Application of Geographic Information System (GIS) for mapping of spatial distribution characteristics of the Sumatran Tigers (Panthera tigris sumatrae) prey in Besitang

N Sulistiyono1*, M I Maulana2, P Patana, and A Purwoko3

1Department of Forest Conservation, Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridarma Ujung No.1 Kampus USU, Medan, Republic of Indonesia-20155.
2Center of Excellence for Mangrove, Universitas Sumatera Utara, Medan, Republic of Indonesia-20155.
3Department of Forest Management, Faculty of Forestry, Universitas Sumatera Utara, Jl. Tridarma Ujung No.1 Kampus USU, Medan, Replublic of Indonesia-20155.

*Email: nurdinsulistyono@usu.ac.id

Abstract. This research is an example of GIS applications used in the field of conservation and landscape ecology. Sumatran tiger habitat management begins with knowing Sumatran tiger prey distribution. Information on Sumatran tiger prey distribution will be very useful in identifying the suitability of habitat for Sumatran tiger. This study objective to determine the spatial distribution of Sumatran tiger prey in Besitang forest. The method used is to overlay the coordinates of the tiger prey findings with the trigger factors that influence the distribution of Sumatran tiger prey using GIS. The results showed animals prey of Sumatran tiger in the Besitang area occurs mostly in sloping areas with low topography and regions that are relatively far to the road and near to the river.

1. Introduction

Geographical information, in its simplest form, is information related to a particular location [1]. In a broad sense, a geographic information system is a tool in processing spatial data into information [2]. The use of GIS is extensive in all science, including conservation and landscape ecology, including this research.

Besitang Forest is a habitat for Sumatran tiger whose existence continues to experience pressure. This can be seen from a study conducted by [3], which reports the deforestation rate of 224.14 ha per year. [4] also says that forest degradation on a massive scale of 527.85 ha in 2008 - 2016. Deforestation and forest degradation that have occurred have resulted in the habitat of the Sumatran tiger getting smaller.

Sumatran tigers are carnivores. The animals prey for Sumatran tigers are wild boar (Sus sp), sambar deer (Cervus unicolor), deer (Muntiacus muntjak), mouse deer (Tragulus sp), wild buffalo (Bubalus bubalis), tapirs (Tapirus indicus), monkeys (Macaca sp), hedgehog (Hystrix brachyura) and pangolin (Manis javanica). Besides, it also preys on reptiles such as turtles, snakes, and monitors lizards as well as various types of birds, fish, and frogs. Domestic animals such as goats, sheep, cows, and chickens are also targeted by tigers [5].

Knowledge of the characteristics of the spread of Sumatran tiger prey as an initial stage of spatial modeling habitat suitability of Sumatran tigers prey, such as research conducted by [6]. Knowledge of habitat preferences for wild animals is essential to formulate a conservation strategy, especially for endangered species [7]. This study objective to determine the characteristics of the spatial distribution of Sumatran tiger prey that occur in Besitang using GIS.
2. Materials and Method

2.1. Research Location

This research was conducted in the Besitang forest, which is part of Management Section of the National Park (MSNP) region VI Besitang that part of Gunung Leuser National Park (GLNP), Langkat Regency, North Sumatra Province. The map of the research location can be seen in figure 1.

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

2.2. Spatial Distribution Analysis of Sumatran Tigers Prey

The animals’ prey of Sumatran tiger found in the research location consists of deer, pigs, mouse deer, weasels, partridges, monkeys, and deer. The coordinates of the animal's presence prey of Sumatran tigers are taken using global positioning system (GPS) and secondary data from Gunung Leuser National Park. The total number of samples was 159 sample points prey of Sumatran tigers. Furthermore, these point of animal prey of Sumatran tiger existence is overlaid with trigger factors of habitat suitability using GIS. GIS analysis in this research using ArcGIS 10.7. Descriptive analysis is carried out to discuss the relationship of animal prey of Sumatran tiger with biophysical factors.

Data of slope and elevation are derived from Shuttle Radar Topography Mission (SRTM). Data of distance from the river and distance from the road were obtained using the euclidian distance [9]. Data of Rainfall is obtained from the Office of the Indonesian Meteorology and Geophysics Agency. Rainfall data is obtained from the results of inverse distance weighting (IDW) interpolation from BMKG stations around the research area. Data of Landsat 8 imagery path/row: 129/57 and path/row: 129/58, with the date of acquisition April 21, 2019, used to obtain Normalized Difference Vegetation Index (NDVI). Information on vegetation density is obtained from NDVI. The NDVI formula was calculated by the equation [8] :

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

where:
NIR : Digital number in Near-Infrared bands
R : Digital number in the Red band
3. Result and Discussion

3.1. Spatial Characteristic of Sumatran Tigers Prey based on Elevation

Elevation is one of the parameters in determining the suitability of Sumatran tiger prey. From the results of this study, it was found that the presence of Sumatran tiger prey tended to vary from low elevation to highland, however lowland areas were the best habitats for Sumatran tiger prey. The elevation class is divided into 5 classes. Sumatran tiger prey distribution based on the elevation class is presented in table 1.

| Elevation Class (m) | Area (ha)   | Sum of animals prey of Sumatran tiger | Percentage (%) |
|---------------------|------------|--------------------------------------|----------------|
| 0 – 356             | 44,395.83  | 138                                  | 86.8           |
| 356 – 820           | 9,597.42   | 1                                    | 0.6            |
| 820 – 1,314         | 17,579.16  | 2                                    | 1.3            |
| 1,314 – 1,873       | 8,845.11   | 8                                    | 5.0            |
| > 1,873             | 34,791.03  | 10                                   | 6.3            |

Based on the elevation factor, it is shown that the animal's prey of Sumatran tiger in Besitang is mostly found in the elevation class 0 – 356 m (86.8%). This is also consistent with the opinion [9] that tiger prey animals prefer forest areas with an elevation between 0 – 300 m. However, tiger prey tracks were also found in class 4 with an elevation of 1,313 – 1,873 m (5%) and class 5 at an elevation of above 1,873 m (6.3%), which shows that tiger prey also likes high areas. This could happen because there is less food availability.

3.2. Spatial Characteristic of Sumatran Tigers Prey based on Slope

The finding of Sumatran tiger prey in Besitang forests is quite evenly distributed in various slope classes. Sumatran tigers prey distribution based on slope class is presented in table 2.

| Slope class (%) | Area (ha)   | Sum of animals prey of Sumatran tiger | Percentage (%) |
|-----------------|------------|--------------------------------------|----------------|
| 0 – 8           | 3,143.61   | 42                                   | 26.4           |
| 8 – 15          | 12,290.58  | 47                                   | 29.6           |
| 15 – 25         | 24,953.49  | 39                                   | 24.5           |
| 25 – 40         | 34,107.84  | 19                                   | 11.9           |
| > 40            | 40,671.18  | 12                                   | 7.5            |

From the results of the study (Table 2), it can be seen that the most common finding points for Sumatran tiger prey are in the slope class 1 until 3, namely 0-25%, with the number of findings being 128 (80.5%). The higher the slope class, the less Sumatran tiger prey, is found. This is also consistent with the statement [10, 11], which states that Sumatran tiger prey prefers sloping areas because if it is on a high slope, it will require more energy for its daily movement.

3.3. Spatial Characteristic of Sumatran Tiger Prey based on Distance from Road

Roads are access to transportation for daily human activities. Sumatran tiger prey distribution based on the distance from the road is presented in table 3.
The diversity of distribution can occur because the distance between each class is very small, the least to class 5. Sumatran tiger prey was found in the rainfall class of more than 4.64 mm/day (3.1%). The least Sumatran tiger prey was found in the rainfall class of more than 4.64 mm/day (3.1%). This diversity of distribution can occur because the distance between each class is very small, where the number of Sumatran tiger prey finds as much as 62 or 39.0% finding point. This shows that the further away from the road, the Sumatran tiger prey feels more comfortable from human disturbance. In general, all wild animals stay away from human activities, including Sumatran tiger prey animals.

### 3.4. Spatial Characteristic of Sumatran Tiger Prey based on Distance from River

A suitable animal habitat must meet all the needs needed for the survival of these animals. Rivers are the most essential thing for wildlife in meeting their water needs. Sumatran tiger prey distribution based on the distance from the river is presented in table 4.

| Distance from the road (m) | Area (ha)   | Sum of animals prey of Sumatran tiger | Percentage (%) |
|---------------------------|------------|--------------------------------------|----------------|
| 0 – 3,606                 | 11,401.83  | 12                                   | 7.5            |
| 3,606 – 8,167             | 60,810.57  | 4                                    | 2.5            |
| 8,167 – 13,364            | 13,250.70  | 32                                   | 20.1           |
| 13,364 – 19,091           | 14,324.13  | 62                                   | 39.0           |
| > 19,091                  | 15,421.32  | 49                                   | 30.8           |

Based on table 3, it can be seen that the less number of Sumatran tiger prey points found at a distance of 3,606 – 8,167 m is 4 (2.5%), and most are located at a distance of 13,364 – 19,091 m with the number of animals finds as much as 62 or 39.0% finding point. This shows that the further away from the road, the Sumatran tiger prey feels more comfortable from human disturbance. In general, all wild animals stay away from human activities, including Sumatran tiger prey animals.

### 3.4. Spatial Characteristic of Sumatran Tiger Prey based on Distance from River

Based on table 4, it can be seen that Sumatran tiger prey is found at a distance of 0 – 732 meters (59.1%) and a distance of 732 – 1,549 meters (29.6%). In areas further away from the river, the number of Sumatran tiger prey finds is getting smaller.

| Distance from river (m) | Area (ha)   | Sum of animals prey of Sumatran tiger | Percentage (%) |
|------------------------|------------|--------------------------------------|----------------|
| 0 – 732                | 10,530.36  | 94                                   | 59.1           |
| 732 – 1,549            | 4,733.82   | 47                                   | 29.6           |
| 1,549 – 2,490          | 19,452.69  | 9                                    | 5.7            |
| 2,490 – 3,640          | 31,807.98  | 1                                    | 0.6            |
| > 3,640                | 48,683.70  | 8                                    | 5.0            |

### 3.5. Spatial Characteristic of Sumatran Tiger Prey based on Rainfall

Sumatran tiger prey distribution based on the rainfall is presented in table 5.

| Rainfall (mm/day) | Area (ha)   | Sum of animals prey of Sumatran tiger | Percentage (%) |
|------------------|------------|--------------------------------------|----------------|
| 0 – 4.38         | 16,940.88  | 42                                   | 26.4           |
| 4.38 – 4.47      | 23,012.10  | 14                                   | 8.8            |
| 4.47 – 4.56      | 23,674.50  | 28                                   | 17.6           |
| 4.56 – 4.64      | 23,097.42  | 70                                   | 44.0           |
| > 4.64           | 28,483.65  | 5                                    | 3.1            |

From table 5, it can be seen that the signs of the presence of Sumatran tiger prey vary from class 1 to class 5. The Sumatran tiger prey is mostly found in the rainfall class 4.56 – 4.64 mm/day (44.0%). The least Sumatran tiger prey was found in the rainfall class of more than 4.64 mm/day (3.1%). This diversity of distribution can occur because the distance between each class is very small, where the

---

**Table 3. Sumatran tiger prey distribution based on distance from the road**

| Distance from the road (m) | Area (ha) | Sum of animals prey of Sumatran tiger | Percentage (%) |
|----------------------------|-----------|--------------------------------------|----------------|
| 0 – 3,606                  | 11,401.83 | 12                                   | 7.5            |
| 3,606 – 8,167              | 60,810.57 | 4                                    | 2.5            |
| 8,167 – 13,364             | 13,250.70 | 32                                   | 20.1           |
| 13,364 – 19,091            | 14,324.13 | 62                                   | 39.0           |
| > 19,091                   | 15,421.32 | 49                                   | 30.8           |

**Table 4. Sumatran tiger prey distribution based on distance from river [12]**

| Distance from river (m) | Area (ha) | Sum of animals prey of Sumatran tiger | Percentage (%) |
|------------------------|-----------|--------------------------------------|----------------|
| 0 – 732                | 10,530.36 | 94                                   | 59.1           |
| 732 – 1,549            | 4,733.82  | 47                                   | 29.6           |
| 1,549 – 2,490          | 19,452.69 | 9                                    | 5.7            |
| 2,490 – 3,640          | 31,807.98 | 1                                    | 0.6            |
| > 3,640                | 48,683.70 | 8                                    | 5.0            |

**Table 5. Sumatran tiger prey distribution based on rainfall [13]**

| Rainfall (mm/day) | Area (ha) | Sum of animals prey of Sumatran tiger | Percentage (%) |
|------------------|-----------|--------------------------------------|----------------|
| 0 – 4.38         | 16,940.88 | 42                                   | 26.4           |
| 4.38 – 4.47      | 23,012.10 | 14                                   | 8.8            |
| 4.47 – 4.56      | 23,674.50 | 28                                   | 17.6           |
| 4.56 – 4.64      | 23,097.42 | 70                                   | 44.0           |
| > 4.64           | 28,483.65 | 5                                    | 3.1            |
Sumatran tiger prey still feels comfortable in the amount of rainfall less than 4.38 mm/day or 4.56 – 4.64 mm/day.

3.6. Spatial Characteristic of Sumatran Tiger Prey based on NDVI

NDVI describes the density of vegetation cover above the soil surface. Sumatran tiger prey distribution based on NDVI class is presented in Table 6.

| Class of NDVI | Area (ha) | Sum of animals prey of Sumatran tiger | Percentage (%) |
|---------------|-----------|--------------------------------------|----------------|
| 0 – 0.24      | 2,152.71  | 0                                    | 0.0            |
| 0.24 – 0.33   | 11,946.87 | 8                                    | 5.0            |
| 0.33 – 0.39   | 26,000.01 | 19                                   | 11.9           |
| 0.39 – 0.44   | 45,189.72 | 93                                   | 58.5           |
| > 0.44        | 29,919.15 | 39                                   | 24.5           |

The highest feeding point for Sumatran tiger was found in NDVI class 0.39 – 0.44 (58.5%) and NDVI class more than 0.44 (24.5%). The NDVI class is a land cover type in the form of shrubs, young secondary forest, and old secondary forest [14, 15]. Sumatran tiger prey is distributed in land cover types ranging from thickets to forests with high density.

4. Conclusion

GIS can be used to identify the distribution of Sumatran tiger prey based on biophysical factors. In general, animal prey of Sumatran tigers in the Besitang area occurs mostly in sloping areas with low topography and regions that are relatively far to the road and near to the river. Sites with a high distribution of Sumatran tiger prey should be a severe concern for the management of Sumatran tiger habitat.

References

[1] Martin, David, 1996 Geographic Information System, Routledge, London
[2] DeMers, Michael N 1997 Fundamentals For Geographic Information System, John Wiley & Sons Inc., USA
[3] Sulistiyono N, Ginting B S P, Patana P and Susilowati A 2019 Land Cover Change and Deforestation Characteristics in The Management Section of National Park (MSNP) VI Besitang, Gunung Leuser National Park Journal of Sylva Indonesiana (JSI) 02 (02) 91 – 100
[4] Sulistiyono N, Nifrody T, Patana P and Susilowati A 2019 Estimation of forest degradation distribution using landsat satellite imagery in Besitang forest landscape The 8th International Symposium for Sustainable Humanosphere IOP Conf. Series: Earth and Environmental Science (2019) 012031 doi:10.1088/1755-1315/374/1/012031
[5] Heryatin T dan Aniger A 1984 Harimau Sumatera di Propinsi Jambi dalam Khazanah Flora dan Fauna Nusantara. Ed. S.D Sastrapradja, S. Adisoemarto dan M.A. Rifai. Yayasan Obor Indonesia. Jakarta.
[6] Sulistiyono N, Rambe B A, Patana P and Purwoko A 2020 Spatial model of the Sumatran tigers (Panthera tigris sumatrae) prey habitat suitability index in Besitang. International Conference on Agriculture, Environment and Food Security (AEFS) 2019
[7] Underwood, A.J., Chapman, M.G. dan Crowe, T.P 2004 Identifying and Understanding Ecological Preferences for Habitat or Prey. Journal of Experimental Marine Biology and Ecology 300: 161-187.
[8] Rouse JW, Haas RH, Schell JA and Deering DW 1973 Nasa Technical Reports Server 74N30727 19740022614 p 309–317
[9] Wibisono H T, Figel J J, Arif S M, Ario A and Lubis AH 2009 Assessing the Sumatran Tiger Panthera tigris sumatrae Population in Batang Gadis National Park, A New Protected Area in Indonesia Fauna & Flora International, Oryx 43 (4) 634 – 8
[10] Suyadi, Jaya INS, Wijanartoa AB, and Wibisono HT 2012 Spatial Model Of Sumatran Tiger (Panthera tigris sumatrae) Potential Habitat Suitability In Bukit Barisan Selatan National Park, Indonesia Berita Ekologi Volume 11, Nomor 1, April 2012.
[11] Nizar M, Munir E, Munawar E and Irvan 2018 IOP Conf. Ser: Journal of Physics 1116(5) 052045
[12] Nizar M, Munir E, Irvan and Waller V 2018 IOP Conf. Ser: Earth and Environ. Sci. 216(1) 012043
[13] Octiva CS, Irvan, Sarah M, Trisakti B and Daimon H 2018 Rasayan J. Chem, 11(2) 791-797
[14] Haryani N, Harahap H, Taslim, Irvan 2020 IOP Conf. Ser: Mater. Sci. Eng. 801(1) 012051
[15] Yanqoritha N, Turmuzi M, Irvan, Fatimah, and Derlini 2018 Oriental Journal of Chemistry 34 (3) 1653-1657.