Spatial model of the Sumatran tigers (*Panthera tigris sumatrae*) prey habitat suitability index in Besitang

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Abstract. The Besitang forest landscape is a habitat for Sumatran tigers (*Panthera tigris sumatrae*) which is one of the key species in Gunung Leuser National Park (GLNP). Deforestation and degradation have caused forest fragmentation so that Sumatran tigers habitat becomes narrow. As the first step in modelling the suitability of Sumatran tiger habitat, it is then knowing the distribution of Sumatran tiger prey needs to be done. The objective of this study was to get information about the suitability distribution of Sumatran tigers’ prey based on biophysical and social factors in Besitang. The Principal Component Analysis (PCA) method is used to select and weight the factors that are thought to influence the distribution of Sumatran tiger prey. Overlay analysis of the factors that influence the habitat suitability is done using Geographic Information System (GIS). The results showed that the index value of habitat suitability of Sumatran tigers’ prey has a range of values from 0 to 1. Areas that have values getting closer to number 1 indicate the area is more suitable for the habitat of Sumatran tiger prey.

1. Introduction

Sumatran tigers are one of the key species that live in the Besitang forest landscape. Knowledge of the suitability of Sumatran tiger habitat is very important in the conservation of these animals. As the first step in modelling the suitability of Sumatran tiger habitat, then knowing the distribution of Sumatran tiger prey needs to be done. Deforestation and forest degradation causes the Sumatran tiger habitat to become increasingly narrow. The impact of deforestation is one of which is increasing edge of the forest causing problems for Sumatran tigers who tend to avoid the edge [1]. The Besitang forest landscape is located in Langkat Regency, where deforestation rates in Langkat Regency are high with a deforestation rate of 1,292.01 ha per year [2], while [3] reports that in Besitang in 2008-2016 deforestation had occurred 224.14 ha per year.

Destruction of forests as habitat for Sumatran tigers has caused Sumatran tiger habitat to be reduced. Destruction of tropical forests in Indonesia has resulted in the Sumatran tiger population continues to decline. Study results [4] in 1978 around 1000 individual then decreased from 400 to 500 individual in
1992 [5]. For this reason, it is necessary to make a serious effort to save the Sumatran tiger habitat to avoid extinction.

Information predicting the level of habitat suitability of Sumatran tiger prey is important to know as an effort to the management of conservation area. The utilization of GIS technology and remote sensing can be used to model the level of habitat suitability of Sumatran tiger prey [6]. The objective of this study was to get information about the index of habitat suitability of Sumatran tiger prey on biophysical and social factors in Besitang.

2. Materials and methods

2.1. Research location
This research was conducted at the National Park Management Section (NPMS) 6 Besitang. NPMS 6 Besitang is part of the Gunung Leuser National Park located in Langkat Regency, North Sumatra Province, covering an area of 115,208.55 ha (Figure 1).

![Figure 1. Map of the study area in Besitang North Sumatra](image)

2.2. Spatial analysis
The sample data in the form of the coordinates of habitat suitability of Sumatran tiger prey were obtained from direct observation in the field using GPS and from secondary data from Gunung Leuser National Park. In this study, the animals that feed the tigers found in the field consist of pigs, deer, mouse deer, monkeys, weasels, partridges, and deer. The total number of samples was 159 sample points. The selection of model data and validation data is done randomly. Furthermore, these point of animal existence is overlaid with trigger factors of habitat suitability using ArcGIS 10.5.

Factors that are suspected as triggers of habitat suitability consist of biophysical and social factors referring to previous studies [6 - 8]. Elevation and slope data are derived from Shuttle Radar Topography Mission (SRTM). Data of distance from the road, distance from the river were obtained using the Euclidian distance [9]. Rainfall data is obtained from the Office of the Indonesian Meteorology and Geophysics Agency. Whereas Normalized Difference Vegetation Index (NDVI) is obtained from Landsat 8 imagery path/row: 129/57 and path/row: 129/58, with the date of acquisition April 21, 2019.
The use of PCA in this study refers to [8], where PCA is used to reduce factors that do not influence and give weight to the factors that influence the distribution of habitat suitability of Sumatran tiger prey. In the PCA analysis, the variable feasibility assessment was tested by measuring the Bartlett test of sphericity and Measure Sampling Adequacy (MSA) with a significance value below 0.05 [10].

The mathematical equation model of habitat suitability of Sumatran tiger prey based on PCA weighting can be written as follows:

\[ Y = aFk_1 + bFk_2 + cFk_3 + dFk_4 + eFk_5 + fFk_6 \]  

(1)

Note:
\( Y \) = total value of habitat suitability of Sumatran tiger prey areas  
\( a-j \) = the weight value of each variable  
\( Fk_1 \) = NDVI  
\( Fk_2 \) = elevation  
\( Fk_3 \) = slope  
\( Fk_4 \) = distance from road  
\( Fk_5 \) = distance from the river  
\( Fk_6 \) = rainfall

3. Results and discussion

3.1. Spatial model

The test results of Kaiser-Meyer-Olkin index (KMO) obtained a value of 0.497 and the Bartlett test of sphericity value of 119.482 with a significance of 0.000; this indicates that the variables and samples that have not been analysed further. To increase the KMO value, it is necessary to issue a variable with a Measure Sampling Adequacy (MSA) value of < 0.5. Variables issued are variables with the smallest MSA value, namely the distance from the river and rainfall. So that the final results of PCA analysis of four are variables that feasible to be analysed further. After issuing the variable with the smallest MSA value, the results of testing the KMO value of 0.611 and the Bartlett test of sphericity value of 59.333 with a significance of 0.000, and it is known that the MSA value > 0.5 for each variable. So that the requirements of the PCA have been fulfilled and the analysis can continue.

| Component | Total Eigenvalues | % of Variance | Cumulative (%) |
|-----------|------------------|---------------|----------------|
| 1         | 1.948            | 48.706        | 48.706         |
| 2         | 1.000            | 25.002        | 73.707         |
| 3         | 0.623            | 15.585        | 89.292         |
| 4         | 0.428            | 10.708        | 100.000        |
Figure 2. Driving factors of habitat suitability of Sumatran tiger prey in Besitang; a) distance from the road, b) rainfall, c) slope, d) distance from the river, e) NDVI, f) elevation

The results of extraction using PCA show that of the seven variables used to build habitat suitability of Sumatran tiger prey model, three new components can explain the total data diversity with a total percentage of 73.707% with the total eigenvalues value exceeding (Table 1). The proportion of diversity that is considered sufficient to represent the total diversity of data if cumulative diversity reaches 70% - 80% [11].

| Table 2. Rotated component matrix |
|----------------------------------|
| Component | 1    | 2    |
| Distance from road | **0.818** | 0.011 |
| Elevation | **0.655** | 0.555 |
| NDVI | **0.787** | 0.051 |
| Slope | -0.006 | **0.959** |

Based on Table 2, third variables are highly correlated with the first component, namely distance from the road, elevation, and NDVI. In other words, these third variables have the most influence on the incidence of habitat suitability of Sumatran tiger prey in the study area. This component as a whole illustrates the activities of Sumatran tiger prey in the environment, with a diversity of 48.706%. The second component consists of the slope, which illustrates the ease of accessibility in finding a feed with a diversity value of 25.001%.

The results of this study reveal many similarities with the results of [6-7], where habitat suitability of Sumatran tiger occur in low elevation and low slope. The area of distribution of Sumatran tigers will follow the area of distribution of its feed, so information modelling of the Sumatran tiger prey habitat will be useful for the determination of Sumatran tiger habitat later.
Based on Table 1 and Table 2, the habitat suitability of the Sumatran tiger prey spatial model formed is written with the following equation: \( Y = (1.948 \times \text{Distance from the road}) + (1.948 \times \text{Elevation}) + (1.948 \times \text{NDVI}) + (1.000 \times \text{Slope}) \). The results of the spatial analysis with weighting method using PCA produces the lowest pixel value of 4.89, the highest pixel value of 34.22. Furthermore, by transforming the value, the index value is made in the interval 0 to 1. The results of the observation are visualized in Figure 3.

![Habitat Suitability Index of Sumatran Tiger Prey in Besitang](image)

**Figure 3.** Map of habitat suitability index of Sumatran tiger prey in Besitang

### 4. Conclusion

The utilization of GIS with weighting using PCA can be used to model the mapping of habitat suitability of Sumatran tiger prey in Besitang. Based on the spatial modelling that has been carried out, areas that have values getting closer to number 1 indicate the area is more suitable for the habitat of Sumatran tiger prey.

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