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Modeling the Habitat Suitability of Javan Banteng (*Bos javanicus javanicus*) Using Geographic Information System in Ujung Kulon National Park

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Abstract

Background: The Banteng population in Ujung Kulon National Park (TNUK) is less than 500 individuals. The habitat of Java Banteng in conservation areas has largely decreased. One approach to assessing the current status of biodiversity at all levels, especially in endangered species, is to use geospatial technology such as remote sensing and geographic information systems combined with spatial data science. This study aims to create a spatial model of the suitability of the Javan Banteng habitat in the TNUK area and identify the use of the Java Banteng habitat and environmental variables that affect the presence of Javan Banteng. **Methods:** This research data was collected through coordinate data for stool sampling and data from BTNUK using a method called maximum entropy (maximum). The analysis used the Relative Use Index, Maximum Entropy modeling, and Relative Abundance Index. **Results:** Based on research, the use of habitat by Java Banteng with the value of making a spatial distribution model can be analyzed by analyzing the contribution of environmental variables based on the level of contribution in percent and the results of the jackknife test, namely the percentage of contribution of environmental variables in this study showed that environmental parameters, slope (37.6%) were the highest parameters, followed elevation (25.8%), land cover (25.3%), and NDVI (6%), rivers (5.3%). The analysis of five environmental variables used in making the Javan Banteng distribution model showed that at an altitude of 45 meters above sea level, Java Banteng preferred to show 95%. The graph decreased at an altitude above 45 mdpl, and Java Banteng at 200 meters above sea level looked at 0%. **Conclusions:** Javan Banteng do not like or do not choose places with altitudes ranging from 200 - 625 meters above sea level.

Keywords: GIS; habitat suitability; Javan Banteng; maxent modeling

Introduction

Banteng (*Bos javanicus* d'Alton, 1826) is divided into three subspecies, namely, *Bos javanicus birmanicus,* which is found in mainland Asia; *Bos javanicus* lowi, which is scattered in many parts of Kalimantan mainland; and *Bos javanicus javanicus* which is found in some locations in Java island (Hogerwerf 1970; Gardner, 2014). The current distribution of Javan Banteng (*Bos javanicus javanicus*) in the Java island can be grouped into two regions, namely, in the western region of Java, i.e., Ujung Kulon National Park (UKNP), i.e., Meru Betiri National Park (MBNP), Baluran National Park (BNP) and Alas Purwo National Park (APNP) (Hakim et al., 2015). The Bornean Banteng (*Bos javanicus* lowi) spread mostly in Kutai NP and Kayan Mentarang NP.

The habitat of the Javan Banteng in conservation areas has largely decreased due to land clearing, the presence of enclaves, and the entry of invasive species. Invasions of invasive species such as *Chromolaena odorata, Cassia tora, Lantana camara, and Acacia nilotica* have invaded Banteng grazing fields by more than 50%, as happened in TNMB, TNAP, TNUK, and Baluran National Park, so the existence of Banteng populations is threatened due to lack of feed availability (Pudyatmoko et al., 2018). To protect Banteng from extinction, the government of the Republic of Indonesia has had laws and regulations since 1931, which are emphasized by PP No. 7 of 1999 because of its endangered population. Banteng is a priority species set by the Indonesian government to restore its population in nature (National Species Conservation Strategic Direction 2008-2018, Regulation of the Minister of Forestry No P.57/Menhut-II/2008).

GIS is a management tool in the form of related computer-aided information with a system of mapping and analyzing everything and events that occur in advance (Putranto et al., 2019). One approach to assessing the current status of biodiversity at all levels, particularly in endangered species, is using geographic information systems (GIS) (Wani et al., 2016). In particular, spatial statistics to determine the distribution of species and their interactions with (1) mapping their spatial distribution, (2) characterizing and measuring spatial patterns, and (3) correlating this spatial distribution to underlying environmental conditions and intraspecies and interspecies interactions (Cushman & Huettmann, 2010).

The use of geospatial technologies, such as remote sensing and geographic information systems combined with spatial science data such as maximum entropy (MaxEnt), is very useful and important in the integration of geospatial data for protected area management and wildlife habitat conservation (Hanif et al., 2020). Spatial data is one of the important elements that become the basis for carrying out and supporting various activities, including the distribution of habitats and species. Modeling with maximum entropy or Maxent has the potential to identify wildlife habitat distribution and selection with consideration depending on the location of their presence (Baldwin, 2009). Maximum entropy modeling is performed using multiple spatial data sets as environmental variables and meeting points as existing data so that the software can perform the probability of species-specific distributions according to environmental conditions.

The MaxEnt model is an ecological niche model increasingly used to assess wildlife habitat distribution (Clements, 2017; Rahman et al., 2019). This modeling is done by processing data on the presence of species and environmental variables that affect the presence of a species so that the spatial distribution of a species can be mapped (Rahman et al., 2019). Maximum entropy modeling will provide predictive results in statistical values (Phillips et al., 2006). Information regarding the distribution and spatial modeling of Java Banteng habitat is needed in conservation efforts. Studies on habitat use and the factors that influence it are still limited, so more in-depth information is needed. Habitat use and its influencing factors can be identified through Maximum Entropy (MaxEnt) modeling. This study aims to identify the use of Java Banteng habitat and predict habitat suitability maps and environmental variables that affect the existence of Java Banteng. The result of this study is hoped to provide a specific dispersal model of Banteng on the island of Java so that it can be considered for protection in areas with high habitat suitability for this species, both within and outside conservation areas.

Methods

Map and Environmental Data Collection

The study was conducted from December 2021 - February 2022 in the TNUK Area (Figure 1). Base maps and environmental variables are needed to gather the information needed to map the distribution of Javan Banteng in TNUK. Environmental variable data consisted of altitude (shuttle radar topography mission = SRTM), slope (SRTM), river network, temperature (30 arc-seconds = 1 km, tile 39), rainfall (30 arc-seconds = 1 km, tile 39), normalized difference vegetation index (NDVI, MOD13Q1, 16 days, 250 m), and land cover. Base map and river network data are downloaded from the Geospatial Information Agency (www.big.go.id), elevation (SRTM) and slope (SRTM) website of https://earthexplorer.usgs.gov, temperature (30 arc-seconds = 1 km, tile 39) and rainfall (30 arc-seconds = 1 km, tile 39) of www.world clim.org. Data NDVI (MOD13Q1, 16 days, 250 m) downloaded from https://lpdaac.usgs.gov, and land cover from BAPLAN 2014 webgis.dephut.go.id. The software used in this study includes 1) ArcGIS 10.5 software to process spatial data, 2) fashionable reprojection tool modeling (MRT) software to process NDVI data from landsatmodis images, maximum modeling software (Maxent) version 3.4.1 to process environmental component data to obtain bull habitat suitability, 3) Microsoft Excel for processing raw data on the presence of bulls, and a laptop to run the software mentioned above.

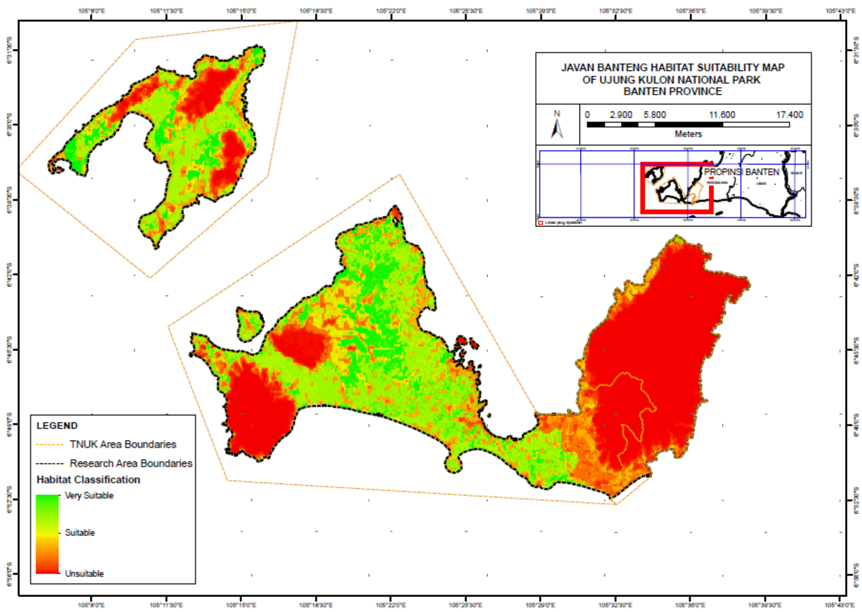

Figure 1. Location Javan Banteng habitat suitability map of Ujung Kulon National Park

Data processing using maximum entropy (Maxent)

Coordinate point data in Excel format comma separated value (CSV) and environment variables format ASCII (asc), spatial resolution 1 km entered into maxent Settings on the four main maxent menus, namely main, basic, advanced, and experimental, must be made as needed to get model results that are following the research objectives. After all the lists in the four menus are filled in, the model is ready to run by pressing the run button. The maxent model output consists of table maxent result, analysis of omission, average sensitivity (AUC), model result map, the contribution of environmental variables to the model, jackknife regularized training gain, and jackknife of test gain.

To recognize vegetation conditions and calculate plant cover on remote detection multispectral information. Modern software is known as the fashionable reprojection tool and ArcGIS 10.5. Making NDVI maps begins by converting fashionable image maps from hdf to raster. The next data processing is done with ArcGIS 10.5, which combines all fashionable images and selects the highest value (maximum) using the mosaic raster tool.

Then, the map is cut according to the boundaries of the research location and saved in ASCII format. The material used in the study was the meeting point of the Java Banteng as presence data for forming a habitat suitability model. The data used in this study is a digital image obtained from the United States Geological Surveys (USGS) that can be accessed for free on http://earthwxplorer.usgs.gov, namely Landsat 8 OLI images with an accuracy of 30x30 meters. Landsat 8 OLI imagery is used for land cover classification in Ujung Kulon National Park. i.e., Normalized Difference Vegetation Index /NDVI, elevation, land slope.

The collection of Javan Banteng data begins with conducting field orientation activities to determine the distribution of these types directly in the research area. Information on the presence of the Javan Banteng is also obtained based on BTNUK information, data, and literature. The Java Banteng directly recorded its coordinates with the help of GPS. Processing coordinate point and variable data begins with extracting the data into an Arc. Gis 10.3 to find out the value of each variable.

Furthermore, the coordinate point and variable data in Arc are overlayed. Gis 10.3 is performed. This extract determines the variable value of each coordinate point (Phillips & Dudik 2008). After that, the coordinate point data is extracted back to Ms. Excel in CSV (Comma Separated Values) format, while the variable data is exported in ASCII format. Coordinate and variable data were then used for MaxEnt analysis (Phillips et al., 2006).

Table 1. The value of the suitability of the habitat (Nursamsi et al., 2018)

Conformity Value	Category
0 - 0.180	Low
0.181 – 0.545	Medium
0.546 – 0.998	High

The results of the accuracy calculations included in the MaxEnt program are represented by the AUC (Area Under the Receiver Operating Characteristics) value. The AUC value tests the accuracy of models created by MaxEnt (Nursamsi et al., 2018). If the AUC value is higher than the standard deviation value, then the model has high accuracy. However, if the standard deviation value is higher than the AUC value, then the accuracy of the model created by MaxEnt is very low (Khan 2016). The standard deviation value measures the distribution of model values in the TNUK region.

Table 2. Accuracy of model performance based on AUC values (Phillips & Dudík, 2008)

AUC Value	Model Performance
0.6 – 0.7	Less Good
>0.7 – 0.8	Medium
>0.8 – 0.9	Good

Overlay

The overlapping of the bull's presence coordinates is carried out on each environmental variable. Next, the classification of each value of environmental variables is carried out in order with the coordinates of the bull discovery. This was done to determine the distribution of Javanese bulls in TNUK based on environmental variables.

Model Validation

Model validation is performed by looking at the maximum processing area below the test value of the curve (AUC). AUC is located under the recipient operating curve (ROC) and is a standard strategy for differentiating the precision of distribution models (Jimenz-Valverde, 2011). If the AUC price is <0.5, the model is unacceptable, and when the AUC starts from 0.5-0.7 (low precision), medium precision is 0.7-0.9, and high precision is > 0.9. In addition, model validation is also carried out by hitchhiking the coordinates of the bull discovery based on the feces found.

Data analysis

State all statistical tests and parameters.

Result

The Habitat Suitability of Java Banteng (Bos javanicus javanicus)

In distribution modeling, one method is Maximum Entropy (MaxEnt). MaxEnt displays have tremendous potential to recognize the spread and choice of wildlife areas. Figure 2 maps the results of Javan Banteng's potential habitat modeling. The result of MaxEnt modeling identifies the potential habitat of Javan Banteng.

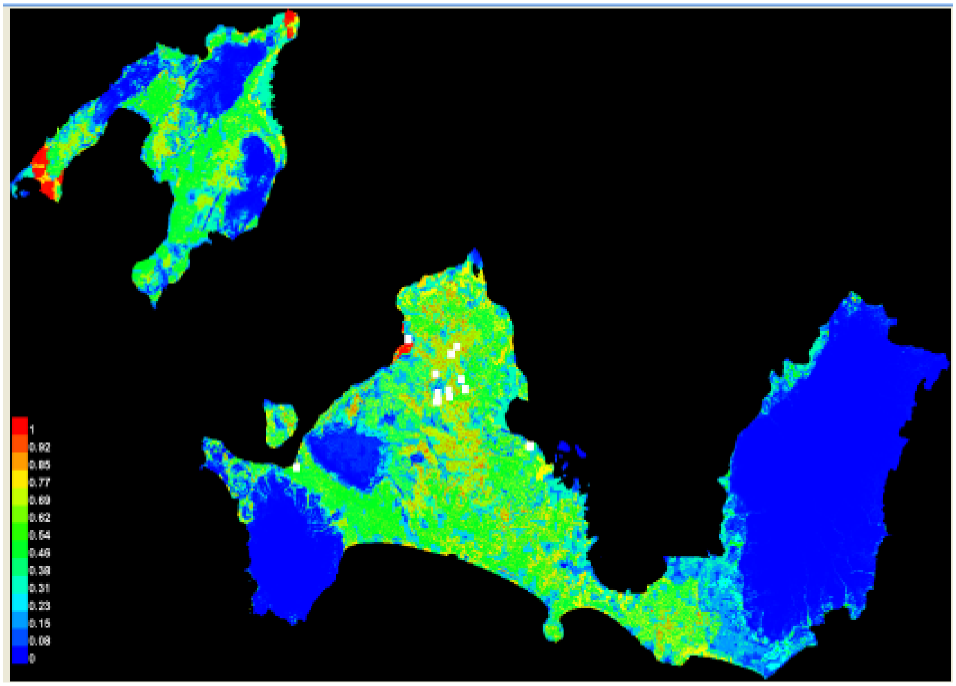

Figure 2. Spatial distribution of Javan bull habitat

The influence of environmental variables on modeling the habitat suitability of Banteng Jawa is shown based on the results of jackknife operations. This method is a way to estimate the importance or contribution of each environmental variable used in modeling (Negga 2007). The results of this operation show that land cover, temperature, and marbles exert the greatest influence on the modeling found in Figure 1 and Figure 2. The higher the location, the lower the use value of the territory. It is believed that the cause was the availability of vegetation that provided food for the Javan bull. Plant varieties decrease with increasing area. Temperature and stickiness are also affected by the increase in increase. An increase of 100 mpdl will cause a decrease in temperature of 0.6oC and an increase in humidity, both of which will stop plant growth (Karyati et al., 2016)

Altitude, one of the other environmental variables, has a significant impact because it is directly related to the presence of feeding areas, such as grazing areas. Javan bulls tend to like flat areas, making it easier for Javanese bulls to move to reach their food and breed. The assessment seen in Jacknife surgery is the amount of AUC test value and test gain value obtained due to the treatment of predetermined environmental variables. (Stevens & Conway (2019) state that test gain is a statistical unit that suspects how good the prediction is. The distribution corresponds to the attendance data compared with the uniform distribution. The greater the AUC test and test gain values obtained from using certain environment variables, the more environment variables are classified as influencing the modeling created. Another criterion for determining how much influence an environmental variable has is to look at the amount of test gain and AUC values that fall or decrease when not used in modeling. Another criterion for environmental variables is if they contribute the highest to the test gain and AUC values when using only these variables. The amount of these values is compared with the AUC test and test gain values when using all variables. If the amount of test gain and AUC do not differ much, then the variable is the variable that contributes the most to the modeling (Lecours et al., 2016).

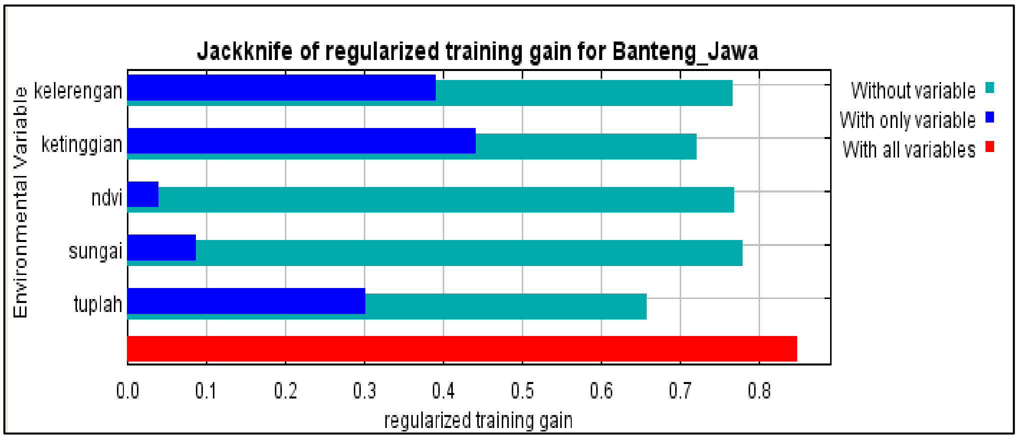

Figure 3. Effect of environmental variables

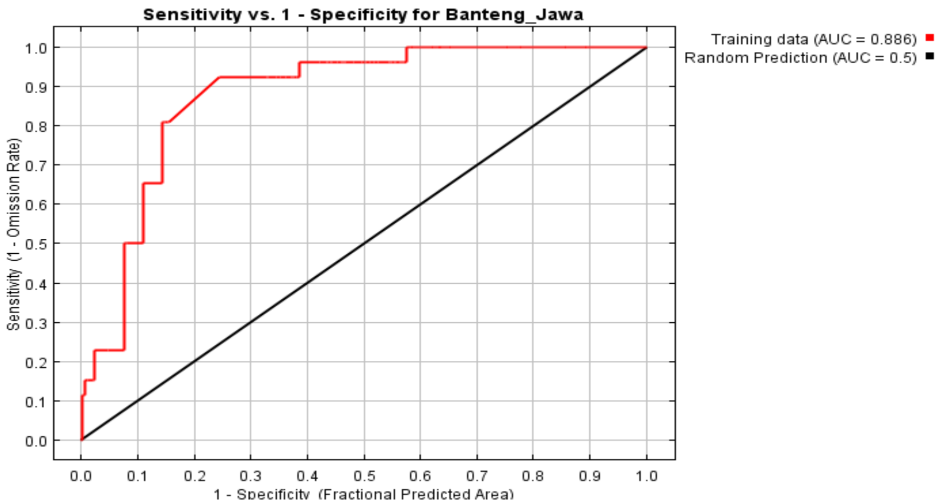

Figure 4. Effect of environmental variables on AUC test values obtained

It shows how much the influence of each environmental parameter contributes to determining the potential of the Banteng Jawa habitat area in several locations spread across Ujung Kulon National Park. The percentage of contribution of environmental variables in this study showed that environmental parameters, namely slope (37.6%), were the highest parameters, followed by altitude (25.8%), land cover (25.3%), and NDVI (6%), rivers (5.3%) (Table 3).

Table 3. Percent contribution of each environmental variable to the Banteng Jawa distribution model

Environmental Variable	Percent Contribution	Permutatin Importance
Slopes	37.6	16.1
Elevation	25.8	38
Vegetation	25.3	18.4
NDVI	6	12.7
River	5.3	14.8

The creation of spatial distribution models can be analyzed by analyzing the contribution of environmental variables based on their contribution rate in percent and jackknife test results against prediction models (Rahman et al., 2017). The analysis of five environmental variables in making the Java Banteng distribution model showed that the highest contribution was in the distance variable to slopes with values of 37.6%.

The elevation class of the Java Banteng

Habitat is quite varied (Figure 3). It can be seen that the elevation starts from 25 mdpl to 625 mdpl. In Ujung Kulon National Park, Habitat conditions are forest areas partly bordered by plantations, settlements, mangrove forests, thickets, swamp thickets, rice fields, and open land. At an altitude of 45 meters above sea level, the Banteng Jawa prefers to show 95%, and the chart decreases at a height above 45 mdpl, and Javanese bulls at an altitude of 200 meters above sea level are seen as 0%. This shows that Javan Banteng does not like or do not choose places with altitudes ranging from 200 - 625 meters above sea level. This is because Javan Banteng are animals classified as grazers or have a habit of grazing. With an altitude of ≥ 200 meters above sea level of 0%, no presence of Javan Banteng was found, indicating that this height is less preferred based on the study data results. The higher the place, the smaller the habitat use value. This is thought to be related to the availability of vegetation that feeds Javan Banteng. The higher the elevation, the lower the diversity of plants (Sa'adah & Siswoyo 2019).

In addition, the increase in elevation also affects temperature and humidity. Every increase of 100 mpdl, will lower the temperature by 0.6 ºC and increase humidity, thus inhibiting the development of plants. If the availability of animal feed is low, then the presence of Javan Banteng is also low because Javan Banteng are classified as grazers. Another environmental variable in height has an important influence because it is directly related to the existence of a place of eating activity, namely grazing fields. Javan Banteng tends to like flat areas because it makes it easier for Javan Banteng to move to reach their food and breed. Grazing fields, with open vegetation, are one of the habitats of Javan Banteng in Ujung Kulon National Park and are used as a place to eat. Javan Banteng can spend quite a long time in grazing fields. In addition, slope, NDVI parameters, and rivers or water sources are also important factors. This is because the habitat type of swamp thickets does not experience human disturbance and is maintained and protected from the dangers of predators in the form of Wild Dogs (*Cuon Alpinus*).

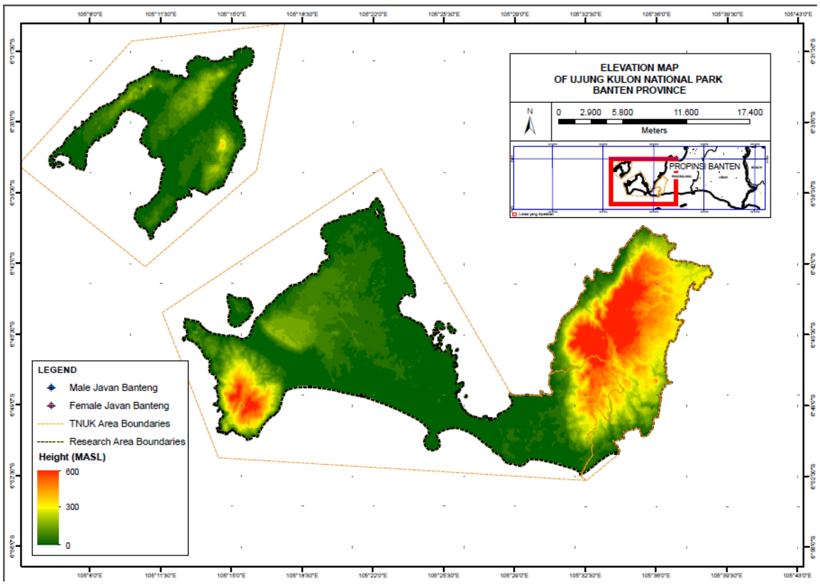

Figure 5. The elevation of the Javan Banteng of Ujung kulon national park

Based on the class of slope s

Javan Banteng is found in three classes of slopes, namely flat (95%), gentle slope (55%), and rather steep (10%). The value of habitat use based on slope class is presented in (Figure 4) High encounters exist in the flat slope class. This shows that Javan Banteng prefers flat areas because of the availability of vegetation that feeds Javan Banteng. The existence of Javan Banteng by looking at the slope class, very easy to reach by humans, and the existence of human activities tends to be high on flat topography, so this area tends to be unsafe for Javan Banteng, so in this area, it is necessary to carry out intensive protection in the form of routine patrols to prevent illegal hunting, so it is relatively safe for wildlife. This is alleged because the movement of Javan Banteng is not to the entire periphery of the region.

The spatial distribution of ecosystem landscapes that refer to land cover maps can represent the ecological condition of an area (Rahman, 2020). With this land cover data, we can identify the distribution of Javan Banteng habitat around the area. The results of spatial model analysis on the land cover show predictions of the presence of Javan Banteng, favoring the habitat types of shrubs, swamp thickets, and secondary forests. Based on Figure 3 shows that in the swamp thicket habitat type, the presence of bulls shows (100%), and in the habitat type of thickets (94%) and secondary forests (93%). The graph decreases or very small percentages in habitat types of primary dryland cover, secondary mangrove forests, plantation forests, settlements, plantations, rice fields, dryland agriculture, and mixed dryland agriculture. This is because the habitat type of swamp thickets does not experience human disturbance and is maintained and protected from the dangers of predators in the form of Wild Dogs (*Cuon Alpinus*).

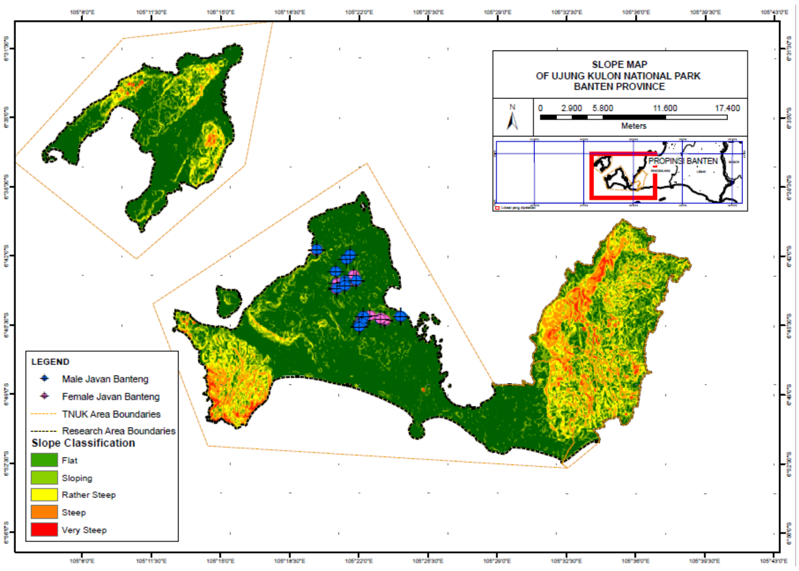

Figure 6. The slope map of the Javan Banteng Ujung Kulon National Park

Conclusion

The analysis used Relative Use Maximum Entropy modeling and Relative Abundance Index. Based on research, the use of habitat for Javav Banteng with the value of making a spatial distribution model can be analyzed by analyzing the contribution of environmental variables based on the level of contribution in percent and the results of the jackknife test, namely the percentage of contribution of environmental variables in this study showed that environmental parameters, slope (37.6%) were the highest parameters, followed elevation (25.8%), land cover (25.3%), and NDVI (6%), rivers (5.3%). The analysis of five environmental variables used in making the Javan Banteng distribution model showed that at an altitude of 45 meters above sea level, Java Banteng preferred to show 95%. The graph decreased at an altitude above 45 mdpl, and Java Banteng at 200 meters above sea level looked at 0%. This shows that Javan Banteng does not like or does not choose places with altitudes ranging from 200 - 625 meters above sea level:

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Declaration statement

The authors reported no potential conflict of interest.

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