Spatial model of human-sumatran orangutan (*Pongo abelii*) conflict vulnerability in Besitang, Indonesia

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Abstract. Sumatran orangutan is one of the key species of wildlife that live in the Besitang forest landscape. Conflicts between sumatran orangutans and humans often occur along with the narrowing of sumatran orangutan habitat. The importance of knowing the distribution of locations at risk of human-wildlife conflict is expected to be used as a reference in efforts to mitigate the occurrence of human-wildlife conflict. This study aimed to get information about the vulnerability distribution of human-sumatran orangutan conflict (HSOC) based on influenced 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 HSOC. Overlay analysis of the factors influencing HSOC distribution is done using Geographic Information System (GIS). The results of the study showed that the vulnerability of HSOC could be divided into three classes namely, the highly vulnerable areas of conflict are 35,282.16 ha (21.66), medium vulnerable areas are 55,662.57 ha (34.17%) and not vulnerable areas are 71,960.85 ha (44.17%). This research will be helpful as an early warning system in HSOC mitigation efforts.

1. Introduction

Human-wildlife conflicts have occurred a lot when humans carry out activities in areas that are wildlife habitats. This problem has existed as long as wild animals and humans share the same resources [1]. The issue of human-wildlife conflict that has occurred a lot is not a new phenomenon. The human-wildlife conflict has been as old as human civilization. Still, currently, this phenomenon poses more serious environmental challenges and has increased over the last few decades [2], including those that have occurred in Besitang forest landscape.

The orangutan habitat in Langkat Regency is getting narrower due to forest degradation and deforestation. As a result, an increasing number of HSOC is occurring in this area. The high rate of deforestation in Langkat Regency in the period 1990-2015 is 1,292.01 ha per year [3], while [4] reports that in Besitang forest landscape deforestation had occurred 224.14 ha per year in the period 2008-2016. The high class of Forest degradation in the Besitang forest landscape, which occurred in 2008-2016 is 527.85 ha [5].

Information to predict the level of HSOC vulnerability is needed as an effort to mitigate HSOC. Information on the level of HSOC susceptibility in the study area is not yet available, so this research is
The utilization of remote sensing and GIS technology can be used to model the level of HSOC. This study aims to build a spatial model of HSOC vulnerability in the Besitang forest landscape.

2. Materials and Method

2.1. Research Location
This research was carried out in the surrounding villages of Management Section of National Park (MSNP) VI Besitang, Gunung Leuser National Park. There are nine villages around the MNSP VI Besitang, namely the village of PIR ADB, Harapan Maju, Bukit Mas, Mekar Makmur, Namo Sialang, Bukit Selamat, Sawit Hulu, Sei Serdang, and Sei Musam. Based on administrative areas, this area is located in the Langkat Regency, North Sumatra Province (Figure 1).

![Figure 1. The site of research in Besitang](image)

2.2. Spatial Analysis
Secondary data in HSOC coordinates were obtained from GNLP, while primary data was obtained through direct HSOC point retrieval using GPS from the field. Fourteen HSOC data used to build the model were selected randomly, while the validation test was five data. ArcGIS 10.5 software is used to perform spatial modeling of HSOC points with HSOC driving factors.

Social and biophysical factors, referring to previous studies [6-7], were used to predict the occurrence of HSOC. Slope and elevation data are derived from Shuttle Radar Topography Mission (SRTM). Data of distance from the settlement, distance from the road, distance from the forest, distance from the oil palm plantation, and distance from the river were obtained using the euclidian distance [6,8]. Landsat 8 imagery path/row: 129/57 and path/row: 129/58 with the date of acquisition February 13, 2018 were used to generate of Normalized Difference Vegetation Index (NDVI). Population density data in 2018 is get from Central Bureau of Statistics.

The use of PCA in this study refers to [6,8], where PCA is part of multivariate statistic analysis. PCA is used to reduce factors that do not influence and give weight to the factors that influence the distribution of HSOC. 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 [9].
The mathematical equation model of the level of HSOC based on PCA weighting can be written as follows:

\[ Y = aFk1+bFk2+cFk3+dFk4+eFk5+fFk6+gFk7+hFk8+iFk9 \] (1)

Note :
- \( Y \) = total value of HSOC areas
- \( a-j \) = the weight value of each variable
- \( Fk1 \) = NDVI
- \( Fk2 \) = slope
- \( Fk3 \) = elevation
- \( Fk4 \) = distance from river
- \( Fk5 \) = distance from road
- \( Fk6 \) = distance from settlement
- \( Fk7 \) = distance from forest
- \( Fk8 \) = distance from oil palm plantation
- \( Fk9 \) = population density

2.3. Model Validation
The validation test for a spatial model of HSOC vulnerability is as follows:

\[ V = \frac{n}{N} \times 100\% \] (2)

Note :
- \( n \) = number of HSOC points in vulnerable class
- \( N \) = total number of HSOC points
- \( V \) = level of validity

3. Result and Discussion
3.1. Spatial Model
Based on the Spearman correlation test results obtained by a variable of population density and distance from the road has a strong correlation with other variables so that both of these variables are excluded and not included in the PCA. The Kaiser-Meyer-Olkin index (KMO) test results obtained a value of 0.438 and the Bartlett test of sphericity value of 21.437 with a significance of 0.433. This indicates that the variables and samples have not been analyzed further. The final variable is elevation, slope, distance from river, distance from oil palm plantation, and distance from settlement.
Table 1. Initial Eigenvalues of driving factors of HSOC in Besitang

| Component | Total | % of Variance | Cumulative (%) |
|-----------|-------|--------------|---------------|
| 1         | 2.182 | 43.635       | 43.635        |
| 2         | 1.417 | 28.345       | 71.980        |
| 3         | 0.827 | 16.537       | 88.517        |
| 4         | 0.312 | 6.241        | 94.758        |
| 5         | 0.262 | 5.242        | 100.000       |

The extraction results using PCA show that of the seven variables used to build the HSOC model, two new components can explain the total data diversity with a total percentage of 71.980% with the value of the total eigenvalue exceeding 1 (Table 1). The proportion of diversity that is considered sufficient represents the total diversity of data if cumulative diversity reaches 70% - 80% [10].

Table 2. Rotated Component Matrix

| Variable                        | Component |
|---------------------------------|-----------|
|                                 | 1         | 2         |
| Elevation                       | 0.911     | -0.045    |
| Slope                           | 0.815     | 0.046     |
| Distance from river             | 0.607     | 0.348     |
| Distance from oil palm plantation| 0.229     | 0.892     |
| Distance from settlement        | -0.055    | 0.872     |

Table 2 can be seen three variables are highly correlated (bold printed) with the first component, namely elevation, slope, and distance from the river. This component as a whole illustrates the biophysical factors, with a diversity of 43.635%. The second component consists of the distance from oil palm plantation and distance from settlement with a diversity value of 28.345%.

The results of the weighting of each driving factors (table 2) based on the PCA diversity score (table 1) are shown in table 3.

Table 3. Weighted of driving factors

| No | Variable                        | Total of eigenvalues |
|----|---------------------------------|----------------------|
| 1  | Elevation                       | 2.182                |
| 2  | Slope                           | 2.182                |
| 3  | Distance from river             | 2.182                |
| 4  | Distance from oil palm plantation| 1.417               |
| 5  | Distance from settlement        | 1.417                |

The results of the weighting method using PCA produce the pixel value of 12.21, until 46.90. The results of the observation are presented in Table 3 and visualized in Figure 3.

Table 4. Vulnerability rate of HSOC in Besitang forest landscape

| No | Vulnerability rate  | Range     | Total (Ha) | Percentage (%) |
|----|---------------------|-----------|------------|----------------|
| 1  | Not vulnerable      | 12.21 – 23.78 | 71,960.85 | 44.17          |
| 2  | Vulnerable          | 23.78 – 35.34 | 55,662.57 | 34.17          |
| 3  | Very vulnerable     | 35.34 – 46.90 | 35,282.16 | 21.66          |
The vulnerable area of HSOC is dominated by the type of land cover of oil palm plantations and mixed plantations that border directly with forests. Medium vulnerable areas of HSOC are scattered in the middle, and some are scattered in the east of the study area. This area is dominated by forest areas adjacent to oil palm plantations and mixed plantations. While primary forest areas dominate the not vulnerable area of HSOC with steep to very steep slopes. This area is also very far from human existence.

The research results [11] report that the best habitat for orangutans is lowland areas, flat slopes, and close to rivers. This study also shows that areas prone to HSOC are suitable for orangutan habitat as in research [11]. Also, the results of this study report that many HSOC occur in areas close to settlements and oil palm plantations.

3.2. Validation Model

HSOC-prone areas consist of vulnerable and very vulnerable classes. The 5 HSOC points used as model validation show that there are 2 points in the vulnerable class and 3 points in the HSOC very vulnerable class. This means that the HSOC vulnerability spatial model that is formed has a validation level of 100%.

4. Conclusions

Weighting using PCA on spatial modeling of HSOC vulnerability in the Besitang forest landscape can predict the HSOC level of 100%. The HSOC prone area is 35,282.16 ha (21.66%) from the study area based on the spatial model of HSOC vulnerability that has been formed.

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