) using the decision trees classification for Marsh [16], Water Vegetation, and Mangrove [1] from various spectral indices, including NDVI (low tide), NDWI, NDMI (high tide), NDBI. Different from other aspects, high vulnerability indicates that not suitable for ecotourism and vice versa. Overall results (Figure 3f) shows that the mangrove area in Batu Ampar has a Low Vulnerability index.

3.3 Landscape Value

A total of 20 respondents from local people were asked to share their perceptions and preferences of the landscape in their environment. In this case, are divided into five classes: mangroves, settlement, agriculture, water bodies, and forest. This approach is
modified from Ecosystem Services Value [9] since we exclude the photograph that represents the landscape considering the respondent are local people and understand well about these landscapes. Each data was calculated and imported into the land use map with the same five land use classes.

The results show that local people highly value the water bodies as part of their sociocultural and economy. It suited well with the local people as the coastal community who depends their lives on the coastal natural resources, see Figure 4, in this case, not only the sea and the rivers, but also to the mangroves forest. Local people also highly value the mangroves for the aesthetics. On the other hand, it is important to encourage their value on the environmental aspects to avoid the overuse of the mangroves areas as one reason for the declining quality of the coastal environment [17].

3.4 Spatial Policy for Ecotourism
One of the best approaches to studying the potential and impact of ecotourism in the policy aspects is examining it according to the spatial scales at which ecotourism and policies are situated [18]. In this research, we focus on the study area’s spatial policies that considerably influence most of the sites’ activities. The policies related to the protected area in Batu Ampar use in this study is the Village Forest and Consensus Forest Use. Based on the Ministry of Environment and Forestry Decision in 2017, ten of fifteen villages in Batu Ampar received the right to manage the Village Forest: Batu Ampar [19], Teluk Nibung [20], Tanjung Harapan [21], Ambarawa [22], Sungai Besar [23], Tasik Malaya [24], Medan Mas [25], Padang Tikar Satu [26], Nipah Panjang [27], and Sungai Jawi [28].
Figure 5 Legal Aspects

The Village Forest's management right includes the Forest Management Group's right to use the area to collect non-timber forest products and environmental services, such as ecotourism. Hence, the Village Forest Area score is the highest. Following that, two forest types from the Consensus Forest Use, the Protected Forest and Other Usage, are possible for ecotourism area but require plenty of permit and approval. On the other hand, the production forest is not supposed for ecotourism, but if the company decided to establish ecotourism, it also require a permit and approval (Figure 5).

3.5 Mangrove Ecotourism Potential Map

Overall, based on the weighted overlay from four aspects in this research, the results show that the study area is potential for mangrove ecotourism, where 414.67 km² (18%) with High Potential area, 697.28 km² (30%) Moderate Potential, 522.39 km² (22.6%), and the rest 672.33 km² (29%) are Not Potential area, from total area 2,306.57 km² of Batu Ampar District. High Potential areas for mangrove ecotourism are situated in Batu Ampar, Telok Nibong, Nipah Panjang, Tanjung Harapan, and Sungai Kerawang (Figure 6). Most of the village in Batu Ampar district has areas that moderately potential mangrove ecotourism.

Comparing the results for mapping the mangrove ecotourism using only Mangrove Ecotourism Sustainability (Figure 2) with the multicriteria results (Figure 6), it is clear that the results are less detailed if using only the mangrove ecotourism sustainability. The mangrove ecotourism sustainability underestimated the area with moderate potential for ecotourism, and this research method manages to delineate the moderately potential area. These results might be beneficial information for the area that has the moderate potential area of ecotourism.
4. Conclusion
This research demonstrated mangrove ecotourism potential mapping in Batu Ampar, Kubu Raya, West Borneo. The results indicated that the study area is potential for mangrove ecotourism. Based on this research, the priority for ecotourism development in Batu Ampar District should be on five villages with high potential areas: Batu Ampar, Telok Nibong, Nipah Panjang, Tanjung Harapan, and Sungai Kerawang. By using the multicriteria mapping, the potential area more specific and detail. Further research about ecotourism plan is needed to develop the ecotourism in Batu Ampar area, to bring benefits for the local community and the government in Batu Ampar, Kubu Raya, West Kalimantan.

Acknowledgement
This research was supported by the Ministry of Research Technology of Higher Education, Republic of Indonesia, through Master’s Thesis Research Scholarship 2020.

References
[1] Zhang X, Treitz P M, Chen D, Quan C, Shi Land L X 2017 Mapping mangrove forests using multi-tidal remotely-sensed data and a decision-tree-based procedure Int. J. Appl. Earth Obs. Geoinf. 62 201–14
[2] Fennell D 2015 Ecotourism (Routledge)
[3] Spalding M, Blasco F and Field C 1997 World Mangrove Atlas ed M Spalding, F Blasco and C Field (Okinawa, Japan: The International Society for Mangrove Ecosystems)
[4] Valiela I, Bowen J Land York J K 2006 Mangrove Forests: One of the World’s Threatened Major Tropical Environments Bioscience 51 807
[5] Karlina E, Kusmana C and Bismark M 2016 Analysis of Sustainability of Mangrove Protection Forest Management in Batu Ampar, Kubu Raya Regency, West Kalimantan Province J. Anal. Kebijak. 13 201–19
[6] Departemen Kehutanan RI 2003 Pedoman Analisis Daerah Objet Oobjek dan Daya Tarik Wisata Alam (ADDO-ODTWA) (Bogor)
[7] Yulianda F 2007 Ekowisata bahari sebagai alternatif pemanfaatan sumberdaya pesosir berbasis konservasi Makal. Semin. Sains
[8] Rogers K, Mogensen L A, Davies P, Kelleway J, Saintilan N and Withycombe G 2019 Impacts and
adaptation options for estuarine vegetation in a large city Landsc. Urban Plan. 182 1–11

[9] Zoderer B M, Tasser E, Erb KH, Lupò Stanghellini P and Tappeiner U 2016 Identifying and mapping the tourists’ perception of cultural ecosystem services: A case study from an Alpine region Land use policy 56 251–61

[10] Saaty T L 2008 Decision making with the analytic hierarchy process Int. J. Serv. Sci. 1 83

[11] Giesen W, Wullftraat S, Zieren M and Liesbeth S 2006 Mangrove Guidebook for Southeast Asia (Bangkok, Thailand: FAO and Wetlands International)

[12] IUCN 2020 The IUCN Red List of Threatened Species Version 2020-3

[13] Alongi D M, Murdiyarso D, Fourquarean J W, Kauffman J B, Hutaehae A, Crooks S, Lovelock C E, Howard J, Herr D, Fortes M, Pidgeon E and Wagey T 2016 Indonesia’s blue carbon: a globally significant and vulnerable sink for seagrass and mangrove carbon Wetl. Ecol. Manag. 24 3–13

[14] Meleod E and Salm R V 2006 Managing Mangroves for Resilience to Climate Change IUCN Global Marine Programme

[15] Rogers K and Woodroffe C D 2016 Geomorphology as an indicator of the biophysical vulnerability of estuaries to coastal and flood hazards in a changing climate J. Coast. Conserv. 20 127–44

[16] Mao D, Wang Z, Du B, Li L, Tian Y, Jia M, Zeng Y, Song K, Jiang M and Wang Y 2020 National wetland mapping in China: A new product resulting from object-based and hierarchical classification of Landsat 8 OLI images ISPRS J. Photogramm. Remote Sens. 164 11–25

[17] Nickerson-Tietze D J 2000 Community-based management for sustainable fisheries resources in Phang-nga Bay, Thailand Coast. Manag. 28 65–74

[18] Fennell D A and Downing R K 2003 Ecotourism Policy and Planning (London: CAB International)

[19] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 515/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Batu Ampar

[20] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 516/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Teluk Nibung

[21] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 518/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Tanjung Harapan

[22] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 519/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Ambarawa

[23] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 520/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Sungai Besar

[24] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 521/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Tasik Malaya

[25] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 522/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Medan Mas

[26] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 523/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Padang Tikar Satu

[27] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 524/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Nipah Panjang

[28] Kementerian Lingkungan Hidup dan Kehutanan R I 2017 SK Nomor 525/MENLHKPSKL/PSKL/PSL.0/2/2017 tentang Pemberian Hak Pengelolaan Hutan Desa Kepada Lembaga Pengelola Hutan Desa Sungai Jawi