RESEARCH ARTICLE

MEDIA KONSERVASI
SCIENTIFIC JOURNAL IN CONSERVATION, ENVIRONMENT & ECOTOURISM

The Sumatran Tiger's Corridor in Agam, West Sumatra: An Initial Analysis of the Metrics Indices Landscape

Munawar Kholis[a], Syartinilia[b], Laksmi Datu Bahaduri[d]

[a] Nature Resources and Environment Management Science Student, Master Program, IPB University, Dramaga Campus, Bogor 16680, Indonesia
[b] Department of Landscape Architecture, Faculty of Agriculture, IPB University, Dramaga Campus, Bogor 16680, Indonesia
[c] Fauna Flora, Indonesia Programme, Jakarta 12450, Indonesia

Article Info:
Received 12 December 2024
Revised 17 January 2025
Accepted 26 March 2025

Corresponding Author:
Munawar Kholis
Department of Nature Resources and Environment Management
Nature Resources and Environment Management
IPB University
E-mail:
kholis.munawar@gmail.com

Abstract

Increased habitat pressure is indicated by high levels of human-tiger conflict (HTC). For Sumatran tigers to survive, structural corridor management is essential to managing the tiger metapopulation. Since 2016, Agam Regency has seen a sharp rise in HTC. This exploratory study aimed to understand variations in the corridor's forest cover and to evaluate the relationship between landscape metric indicators and fluctuations in HTC density. Agam's corridor is separated into 31 grids (3x3km). HTC information was gathered from earlier studies and web searches for incidents from 2000 to 2024. Tropical Forest Monitoring's landcover dataset was obtained through the use of a Google Earth Engine script. The LecoS plug-in is used to calculate landscape metric indices. For non-normally distributed data, the Spearman correlation statistic (95% CI) is employed. Before the HTC series in 2016, there was a twofold increase in deforestation, from 0.56% to 1.1% between 2010 and 2015. Nine landscape metrics, including forest area, forest proportion, NP, PD, GPA, LPI, PCI, and splitting index, exhibited a significant correlation with HTC density (p-value < 0.05). Around the corridor, high HTC density was associated with PD >10 patches km-2, LPI <44%, forest fraction <50.76%, and more disaggregated patches (PCI<9.79%). Since it may not be feasible to reduce HTC to zero incidents in the vicinity of human-dominated tiger habitats, expectations should be moderated, as lower HTC density occurs in wider landscape metric ranges. Improving PCI by aggregating patches and reducing NP while maintaining the remaining forest can potentially reduce HTC incidents and increase corridor function in tiger metapopulation management. The challenges are enormous, as 94% the corridor is in a non-protected area.

Keywords: Corridor, fragmentation, human-wildlife conflict, landscape metrics.

1. Introduction

Tigers, as apex predators, can adapt to various types of habitats [1], although their preference for habitat remains unchanged, staying away from human presence and inhabiting areas with higher prey density and sufficient cover [2–5]. Prey density plays a more significant role in determining the size of the territory, as a lower prey density forces tigers to roam wider [6] in search of deer, wild boar, and muntjak as preferred wild prey species [7]. In addition to moving in search of prey, tiger movement and territory are closely related to their reproductive behavior and dispersal stages [8,9]. For example, a breeding female travels as far as 20 km to a separate forest block in anticipation of infanticide by a male tiger [10].

Rapid population growth in Sumatra, accelerated by the transmigration program in the 1970s, has caused a decline in forest cover throughout Sumatra, as 5 million hectares gradually disappeared between 1990-2000 [11] and continued to be lost for another 3.5 million hectares between 2000-2012 due to conversion to industrial forestry plantations, illegal logging, and encroachment [12]. Tigers showed a clear preference for natural forests over palm oil plantations at all spatial scales (local, landscape, and regional).

The occupancy probability was significantly higher in forested areas and near forest patches, confirming that forest cover is the primary driver of tiger presence [3]. The reduction of suitable habitat has pushed Sumatran tigers (*Panthera tigris sumatrae*) to inhabit higher altitudes [13], where prey animals are increasingly rare [6]. Fragmentation as a result of continuous deforestation has chopped forests into remnants [14], seemingly bringing humans closer to wildlife in conflict circumstances [15–18]. Tigers in human-dominated landscapes are less likely to survive for a long time if threats such as deforestation, fragmentation, poaching, and removal of problematic individuals are present [19].

The selective harvesting process generally causes forest degradation and can occur over a long period of time, starting with the thinning of the forest canopy becoming thinner and thinner, while deforestation is a permanent change with the loss of all forest cover to non-forest cover [14,20]. Forest cover in West Sumatra decreased at a rate of 0.99%, losing 220.08 km^2 in the period 2000-2012 dominated by the conversion of forests for plantation and agricultural purposes [21]. An analysis published by Global Forest Watch indicated that West Sumatra Province experienced 19% tree cover loss between 2001-or an average of 0.86%$year^{-1}$. The anthropogenic conversion of forests to agricultural land increases the chances of interaction between humans and tigers [5,22–27].

Few species benefit from fragmentation, but it would not work for species with large body sizes, such as tigers, as it is correlated with a higher probability of extinction [24-26]. A group of Indonesian scientists recorded that six (6) out of 29 tiger habitats have lost their tiger population during the last decade [20]. High mortality caused by poaching and potentially caused by the high removal rate of problem tigers from 2001 to 2016, a total of 130 tigers were removed from their habitat throughout Sumatra; the removal index in 2007 was 0.23 tiger incidents, increased in 2012 to 0.32, and the highest was 0.55 in 2015 [27], illustrating the magnitude of human–tiger conflict (HTC) mitigation measures that could determine the fate of Sumatran tiger survival [27].

A comprehensive study of the connectivity between the largest remaining forests in the Western Sumatra Region has been conducted in recent years to successfully identify priority corridors to facilitate tiger metapopulation management and mitigate human-tiger conflict (HTC) [5,28]. One of the corridors is located in Agam Regency, connecting the Maninjau Nature Reserve, Barisan Wildlife Sanctuary, and Malampah-Alahan Panjang Wildlife Sanctuary. West Sumatra has an average of 5.6 incidents/year between 2001 and 2016 [27] and continues to this day.

Identifying corridors is challenging because it requires a large amount of continuous data to be collected through extensive surveys, as well as substantial manpower, financial support, and strong commitment from stakeholders. The next challenge is how to manage these identified corridors that face anthropogenic pressures, such as roads, settlements, and agricultural lands [5,29], especially in non-protected forests. This preliminary study aimed to analyze the patch structure of a corridor in Agam Regency, which has the highest number of clustered conflicts since 2016, and to identify areas for corridor structure improvement.

2. Materials and Methods

This study is a desktop-based analysis that applies landscape metrics to assess human–tiger conflict (HTC) incidents and changes in forest cover using secondary data sources. The analytical process was conducted in stages, as illustrated in Figure 1. This preliminary study was conducted in the tiger corridor in Agam Regency, West Sumatra, which is one of the nine potential tiger corridors in West Sumatra [5]. This area has experienced high HTC incidents since 2016 [30–32]. HTC data from West Sumatra were obtained from previous publications and web crawling. This study emphasized data collection through web crawling to minimize the possibility of double-counting and eliminate information that was not location-specific. HTC incident data were mapped, and their density was measured using Kernel Density Estimation (KDE), with a bandwidth of 5.6 km, which was based on the maximum recorded HTC incident distance off forest edges [5], spherical/quartic shape, and 1 km scaling value.

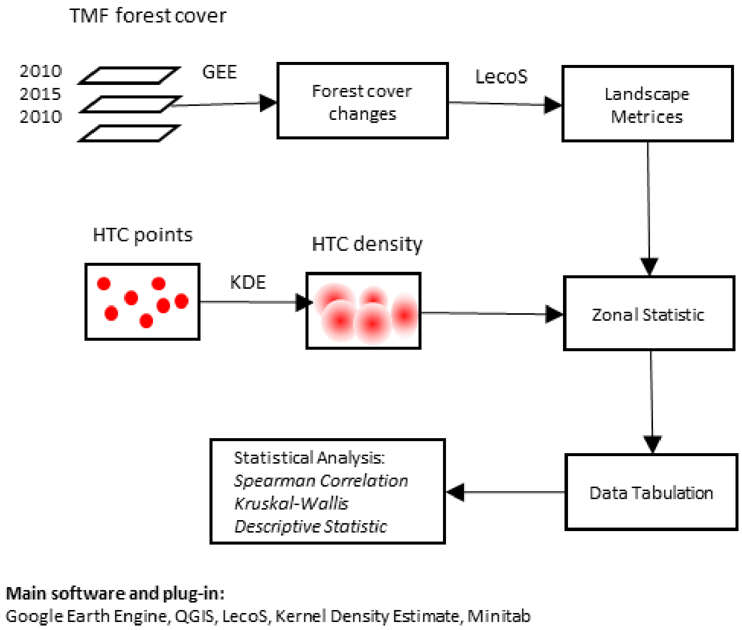

Figure 1. The analysis was conducted to examine landscape metrics within the tiger corridor in Agam, West Sumatra. The diagram outlines a methodological framework that integrates occurrence points with spatial variables, including forest cover change, landscape metrics, and zonal statistics, to produce a structured analytical dataset. The resulting data were then evaluated using Spearman correlation, the Kruskal–Wallis test, and descriptive statistics to explore relationships between landscape attributes and observed occurrences.

The classified land cover map of the Tropical Moisture Forest (TMF) produced by the European Commission - Joint Research Center was used as the basis of forest cover change assessment, an open-source map that supports the Google Earth Engine (GEE) script that we used to obtain the desired land cover classifications (2010, 2015, and 2020) and periodic changes in land cover [33]. It classifies forests into undisturbed, degraded, and deforested for complete forest loss, forest regrowth, water surfaces, and a class that is classified as other classifications. Further spatial analysis was conducted using the open-source QGIS 3.34.11 Prizren version and several plug-ins, such as Density Analysis version 2024.8.28 and Landscape Ecology Statistic (LecoS) version 3.0.1.

A landscape metric class-level analysis was conducted for the undisturbed, degraded, and deforested classes. For landscape and patch metric indices, we measured the area, landscape proportion, number of patches, patch density, edge length, edge density, largest patch index, patch cohesion index, and splitting index [20,34,35]. In addition, this study calculated forest changes between periods to understand which period of the study had drastic and significant land use changes.

Initially, regression analysis was used to determine the contribution of each landscape metric index to HTC density. However, since the data were not normally distributed, we used a non-parametric Spearman Correlation test [36,37] with a 95% confidence level and Kruskal-Wallis test [38] to detect landscape metric influence and significant differences in landscape metric indices between periods of observation and HTC density.

2.1. Study Site

The study area focuses on the highest conflict intensity area, which coincides with the presence of a potential corridor in Agam (Figure 2). In landscape ecology studies, we need to adjust to the territorial behavior of the target species [39], and we used this grid size based on the grid size, which is used to estimate the distance between camera trap stations in tiger biological monitoring [40].

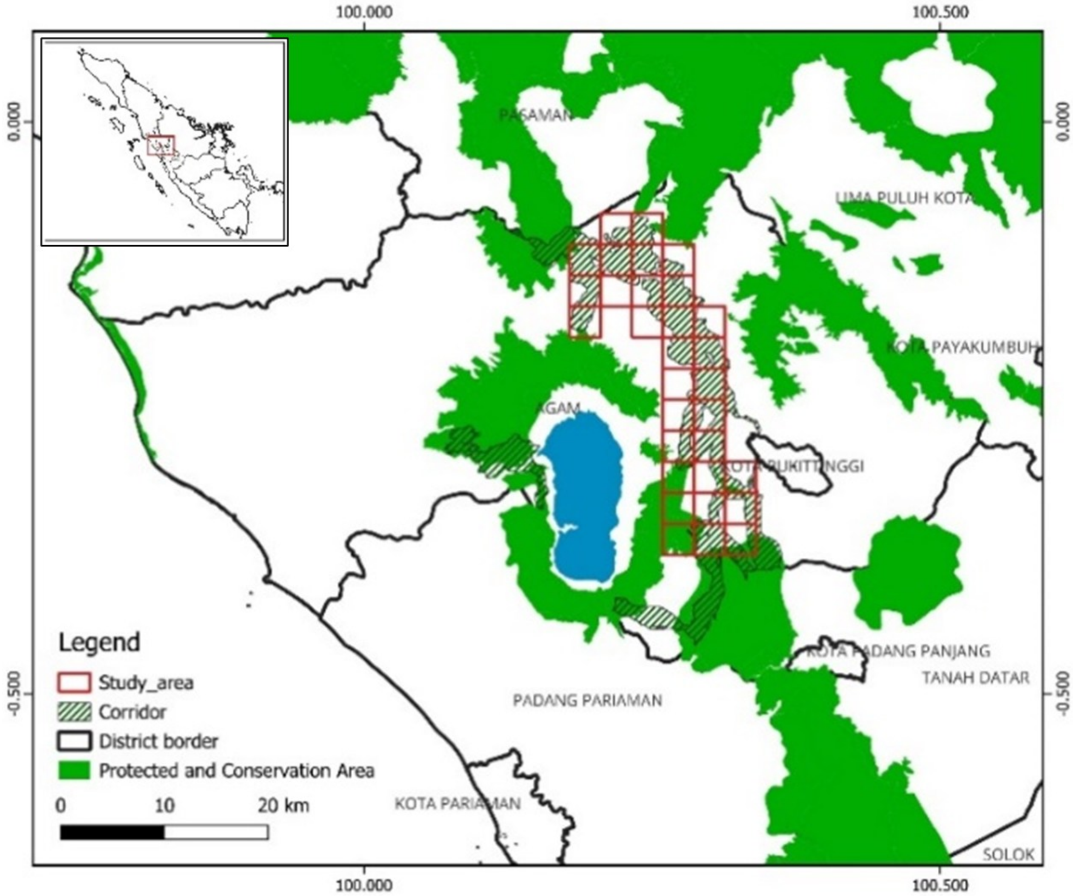

Figure 2. Study area at the corridor in Agam Regency, West Sumatra. Total study area divided into 31 grids surrounded by combined conservation area and protected forest.

The study region is located in a landscape encircled by various conservation areas and protected forests that play crucial ecological roles and act as partial buffers. The primary zones consist of the Maninjau Nature Reserve, which covers 218.91 km², the Malampah-Alahan Panjang Wildlife Sanctuary, which extends over 382.08 km², and the Singgalang-Tandikat Eco-Park, which encompasses 98.03 km². Nearby protected forests further bolster these officially safeguarded areas, although the continuity and effectiveness of these buffers are limited. Conversely, numerous potential ecological corridors are found within non-protected forests, where ongoing deforestation, habitat degradation, and landscape fragmentation present significant challenges to biodiversity conservation and ecosystem connectivity [41].

3. Results and Discussion

3.1. Results

HTC incident data were obtained from previous studies [30,31] and web crawling data across 14 regencies in West Sumatra from to 2005-2024. The HTC cluster was determined by identifying five incidents within a 17 km radius. We identified five clusters of HTC incidents in West Sumatra: Agam (20 incidents), Pesisir Selatan and Padang (16 incidents), and Solok Selatan (7 incidents). Pasaman had two separate clusters, each with five incidents. Of the 94 HTC incidents, 38 occurred in the districts of Agam and adjacent regencies. The African Swine Fever (ASF) outbreak in 2019 caused high wild boar mortality and is believed to be linked to an increase in Human-Tiger Conflict (HTC) density.

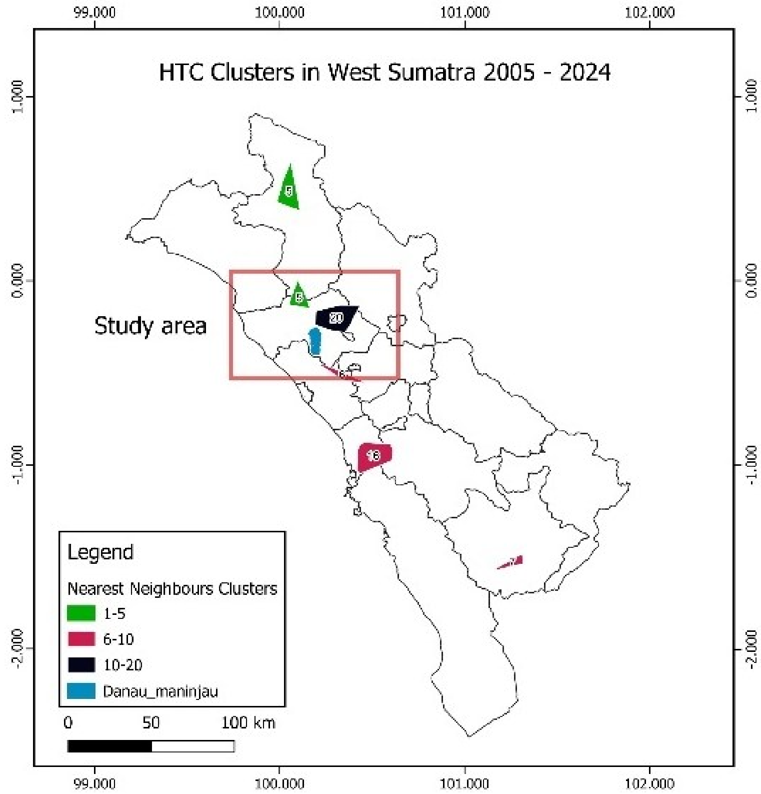

Figure 3. HTC incident between 2005-2024 forming clusters of ≥ 5 incidents in a 17 km radius. The focus study area in Agam has a dense cluster.

3.1.1. Kernel Density Estimation of HTC incidents

To assess the extent of each human-tiger conflict (HTC) event, kernel density estimation (KDE) was employed using spherical and quartic functions [16]. The analysis was divided into three distinct time frames: 2010–2014, 2014–2019, and 2020–2024 to capture changes over time. The KDE values generated offered a detailed spatial depiction of the intensity of the incidents throughout the study region. Following this, the average KDE value for each timeframe was extracted into 31 spatial grids using zonal statistical tools in QGIS, as shown in Figure 4.

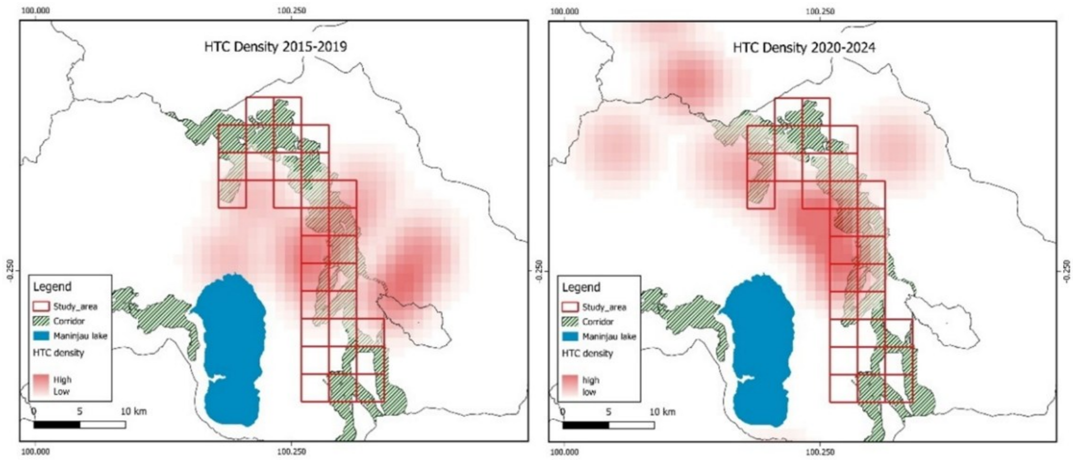

Figure 4. Kernel Density Estimate (KDE) analysis of the HTC density period 2015-2019 (left); kernel density estimate of the HTC density period 2020-2024 (right). Light red indicates low density, and dark red indicates higher conflict density.

In the initial observation phase from 2010 to 2014, the kernel density estimation (KDE) value for human-tiger conflict (HTC) was noted as zero, indicating no HTC incidents occurred in or near the study area. Conversely, the period from 2015 to 2019 saw a notable rise in the KDE values, signifying a substantial increase in conflict intensity across the spatial grids. The following period, spanning 2020 to 2024, experienced a continued increase in the KDE values, although at a more moderate rate than the previous period. These trends are detailed in Table 1, which outlines the descriptive statistics of the KDE values over the three time frames, including the mean, standard deviation, minimum, and maximum values calculated for 31 grid units.

Table 1. Descriptive statistics of HTC density (KDE) for three observation periods: 2010–2014, 2015–2019, and 2020–2024.

Variable	Year	N	Mean	StDev	Min	Max
HTC density	2010-2014	31	0	0	0	0
	2015-2019	31	0.41	0.55	0	1.99
	2020-2024	31	0.45	0.63	0	2.16

The zero value is shown from 2010 to 2014, as no HTC incident was recorded in or around the study area. The period–2015-2019 had a significant rise in the KDE and a slight increase in the period–2020-2024. HTC density was then grouped into four categories, thus providing a sense of conflict intensity (Table 2). In Figure 5, we visualize the concept of point distribution, calculated density value, and extracted value.

Table 2. Categorization of HTC density levels using Kernel Density Estimation (KDE), featuring explanations and the respective count of grid cells within each level.

HTC Category	Description	Grid count
HTC = 0	No HTC incident	53
0 < HTC ≤ 1	Low density of HTC	30
1 < HTC ≤ 1.5	Moderate density of HTC	4*
HTC > 1.5	High density of HTC	6

*Low number of samples in for the moderate density of conflict could cause abnormality in statistical analysis

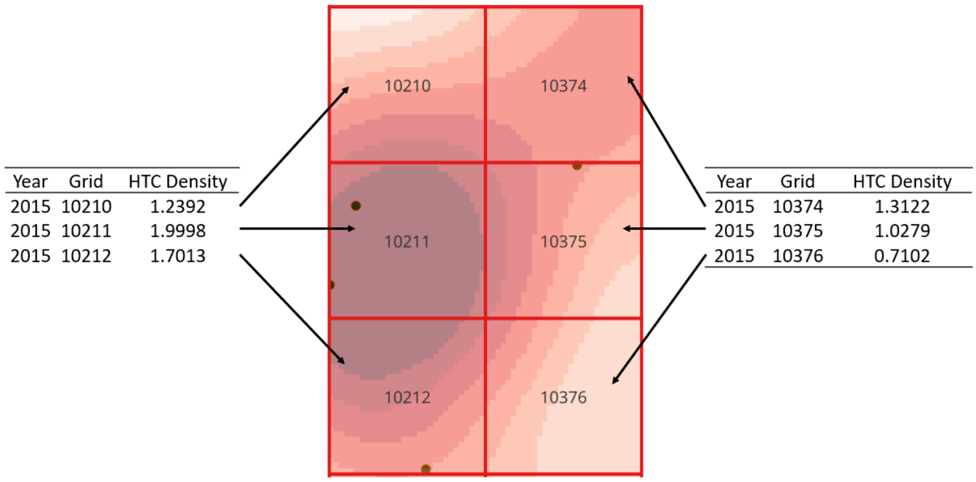

Figure 5. Kernel Density Estimation (KDE) metrics for human-tiger conflict (HTC) in 2015, illustrating grid positions and their respective density values.

The HTC density on grid #10210 has no conflict points inside the grid, as this grid is influenced by the presence of HTC incident in grid #10211, mean HTC density = 1.2392, and is categorized as a grid with moderate HTC density (1 < HTC ≤ 1.5). Grid #10211 has two conflict points and a mean HTC density of 1.99; thus, it is categorized as a grid with a high HTC density

(HTC > 1.5). Meanwhile, grid #10212 has a point of HTC incidence and is categorized as having a high HTC density, owing to the influence of the point in grid #10211. From this visualization, a high HTC density will be counted if two incidents occurred at a 3 km distance in the space of 5 years or recurrent HTC.

3.1.2. Forest conversion at the corridor

Deforestation increased (def%) almost twice, from 0.56% in 2005-2010 to 1.10 in 2010-2015 and a slight increase to 1.17 in 2015-2020, meanwhile the degradation rate range of 2.29-2.53%. The greatest deforested patch area (DefGPA) increased from 2.6 ha in 2005-2010 to 5.1 ha in 2010-2015 and 5.4 ha in 2015-2020, indicating smallholder-type deforestation by the local community. The number of deforested patches (DefNP) increased from 2010-2015 while degraded patches (DegNP) decreased. Figure 6 shows the continued increase in degradation and deforestation. Matrix plots were provided to visualize landscape metric indices that statistically correlated with HTC density, indicating a weak correlation at lower HTC densities. In comparison, higher HTC densities had a stronger correlation with landscape metric indices (Figure 6).

Table 3. This table presents data on deforestation and degradation in the study area over 3-time frames (2005–2010, 2010–2015, and 2015–2020), detailing the area in hectares, percentages, and effects within both non-protected (NP) and protected (GPA) forests.

Period	Deg(ha)	deg%	DegNP	DegGPA(ha)	Def(ha)	def%	DefNP	DefGPA(ha)
2005-2010	971.7	2.53	4289	16.0	216	0.56	1358	2.6
2010-2015	836.7	2.29	4142	10.2	399.7	1.10	1901	5.1
2015-2020	855.1	2.46	3977	20.8	405.5	1.17	2266	5.4

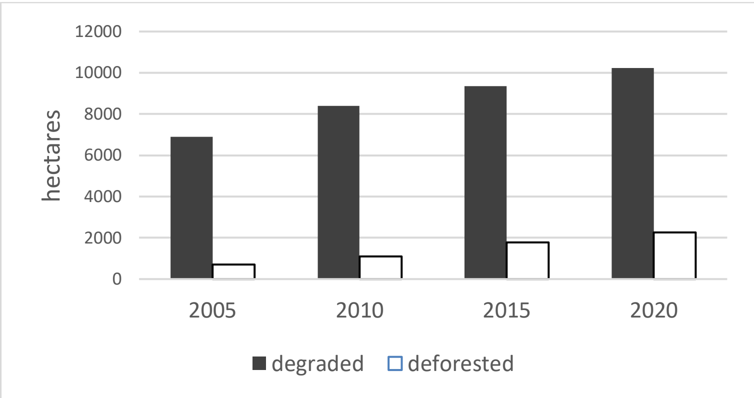

Figure 6. Patterns of forest degradation and deforestation (quantified in hectares) throughout the study region in 2005, 2010, 2015, and 2020.

3.1.3. Degraded and Deforested class correlation to HTC density

We investigated the correlation between HTC density and landscape metric indices of the degraded forest and deforested classes using Spearman's correlation test. The degraded forest class showed only one variable (patch density) that closely met the critical p-value. The deforested class did not show a single variable close to the critical p-value (Table **4**). This finding confirms the limited influence of deforested patches on HTC incidents [42].

Table 4. Spearman Correlation of HTC density vs. landscape metrics in degraded forest and deforested classes.

Sample 1	Sample 2	N	Correlation	95% CI for ρ	P-Value
LanPro DEGRADED	HTC density	93	0.103	(-0.103, 0.301)	0.324
EdgDen DEGRADED	HTC density	93	0.127	(-0.080, 0.323)	0.225
PatDen DEGRADED	HTC density	93	0.204	(-0.002, 0.393)	0.050*
LanPro DEFORESTED	HTC density	93	-0.008	(-0.211, 0.196)	0.942
EdgDen DEFORESTED	HTC density	93	0.038	(-0.167, 0.240)	0.718
PatDen DEFORESTED	HTC density	93	0.008	(-0.196, 0.211)	0.942

*Patch Density of degraded forest has closest p-value to CI 95%

3.1.4. Undisturbed forest class correlation to HTC density

The analysis of the undisturbed land cover category in relation to human-tiger conflict (HTC) density demonstrated a significant link between landscape metrics as predictor variables and HTC density as the outcome variable. This result underscores the significance of spatial landscape features in explaining variations in conflict intensity across the study region. Nine landscape metrics were identified as statistically significant predictors, each exceeding a critical threshold of $p < 0.05$. These metrics include land cover, land proportion, number of patches, patch density, largest patch area, average patch area, largest patch index, patch cohesion index, and splitting index (Table 5).

Table 5. Spearman Correlation pairwise of HTC density vs landscape metrices in undisturbed forest class.

Predictor	Response	N	Correlation	95% CI for ρ	P-Value
COV	HTC density	93	-0.258	(-0.441, -0.054)	0.013*
LanPro	HTC density	93	-0.275	(-0.456, -0.072)	0.008**
EL	HTC density	93	0.028	(-0.177, 0.230)	0.792
ED	HTC density	93	0.028	(-0.176, 0.231)	0.787
NP	HTC density	93	0.220	(0.015, 0.408)	0.034*
PD	HTC density	93	0.239	(0.034, 0.424)	0.021**
GPA	HTC density	93	-0.252	(-0.436, -0.047)	0.015*
SPA	HTC density	93	-0.088	(-0.287, 0.119)	0.404
mPA	HTC density	93	-0.237	(-0.423, -0.032)	0.022*
MedPA	HTC density	93	0.034	(-0.171, 0.236)	0.744
LPI	HTC density	93	-0.268	(-0.451, -0.065)	0.009**
FDI	HTC density	93	-0.014	(-0.217, 0.190)	0.893
MPS	HTC density	93	0.018	(-0.186, 0.221)	0.864
PCI	HTC density	93	-0.260	(-0.443, -0.056)	0.012**
SPLIT	HTC density	93	0.270	(0.066, 0.452)	0.009*

COV= land cover; LanPro=proportion of land cover; EL= edge length; ED= edge density; NP= number of patches; GPA= greatest patch area; SPA= smallest patch area; mPA=mean Patch Area; MedPA=Median Patch Area; LPI=Largest Patch Index; FDI=Fractal Dimension Index; MPS=Mean Patch Shape; PCI= Patch Cohesion Index; SPLIT=Splitting Index.

Landscape metric attribute (*) as a function of other attributes, such as COV, is a function of LanPro, Number of Patches as a function of Patch Density, Greatest Patch Area as a function of the Largest Patch Index, and SPLIT as a function of PCI; the discussion is provided only for five attributes (**).

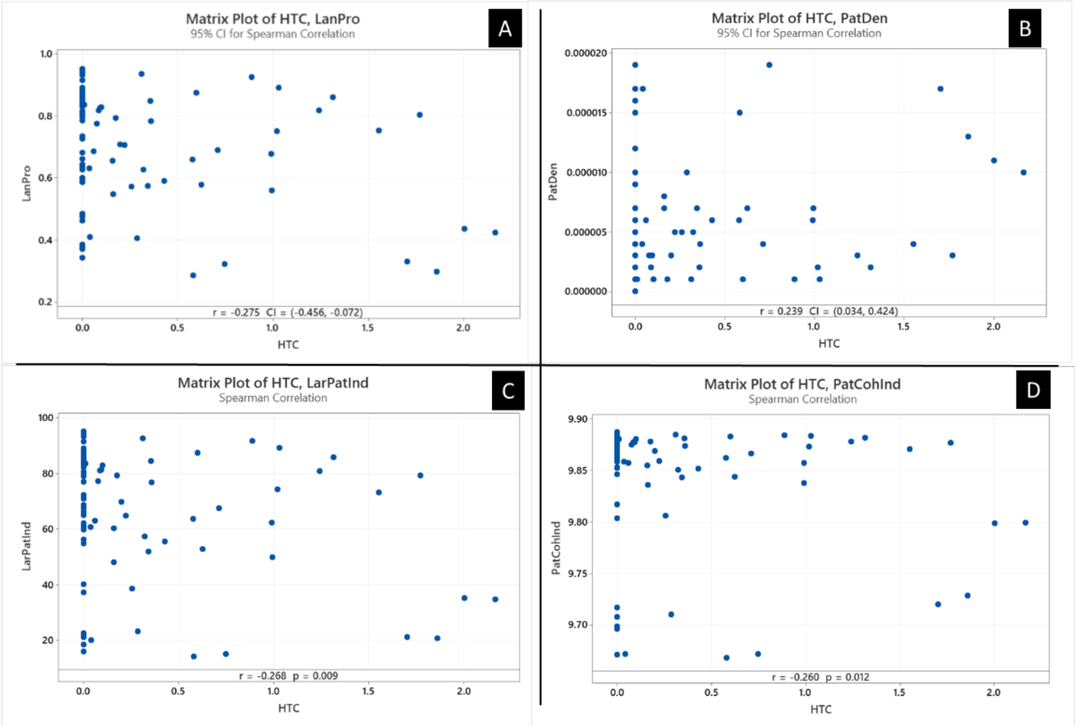

Figure 7. The figure presents four scatter plots showing the Spearman correlation between human tiger conflict intensity (HTC) and landscape metrics in the Agam tiger corridor, including landscape proportion, patch density, largest patch index, and patch cohesion index. The plots display weak negative correlations for landscape proportion, largest patch index, and patch cohesion, alongside a weak positive correlation for patch density, with correlation values ranging from r = −0.275 to r = 0.239. These results illustrate that areas with more fragmented and less cohesive landscapes tend to exhibit higher levels of human-tiger conflict.

To add more understanding of the landscape metric variables that have significant correlation with HTC density (LanPro, PD, LPI, and PCI), we conducted Kruskal-Wallis's statistical test to determine the significance of the landscape metric changes between observed datasets, resulting in no statistically significant difference in landscape metrics between datasets, as all p-values were >0.05. The non-significant finding of the Kruskal-Wallis statistic should not be interpreted as a corridor with no significant pressure. We then observed the distribution of landscape metric data using descriptive statistics (Table 6). Finally, the statistical distribution of each HTC density category with the corresponding landscape metric indices indicated the threshold value of each HTC category according to the landscape fragmentation level (Table 7).

Table 6. Summary statistics for selected landscape metrics (LanPro, PD, LPI, and PCI) for the years 2010, 2015, and 2020.

Variable	year	N	Mean	StDev	Minimum	Median	Maximum
LanPro	2010	31	74.67	16.69	37.58	79.66	95.08
(%)	2015	31	71.17	18.00	32.18	74.99	94.63
	2020	31	67.74	18.69	28.53	70.76	93.84
PD	2010	31	4	4	1	3	19
(Patch km^{-2})	2015	31	5	4	1	4	19
	2020	31	5	4	1	4	16
LPI (%)	2010	31	71.03	22.18	15.99	79.04	94.99
	2015	31	67.21	23.06	14.93	74.19	94.57
	2020	31	63.40	23.28	14.18	69.55	93.79
PCI (%)	2010	31	9.8547	0.0524	9.6986	9.8754	9.8867
	2015	31	9.8460	0.0627	9.6717	9.8729	9.8865

Variable	year	N	Mean	StDev	Minimum	Median	Maximum
	2020	31	9.8410	0.0630	9.6681	9.8689	9.8861

Table 7. Descriptive statistics for HTC density category and statistically correlated landscape metrics.

Variable	HTC category	N	Mean	StDev	Min	Med	Max
LanPro (%)	No incident	53	74.94	16.59	34.26	80.77	95.08
	Low density	30	67.09	6.82	28.53	68.18	93.44
	Moderate density	4	82.98	6.12	74.99	83.89	89.14
	High density	6	50.76	21.72	29.75	42.98	80.41
PD (Patch km^{-2})	No incident	53	4	4	1	3	19
	Low density	30	6	5	1	5	19
	Moderate density	4	2	1	1	2	3
	High density	6	10	5	3	11	17
LPI (%)	No incident	53	71.77	21.47	15.99	79.89	94.99
	Low density	30	61.79	22.22	14.18	63.18	92.41
	Moderate density	4	82.41	6.45	74.19	83.18	89.09
	High density	6	44.0	25.8	20.5	34.9	79.30
PCI (%)	No incident	53	9.86	0.054	9.67	9.88	9.88
	Low density	30	9.84	0.066	9.67	9.86	9.88
	Moderate density	4	9.87	0.004	9.87	9.88	9.88
	High density	6	9.79	0.067	9.72	9.79	9.87

3.2. Discussion

The visual interpretation of the two highest HTC cluster distributions in West Sumatra, during 2005-2015 it formed a clustered pattern in the Pesisir Selatan Regency, and from to 2015-2019 form a cluster in the Agam Regency. In the Cluster in Pesisir Selatan, the movement of tigers originated from Kerinci-Seblat NP, which dispersed through SM Arau Hilir and Air Tarusan and headed to the Maninjau Nature Reserve, which is only 47 km away, whereas in Central India, tigers dispersed up to 345 km from their birthplace [43]. The HTC cluster in Agam and transient tigers from both populations in Kerinci-Seblat NP and Malampah-Alahan Panjang WR could potentially be present in the Agam corridor. An increase in the tiger population within the core area may be one of the contributing factors to Human-Tiger Conflict (HTC) incidents, particularly in the surrounding areas where there has been a significant decline in prey populations and high levels of human activity [44].

Statistical analyses showed a linear trend between conflict density and landscape metrics; however, we obtained exceptional results for the moderate HTC density category. The most likely explanation is that we need further study that includes information on the chronology of each conflict incident as the basis of the analysis, as this type of HTC incident may not be related to landscape structure. For example, when a tiger attacks humans in the middle of a forest, it may occur due to the natural behavior of the tiger, such as a tigress caring for a cub that feels threatened by the presence of humans, a young tiger learning to hunt prey, or even an old tiger that is no longer able to hunt prey animals [45].

The sharp reduction in wild boar populations due to the ASF outbreak in 2019 throughout Sumatera led to a scarcity of natural prey for tigers, compelling them to venture closer to human settlements in search of food. This shift increases the likelihood of tigers preying on livestock and, in some cases, attacking humans, thereby escalating HTC incidents. Anecdotal connections raised by community and conservation officers indicate that the increase in HTC density from to 2020-2024 could also be attributed to the ASF outbreak.

3.2.1. Understanding tiger behaviour in the fragmented habitat and formulate better HTC mitigation

HTC and forest proportion

Lower HTC density (0< HTC <1) occurred in grids with a mean forest proportion of 67.1% and ranged between 34-95%, indicating that all grids adjacent to the tiger habitat had potential low-intensity HTC. High HTC density (HTC> 1.5) occurred in grids with lower forest proportions, with a mean of 50.76% (42-80%), while forest proportions with a mean > 74.94%

had near-zero HTC density. We identified additional challenges in preserving the forest proportion, as Law No. 11/2020 removed the obligation of the local government to preserve at least 30% of the forest proportion [46]. Scientists should anticipate the enactment of this law by continuing to conduct research and provide comprehensive consideration when it comes to the local government to alter forest cover in the highly important corridors and integrate it into the establishment of "preservation area" that is mandated by the Law No.32/2024 on Conservation of Biodiversity and Ecosystems.

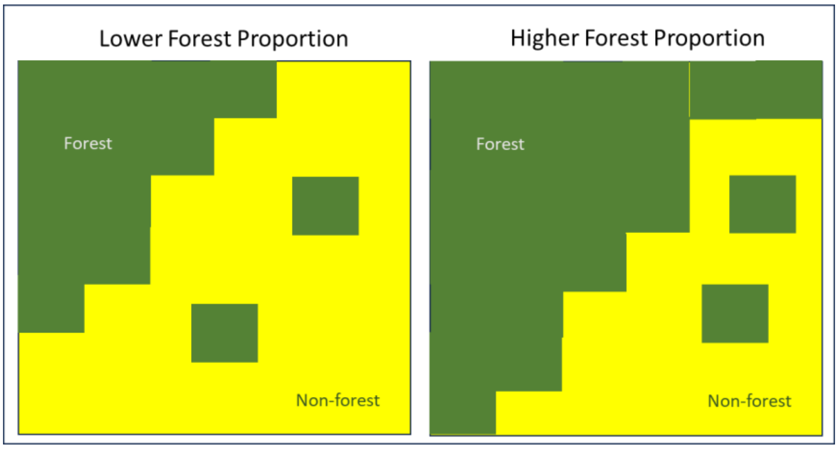

Figure 8. Depiction of the distribution patterns of forested (green) and non-forested (yellow) areas, highlighting the variations in spatial arrangement and fragmentation across two different landscapes.

HTC and Largest Patch Index (LPI)

The Largest Patch Index (LPI) is the area of the largest patch divided by the total grid area [34]. The LPI is negatively correlated with conflict incidents, where smaller greatest patch areas have a higher conflict density. In comparison, the greatest patch area > 71.7 ha had a low HTC density. It has been confirmed that tigers need a large area for roaming, particularly in areas with a low density of prey species [6], in addition to high prey density as an ecological need [23].

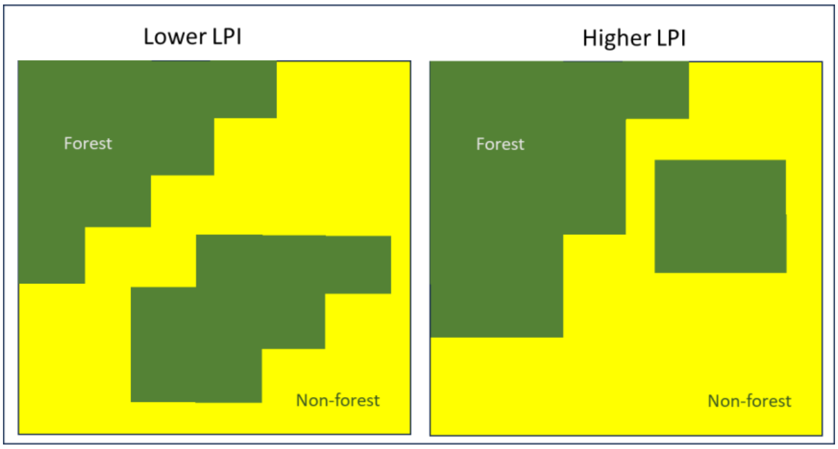

Figure 9. A comparison of spatial arrangements in forested (green) and non-forested (yellow) areas, highlighting variations in patch size and distribution across the two different landscapes.

HTC and Patch Cohesion Index (PCI)

An increase in the PCI value indicates that the patch structure is more aggregated. PCI values were negatively correlated with the HTC density. High HTC density occurred in grids with a lower PCI (PCI= 9.79 (SD ± 0.067]). However, areas with PCI > 9.86 have a lower HTC density. PCI in this study had narrow ranges, and small changes in PCI could potentially reduce recurrent HTC or create an impermeable gap for tigers to cross. PCI can also be used to limit tiger movement in and out of the corridor. The minimum PCI value in zero HTC grids was 9.67; therefore, targeting the shape of patches outside the corridor to have a value <9.67 would potentially limit HTC, as tigers may not consider it a suitable patch to move to.

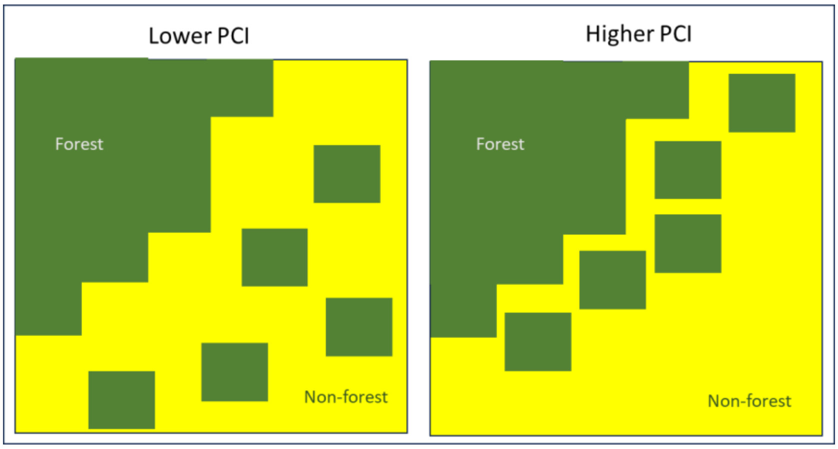

Figure 10. The image shows forest (green) and non-forest (yellow) areas. Numerous small forest patches are scattered throughout the left side. On the right, the forest areas were larger and more connected.

HTC and Patch Density

Compared to the three other variables, patch density (PD) had the weakest correlation with HTC density, with the highest p-value. A low HTC density (0<HTC<1) occurred in grids with an average of six patches km^{-2}. PD's wide range between 1 and 19 patches km^{-2}, indicating that HTC is likely to occur at all patch density levels, and the forest only consists of one large patch. Landscape structure is a multifactorial driver of tiger conflict. Individuals that move out of the habitat because of intrinsic factors such as age, sex, and territorial behavior, and physical conditions such as dispersal, old age, and injury seem to be more involved in HTC [26].

High-density HTC was positively correlated with high PD (mean of 10 patches km^{-2}). While moderate-intensity conflicts (1 <HTC<1.5) with n=4 showed a different pattern, the incident occurred at a mean PD = 2 patches km^{-2}. To explain the specific phenomenon, it is necessary to trace the facts of the conflict incident, whether it is a stray tiger, livestock depredation, human attack, or conflict caused by human provocation, such as setting a snare that caught tigers [27,47].

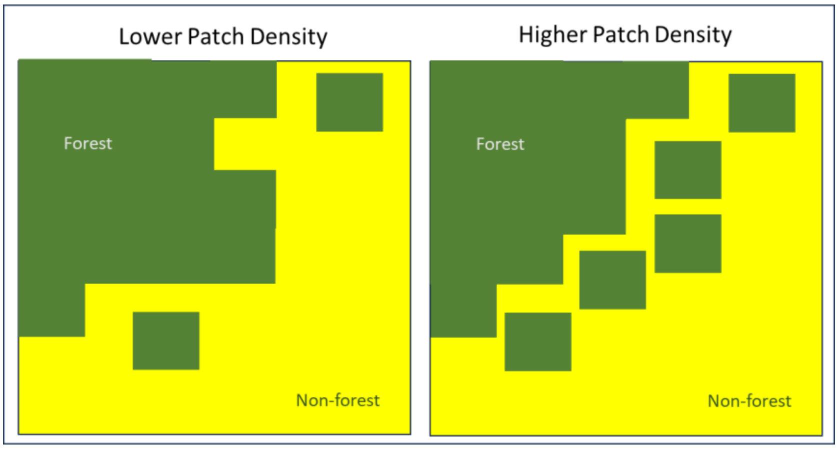

Figure 11. The spatial arrangement of forested (green) and non-forested (yellow) regions highlights variations in fragmentation patterns: the left side depicts larger, more unified forest areas with a lower density of patches, whereas the right side shows increased fragmentation with numerous smaller, isolated patches.

3.2.2. Improving Landscape Structure in Agam Corridor

We find that the degree of fragmentation leads to varying levels of conflict intensity. The lowest p-values were obtained for the LandPro LPI, PCI, and PD. Improving the land proportion through reforestation in deforested or degraded patches to create larger, aggregated forest patches would reduce the intensity of the HTC. Our study also confirmed that habitats fragmented to a certain degree still provide an opportunity for Sumatran tigers to cross [5,48].

Reforestation by aggregating patches or growing forest patches near each other positively affects reducing HTC. The aggregation of patches (increased PCI) simultaneously increased LanPro and LPI. Meanwhile, outside the corridor, reducing the PCI by utilizing agricultural options with high resistance to tiger movement and minimizing human activity to limit tiger movement is anticipated to reduce the probability of tigers moving out of the corridor. Moreover, if reforestation is performed by connecting fragmented patches, it will reduce the area. Fragmented corridor conditions in Agam can only be improved by involving all stakeholders, led by the provincial government, with the involvement of the BKSDA, and community consent and participation must be considered. Economic impact assessment and finding a socially accepted solution underpin the whole effort, as the largest part of the corridor in Agam lies in a non-protected forest area. This factual condition of the Sumatran tiger requires the synergy of coexistence with the development of human civilization [18,49–52].

Further direction in HTC mitigation and corridor management

Since the Sumatran Tiger Conservation Strategy and Action Plan was introduced in 2007, the government and various conservation organizations have built their capacity to monitor populations and respond to human-tiger conflict incidents. Tiger rehabilitation centers operating in West Sumatra province also provide fast responses to problem tiger rescue and rehabilitation. Communities living in rural areas have direct communication channels through social media and proactive authorities to respond to HTC incidents. Faster and more direct reports from the community tend to increase the pressure on authorities to capture problematic tigers, as shown by the removal index trend [27].

HTC mostly involves transient tigers [53]; identification of problematic individuals becomes crucial in decision-making to capture, where transient tigers bring genetic diversity to the destination habitat, which is essential to reduce the probability of extinction in medium- and small-sized landscapes [17,19]. Tiger removal is generally aimed at individuals who attack humans [13,53]. Requiring an accurate identification process before capture, as there is some evidence of a mistaken capture. Individuals that are mistakenly captured would possess high-value information if they were released after being fitted with the GPS collar. Unfortunately, a negative perspective or stigma toward collared tigers is common in communities that call it the “government’s tiger” which needs to be addressed to facilitate further research on HTC management effectiveness in the future. Conservation activities such as this are often conducted without the Free, Prior, and Informed Consent (FPIC) stage, and implementing proper FPIC would be beneficial in gradually eliminating this stigma.

HTC mitigation measures widely used in Sumatra include strategies for reducing grazing livestock through tiger-proof enclosures [18,42,54]. For livestock management, limiting grazing livestock reduces livestock casualties and coincides with an increase in tiger attacks on humans (Gurung et al. 2009). Higher attacks on humans will increase the pressure to remove problem tigers, and HTC mitigation practices must be evaluated to formulate better strategies. To strengthen corridor management, it is essential to consistently collect genetic samples from all tigers involved in conflicts. This will facilitate a better understanding of kinship relationships among individuals using microsatellite DNA analysis.

4. Conclusions

This study highlights that Human-Tiger Conflict (HTC) in West Sumatra is spatially correlated with landscape structure, prey availability, and human activity levels. High HTC densities were typically found in areas with lower forest cover, smaller and more fragmented patches, and reduced patch cohesion. These findings confirm that tiger movement through fragmented corridors, especially by transient individuals, can lead to increased conflict, particularly when prey density is low, or human presence is high. Landscape metrics, such as forest proportion, Largest Patch Index (LPI), Patch Cohesion Index (PCI), and Patch Density (PD), showed varying degrees of influence on HTC incidence. Among these, the LPI and PCI demonstrated the strongest negative correlations, indicating that preserving or restoring large cohesive forest patches can effectively mitigate conflicts. Mitigation efforts must extend beyond reactive tiger removal and prioritize habitat connectivity, reforestation, and coexistence strategies. Strengthening local policies and integrating scientific evidence, such as conflict chronologies, genetic analyses, and GPS tracking, into management decisions will enhance the functionality of these corridors. Engaging communities, improving livestock management, and addressing social perceptions of conservation technologies are crucial for the long-term success of reducing HTC and ensuring the survival of Sumatran tigers in the wild.

Author Contributions

MK: Conceptualization, Methodology, Software, Investigation, Writing - Review & Editing; **S:** Review & Editing, Supervision; **LDB**: Data Curator, Writing - Review & Editing.

AI Writing Statement

The authors did not use any artificial intelligence assisted technologies in the writing process

Conflicts of interest

There are no conflicts to declare.

References

1. Khan, M.M.H.; Chivers, D.J. Habitat Preferences of Tigers Panthera Tigris in the Sundarbans East Wildlife Sanctuary, Bangladesh, and Management Recommendations. *Oryx* **2007**, *41*, 463–468, doi:10.1017/S0030605307012094.
2. Wibisono, H.T.; Linkie, M.; Guillera-Arroita, G.; Smith, J.A.; Sunarto; Pusparini, W.; Asriadi; Baroto, P.; Brickle, N.; Dinata, Y.; et al. Population Status of a Cryptic Top Predator: An Island-Wide Assessment of Tigers in Sumatran Rainforests. *PLoS One* **2011**, *6*, doi:10.1371/journal.pone.0025931.
3. Sunarto, S.; Kelly, M.J.; Parakkasi, K.; Klenzendorf, S.; Septayuda, E.; Kurniawan, H. Tigers Need Cover: Multi-Scale Occupancy Study of the Big Cat in Sumatran Forest and Plantation Landscapes. *PLoS One* **2012**, *7*, doi:10.1371/journal.pone.0030859.
4. Weiskopf, S.R.; McCarthy, J.L.; McCarthy, K.P.; Shiklomanov, A.N.; Wibisono, H.T.; Pusparini, W. The Conservation Value of Forest Fragments in the Increasingly Agrarian Landscape of Sumatra. *Environ. Conserv.* **2019**, 68–108, doi:10.1017/S0376892919000195.
5. Wibisono, H.T.; McCarthy, K.P. Modeling Potential Connectivity of Fragmented Habitats of Sumatran Tiger in West Sumatra, Indonesia. Di Dalam: Wibisono. HT. 2021. An Island-Wide Status of Sumatran Tiger (Panthera Tigris Sumatrae) And Principal Prey in Sumatra, Indonesia. Doctor of Philo. **2021**, 68 – 108.
6. Priatna, D.; Santosa, Y.; Prasetyo, L.B.; Kartono, a P. Home Range and Movements of Male Translocated Problem Tigers in Sumatra. *Asian J. Conserv. Biol.* **2012**, *1*, 20–30.
7. Seidensticker, J.; McDougal, C. Tiger Predatory Behaviour, Ecology and Conservation. *Mamm. as Predators* **1993**, 105–125, doi:10.1093/oso/9780198540670.003.0006.
8. Kerley, L.L.; Goodrich, J.M.; Miquelle, D.G.; Smirnov, E.N.; Quigley, H.B.; Hornocker, M.G. Reproductive Parameters of Wild Female Amur (Siberian) Tigers (Panthera Tigris Altaica). *J. Mammal.* **2003**, *84*, 288–298, doi:10.1644/1545-1542(2003)084<0288:RPOWFA>2.0.CO;2.
9. Singh, R.; Krausman, P.R.; Pandey, P.; Qureshi, Q.; Sankar, K.; Goyal, S.P.; Tripathi, A. First Parturition of Tigers in a Semi-Arid Habitat, Western India. *Eur. J. Wildl. Res.* **2014**, *60*, 383–386, doi:10.1007/s10344-013-0784-x.

10. Singh, R.; Nigam, P.; Qureshi, Q.; Sankar, K.; Krausman, P.R.; Goyal, S.P. Strategy of Female Tigers to Avoid Infanticide. *Curr. Sci.* **2014**, *107*, 1595–1597.
11. Gaveau, D.L.A.; Curran, L.M.; Paoli, G.D.; Carlson, K.M.; Wells, P.; Besse-Rimba, A.; Ratnasari, D.; Leader-Williams, N. Examining Protected Area Effectiveness in Sumatra: Importance of Regulations Governing Unprotected Lands. *Conserv. Lett.* **2012**, *5*, 142–148, doi:10.1111/j.1755-263X.2011.00220.x.
12. Margono, B.A.; Turubanova, S.; Zhuravleva, I.; Potapov, P.; Tyukavina, A.; Baccini, A.; Goetz, S.; Hansen, M.C. Mapping and Monitoring Deforestation and Forest Degradation in Sumatra (Indonesia) Using Landsat Time Series Data Sets from 1990 to 2010. *Environ. Res. Lett.* **2012**, *7*, doi:10.1088/1748-9326/7/3/034010.
13. Forum Harimau Kita *AUM! ATLAS HARIMAU NUSANTARA*; Prijono, A., Kholis, M., Bahaduri, L.D., Eds.; Direktorat Konservasi Keanekaragaman Hayati, Direktorat Jenderal Konservasi Sumber Daya Alam, Kementerian Lingkungan Hidup dan Kehutanan, GEF UNDP. Jakarta, 2019; ISBN 9786020854328.
14. Tejaswi, G.; Holmgren, P. Manual on Deforestation, Degradation, and Fragmentation Using Remote Sensing and GIS. Strengthening Monitoring, Assessment and Reporting on Sustainable Forest Management in Asia (GCP/INT/988/JPN). **2007**, 49.
15. Nad, C.; Roy, R.; Roy, T.B. “Human Elephant Conflict in Changing Land-Use Land-Cover Scenario in and Adjoining Region of Buxa Tiger Reserve, India.” *Environ. Challenges* **2022**, *7*, 100384, doi:10.1016/j.envc.2021.100384.
16. Ruda, A.; Kolejka, J.; Silwal, T. GIS-Assisted Prediction and Risk Zonation of Wildlife Attacks in the Chitwan National Park in Nepal. *ISPRS Int. J. Geo-Information* **2018**, *7*, 1–21, doi:10.3390/ijgi7090369.
17. Wegge, P.; Yadav, S.K.; Lamichhane, B.R. Are Corridors Good for Tigers Panthera Tigris but Bad for People? An Assessment of the Khata Corridor in Lowland Nepal. *ORYX* **2018**, *52*, 35–45, doi:10.1017/S0030605316000661.
18. Patana, P.; Alikodra, H.S.; Mawengkang, H.; Hamdani Harahap, R. State of Human Tiger Conflict around Gunung Leuser National Park in Langkat Landscape, North Sumatra, Indonesia. *Biodiversitas* **2023**, *24*, 837–846, doi:10.13057/biodiv/d240220.
19. Pusparini, W.; Ariyanto, T.; Sadikin, L.; Widodo, F.A.; Wahyudi, H.A. Report: Sumatran Tiger Population Viability Analysis. *Kementeri. Lingkung. Hidup dan Kehutan.* **2019**.
20. Vásquez-Grandón, A.; Donoso, P.J.; Gerding, V. Forest Degradation: When Is a Forest Degraded? *Forests* **2018**, *9*, 1–13, doi:10.3390/f9110726.
21. Supriatna, J.; Dwiyahreni, A.A.; Winarni, N.; Mariati, S.; Margules, C. Deforestation of Primate Habitat on Sumatra and Adjacent Islands, Indonesia. *Primate Conserv.* **2017**, *31*, 71–82.
22. Wikramanayake, E.; Dinerstein, E.; Seidensticker, J.; Lumpkin, S.; Pandav, B.; Shrestha, M.; Mishra, H.; Ballou, J.; Johnsingh, A.J.T.; Chestin, I.; et al. A Landscape-Based Conservation Strategy to Double the Wild Tiger Population. *Conserv. Lett.* **2011**, *4*, 219–227, doi:10.1111/j.1755-263X.2010.00162.x.
23. Gurung, B.; Nelson, K.C.; Smith, J.L.D. Impact of Grazing Restrictions on Livestock Composition and Husbandry Practices in Madi Valley, Chitwan National Park, Nepal. *Environ. Conserv.* **2009**, *36*, 338–347, doi:10.1017/S0376892910000160.
24. Kartika, E.C. Human-Tiger Conflict: An Overview of Incidents, Causes and Resolution. **2013**, doi:10.13140/RG.2.1.3754.2808.
25. Kholis, M.; Faisal, A.; A, F.; Widodo; Hasihola, W.; Musabine, S.E.; Kartika, E.C. Pedoman Penanggulangan Konflik Manusia-Harimau. **2017**, 1–100.
26. Lamichhane, B.R.; Persoon, G.A.; Leirs, H.; Musters, C.J.M.; Subedi, N.; Gairhe, K.P.; Pokheral, C.P.; Poudel, S.; Mishra, R.; Dhakal, M.; et al. Are Conflict-Causing Tigers Different? Another Perspective for Understanding Human-Tiger Conflict in Chitwan National Park, Nepal. *Glob. Ecol. Conserv.* **2017**, *11*, 177–187, doi:10.1016/j.gecco.2017.06.003.
27. Kartika, E. Spatio-Temporal Patterns of Human-Tiger Conflicts in Sumatra 2001-2016. **2017**, 31.
28. Rahman, H.; Hidayat, R.A.; Nofrizal, A.Y.; Wilastra, I.; Nasution, A.F.R. Priority Corridor Zone for Human-Tiger Conflict Mitigation: A Landscape Connectivity Approach in West Sumatra Region, Indonesia. *J. Nat. Conserv.* **2023**, *76*, 126501, doi:10.1016/j.jnc.2023.126501.
29. Sulistyawan, B.S.; Eichelberger, B.A.; Verweij, P.; Boot, R.G.A.; Hardian, O.; Adzan, G.; Sukmantoro, W. Connecting the Fragmented Habitat of Endangered Mammals in the Landscape of Riau–Jambi–Sumatera Barat (RIMBA), Central Sumatra, Indonesia (Connecting the Fragmented Habitat Due to Road Development). *Glob. Ecol. Conserv.* **2017**, *9*, 116–130, doi:10.1016/j.gecco.2016.12.003.

30. Ritonga, R.P.; Novarino, W.; Mahdi Pengaruh Aktifitas Sosial Ekonomi Masyarakat Pada the Influence of Socio-Economic Activities on Extraordinary. *Menara Ilmu* **2023**, *XVII*, 256–266.
31. Wati, V.W. Pemodelan Potensi Konflik Manusia Dengan Harimau Sumatera (Panthera Tigris Sumatrae) Berdasarkan Data Historis Di Sumatera Barat. *Dep. Biol. Andalas Univ. Indones.* **2021**.
32. Kartika, E.C.; Koopmans, F. Human-Tiger Conflict : An Overview of Incidents , Causes and Resolution Human-Tiger Conflict : An Overview of Incidents , Causes and Resolution. **2016**, 1–27, doi:10.13140/RG.2.1.3754.2808.
33. Vancutsem, C.; Achard, F.; Pekel, J.F.; Vieilledent, G.; Carboni, S.; Simonetti, D.; Gallego, J.; Aragão, L.E.O.C.; Nasi, R. Long-Term (1990–2019) Monitoring of Forest Cover Changes in the Humid Tropics. *Sci. Adv.* **2021**, *7*, 1–21, doi:10.1126/sciadv.abe1603.
34. McGarigal, K.; Marks, B.J.; Cushman, S.A.; Neel, M.C.; Ene, E. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. *Gen. Tech. Rep. PNW-GTR-351. US …* **1994**, *97331*, 134.
35. Tischendorf, L.; Bender, D.J.; Fahrig, L. Evaluation of Patch Isolation Metrics in Mosaic Landscapes for Specialist vs. Generalist Dispersers. *Landsc. Ecol.* **2003**, *18*, 41–50, doi:10.1023/A:1022908109982.
36. Wadgave, U.; Ravindra Khairnar, M. Parametric Test for Non-Normally Distributed Continuous Data: For and Against. *Electron. physician* **2019**, *11*, 7468–7470, doi:10.19082/7468.
37. Leon, A.C. Descriptive and Inferential Statistics. *Compr. Clin. Psychol.* **1998**, 243–285, doi:10.1016/B0080-4270(73)00264-9.
38. Ostertagová, E.; Ostertag, O.; Kováč, J. Methodology and Application of the Kruskal-Wallis Test. *Appl. Mech. Mater.* **2014**, *611*, 115–120, doi:10.4028/www.scientific.net/AMM.611.115.
39. Prasetyo, L.B. *Pendekatan Ekologi Lanskap*; 2017; ISBN 2013206534.
40. Haidir, I..; Albert. W.r; Pinondang, I.M.R.; Ariyanto, T.; Widodo, F.A.; Ardiantiono Panduan Pemantauan Populasi Harimau Sumatera, Direktorat Konservasi S 2017, 154.
41. Condro, A.A.; Prasetyo, L.B.; Rushayati, S.B.; Santikayasa, I.P.; Iskandar, E. Protected Areas Slow down Tropical Rainforest Disturbance in the Leuser Ecosystem, Indonesia. *J. Land Use Sci.* **2022**, *17*, 454–470, doi:10.1080/1747423X.2022.2115571.
42. Lubis, M.I.; Pusparini, W.; Prabowo, S.A.; Marthy, W.; Tarmizi; Andayani, N.; Linkie, M. Unraveling the Complexity of Human–Tiger Conflicts in the Leuser Ecosystem, Sumatra. *Anim. Conserv.* **2020**, *23*, 741–749, doi:10.1111/acv.12591.
43. Joshi, A.; Vaidyanathan, S.; Mondo, S.; Edgaonkar, A.; Ramakrishnan, U. Connectivity of Tiger (Panthera Tigris) Populations in the Human-Influenced Forest Mosaic of Central India. *PLoS One* **2013**, *8*, doi:10.1371/journal.pone.0077980.
44. Luskin, M.S.; Albert, W.R.; Tobler, M.W. Sumatran Tiger Survival Threatened by Deforestation despite Increasing Densities in Parks. *Nat. Commun.* **2017**, *8*, doi:10.1038/s41467-017-01656-4.
45. Goodrich, J.M. Human-Tiger Conflict: A Review and Call for Comprehensive Plans. *Integr. Zool.* 2010, *5*, 300–312.
46. Nugroho, A. wahyu Membaca Arah Perubahan Kehutanan Pasca-Terbitnya Undang-Undang Cipta Kerja. *J. Huk. Lingkung. Indones.* **2021**, *7*, 275–296, doi:10.38011/jhli.v7i2.278.
47. Chouksey, S.; Singh, S. Assessment on the Impacts of Human-Tiger Conflict and Community-Based Conservation in Bandhavgarh Tiger Reserve, Madhya Pradesh, India. *J. Threat. Taxa* **2018**, *10*, 11844–11849, doi:10.11609/jott.3015.10.7.11844-11849.
48. Thapa, K.; Wikramanayake, E.; Malla, S.; Acharya, K.P.; Lamichhane, B.R.; Subedi, N.; Pokharel, C.P.; Thapa, G.J.; Dhakal, M.; Bista, A.; et al. Tigers in the Terai: Strong Evidence for Meta-Population Dynamics Contributing to Tiger Recovery and Conservation in the Terai Arc Landscape. *PLoS One* **2017**, *12*, doi:10.1371/journal.pone.0177548.
49. Linkie, M.; Haidir, I.A.; Nugroho, A.; Dinata, Y. Conserving Tigers Panthera Tigris in Selectively Logged Sumatran Forests. *Biol. Conserv.* **2008**, *141*, 2410–2415, doi:10.1016/j.biocon.2008.07.002.
50. McKay, J.E.; St John, F.A.V.; Harihar, A.; Martyr, D.; Leader-Williams, N.; Milliyanawati, B.; Agustin, I.; Anggriawan, Y.; Karlina; Kartika, E.; et al. Tolerating Tigers: Gaining Local and Spiritual Perspectives on Human-Tiger Interactions in Sumatra through Rural Community Interviews. *PLoS One* **2018**, *13*, doi:10.1371/journal.pone.0201447.

51. Campbell-Smith, G.; Simanjorang, H.V.P.; Leader-Williams, N.; Linkie, M. Local Attitudes and Perceptions toward Crop-Raiding by Orangutans (Pongo Abelii) and Other Nonhuman Primates in Northern Sumatra, Indonesia. *Am. J. Primatol.* **2010**, *72*, 866–876, doi:10.1002/ajp.20822.

52. Dertien, J.S.; Negi, H.; Dinerstein, E.; Krishnamurthy, R.; Negi, H.S.; Gopal, R.; Gulick, S.; Pathak, S.K.; Kapoor, M.; Yadav, P.; et al. Mitigating Human-Wildlife Conflict and Monitoring Endangered Tigers Using a Real-Time Camera-Based Alert System. *Bioscience* **2023**, *73*, 748–757, doi:10.1093/biosci/biad076.

53. Lamichhane, B.R.; Persoon, G.A.; Leirs, H.; Musters, C.J.M.; Subedi, N.; Gairhe, K.P.; Pokheral, C.P.; Poudel, S.; Mishra, R.; Dhakal, M.; et al. Are Conflict-Causing Tigers Different? Another Perspective for Understanding Human-Tiger Conflict in Chitwan National Park, Nepal. *Glob. Ecol. Conserv.* **2017**, *11*, 177–187, doi:10.1016/j.gecco.2017.06.003.

54. Wibisono, H.T.; Pusparini, W. Sumatran Tiger (Panthera Tigris Sumatrae): A Review of Conservation Status. *Integr. Zool.* **2010**, *5*, 313–323, doi:10.1111/j.1749-4877.2010.00219.x.