




Mapping Ecotourism Suitability Zones and Potential: A Case Study Using Remote Sensing Geospatial Information in Bogor Regency

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Abstract: Over the past few decades, the trend toward sustainable development globally has increased, and there are many cases of development that has a negative impact on the environment. The ecotourism scheme is one of the answers that can be used to reconcile economic development with aspects of environmental sustainability. Along with the increasing use of ecotourism schemes, of course, the provision of adequate infrastructure is fundamental to running the scheme. This research aims to map ecotourism suitability zones in Bogor Regency based on a geoecotourism model obtained through the integration of various remote sensing geospatial information. The model can produce an integrated landscape component analysis consisting of distance from water bodies, land use, distance from roads, distance from settlements, aspect, slope, and elevation. The results of the analysis are grouped into four classification zones based on ecotourism potential, namely low, medium, high, and very high ecotourism potential zones. Most of Bogor Regency has zone level 3, namely high ecotourism suitability with a total area of 235,940.06 ha or around 77.45% which is dominated by land cover in the form of agricultural land and plantations (coffee, rubber, and tea). Areas with low ecotourism suitability are caused by vulnerability to disasters such as floods and landslides. Based on the classification of the ecotourism potential zones, the direction of infrastructure development in each zone is determined to maximize the ecotourism scheme being implemented. The results of this study are expected to provide recommendations to the Bogor Regency Tourism Office regarding the provision of adequate infrastructure in various ecotourism zones in Bogor Regency and implementing the Society 5.0 concept in Indonesia.

Keyword: Ecotourism, Geoenvironmental, Geospatial

INTRODUCTION

Over the past few decades, the trend toward sustainable development globally has increased and there are many cases of development that has a negative impact on the environment. The impact of development will always clash in terms of economic, environmental, and social aspects. Careful planning in the development process needs to be done so that all aspects that have an impact can run efficiently. Nowadays, the ecotourism sector is one of the most

important sectors and the largest contributor to foreign exchange in Indonesia.

Given that Indonesia is in the spotlight of the world over the impact of the 2022 G20 (*Group of Twenty*) in Bali, which will certainly have an impact on the social and economic aspects of the community. Ecotourism infrastructure development can be used as an innovation that is applied in prioritizing managerial schemes that certainly pay attention to environmental, social and economic aspects. According to Inati and Salahudin (2022), ecotourism planning is an effective



strategy for solving problems with unproductive land use in the community by prioritizing various aspects responsibly between the community and the environment. Infrastructure is one of the important physical capitals that needs to be considered in the development of sustainable ecotourism. On the development side, infrastructure plays a role in increasing employment and social growth in the community. Infrastructure planning around the forest must be planned to maintain the sustainability of the forest to be managed. Inadequate infrastructure conditions will limit the potential of an area to develop in general. Especially in Bogor Regency, West Java according to *Jaelani et al. (2018)*, the potential for ecotourism in the region still needs to be improved in the infrastructure sector such as management access and road access so that areas that have tourism potential can develop and increase. In addition, this research is a follow-up study by *Fatahudin et al. (2021)* regarding infrastructure development planning for ecotourism areas in Bogor Regency, which explains that there is a need for infrastructure zoning arrangements to provide protection, use, and control of resources such as roads, waste management systems, and parking lots that are not yet adequate.

A spatial remote sensing approach in ecotourism infrastructure planning is needed to supports sustainable ecotourism development. One of the technologies that support the zoning planning of tourism potential is GIS technology. GIS (Geographic Information System) is a spatial tool that integrates computer-based geographic data processing (*Siregar et al. 2020*). GIS is also generally a system that works effectively with each other to enter, store, repair, update, manage, manipulate, integrate, analyze and display data in an information (*Annugerah et al. 2016*). GIS technology is needed in determining the interpretation of visual resources, land management, identification of suitable locations for infrastructure, and even classifying the suitability zone class for the planned infrastructure. In implementing infrastructure development in Bogor Regency, West Java, it is necessary to consider the characteristics of the region in determining the direction of decisions to be taken. Research that examines ecotourism infrastructure is very limited in the spatial method approach in Indonesia, this study has the potential to contribute to determining the direction of policy in tourism planning for the government. Therefore, this study aims to map the level of ecotourism suitability in Bogor Regency using a spatial approach and GIS technology.

METHODOLOGY

Location and Time of Research

This research was conducted on December 5-15, 2022, with a tourist area development plan located in Bogor Regency, West Java. This location was chosen based on the many potential accesses that exist in Bogor Regency as a tourist destination that still need to be improved in evaluating its application.

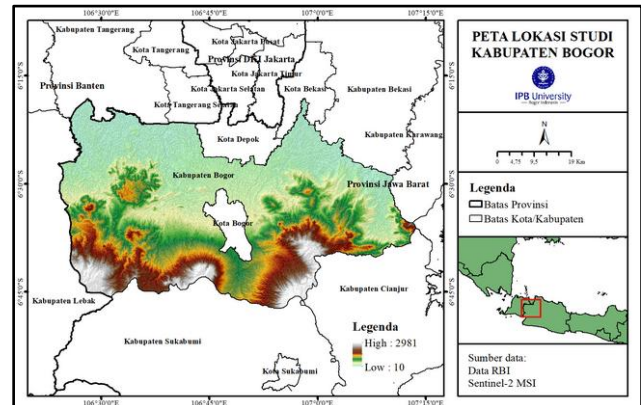


Figure 1. Research location

Concept and Research Model

The research was conducted by analyzing suitability zones based on zoning carrying capacity such as geological units, soil types, contours, distance from river bodies, slope, aspect, elevation, land use, distance from roads, and distance from residential areas. After the suitability zone is done, the data is classified into classes based on the data needed. The research flow of thought is presented in the flow chart in Figure 2.

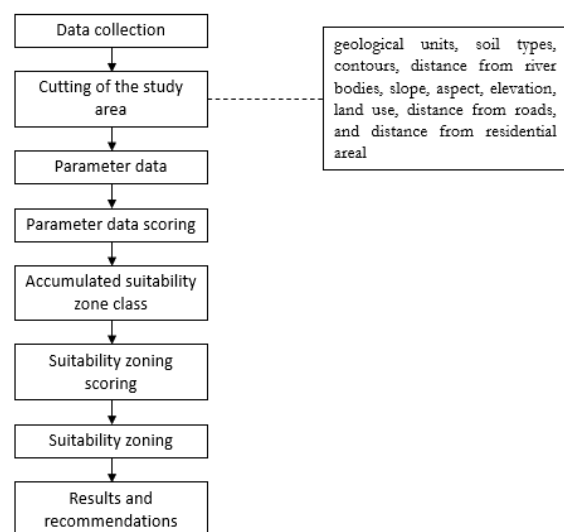


Figure 2. Research flow chart

Table 1. Parameter descriptions and their uses

No	Parameter	Data resource	Data usage
1	Distance from water body	Rupa Bumi Indonesia (RBI), Indonesia Geospatial Agency (BIG)	Determine ecotourism attractions related to water bodies
2	Slope	Digital Elevation Model (DEM) - Indonesia Geospatial Agency (BIG)	Analyze the convenience of ecotourism visitor accessibility, scenic beauty and topographic conditions to determine the type of ecotourism.
3	Aspect	Digital Elevation Model (DEM) - Indonesia Geospatial Agency (BIG)	Determining the timing of ecotourism operations and influencing the microclimate of ecotourism sites
4	Elevation	Digital Elevation Model (DEM) – Indonesia Geospatial Agency (BIG)	Affects the scenic beauty and visibility of the local landscape
5	Land use	Penggunaan Lahan 2019, Ministry of Forestry of Indonesia	Affects ecosystem service potential related to ecotourism
6	Distance from the road	Rupa Bumi Indonesia (RBI), Indonesia Geospatial Agency (BIG)	Affects the ease with which visitors can reach the ecotourism site
7	Distance from settlements	Rupa Bumi Indonesia (RBI), Indonesia Geospatial Agency (BIG)	Ensure resilience of ecosystem service provision

Modified from Guerrero et al. (2020)

Data Collection

Data collection uses a literature study method from several sources of information from research results, studies, and institutions. The literature review used is the scoring of spatial variables that affect the suitability of ecotourism. In addition, spatial variables such as river maps, highways, land use are taken from the Geospatial Information Agency (BIG) while slope and elevation data are taken from DEMNAS (table 1). Furthermore, the data is analyzed to determine the level of suitability and carrying capacity of the ecotourism area in order to produce a zoning of the ecotourism area to be managed which will be used according to the conditions of the study area used..

Data Processing

Ecotourism suitability zoning mapping is carried out using geospatial modeling as a tool to identify the infrastructure sector. The geoenvironmental model in ecotourism is compiled through four steps, namely data collection, mapping parameter data processing, scoring or weighting per parameter data, and accumulation of suitability zoning classes and ecotourism potential. The results of the zoning class are then analyzed in terms of the infrastructure sector based on literature studies to produce recommendations related to the ecotourism infrastructure sector in Bogor Regency.

The geoenvironmental model used in the research is composed of seven parameters, namely distance from water bodies, slope, aspect, elevation, land use, distance from roads, and distance from settlements. Materials and sources for each parameter are presented in Table 1. Geospatial information from remote sensing (Table 1) for each parameter was processed using Arcmap 10.5 software. Numerical tables and graphs were processed using Microsoft Excel.

The use of multiple cartographic products in a GIS requires standardized values based on mathematical weights, resulting in a class for each parameter (Malczewski and Rinner 2015). Parameter class standardization defines factor values that are adequate for a common scale for comparison. The class standardization used in the research is based on the research of Guerrero *et al.* (2020), which is divided into four zones according to land suitability for implementing ecotourism practices, namely low (1), medium (2), high (3), and very high (4). The attributes analyzed for each parameter are presented in Table 2. According to this source, the variables that influence the suitability of ecotourism are distance to water body, slope, aspect, elevation, land use, distance from the road, and distance to settlement.

Table 2. Attributes and parameter assessment

Parameter				
Value	Z1 Low	Z2 Moderate	Z3 High	Z4 Very High
Distance from water body	>500 m	300-500 m	150-300 m	0-150 m
Slope	25-35%	15-25%	3-15%	0-3%; >35%
Aspect	West, East	Southeast, Southwest	Northwest, South	North, Northeast
Elevation	<550 m	550-650 m	650-750 m	0-750 m
Land use	Open land, dryland farming, mixed dryland farming, rice field, airport, harbor, mining, secondary dryland forest, plantation, settlement	Farm	Scrub	Primary dryland forest, water bodies
Distance from the road	>1500 m	750-1500 m	350-750 m	0-350 m
Distance from settlements	>1000 m	500-1000 m	300-500 m	0-300 m

Modified from Guerrero et al. (2020)

After the zoning of ecotourism potential and suitability is produced, further checking of the infrastructure sector in each zone is carried out using literature studies such as journals, government data, and related news. Based on these checks, recommendations can be made relating to the implementation of ecotourism activities in Bogor Regency.

RESULTS AND DISCUSSION

Assessment of suitability parameters

The results of modeling each parameter used to model the suitability zone and ecotourism potential of Bogor Regency are as follows:

Distance from water body

Water is one of the most important elements in development in order to fulfill primary needs to determine the attractiveness of ecotourism. In addition to determining the attractiveness of ecotourism, analyzing the distance from the water body to the procurement destination will affect the infrastructure facilities that will support ecotourism to meet the

standard needs of visitors. the level of ecotourism suitability is influenced by the distance to the water body. The map of the distance to the water body is shown in Figure 3, while the area of each zone is presented in Table 3.

Table 3. Area of parameter zone distance from water body

No	Area (ha)	Percentage (%)
1	58.102,84	19,07
2	57.787,12	18,97
3	75.050,24	24,64
4	113.691,23	37,32
Total	304.631,44	100

Slope

Slope is the ratio between the height difference (vertical distance) of a land and its horizontal distance

(Yumai *et al.* 2019). Areas with flat slopes are considered suitable for ecotourism because of their easy accessibility. In addition, areas with high slopes are also considered favorable because they have typical topographic conditions such as waterfalls and have beautiful scenic value.

Aspect

Aspect data spatially indicate the places with the highest solar incidence in a landscape, which directly regulates the local microclimate (Francisca *et al.* 2012). In the case of the study area, areas towards the north and northeast are areas with high solar insolation and thus have the best conditions for local ecotourism.

Elevation

Elevation is a measure of the height of a place or location measured from sea level (Darmawan *et al.* 2017). Elevation parameters are very important to consider because they describe the scenic beauty of an ecotourism site and affect the viewing distance of the local landscape.

Land use

Land use is the allocation of a land function and needs to be considered in ecotourism suitability zones to see the potential ecosystem services that can be offered.

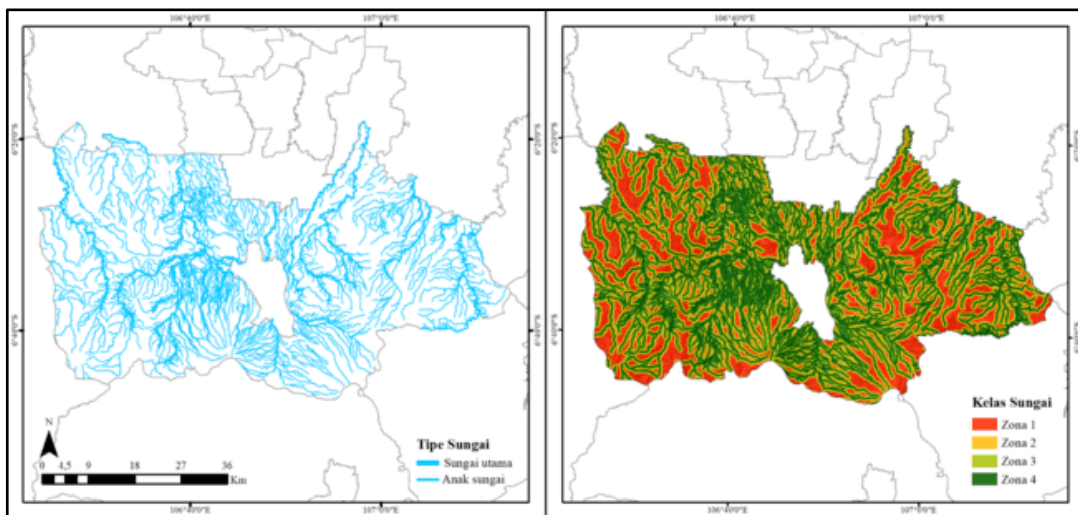


Figure 3. Zone analysis of distance from water bodies parameter

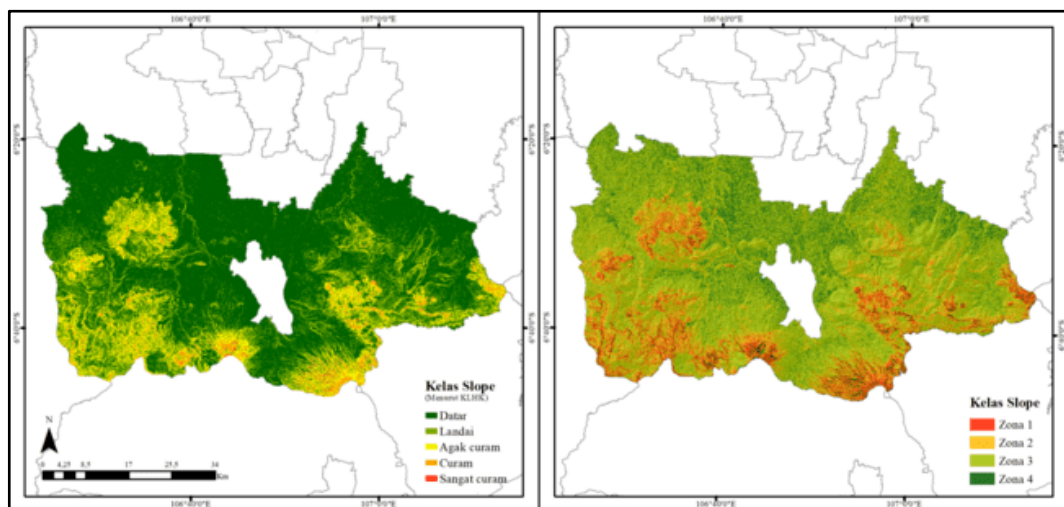


Figure 4. Zone analysis of slope parameters

Table 4. Slope parameter zone area

No	Area (ha)	Percentage (%)
1	21.072,67	6,92
2	48.692,19	15,98
3	190.281,09	62,46
4	44.585,49	14,64
Total	304.631,44	100

Table 5. Aspect parameter zone area

No	Area (ha)	Percentage (%)
1	9.315,72	3,06
2	75.613,02	24,82
3	17.331,69	5,69
4	202.371,01	66,43
Total	304.631,44	100

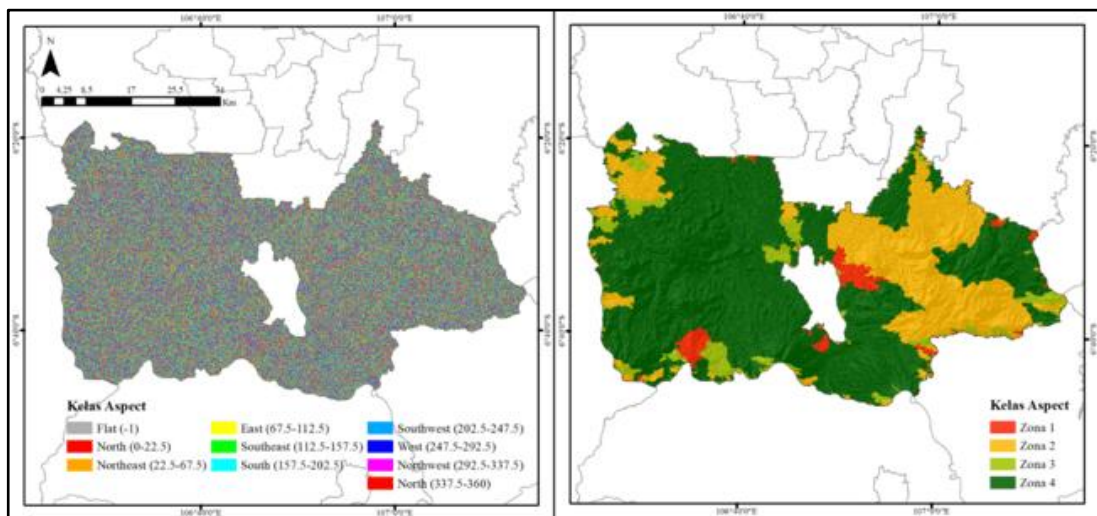


Figure 5. Zone analysis of aspect parameters

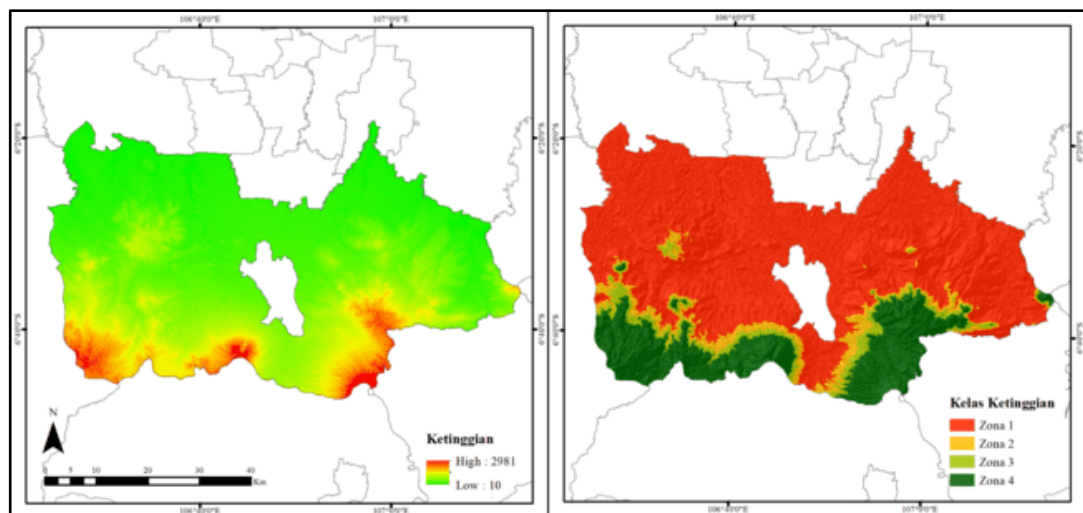


Figure 6. Zone analysis of elevation parameters

Table 6. Elevation parameter zone area

No	Area (ha)	Percentage (%)
1	218.788,21	71,82
2	18.031,79	5,92
3	13.177,82	4,33
4	54.633,63	17,93
Total	304.631,44	100

Table 7. Land use parameter zone area

No	Area (ha)	Percentage (%)
1	301.77,44	99,13
2	-	-
3	233,81	0,08
4	2.420,18	0,79
Total	304.631,44	100

Table 8. Distance from road parameter zone area

No	Area (ha)	Percentage (%)
1	70.644,58	23,19
2	54.715,74	17,96
3	60.926,67	20,00
4	118.344,45	38,85
Total	304.631,44	100

Table 9. Area of zone parameter distance from settlements

No	Area (ha)	Percentage (%)
1	188.938,59	62,02
2	32.380,42	10,63
3	41.446,84	13,61
4	41.865,59	13,74
Total	304.631,44	100

Table 10. Area of suitability zones and ecotourism potential in Bogor Regency

No	Area (ha)	Percentage (%)
1	0,19	0,00006
2	65.227,7	21,41
3	235.940,06	77,45
4	3.463,49	1,14
Total	304.631,44	100

Distance from roads

The ease with which visitors can reach the ecotourism site will affect the number of visitors and the income earned so that it becomes one of the important factors that need to be considered.

Distance from residential area

Sustainability needs to be considered to maintain sustainable ecotourism management from an existing economic and ecological perspective. An analysis of the distance from settlements to ecotourism is carried out to determine management, visitor access, and ensure the resilience of ecosystem service provision by considering the influence of communities around ecotourism.

Accumulated ecotourism suitability and potential zoning

The parameters of the geoenvironmental model were normalized using a numerical allocation process with the transition zone attributes of each data to obtain ecotourism attraction zones divided into several classes. The research area is identified in the order of the zone from the smallest (worst) to the largest (best) which aims to describe an area related to infrastructure planning decisions in the zone. The accumulated suitability zone (table 10) has an area from smallest to largest, namely zone 1 (0.00006%), zone 4 (1.14%), zone 2 (21.41%), and zone 3 (77.45%), which indicates that the Bogor district area has good ecotourism potential dominated by zone 3, which covers 235,940.06 ha. The large area of ecotourism potential in Bogor Regency must be balanced with the establishment of supporting infrastructure that is

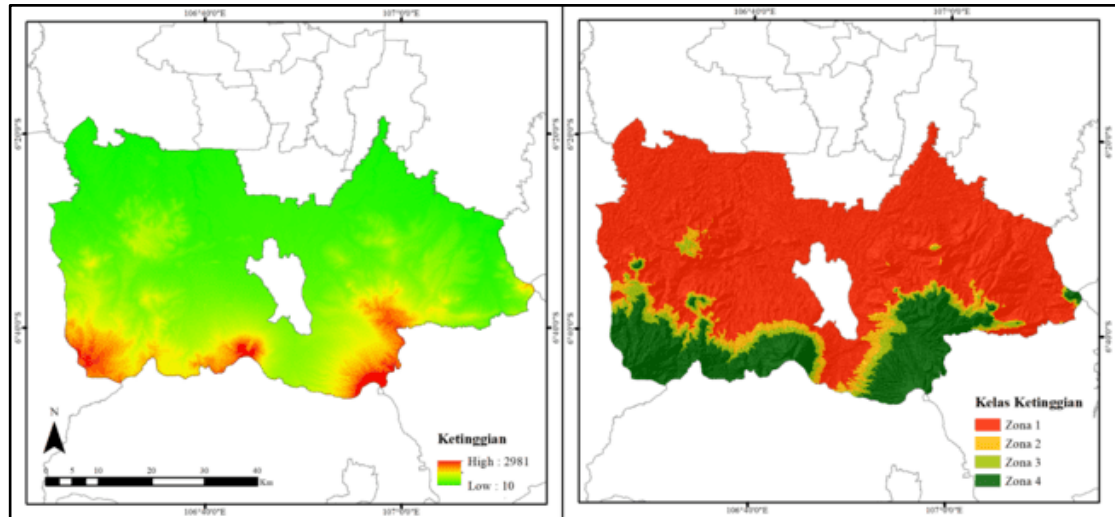


Figure 6. Zone analysis of elevation parameters

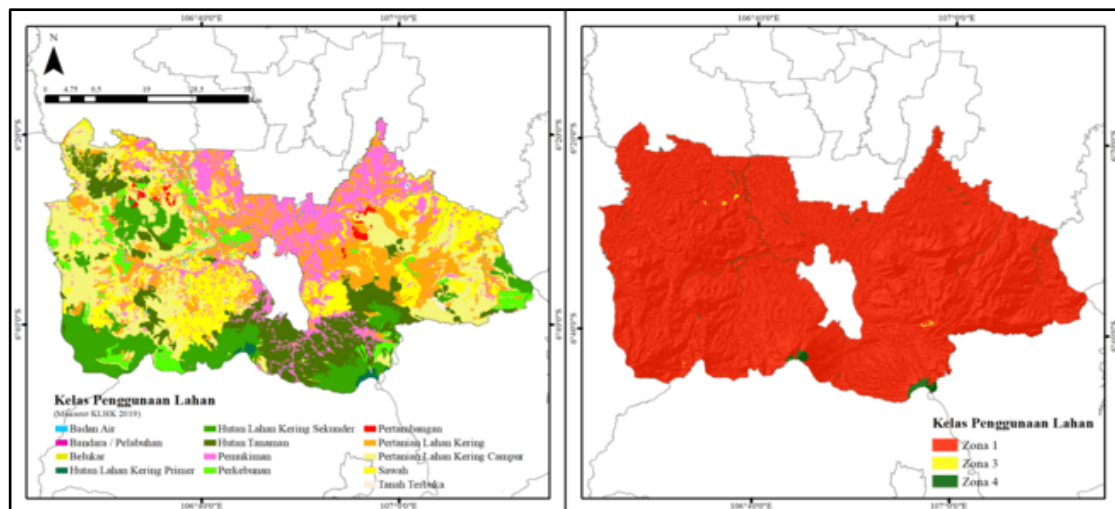


Figure 7. Zone analysis of land use parameters

certainly in accordance with the geoenvironmental conditions in the zone.

Ecotourism suitability and potential in each zone

Zone 1 – Low ecotourism suitability and ecosystem service potential

Zone 1 indicates areas where the utilization of ecosystem services provided by ecotourism features is inadequate. This area occupies 0.0006% or 0.19 hectares of the study site (Picture 10), and the main characteristic of the area is the fragility of its geoenvironmental structure, mainly due to its vulnerability to flooding and landslides. In addition, one factor that proves the inability of this area for

ecotourism is that no active tourist attraction has been identified there, either by local government inventories or related news.

Zone 1 is located in part of Cileuksa Village, Sukajaya Sub-district and this village is one of the villages in Bogor District that directly borders Banten Province. Prihartini et al. (2021) mentioned that Cileuksa Village is vulnerable to floods and landslides. In early 2020, Cileuksa Village became the worst flood-affected area in Bogor Regency because it was part of the red zone, which means that the affected area cannot be reoccupied after a disaster. This area has low elevation and geological formations with fragile soils on slopes. The results of the Cereda and Rohn (2014) study show that areas with these characteristics have high

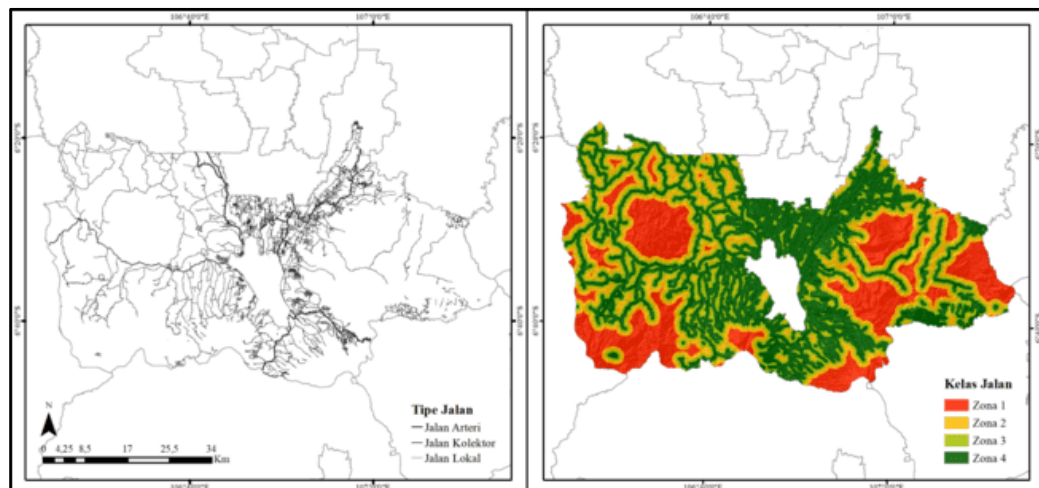


Figure 8. Zone analysis of distance from road parameters

environmental vulnerability related to erosion processes, posing a risk if tourism infrastructure is destroyed.

Zone 2 – Ecotourism suitability and ecosystem service potential are moderate

Zone 2 covers 21.41% or 65,227.7 hectares of the total study area. The spatial distribution of this zone is spread throughout the study area, but the highest concentration is in the northeast to southeast and northwest to southwest (Picture 10). These areas are considered environmentally constrained due to their geoenvironmental characteristics (the majority of elevations are not very high, slopes tend to be low, and road access is not fully adequate). However, the area still has some potential for ecotourism.

The lower slope levels reflect the low likelihood of large waterfalls, river rafting and extreme sports. However, the landscape has potential for activities such as fishing, hiking and camping. In this zone, ecotourism objects that have been operating include Gunung Terung Puraseda Leuwiliang Bogor and Talaga Saat Puncak. This shows that even in moderate areas there are prospects for ecotourism exploration. However, due to the potential fragility of the land, mitigation measures should be designed for visitor safety and focused on mitigation with low environmental impact.

Zone 3 – High ecotourism suitability and ecosystem service potential

Zone 3 has a distribution of 77.45% or equivalent to 235,940.06 hectares of the Bogor Regency area

(Picture 10). This zone shows that a collection of factors that form a local geoenvironmental structure that reflects favorable conditions for the existence of tourist interest morphology. The structure of this zone consists of rolling hills, steep cliffs, and dissected lowlands; common geoenvironmental characteristics include relative proximity to water resources, good accessibility, and favorable geological formations. In this area, the presence of springs with landscape potential (Picture 13a), waterfalls (Picture 13b), rapids, and landscape contemplation areas (at the highest elevations) are prominent.

In terms of land use, this zone is dominated by agricultural and plantation landscapes, such as coffee, rice, rubber, and others whose utilization is still limited to production activities. Seeing the potential of the commodity, the landscape can be developed into ecotourism, one of which is the concept of sustainable agritourism. Palit *et al.* (2017) define agritourism as a series of tourism activities by utilizing the potential of agriculture and plantations as tourist objects, both in the form of panoramas, natural agricultural areas and the uniqueness and diversity of production activities and agricultural technology and the culture of the community. Agritourism activities can be packaged from cultivation to post-harvest activities by taking into account environmental and cultural values in each activity, so that agritourism can have a positive impact, both on the survival of local communities and the surrounding environment.

One of the agro-tourisms in Bogor Regency that has existed for the past two decades is Kampoeng

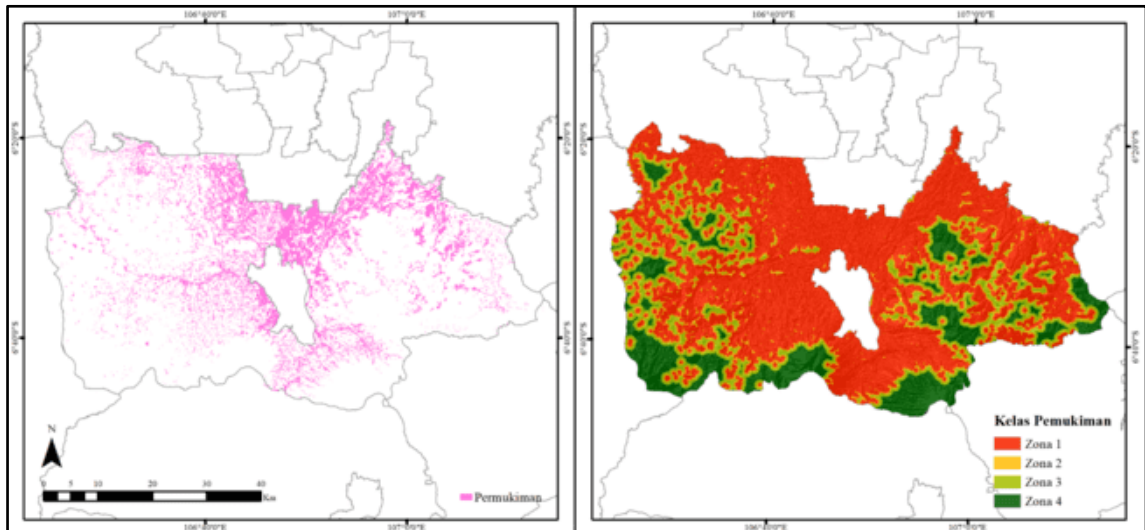


Figure 9. Zone analysis of distance from residential area

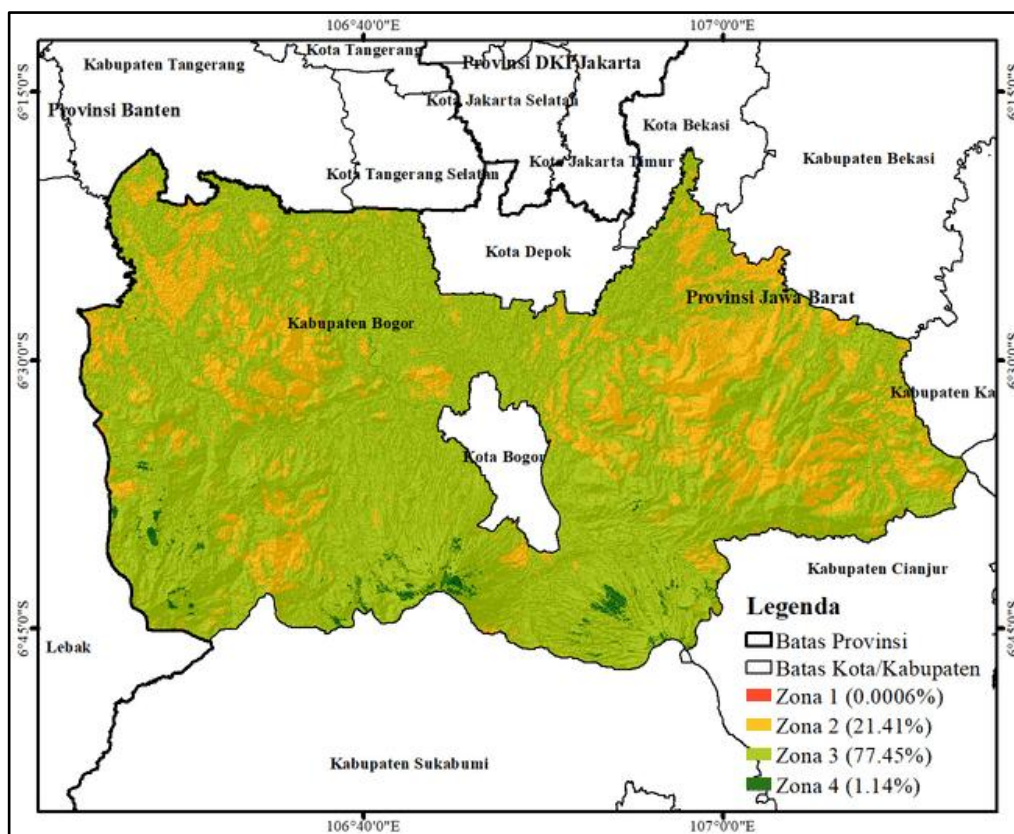


Figure 10. Map of suitability zones and ecotourism potential in Bogor Regency

Wisata Cinangneng. Priambodo (2022) said that this tourism focuses on Sundanese cultural education, maintaining Sundanese cultural wisdom, preserving the environment, and providing employment for local villagers. This shows that the development of the concept of agritourism in agricultural and plantation areas clearly shows clear evidence of economic

improvement, cultural preservation, and environmental quality in Bogor Regency.

Seeing that the greatest ecotourism potential is in Zone 3, the relevant stakeholders can utilize this potential as much as possible. The provision of appropriate infrastructure in Zone 3 is necessary and can be developed based on geoenvironmental

characteristics, in order to increase the productivity of ecotourism in Bogor Regency. In addition, intensive socialization and assistance to local communities regarding the concept of ecotourism are also needed to facilitate further strategies that can maximize the provision of ecotourism.



Figure 11. Cileuksa village after being affected by floods and landslides (Ali 2020)



Figure 12. (a) Terung Puraseda Mountain, Leuwiliang Bogor (Purwaningrum 2020), (b) Talaga Saat Puncak (Detiktravel 2022)



Figure 13. (a) Taman Safari Indonesia (Echi 2018), (b) Curug Ciampea (Ratih 2022)



Figure 14. (a) Kawah Ratu (Sastri 2021), (b) Curug Cibadak (Yodik 2022)

Zone 4 – Very high ecotourism suitability and ecosystem service potential

Zone 4 represents areas with very high potential for the provision of ecosystem services for ecotourism across the landscape and covers 1.14% of the study area or equivalently to 3,463.49 hectares (Picture 10). The structural composition of this zone includes natural landscapes that promote scenic beauty, such as high waterfalls and recreational spaces (peaks and plateaus), natural land uses (forests and water bodies), easy accessibility for visitors, proximity to usable water resources, and unique surface geological formations (e.g. craters) as ecotourism attractions.

Based on observations, the low provision of ecotourism in this zone is not due to low local ecotourism potential, but rather due to the high level of anthropization, where the landscape consists mostly of extensive plantations and agriculture, which directly affects the geoenvironmental model applied. In addition, there is still a lot of tourism potential that has not been managed optimally due to the lack of human resource capabilities and supporting infrastructure, such as road access and supporting buildings. Based on a study conducted by Rahayuningsih and Muntasib (2012), human resources in the development of ecotourism in Bogor Regency is one component that still needs a lot of improvement and development. Things that need to be improved by related stakeholders include increasing the understanding of bureaucrats and the surrounding community towards ecotourism and community-based tourism. Both parties need to equalize their perceptions of the concept of ecotourism, so that the acceptance of support from the parties, especially bureaucrats, towards community-based tourism development efforts will be better. Areas that have the potential to be developed as ecotourism in this zone require the development of sustainable environmental management instruments and adequate infrastructure, so as to create a more harmonious relationship between local communities and sustainable development. Therefore, a more in-depth study with a larger and more detailed cartographic breakdown is recommended for zones 3 and 4 to enable a more efficient analysis of what types of ecotourism can be applied and the design of appropriate infrastructure in each mapped area.

Infrastructure in ecotourism

Infrastructure is a basic right in ecotourism development that will determine the sustainability of resources for ecotourism itself. This is in line with [Azkadinitra and Koswara \(2019\)](#), who state that the infrastructure of a place will affect the behavior of the surrounding community directly or indirectly. The relationship between infrastructure development and ecotourism is interdependent. Good infrastructure can support progress in terms of economic, social and resources for the welfare of the community. If the infrastructure to reach tourism in the village is very minimal, it will be difficult to increase visitors in an ecotourism area. For example, in the research of [Azkadinitra and Koswara \(2019\)](#), it is explained that the distance parameter from settlements in Atas Angin State Tourism, Bojonegoro affects the number of visitor access because the distance between tourism and the community results in poor ecotourism management such as signs and damaged roads to boring road access. In addition, in the research of [Rediteani and Setiawina \(2018\)](#) they discuss the case of length of visit in Denpasar City, Bali which is caused by the slope parameter exposed to sunlight (aspect), one of which results in many resorts or hotels. The infrastructure is made because of the many tourists or visitors who come to see the view of the sunset, which of course will have an impact on economic growth and community behavior.

Infrastructure in the development of ecotourism in Bogor Regency

The development of ecotourism requires in-depth analysis to determine the right strategy for developing ecotourism. The analysis of zoning suitability produces recommendations for ecotourism development, especially in the aspect of infrastructure. This is important so that ecotourism can be sustainable in ecological, economic and socio-cultural aspects. Each ecotourism zone from zone 1 to zone 4 has its own advantages and disadvantages both in terms of facilities and infrastructure, accessibility and attractiveness of the ecotourism attractions offered. This is the basis for determining the infrastructure recommendations given for each zone except zone 1 because as explained in the previous sub chapter this zone is not suitable to be used as an ecotourism site. Zone 1 generally has a low carrying capacity due to topography and soil conditions that can cause environmental damage.

Ecotourism in zone 2 of Bogor Regency ecotourism, a case study of Gunung Terung Puraseda Leuwiliang Bogor and Telaga Saat Puncak was taken. Gunung Terung Puraseda Leuwiliang Bogor presents a very beautiful view that invites passing motorists to stop for a moment and take photos or just sit in a shop to enjoy the view while drinking coffee. Unfortunately, this is the only thing that can be done at the location so it lacks attractiveness to attract visitors. In addition, the unavailability of toilets is also a shortcoming of this ecotourism. So that the infrastructure recommendations provided are to increase attractiveness through the attractions offered such as by adding outbound and paragliding tours. In addition, it is necessary to complete facilities and infrastructure, for example building toilets to ensure the comfort of ecotourism visitors. The second case study is Telaga Saat Puncak. Telaga Saat Puncak is one of the most popular ecotourism sites located in the Puncak area, Bogor. This ecotourism site was officially opened on October 28, 2018. As one of the ecotourisms in Zone 2, this place has quite a lot of attractions such as camping, picnicking, boat rides, and taking pictures. In fact, it is not uncommon for some to do pre-wedding photos here. However, the available facilities are very minimal, including toilets, parking areas, gazebos and food stalls. So it is necessary to build other facilities to support ecotourism activities, especially prayer rooms. Another obstacle in this ecotourism place is the difficulty of accessibility to reach the location, the main road that must be passed to reach this area is very steep, full of rocks, narrow (only enough for one car) and on the left and right there is a ravine which is one of the obstacles to this ecotourism developing because not many visitors can pass the road. So to overcome this, it is necessary to build a better and stronger road to support the load on it because if it is not strong it is feared that landslides will occur and injure visitors. In addition, the rise of illegal levies (extortion) causes many visitors to discourage coming to this place. Even after being asked for the entrance fee, visitors are also charged again to be able to enjoy the view of Telaga Saat Puncak. For this reason, it is necessary to improve the payment system in this place and eradicate those who practice extortion.

Furthermore, zone 3 took a case study of Curug Ciampea and Taman Safari ecotourism. Curug Ciampea is one of the ecotourisms in Bogor Regency, precisely

in Tapos 1 Village, Tenjolaya District (Hanafi 2020). (Hanafi 2020) also added that Curug Ciampea has a large carrying capacity from the socio-economic aspect and attractiveness to be used as an ecotourism destination. With this large carrying capacity, the ecotourism activities that can be carried out there also vary from swimming, diving in the Green Lagoon and Leuwi Ngumpet, to hammocking placed around the trees near the waterfall (Ratih 2020). However, Curug Ciampea is still considered lacking in the aspect of accessibility because the path to the waterfall is very small and not well maintained, resulting in a high risk to visitor safety. In addition, the road taken is quite far, which is about 1.5 km from the vehicle parking lot. Therefore, it is necessary to repair and widen the path in order to ensure the safety of visitors passing through it. The second case study is Telaga Saat Puncak. Telaga Saat Puncak is one of the most popular ecotourism sites located in the Puncak area, Bogor. This ecotourism site was officially opened on October 28, 2018. As one of the ecotourisms in Zone 2, this place has quite a lot of attractions such as camping, picnicking, boat rides, and taking pictures. In fact, it is not uncommon for some to do pre-wedding photos here. However, the available facilities are very minimal, including toilets, parking areas, gazebos and food stalls. So it is necessary to build other facilities to support ecotourism activities, especially prayer rooms. Another obstacle in this ecotourism place is the difficulty of accessibility to reach the location, the main road that must be passed to reach this area is very steep, full of rocks, narrow (only enough for one car) and on the left and right there is a ravine which is one of the obstacles to this ecotourism development because not many visitors can pass the road. So to overcome this, it is necessary to build a better and stronger road to support the load on it because if it is not strong it is feared that landslides will occur and injure visitors. In addition, the rise of illegal levies (extortion) causes many visitors to discourage coming to this place. Even after being asked for the entrance fee, visitors are also charged again to be able to enjoy the view of Telaga Saat Puncak. For this reason, it is necessary to improve the payment system in this place and eradicate those who practice extortion.

The second case study in Zone 3 is Taman Safari, which is an environmental science-based ecotourism site that focuses on animal habitats in the wild. The

number of visitors is increasing every year. This is due to its unique attraction where visitors can travel around to various places using private cars and tourist trains provided while seeing all kinds of animals and feeding them. The facilities available here are very complete such as accommodation, restaurants, toilets, prayer rooms, to souvenir shops for incentive travel needs (Rossi 2020). Based on all these advantages, it is not surprising that this place is included in zone 3 in the ecotourism zone suitability analysis. Although the location of ecotourism is considered good, it still causes other losses felt by the local community, especially after the land conversion in the context of developing Taman Safari. Land conversion causes environmental damage in the form of non-functioning water catchment areas due to the presence of buildings in the form of lodging (hotels, villas, etc.). In addition, it also resulted in reduced agricultural land and worsened access to forests because the Safari Park converted forests, thus limiting community access to utilize forest products (Halumiah *et al.* 2014). Thus, it is necessary to carry out a strategy to prevent land conversion through cooperation with the government to curb the construction of ecotourism supporting facilities such as hotels, villas and other facilities around Taman Safari. Finally, the case studies in zone 4 are Kawah Ratu and Curug Cibadak. Kawah Ratu is one of the ecotourism sites located in the highlands of Hutan Gunung Salak, precisely in Pasir Reungit Village, Bogor Regency (Hasibuan 2017). The eruption of Gunung Salak formed a crater with a high sulfur content. Some visitors sometimes use this sulfur as a natural mask on the body and face. The beauty of Kawah Ratu is unquestionable, with many irregularly located rocks, toska-colored crater water and white smoke around the crater adding to the beauty and charm of this place, especially when immortalized through a camera. Activities that can be done at Kawah Ratu include visitors can camp in the area that has been provided, of course far from the crater because it will have bad consequences if inhaling sulfur for a long time and can soak in hot springs which are located not far from the crater. (Ratih 2020), to be able to reach the location, it is necessary to trek as far as 3.6 km or about 2-3 hours. In taking this path, of course, you need adequate food and drink supplies, especially since there is a very steep path with a 90-degree slope. Therefore, in order to prevent visitors from lacking provisions or needing

something while traveling and to increase income, stalls should be built around the trekking track.

The second case study in zone 4 is Curug Cibadak. Curug Cibadak is located in Loji Village, Cigombong District. Besides being able to enjoy the beauty of the waterfall between the cliffs in the valley of Gunung Salak, there is also an eagle breeding area and a campground. The eagle breeding area, better known as "Loji", is located about 300m from the campground. There are three types of eagles in captivity including the Brontok Eagle, Bido Snake Eagle and Javanese Eagle. In terms of accessibility, it is considered quite good. Unlike waterfalls in zones 2 and 3, the path to access the location is quite safe and well-maintained although there is still an uphill path. However, there is a bridge made of wood to reach the location. According to [Setiadi et al. \(2021\)](#) bridges with wood material have shortcomings in terms of durability and durability, extreme temperatures and weather can cause wood to weather while good quality wood is now decreasing in availability, so another alternative is to build bridges using stronger materials such as steel and iron. If you continue to use wood, you need strict supervision and selection of the wood used and need to check the bridge regularly so that it can be immediately recognized if there is damage.

CONCLUSIONS

GIS technology can be used in determining visual resource interpretation, land management, identification of suitable locations for infrastructure, and classification of suitability zone classes for planned infrastructure. GIS helps in the processing of numerical data integrated with identified geoenvironmental parameters. Analysis of ecotourism development zoning is divided into 4 classes that determine the suitability and potential of good and bad ecotourism. Bogor Regency is dominated by Zone 3 with an area of 235,940.06 ha or 77.45%. Most of the areas that have Zone 4 are in the highlands such as the Mount Gede and Pangrango areas. Areas that have zone 4 have the potential to be developed such as environmental management instruments so that harmonious sustainable land management is created. of the total area which shows that the Bogor Regency area has great ecotourism potential that can be supported by adequate infrastructure development planning.

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