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State of human tiger conflict around Gunung Leuser National Park in Langkat Landscape, North Sumatra, Indonesia

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Abstract. *Patana P, Alikodra HS, Mawengkang H, Harahap RH. 2023. State of human tiger conflict around Gunung Leuser National Park in Langkat Landscape, North Sumatra, Indonesia. Biodiversitas 24: 837-846.* The Sumatran tiger (*Panthera tigris sumatrae*) is one of the key species which is considered an endangered species by the IUCN (2008). There has also been a recent threat to their population due to conflict with humans. Information about landscape characteristics and livelihood related to human-tiger conflict (HTC) is needed for a proper mitigation strategy based on local parameters. Therefore, this study was carried out around Gunung Leuser National Park (GLNP) using quantitative and qualitative methods. Principal component analysis (PCA) was used to analyze and map the risk of HTC using landscape characteristics. The physical factors, including land cover, slope, elevation, distance from rivers, and settlement, were analyzed. The livelihood aspect related to land use change was described descriptively and became a major analysis. The study area is located in the buffer zone of GLNP in Langkat District. The results showed that the Eigen weight value for the slope, elevation, and land cover factor was greater than the distance to the river and settlement. The spatial analysis also revealed that Langkat Landscape was in the medium risk of HTC by covering 60% area, while 40% was in the interval of high to very high risk. Furthermore, the high dependence on land for agriculture and the activity of livestock has become a trigger for more massive HTC in the last three years. It is a challenge in human-tiger conflict mitigation to involve the resolution of people's livelihoods surrounding the national park. The livelihood approach could be a future solution that bridges human and tiger aspects, in addition to habitat management and protecting conservation areas.

Keywords: Conflict, Gunung Leuser, livelihood, Sumatran tiger

INTRODUCTION

The Sumatran tiger (*Panthera tigris sumatrae*) is one of the 3 subspecies of tigers that are still alive in Indonesia (Wibisono and Pusparini 2010). Previous reports showed that it is on the verge of extinction because there are only 500 to 600 individuals in the population (Ministry of Environment and Forestry 2019, unpublished data). It has also been categorized as a critically endangered species on the International Union for Conservation of Nature and Natural Resources (IUCN) red list in 2015 (Godrich et al. 2015). The other subspecies, namely the Balinese tiger (*Panthera tigris balica*) and Javan tiger (*Panthera tigris sondaica*), have been declared extinct (Burton et al. 2020; Herdiana et al. 2022). The decline in the population of Sumatran tigers was caused by the high rate of habitat loss at 3.2-5.9%/year, as well as the illegal trade of these animals (Linkie et al. 2008). From 1998-2002, at least 51 of them were killed per year, of which 76% and 15% were caused by trafficking and human-tiger conflicts, respectively (Cochard et al. 2017). From 2001-2016 throughout Sumatra, there were 1065 cases of conflict, including 375 low-risk (tigers roaming around humans), 376 medium-risk (tigers attacking livestock), as well as 184 high-risk cases (tigers attacking humans) with 130 high risks cases ending in the death of the animal (Kartika 2017).

Human-tiger conflict (HTC) as a part of human-wildlife conflict (HWC) is one of the recent challenges in wildlife conservation (Chowdhury et al. 2016; Doubleday and Adams 2020). A recent study revealed that 87% of the publications on HWC were carried out in Asian countries, such as India, Nepal, and Indonesia, over the last decades (Torres et al. 2018). Consequently, reducing the intensity and mitigating conflicts have become top priorities in tiger conservation (Dhunghana et al. 2016). Comprehensive approaches are also needed to manage HTC to minimize risks to humans and animals (Bhattarai et al. 2019; Lubis et al. 2020). If these conflicts are not properly managed, it can lead to injury or death of domestic animals, as well as humans (Madden and McQuinn 2014). Human-wildlife interactions occurred in several rural communities and potentially impacted livelihood vulnerability (Pereira et al. 2021). Mitigation can be used to reduce HTC as well as bridge human communities to coexist with wildlife (Struebig et al. 2018; Wuttunee and Blanchard 2022).

Gunung Leuser National Park (GLNP) is an important habitat for four key species, including elephants, tigers, orangutans, and rhinos. Its landscape ranges between Aceh and North Sumatra Provinces, and Langkat is the only stretch of GLNP in North Sumatra. The increase in HTC in Langkat Landscape has become a complicated problem for the last three years. Various studies on HTC showed that the solutions vary with location due to their unique characteristics (Goswani et al. 2015). Therefore, this study used two approaches, namely, characteristics of the landscape and livelihoods of the community around GLNP. A proper understanding of the local characteristics of the HTC area is very necessary for mitigation efforts (Kholis et al. 2017; Patana et al. 2021).

The large-scale deforestation problem in Sumatra has disturbed the Sumatran tiger's entire range (Sunarto et al. 2012). A global study revealed that deforestation often occurs primarily where property rights are uncertain and mostly on land that are directly or indirectly under state responsibility (Reydon et al. 2020). Data related to the landscape in the GLNP buffer zone is needed to evaluate HTC's mitigation strategy by stakeholders. Information on landscape characteristics with livelihood-related HTC, particularly in Langkat is still limited because previous studies often focus on a large scale of the Leuser Ecosystem (Lubis et al. 2021). Therefore, this study aims to identify and analyze several factors of landscape characteristics within the GLNP and buffer zone related to livelihood that are triggers of HTC. The results are expected to be useful in mitigating human-tiger conflict in the GLNP buffer zone, especially in Langkat District, North Sumatra Province, Indonesia.

MATERIALS AND METHODS

Study area

The study area is Gunung Leuser National Park (GLNP) and its buffer zone in Langkat District, North Sumatra Province, Indonesia, on 3º12'14"-4º03'03" N, 97º52'00"-98º32'23" E. It is directly adjacent to the national park and serves as a limited production forest (LPF). This study was carried out from September 2019 to December 2020. Based on land status, this area was authorized by the forest management unit, KPH (Kesatuan Pengelolaan Hutan) I Stabat (Figure 1). The majority of the area is encroached, occupied and overlapped by communities and corporate organizations. Data on human-tiger conflicts from 2007-2020 were collected in this study. It's compilation data from reports of government and non-government agencies of conservation in North Sumatra.

Procedures

The data used in this study were obtained from primary and secondary sources through interviews and focus group discussion (FGD) with stakeholders and field observations to get more explanation on HTC in this area. I made an FGD among the key persons of villagers, heads of villages, plantation holders, non-government organizations related to wildlife and forest authority from GLNP and North Sumatera Conservation Agency. This technique was widely used as a form of participatory research in conservation (Nyumba et al. 2018).

Respondents of the interview were those who lived and interacted in tiger conflict areas inside the national park (Section VI GLNP) of Besitang Sub-district, as well as outside the national park, including enclave (Sembelin and Sapo Padang) and several villages in Bahorok Sub-districts (Section V GLNP). A purposive sampling by snowball technique was used through deep interviews with people who were directly involved in HTC. The questions used an open questionnaire system so that the interviewees were free to convey messages.

The tools include a camera, Global Positioning System (GPS), Arc GIS 10.3., stationery, SPSS 22, and Microsoft Excel, which was used for data processing. The materials used were a time series data of HTC and an administrative map of Langkat District, village map, map of KPH I, river network map, slope map, and elevation.

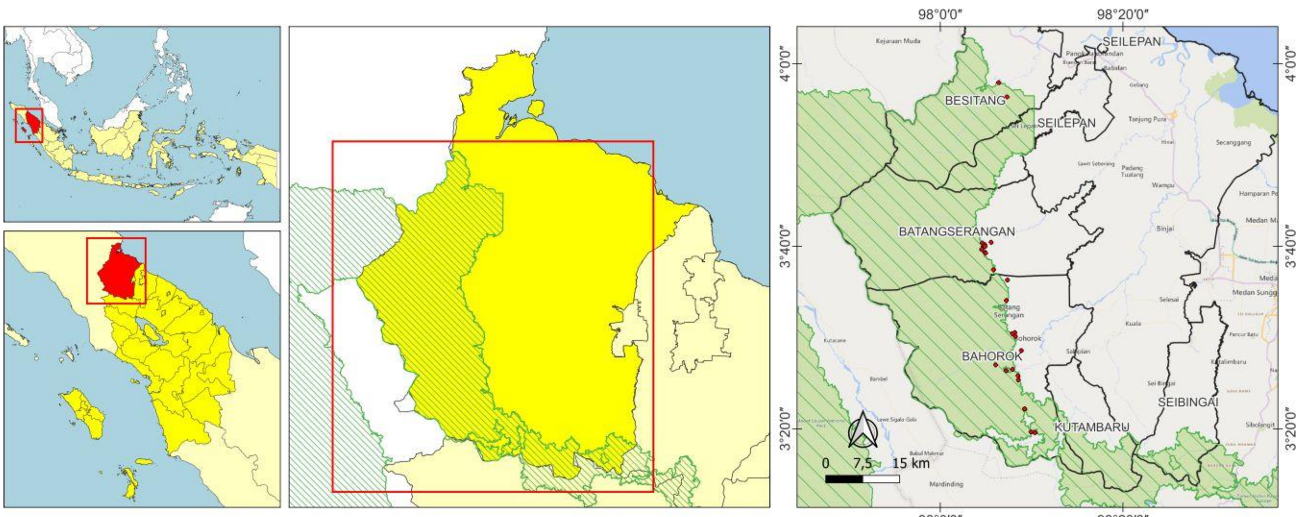

Figure 1. Location of GLNP and buffer zone at Langkat Landscape, North Sumatra Province, Indonesia

Data analysis

Ground checks were carried out to obtain the data on the actual condition by marking village areas with HTC. The parameters in this study include land cover, slope, altitude, distance from river and settlement. Secondary data consists of data on the distribution of conflict points obtained from related agencies or institutions under The Ministry of Environmental and Forestry, as well as land cover maps in the year of 2007, 2013 and 2020. All data of contour, elevation and slope maps were generated from Digital Elevation Model (DEM) maps downloaded via tides.big.go.id/DEMNAS/Sumatera.html. The buffer facility was used in determining the distance to objects whose results are shapefiles (features) or graphic objects. Furthermore, the data were analyzed using the following methods:

Principal Component Analysis (PCA)

PCA was carried out to identify the most meaningful basis to express a given data set (Kurita 2020). It is also used to detect the most influential factors for conflict intensity. The variables were inputted into PCA, including land cover, slope, altitude, distance from the river and settlement. The PCA results were then processed for the determination of the weight of each factor affecting the intensity of the conflict. PCA analysis was performed using the IBM SPSS 22 application.

Spatial analysis

Spreadsheet data with coordinate information was used and imported into ArcGIS for spatial analysis (Siljander et al. 2020), which was carried out by overlapping (overlay), classing, and scoring. The value of the conflict vulnerability class was determined by giving a score to each parameter. Subsequently, an overlapping process was carried out for each variable. The class with the highest conflict incidents was given the highest score.

Validation was performed to determine the level of confidence in the model being built. A total of 24 points were used for the development process, while the remaining 10 were for validation tests. Furthermore, it was carried out by looking at the accuracy of the conflict points in the location based on the hazard map built based on the model. The model of areas vulnerability to human-tiger conflict used PCA weighting by modifying the equation (Sulistiyono et al. 2019), $Y = aFk1 + bFk2 + cFk3 + dFk4 + eFk5$, where Y: total value of vulnerable conflict area; a-e: coefficient; Fk1: elevation factor; Fk2: slope factor; Fk3: river factor; Fk4: settlement factor; Fk5: population density factor.

RESULTS AND DISCUSSION

The occurrence of human and tiger conflicts demands an understanding of the landscape conditions around the location and livelihood activities. This is because it directly or indirectly provides an idea of how conflict is caused by inseparable interactions.

Conflict intensity and land cover change

In North Sumatra Province, HTC from 2007-2020, in all typical conflicts occurred 83 times or at least 6 incidents per year, and it was distributed across 14 of 33 total regencies (42%). These events were more dominant in Langkat during this period, namely 38 incidents or 2.71 (=3) times per year, and it accounted for 45.2% of North Sumatra cases, as shown in Figure 2A. The results also showed that conflicts were distributed over five sub-districts in the buffer zone of GLNP, namely Bahorok, Salapian, Sei Binge, Batang Serangan, and Besitang. The peak of HTC occurred in 2020 in Langkat Landscape, namely 24 times compared to North Sumatra cases with a total 26. Bahorok Sub-district becomes the highest contributor with 12 incidents, as shown in Figure 2B. The distribution of HTC in North Sumatra as well as in the Langkat landscape is presented in Figure 2.

Interviewees of some environmentalists who have been working for a long period on the Sumatran tiger suspected that the lack of feed and rearing of livestock on the forest edge is the major cause of provoked predation. In 2020, these events almost coincided with the outbreak of African Swine Fever (ASF) attacking domestic pig livestock within North Sumatra Province. A fairly high mortality of 86,074 pigs occurred from October 2019 to April 2020 spreading across 22 districts/cities, including Langkat (Naipospos 2020). Mighell and Ward (2021) revealed that the ASF pandemic in Asia spread across 14 countries. However, there was no official clarification regarding HTC's relationship with the deaths of wild boars (*Sus scrofa*) around GLNP. The opportunity for ASF pathogens to infect wild pigs was also relatively open because the dead bodies of the animals were dumped into rivers in some areas. This pathogen is very dangerous due to its 100% mortality in domestic pigs and wild boars (Primatika et al. 2022).

The HTC incident in 2020 at Langkat landscape was surprising to several parties during the early COVID-19 pandemic, and the intensity was unprecedented. This condition gave a different point of view regarding the driving factors for these events. Communities around the HTC location often suspect deforestation was the main triggering factor compared to the lack of tiger food. They also assumed that there was still an abundance of deer or wild boars in the jungle, but deforestation caused tigers to move to the forest edge and come close to the farmland. Therefore, a land cover change study is a possible response to the occurrence of HTC. In many cases, it is important to note that deforestation can drive HTC directly or indirectly (Petrenko et al. 2016; Struebig et al. 2018; Lubis et al. 2020).

Based on spatial analysis within land cover of HTC areas, particularly in the buffer zone of GLNP, the region is dominated by plantations (31.78%) and dryland farming (39.63%). The current state of the forest has raised concern because the total area of primary and secondary dryland forests was only 1903 ha (5.62%), as shown in Table 1. From observation, the complex problems of land tenure management in the Langkat landscape are also influenced by improper areal management by the authority based on their function and status. For example, a limited production forest (LPF) area that is directly adjacent to GLNP is currently in the status quo of management since 2019. Therefore, several interested parties use this region for various activities, especially for agriculture and plantation. The majority of people who took over the land considered themselves landowners. This overlapping of landownership becomes more complicated because there was no quick response from the authority. The land was occupied by communities for more or less than 3 decades. This situation showed a complex problem in conservation, land tenure, and livelihood in Leuser (Lubis et al. 2020). This problem is not only peculiar to GLNP but has also occurred in several protected areas (Robinson et al. 2011; Singh 2017; Lamichhane et al. 2019; Budiman et al. 2020; Nindyatmoko et al. 2022).

Land cover change during 2006-2020 showed how activities surrounding the park are being carried out. The connection between this change and HTC frequency led to the occurrence of the highest percentage of HTC in plantations (39%) and mixed dryland farming (34%), while the smallest percentage was found in primary and secondary dryland forests (8%). It is important to determine how human-tiger conflict is associated with land cover change. HTC incidents occurred in forest edge areas where humans carry out their livelihood activities. Several studies on human-wildlife interaction revealed that these areas or buffer zone of the conservation region are transitional for wildlife and human, hence, the number of conflicts is very high (Siljander et al. 2020; Pereira et al. 2021; Shanko et al. 2021). Data of HTC and land cover in the Langkat landscape, particularly in buffer zone of GLNP is presented in Table 2.

Table 1. State of land cover (LFP) in the buffer zone of GLNP

Land cover	Size (ha)	Percentage (%)
Primary dryland forest	152.82	0.45
Secondary dryland forest	1750.41	5.17
Shrub	3504.59	10.35
Plantation	10,758.27	31.78
Settlement	24.60	0.07
Open ground	308.27	0.91
Waterbody	0.00	0.00
Dryland farming	13,417.17	39.63
Mixed dryland farming	3895.33	11.51
Paddy field	41.31	0.12
Total	33,852.76	100.00

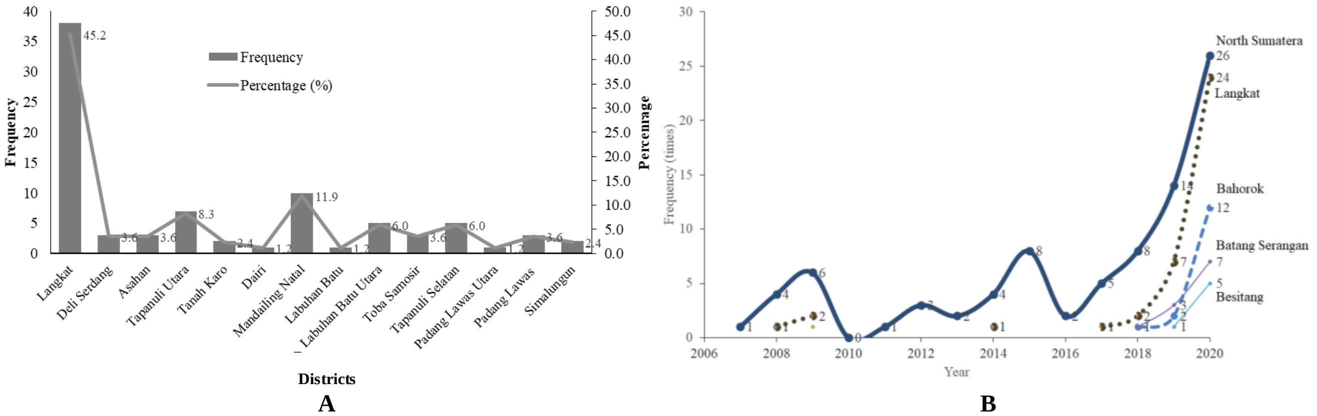

Figure 2. Comparison number of HTC in North Sumatera (A) and each Sub-district (SD) of Langkat (B) in 2007-2020 (Source: compilation data of North Sumatera Conservation Agency (BBKSDASU), GLNP and WCS)

Table 2. Land cover area in Langkat Landscape, GLNP 2006-2020

Type of land cover	Area (ha)					HTC frequency	Percent. of HTC (%)
	2006	2013	2020	Change 2006-2013	Change 2013-2020		
Water body	164.8	164.8	164.80	0	0.00	0	0
Shrub	9943.10	17,382.02	9118.95	7438.92	-8263.07	4	11
Primary dryland forest	189,344.23	189,032.73	188,557.15	-311.5	-475.58	3	8
Secondary dryland forest	8726.89	5335.15	5291.60	-3391.74	-43.55	3	8
Settlement	24.6	24.6	24.60	0	0.00	0	0
Plantation	10,525.29	11,596.38	15,447.50	1071.09	3851.12	15	39
Dryland farming	7898.74	11,951.39	21,878.83	4052.65	9927.44	0	0
Mixed dryland farming	19,780.16	12,732.98	3553.91	-7047.18	-9179.07	13	34
Paddy field	241.45	175.21	175.21	-66.24	0.00	0	0
Open area	90.5	1203.66	2527.21	1113.16	1323.55	0	0
Total	246,739.76	249,598.92	246,739.76			38	100

Note: Data processing of satellite

There are contrasting conditions in land cover changes since shrubs and dryland farming became larger, while secondary dryland forest and mixed dryland farming decreased from 2006 to 2013. Based on the location, the addition of shrubs occurred around Besitang, Sekoci (SPTN VI), which became the largest encroachment area of GLNP since various communities inhabited this region (Sulistiyono et al. 2019). Meanwhile, a reduction in mixed dryland farming was observed in SPTN V (Resort of Bahorok, Tangkahan, Cintaraja and Bukit Lawang). They changed from mixed farming to monoculture, such as palm oil. From 2013-2020, the coverage of mixed dryland agriculture decreased again, followed by shrubs. This shows that plantation and dryland farming got a larger area than others.

Land cover change has an ecological effect on the ecosystem balance surrounding areas, such as space for life and food. In term of changes trend, mixed farming land that are close to the agroforestry system has a better biodiversity state compared to monoculture models (Kamin 2018; Murillo et al. 2019; Chaiyarat et al. 2020; Ulman et al. 2021a,b). It is important to note that it also has a relationship with wildlife-supporting systems, such as food chain of tiger prey. However, the interests of people's livelihoods focus on economic commodities rather than environmental aspects. For example, during the decline in rubber prices, farmers converted the plantation to palm oil because it has a good market price and requires lesser labor. This situation didn't only occur in Langkat Landscape, it was also observed in several human-dominated landscapes of Sumatra (Collins 2018). Several cases of conversion from mixed farmland to monoculture plantations by communities have not considered the broader aspects of the environment, such as biodiversity or microclimate (Alitieri et al. 2015; Meijide et al. 2018).

The current pattern of community livelihoods in the Langkat landscape tends to be more pragmatic, and they often involve economical practices that use natural resources. The local wisdom of the coexistence of human-wildlife relationships in the previous time has been degraded by economic need. Human pressure within the national park triggered a negative impact on tiger habitat. This can be observed in Besitang Resort of GLNP, where tree cultivation as part of the social forestry program within the national park attracted these animals since they followed the movement of wild boars that came to the same area for food. It can be seen from cases that victims, namely a farmer and livestock belonging to the conservation forest farmer group (CFFG) member in 2020 and 2021 died due to tiger attacks. Furthermore, this was assumed to be caused by the movement of wild boars to cultivated land, which creates the opportunity for tiger predation as its preference in their home range (Hayward et al. 2012; Pusparini et al. 2018; Sulistiyono et al. 2020; Allen et al. 2021). Apart from the natural conditions of the prey, the presence of livestock created more opportunities for the long series of conflicts between humans and this animal. Since the tiger is an opportunistic species, it often prefers to catch livestock when it was available and easier to prey on. There are concerns that ecological traps had occurred on the Sumatran tiger when the predictive adaptive habitat preferences became maladaptive due to individuals settling preferentially in poor habitats, thereby leading to lower fitness than other alternatives (Fletcher et al. 2012; Hale and Swearer 2016).

People who are members of the CFFG actually understood the vulnerable livelihood in the national park area, but it is often carried as a source of income. The data show that the conflict rate in the area around the plantation was the highest (39%) compared to other land covers. There were land cover changes in GLNP due to deforestation occurring around the buffer zone for years. The problem of securing the area became very crucial in the midst of the needs of people who are looking for a livelihood around the forest. Furthermore, deforestation has threatened the Sumatran tiger's survival and has occurred massively in the Sumatran landscape (Luskin et al. 2017; Poor et al. 2019a, b). A portrait of land cover change in the Langkat Landscape around GLNP, as shown in Figure 3.

Conflict density

A conflict density map was created using the Kernel density tool in ArcGIS 10.3. It shows the concentration of conflict in an area where these events have occurred, as well as the surrounding GLNP areas, which are considered vulnerable. Furthermore, the various density classes are presented in Table 3. This data can be used as an early warning system for GLNP managers on the importance of providing awareness to all parties regarding potential conflicts that can occur in the future.

Langkat landscape has a typical conflict density from moderate to very high. The study location has a very high-density class, where the interval of 71.01-77.00 is distributed around 4.98% of the total area (12,338 ha). The highest value in this landscape was in the level of high risk, around 57.01% of the total area. This is a signal that all parties must be more aware of conflicts that might occur at any time. The escalation of HTC in early 2021 at the Bahorok sub-district shows that areas in high-class density can turn into a very high class. Forest edge needs priority attention, as well as restoration activities within GLNP under the CFFG program in the Besitang region. A human victim in 2021 must be potentially considered as the result of a high level of human interaction within the national park. Uncontrol expansion of agriculture can broadly trigger human-wildlife conflict broadly (Smith et al. 2018; Vasavi 2020).

Access to the GLNP core zone is very easy due to weak supervision, the absence of a boundary fence, and the high activities of the community adjacent to GLNP. This greatly opens up opportunities for increasing conflict intensity in the future. Therefore, it is necessary to manage the buffer zone and protect the GLNP from moderate to high-class density of HTC (29.01-71.00), which covers a total of 235,382 ha. Buffer zone management through awareness of HTC risks and various sustainable income-generating sources is an option in providing understanding and tolerance of communities who are directly fortifying the national parks in an effort to overcome conflict towards a coexistent livelihood (Branco et al. 2019; Lamichhane et al. 2019; Digun-Aweto et al. 2020; Birendra et al. 2021).

Driven factor of HTC

The variables used in the principal component analysis (PCA) in this study include slope, land cover, elevation, distance from the river, and distance from the settlement. These variables were selected by considering habitat and anthropogenic factors. Each study has considerations in determining variables based on the characteristics of the location and necessity supporting data. For example, a study on tiger habitat suitability used variables such as vegetation suitability, prey density, elevation, slope, population density, and distance to the main road (Sulistiyono et al. 2021). The data used in the main component analysis is the distribution of human-tiger conflict. Each point of conflict distribution was analyzed for its spatial location. According to (Constantin 2014), in the first step of the analysis, testing was carried out to determine the suitability of the data with the method, namely by measuring the magnitude of the Kaiser-Meyer-Olkin index (KMO). The KMO test result value was 0.542 with a range of 0-1, and the data was considered suitable for PCA if the index is ≥0.50. The result of data processing is presented in Table 4.

Major component analysis shows that the first component has 4 variables, which have a positive relationship, and only 3 of them were higher than component 2, namely slope, land cover, and elevation. The second component has 3 variables with positive relationships, and only two of them were higher than component 1, namely distance from the river and settlement, as shown in Table 5. This shows that HTC mitigation must consider more biophysical components that support tiger habitat than the distance from river and settlements. Community intervention that goes too far into areas containing tiger habitat are certainly very dangerous. Each species has unique variable characteristics, which are related to conflict with humans (Kholis et al. 2017). However, the highest value of each component was used to build the model. Table 5 shows the total eigenvalues of each component of HTC in Langkat, which has been obtained.

The variables of slope, elevation, and land cover have higher eigenvector values based on the first component, hence, the three variables have a value of 2.007. The distance to river and settlement variables has eigenvalue of 1.291 because the highest positive correlation value refers to the second component. The eigenvalues were determined by considering the PCA score and eigenvalues vector of each main component (Prasetyo et al. 2007). All eigenvalues of each main component in PCA can be seen in Figure 4.

The total eigenvalue of each variable is presented in Table 6. The weight of each variable was used to create a model equation for conflict-risk areas. The model of areas vulnerable to human-tiger conflict in the Langkat landscape has equation Y = (2.007*slove) + (2.007*land cover) + (2.007*elevation) + (1.291*river distance) + (1.291*settlement distance).

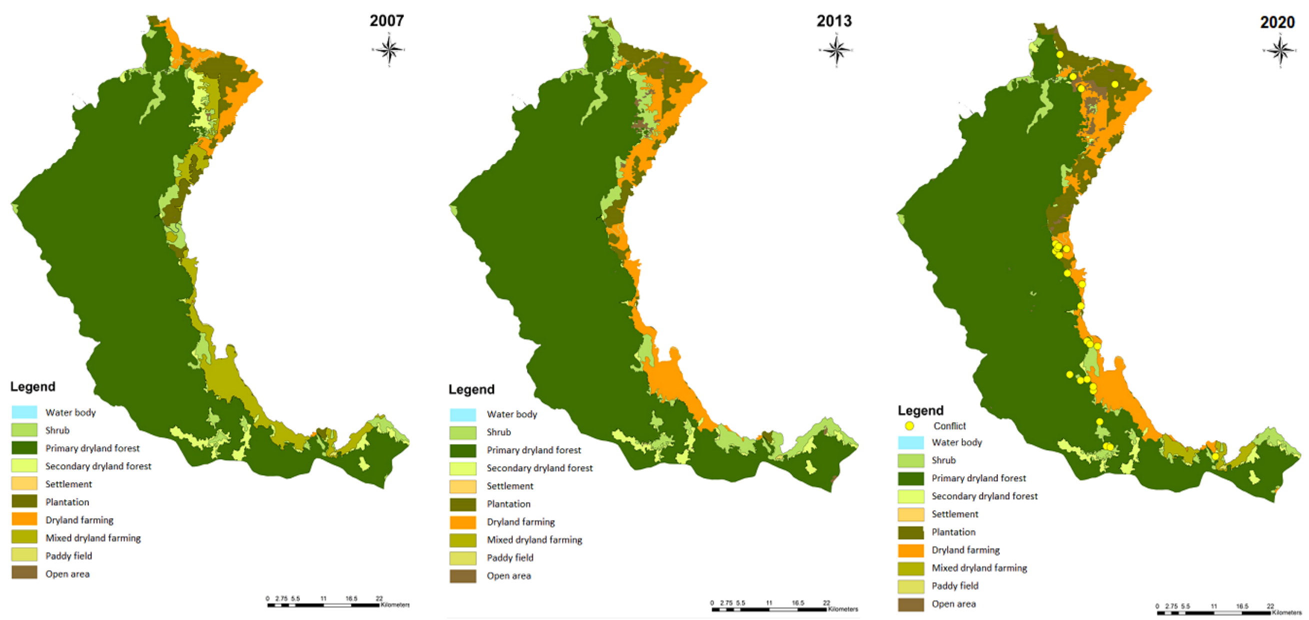

Figure 3. Land cover changes Surrounding GLNP in Langkat

Table 3. Class of conflict density in Langkat Landscape

Class	Interval	Large (ha)	Percentage (%)
Very low	1.00-8.00		
Low	8.01-29.00		
Moderate	29.01-50.00	94,153	38.01
High	50.01-71.00	141,229	57.01
Very high	71.01-77.00	12,338	4.98

Table 4. Initial eigenvalues

Component	Initial Eigenvalues		
	Total	% Variation	Cumulative %
1	2.007	40.131	40.131
2	1.291	25.814	65.945
3	0.891	17.818	83.763
4	0.455	9.094	92.857
5	0.357	7.143	100.000

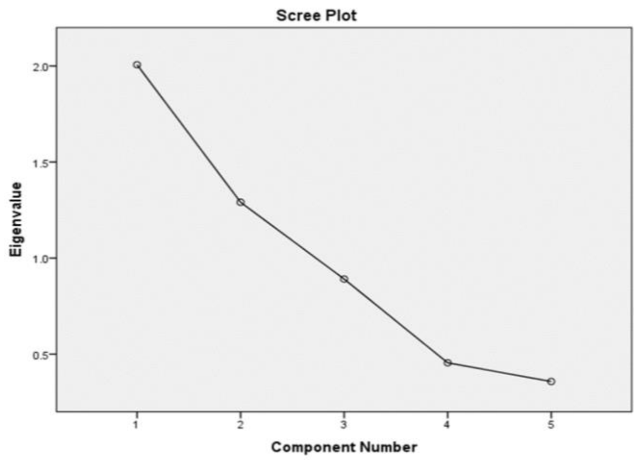

Figure 4. The eigenvalue of each main component from all variables inputted into PCA

Table 5. Eigen vector from major component analysis

Variable	Component	
	1	2
Slope	0.844	-0.082
Land cover	0.616	-0.372
Elevation	0.781	0.412
Distance from river	0.222	0.886
Distance from settlement	-0.505	0.436

Table 6. Weight value of each variable

Variable	Total of eigenvalue
Slope	2.007
Land cover	2.007
Elevation	2.007
Distance to river	1.291
Distance to settlement	1.291

Table 7. Validation of tiger conflict vulnerability model

Class of conflict vulnerability	Number of conflict	Percentage (%)
Fairly vulnerable (moderate)	6	60.00%
Vulnerable (high-very high)	4	40.00%
Not vulnerable (low-very low)	0	0

Based on field conditions, the slope of the HTC location was not too steep. The land cover in HTC was a transition between forests and plantations. Meanwhile, in terms of altitude, it is still less than 300 meters above sea level. The biophysical condition of HTC has suitability for tiger habitat in a human-dominated landscape. The community's existence in a location of the animals' roaming area is certainly risky. Therefore, it is necessary to take appropriate habitat management interventions by combining anthropogenic and wildlife aspects to avoid victimization in the future (Wikramanayake et al. 2004; Harihar et al. 2014; Lamichhane et al. 2019; Schoen et al. 2022). The spatial analysis was performed using the method of overlapping (overlay) all variables of HTC. It produced a class of conflict vulnerability in the Langkat landscape. The map of HTC's vulnerability is presented in Figure 5.

A validation assessment was carried out to examine this vulnerability model as well as to determine the level of confidence in the model being built (Prasetyo et al. 2007). The number of points of conflict distribution used for the process was 10 points, which were randomly selected. Based on the validation test, the model has a moderate level of accuracy to predict conflict risk areas by 60.00%, and the rest were vulnerable class (from high to very high vulnerability), as shown in Table 7.

The existence of various community activities around GLNP that intersect with tiger habitat is certainly very risky because these animals need sufficient space in their habitat. Cooperation with various parties is an important key in implementing HTC mitigation (Asimopoulos 2016; Borah et al. 2018). This is urgently needed to find the solution of sustainable livelihood toward human-wildlife coexistence surrounding GLNP. The current HTC problem has a direct impact on Sumatran tiger conservation and also the livelihoods of people living in the buffer zone of the national park (Patana et al. 2018).

Efforts to improve the decline of wildlife are likely to be ineffective if carried out with a business-as-usual model or like a machine. It must be carried out with care and networks with various interests and other work units (Alikodra 2019). Some efforts to mitigate human-tiger conflicts in the Langkat landscape based on livelihoods include (i) Livelihood development program in the GLNP buffer zone based on economic and social ecology; (ii) Completion of the status of the occupied area by the community or corporations around the national park; (iii) Developing awareness programs to the community about tiger behavior and the importance of preserving them by utilizing their value through ecotourism; (iv) Adaptation and mitigation of HTC with friendly land use patterns and safe livestock management from tiger attacks; (v) Provide incentives to farmers who manage land with mixed farmland models or agroforestry to reduce the chance of conversion to a monoculture system; (vi) Strengthening local wisdom about the risk to livelihoods around the forest, thereby reducing the community conflict during the appearance of tigers in the human-dominated landscape. (vii) Applying the map of HTC vulnerability as part of developing early warning system to mitigate conflict by considering driven factors and choosing particular interventions needed. These efforts to realize the coexistence of humans and tigers are steps that must be carried out collaboratively to bring a balance.

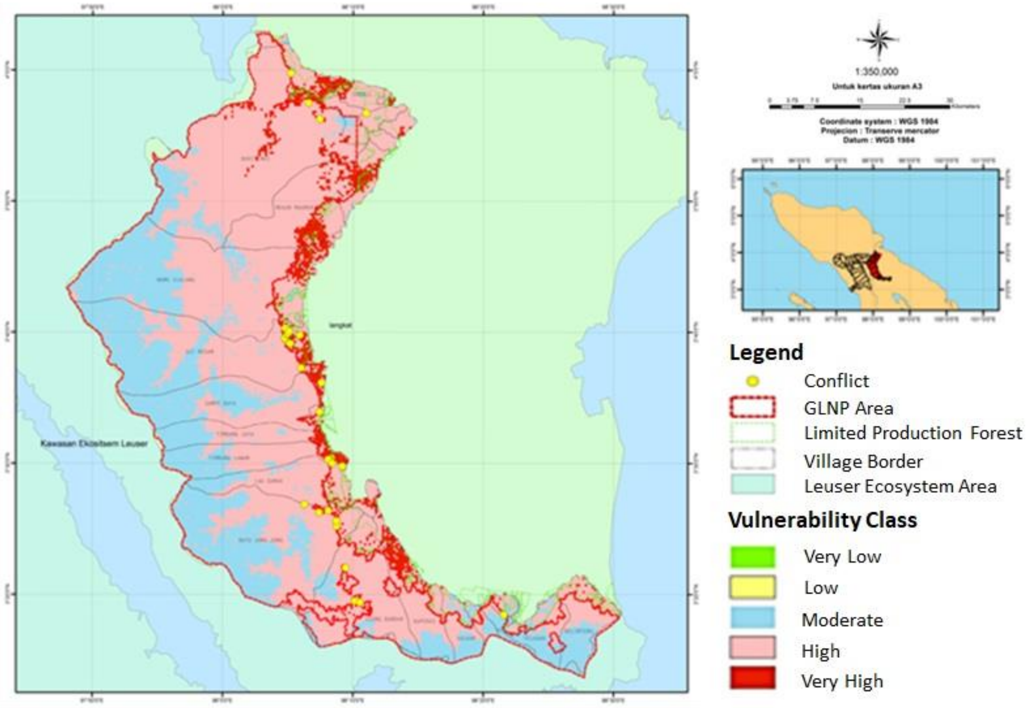

Figure 5. Map of HTC vulnerability in Langkat District, North Sumatra Province, Indonesia

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