The Land Cover Change Effect for Javan Rhinoceros Site Suitability

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ABSTRACT:
The Javan rhinoceros (Rhinoceros sondaicus) is one of the endemic animals in Java, Indonesia, which is currently threatened with extinction and is included in the 25 species program as the top priority for the Indonesian government. In 2021 the Indonesian Ministry of Environment and Forestry said that only 75 Javan rhinos remained in Ujung Kulon National Park in Banten Province. Ujung Kulon National Park is the primary habitat of the Javan rhino, so it requires special attention to protect this habitat. One of the reasons for the reduced population of the Javan rhinoceros is the diminishing availability of habitat. Habitat reduction occurs due to changes in land cover due to human activities. This study aims to identify changes in the habitat suitability of the Javan rhinoceros due to human pressure. Parameters of human pressure will be identified using changes in land cover in 2000 and 2018. Remote sensing and GIS technology will be used to monitor habitat suitability for endemic animals over a large area and a long time. The Javan rhino habitat suitability analysis in 2000 and 2018 will integrate geographical, environmental, and meteorological parameters. The MCDA (Multi-Criteria Decision Analysis) method will determine a decision from several suitability parameters. Based on observations of human activities parameters, there have been significant changes to land cover from 2000-2018, especially in residential areas, which negatively impacted the suitability of the Javan Rhino's habitat. The results of this study can identify priority areas that require protective action for the Javan Rhinoceros habitat. This research is expected to be the basis for protecting endangered endemic animals, especially the Javan Rhinoceros, so their habitat is preserved.

1. INTRODUCTION

Currently, Indonesia is experiencing an increase in its population every year. Based on statistical data from 2020-2022, the population growth rate in Indonesia is above 1% annually (BPS, 2022; Ihsan et al., 2022). One of the impacts of this population increase is changes in land cover (Biedemariam et al., 2022; Bucała, 2014). The growing population will drive the need for residential land, resulting in changes in land cover. Furthermore, other changes in land cover may occur due to human activities, leading to land use conversion.

The impacts of these land cover changes pose a threat to various aspects of the Earth's ecosystem, such as food security and agriculture (Virtriana, et al., 2022; Virtriana, et al., 2022), ecosystem services (Wu et al., 2020), natural disasters (Adnan et al., 2020; Tollan, 2002), climate change (Mantyka-Pringle et al., 2015), loss of wildlife habitats (Kessler et al., 2009; Plieninger, 2006), and others. One of the endangered species due to human pressures is the Javan Rhinoceros. The Javan Rhinoceros is an endemic animal to Java Island (Indonesia) and is currently listed as critically endangered by the Ministry of Environment and Forestry KLHK, (2021). In fact, as of 2021, KLHK (2021) reported that there are only around 75 Javan Rhinoceros individuals remaining in their original habitat.

There have been several previous studies related to the suitability of Javan Rhinoceros habitat. The first study is by Rahmat et al., (2008), which analyzed the suitability of Javan Rhinoceros habitat by observing the presence of Javan Rhinoceros at a certain location using linear regression method. The second study is conducted by Riba'i et al., (2015), which modeled the suitability of Javan Rhinoceros habitat using the Multi-Criteria Decision Analysis (MCDA) method in Cikepuh Wildlife Sanctuary, Banten, at a specific time. The third study is by Sumunar et al., (2019), which investigated the suitability of Javan Rhinoceros habitat in Ujung Kulon National Park using GIS method at a specific time.

Based on previous research, this study will focus on the impact of land cover changes on the loss of Javan Rhinoceros habitat, particularly in the Banten province . This study will identify the changes in Javan Rhinoceros habitat in the Banten Province in the years 2000 and 2018. The study will integrate various parameters, including geographic, environmental, and meteorological parameters, to identify the suitability of Javan Rhinoceros habitat at two different time periods. This study aims to determine the degraded areas of Javan Rhinoceros habitat over the past 18 years, providing a basis for the conservation of Javan Rhinoceros habitat in the future.

2. METHODOLOGY

2.1 Study Area

The study area is the province of Banten, located on the island of Java, Indonesia. The selection of this research area is due to the fact that the largest Javan Rhino conservation area in Indonesia is located in the province of Banten, specifically in the Ujung Kulon area.

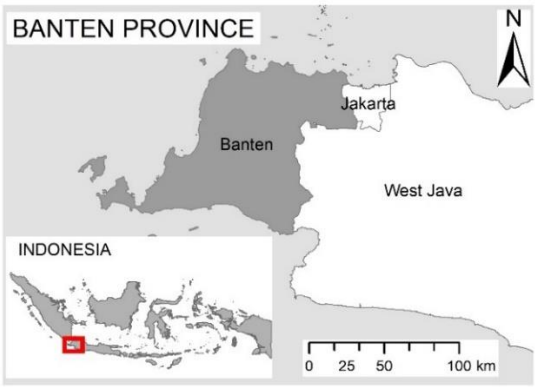

Figure 1. Study area

2.2 Data

The data used in this study can generally be seen in Table 1. The land cover data is obtained from the Ministry of Environment and Forestry (KLHK, 2022) with a data scale of 1:250,000 and temporal data for the years 2000 and 2018. This land cover data will be used to calculate land cover changes that occur in the Banten region. Administrative data is obtained from the National Geospatial Information Agency (BIG, 2022) with a data scale of 1:250,000 and temporal data for the year 2017. The administrative data serves as the boundary for the study area. The Digital Elevation Model (DEM) will use data from the Shuttle Radar Topography Mission (SRTM) with a spatial resolution of 30 m and a temporal resolution of 2008 (Jarvis et al., 2008). Temperature data will be obtained from the NASA EOSDIS Land Processes DAAC with a spatial resolution of 1 km and an 8-day temporal resolution for the years 2000 and 2018 (Wan et al., 2021). Soil pH data will use data from (Hengl, 2018) with a spatial resolution of 250 m and temporal data for the years 2000 and 2018. Similar to the spatial and temporal resolution of soil pH, NDVI data will be obtained from the NASA EOSDIS Land Processes DAAC (Didan, 2021). River data will be extracted from (BIG, 2022) with a scale of 1:50,000. Lastly, road data will be obtained from OpenStreetMap (OSM, 2022). The land cover data, DEM, temperature, soil pH, NDVI, rivers, and roads will be used for the analysis of Javan Rhinoceros habitat suitability in Banten. It is assumed that the administrative data, DEM, rivers, and roads have different temporal resolutions compared to other data or the study period because they are assumed to be static data that do not change over a certain period of time.

No	Data	Resolution	Temporal	Reference
1	Land Cover	1:250,000	2000-2018	(KLHK, 2022)
2	Administrative Data	2017	1 : 250.000	(BIG, 2022)
3	DEM	30m	2008	(Jarvis et al., 2008)
4	Temperature	1 Km	8 days average, 2000-2018	(Wan et al., 2021)
5	Land pH	250 m	2000-2018	(Hengl, 2018)
6	NDVI	250 m	2000-2018	(Didan, 2021)
7	River	1:50,000	2012	(BIG, 2022)
8	Road	-		(OSM, 2022)

Table 1. Data

2.3 Methods

In determining changes in the level of suitability for Javanese ?rhino?bada, there are several stages carried out. The main stage in this study is to determine the appropriate location using multi-criteria analysis. In multi criteria analysis will be integrated several different years of data to obtain the level of suitability for the Javan rhinoceros. In general, the method used can be seen in Figure 2.

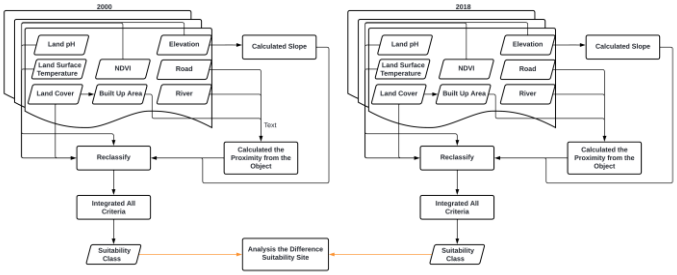

Figure 2. General Methodology

2.3.1 Land Cover Change

The method for analyzing land cover changes will use overlay analysis, as illustrated in Figure 3.

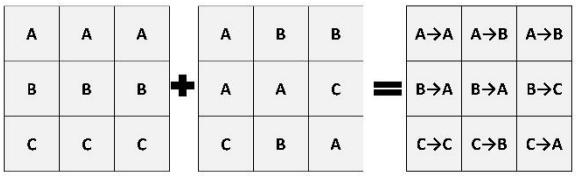

Figure 3. Overlay Analysis for GIS Data

Before conducting the overlay analysis, the land cover data (KLHK, 2022) needs to be simplified by reclassifying it. Generally, the reclassification of land cover data will involve 8 classes, including forest protected area, built-up area, meadow, plantation, wetland farming, dryland farming, and water body. Subsequently, this study will assign symbols to each land cover class, as illustrated in Table 2.

No	Land Cover	Symbol
1	Forest	F
2	Protected Area	PA
3	Built-Up Area	BA
4	Meadow	M
5	Plantation	PL
6	Wetland Farming	WF
7	Dryland Farming	DF
8	Water Body	WB

Table 2. Land Cover Symbol

2.3.2 Site Suitability for Rhinoceros Sondaicus Habitats:

In determining the appropriate location will be carried out with a multi-criteria analysis method (Riba'i et al., 2015). There are 10 parameters used in this study, namely height, slope slope, distance from the beach, air temperature, soil pH, NDVI, land cover, distance from rivers, distance from roads, distance from settlements. Then each data will be classified based on the criteria taken. The criteria are determined based on previous research. The scoring for each parameter used can be seen in table 3. After all of the data have score, the next step integrated all of the data. Next stage is making the integrated data into 5 suitability classes.

No	Data	Criteria	Score	Reference
1	Eleveation	< 100 m 100-500 m >500 m	3 2 1	(Rahmat et al., 2008; Riba'i et al., 2015)
2	Slope	<4% 4-8% >8%	3 2 1	(Rahmat et al., 2008)
3	Distance from beach	<400 m 400-800 m >800 m	1 2 3	(Rahmat et al., 2008)
4	Temperature	26-29 ˚C 29-32 ˚C T<26 or T>32 ˚C	3 2 1	(Riba'i et al., 2015)
5	Land pH	4-5 6-7 <4 or >7	3 2 1	(Rahmat et al., 2008; Riba'i et al., 2015)
6	NDVI	>80% 40-80% <40%	3 2 1	(Riba'i et al., 2015)
7	Land Cover	Forest Non Forest	3 1	(Medhi and Saha, 2014; Mukherjee et al., 2020)
8	Distance from river	<1000 m 1000-2000 m >2000 m	3 2 1	(Suheri et al., 2014; Sumunar et al., 2019)
9	Distance from the road	>300 m 100-300 m <100 m	3 2 1	(Medhi and Saha, 2014; Mukherjee et al., 2020)
10	Distance from built up area	>2000 m 1000-2000 m <1000 m	3 2 1	(Medhi and Saha, 2014; van Merm, 2008)

Table 3. Site Suitability Parameter

3. RESULT AND DISCUSSION

3.1 Land Cover Change

Figure 4 shows the land cover data for the years 2000 and 2018, as well as the land cover change results from 2000 to 2018 in the Banten Province. Additionally, Table 4 presents statistical results on the area of land cover change from 2000 to 2018 in the Banten Province, presented in a change matrix. These statistical results indicate the area in square kilometers.

In Figure 4(a) and 4(b), significant changes can be observed in the land cover class of settlements or built-up areas. There has been an increase in settlements in the northern regions of the Banten Province. Furthermore, noticeable decreases can be observed in the forest class in the southern regions of the province. Over the 18-year period, the land cover classes that experienced a decrease in area were F, PA, WF, PL, and M, with consecutive decreases of 304 km^2 (14.78%), 19 km^2 (6.78%), 521 km^2 (29.34%), 108 km^2 (19.67%), and 177 km^2 (76.96%). On the other hand, several land cover classes experienced an increase in area, namely DF, BA, and WB, with increases of 340 km^2 (12.85%), 788 km^2 (64.80%), and 2 km^2 (1.67%).

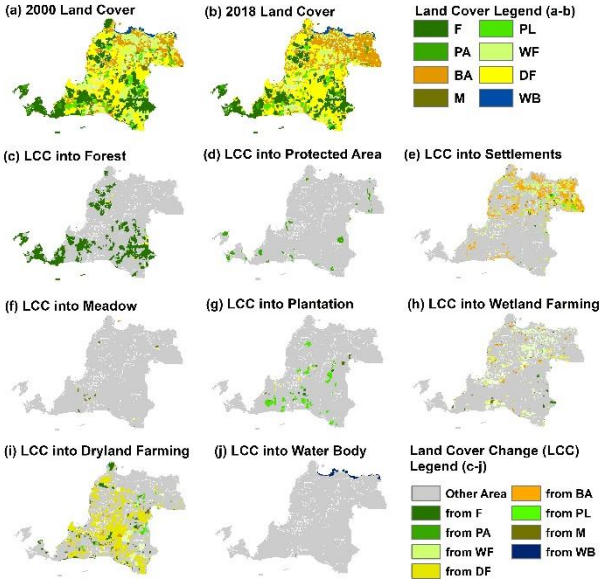

Figure 4. Land Cover and Land Cover Change 2000-2018

Figure 4(c), 4(d), 4(e), 4(f), 4(g), 4(h), 4(i), and 4(j) respectively show the changes from one land cover class to another, namely F, PA, BA, M, PL, WF, DF, and WB. In Figure 4(c), it is noticeable that there are many changes from DF class to F class, amounting to approximately 36 km^2. Figure 4(d) shows no significant changes, but from Table 4, it can be seen that some WF areas changed to PA, approximately 7 km^2. The changes to BA class in Figure 4(e) are quite significant, with the largest change occurring from WF class, approximately 529 km^2. Figure 4(f) does not show significant changes to the M class. Figure 4(g) indicates numerous changes from F, M, and DF classes to the PL class. Figure 4(h) shows the number of land cover classes that changed to the WF class, with the largest changes occurring from BA and DF classes, approximately 127 km^2 and 157 km^2, respectively. Furthermore, Figure 4(i) displays the changes to the DF class, with the largest changes occurring from F, PL, and WF classes, approximately 254 km^2, 118 km^2, and 339 km^2, respectively. Lastly, Figure 4(j) shows no significant changes in the WB class over the 18-year period.

		2018 (km^2)								
		F	**PA**	**BA**	**M**	**PL**	**WF**	**DF**	**WB**	**Total**
2000	**F**	1737	0	20	15	25	45	254	1	2097
	PA	1	251	8	0	0	9	10	1	280
	BA	1	1	997	4	0	127	86	0	1216
	M	0	0	42	24	40	25	99	0	230
	PL	9	0	60	0	354	8	118	0	549
	WF	9	7	529	0	0	882	339	10	1776
	DF	36	1	344	10	22	157	2076	0	2646
	WB	0	1	4	0	0	2	3	110	120
	Total	1793	261	2004	53	441	1255	2985	122	8914

Table 4. Land Cover and Land Cover Change Area 2000-2018

3.2 Site Suitability

In this study, the calculation of location suitability for Javan rhinos was carried out in two different years, namely 2000 and 2018. The results of the area of conformity in this study can be seen in Figure 5. Figure 5a is the level of suitability of the Javan rhino where the area marked box is the location of Ujung Kulon National Park where the place is a conservation place for Javan rhinos. In this area, it can be seen that the Ujung Kulon conservation area has a relatively high suitability index? . When compared to the 2018 conformity in figure 5b, there was a decrease in conformity class in some locations.

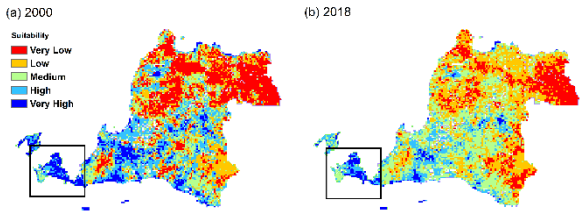

Figure 5. Site Suitability (a) 2000, and (b) 2018

Overall changes in the level of regional suitability for Javan rhinos in Banten can be seen in table 5. It can be seen that there was a decrease in the level of regional suitability very high and high in 2018. This can happen because there is a change in land use in Banten City. One of the causes of land cover change is caused by the increasing number of people inhabiting the Banten area which pressures other types of land cover to be converted into settlements.

Suitability	2000 (ha)	2018 (ha)	Difference (ha)
Very Low	**2498**	**1535**	**-963**
Low	**1776**	**3045**	**1269**
Medium	**1705**	**2778**	**1073**
High	**2022**	**1185**	**-837**
Very High	**873**	**321**	**-552**

Table 5. Site Suitability Statistic

3.3 Limitation and Future Study

This study in determining the level of suitability in 2000, using data in 2018. This is due to the unavailability of research data. The data used is likely to change after 18 years. Road data that is likely to be changed after 18 years after construction. However, this can be covered by the use of land cover and built-up areas as an parameters in this study. In this study, we are not consider weight for each parameter used. In the future, weighting method can be used in determining each parameter to show the dominant parameter that used to determine the suitability area. This research also can be improved by predicting the condition of the area of suitability for rhinos in the future. So that it can be prepared to protect the Javan rhino conservation area.

4. CONCLUSION

This research focuses on modeling the suitability area of the Javan Rhinoceros habitat in the Banten Province, Indonesia, based on land cover changes that occurs from 2000 until 2018. The study reveals a continuous decrease in forested land each year. On the other hand, other land covers experienced fluctuations due to human pressures. This poses a significant threat to the habitat of rare animals, particularly the Javan Rhinoceros. Based on the suitability results, there was a decline in suitability classes for the Javan Rhinoceros from 2000 to 2018. The very high and high suitability classes experienced a decline of up to 48% during the period from 2000 to 2018.

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