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Research Article

Spatial Modelling Habitat Suitability of Javan Langur (*Trachypithecus auratus* É. Geoffroy Saint-Hilaire, 1812) in Bromo Tengger Semeru National Park (TNBTS), East Java

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ABSTRACT
Javan Langur *(T. auratus)* is well-known as one of endemic primates from Java, Bali and Lombok Islands. The activities of land clearing, vegetation conversing, wild hunting and illegal wildlife trading are the main causes of the extinction of the Javan Langur. It can be used as an important issue for conservation action by making prediction maps of suitable habitat potential, especially for species facing a high risk of extinction in the wild. We were documenting an information about potential habitat for Javan langur using spatial suitability model in order to provide rigorous information as the basis for conservation activities of Javan langur in TNBTS. We used Landsat-8 TM image and geospatial data to support analysis as a representative of environmental parameters in order to develop the habitat model. We were using maximum entropy (MaxEnt) algorithm refers to Javan langur presence or absence. The results showed that the suitability of the Javan langur habitat in TNBTS has an excellent model accuracy level with an AUC (Area Under the Receiver Operating Characteristics) value of 0.964 and a standard deviation of 0.961. Parameters with the highest response values here are elevation, NDVI (Normalised Difference Vegetation Index) and temperatures.

INTRODUCTION

Human activities such as land clearing and vegetation conversing are the leading causes of habitat loss and fragmentation that threaten species into an extinction (Chapman & Onderdonk 1998). Illegal hunting regarding to consumption and illegal trading as pets pose a threats for wildlife populations (Ervina & Wasiq 2018). Those evidences are essential issues in relation to conservation activities by making prediction maps of suitable habitat potential (Gaston 1996) for species struggle from extinction in the wild, and Javan langur is one of species belong to those groups. They are endemic primate to the islands of Java, Bali and Lombok Indonesia (Nijman & Supriatna 2008) and protected by Minister of Environment and Forestry of the Republic of Indonesia No. P.20/MENLHK/SETJEN/KUM.1/6/2018. Javan langur found in various habitats: primary, secondary, coastal to mangrove forests (Nijman & Supriatna 2008).

Bromo Tengger Semeru National Park (TNBTS) is known as an essential habitat for Javan langur. This species characterised by wide home range and quadrupedal, which make this primate is very dependent on the presence of forest vegetation and canopies to support their movement behaviour. The potential density of tree stands is still high with conditions of various diameters, which are still commonly found in forest land cover in TNBTS (Noor'an et al. 2015). Javan Langur is closely related to the presence of trees for all of its activities (Subarkah et al. 2011). However, the essential habitat of the Javan langur is also an important area for the people who live and other villages around the TNBTS area (Sayektiningsih et al. 2008). TNBTS is also one of the leading star objects and natural tourist attractions for the East Java area (Sutiarso & Susanto 2018). Human activities around these wildlife habitats can indirectly affect movement (Doherty et al. 2021), health to population decline and quality of life (Fraser & MacRae 2011).

Species distribution modelling is widely used to predict habitat suitability and habitat used by a species (Peterson 2006). Javan langur are very dependent on forest vegetation (Fahmi & Bintarawati 2018), which predominantly consume leaves and the rest are flowers, fruits, insect and other plant parts (Zakki et al. 2017; Aryanti & Azizah 2019). Habitat suitability models can relate the presence of species and the biophysical environment (Elith et al. 2006; Kumar & Stohlgren 2009) at the study site. Moving animal objects such as Javan langurs can use spatial approaches and models such as the Species Distribution Model (SDM) or ecological niche modelling that can relate data on the presence of species with various impact components that affect them (Warren & Seifert 2011; Prasetyo 2017). Technically SDM can prepared using the Maximum Entropy Algorithm (MaxEnt) which can only use incident records along with environmental characterisation to identify the preferred environment of the organism under study (Morales et al. 2017; Widyastuti et al. 2020; Valencia-Rodríguez et al. 2021). We determined the potential habitat's spatial suitability model and expected that it will provide comprehensive information as recommendation related to planning for the conservation of Javan langur in TNBTS. Otherwise, we also identified the environmental factors that give significant influences to the suitability of the Javan langur habitat in TNBTS.

MATERIALS AND METHODS

Study Area

This research was conducted in October 2019 - January 2020 and carried out throughout the TNBTS area, an important habitat for Javan langur. TNBTS area covers Malang, Pasuruan, Probolinggo and Lumajang regencies in East Java with a total area of 50276.3 Ha (Figure 1).

Materials

The equipment used for data collection of Javan langur includes GPS (Global Positioning System), binoculars, rangefinder, hygro-thermometer, camera, tally sheet and stationery. Analysing data using a PC/laptop, ArcGIS 10.3 software, Indonesian earth maps, DEMNAS (National Digital Elevation Model), Landsat 8 and MaxEnt 3.4.4 software. The material used in this study was the encounter point of the Javan langur as presence data for forming a habitat suitability model (Cahyana et al. 2016).

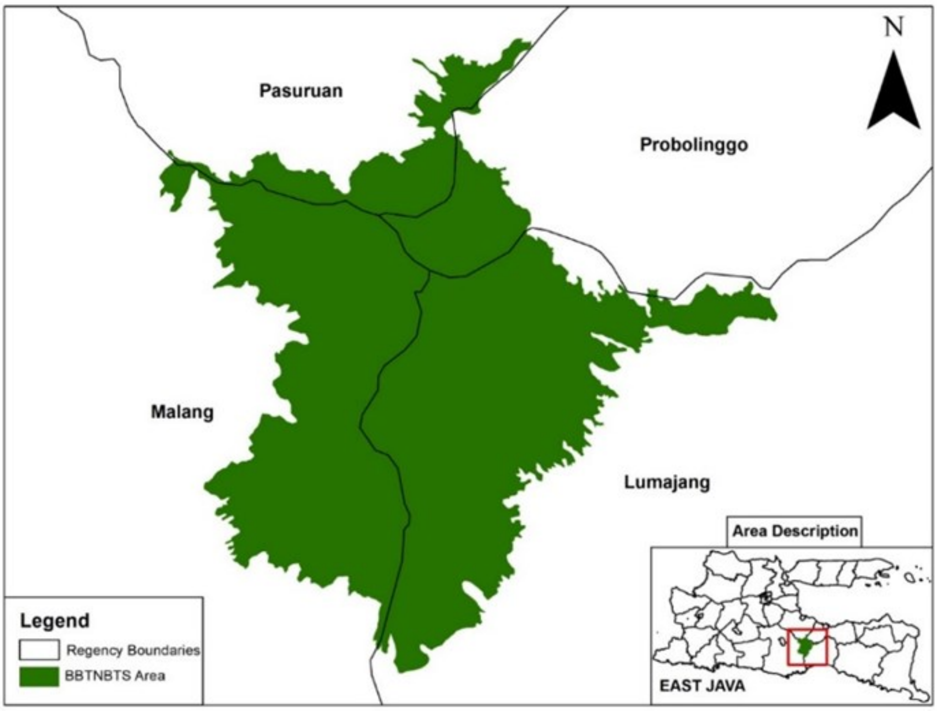

Figure 1. Map location for data collection on the habitat suitability of the Javan langur TNBTS.

Method

Occurrence data of Javan langurs with had survey and collected information from research that has been carried out and information from the community or TNBTS officers. We are collected GPS coordinates from the individual/population presence of Javan langur throughout the TNBTS area, using direct encounter and line transect sampling methods. GPS Coordinates of the Javan langur were recorded using the Garmin GPSMAP 60 CSx. The data presence coordinates were transferred into Microsoft Excel and saved in CSV.

Observations conducted during the active time of the Javan langur, starting from morning to evening (06.00-18.00 WIB) (Sulistyadi et al. 2013). Environmental data collected were elevation, slope, temperature, NDVI (Normalized Difference Vegetation Index) and distance from the road access. NDVI described the canopy condition from vegetation composition (El-Shikha et al. 2008; Sulistyo et al. 2010), where most of their daily activity utilizes the canopy plant (Subarkah et al. 2011). The elevation and slope map data were obtained from topographic data using 32-bit DEMNAS with a resolution of 5-8 m which downloaded from the BIG websites (Geospatial Information Agency) (Morales et al. 2017). NDVI and temperature data were obtained from Landsat-8 TM image data (Widyastuti et al. 2020). Distance of the Javan langur to roads were obtained from RBI (Rupa Bumi Indonesia) map.

Data analysis

GPS Coordinates of Javan langur presence were extracted using Arc.Gis 10.3 software. The objective was to determine variable's class and the relationships between each environmental variable based on the distribution of Javan langur (Elith et al. 2011). The results of the extracted data were used to perform multicollinearity tests on SPSS (Statistical Package for the Social Sciences) software. Multicollinearity test was conducted to determine the relationships between the used variables. When there is a linear relationships among variables, one of the variables should be removed (Hansen et al. 2020). Afterward, the coordinates point data was extracted back to Ms Excel in CSV format, while the variable data was exported in ASCII format (Fitzgerald et al. 2018). The data presence coordinates and the environmental variable used to build the suitability habitat model by Maxent 3.4.1. (http://www.cs.princeton.edu/~schapire/maxent/) and effective even with the small number of occurrence records (Kumar & Stohlgren 2009).

MaxEnt generates logistic outputs with approximate relative probabilities of the type distribution with values from 0 (lowest probability) to 1 (highest probability) (Elith et al. 2011). To evaluate the performance of the habitat suitability model, we focused on how the five variables affect the model was measured by the AUC (Area Under the Receiver Operating Characteristics) value (Table 1). The AUC value was used to test the model's accuracy created by MaxEnt (Morales et al. 2017). The AUC value was higher than the standard deviation value, the model has a very high accuracy. However, if the standard deviation value was higher than the AUC value, then the accuracy of the model created by MaxEnt was very low (Fitzgerald et al. 2018). The standard deviation value was used to measure how the model values were distributed in the TNBTS area.

Table 1. Accuracy of model performance based on the AUC Value (Elith et al. 2011).

AUC Value	Model Performance
0,6 – ≤ 0,7	Not good
>0,7 - ≤ 0,8	Good
>0,8 – 0,9	Very Good

RESULTS

The results of spatial data from environmental parameters (NDVI, slope, distance from the road, temperature and elevation) are viewed in figure 2. The NDVI parameter has shown a value of -0.6 to 0.63, with the Javan langur are commonly found at the highest NDVI value. The condition of these area is a dry land forests with high density of forest vegetation. In this class, the dominant populations are Ficus spp, *Maesopsis eminii* (Engl.), *Erythirna variegate* (L.) Merr, *Trema orientalis* (L.) Blume and *Nauclea excelsa* (Bl.). It is obvious that the Javan langur very depending on the habitat conditions with dense canopies, since it will be related to movements of this population over branches, trees, and also the way to stay away from predator. Though, based on the slope parameter, it was known that the slope strongly influences the distribution of the Javan langur in TNBTS. The slope was related to the distribution of forage plants, safety from predators and human disturbances and the selection of sleeping trees for Javan langur (Abdillah 2014). The slope of the TNBTS area ranges from 0 - 70.30 %, but the Javan langur were mostly found on slopes of 10.76 % - 23.70 %. The categories of slope found of Javan langurs were 15-25% (wavy) and 25-40% (steep) (Sari et al. 2020).

The temperature parameter values in TNBTS range from 8-30°C. The presence of Javan langur was found in the morning with a temperature range of 8-24°C. When the weather warmer, the Javan langur prefers to take a rest by taking shelter under the dense canopy of trees (Santono et al. 2016), otherwise, these species will digests the food which has consumed previously (Sulistyadi et al. 2013). Thus, from the recorded elevation map of these presence, the Javan langur was mostly found at an 829 – 1,642 a.s.l. This elevation factor is closely related to the availability of foraging behaviour and safe from predators. Both become the dominant factors in determining the distribution and level of presence Javan langur in TNBTS. Additionally, the distance parameter is related to hu-

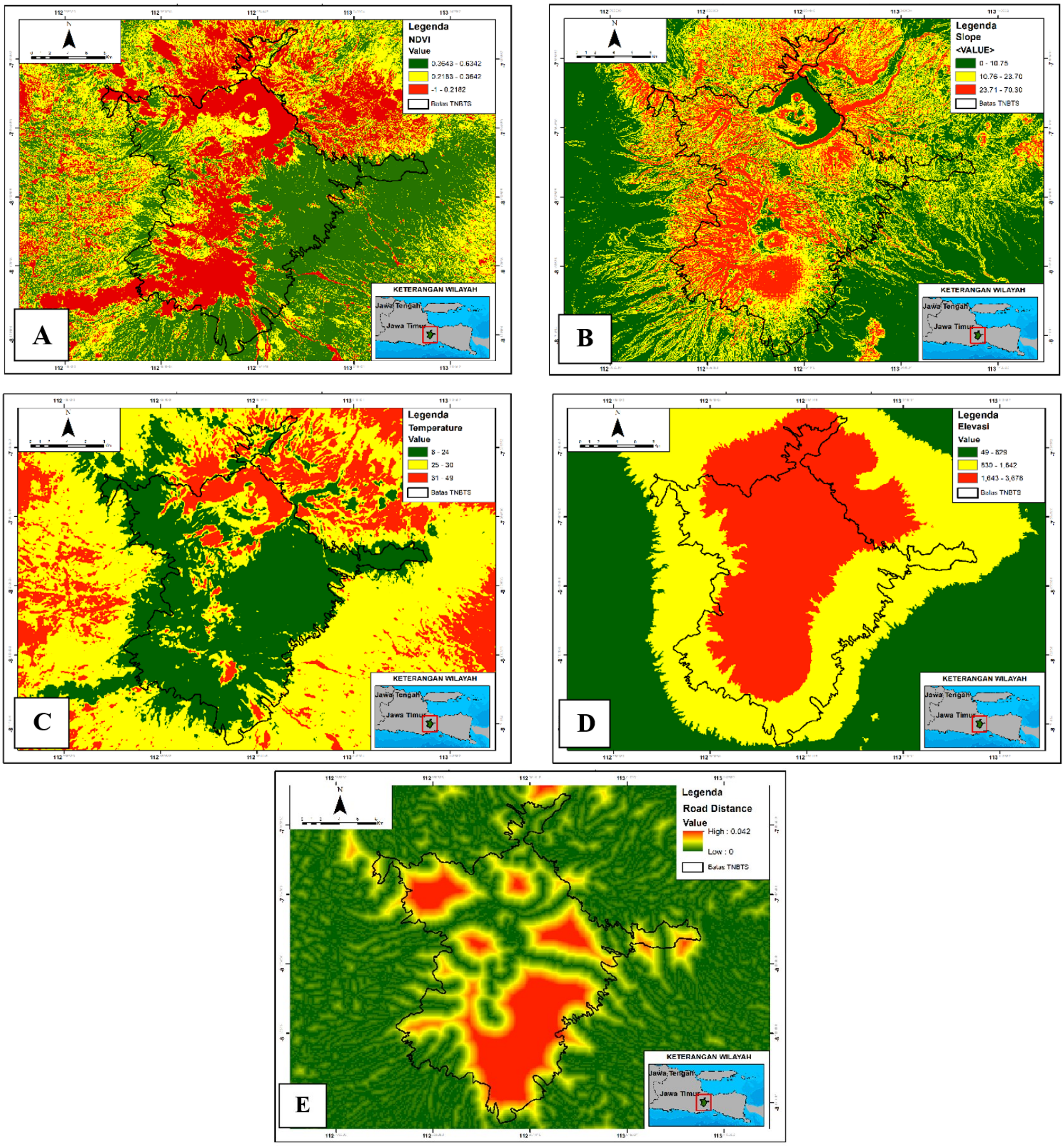

Figure 2. Map of environmental parameters to build the Javan langur habitat model : A. NDVI, B. Slope, C. Temperature, D. Elevation, E. Road Distance.

man disturbances through human activities and noises. Human pressure is also the suspected factor that could be a barrier to habitat conditions for the Javan langur family (Sulistyadi et al. 2013). Commonly, the Javan langur found at distance of 100 - 1000 meters from the activities of residents in the TNBTS area.

The presence of data collection Javan langur was needed to build models and validate map performance. We are detected 48 occurences of Javan langur in TNBTS. The amount was split 70% for model building and 30% for validation. Therefore, more data in the field will be accurate to the habitat suitability model for those animals (Onojeghuo et al. 2015). The value of each parameter was analysed by multicollinearity in order to determine the correlation between the environmental variables. When the values increase, it will significantly influence the results of the modelling made (Nadler et al. 2007). The results of the multicollinearity test showed the Variance Inflating Factor (VIF) values are < 10 and the tolerance value > 0.10 for all environmental variables (Table 2). It means there was no multicollinearity in these parameters and no parameters that must be omitted in developing a habitat suitability for Javan langur.

Table 2. Multicollinearity test between parameters.

Parameter	Tolerance Value	VIF
Elevation	0.33	3.00
NDVI	0.18	5.38
Temperature	0.16	5.97
Slope	0.29	3.40
Road Distance	0.44	2.25

Habitat modeling was carried out using the MaxEnt 3.4.4 program. MaxEnt is considered capable of mapping the distribution of species where each pixel's value represents the possibility of species in suitable habitats (Rupprecht et al. 2011). The modelling used five parameters that were previously processed in the form of raster data types. Parameters and data presence of Javan langur were overlaid with MaxEnt. The habitat estimation model results in potential Javan langur habitat in Figure 3.

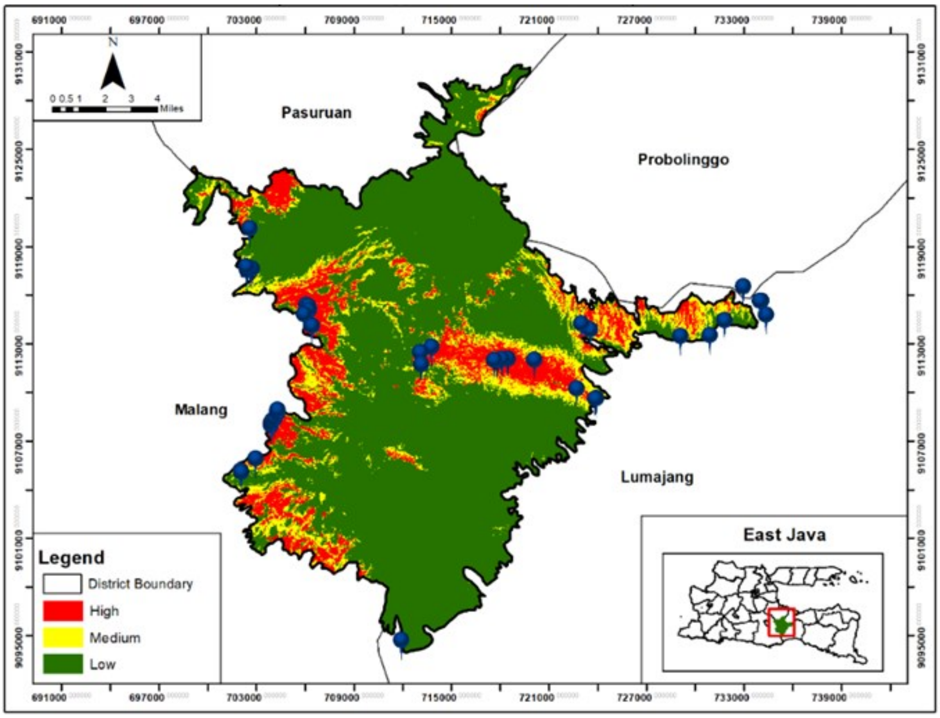

Figure 3. The map of suitability of habitat for Javan langur TNBTS.

It can be seen that there are three colors generated in establishing the model. Red color indicates very high habitat suitability, yellow color moderate habitat suitability and green color low habitat suitability (Prasetyo 2017). Each color has a proportion value which is the presentation value of Javan langur habitat suitability class in TNBTS. The habitat area with high suitability (4,783.4 Ha) for Javan langur in TNBTS was still a primary forest area with high vegetation with overlapping canopy conditions. The low (39,358 Ha) and medium (6,134.9 Ha) habitat suitability classes were volcanic areas with bush and savanna vegetation conditions. The Javan langur has chosen a location with good vegetation cover such as primary forest, but its home range also includes secondary forest (Hansen et al. 2020). It was due to the availability of vegetation that supports the needs of diurnal primates, especially the availability of food from pole and tree growth form vegetation. In building a habitat model some parameters considered essential and contributed to the resulting model (Table 3). Essential parameters are considered capable of contributing if the value is > 10% (Abdillah 2014).

Table 3. Important parameter values in building a habitat suitability model Javan langur.

Parameter	Contribution Percentage (%)
Temperature	35.9
Elevation	34.7
NDVI	15.8
Road Distance	13.4
Slope	0.1

Based on the predicted percentage of environmental parameters that contribute to the presence of Javan langur in TNBTS to the model (Table 3), temperature (35.9%), elevation (34.7%), NDVI (15.8%) and distance from human roads (13.4%). In the TNBTS area at the highest elevation was the peak of a volcano in the form of savanna and bare ground so no Javan langur is found. Temperature also affected presence because high temperatures, the influence of volcanoes, were not found in Javan langur. The high activity of the Javan Langur is influenced by internal factors, namely the fulfillment of feed intake which will become energy, as well as external factors, namely temperature and humidity which tend to make the Javan Langur active between 10-30^{o}C (Sulistyadi et al. 2013). The results of the important variable values were then further tested with the Area Under the Receiver Operating Characteristic (ROC) Curve AUC in order to determine the variables and their effects on the habitat suitability model of Javan langur in TNBTS (Figure 4) (Onojeghuo et al. 2015).

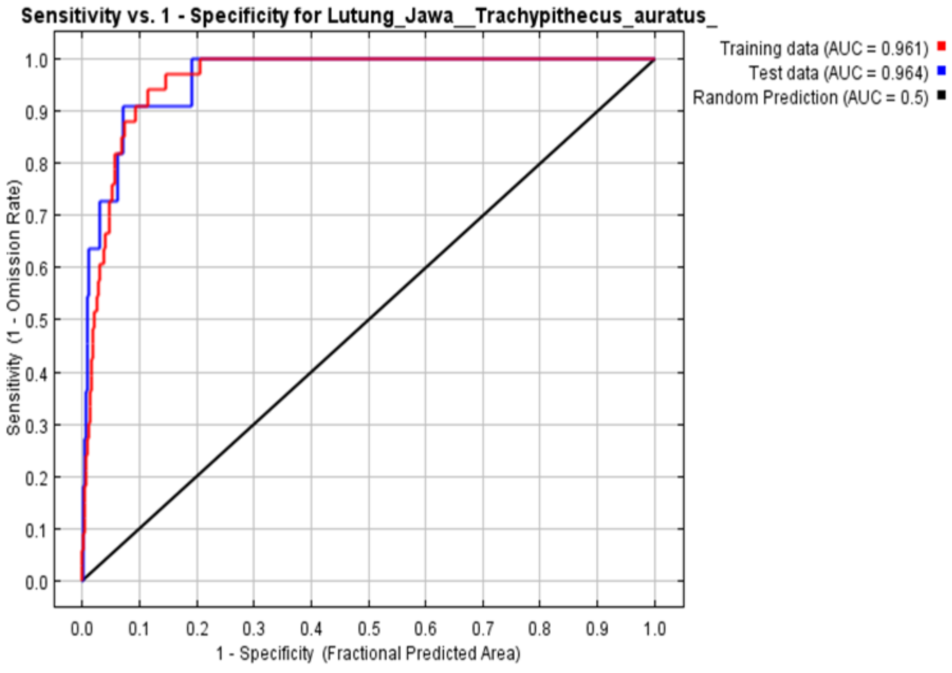

Figure 4. Graph of AUC test results for the suitability of Javan langur in TNBTS habitat.

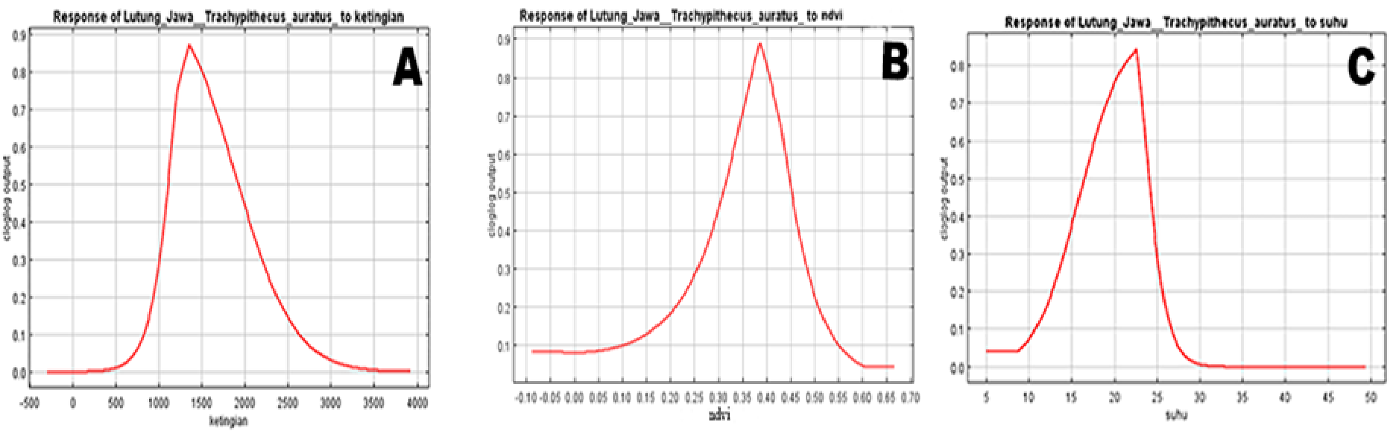

Figure 5. Graph of parameters response that contributes highly in building the habitat suitability model for the Javan langur TNBTS habitat A. Elevation, B. NDVI, C. Temperature.

The results of the AUC test were an evaluation of the model in estimating the suitability of Javan langur habitat in TNBTS. The results of this test showed an AUC value of 0.964 with a standard deviation of 0.961, which describes an excellent level of model accuracy. The value of the deviation was smaller than the AUC value, the AUC value was very good, which exceeds the value of 0.90 (Cahyana et al. 2016). The relationship between probability the presence of Javan langur with environmental parameters was shown by a graph of response each variable. In Figure 5, it can be seen that the variation of environmental parameters affect the prediction of of Javan langur's presence in TNBTS.

The results of the response parameters contribute highly to building the habitat suitability model of Javan langur TNBTS habitat and it was known that the area was at an altitude of 812 – 1,642 mdpl, NDVI class 0.37–0.63% and a temperature of 8–24°C. Therefore, it can be said that these parameters were associated in a complex manner and affected the habitat characteristics of Javan langur either directly or indirectly.

CONCLUSIONS

Based on the evaluation of the model using MaxEnt, the suitable habitat area for the Javan langur is in the high category (9.5%) and medium (12.2%) of the TNBTS area, with the model accuracy level of the AUC value of 0.964. In that area, the environmental conditions affecting Javan langurs' presence were elevation, NDVI and temperature. To increase Javan langur's area of suitable habitat because arboreal species, it is necessary to protect vegetated stands, especially with overlapping crowns at locations with an effective environmental variable approach.

AUTHOR CONTRIBUTION

The NAA, ANN and IYA analysed the data and wrote the manuscript. TSSDS and MR worked in the field and made research maps and habitat suitability maps.

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CONFLICT OF INTEREST

All authors declare that there was no personal or group conflict of interest. The author is fully responsible for the content and writing of the published article.

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