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Analysis of Geospatial Factors Influencing Human-Elephant Conflict Using Remote Sensing and GIS Techniques: A Case Study in Anuradhapura District

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Abstract: ***Human Elephant Conflict (HEC) can be considered as a major social and economic challenge in Sri Lanka, which causes significant damages to both the human lives and elephants. The study investigates the major environmental factors that has been identified to be affecting the HEC in Anuradhapura district in terms of their spatial patterns with the aid of Remote Sensing (RS) and Geographic Information Systems (GIS) techniques. It was identified that the variations in Land use/Land cover (LULC) classes over time, Population, expansion of agricultural lands, transportation network, temperature deviations, and the proximity to existing water bodies as key influencing factors for the HEC and were analysed accordingly with the use of geospatial programming. Datasets derived from satellite sensors and spatial modelling of those data were used for the identification of the high risk zones and the contribution of the assess factor to the HEC incidents. Results of the analysis revealed that the HEC incidents already occurred in this area is strongly associated with the expansion of agricultural areas that are near to the forest reserves, close proximity areas to water bodies, and fragmented habitats. Land Surface Temperature increment and development of infrastructure aids further to intensify the migration of elephants into human habitats. The research emphasizes the role of spatial technology in terms of detailed spatial mitigation planning for decision making process and how the RS and GIS based spatial modelling can support these long term conservation strategies.***
Keywords: Human Elephant Conflict (HEC), Remote Sensing, GIS, LULC, LST, Sri Lanka

I. INTRODUCTION

HEC (Human Elephant Conflict) can be considered as one of the growing socio economic and environmental issue in Sri Lanka, especially in the dry zone of the country where it can be seen that the human settlements and agricultural areas overlaps with the elephant habitats. In Sri Lanka this issue has becoming a threat due to the increasing populations of both humans and elephants. Mainly land which belonged to elephants as their habitats has been taken over by the humans for various reasons like farming and residential lands. The crop raiding behavior of the elephants, change of land use types, change of agricultural types has become main reasons for the Human Elephant Conflict (HEC) (Gunawansa *et al.*, 2023; Köpke *et al.*, 2023). It has recorded nearly 90 human deaths and around 300 elephant deaths annually because of HEC, which makes Sri Lanka one of the most affected countries in South Asia (Köpke *et al.*, 2023). And hence the careful monitoring of the current status and the in-depth understanding of the historical events can be considered as crucial turning point in HEC. For that the use of Geographical Information Systems (GIS) and Remote Sensing (RS) plays a huge role as it makes it easier for the decision makers to take carful measure about managing the elephant habitat and human settlement so that both the parties can avoid the conflicts. And they have proven to be effective in not only in Sri Lanka, but also several other countries as well for the better mitigation of the HEC issue (Hoare, 1999; Sitati *et al.*, 2003; Sharma *et al.*, 2012). Although there has been several different efforts has been made for the mitigation of this issue the severity of this HEC in Sri Lanka, it can be seen any significant decrease in the cases of HEC. In Sri Lanka, it is considering some traditional methods for mitigation of HEC like electric fencing, changing the residing locations of problem elephants and government compensation but it still fail to respond to the issue very well (Gunaratne and Premarathne, 2005).

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Hence it is evident that the monitoring of the issue and understanding the main factors influencing the HEC is crucial, which can be achieved through the use of GIS and RS techniques. Moreover elephants can be considered as a seriously affected species of animals for danger and hence have chance of become an extinct species.

II. LITERATURE REVIEW

HEC is huge problem that is widespread issue intensifying its effects across Asia and Africa, where the expansion of human settlements have evaded the elephant habitats. It has led to severe and frequent confrontations between elephants and people. This issue has posed grave challenges to the conservation of biodiversity, more specifically the survival of the Asian elephant (*Elephas maximus*) and African elephants (*Loxodonta africana* and *L. cyclotis*). The incidents often reported in all elephant residing countries in the areas closer to the protected forest reserves or elephant orphanages, mostly during harvest seasons and crop growing seasons (Sitati *et al.*, 2003; Wilson *et al.*, 2015).

A. Consequences of HEC in the world

In India, near the fragmented elephant habitats high HEC incident rates can be observed due to agricultural zones and human settlements. Annually around 300 human deaths and 200 elephant deaths have been reported while 8 – 10 million hectares of agricultural lands have been damaged (Perera, 2009). In Bangladesh, Sri Lanka and China hundreds of HEC incidents occur annually with the increasing number of fatalities and the economic costs (Perera, 2009). In Africa Around 50 – 120 problem elephants are being killed annually only inside Kenya with the report of hundreds of human fatalities between 2010 – 2017 (Wahed, Ullah and Irfanullah, 2016). High intensity infrastructure and crop damages can be seen in Zimbabwe and Namibia near the protected areas (Nelson, Bidwell and Sillero-zubiri, 2003).

B. Historical review of HEC in Sri Lanka

Sri Lanka is home to around 6000 Asian elephants, that has been facing the Human – Elephant Conflict (HEC) for a long period of time making it a very critical conservation issue in South Asia (Fernando et al., 2021). Mainly the relationship between the humans and the elephants has been changed drastically over time due to elephant habitat destructions and human settlement expansions. Sri Lanka has lost nearly up to 50 % of its elephant habitats between the year 1950 – 2000 (Bandara et al., 2022). Mostly the Anuradhapura, Polonnaruwa, and Hambantota districts have become high level conflict zones as more areas of the land was cleared for human settlements and paddy cultivations. (Dharmarathne et al., 2019). These fragmented elephant corridors result in elephants migrating through villages and farmlands. Man-made infrastructures including roads and reservoirs made it more difficult as many of the elephant corridors are blocked for example, the expressway have limited the movements of elephants which have pushed them closer to human settlement areas (Wijesinghe et al., 2021; Fernando et al., 2020). The increasing rural population in these areas has make it more severe as it has identified that the HEC incidents in Anuradhapura district have increased in 30% due to the expansion of human settlements (Dharmarathne et al., 2019). Although the National Action Plan for HEC mitigation have been launched in year 2020, the enforcement of the plan have been weak as the farmers have receive less compensation for crop damages which reduce their support for conservation measures (Ministry of Wildlife, 2020).

C. Identification of main factors affecting HEC

In terms of HEC there are different factors that have great influence for these incidents in both Sri Lanka and the world. The main identified factors can be described as below.

1) Land use and Land cover changes

HEC is a global issue that is mainly tied with the rapid increases in Land use/Land cover changes. The vastly distributed forest network is being reduces with time and the habitat that were once belong to elephants are becoming lands owned by humans for several purposes like settlements, agriculture and etc (Hoare, 1999). Mainly these lands were encroached by humans for agriculture purposes. Moreover when the LULC changes around water ways it become hard for the elephants to approach water sources due to human activities around them. This can also be a cause for HEC as water is a basic need for all types of animals. Therefore these reasons may enhance the interactions between the elephants and humans which may then lead to bloody conflicts (Sharma *et al.*, 2012; Chithrangani *et al.*, 2022). It has been proved that HEC incidents are mainly correlated with the LULC changes that has convert the forest areas into human settlements or agricultural lands. As stated by (Bandara and Tisdell, 2002) around 70% of the HEC incidents has been happened in deforestation areas or where there are land encroachments by humans.

Historically, the development plans that were initiated after the colonial period also add to the changes in LULC as more agricultural projects were started based on the irrigation network in the dry zone of Sri Lanka. For example, Mahaweli development project aids for providing water for agricultural areas which encouraged people to take the use of forest lands for cultivations purposes. This lead to the deforestation and the fragmentation of elephant habitats, which forced them to come to human settlements in search of food and water (Parveen, Bashir and Praveen, 2018).

2) Expansion of Agricultural lands

Agricultural land expansion is one of the main reasons for the HEC in Sri Lanka. In term of different types of crops sugarcane, paddy, and banana are highly favored food resources for elephants. Therefore they travel to human settlement areas in order obtain foods they prefer. And this behavior of elephants is more prominent in areas such as Anuradhapura, Moneragala and Hambanthota, where these deforestation process for agricultural purposes is mostly observed (Withanage *et al.*, 2023). Moreover elephants have seasonal migration routes in their herds as well as for individual elephants. Due to the increased population and encroachment of forest land for human settlements their trails have been restricted, which leads them to travel through human settlements and agricultural lands in order to reach their destination (Abdelkaebir, Mokhtari and Engel, 2024). Due to the connectivity loss between the forests or habitat of elephants the interaction between humans and elephants are increasing and then it leads to conflicts between the two species (Younis and Ammar, 2018). Although farmers and the authorities are using mitigation measures like electric fences and other defensive setups, they also can be harmful to both elephants and humans as well. There can be seen several such cases in Sri Lanka (Prasad *et al.*, 2011). Earlier research work on this HEC have discovered that the HEC hotspots mainly falls in the areas where there were LULC changes from forest land cover to agricultural land cover. They have applied RS and GIS techniques in order to get better interpretation of data (Chithrangani *et al.*, 2022).

3) Population

In order to accommodate the increasing population, the forest lands or the habitats of elephants have been converting into agricultural and human settlements areas (Centre for Conservation and Research, 2024). Hence the elephants are forced out from their habitats and allowed the habitat fragmentation which then will be often surrounded with agricultural lands, especially in Anuradhapura district. Although elephants are migrating from place to place during different seasons it is hard for them due to this habitat fragmentation not to cross human settlements areas, which lead to conflicts (Madhushanka and Ranawana, 2021). This increasing population has introduced several development schemes like Mahaweli development program. They take the initiative to relocate the thousands of people along the watershed of Mahaweli river basin. This is the issue in most parts of the North central, Uva and Eastern provinces. This is mainly associated with increment of agricultural activities in these regions. Hence it can be said that population growth is the main reason for other factors affecting the HEC as well (Gunawansa *et al.*, 2023).

4) Temperature

Surface temperature variations have been identified as another key environmental factor affecting HEC not only in Sri Lanka but also in other elephant ranges. It has proven that the rising temperature can have significant influence on the elephant movements in search for food and water which often guide them closer to human settlements (Campos-Arceiz et al., 2011). They tend to travel to villages in search of food mostly during drought periods (Fernando et al., 2011). Pastorini et al. (2013) have identified that elephants become more mobile during hotter seasons that shows the effect of temperature on elephant behaviors. On the other hand Pittiglio et al. (2014) have stated that elephants who are facing the heat stress are tend to be more active at night and tend to evade crops in darkness. Srinivasaiah et al. (2019) have found that the climatic changes have caused the elephant herds to alter their movements during different seasons, mostly to the human occupied areas. In order to identify these patterns more clearly there have been studies carried out using remote sensing and modelling as Li et al. (2018) has used temperature information and satellite data in order to map the elephant movements that shows how the temperature variations effect the elephant migrating routes.

5) Railways and roads

The infrastructures like roads and railways have become a major factor that has been adding to the HEC in Sri Lanka. These man-made structures are laid through the elephant habitats which have caused to fragment their ranges and have create physical barriers that have cause to interfere with their normal movements and behaviors (Jayasundere et al., 2021). Among these railway lines are proven to be particularly dangerous in the Human – Elephant Conflict zones. As Roy and Sukumar (2017) have recorded numerous elephant deaths due to collisions with trains in India, specifically in areas where the railway lines intersect with existing elephant

corridors that are leading food or water sources. In the context of Sri Lanka such developments have not just affected the safety of elephants but also to shift their normal routes that generates new HEC incident areas Perera et al. (2023). In terms of roads it has identified that the deaths of elephants recorded near to the roads that has poor visibility, closer to the fragmented forest areas (Wadey et al. (2018).

6) Distance from water bodies

The connection between the water resources and HEC is a important factor in Sri Lanka. According to the findings elephants require a significant amount of water daily when compared to a human. As a result the locations of hydrological features like rivers, tanks or reservoirs plays a major role in identifying the elephant migrations routes and areas where the conflicts are likely to occur (Fernando et al., 2010). Fernando et al. (2010) found that the closer the elephants are to permanent water bodies, it is more likely to arise conflicts between humans and elephants. The spatial analysis showed that a majority of the HEC incidents occurred within a short distances of such water sources, and that the probability of conflict dropped as the distance increased. When limited water availability area forcing elephants to gather around remaining sources, this trend was more noticeable during the dry season. Similarly, Perera (2009), in the study of the Northwestern Province of Sri Lanka, observed that condition of droughts intensified this relationship, as elephants moved closer to human habitats in search of water. Moreover, Webber et al. (2011) found that villages that are located between elephant habitats and key water resources were prone to conflicts more than those without water bodies in between.

Basically the increasing HEC incidents are directly linked with man-made environmental alterations such as human settlement expansions and infrastructure development. The main goal of this study is to identify and investigate the main factors affecting the increment of HEC incidents in Sri Lanka despite all the risk reduction strategies taken by the related authorities. Hence through the use of comprehensive understanding of the related studies and the use of RS and GIS, it was intended to get in-depth understanding of the issue and model the problem for Anuradhapura district as it is one of the district that has been reported many cases regarding the HEC. And it was done using the most leading method of GIS, which is the use of programming languages.

III. METHODOLOGY

Methodology segment consists of a description of data sources and the development of ER diagram together with the flow of the process. This also describe how the maps of each of the factors were prepared for the analysis.

A. Data and Study area

HEC is a type of incidents that can be seen prominently in most of the parts of the country, as Sri Lanka is a tropical country and large part of the island is covered with forests and sanctuaries both man-made and natural. And Asian elephant is species that can be seen in most of these forests as a habiting animal. Among all the administrative districts in Sri Lanka, Anuradhapura can be considered as one of the districts that is very highly affected by this issue as North Central province contribute 42% of HEC issue.

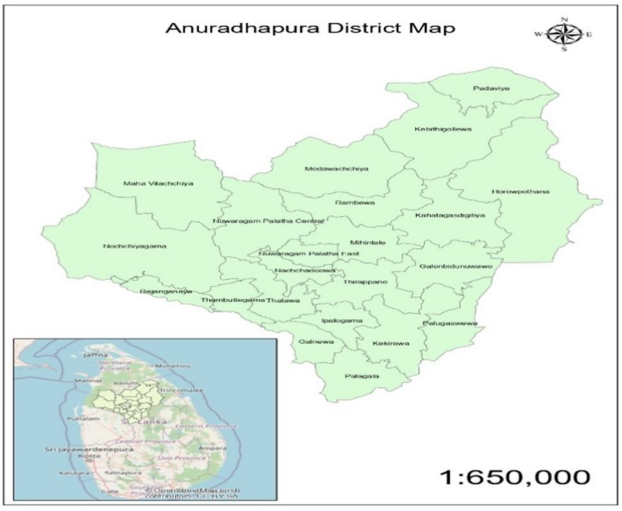

Fig. 1: Anuradhapura District map with DS Divisions

Most parts of Anuradhapura is covered with paddy fields or forests. With the increasing population, the people in this district is encroaching the forest lands which make the elephants loss their habitats and limit them into a smaller space. 60% of the damages caused by elephants are for crop damages, for which they have been not properly compensated. For mitigating this issue there should be a better understanding about the influence of factors on HEC in the study area (Gunawardhana, 2018).

Among the data Sentinel 2 images were used for LULC images as they have 10m resolution which is higher than the resolution of Landsat images. But as the sentinel does not contain a thermal band, for the computation of land surface temperature it could not be used. Therefore Landsat 8 image were utilized as Landsat 8/9 image series consist of 2 thermal bands that can be used to get the temperature as LST index value. Population data was obtained with respect to DS divisions of Anuradhapura district. Meanwhile the railway paths were digitized from the google map to be overlaid and check the relationship of railway locations and the HEC incidents. Data about deaths of humans and elephants due to this HEC were obtained from the Department of Wild life conservation of Sri Lanka. But they did not agreed to provide data about property damages without a request letter from a supervisor for the study. And finally the forest boundary map of the study area was obtained from the forest department for the analysis.

B. Workflow

The following flow chart showcase the methodology that was followed for the spatial analysis of the factors which are bringing out the occurrence of HEC event in Sri Lanka and the HEC incidents occurred in study area.

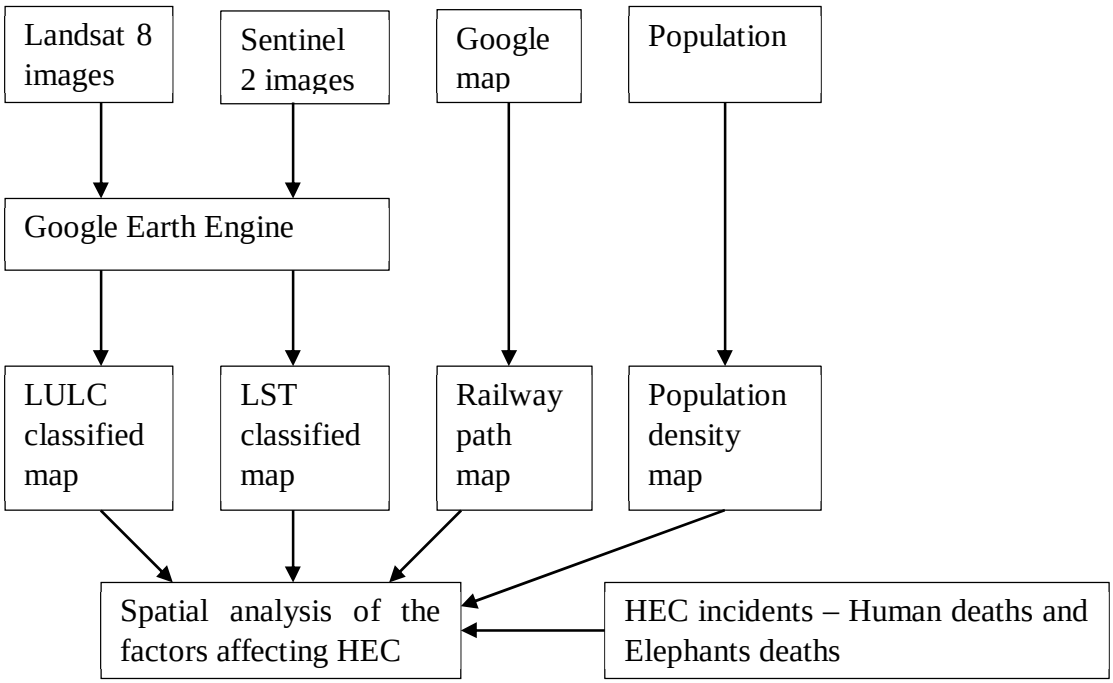

Fig. 2: Flow chart of the methodology followed for the study

1) Land Surface Temperature (LST)

Here the LST was computed using the Landsat 8 images as the sentinel 2 images does not contain a thermal band but Landsat 8 contain 2 thermal bands. Here the LST was calculated using the following formula;

Brightness temperature:

$$BT = Surface\ temperature\ Band\ 10 * 0.00341802 + 149.0$$

Normalized Difference Vegetation Index:

$$NDVI = \frac{Band\ 5\ (NIR) - Band\ 4\ (Red)}{Band\ 5\ (NIR) + Band\ 4\ (Red)}$$

Proportion of vegetation:

$$PV = \left(\frac{NDVI - NDVImin}{NDVImax + NDVI\ min}\right)^2$$

Emissivity:

$$E = PV * 0.04 + 0.986$$

Land Surface Temperature:

$$LST = \left(\frac{BT}{(1 + (W * (BT/C2)) * \ln E} - 273.15\right)$$

Where, LST is the Land Surface Temperature

BT - Brightness temperature

PV – Proportion of vegetation

E – Emissivity

W – Wavelength of the Band 10

C2 – Plank's 2nd constant

Here the NDVI is used for the assessment of the health of plants or as a measurement on greenness. The script used for this process generates the LST map of the area using the Plank's law as specified above (Ridho, 2023).

2) LULC Classification

The LULC classification was done using the Google Earth Engine by collecting training samples for each feature class that the image need to be classified into. Mainly the image was classified into 5 feature classes as Water, Forest, Built up areas, bare lands and Agricultural lands. Then samples were selected for each classes and they were merged into 5 classes. The Random Forest classifier was used for the classification using the selected training samples.

3) Population

Population data obtained from the Department of census and statistics were keenly observed and identified the attributes available in the data tables. Then a shape file was obtained for the Anuradhapura district with DSD in the attribute table. Then using the population and area population density was calculated.

4) Railway

Railway paths were digitized using the Google earth software for the Anuradhapura district, which was then imported for generating map layout by overlaying the HEC incidents shape file.

Finally all of these maps were overlaid with the shape containing human and elephant death incidents due to HEC in the Anuradhapura district for generation of final map layouts that depicts the influence of all these factors for HEC events in Anuradhapura district, which can be either negative impact or a positive impact.

IV. RESULTS AND DISCUSSION

A. Spatial Distribution of the Incidents of HEC

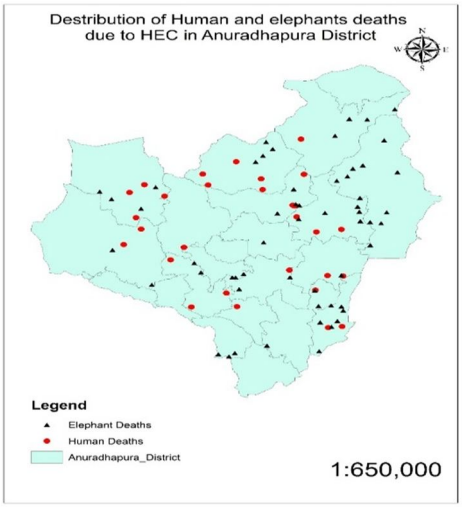

Fig. 3: Human and elephant death distribution due to HEC in Anuradhapura district.

The HEC mainly affect the daily life of people as well as the elephants. With increasing population and the deforestation near elephant habitat has greatly influence the continuous interaction between the 2 species. Hence it is evident that both parties can be damages in various extents (Fig. 3).

According to the map human and elephant deaths are closely correlated and the location of these incidents have fallen not inside the forest or sanctuaries but near to the forest boundaries where there can be LULC changes occurred over time.

B. Factors affecting HEC

1) Land use/Land cover

The Anuradhapura District's landscape changed dramatically between 2020 and 2024 due to changing land use patterns, which were closely linked to an increase in both human and elephant fatalities. Elephant movement patterns have been significantly impacted by the shifting terrain. Elephants are being forced toward human settlements as a result of the increase in forest cover from 258,310 to 289,260 hectares, as shown in Fig. 4. The findings of Fernando et al. (2021), who examined the effects of landscape changes throughout Sri Lanka on elephant distribution and mortality, are consistent with this pattern of habitat loss. From 4,602 to 14,570 hectares, built-up areas increased significantly (Fig. 4), posing risks and obstacles for elephants traveling along customary routes. The Fig. 4 shows that the water bodies shrunk by 11% (36,053 to 32,044 hectares), forcing elephants to travel further across hazardous terrain for this key resource. Death clusters appear near remaining water sources and along connecting paths. Elephant deaths predominantly occur in transitional zones between natural and developed areas. As fragmentation increases, these dangerous edge habitats multiply across the landscape.

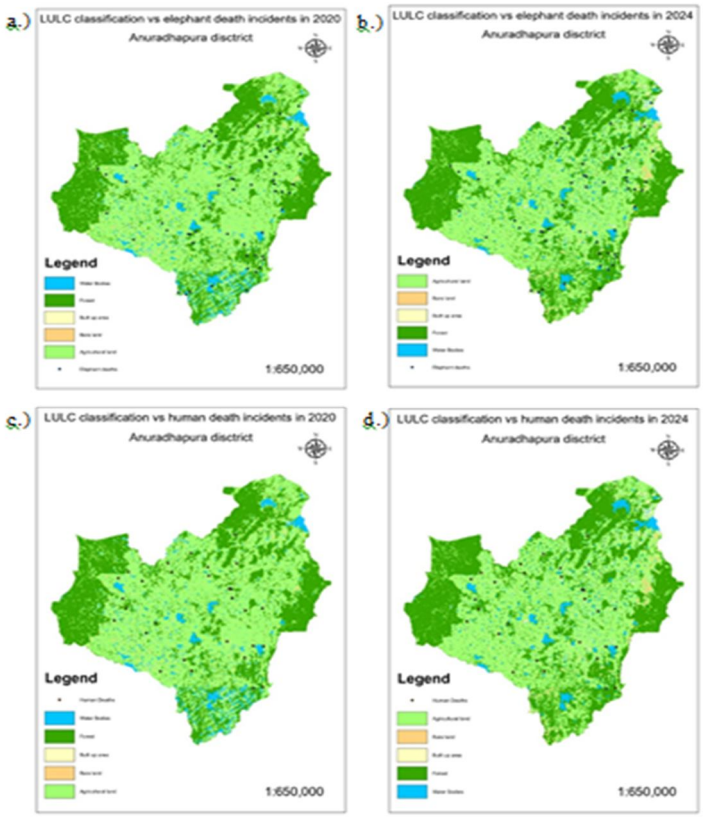

Fig. 4: Maps of LULC classification of Anuradhapura district with a.) & b.) Elephant deaths and c.) & d.) Human deaths incidents due to HEC

Unexpected encounters between humans and elephants have increased in frequency and severity due to the loss of elephant territories and the reduction in forest cover. Elephants and humans compete for the few remaining water sources when resources are reduced, and during dry spells, deaths tend to concentrate around these locations. Because of the resulting fragmented landscape, there are no longer any distinct boundaries between human and elephant territories, which leads to unpredictable and occasionally deadly interactions.

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2) Expansion of the agricultural lands

The region's agricultural lands show a remarkable increase from 416,069 hectares to 781,314 hectares between 2020 and 2024 (Fig. 4). Elephants and humans have suffered greatly as a result of this 88% jump, which has fundamentally altered the landscape. Elephant habitat has been converted into appealing crop zones as a result of this conversion, which attracts animals into conflict situations. Elephants that enter agricultural areas run the risk of being poisoned (intentionally or by chemicals), getting hurt by crop protection measures, and getting into arguments with farmers. Some elephants are trapped in habitat islands encircled by farmland because the rate of conversion has surpassed their capacity to adapt. Elephants are probably forced into irrigated areas where they are more likely to die because the agricultural frontier has taken over prime water access points. The maps' death patterns show these hazardous resource concentrations produced by expanding agriculture.

A tragic result of agricultural expansion into traditional elephant ranges is the death of humans during elephant encounters. Farmers are put at greater risk because newly converted areas typically lack warning systems or elephant deterrents. Farmers guard crops at night, which is a risky practice due to poor visibility and frequently results in fatal incidents. Changes in the distribution of deaths between 2020 and 2024 suggest that the vast new "conflict edges" where farmland meets elephant habitat are especially dangerous. Conflict intensity is highest where agriculture disrupts elephant movement patterns rather than where agriculture has been established for a long time, as evidenced by the concentration of human fatalities where recent agricultural conversion disrupts established elephant pathways or resources. There is currently a lot of overlap between elephant and human use in this quickly changing landscape, and there are no adequate management or separation strategies to guarantee the safety of both species.

3) Population

There are intricate and frequently non-linear relationships between the spatial distribution of elephant deaths and population density throughout Anuradhapura District. The observed pattern in 2024 casts doubt on the initial hypothesis that higher population densities would directly correlate with higher elephant mortality due to greater human-wildlife encounters. Elephant deaths are documented in a variety of population densities, with comparatively low-density regions producing some of the highest death tolls. The highest number of elephant deaths was reported in Horowpothana, which has a population density of only 48 people per square kilometer (Fig. 5). Similarly, three and four elephant deaths were reported in Kebithigollewa and Maha Vilachchiya, two low-density divisions with only 40 people per square kilometer, respectively. These findings suggest that divisions with lower population densities are important hotspots for conflict, frequently lying next to or overlapping with forested areas and elephant corridors. However, fewer or no elephant deaths were reported in the more populated DSDs, including Rajanganaya (367/km2), Thambuttegama (420/km2), and Nuwaragam Palatha East (848/km2). The information makes it abundantly evident that demographic data, such as population density, cannot be the only basis for conservation and conflict mitigation initiatives. Rather, they need to incorporate landscape-level factors like land-use patterns, the presence of elephant corridors, and the efficiency of current mitigation strategies.

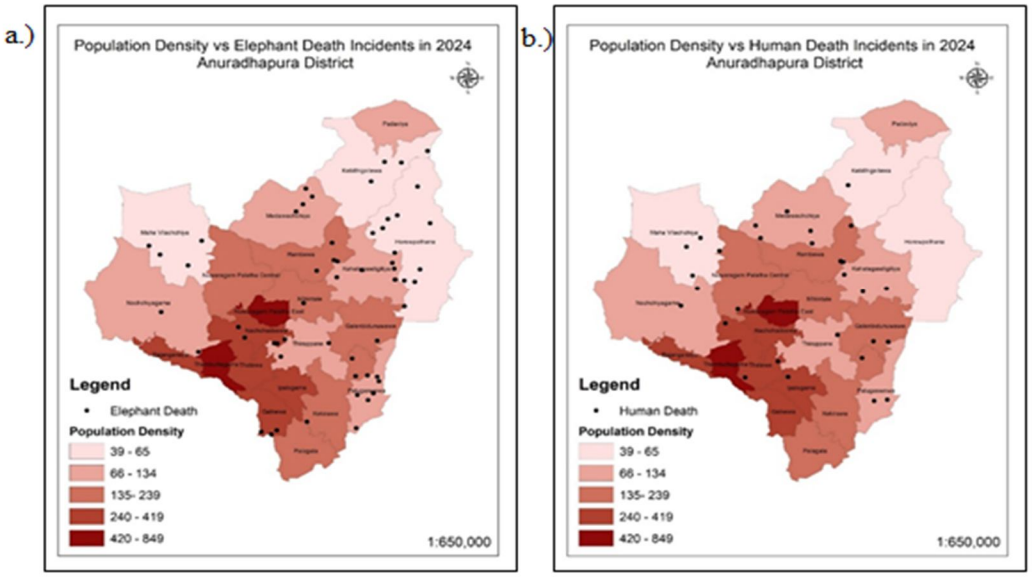


Fig. 1: Population density map Anuradhapura district with a.) Elephant deaths due to HEC and b.) Human deaths due to HEC

4) Temperature

Temperature is a factors that highly likely be influence to the behavior of the elephants making them more violent and dangerous. This LST map was classified in to 5 classes by considering the normal body temperature for the elephants and the temperature limits that they can endure (Fig. 6). There cannot be observed much of a relationship among these parameters, but it was observed that around one third of the elephant death events falls over the very high, high temperature regions in the map. Palagala, Kahatagasdigiliya, Galenbidunuwawe, Rambewa and Thirappane DSD are experiencing regions of very high and high temperature when compared to other regions. In terms of population also there can be seen moderate population density in these areas of high temperature. Moreover increasing temperature results in the reduction of water sources and unavailability of foods in the forests for the elephant. Therefore although it cannot be said that temperature alone may have a huge impact on HEC events, it can be said that the together with the land use changes, temperature also have a considerable impact on HEC. And when it comes to events of human deaths due to HEC, it was also evident that the majority of events falls with the areas where there are very high temperature on the surface. Hence it is evident that there is some kind of relationship between the temperature and the human deaths due to HEC. This can be said as when the surface temperature rises, elephants a lack of foods and water which force them to take those things from humans as they have encroached the habitats of elephants. And there also can be an effect to their behavior with the rising temperature, which make them behave more violently damaging properties and crops and most importantly killing people.

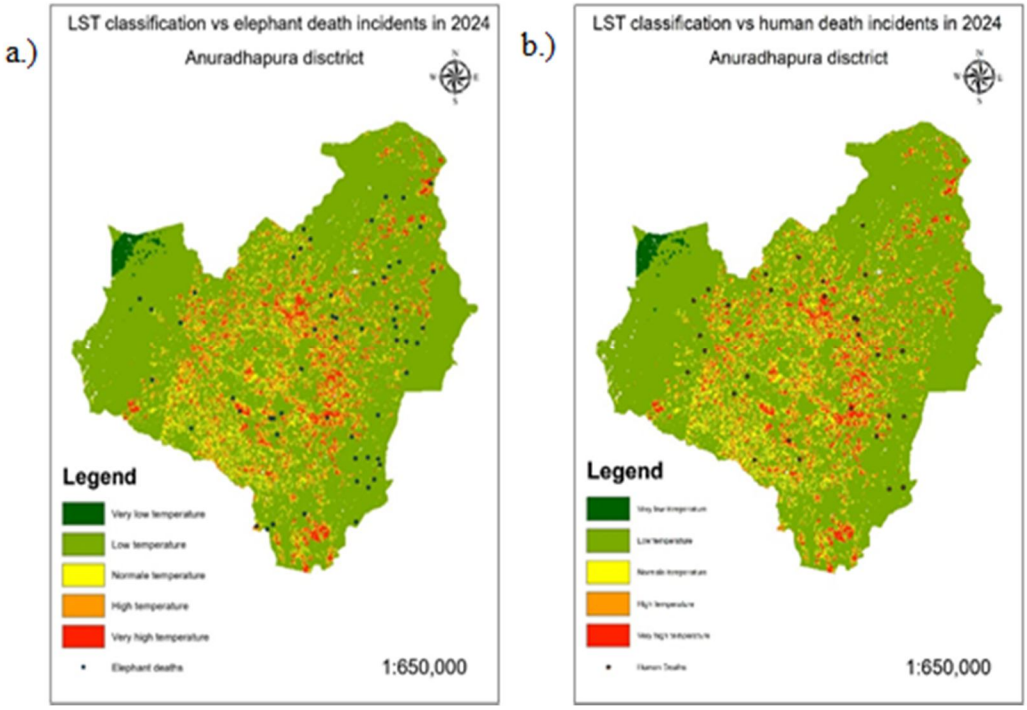


Fig. 6: LST map of the study area with distribution of a.) elephant death & b.) human events due to HEC

5) Railways

In Anuradhapura, Sri Lanka, human conflict with elephants has resulted in unfortunate incidents for both human beings and elephants. Roads and railway lines that traverse through these forest areas have become fatal for elephants, as they are frequently struck by trains or vehicles while crossing these roads, while human beings are also losing their lives due to unexpected encounters or attacks by wild elephants. These roads and railway lines have also divided the habitats of these wild elephants, thus bringing them in close proximity with human beings, which has increased conflict between them. The purple circles on the map show where human beings as well as elephants have lost their lives on these roads and railway lines due to human conflict with elephants in Anuradhapura (Fig. 7).

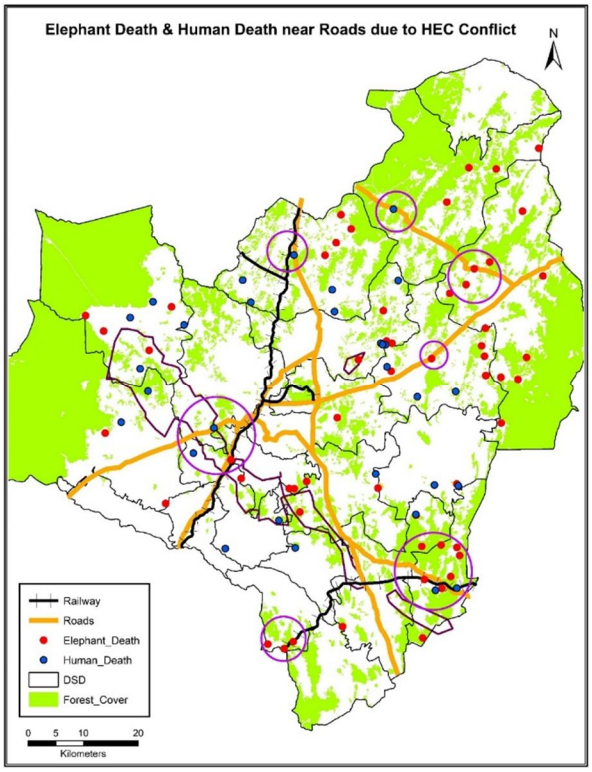


Fig. 7: Human and elephant death event due to HEC near the roads and railway lines

V. CONCLUSION

Elephants are identified to be a species of endangered animals in Asia because of the increasing incidents of HEC. As proven through the literature review increasing population of the world the needs of the people are increasing and hence they tend to grab what belongs to animal as well. They encroached their habitats for both human settlements and agricultural purposes. This leads to conflicts between humans and elephants, especially in Anuradhapura district. Mainly these elephants death events are more sided to the Horowpothana and palugaswawe. Most events of human deaths are reported from Madawachchiya and Kahatagasdigiliya side of the district. The significant changes in the land use types in Anuradhapura have resulted in different behaviors of elephants. Due to the habitat fragmentation due to the deforestation the elephant migration paths have fallen across human settlements areas, which lead to higher interaction rate between the 2 species. Reduction of the water resources inside the forest areas resulting in elephants encroaching the human lands in search of water and food. Mainly the increasing expansion of the agricultural areas leads many of these HEC events. Mainly all this is occurring due to the increasing population. It works like a chain, as population increases needs, needs lead people to conquer more lands for cultivation, that leads to HEC. Temperature can be have an effect on HEC on human deaths as most of the human death events falls within the high temperature region. Moreover as the temperature increases elephants migrate from their habitat in search of water, as Anuradhapura being a region in the dry zone of Sri Lanka, there can be droughts really quickly. When the roads and railway lines were considered the considerable number of events falls over these paths or closer to these paths. Hence the mitigation of HEC needs a careful understanding about these factors in detail which is easily obtained with the use of remote sensing and GIS. A time series analysis of these factors and their influence on HEC may aids in better decision making in terms of mitigating this bloody battle between the 2 species.

REFERENCES

[1] Abdelkaebir, B., Mokhtari, E. and Engel, B. (2024) 'Assessment of land use and land cover changes on hydrological responses in the Wadi Soummam watershed, Algeria using the HEC–HMS model', Water Pratice and Technology, 19(9), pp. 3555–3577. Available at: https://doi.org/https://doi.org/10.2166/wpt.2024.224.

[2] Bandara, R. and Tisdell, C. (2002) 'Willingness to pay for Conservation of the Asian Elephant in Sri Lanka: A Contingent Valuation Study', Malaysia's Socio-Economic Transformation: Ideas for the Next Decade [Preprint], (May).

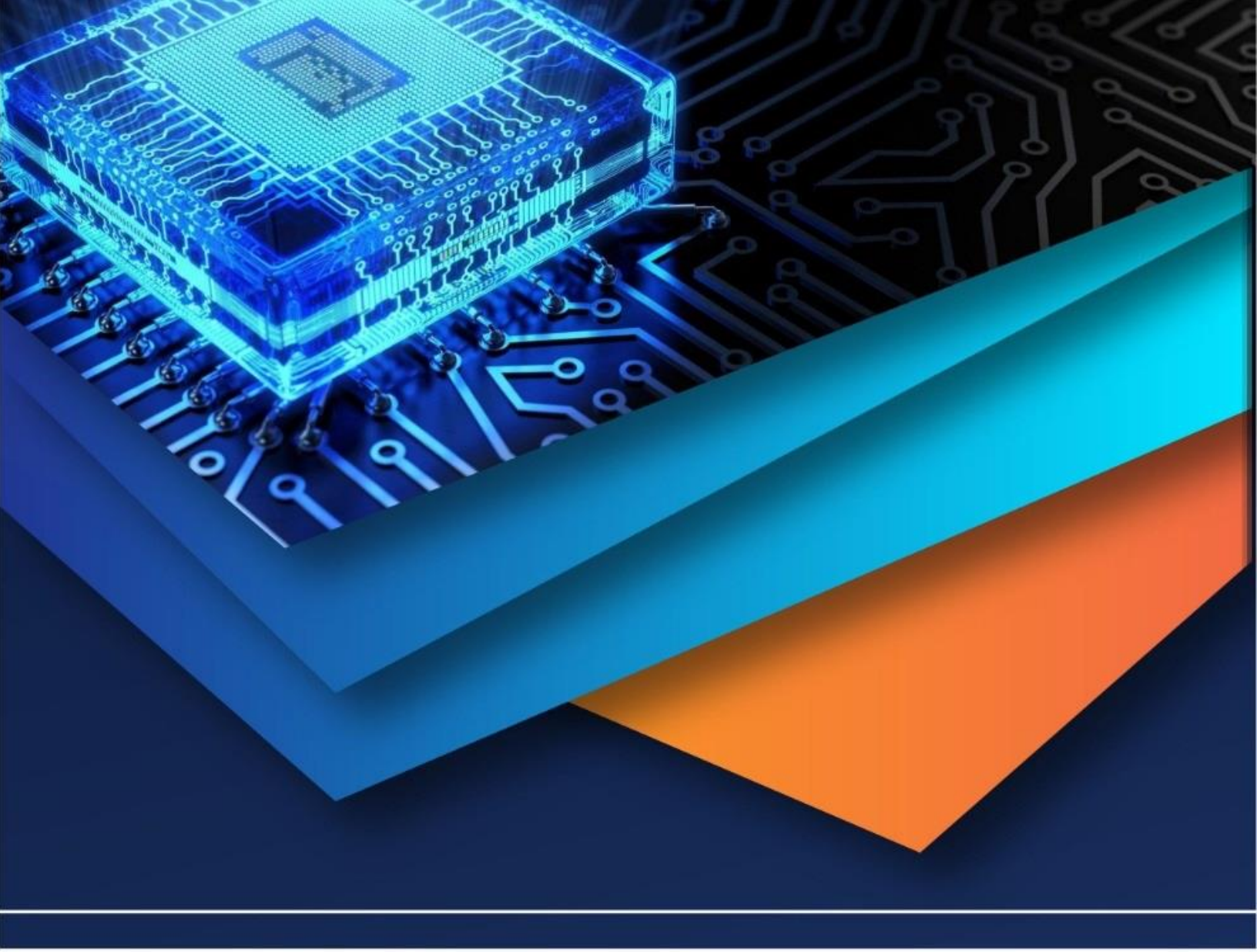
[3] Bandara, R., Herath, S. and Ranasinghe, T. (2022) 'Remote sensing applications in human-elephant conflict mitigation in Sri Lanka', Journal of Wildlife Management, 86(3), pp. 512-525. doi:10.1002/jwmg.22145.

[4] Campos-Arceiz, A., Takatsuki, S., Ekanayaka, S. K. K., & Hasegawa, T. (2011). The human-elephant conflict in southeastern Sri Lanka: Type of damage, seasonal patterns, and sexual differences in the raiding behavior of elephants. Gajah, 34, 20-28.
[5] Centre for Conservation and Research, S.L. (2024) Human Elephant Conflict (HEC). Available at: https://www.ccrsl.org/Programs/elephant-conservation/human-elephant-conflict-hec.
[6] Chithrangani, W.M.R. et al. (2022) 'Human–elephant conflict and land cover change in Sri Lanka', Applied Geography, 143. Available at: https://www.sciencedirect.com/science/article/abs/pii/S014362282200056X.
[7] Dharmarathne, S., Gunatilake, J. and Wickramasinghe, L. (2019) 'Human settlement expansion and human-elephant conflict in Sri Lanka's dry zone', Applied Geography, 107, pp. 12-20. doi:10.1016/j.apgeog.2019.04.005.
[8] Gunaratne, L.H.P. and Premarathne, P.K. (2005) The Effectiveness of Electric Fencing In Mitigating Human- Elephant Conflict in Sri Lanka, Eepsea. Available at: www.eepsea.org.
[9] Fernando, P., Kumar, M. A., Williams, A. C., Wikramanayake, E., Aziz, T., & Singh, S. M. (2010). Review of human-elephant conflict mitigation measures practiced in South Asia. AREAS Technical Support Document Submitted to World Bank, WWF.
[10] Fernando, P., Kumarasinghe, J. and Weerasinghe, R. (2021) 'Historical land-use changes and elephant displacement in Sri Lanka: 1800-2020', Biological Conservation, 256, 109042. doi:10.1016/j.biocon.2021.109042.
[11] Fernando, P., Silva, D. and Perera, R. (2020) 'Agricultural encroachment and human-elephant conflict hotspots in Sri Lanka', Tropical Conservation Science, 13, pp. 1-15. doi:10.1177/1940082920920565.
[12] Gunawansa, T.D. et al. (2023) 'The human-elephant conflict in Sri Lanka: history and present status', Biodiversity and Conservation, 32(10), pp. 3025–3052. Available at: https://doi.org/10.1007/s10531-023-02650-7.
[13] Gunawardhana, L.M.A.P. (2018) 'An analysis of Human-Elephant conflict as a disaster : A case study in Anuradhapura district of Sri Lanka An analysis of Human-Elephant conflict as a disaster : A case study in Anuradhapura district of Sri Lanka', Journal of Tropical Environment, 1(1), pp. 40–55. Available at: https://www.researchgate.net/profile/Asanka_Gunawardhana/publication/327155123_An_analysis_of_Human-Elephant_conflict_as_a_disaster_A_case_study_in_Anuradhapura_district_of_Sri_Lanka/links/5b7d0db4a6fdcc5f8b5b14a7/An-analysis-of-Human-Elephant-conflict-as.
[14] Hoare, R.E. (1999) 'Determinants of human ± elephant con ¯ ict in a land-use mosaic', pp. 689–700.
[15] Jayasundere, M., Fernando, P., & Jayewardene, J. (2012). Habitat connectivity and corridor use by elephants in Sri Lanka. Frontiers in Conservation Science, 2, 735354.
[16] Köpke, S. et al. (2023) 'Human-elephant conflict in the Sri Lankan dry zone: investigating social and geographical drivers through field-based methods', GeoJournal, 88(5), pp. 5153–5172. Available at: https://doi.org/10.1007/s10708-023-10913-7.
[17] Li, W., Liu, P., Guo, X., Wang, L., Wang, Q., Yu, Y., Dai, Y., Li, L., & Zhang, L. (2018). Human-elephant conflict in Xishuangbanna Prefecture, China: Distribution, diffusion, and mitigation. Global Ecology and Conservation, 16, e00462. https://doi.org/10.1016/j.gecco.2018.e00462
[18] Madhushanka, S. and Ranawana, K.B. (2021) 'Human Elephant Conflict (Hec) in Sri Lanka: a Review', 9(3), pp. 361–370.
[19] Ministry of Wildlife (2020) *National action plan for the mitigation of human-elephant conflict 2020-2025*. Colombo: Government of Sri Lanka.
[20] Nelson, A., Bidwell, P. and Sillero-zubiri, C. (2003) 'A review of human-elephant conflict management strategies', Wildlife Conservation, (January 2003), p. 27. Available at: www.peopleandwildlife.org.uk/crmanuals/HumanElephantConflictP&WManual.
[21] Parveen, S., Bashir, J. and Praveen, B. (2018) 'a Literature Review on Land Use Land Cover Changes.', International Journal of Advanced Research, 6(7), pp. 1–6. Available at: https://doi.org/10.21474/ijar01/7327.
[22] Pastorini, J., Nishantha, H. G., Janaka, H. K., Isler, K., & Fernando, P. (2013). Water-body use by Asian elephants in Southern Sri Lanka. Tropical Conservation Science, 6(6), 770-780.
[23] Perera, B. (2009) 'Post-independence habitat loss and its impact on Sri Lankan elephants', Gajah, 31, pp. 12-20.
[24] Perera, K., Apan, A., & Nandita Hettiarachchi. (2023). The human-elephant conflict in Sri Lanka: history and present status. Biodiversity and Conservation, 32. https://doi.org/10.1007/s10531-023-02650-7
[25] Pittiglio, C., Skidmore, A. K., van Gils, H. A., & Prins, H. H. (2014). Elephant response to spatial heterogeneity in a savanna landscape of northern Tanzania. Ecography, 37(4), 370-379.
[26] Prasad, G. et al. (2011) 'A GIS based spatial prediction model for human - elephant conflicts (HEC)', Wildlife Biology in Practice, 7(2), pp. 30–40. Available at: https://doi.org/10.2461/wbp.2011.7.14.
[27] Ridho, M. (2023) Analyzing Land Surface Temperature (LST) with Landsat 8 Data in Google Earth Engine, Medium. Available at: https://medium.com/@ridhomuh002/analyzing-land-surface-temperature-lst-with-landsat-8-data-in-google-earth-engine-f4dd7ca28e70.
[28] Roy, M., & Sukumar, R. (2017). Railways and wildlife: A case study of train-elephant collisions in northern West Bengal, India. In Railway Ecology (pp. 157-177). Springer.
[29] Sharma, A. et al. (2012) 'Gis in Understanding Human Elephant Conflict and It'S Management', Journal of Biological Chemistry, 1(12), pp. 1–4. Available at: https://doi.org/10.13140/RG.2.2.29805.61924.
[30] Sitati, N.W. et al. (2003) 'Predicting spatial aspects of human-elephant conflict', Journal of Applied Ecology, 40(4), pp. 667–677. Available at: https://doi.org/10.1046/j.1365-2664.2003.00828.x.
[31] Srinivasaiah, N. M., Anand, V. D., Vaidyanathan, S., & Sinha, A. (2019). Ranging patterns of Asian elephants (Elephas maximus) across a human-dominated landscape in southern India. PLoS ONE, 14(9), e0223207.
[32] Wadey, J., Beyer, H. L., Saaban, S., Othman, N., Leimgruber, P., & Campos-Arceiz, A. (2018). Why did the elephant cross the road? The complex response of wild elephants to a major road in Peninsular Malaysia. Biological Conservation, 218, 91–98. https://doi.org/10.1016/j.biocon.2017.11.036.
[33] Webber, C. E., Sereivathana, T., Maltby, M. P., & Lee, P. C. (2011). Elephant crop-raiding and human-elephant conflict in Cambodia: Crop selection and seasonal timings of raids. Oryx, 45(2), 243-251.
[34] Wijesinghe, L., de Silva, S. and Mendis, P. (2021) 'Climate change and elephant movement patterns in Sri Lanka', Climate Change Ecology, 2, 100030. doi:10.1016/j.ecochg.2021.100030.
[35] Wilson, S. et al. (2015) 'Understanding spatial and temporal patterns of human-elephant conflict in Assam, India', Oryx, 49(1), pp. 140–149. Available at:

https://doi.org/10.1017/S0030605313000513.

[36] Withanage, W.K.N.C. et al. (2023) 'Indexing habitat suitability and human-elephant conflicts using GIS-MCDA in a human-dominated landscape', Geography and sustainabiltiy, 4(4), pp. 343–355. Available at: https://www.sciencedirect.com/science/article/pii/S2666683923000469.

[37] Younis, S.M.Z. and Ammar, A. (2018) 'Quantification of impact of changes in land use-land cover on hydrology in the upper Indus Basin, Pakistan', The Egyptian Journal of Remote Sensing and Space Science, 21(3), pp. 255–263. Available at: https://doi.org/https://doi.org/10.1016/j.ejrs.2017.11.001.



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