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Identification of Human-Leopard Conflicts, Conservation Threats and Habitat Suitability in the Urban Landscapes of Guwahati City, Assam, India using Field-based and Geospatial Techniques

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Abstract

Increasing human population put significant impact on the wild-life habitats all over the globe. Guwahati, the largest city of North-Eastern part of India experiences the human-leopard conflict from last few decades. Studies advocate that once this region was a suitable abode for many animal species, especially for the leopards. But the growing urban built-up progressively shrinks the suitable habitation site for this species that leading to the frequent conflicts between man and leopard within the city region. Rapid decrease of leopard population and increasing incidences of encounters are the major concern for the sustainable conservation of the species. In this study, an effort has been made to evaluate the habitat suitability of leopards in Guwahati city region by using composite score method. Four parameters are considered to perform the spatial analysis such as leopard conflict locations collected using camera traps, pug marks/scat, and conflict locations; spatial distribution of population derived from LandscanTM population data; land use/ land cover data classified using Landsat 8 OLI satellite imagery and elevation information extracted from SRTM Digital Elevation Model (DEM). Results of the analysis suggests that the region near Fatasil hill, Japorigog hill and areas of Amsang Reserve forest as the most suitable habitat for the leopards. Outcome of this study will help the people living within or near those region to avoid possible encounters, while it will also help the concerned authorities to take adequate steps for the conservation of the species as well as the habitats.

Keywords: *Guwahati city, human-Leopard conflict (HEC), habitat-suitability, composite score, spatial analysis*

1. Introduction

Human impact on the forest and wildlife have been well monitored, documented [1, 2,3] and established in different parts of the globe. Out of the many factors leading to deforestation and extinction of wildlife, the human footprints[4, 5, 6] have been the prominent one and many contemporary researchers have believed that human influence arguably is the most influencing factor affecting all kinds of life form in today's world[2]. Urban forest has been increasingly fragmented [7, 8], deteriorated due to anthropogenic pressure [9, 10, 11, 12] and has been reflected in growing fragmentation, encroachments and increasing concrete surfaces, etc. The wildlife of the urban forest has been worst

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affected as reducing prey density [13, 14], habitat and retaliatory casualties [15] are on the rise. In situ conservation or protected areas offer asylum to those threatened species, however, it is not sufficient to reduce growing man-animal conflict [16, 17, 18, 19], [20],.However, conflicts outside the peripheries of the protected areas are more significant and often remain unnoticed and uncounted.

Although the increase of human population is often related to decreasing of wildlife population, yet in many cases the human concentrations ie urban centers also accommodate a lot of wildlife [21, 22]. The conservation efforts, therefore, warrants inclusion of new and untouched areas into the ambit of conservation[23, 24],. The numerous cases from countries all over the world demonstrate the severity of human-wildlife conflict [25, 26, 27] and suggest that (IUCN - the World Conservation Union - Red List of Threatened Species, 2003) an in-depth analysis is essential to understand the problem and support the conservation prospects of threatened and potentially endangered species. this for the first paragraph in a section, or to continue after an extract.

Leopards are highly adaptive species that live in and around many human-dominated, both urban and agricultural landscapes. It is a daunting challenge to ensure the peaceful co-existence of leopards among high densities of human settlements[27]. Carnivore density is known to be dependent on prey density. Research indicates that even in such high human density areas, attacks on humans and domestic animals in most cases can be kept in very low levels. The goodwill and trust of people especially in these areas are vital to dealing with crisis situations arising out of the loss of life and livestock by leopards. The Guwahati, the largest city of the North-eastern part of India also experience growing man-leopard conflict which needs to be addressed not only to save this species but also to reduce growing human and leopard casualties arising out of the conflicts. The present study attempts to identify and record the human-leopard conflict areas in Guwahati city through field observations, camera trapping, GPS survey, etc. based on the 168 field observations over a span of three years (2015-2018) and tried to prepare a habitat suitability map and zonation so that in-situ conservation planning can be extended to the one of the most beautiful predator on earth besides minimizing human casualties through the adoption of necessary proactive measures.

2. Study Area and database

2.1 Study Area: Guwahati, the capital city of Assam confined to the Kamrup Metropolitan District. It covers an area of 178.5 km^2 (excluding the area covered by the Brahmaputra River) and having the population of 9.68 lakhs according to the 2011 census. The average altitude of the city is 49.5- 55.5m above the MSL[28]. The city Guwahati is demarcated in the north by the Brahmaputra river; in the south by the extension of the Khasi Hills of Meghalaya plateau; in the south and south-west by the Rani Reserve Forest, Deepor Beel, an important Ramsar site and the alluvial tracts of the Brahmaputra Plain; and in the east by the hill ranges of Meghalaya. The Guwahati city enjoys the Sub-tropical climatic conditions characterized by the high humidity and heavy precipitation in the summer and mild winter [28]. The Guwahati city experiences maximum temperature of 35–39 °C in summer and 5–8 °C in winter [29]. The soil taxonomy of the Guwahati city is characterized by coarse-loamy (Mollic Fluvaquents), clayey (Typic Kandihumults) and fine (Typic Kandihumults) soils according to the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP) State Soil Map.

The city is inhabited with Indian Common Leopard (*Panthera pardus fusca*), a schedule one species under Indian Wildlife (Protection) Act 1972. However, over the years, there have been growing casualties on human-leopard conflicts in the region which requires urgent attention to mitigate the conflict[30] and adopt sustainable conservation measures.

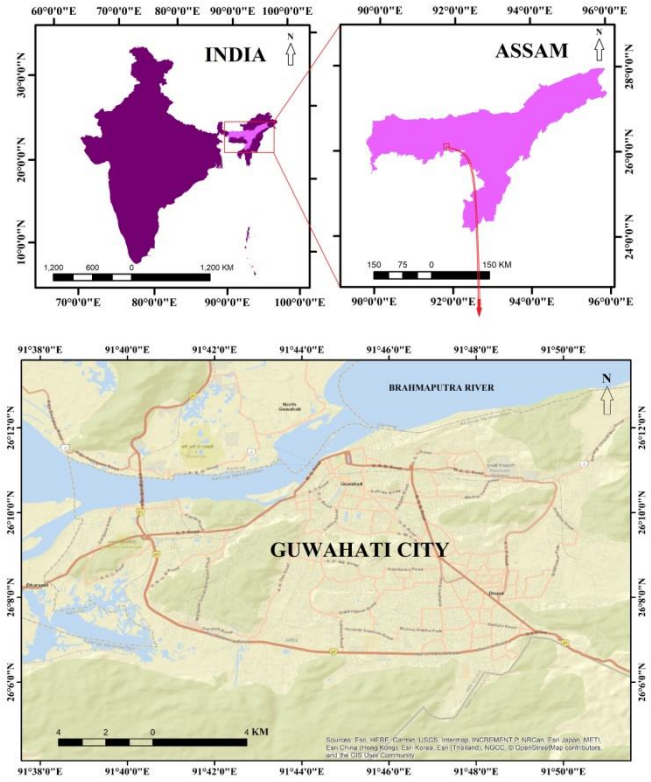

Figure 1: Location of the Study Area

2.2 Database: Different datasets were used for this study to fulfill the mentioned objectives. Digital Elevation Model (DEM) plays important role to understand the behaviour of leopard habitat with respect to different altitudes. Here we considered the Shuttle Radar Topography Mission (SRTM) DEM of 1 Arc-Second (30m) for elevation information of the study area. Land use/Land cover of the study area prepared using Landsat 8 OLI level-1 data. Both DEM and Landsat 8 OLI imageries were downloaded from https://earthexplorer.usgs.gov/. Nine classes were made in the Landsat images using supervised classification technique by applying Maximum likelihood Classification (MLC) method in ArcGIS 10.6 environment. On the other hand human population data of the study area derived from LandScan 2017TM. Necessary leopard observations were made using extensive field survey, camera traps, pug-mark survey, questionnaire, and scat sample survey. Den areas and conflict locations were marked with GPS during the field observation. All the datasets used in this study are represented in the (Table 1). For geo-visualization and spatial analysis ArcGIS 10.6 was used.

Table 1: Data used in the study

Sl No	Data	Description	Source
1	DEM	SRTM DEM (30m)	https://earthexplorer.usgs.gov/
2	Population	LandScan 2017TM	https://landscan.ornl.gov/
3	Land use/Land cover	Landsat 8 OLI	https://earthexplorer.usgs.gov/

3. Methodology

To achieve the required objectives following methodology have been applied (Figure 2).

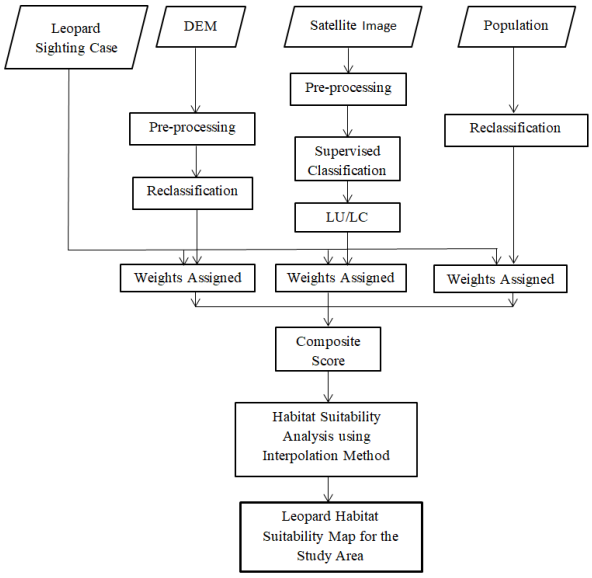

Figure 2: Methodology adopted in the study

3.1 Identification of Leopard Sighting Cases: Leopard sighting cases were identified with a detailed fieldwork, where human-leopard conflict, pugmarks, camera traps, wild caught, cattle lifting, scats, mortality and accidental deaths, and rescue cases, etc. analyzed and GPS points for every location were recorded. Altogether 168 identification sites were finalized and considered for this study.

3.2 Digital Elevation Model: Digital elevation model of SRTM for the region was clipped and re-classified into five different classes based on their elevation. Value for each class was assigned based on actual occurrences of human-leopard conflict in each zone.

Table 1: Elevation wise Leopard Sighting Cases

Sl. No.	Altitude (m)	Frequency of HLC	Assigned Weights
1	<72	47	4
2	72-107	37	3
3	107-146	57	5
4	146-193	18	2
5	>193	9	1

3.3 Land Use/Land Cover: Supervised classification technique was applied to classify the different land use/land cover categories following the work of [31, 32, 33 , 34].

Landsat 8 OLI-TIRS (Operational Land Imager/Thermal Infrared Sensor) multispectral satellite imagery for the year 2018 was obtained from the USGS (United States Geological Survey) Earth Explorer with zero percent cloud cover to perform the image classification process. Radiometric correction of the satellite image was done using dark pixel subtraction method. Spectral enhancement techniques such as band ratio were applied to enhance the image quality and to improve the quality of the interpretation. The Supervised classification techniques using both parametric (Maximum likelihood) and non-parametric (Feature space) decision rules in Erdas Imagine (v 2014) were used with sub-setted satellite imagery. During the signature collection process with respect to each LULC category, information from Google Earth, Survey of India topographical maps (1:50,000) and a handheld Global Positioning System (GPS) device were used.

Table 2: Land use/ Land cover classes and assigned values

Land use/ land cover classes	Value assigned
Unclassified	0
Open forest	3
Non-forest/Grassland	2
Dense Forest	4
Built up	1

3.4 Population: According to the census of India 2011, the population of Guwahati city is 9,57,352 persons. In this study LandscanTM population data of 2017 was used. The population data was clipped on the basis of city extend and re-classified into 5 different classes (Table 4).

Table 4: Population class wise assigned values

Population (per km2)	Class	Value assigned
<906	Very low	5
906-2035	Low	4
2035-4681	Moderate	3
4681-9694	High	2
>9694	Very High	1

3.5 Habitat Suitability Analysis: A habitat suitability model attempted with the existing datasets. Each spatial dataset was reclassified into five classes and a value assigned for each class ranging from 1-5. A composite score map was generated based on the assigned values for each class. The composite score values were interpolated using Inverse Distance Weighted (IDW) method and habitat suitability of leopard in the study area was visualized.

4. Results and Discussion

4.1 Leopard Sighting Cases: As mentioned in the methodology sections, depending on the human-leopard conflict, pugmarks, camera traps, wild caught, cattle lifting, scats, mortality and accidental deaths, and rescue cases, etc., leopard sighting cases were considered and GPS locations were recorded. Here in Figure 3, all the 168 sighting locations were visualised. Out of the total 168 cases, maximum of 32 were rescue cases, 31 were human-leopard conflict cases, 22 were wild caught, another 22 were mortality &

accidental death cases, 18 cases recorded as scat, 17 cases were pugmarks, 17 cases recoded as cattle lifting and rest 9 were recorded as camera trap cases (figure 4).

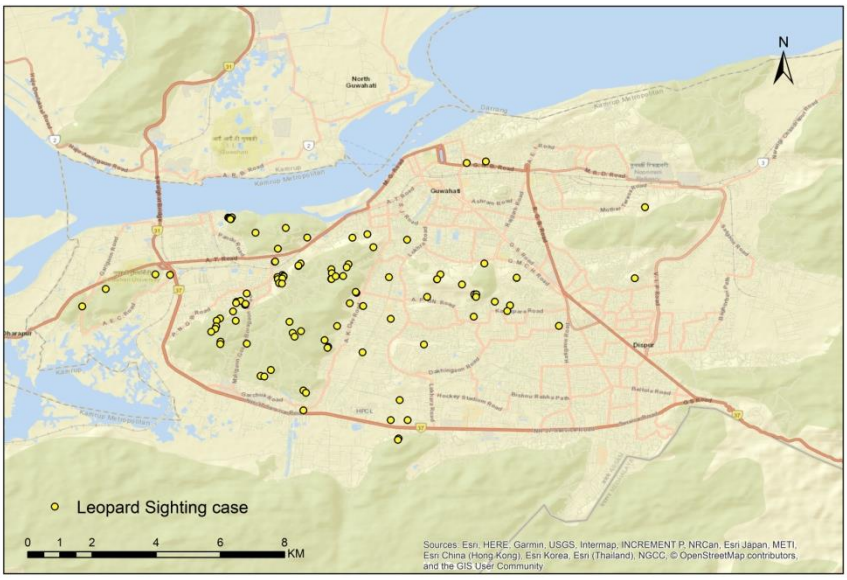

Figure 2: Leopard Sighting Cases

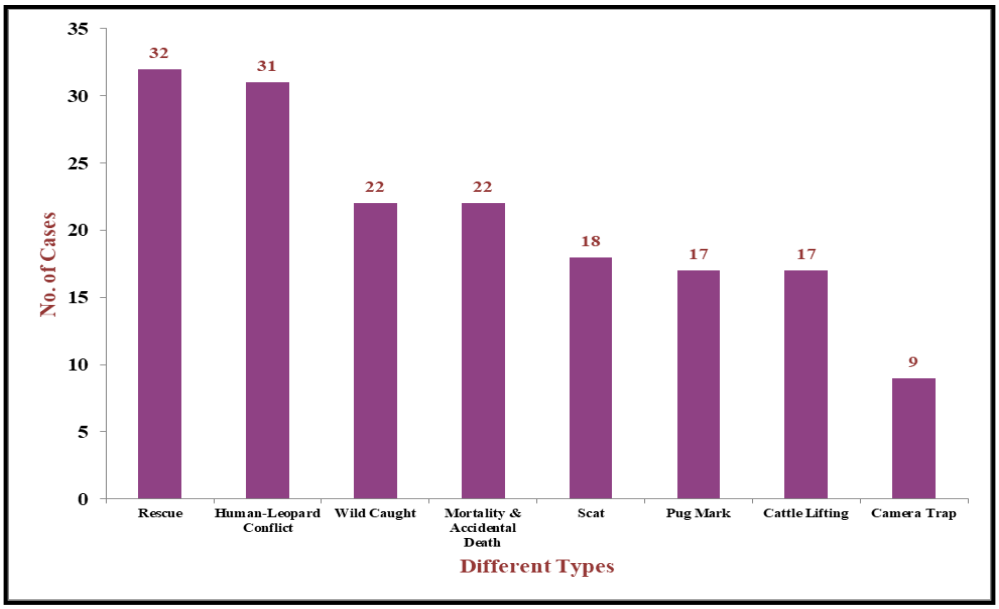

Figure 3: Histogram showing category wise sighting cases within the study area

4.2 Land use/ land cover in Guwahati: The classification scheme has been developed based on ancillary information, fieldwork, local knowledge and visual interpretation of each class of land cover over satellite imagery and Google Earth. The study area has been classified into nine broad classes namely dense forest, open /degraded forest, non-forest area (inside RFs) (as per FSI report 1987), non-forest area (outside RFs), grassland (riverine grassland), tree outside forest area, mining area (stone quarrying), rivers & water bodies and sand & dry river beds. The classes are further reclassed into six types based on present study. The resulting LULC map was analyzed for both within and outside the

reserve forests and their habitat change attributes within the reserve forest are shown in the table 5 below.

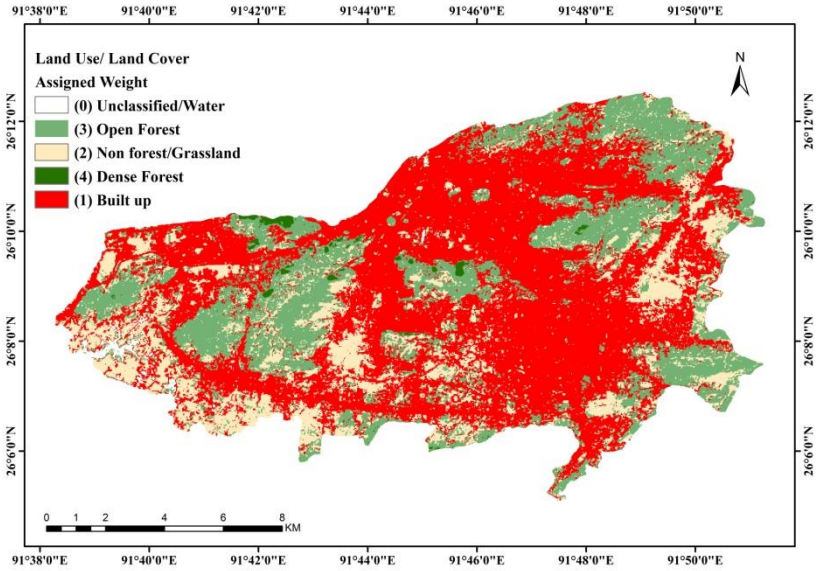

Figure 4: Land-use/ land-cover of Guwahati City

Table 5: Wildlife habitat change in the reserve forests in Guwahati

WILDLIFE HABITAT CHANGE			
Habitat Types	**Area in sq. km**		
	1988	2008	2018
Dense Forest	10.12	5.45	5.1
Open Forest	8.1	4.12	5.78
Degraded Forest	3.42	11.75	12.08
Scrub Forest	2.78	3.21	2.7
Grassland	1.44	2.87	1.78
Water Body	2.65	1.11	1.07
Total	**28.51**	**28.51**	**28.51**

4.3 Suitable habitats for leopard in Guwahati: In search of the suitable habitat for leopard in Guwahati the habitat suitability map has been further reclassifies to get four classes of suitability (figure 6). From the analysis it is revealed that despite heavy anthropogenic pressure the city of Guwahati still possess an area of 18.97 km^2 as highly suitable habitat and 67.67 km^2 as suitable region. This highly suitable and suitable part of the region needs urgent conservation intervention so that those areas can be preserved for leopard habitat.

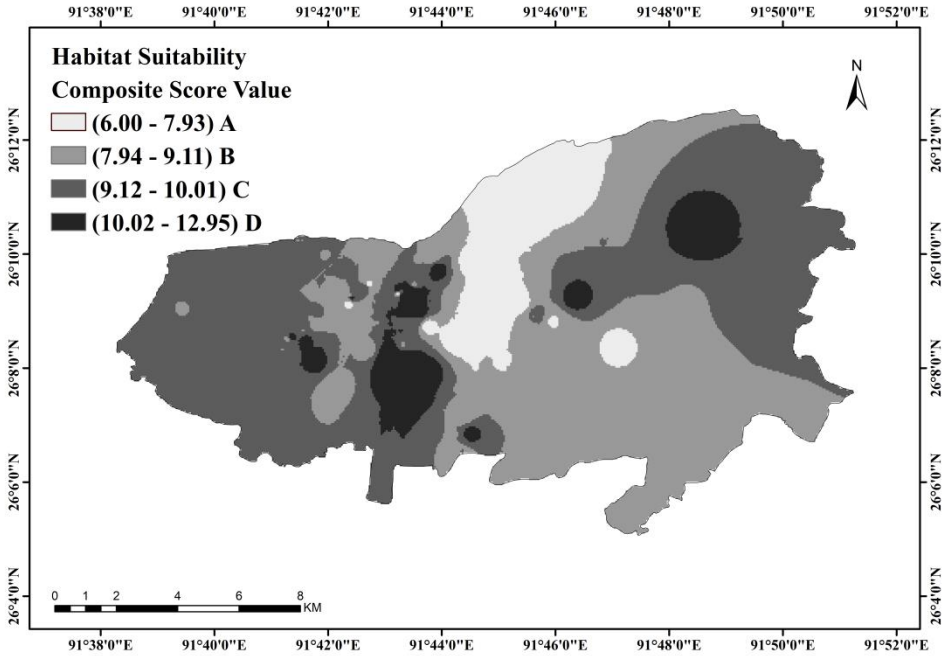

Figure 6: Leopard habitat suitability map of Guwahati city

Table 6: Habitat suitability classes for Leopards in Guwahati

	Zone	Area (km2)	Area (%)
Highly suitable	A	18.97	10.73
suitable	B	67.67	38.29
moderately suitable	C	78.38	44.35
not suitable	D	11.73	6.63
	Total	**176.75**	**100.00**

5. Conclusion

The rise of the human population and expansion of settlements if the leopard habitats is one of the major cause of growing human leopard conflict. To reduce the present conflict level in both the respondents, it is required to conduct a thorough survey on the population structure and size of leopard and to install alarming devices on the periphery of the designated site to monitor their movement. The region identified as highly suitable leopard habitat should be prioritized for leopard conservation zones. Since the city has become major business hub and concentration of anthropogenic activities sees a high in recent times all development planning should also keep in mind the urban wildlife specially the Leopards. Since leopards are a territorial species their twrritory needs to ne preserved for lesser man-leopard conflict.

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References:

[1] A. Saikia, R. Hazarika, and D. Sahariah, 'Land-use/land-cover change and fragmentation in the Nameri Tiger Reserve, India', *Geogr. Tidsskr.*, vol. 113, no. 1, 2013.
[2] R. Lande, 'Anthropogenic, ecological and genetic factors in extinction and conservation', *Popul. Ecol.*, vol. 40, no. 3, pp. 259–269, 1998.
[3] H. E. K. Winterbach, C. W. Winterbach, and M. J. Somers, 'Landscape suitability in Botswana for the conservation of its six large African carnivores', *PLoS One*, vol. 9, no. 6, 2014.
[4] E. W. Sanderson, M. Jaiteh, M. A. Levy, K. H. Redford, A. V. Wannebo, and G. Woolmer, 'The Human Footprint and the Last of the Wild', *Bioscience*, vol. 52, no. 10, p. 891, 2002.
[5] L. See *et al.*, *Mapping human impact using crowdsourcing*. 2016.
[6] J. C. Laso Bayas *et al.*, 'A global reference database of crowdsourced cropland data collected using the Geo-Wiki platform', *Sci. Data*, vol. 4, 2017.
[7] A. Colantoni, A. Mavrakis, T. Sorgi, and L. Salvati, 'Towards a "polycentric" landscape? Reconnecting fragments into an integrated network of coastal forests in Rome', *Rend. Lincei*, vol. 26, pp. 615–624, 2015.
[8] Y. Ji *et al.*, 'Unbalanced forest displacement across the coastal urban groups of eastern China in recent decades', *Sci. Total Environ.*, vol. 705, 2020.
[9] I. P. Farias, W. G. Santos, M. Gordo, and T. Hrbek, 'Effects of Forest Fragmentation on Genetic Diversity of the Critically Endangered Primate, the Pied Tamarin (Saguinus bicolor): Implications for Conservation', *J. Hered.*, vol. 106, no. S1, pp. 512–521, 2015.
[10] R. Lapaix, K. Harper, and B. Freedman, 'Patterns of exotic plants in relation to anthropogenic edges within urban forest remnants', *Appl. Veg. Sci.*, vol. 15, no. 4, pp. 525–535, 2012.
[11] A. B. Nielsen, M. Hedblom, A. S. Olafsson, and B. Wiström, 'Spatial configurations of urban forest in different landscape and socio-political contexts: identifying patterns for green infrastructure planning', *Urban Ecosyst.*, vol. 20, no. 2, pp. 379–392, 2017.
[12] C. Tannier, J.-C. Foltête, and X. Girardet, 'Assessing the capacity of different urban forms to preserve the connectivity of ecological habitats', *Landsc. Urban Plan.*, vol. 105, no. 1–2, pp. 128–139, 2012.
[13] P. Henschel, L. T. B. Hunter, L. Coad, K. A. Abernethy, and M. Mühlenberg, 'Leopard prey choice in the Congo Basin rainforest suggests exploitative competition with human bushmeat hunters', *J. Zool.*, vol. 285, no. 1, pp. 11–20, 2011.
[14] R. Rajaratnam, M. Sunquist, L. Rajaratnam, and L. Ambu, 'Diet and habitat selection of the leopard cat (Prionailurus bengalensis borneoensis) in an agricultural landscape in Sabah, Malaysian Borneo', *J. Trop. Ecol.*, vol. 23, no. 2, pp. 209–217, 2007.
[15] R. Partasasmita *et al.*, 'Human-leopard conflict in Girimukti Village, Sukabumi, Indonesia', *Biodiversitas*, vol. 17, no. 2, pp. 783–790, 2016.
[16] S. Chouksey, S. Singh, V. S. Tomar, R. P. S. Baghel, S. B. Lal, and A. Bijalwan, 'Human leopard conflict in bandhavgarh tiger reserve: The emerging drift and community perspective', *Indian J. Ecol.*, vol. 44, no. 1, pp. 58–62, 2017.
[17] M. Kabir, A. Ghoddousi, M. S. Awan, and M. N. Awan, 'Assessment of human-leopard conflict in Machiara National Park, Azad Jammu and Kashmir, Pakistan', *Eur. J. Wildl. Res.*, vol. 60, no. 2, pp. 291–296, 2014.
[18] I. Khorozyan, S. Ghoddousi, M. Soufi, M. Soofi, and M. Waltert, 'Cattle selectivity by leopards suggests ways to mitigate human-leopard conflict', *Int. J. Bus. Innov. Res.*, vol. 17, no. 3, pp. 8011–8018, 2018.
[19] S. Kumbhojkar, R. Yosef, Y. Benedetti, and F. Morelli, 'Human-Leopard

(Panthera pardus fusca) Co-Existence in Jhalana Forest Reserve, India', *Sustainability*, vol. 11, no. 14, p. 3912, Jul. 2019.

[20] D. Naha, S. Sathyakumar, and G. S. Rawat, 'Understanding drivers of human-leopard conflicts in the Indian Himalayan region: Spatio-Temporal patterns of conflicts and perception of local communities towards conserving large carnivores', *PLoS One*, vol. 13, no. 10, 2018.

[21] S. W. Mohamad *et al.*, 'The first description of population density and habitat use of the mainland clouded leopard Neofelis nebulosa within a logged-primary forest in South East Asia', *Popul. Ecol.*, vol. 57, no. 3, pp. 495–503, Jul. 2015.

[22] C. K. Pawe and A. Saikia, 'Unplanned urban growth: land use/land cover change in the Guwahati Metropolitan Area, India', *Geogr. Tidsskr. - Danish J. Geogr.*, 2018.

[23] D.-F. Bai, P.-J. Chen, L. Atzeni, L. Cering, Q. Li, and K. Shi, 'Assessment of habitat suitability of the snow leopard (Panthera uncia) in Qomolangma National Nature Reserve based on MaxEnt modeling', *Zool. Res.*, vol. 39, no. 6, pp. 373–386, 2018.

[24] A. Ebrahimi, A. Farashi, and A. Rashki, 'Habitat suitability of Persian leopard (Panthera pardus saxicolor) in Iran in future', *Environ. Earth Sci.*, vol. 76, no. 20, 2017.

[25] N. L. Constant, S. Bell, and R. A. Hill, 'The impacts, characterisation and management of human–leopard conflict in a multi-use land system in South Africa', *Biodivers. Conserv.*, vol. 24, no. 12, pp. 2967–2989, 2015.

[26] A. Kshettry, S. Vaidyanathan, and V. Athreya, 'Leopard in a tea-cup: A study of leopard habitat-use and human-leopard interactions in north-eastern India', *PLoS One*, vol. 12, no. 5, 2017.

[27] S. Sidhu, G. Raghunathan, D. Mudappa, and T. R. S. Raman, 'Conflict to Coexistence: Human - Leopard Interactions in a Plantation Landscape in Anamalai Hills, India', *Conserv. Soc.*, vol. 15, no. 4, pp. 474–482, 2017.

[28] A. Singh, A. K. Patel, J. P. Deka, A. Das, A. Kumar, and M. Kumar, 'Prediction of arsenic vulnerable zones in the groundwater environment of a rapidly urbanizing setup, Guwahati, India', *Chemie der Erde*, no. November, p. 125590, 2019.

[29] A. Paul, J. Deka, N. Gujre, L. Rangan, and S. Mitra, 'Does nature of livelihood regulate the urban community's vulnerability to climate change? Guwahati city, a case study from North East India', *J. Environ. Manage.*, 2019.

[30] The Times of India, 'Now, dial helpline for leopard attacks', *The Times of India*, 2012.

[31] J. R. Anderson, E. E. Hardy, J. T. Roach, and R. E. Witmer, 'A Land Use And Land Cover Classification System For Use With Remote Sensor Data'.

[32] D. M. Chen and D. Stow, 'The effect of training strategies on supervised classification at different spatial resolutions', *Photogrammetric Engineering and Remote Sensing*. 2002.

[33] S. Gupta and M. Roy, 'Land Use/Land Cover Classification of An Urban Area -A Case Study of Burdwan Municipality,India', *Int. J. Geomatics Geosci.*, vol. 2, no. 4, pp. 1015–1026, 2012.

[34] R. Hazarika and A. Saikia, 'The pachyderm and the pixel: an assessment of elephant habitat suitability in Sonitpur, India', *Int. J. Remote Sens.*, 2013.