Spatial distribution characteristics of human-elephant conflict (HEC) in Besitang

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Abstract. The conflict between humans and wildlife tends to increase lately, especially the human-elephant conflict (HEC). The high level of human activity around the forest causes an increase in the rate of forest destruction. The opening of agricultural land in and around the forest, causing the elephant habitat to become narrow so that the elephant looks for new space to move to community land. HEC occurs when elephants and humans fight over the same resource. The purpose of this study is to obtain information on the characteristics of the spatial distribution of human-elephant conflict in Besitang. The method used in this study is the analysis of HEC points overlay with several biophysical variables using GIS. The results of this study show that the distribution of HEC occurs mostly in sloping areas with low topography and areas relatively close to forests, plantations / agricultural communities, settlements, and rivers.

1. Introduction

Habitat of sumatran elephant (Elephas maximus sumatranus) in Langkat Regency increasingly narrows because of deforestation and forest degradation that has occurred. As a result, an increasing number of HEC is happening in this area. This can be seen from the high rate of deforestation in Langkat Regency at 1,292.01 ha per year in the period 1990-2015 [1], while [2] reports that in Besitang in 2008-2016 deforestation had occurred 224.14 ha per year. In the Besitang forest landscape, forest degradation that occurred in the period 2008-2016 is divided into high (527.85 ha), medium (9,763.83 ha), and low (28,898.73 ha) [3].

The higher the human activity around the forest area, the increasing the rate of forest destruction, which causes the elephant habitat to be narrow. As a result, elephants will look for new space to move to residential areas, resulting in HEC [4]. Knowledge of the characteristics of the spread of HEC as an initial stage of spatial modeling activities of HEC vulnerability becomes essential to know in HEC mitigation planning activities [5]. This study aims to determine the characteristics of the spatial distribution of HEC that occur in Besitang.
2. Materials and Method

2.1. Research Location
This research was conducted in the Management Section of the National Park (MSNP) region VI Besitang of Gunung Leuser National Park (GLNP), and surrounding villages. The villages around the MSNP region VI Besitang are Bukit Selamat, Bukit Mas, PIR ADB, Harapan Maju, Mekar Makmur, Sawit Hulu, Sei Serdang, Namo Sialang and Sei Musam located in Langkat Regency, North Sumatra Province (Figure 1).

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

2.2. Spatial Distribution Analysis of HEC
HEC event data was obtained from direct observations in the field as well as secondary data on HEC event coordinates from the Gunung Leuser National Park Office. Retrieval of the HEC coordinate point in the area is done using GPS. Furthermore, the HEC coordinate data is overlayed with biophysical and population variables (elevation, slope, distance from the road, distance from the river, distance from the edge of the forest, distance from oil palm plantations, distance from mixed plantations, distance from settlements and population density). Descriptive analysis is carried out to discuss the relationship of HEC with biophysical factors and the population.

Land cover classification is carried out through an on-screen digitization process on Google Earth imagery using ArcGis 10.7 software. Class determination is taken through the results of a ground check. It adjusts to the conditions on the ground to obtain 7 types of land cover, namely forests, oil palm plantations, mixed gardens, shrubs, settlements, water bodies, and bare soil.

Information on vegetation density is obtained from NDVI (Normalization Difference Vegetation Index). The making of NDVI in this study was obtained from Landsat Image 8 path/row: 129/57 and path/row: 129/58, with the acquisition date February 13, 2018. The NDVI formula was calculated by the equation [6]:

\[
\text{NDVI} = \frac{(\text{NIR} - \text{R})}{(\text{NIR} + \text{R})}
\]  

(1)
Where NIR: Digital value in Near-Infrared bands, R: Digital value in the Red band

The distance map from the road is made from the road network map, the distance map from the river is made from the river network map, and the distance map from the forest, oil palm plantations, mixed gardens and settlements is made from the land cover map. Elevation and slope maps are made from the Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM). Whereas the population density data for 2017 was obtained through the Central Statistics Agency.

3. Result and Discussion

3.1. Spatial Characteristic of HEC based on Elevation
Spatial analysis results are known that the elevation at the study site ranged from 0 - 2843 m. The elevation class is divided into 5 classes. The distribution of HEC points based on the elevation class is presented in Table 1.

| No | Elevation Class (m) | Area (ha) | Sum of HEC | Percentage (%) |
|----|---------------------|-----------|------------|----------------|
| 1  | 0 – 50              | 22,645.80 | 24         | 63.16          |
| 2  | 50 – 100            | 45,223.02 | 6          | 15.79          |
| 3  | 100 – 150           | 15,026.22 | 4          | 10.53          |
| 4  | 150 – 200           | 3,807.27  | 4          | 10.53          |
| 5  | > 200               | 76,203.27 | 0          | 0              |

Based on the elevation factor, it is shown that the HEC in Besitang is mostly found in the elevation class 0 - 50 m. The higher the elevation, the less HEC is found. In the elevation class >2000 m HEC was not found because this area is an area in the forest that is far from human activities (settlement, agriculture, roads, or other human activities). Besides that, this area is also not a habitat that is preferred by elephants. Although the elephant can move to various heights, but prefers the lowlands because of the availability of food sources and easy to move the elephant [7].

3.2. Spatial Characteristic of HEC based on Slope
Based on the slope factor, HEC in Besitang mostly occurs in slope 0 - 8%. HEC is less found with increasing slope values. The distribution of HEC points by slope class is presented in Table 2.

| No | Slope class (%) | Area (ha) | Sum of HEC | Percentage (%) |
|----|----------------|-----------|------------|----------------|
| 1  | 0 – 8          | 37,733.67 | 19         | 50.00          |
| 2  | 8 – 15         | 30,722.58 | 16         | 42.11          |
| 3  | 15 – 25        | 22,667.49 | 3          | 7.89           |
| 4  | 25 – 40        | 18,491.67 | 0          | 0              |
| 5  | > 40           | 53,290.17 | 0          | 0              |

HEC in Besitang is only found in areas that have 0 - 25% slope and not in areas that are> 25%. According to [9], Sumatran elephants have a larger body size compared to other herbivorous animals in Sumatra. This body size affects the ability of elephants to move on steep slopes, if there is an elephant that can reach the hills tall, the elephant must have been looking for a mountain ridge to avoid the steep slope. Elephants are more comfortable to move and protect their offspring from predators and easier to get food in groups or solitary, and avoid heavy areas and mountains [8].

1.1. Spatial Characteristic of HEC based on Distance from Road
Roads are access to transportation for daily human activities. The distribution of conflict points based on the distance from the road is presented in Table 3.

### Table 3. Distribution of HEC points based on distance from road

| No | Distance from road (m) | Area (ha) | Sum of HEC | Percentage (%) |
|----|------------------------|-----------|------------|----------------|
| 1  | 0 – 500                | 50.612,49 | 28         | 73.68          |
| 2  | 500 – 1000             | 10.196,10 | 9          | 23.68          |
| 3  | 1000 – 1500            | 4.954,50  | 1          | 2.64           |
| 4  | 1500 – 2000            | 3.859,20  | 0          | 0              |
| 5  | > 2000                 | 93.283,29 | 0          | 0              |

Many HEC in Besitang occurs in areas that tend to be close to the road. Based on direct observations in the field, roads in oil palm plantations are the most frequently found by HEC. Signs of elephant presence on oil palm plantation roads were found in the form of elephant dung and elephant footprints on the road. The relatively flat and open nature of the road makes it easy for elephants to move.

3.3. **Spatial Characteristic of HEC based on Distance from River**

Elephants choose habitats that have water sources for drinking and wallowing. The distribution of conflict points based on the distance from the river is presented in Table 4.

### Table 4. Distribution of HEC points based on distance from river

| No | Distance from river (m) | Area (ha) | Sum of HEC | Percentage (%) |
|----|-------------------------|-----------|------------|----------------|
| 1  | 0 – 1000                | 75,507.12 | 30         | 78.95          |
| 2  | 1000 – 2000             | 42,901.83 | 4          | 10.53          |
| 3  | 2000 – 3000             | 24,752.07 | 2          | 5.26           |
| 4  | 3000 – 4000             | 12,776.31 | 0          | 0              |
| 5  | > 4000                  | 6,968.25  | 2          | 5.26           |

Many HEC in Besitang occurs in areas closer to the river. The river is an essential factor for elephants to meet their needs for drinking, bathing, and wallowing. Elephants are classified as water-dependent species, which are animals that need water to destroy food and facilitate digestion.

3.4. **Spatial Characteristic of HEC based on Distance from Forest**

Elephants are one type of animal that has feed mostly located in the forest area. HEC usually occurs in many border areas between forests and residential and agricultural areas. The distribution of conflict points based on the distance from the forest is presented in Table 5.

### Table 5. Distribution of HEC points based on distance from forest

| No | Distance from forest (m) | Area (ha) | Sum of HEC | Percentage (%) |
|----|--------------------------|-----------|------------|----------------|
| 1  | 0 – 500                  | 14.168,79 | 34         | 89.47          |
| 2  | 500 – 1000               | 7.872,39  | 4          | 10.53          |
| 3  | 1000 – 1500              | 6.124,86  | 0          | 0              |
| 4  | 1500 – 2000              | 5.038,11  | 0          | 0              |
| 5  | > 2000                   | 129.701,43| 0          | 0              |
Many HEC in Besitang occur at a range of 0 - 500 m, with fewer HEC found with the distance from the forest. In other words the closer to the forest, the more conflicts that occur. Elephants also really need the existence of forests as a place to live, breed, take refuge and so on.

3.5. Spatial Characteristic of HEC based on Distance from Oil Palm Plantation

Oil palm plantations are the most extensive land cover after forests in the study area. Nearly the entire MSNP region VI Besitang of GLNP is directly adjacent to palm oil plantations owned by individuals and companies. The distribution of HEC points based on distance from oil palm plantations is presented in Table 6.

### Table 6. Distribution of HEC points based on distance from oil palm plantations

| No | Distance from oil palm plantations (m) | Area (ha)   | Sum of HEC | Percentage (%) |
|----|--------------------------------------|-------------|------------|----------------|
| 1  | 0 – 1000                              | 55.016,19   | 31         | 81,58          |
| 2  | 1000 – 2000                           | 8.166,78    | 5          | 13,16          |
| 3  | 2000 – 3000                           | 7.583,13    | 1          | 2,63           |
| 4  | 3000 – 4000                           | 6.533,55    | 1          | 2,63           |
| 5  | > 4000                                | 85.605,93   | 0          | 0              |

Many HEC occur in oil palm plantations, which border directly with forest areas. Based on the type of land cover, oil palm plantations are one of the types of land cover that many elephant conflicts occur. Plantation crops such as oil palm is one of the plants that elephants like.

3.6. Spatial Characteristic of HEC based on Distance from Mixed Garden

HEC also happens a lot in mix gardens. Distribution of conflict points based on distances from mixed plantations is presented in Table 7.

### Table 7. Distribution of HEC points based on distance from mixed garden

| No | Distance from mixed garden (m) | Area (ha)   | Sum of HEC | Percentage (%) |
|----|--------------------------------|-------------|------------|----------------|
| 1  | 0 – 1000                       | 40.152,87   | 31         | 81,58          |
| 2  | 1000 – 2000                    | 16.533,00   | 5          | 13,16          |
| 3  | 2000 – 3000                    | 11.507,04   | 2          | 5,26           |
| 4  | 3000 – 4000                    | 8.056,98    | 0          | 0              |
| 5  | > 4000                         | 86.655,69   | 0          | 0              |

Community rubber gardens are locations frequented by elephants. Elephants were found uprooting and eating young rubber leaves. Elephants like rubber leaves that are young because they are soft and have a white exudate liquid which elephants also like. Elephants tend to use old rubber plantation land to rest, rub against the trees and salt.

3.7. Spatial Characteristic of HEC based on Distance from Settlement

Distance from settlement is one of the crucial factors that is suspected to influence the vulnerability of elephant conflict because settlement is a place where people live and carry out their daily activities. The distribution of conflict points based on the distance from the settlement is presented in Table 8.
Table 8. Distribution of HEC points based on distance from settlement

| No | Distance from settlement (m) | Area (ha)     | Sum of HEC | Percentage (%) |
|----|------------------------------|---------------|------------|----------------|
| 1  | 0 – 1000                     | 38.176,83     | 18         | 47.37          |
| 2  | 1000 – 2000                  | 18.490,68     | 11         | 28.95          |
| 3  | 2000 – 3000                  | 9.804,06      | 9          | 23.68          |
| 4  | 3000 – 4000                  | 7.197,39      | 0          | 0              |
| 5  | > 4000                       | 89.236,62     | 0          | 0              |

Based on the distance from the settlement, elephant conflict in the study location mostly occurred at a distance of 0-1000 m totaling 18 points (47.37%). Elephant conflicts are mostly found in locations close to settlements, and conversely, fewer are found in locations that are far from settlements.

3.8. Spatial Characteristic of HEC based on NDVI

NDVI describes the density of vegetation cover above the soil surface. The distribution of elephant conflict points by NDVI class is presented in Table 9.

Table 9. Distribution of HEC points based on NDVI

| No | Class of NDVI | Area (ha) | Sum of HEC | Percentage (%) |
|----|---------------|-----------|------------|----------------|
| 1  | < 0           | 125,28    | 0          | 0              |
| 2  | 0 – 0,3       | 8.622,18  | 0          | 0              |
| 3  | 0,3 – 0,4     | 41.963,76 | 5          | 13.16          |
| 4  | 0,4 – 0,5     | 106.654,41| 30         | 78,95          |
| 5  | > 0,5         | 5.539,95  | 3          | 7.89           |

Many HEC in the study site occur in areas with tight canopy densities. Canopy density is rarely a condition that is not often visited by elephants. Elephants need places that have good canopy closure as a shelter because elephants cannot stand the heat of the sun.

3.9. Spatial Characteristic of HEC based on Population Density

The distribution of conflict points based on population density is presented in Table 10.

Table 10. Distribution of HEC points based on population density

| No | Class of population density (jawa/km²) | Area (ha)     | Sum of HEC | Percentage (%) |
|----|---------------------------------------|---------------|------------|----------------|
| 1  | 0 – 23                                | 121.226,85    | 11         | 28.94          |
| 2  | 23 – 46                               | 18.044,82     | 22         | 57.90          |
| 3  | 46 – 69                               | 13.388,49     | 3          | 7.90           |
| 4  | 69 – 92                               | 6.684,30      | 2          | 5.26           |
| 5  | > 92                                  | 3.561,12      | 0          | 0              |

Elephants tend to stay away from areas with a relatively high population density, because it has become the nature of wild animals that tend to stay away from disturbances or threats to their life. But based on information from the public, elephants are often not afraid of human existence. This is evidenced by the more frequent elephants entering community land.

The more dense population in the villages around the forest causes more and more human activities around the forest both in land use and other activities. Should the high population density be more prone to HEC. However, returning to the actual conditions on the ground, that villages bordering the forest area in the MSNP VI Besitang Gunung Leuser National Park, turned out to have relatively low population densities, and conversely, villages with high population densities were far away with forest areas.
4. Conclusion
In general, HEC in the Besitang area occurs mostly in sloping areas with low topography and areas that are relatively close to forests, plantations / agricultural communities, settlements and rivers.

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