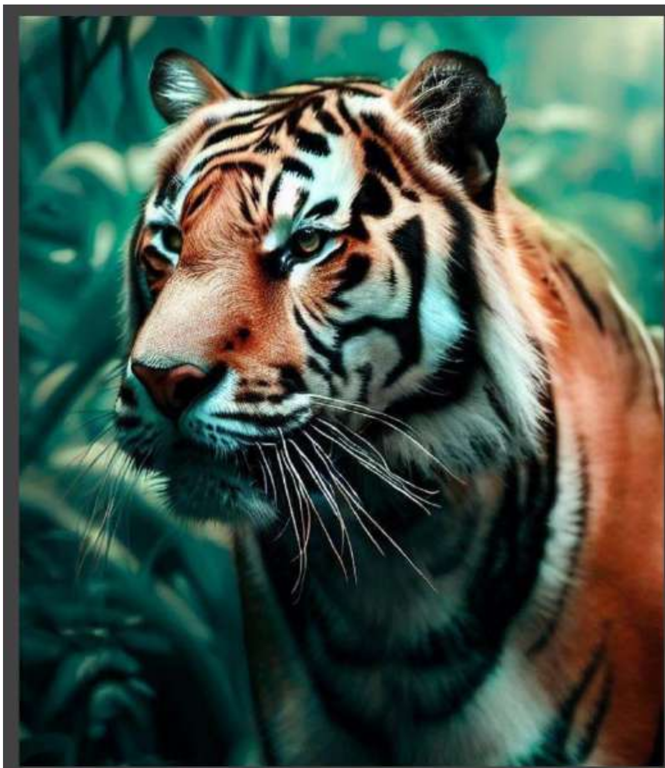




# ASSESSMENT OF HUMAN DIMENSIONS OF HUMAN WILDLIFE CONFLICTS AND ITS IMPACTS ON WILDLIFE CONSERVATION IN TAMIL NADU

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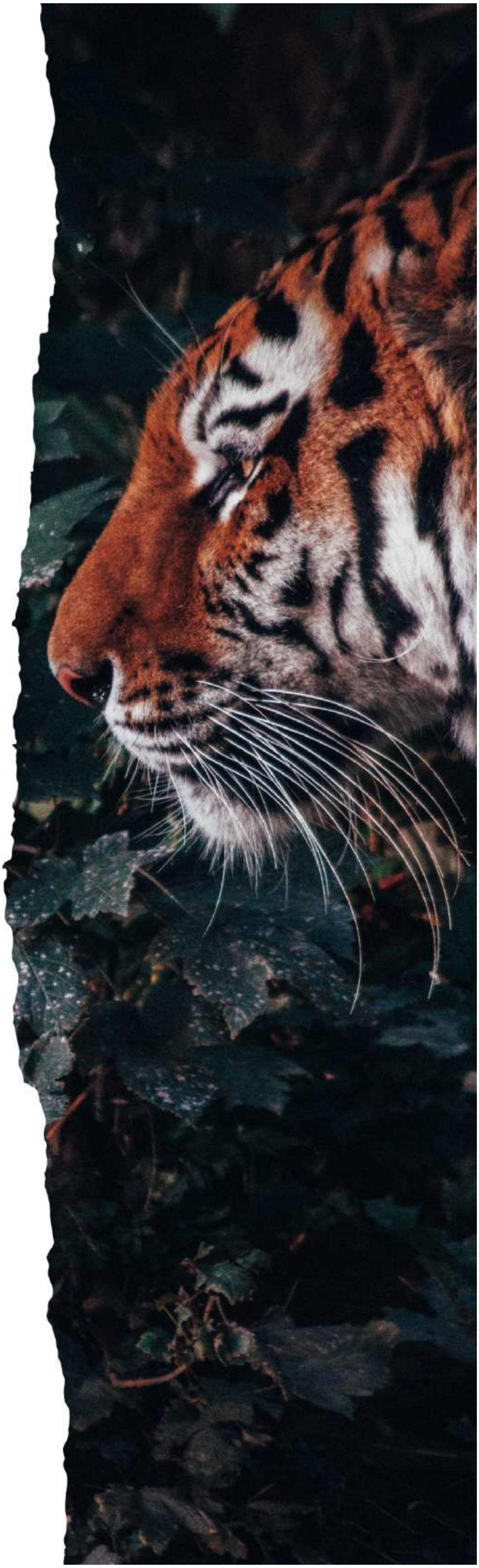
**Authors**

## Executive summary

The conducted study presents a comprehensive assessment of the human dimensions of human-wildlife conflicts (HWC) in Tamil Nadu, focusing on their implications for wildlife conservation. The study pursued three primary objectives: first, the identification of wildlife conflict zones across the state, focussing on their spatial and temporal dynamics; second, evaluating the efficacy of existing measures aimed at mitigating human-wildlife conflicts; and third, a global perspective integration to extract best practices in conflict mitigation for potential implementation in Tamil Nadu.

The research methodology encompassed a robust data collection effort spanning the years 2016 to 2021, utilizing both secondary sources and direct field observations. The collected data were meticulously processed to segregate and analyze conflict incidents involving key species, including Asian elephant (*Elephasmaximus*), wild pig (*Sus scrofa*), leopard (*Pantherapardus*), Tiger (Pantheratigris), Gaur (*Bosgaurus*), and Sloth bear (*Melursusursinus*). A temporal analysis was conducted by categorizing the data into annual and monthly trends, offering insights into the evolving patterns of conflicts over time.

A significant analytical component involved the visualization of conflict frequencies using bar graphs in Excel, offering a clear representation of conflict types and their prevalence. The spatial distribution of conflict incidents was mapped using GIS technology, providing a geographical understanding of conflict hotspots. The culmination of these efforts resulted in an ensemble modeling technique that effectively identified high-risk zones for different species involved in conflicts.

The study's findings underscore a concerning trend of escalating human-wildlife conflicts over recent years. A staggering total of **13,818** major conflict incidents were reported, with the highest concentration in the **Hosur** division (4,408 incidents) followed by the **Coimbatore** division (1,996 incidents). ***Elephas maximus*** emerged as a predominant contributor to conflicts, closely followed by ***Sus scrofa***.

An in-depth conflict type analysis exposed **crop damage** as the prevailing issue, outweighing human casualties and livestock predation. This observation prompts a critical examination of existing mitigation strategies to address this specific aspect of conflicts.

The implications of this study extend beyond the boundaries of Tamil Nadu. By contextualizing local findings within the broader global landscape of human-wildlife conflicts, the study discerns valuable insights into effective mitigation practices from around the world. These insights, combined with the meticulously collected and analyzed data, serve as a cornerstone for informed decision-making. The study provides an indispensable baseline for comprehending the intricate dynamics of human-wildlife conflicts in Tamil Nadu, ultimately informing targeted and effective mitigation measures, advancing harmonious coexistence, and fortifying wildlife conservation initiatives throughout the region.

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# 1. Introduction

## 1.1. Overview of Human-wildlife conflict (HWC):

HWC is a term used to describe any interaction or conflict between humans and wild animals that results in negative impacts on either humans or wildlife (Mekonen 2020). It is an increasingly common issue around the world, as human populations continue to expand into areas traditionally occupied by wildlife, and as habitat loss and fragmentation force wildlife to live in closer proximity to human settlements. These factors contribute to forcing them to come in contact with humans and further leads to conflicts. HWC needs an interdisciplinary approach that includes understanding human thoughts and behaviours, social psychology etc., as a part of the focus (Teel et al. 2022). With the increase in dependence on natural resources, humans and animals have been interacting negatively, especially near protected areas (Prasad et al. 2020).

## 1.2. HWC can take many forms, including:

- ***Crop and livestock raiding:*** Wildlife such as elephants, monkeys, and wild pigs may raid agricultural fields and destroy crops or livestock, leading to economic losses for farmers and communities.
- ***Property damage:*** Wild animals such as bears, deer, and raccoons may damage property, including homes, gardens, and vehicles, leading to financial losses and safety concerns for residents.
- ***Human injuries and fatalities:*** Some wild animals, such as elephants, big cats, crocodiles, and snakes, may attack humans, resulting in injuries or even fatalities.
- ***Conservation conflicts:*** Efforts to protect wildlife and their habitats can sometimes conflict with the needs and interests of local communities, leading to tensions and conflicts over issues such as land use and resource access.

## 1.3. Climate change and HWC:

Climate change is expected to have significant impacts on HWC, as changes in temperature, precipitation patterns, and other climate variables can alter the behaviour and distribution of wildlife, as well as human activities and land use patterns.

Some of the ways in which climate change may exacerbate HWC include:

- ***Changing distribution and behaviour of wildlife:*** Climate change can alter the distribution and behaviour of wildlife species, leading to increased interactions with humans in areas where they were previously rare or absent. For example, rising temperatures and changes in rainfall patterns may force wildlife to move to new areas in search of food and water, bringing them into closer proximity to human settlements.
- ***Habitat loss and fragmentation:*** Climate change can also exacerbate habitat loss and fragmentation, as rising temperatures, sea level rise, and other climate impacts can alter ecosystems and reduce available habitat for wildlife. This can force wildlife to live in smaller and more fragmented habitats, increasing the likelihood of interactions with humans.
- ***Changes in agricultural practices:*** Climate change can also lead to changes in agricultural practices, such as shifting planting times or crop choices, which can alter the availability of food for wildlife and may lead to increased crop raiding or livestock predation.
- ***Human displacement:*** Climate change can also lead to human displacement, as extreme weather events, sea level rise, and other impacts force people to move to new areas. This can bring humans into new areas and increase the likelihood of interactions with wildlife.

India is home to a rich and diverse array of wildlife species, including large carnivores such as tigers, leopards, and wolves, as well as herbivores such as elephants, deer, and wild boars. However, the increasing human population and encroachment into wildlife habitats has led to a rise in HWCs across the country. Tamil Nadu, like many other states in India, faces a range of HWCs. Some of the common conflicts in Tamil Nadu include:

- ***Elephant Conflict:*** Human-elephant conflict, leading to loss of lives of people and elephants and damage to property and crops, poses a major challenge for conserving elephants outside Protected Areas across Asia (Kumar & Raghunathan. 2019). Tamil Nadu has a significant population of wild elephants, which frequently come into conflict with humans living in the areas bordering forest reserves. Elephants may raid agricultural crops or damage property, and there are also incidents of elephants attacking humans, resulting in injuries or fatalities (Senthilkumar et al. 2016). With the loss of elephant habitat due to human encroachment and fragmentation of forests, these mega herbivores are left with no choice but to come into contact with humans for the nutritious food resources available in the agricultural fields.
- ***Leopard Conflict:*** Conflict between humans and Leopard *(Panthera pardus)* is a growing concern in India, including Tamil Nadu. With the increase in the human population over the past few years, there has been a constant interaction between humans, livestock, and wild animals. Leopards are also present in Tamil Nadu, and there have been incidents of leopards attacking livestock, pets, and occasionally humans. The conflicts are often attributed to the loss of leopard habitat due to human encroachment and habitat fragmentation, as well as a lack of prey in the forests.
- ***Tiger conflict:*** the escalating conflict between humans and tigers in Tamil Nadu is a result of increasing encroachment and habitat fragmentation. Along with this, the livestock provide the predators with easy and nutritious alternatives to traditional

prey. The five tiger reserves and the fringes see a high rate of Tiger conflict because of shared boundaries. Often they wander off to human settlements and cause conflict, mostly through human attacks and livestock depredation.

- ***Sloth bear conflict:*** Sloth bear conflict is another type of HWC that occurs in Tamil Nadu, particularly in the areas bordering forest reserves where sloth bears are known to inhabit. Sloth bears are known to raid houses for food and damage property along the way, and there have also been incidents of sloth bear attacks on humans, resulting in injuries or fatalities.
- ***Guar Conflict***: Gaurs otherwise known as Indian bison prefer to inhabit the forested regions of Tamil Nadu. They have been seen to venture into fields and create havoc, causing huge losses to the farmers. There have been instances of human injury as well while coming into contact with these giant herbivores. they can be very aggressive creatures when feel threatened or cornered
- ***Wild pig conflict:*** The expanding population of wild pigs and the associated economic loss have been a challenge for the government and conservation biologists, for over a decade globally (Milda et al. 2023) Wild pig conflicts are a common issue in Tamil Nadu, particularly in agricultural areas. The increase in population of wild pigs with no increase in forest area poses a danger to farmers (Kumar et al. 2020). Wild pigs are known to cause significant damage to crops, resulting in significant economic losses for farmers. In Tamil Nadu, there have been reports of wild pig attacks resulting in human injuries and fatalities, particularly in agricultural areas where wild pigs often visit to raid crops.

## 2. Objectives:

- Demarcating wildlife conflict zones in Tamil Nadu and trends in conflict both spatially and temporally.
- Evaluate the efficacy of the human wildlife conflict mitigation measures implemented in Tamil Nadu.
- Assess the mitigation measures in specific human wildlife conflicts globally and identify the best practices for trial and adoption in Tamil Nadu.

## 3. Study area

The state of Tamil Nadu has 26,419 sq. km. of forest coverage, which constitutes around 20% of the whole geographical area. The state is home to many different types of forests, such as Tropical wet evergreen, Tropical semi-evergreen, Tropical moist deciduous, Littoral and swamp, Tropical dry deciduous, Tropical thorn, Tropical dry evergreen, Sub-Tropical Broad-leaved hill, and Montane wet temperate forests. Since the forest coverage is high, so is the number of protected areas (7,072.95 sq. km.), including 5 National parks, 15 Wildlife sanctuaries, 15 bird sanctuaries, and 2 conservation reserves, besides 5 Tiger reserves, viz. Anamalai, Kalakkad - Mundanthurai, Mudumalai, Sathyamangalam, and Srivilliputtur Megamalai. Studies have been conducted in and around these protected areas, and found that Human conflicts are mostly common in the fringe areas or intersecting areas of protected areas and human settlements. There has been a steep increase in the number of studies being conducted in Tamil Nadu by both State and central government institutes.

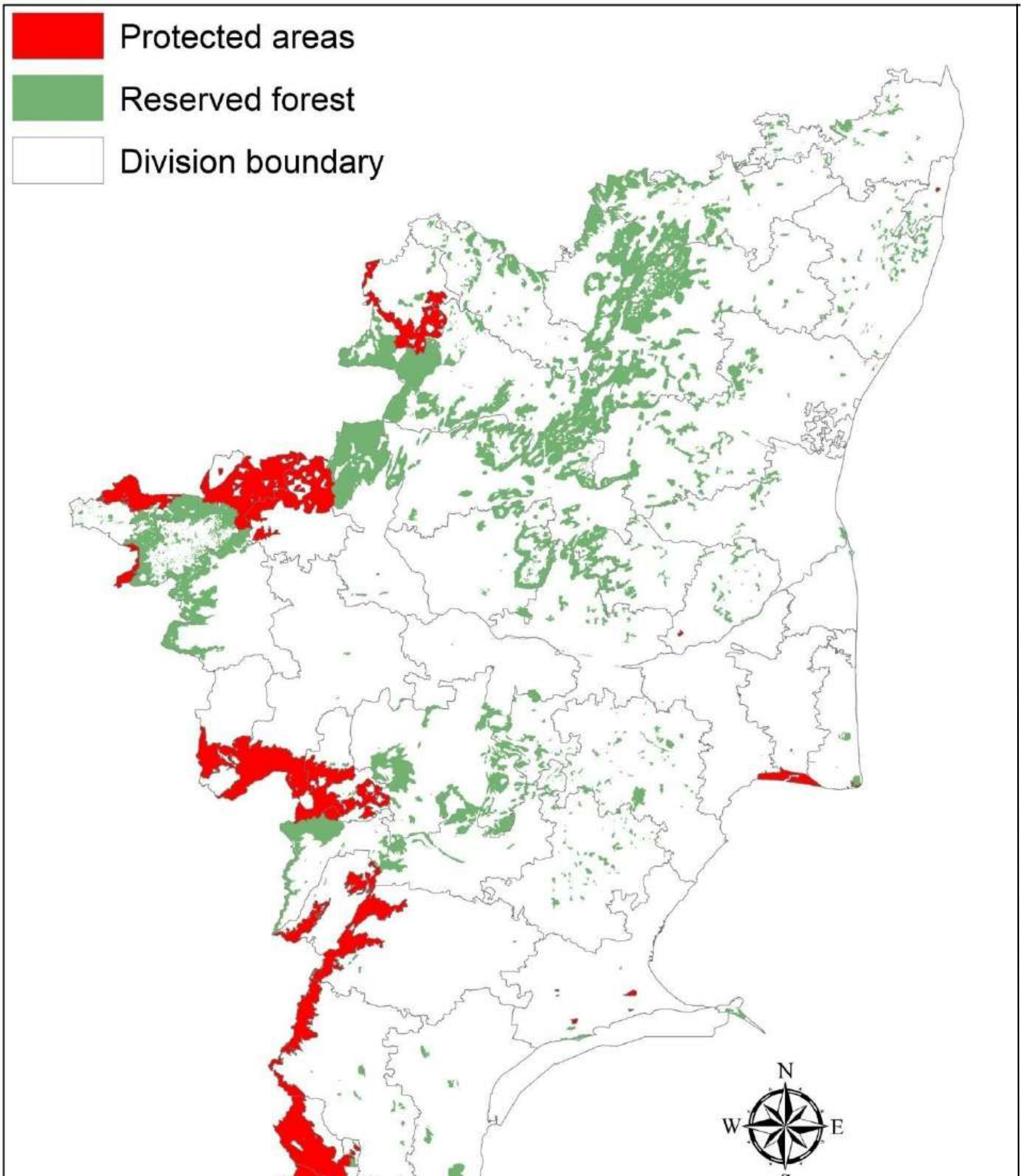



**Figure 1. Map of the forest divisions of Tamil Nadu.**

# 4. Methodology

## 4.1. Data Collection and Analysis:

- We collected data from 2016–2021 on HWC incidents both from secondary sources and from field visits as well.
- From the raw data we segregated targeted species, such as Elephants, Wild pigs, Leopards, Tigers, Gaurs, Sloth bears.
- We used the Pivot table as a tool to group the data yearly, and monthly to conduct temporal analysis.
- We used a bar graph in Excel to represent the frequencies of conflicts.
- The geo-coordinates of each conflict were pooled and plotted in the GIS platform (using QGIS) to understand their spatial distribution.

## 4.2. Environmental variables (GIS modeling):

- **The Terrain Ruggedness Index**

The Terrain Ruggedness Index (TRI) is a unit less measure of the surface roughness or terrain ruggedness derived from digital elevation models (DEMs). The scale of the TRI calculation depends on the spatial resolution of the DEM. However, in general, higher values of TRI indicate rougher or more rugged terrain, while lower values indicate smoother terrain. For example, in a terrain analysis application, areas with high TRI values may be more challenging to navigate or build infrastructure on, while areas with low TRI values may be more suitable for these activities. In a biodiversity study, high TRI values may correspond to areas with more diverse microhabitats, while low TRI values may correspond to more homogeneous areas.

- ***Annual Mean Temperature***

The mean annual temperature is one of the 19 bioclimatic variables derived from monthly temperature and precipitation values and is widely used in ecological and bio geographical research to characterise the climate conditions of a given location. The variable represents the long-term average temperature at a particular location, usually measured in degrees Celsius or Kelvin. It is calculated as the average of the monthly temperatures for each month of the year, and provides a measure of the overall thermal regime of the area. Locations with higher values tend to have warmer climates, while locations with lower values tend to have cooler climates.

- ***Isothermality***

Isothermality is one of the 19 bioclimatic variables that are commonly used in ecological and bio geographical research to characterise the climate conditions of a given location. Isothermality is a measure of the uniformity of temperature throughout the year, and is calculated as the ratio of the temperature seasonality to the mean annual temperature. Isothermality can provide useful information about the thermal stability of a particular location, and is commonly used in ecological and bio geographical research to model species distributions, predict range shifts under climate change, and analyze biodiversity patterns.

- ***Distance to forest cover***

Distance to forest cover can also be used as a predictor variable in human animal conflict risk modeling (HACRM) to help identify areas that may be at higher or lower risk of conflict between humans and wildlife. Including distance to forest cover as a variable in a conflict risk model assumes that the proximity or density of forested areas may affect the likelihood of human-wildlife conflicts in a particular location. Incorporating distance to forest cover into a conflict risk model can help identify areas that may be at higher risk of human-wildlife conflicts due to forest-related issues. For example, areas that are close to forested areas but predicted to have high human activity could be targeted for human-wildlife conflict mitigation efforts, such as education campaigns or land use planning, to minimise the risk of conflicts between humans and wildlife.

- ***Distance to road***

Distance to the road can be used as a predictor variable in HACRM to help identify areas that may be at higher or lower risk of conflict between humans and wildlife. Including distance to roads as a variable in a conflict risk model assumes that the proximity or density of roads may affect the likelihood of human-wildlife conflicts in a particular location. Incorporating distance to the road into a conflict risk model can help identify areas that may be at higher risk of human-wildlife conflicts due to road-related issues. For example, areas that is close to roads but predicted to have high human activity could be targeted for human-wildlife conflict mitigation efforts, such as the installation of wildlife crossings or the implementation of speed limits and other measures to reduce the risk of collisions between vehicles and wildlife.

- ***Distance to water***

Distance to water can also be used as a predictor variable in HACRM to help identify areas that may be at higher or lower risk of conflict between humans and wildlife. Including distance to water as a variable in a conflict risk model assumes that the proximity or availability of water sources may affect the likelihood of human-wildlife conflicts in a particular location. Incorporating distance to water into a conflict risk model can help identify areas that may be at higher risk of human-wildlife conflicts due to water-related issues. For example, areas that are close to water sources but predicted to have high human activity could be targeted for human-wildlife conflict mitigation efforts, such as the installation of fencing or the use of deterrents, to reduce the risk of conflicts between humans and wildlife.

- ***Distance to crop land***

Distance to crop land can also be used as a predictor variable in HACRM to help identify areas that may be at higher or lower risk of conflict between humans and wildlife. Including distance to crop land as a variable in a conflict risk model assumes that the proximity or density of crop land may affect the likelihood of human-wildlife conflicts in a particular location.

Incorporating distance to crop land into a conflict risk model can help identify areas that may be at higher risk of human-wildlife conflicts due to agriculture-related issues. For example, areas that are close to crop land but predicted to have high wildlife activity could be targeted for wildlife management efforts to reduce the risk of conflicts between humans and wildlife.

- ***Distance to built-up area***

Distance to built-up areas can also be used as a predictor variable in HACRM to help identify areas that may be at higher or lower risk of conflict between humans and wildlife. Including distance to built-up areas as a variable in a conflict risk model assumes that the proximity or density of built-up areas may affect the likelihood of human-wildlife conflicts in a particular location.For example, in regions where human populations are expanding and encroaching on wildlife habitat, conflicts may arise over issues such as crop damage, livestock predation, or attacks on humans by large predators. Additionally, in areas where urbanisation is rapid or uncontrolled, there may be conflicts related to habitat fragmentation, wildlife corridors, or access to food and shelter for wildlife.

- ***Normalized Difference Vegetation Index***

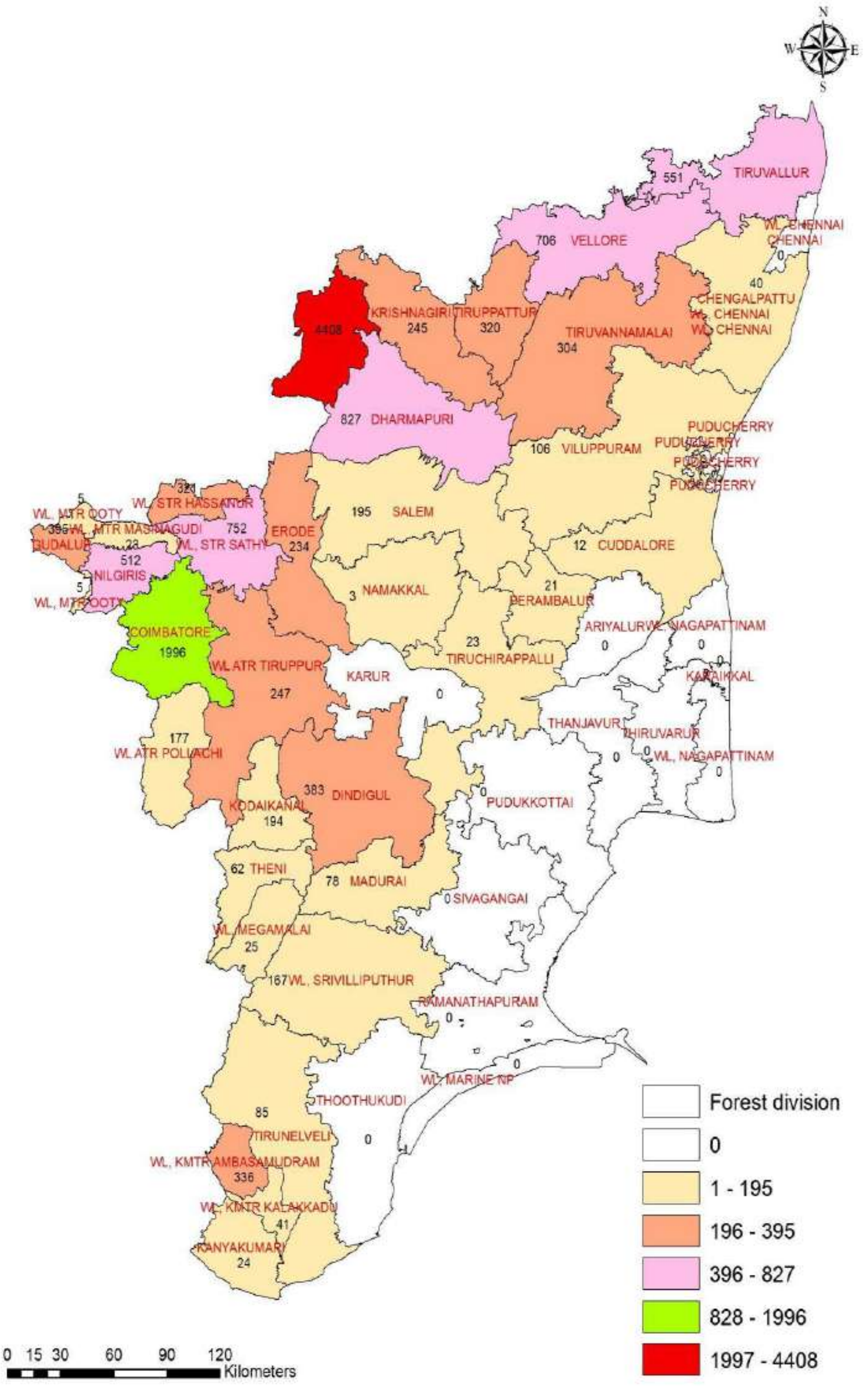
Normalized Difference Vegetation Index (NDVI) can also be used as a predictor variable in HACRM to help identify areas that may be at higher or lower risk of conflict between humans. The NDVI is a remote sensing index that estimates vegetation cover and can be used to monitor changes in vegetation over time. Incorporating NDVI into a human conflict risk model can help identify areas that may be at higher risk of conflict due to vegetation-related issues. For example, areas with low NDVI values may be targeted for interventions such as reforestation or the implementation of sustainable land management practices to reduce the risk of conflicts over natural resources. Additionally, areas with high NDVI values may be targeted for interventions such as the installation of fences or other barriers to reduce the risk of conflicts between humans and wildlife.

### 4.3. Conflict risk modeling:

Species distribution modeling (SDM) is one of the most powerful tools in conservation planning and has been implemented in various studies (Shameer et al 2023; Shameer et al 2022; Shameer et al 2021). Recently the ensemble modelling framework suggested by (Grenouillet et al. 2016) has gained popularity in predicting reliable SDMs. Ensemble modeling is a powerful approach for improving the accuracy and robustness of species distribution models (SDMs), which involves fitting multiple models using different algorithms, predictors, or modeling techniques and combining the predictions using a weighted average or other aggregation method. (Naimi & Araújo, 2016) This approach can help reduce the effects of over fitting, account for model uncertainty, and capture the complexity of the relationship between species and the environment. The "sdm" package (Naimi & Araújo, 2016) in R provides several functions for ensemble modeling, which enable users to create a set of candidate models, evaluate their performance, and combine them into an ensemble using various methods such as boosting, bagging, or random forest. This model has also proven its efficiency in producing reliable prediction of human wildlife conflict (Mpakairi et al 2018).

## 5. OVERVIEW OF THE HUMAN WILDLIFE CONFLICT IN TAMIL NADU:

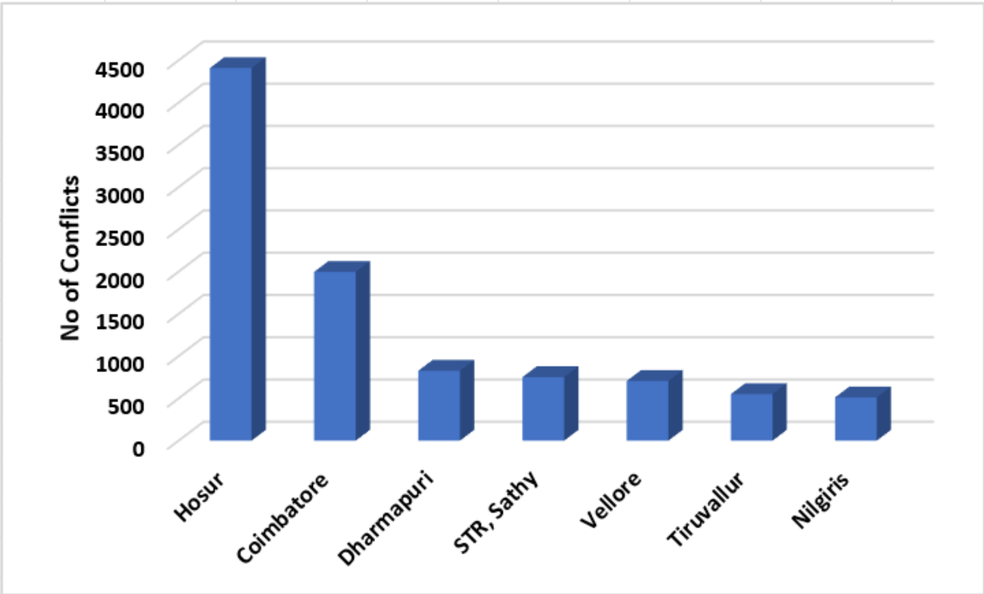
Tamil Nadu is witnessing an escalating trend in HWC cases. The dependency on mutual resources for survival becomes the driving force behind this trend. Approximately 15000 HWC cases have been reported from the state, out of which **13818** were found to be from major species involved in conflicts. The spatial distribution shows that **Hosur division** witnesses the highest number of conflicts overall, followed by **Coimbatore division.**



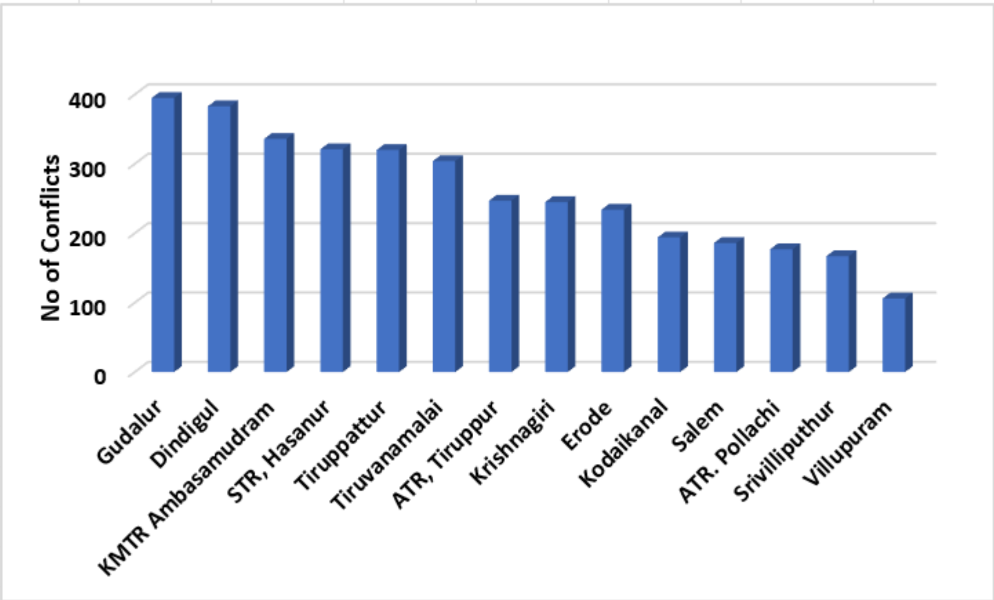

**[Fig - 02]** shows the spatial distribution of conflict incidents in forest divisions of Tamil Nadu.

**5.1 Frequency analysis:**

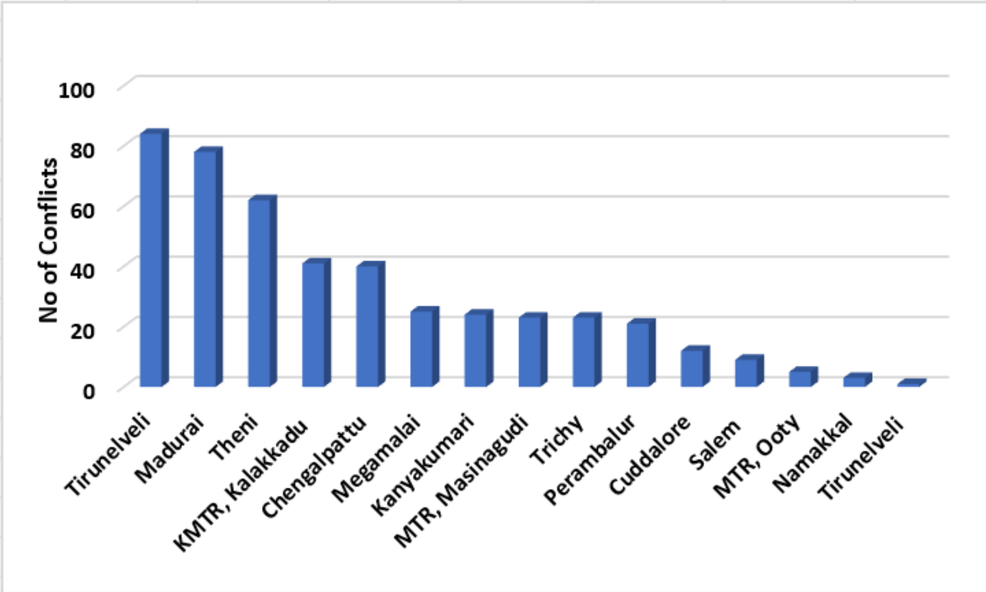
- The data revealed that wildlife conflict has been rising for the past few years. A total of **13818** major wildlife conflict records in the state were reported. Out of these, the maximum number of conflicts were found to be in **Hosur (4408),** followed by **Coimbatore division (1996**). **[Fig - 03]**




**[Fig - 03] Graph showing the divisions with (on a scale of 500 - 4500) conflict cases.**



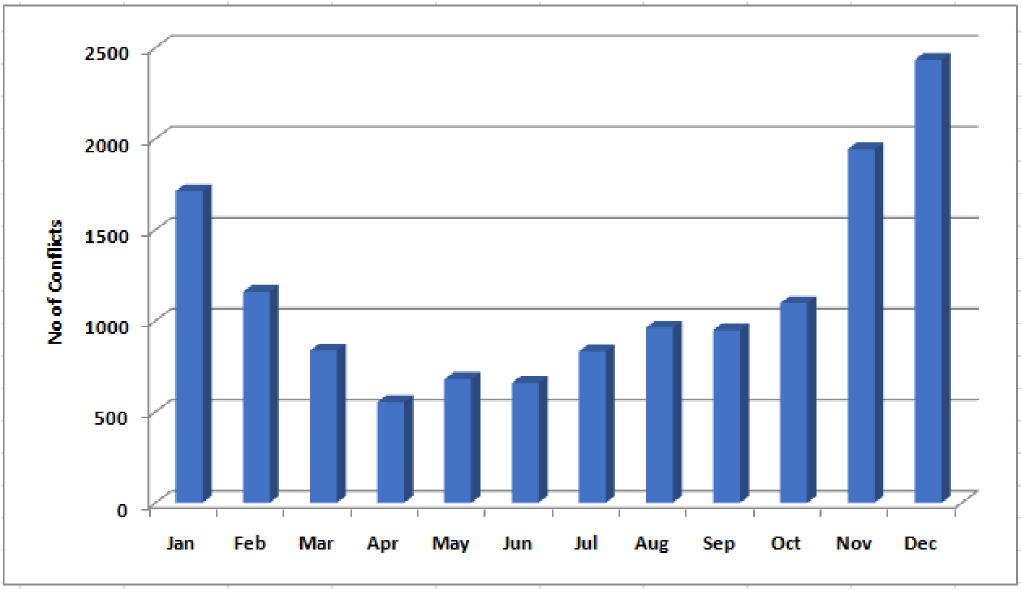

**[Fig - 04] Graph showing the divisions with (on scale of 100 - 500) conflict cases.**



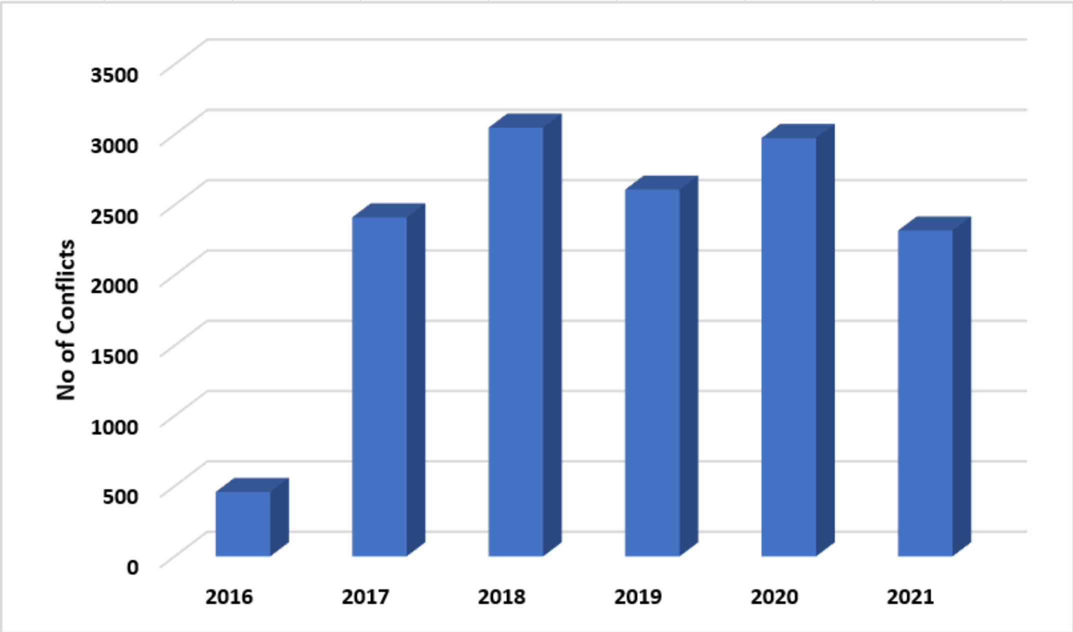

**[Fig - 05] Graph showing the divisions with (on a scale of 0 - 100) conflict cases.**

### 5.2 Temporal analysis:

Through analyzing the overall data temporally, it became evident that most of the conflicts happened from December to February **[Fig - 06]**. This shows the relationship between crop damage as it dominates the conflict types, and as harvesting season falls during these months. The year wise analysis prevailed in the 5 years (2016 - 21) of data taken into analysis, out of which the 2018 year showed the highest peak of conflict cases reported **[Fig - 07]**.




**[Fig - 06] Graph showing the month wise overall temporal pattern of HWC.**

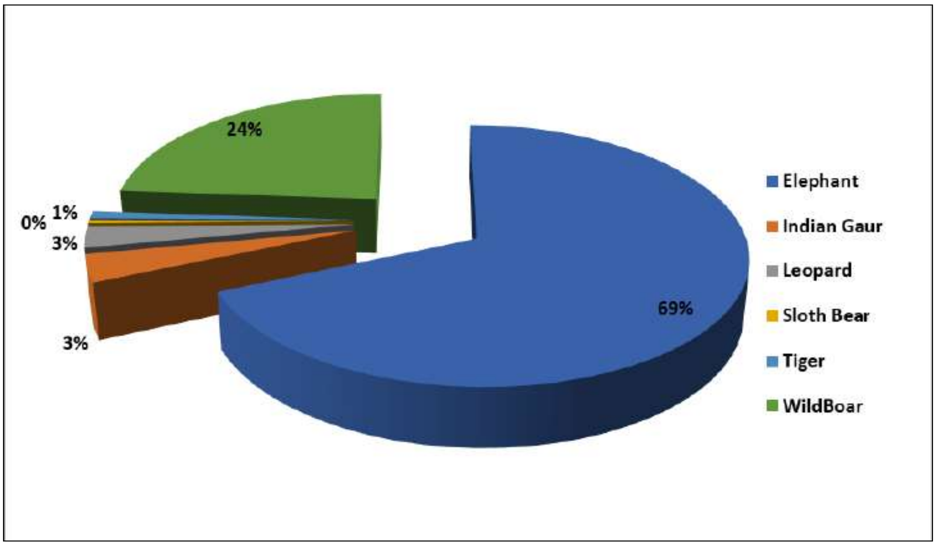



**[Fig - 07] Graph showing the overall pattern of HWC year wise.**

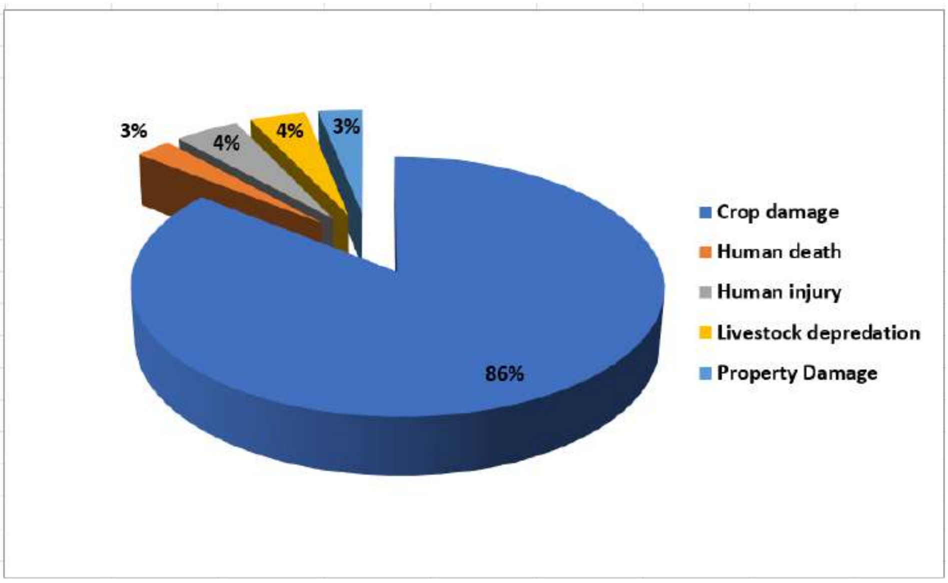
### 5.3 Conflict analysis:

Out of the overall data analyzed and a species wise analysis, it was observed that most of the conflict cases reported was elephant conflict cases, with wild pig conflict cases following. These two species are frequently involved in conflict **[Fig - 08]**.

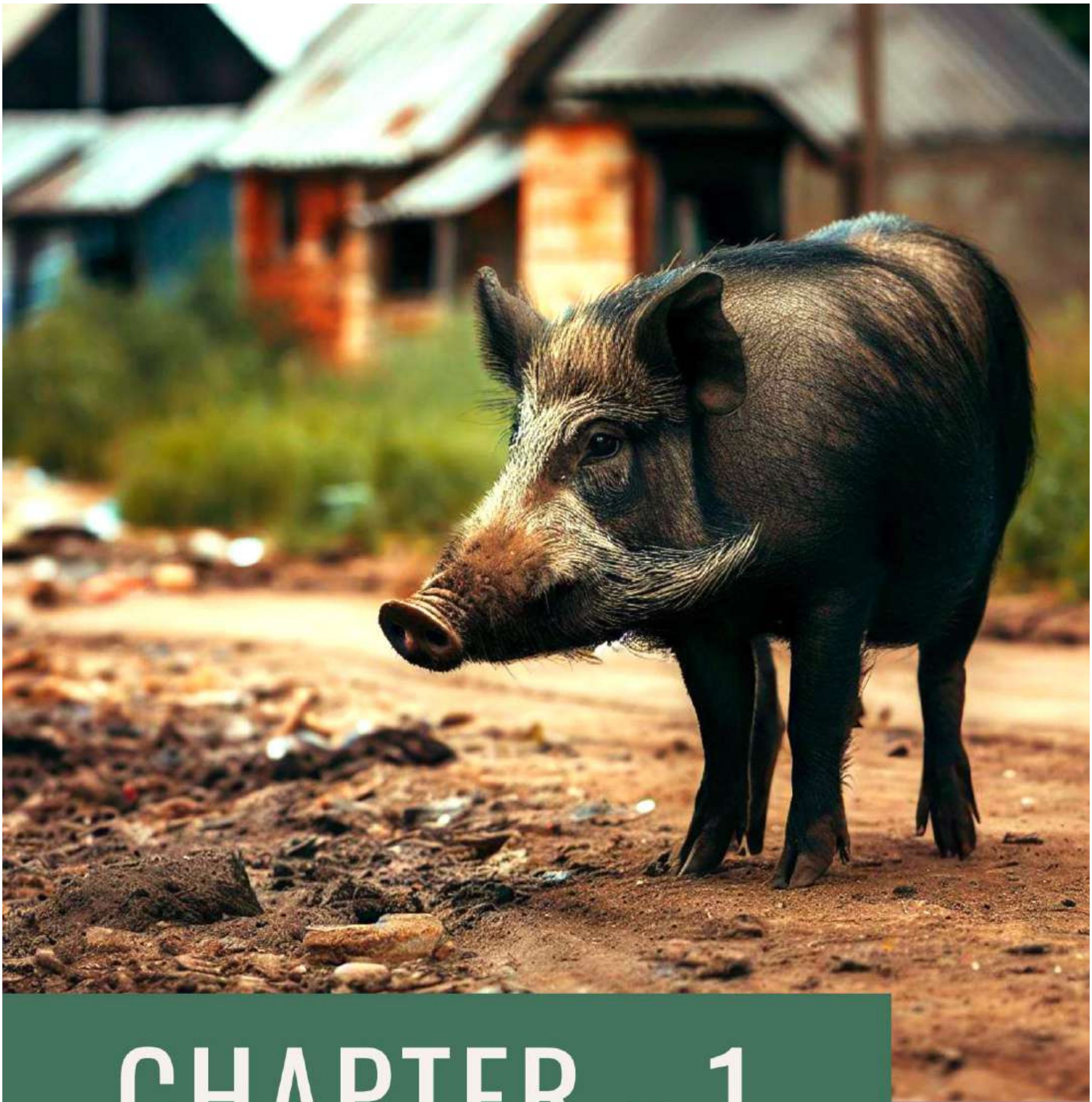
Similarly, to understand the conflict type pattern, a conflict type analysis was carried out, and it was found that crop damage is predominant among all the types of conflicts in comparison to human death or livestock depredation. Other types of conflicts are approximately contributing an equal amount of contribution towards the overall conflict cases in the state **[Fig - 09]**.




**[Fig - 08] Pie chart showing species wise overall conflict**




**[Fig - 09] A pie chart depicting the types of conflicts**



# CHAPTER - 1

## HUMAN - WILD PIG CONFLICT

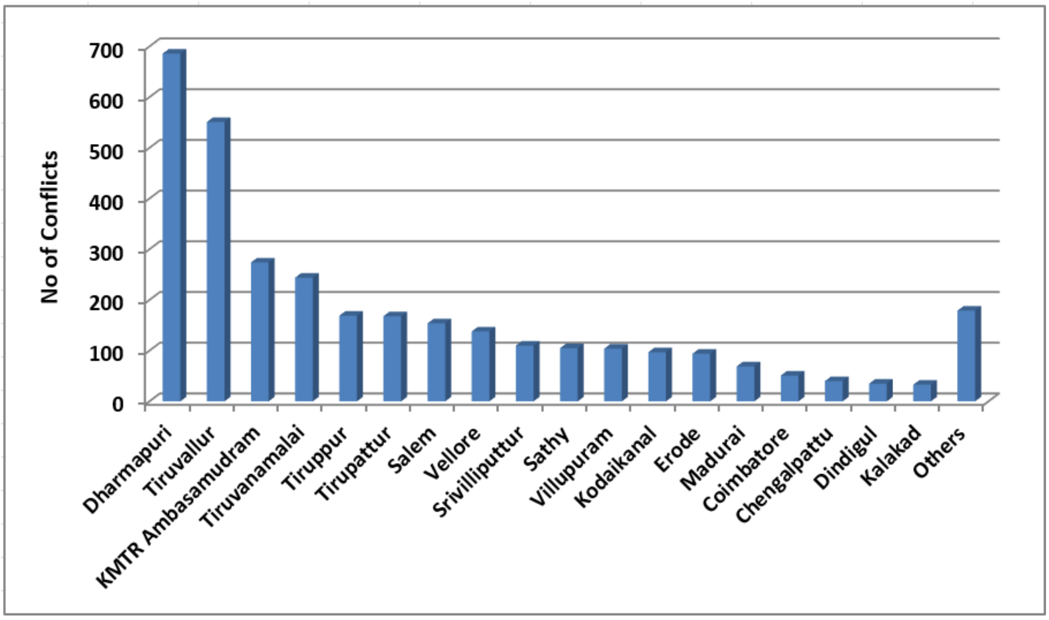
# 6. CHAPTER 1: HUMAN WILD PIG CONFLICT (HWPC)

Human wildlife conflict has been able to gather escalating attention among wildlife conservationists. This is one of the most concerning topics for which conservationists fail to come up with a solid and effective solution. Human wild pig conflict (HWPC), especially in Southern India, has become a challenging issue for the state Governments. We have made a mere attempt to understand the multilayer of factors contributing to the overall HWPC in Tamil Nadu. We are certain that our data analysis and risk modeling approach will definitely tell a better story in order to take appropriate actions. We have shared our insights into the management actions and difficulties faced by both officials and victims in order to fill the shortcomings of current mitigation measures.

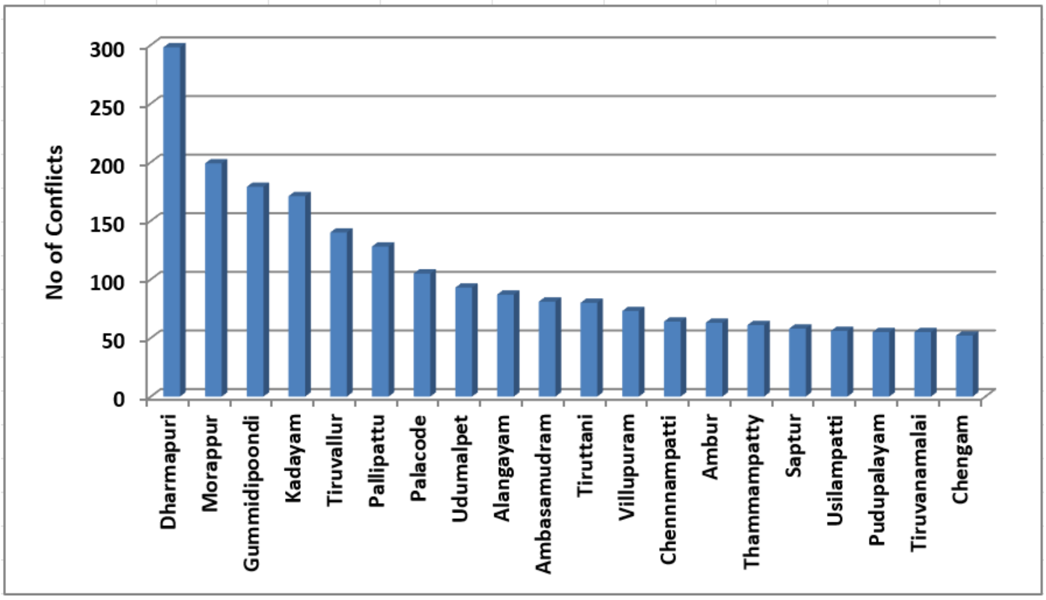
## 6.1. Results:

### 6.1.1. Frequency analysis:

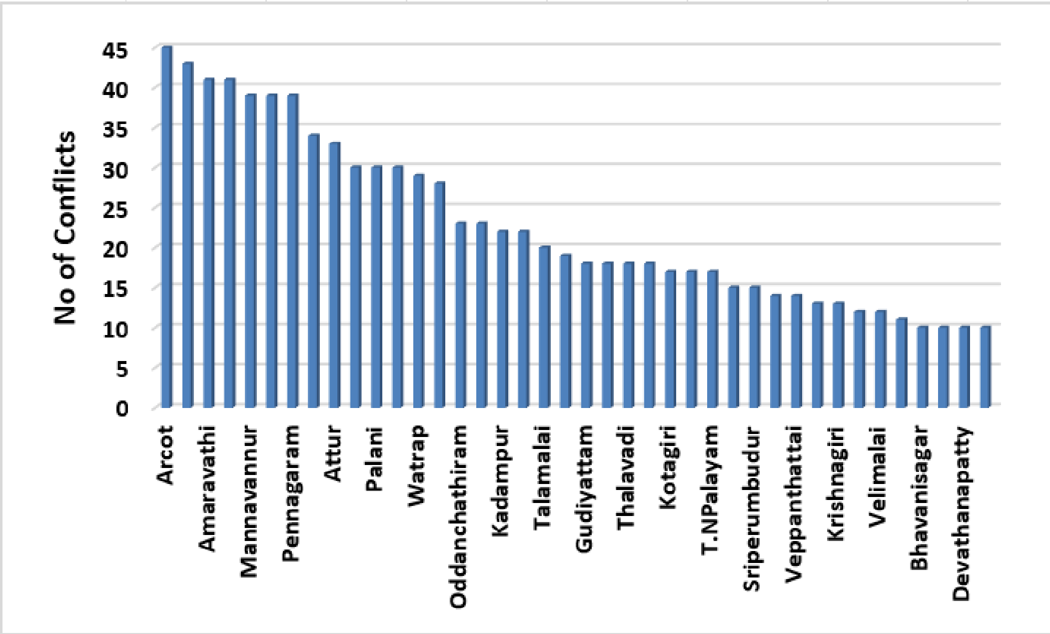
- From the above study, we have observed that wild pig conflict has been rising for the past few years. From the collected secondary data, it seems there are **3301** wild boar conflict records in the state. Out of these, the maximum number of conflicts were found to be in **Dharmapuri division (686),** followed by **Thiruvallur (551**) **[Fig - 10]**.
- **Dharmapuri range (302**) was observed to have the highest wild pig conflict, followed by **Morappur range (199**) and **Goomidipoondi range (180**) **[Fig - 11]**.



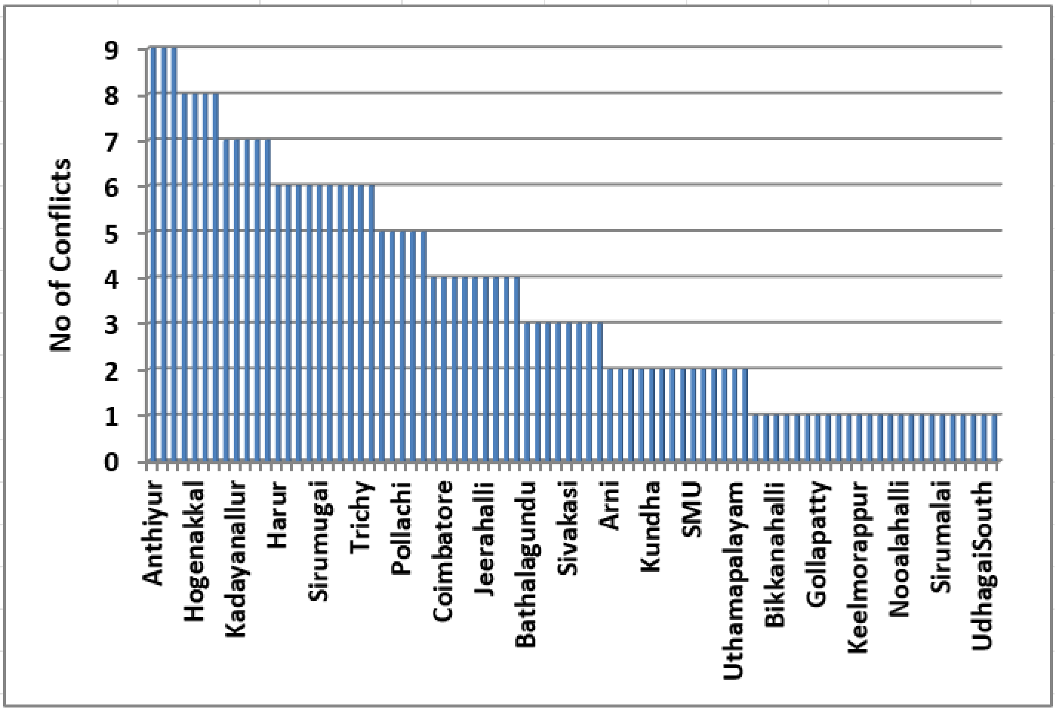

**[Fig. 10] Shows the frequency of the HWPC (Human Wild Pig Conflicts) in Division wise.**




**[Fig. 11] Shows the frequency of the HWPC in forest ranges (On a scale of 50 - 300).**



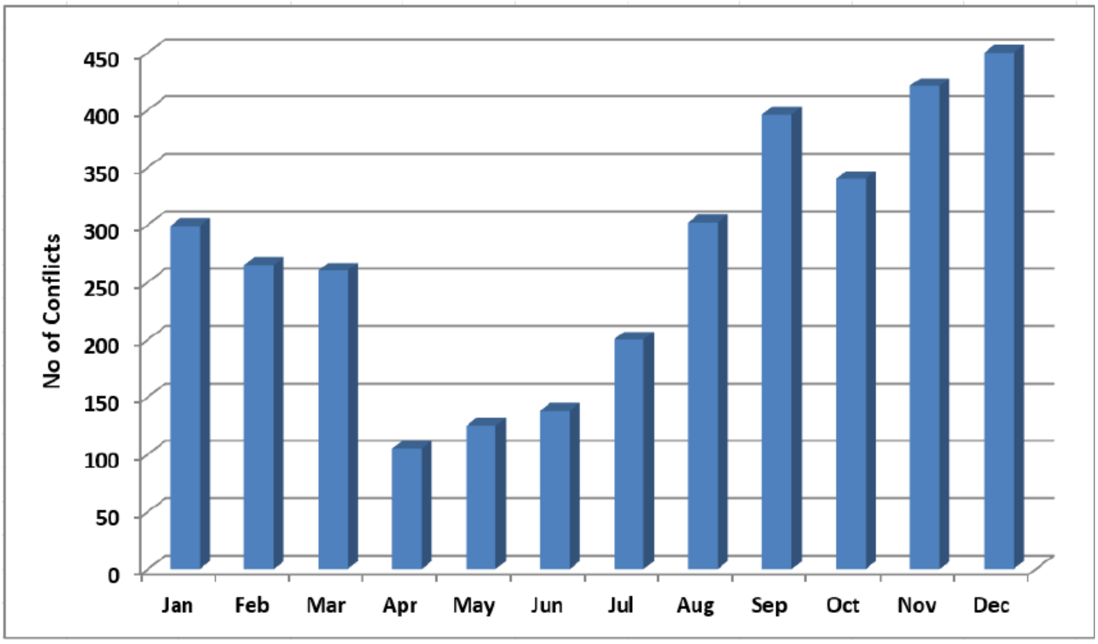

[Fig - 12] Shows the frequency of the HWPC in forest ranges (on a scale of 10 - 50).



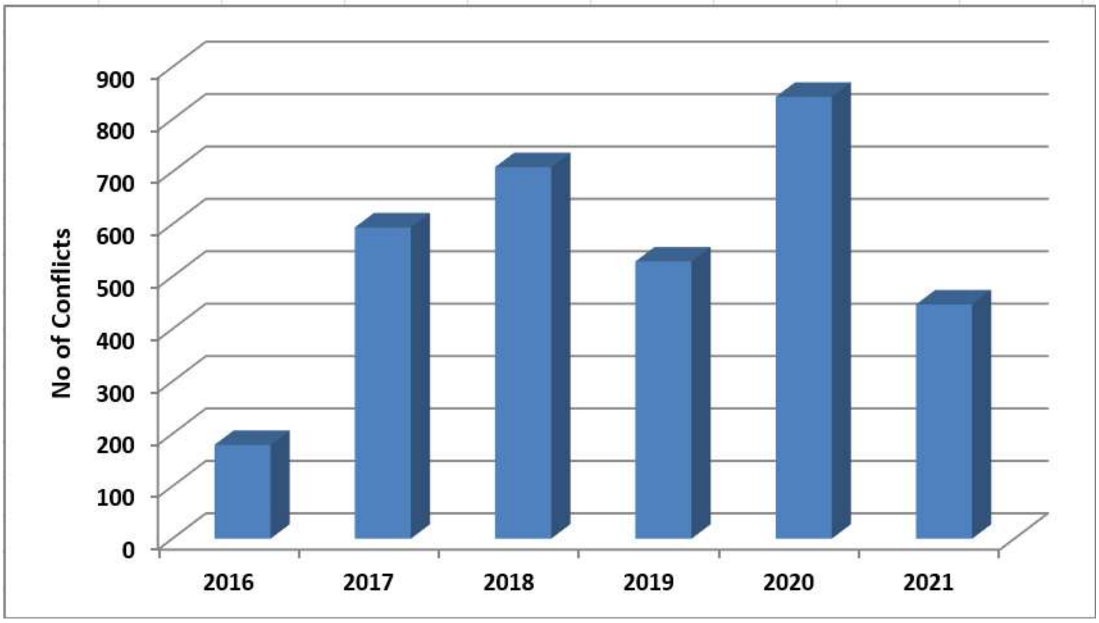

[Fig - 13] shows the frequency of the HWPC in forest ranges (on a scale of 0 - 10).

### 6.1.2. Temporal analysis:

- Overall, the conflict was high for the past few years (2016–2021) in the month of **December**, followed by **November** and **September**. The January, February, and March months showed a moderate amount of conflict. April was the least conflicted month, followed by May and June. While comparing the year-wise data, the same trends were observed. Out of the 5 years of data taken, the year 2020 saw the highest conflict **[Fig - 14]**.




**[Fig. 14] Shows the overall temporal pattern of HWPC (2016–21).**

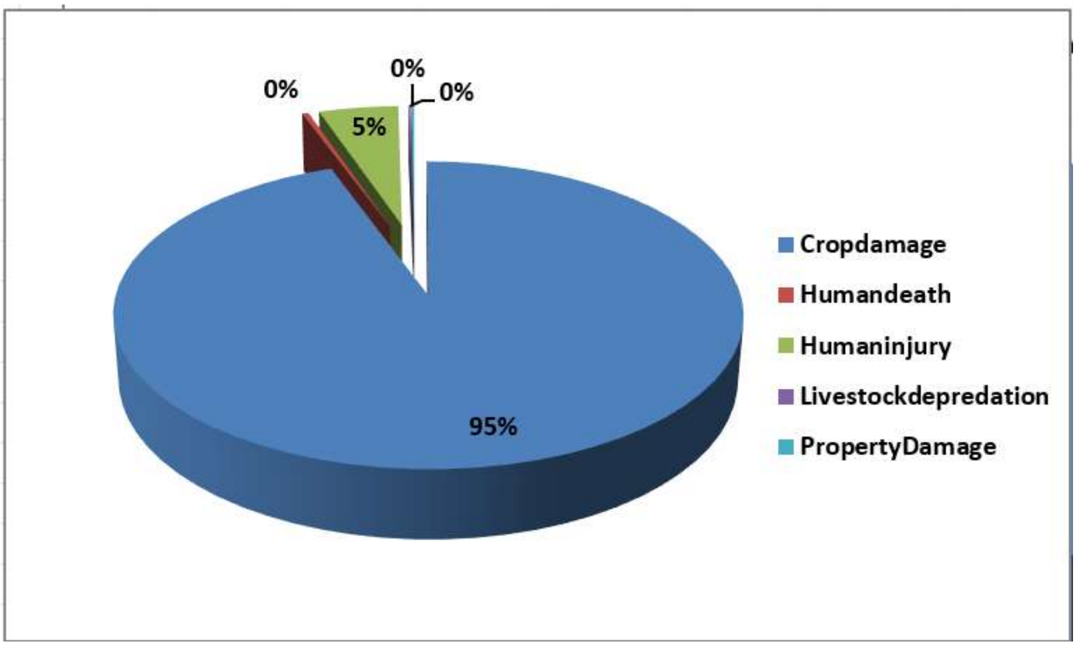



**[Fig. 15] Shows the year-wise pattern of HWPC.**

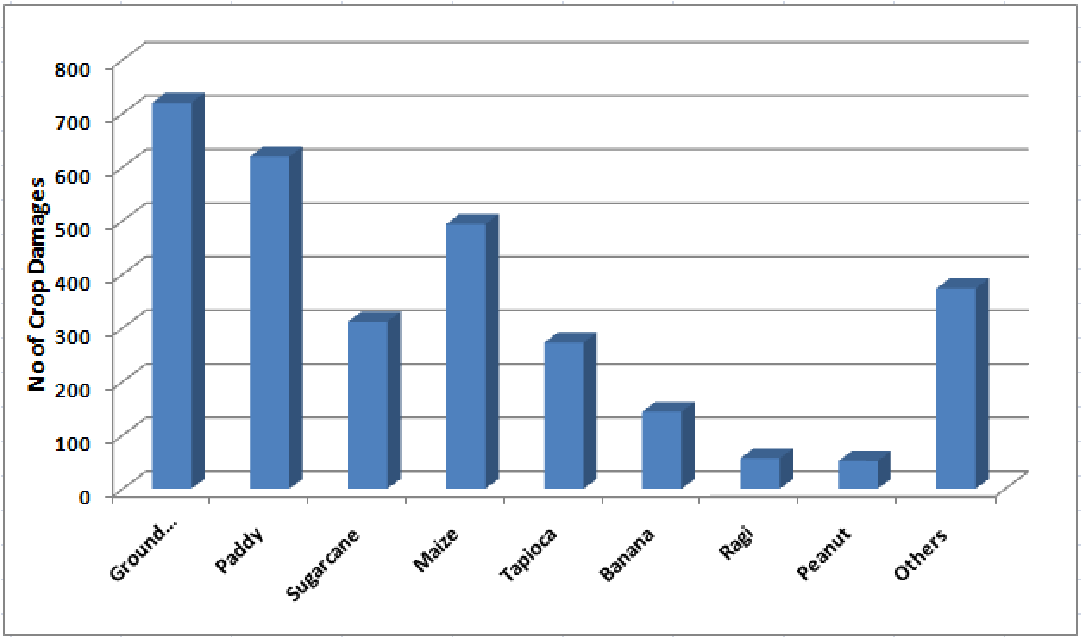
The above graph depicts the temporal pattern of conflict, which indicated that the highest conflict occurred in 2020, followed by 2018 and 2017. A very low frequency of conflict was observed in 2016, comparatively.

### 6.1.3. Conflict analysis

- Out of all conflict incidents wild pig found to be mostly involved with **crop damage (3171)** followed by **human injury (169**), **[Fig - 16]** and in crop damage category, out of **77 crops** being damaged, crop **groundnut (720 times**) was damaged most, followed by **paddy (620 times)**, **maize (485 times**) and **sugarcane (312 times**) **[Fig - 17]**.

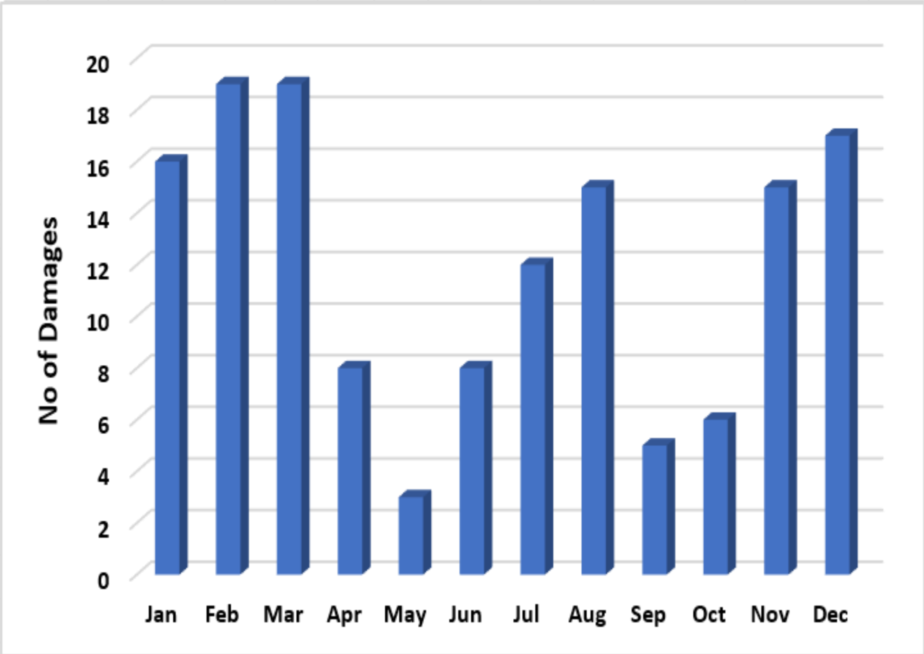



**[Fig – 16] Showing the frequency of types of conflicts.**



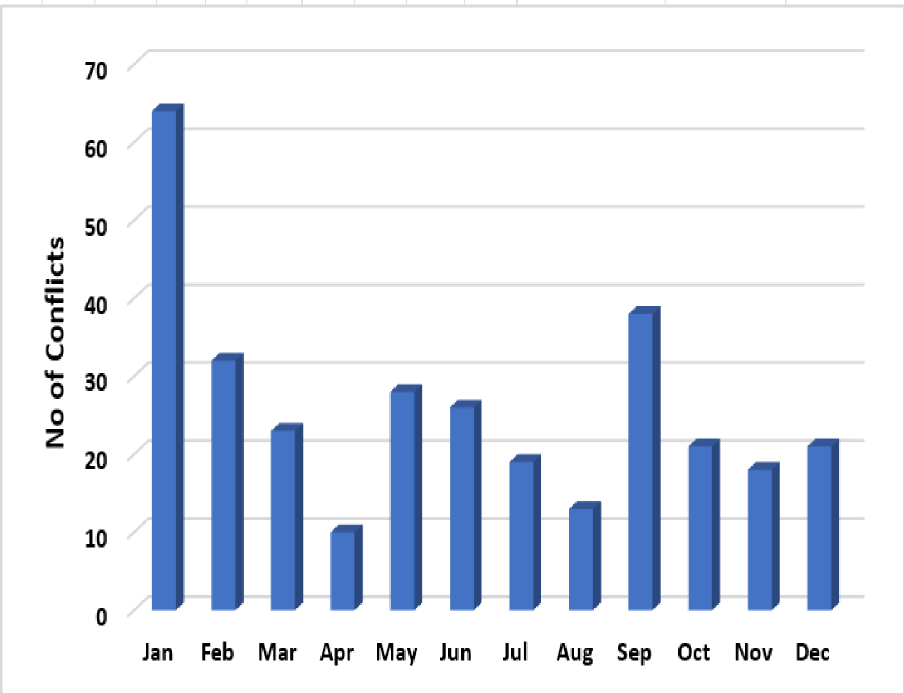

**[Fig. 17] Shows the crop wise frequency of damage.**

The above graph depicts the type of major crop damaged by wild pigs, which indicates that groundnut and paddy were the most damaged crops.



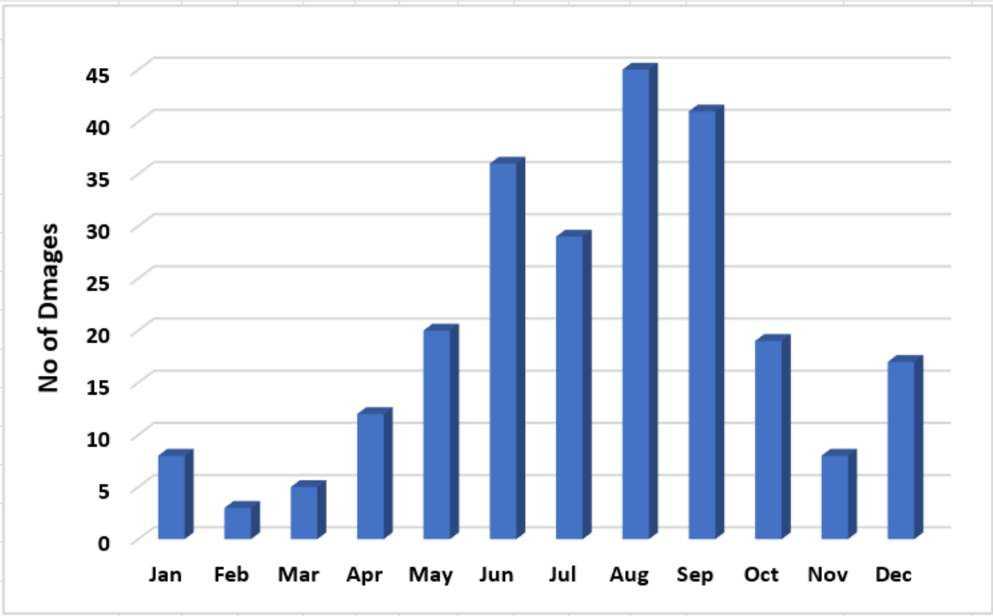

**[Fig. 18] Showing the temporal pattern of the banana crop damage.**

The above graph depicts that high banana crop damage was seen mostly during the months of November and March.



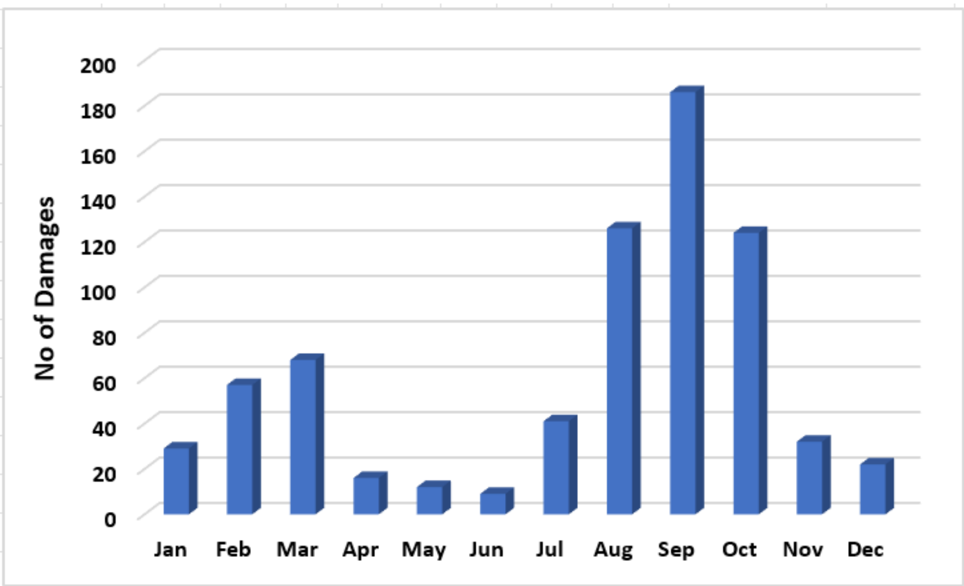

**[Fig. 19] Showing the temporal pattern of the Sugarcane crop damage.**

The above graph shows that sugar cane was mostly damaged during the month of January, followed by September.



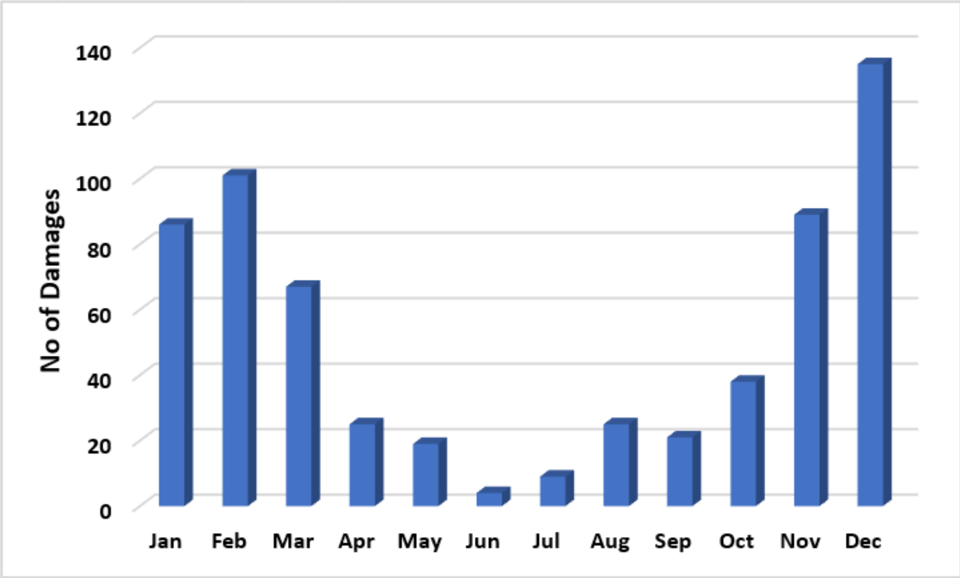

**[Fig – 20] Showing the temporal pattern of the damage to the tapioca crop.**

The above graph shows that Tapioca was mostly damaged from June to September.



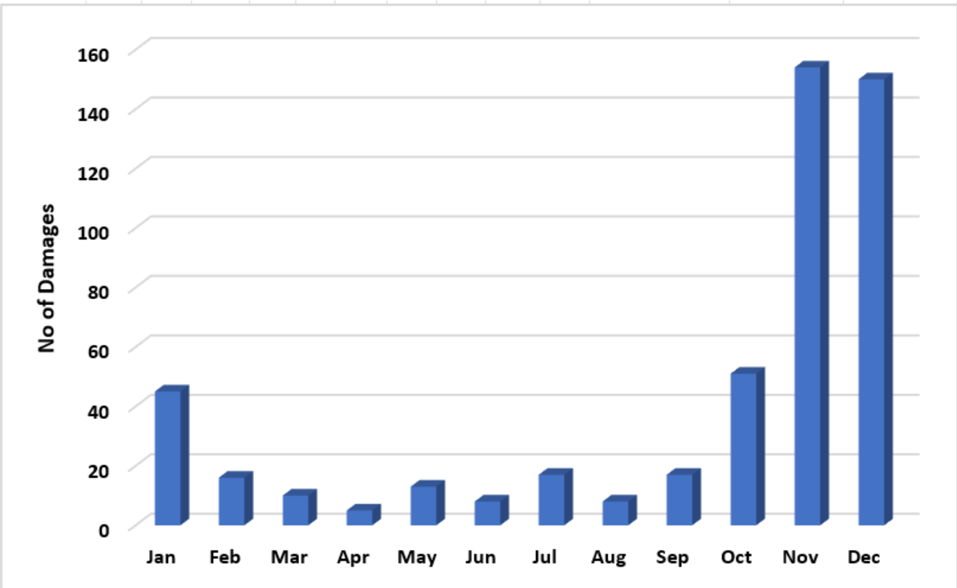

**[Fig. 21] Showing the temporal pattern of the Groundnut crop damage.**

The above graph shows that Groundnut Is mostly damaged from August to October.




**[Fig. 22] Showing the temporal pattern of the Paddy crop damage.**

The above graph shows that Paddy was mostly damaged during the months of November to March.

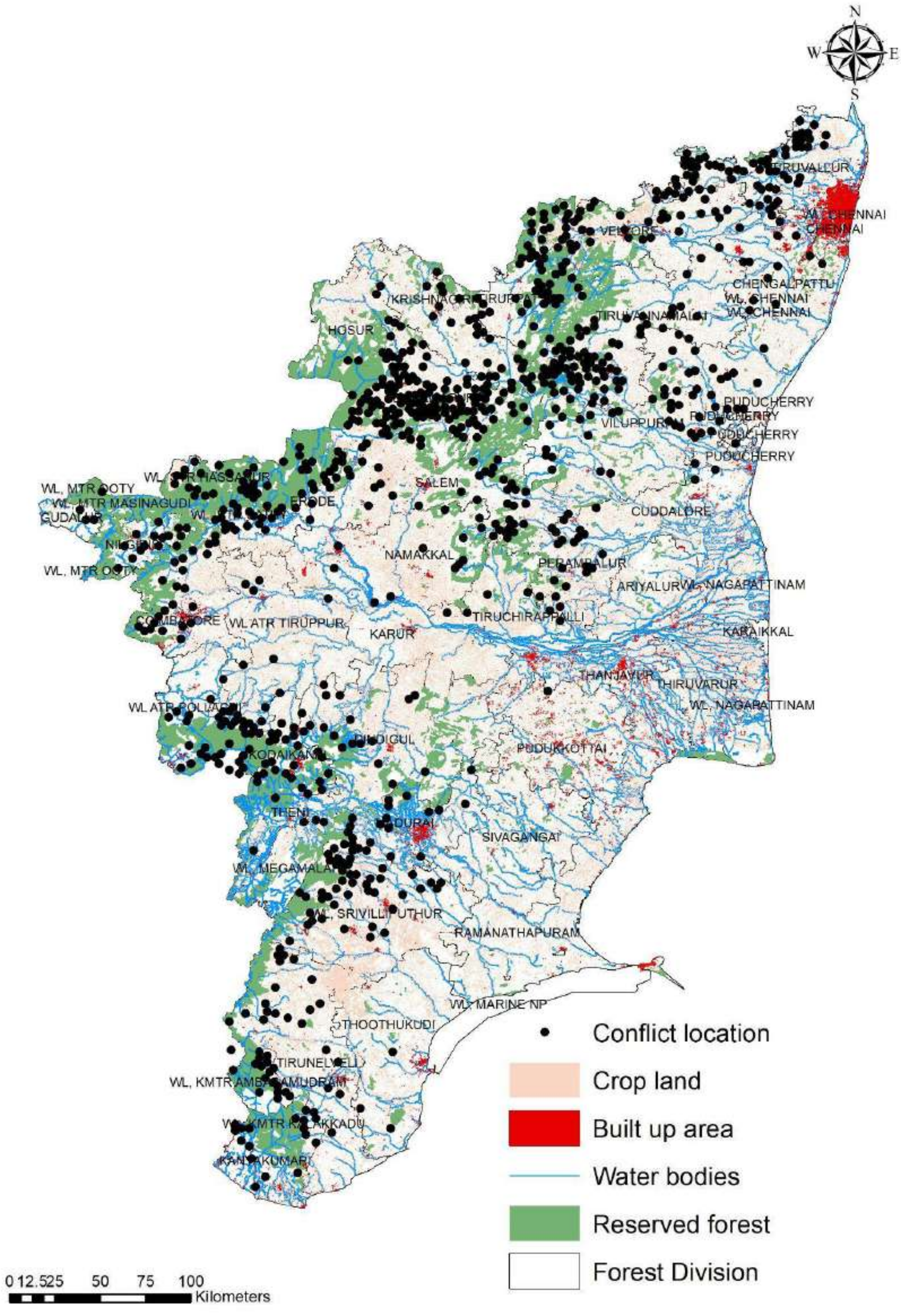



**[Fig – 23] Showing the temporal pattern of the damage to the Maize crop.**

The above graph shows that Maize was mostly damaged during the months of November and December.

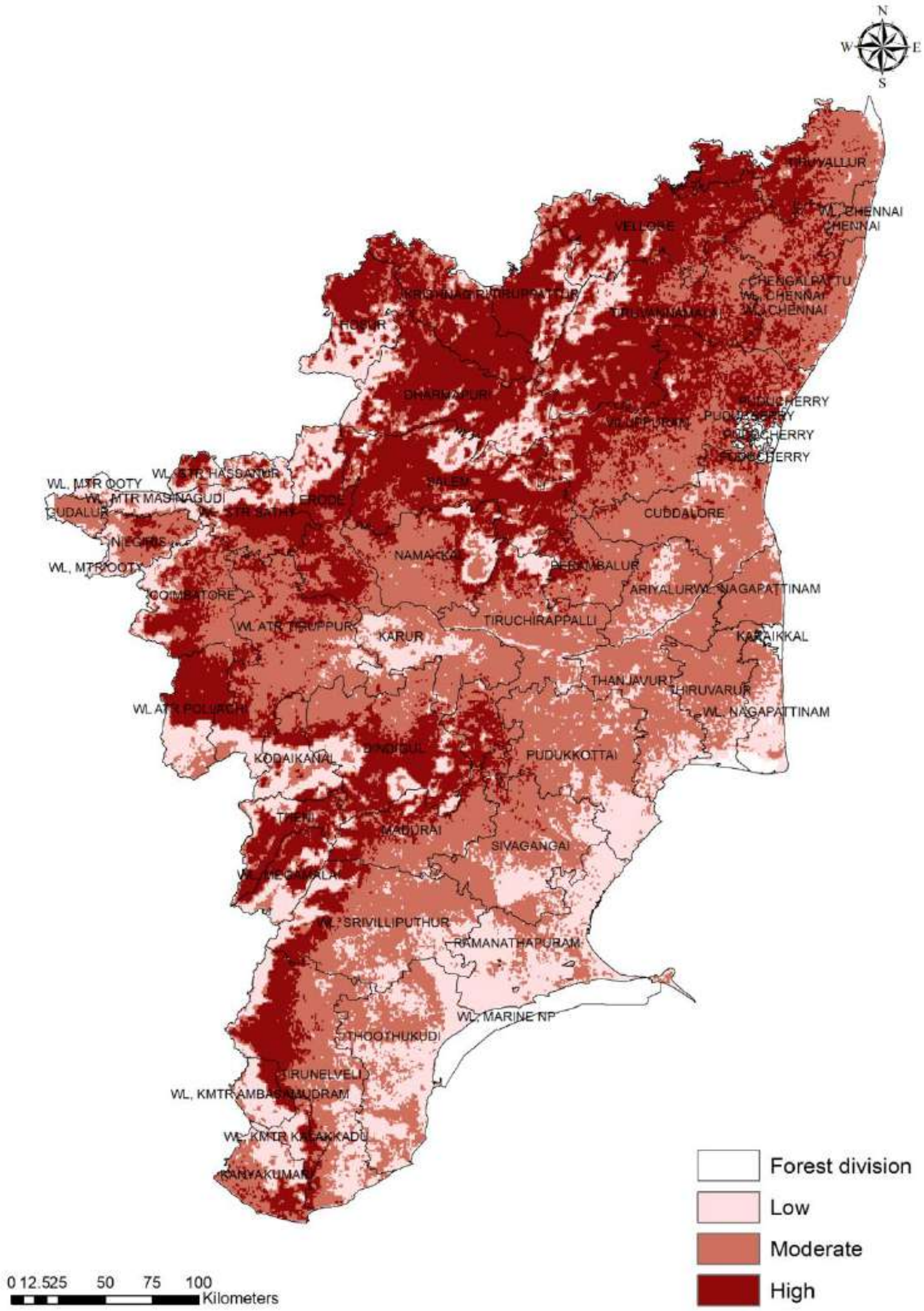
### 6.2.Compensation Payments:

- Total of **2907** wild pig conflict incident claims were settled as compensation by the state Govt **(35840759/-)** in a period of **5 years (2016 – 21**).
- Out of which **3825000/-** paid by Govt in accordance with human death (13 incidents) by wild boars and **4034886/-** settled for human injuries caused by wild boar.
- Total of **28200/-** paid for livestock and property damages, and **27952673/-** settled for all the crop raids caused by wild boars.



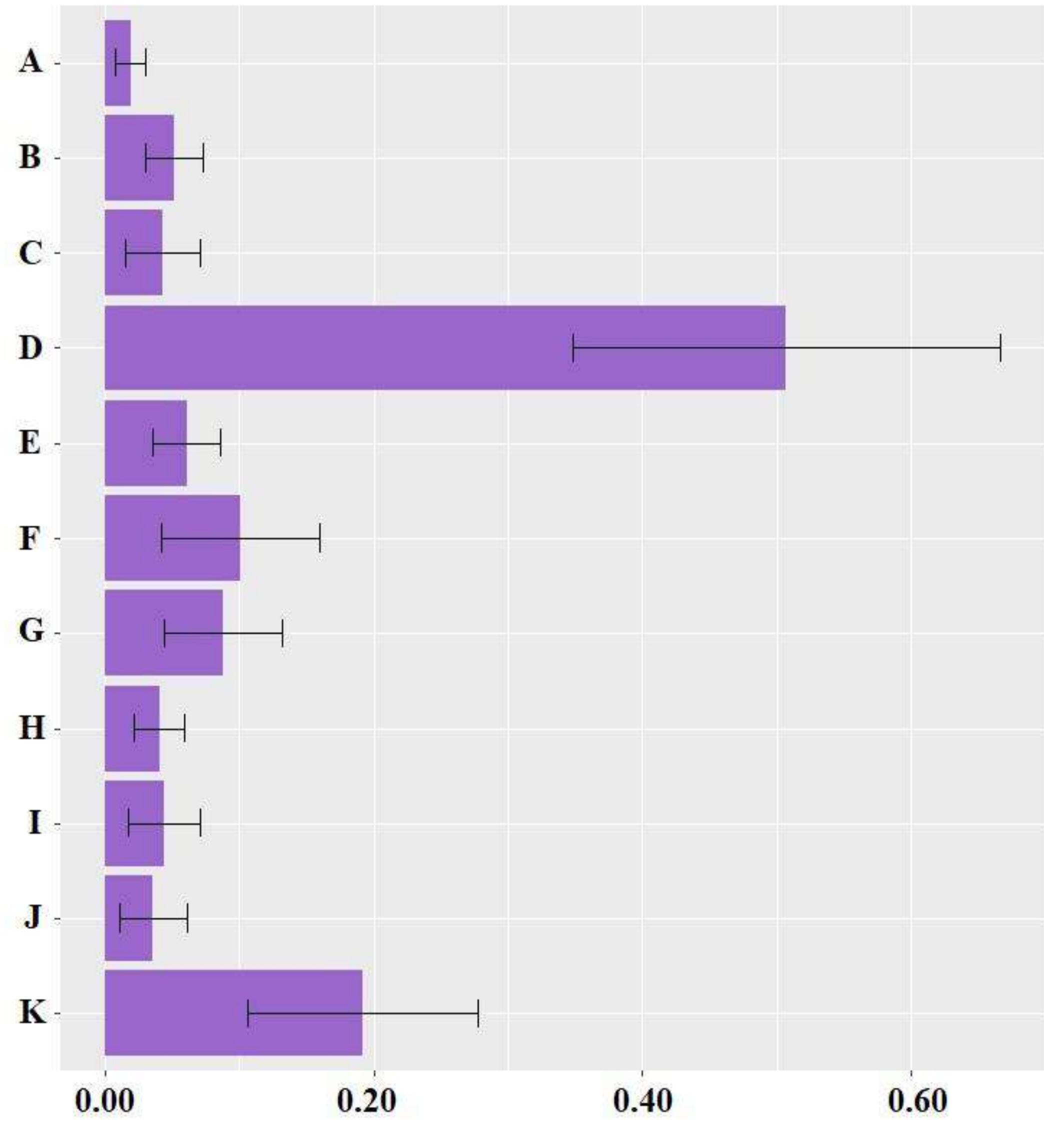

**[Fig – 24] Showing the spatial distribution of conflict locations of HWPC in the state.**

The above map shows that more conflicts happened in the North, North West, West and South west direction of the state.




**[Fig. 25]Map showing likelihood based predicted conflict risk zones of HWPC in the forest division of Tamil Nadu Red colour indicates high conflict risk zones.**

The spatial hotspot map shows high density at Dharmapuri, Krishnagiri, Tirupattur, Tiruvannamalai, Vellore, Salem, Dindigul, Theni, Megamalai and Tirunelveli Forest divisions.As per the modelling around **49223 km2** area comes under high conflict zone.




**[Fig - 26] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Human modification index, E. Normalised vegetation index, F. Distance to forest cover, G. Digital elevation model, H. Distance to crop land, I. Distance from built up area, J. Isothermality, K. Annual precipitation, L. Mean annual temperature.**

The above graph shows that the human modification index has contributed maximum to the HWPC risk modeling followed by Annual precipitation and Distance from forest cover.

## 6.3. Glimpses of field visits

**[Fig – 27]** Cloth fencing as a mitigation measure for wild pigs, the lady came to this tea plantation for work while the pig attacked.

**[Fig – 28]** A lady was attacked by a Wild Pig in Kattabettu range.

### 6.4.Discussion:

The above study reveals the forest divisions and ranges that are high in wild pig conflicts as these ranges provide a varied choice of crops, as well as forest coverage and human settlements near the RFs **[Fig - 10, 11, 12, 13]**. These settlements provide an easy option to them in the form of nutritious crops **[Fig - 17]**. Crops such as banana, groundnut, tapioca, sugarcane, paddy and maize provide them with a delicious and nutritious alternative compared to the forest. The above analysis shows that crop damage is the highest type of conflict happening followed by human injury, which is because they get aggressive while chasing them or keeping them away from the crops **[Fig - 16].** Cultivation of vegetables such as tomatoes and cabbages etc attracts wild pigs (Senthilkumar et al. 2020). Globally, similar studies show that wild pigs prefer vegetables such as tubers (potatoes) and maize and millets (Chauhan et al. 2009; Chauhan 2011; Singh and Kumar 2018; Liu et al. 2019). Extensive human modifications have reduced the forest cover and made it inevitable for the wild pigs to live in fragmented and disturbed habitats, which are further associated with causing conflicts (Chauhan 2011).

From the above data, we can observe the temporal pattern of crop damage. Overall damages happen during crop harvesting time which is around Sep to Dec and Jan to Mar **[Fig 14]**. While we can understand the temporal pattern of overall crop damages, it is important to understand the months can fluctuate according to the type of crops. While banana crops can be attacked mostly during Feb and Mar and the winter season, we still see a spike around Jul, Aug also which indicates that they attack during the young stage as well. The root mass of banana trees is nutritious and tasty to them; and the stem part is easily accessible to them during the young stage. That shows that even if the harvesting time can be different, their attack timelines can be different according to their preference and crop type **[Fig 18].**

Tapioca and groundnut we can observe somewhat similar types of temporal patterns of conflicts because they have different harvesting times that is during Jul, Aug and Sep. That is the time for wild pigs to attack the crops **[Fig 20, 21].** Paddy and corn are both winter crops which mean their harvesting starts in Nov and lasts till Feb. Hence the rise in the graph checks out **[Fig 22, 23].**

The human-wild-pig conflict in Tamil Nadu is one of the major HWC cases. The government and biologists both still haven't figured out the solutions to it. Wild pigs can get aggressive and that is when they sometimes attack humans. They are voracious feeders and dig up all the roots and eat tubers and damage the property, and while digging they harms other crops too. They also eat fruits and nuts etc. so they have a varied selection of crops which make them dangerous throughout the year as they can have many different foods according to the harvesting month. They can charge at humans if they feel threatened or cornered, this results in severe injuries or sometimes even death.

As the map **[Fig – 24]** shows conflict locations of HWPC across the state and it clearly shows that the intensity of conflict is higher in the North, North West, West and South West directions which constitutes densely populated districts like Vellore (4,566,538), Tiruvallur (4,324,973), Dharmapuri (1,748,089) and Tiruvannamalai (2,859,501). These districts grow higher cash crops such as groundnut, paddy, and corn. Veggies like okra and eggplants, fruits like mangoes and bananas, which matches our data of crops damaged by wild pigs. These factors contribute to higher occurrence of HWPC in these districts as human population and having vast cultivation areas attracts the wild pig population in the forest fringes to raid crops. As the map **[Fig - 25]** shows the risk prediction of the HWPC in the state, we can conclude that bright red coloured divisions require more focus in aspects of HWPC management.

### 6.5. Management Implications for HWPC:

The management of Human-Wildlife Conflict (HWPC) has prompted a range of strategies employed by both the forest department and local farmers. The existing measures encompass cloth fencing, low-height electric fencing, and chasing, compensation, and awareness campaigns. Notably, among these, cloth fencing has demonstrated a degree of effectiveness, as reported by forest officials and farmers. Additionally, certain areas have experimented with Bio repellent oil as a mitigation measure, although its utility is limited due to its high cost and short duration of effectiveness. Addressing the complexity of the issue demands a multi-faceted approach, drawing on insights from various disciplines. This entails active collaboration between local farmers, panchayats, police departments, and medical departments to expedite compensation processes. A strategic proposition involves the introduction of insurance options for farmers or the provision of subsidies to those unable to install protective fences. Emphasizing community engagement is crucial, given the interconnected nature of the challenge; securing one farm might inadvertently lead to wild pig raids on neighbouring crop fields, thereby escalating wild pig conflicts. To address this, a comprehensive solution is proposed: the establishment of fencing encompassing entire community croplands, facilitated by NGOs or government initiatives. In this arrangement, farmers would assume responsibility for fence maintenance, adapting it as necessary. By fostering this collaborative model, a more sustainable approach to managing HWPC can be achieved, minimizing conflicts while promoting harmonious coexistence between humans and wildlife.

During our discussions with forest officials, it became evident that a more streamlined approach is needed for the allocation of funds. The current allocation doesn't adequately cater to the varying degrees of challenges faced by different ranges. It's imperative to adopt a more nuanced funding strategy that takes these variations into account. To enhance the efficiency of wildlife conflict management, forest officials have highlighted the necessity of revising the allocated budget. This is particularly critical for ranges that engage in frequent nightly patrolling and pursuit activities. A recurring issue arises from the promotion of watchers to guard positions, resulting in vacant watcher and anti-poaching watcher (APW) roles. To address this, a consistent recruitment process for these positions needs to be established. Furthermore, there's a disparity in resources and staffing between larger and smaller ranges. Some ranges lack sufficient vehicles and fuel, impacting their operational capabilities. It's worth exploring the allocation of additional resources to address these discrepancies. Additionally, for larger ranges, there's potential to optimize management by dividing them into smaller units and recruiting new staff accordingly. This approach could significantly enhance conflict resolution efficiency. In pursuit of a comprehensive solution, there's a suggestion to empower and educate local tribes. This can be achieved through training programs that enable them to form committees dedicated to conservation and sustainability. By involving the local communities, we not only disseminate crucial knowledge about wildlife conservation but also create an avenue for passing on this awareness to the younger generation. This approach has the potential to cultivate a generation of wildlife guardians who understand and value the significance of conservation efforts.

Engaging with farmers, we have unearthed certain limitations in the current compensation structure, which appears to be somewhat superficial. For instance, the prevailing practice of offering a flat compensation of 500/- per coconut tree, regardless of its maturity, is being questioned. Farmers propose a more context-sensitive approach by factoring in the developmental stage of the crop when determining compensation. This suggestion applies not only to coconut trees but extends to other crops as well. Implementing such an approach could render compensation more reflective of the actual losses suffered by farmers.

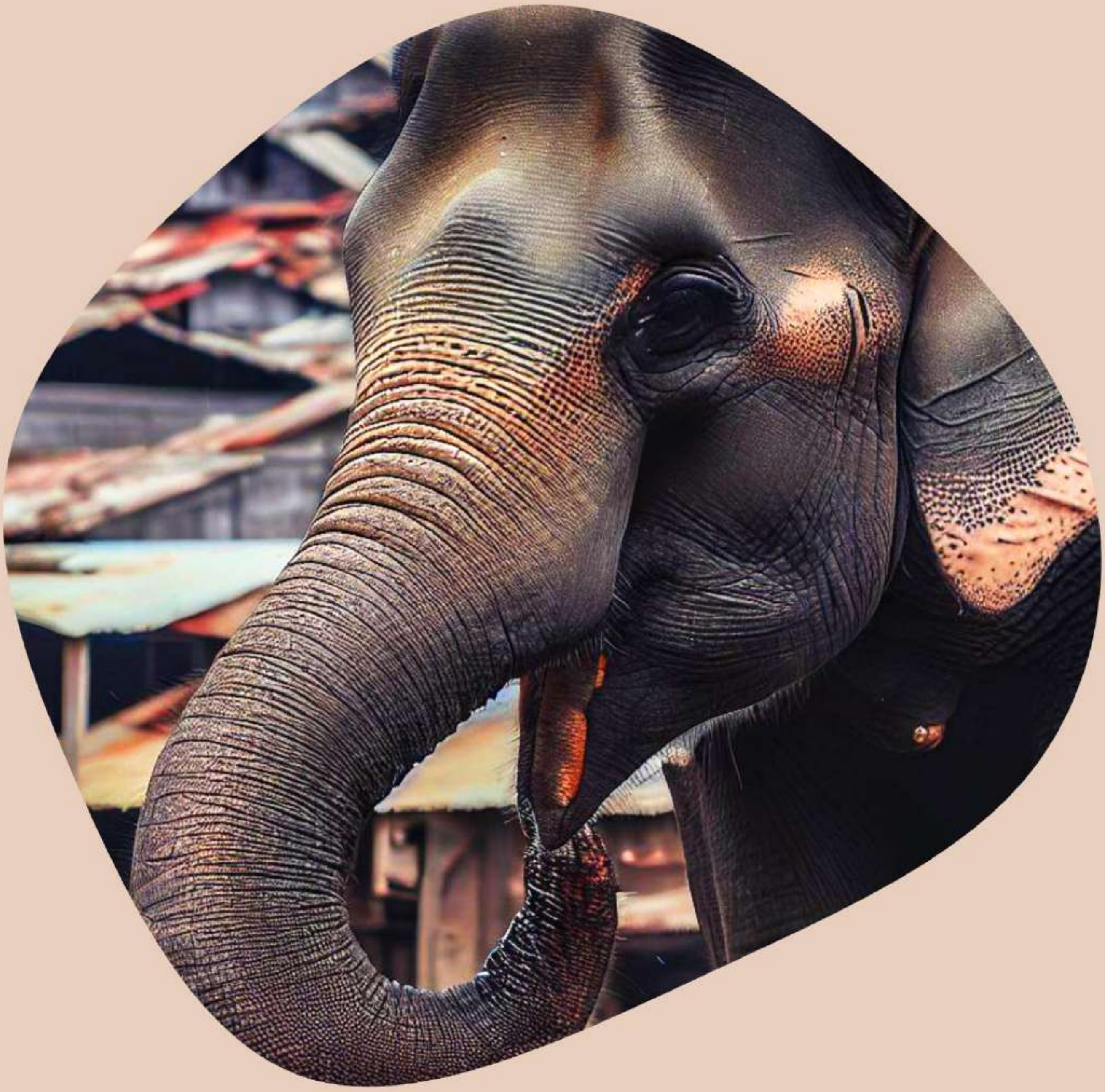
Drawing inspiration from global and national examples, an innovative measure involves using human scalp hair (HSH) as a deterrent. This method has demonstrated effectiveness in different Indian states. The hair, when ingested by wild pigs, causes irritation and disrupts their activities. Pigs encountering individuals with hair in their snouts produce alarm calls, deterring others from venturing into crop lands (Rao et al. 2015). Likewise, other practices from various regions have been identified, such as deploying solutions derived from wild pig dung and burning dried dung cakes to minimize territorial conflicts (Rao et al. 2015).

It's recommended that mitigation strategies be tailored to the specific location, household socioeconomic status, wildlife species, and regional policies (Karanth et al. 2017). Numerous researchers have put forth additional suggestions, including the use of wire mesh fencing (Thapa, 2010), pig-proof barriers (Chauhan et al. 2009), and cultivating less preferred crops or altering cropping patterns (Barwal, 2013). Population control strategies have also been explored, as demonstrated by studies (Colomer et al. 2021).

The concept of the "Reserve effect" proposes occasional hunting to disrupt wild pig social organization. Studies suggest that such hunting can potentially mitigate crop damage caused by wild pigs (Geisser et al. 2004). By leveraging these insights and practices, a more comprehensive and effective approach to managing human-wildlife conflict can be developed, ultimately benefiting both farmers and wildlife conservation efforts.

# CHAPTER - 2

## HUMAN - ELEPHANT CONFLICT



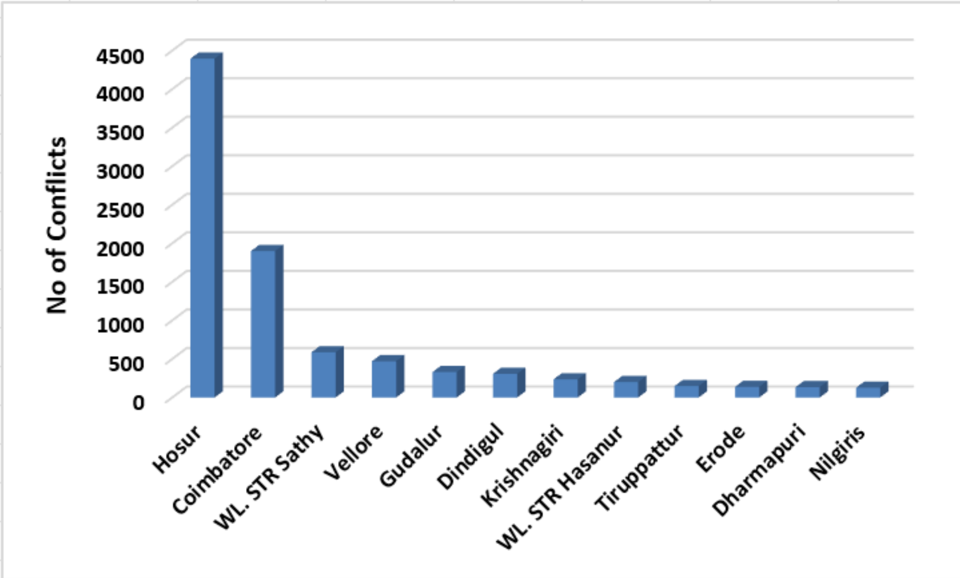
# 7. CHAPTER 2: HUMAN ELEPHANT CONFLICT (HEC)

Elephants are intelligent and resilient mega herbivores who tend to be quick learners. Their taste for fruits such as jackfruit, banana, etc. often brings them face to face with humans. These kinds of situations further lead to HEC, and often they end with fatal consequences for both parties. Elephants migrate out of their habitat for two of the most common reasons that are fodder and mate selection. During these movements, they often come across human settlements and their croplands. This further leads to various kinds of conflicts, such as crop damage, human death, and injuries. These conflicts have escalated in the past decade, making them a grave concern for the forest department and conservationists as well. Hence, thorough research and analysis are needed to uncover the underlying factors such as anthropological pressures, socioeconomic impacts, and behavioural patterns. We have presented our analysis of the spatiotemporal distribution of HEC. We believe that these insights will provide better perspectives for the management to better handle HEC in the state.

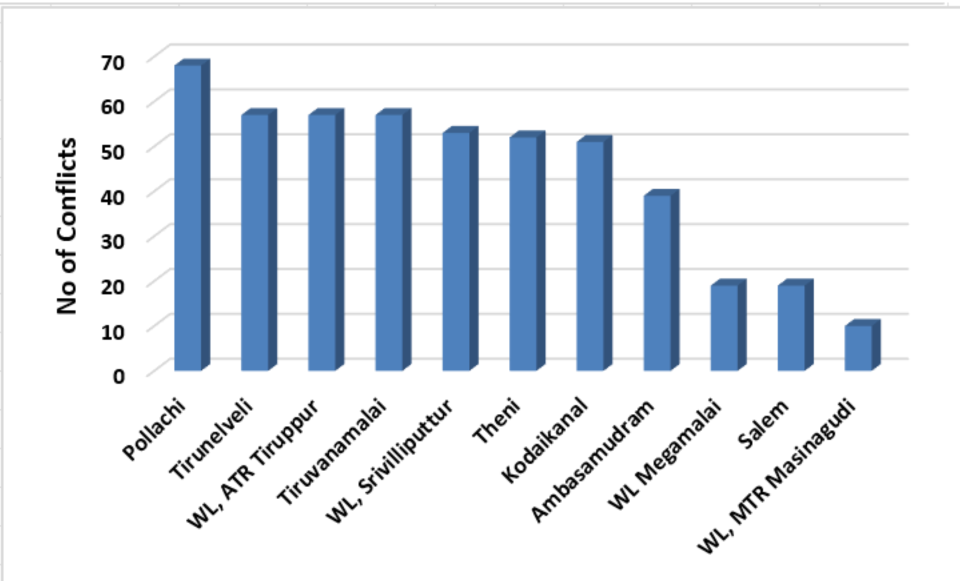
## 7.1. Results

### 7.1.1. Frequency analysis:

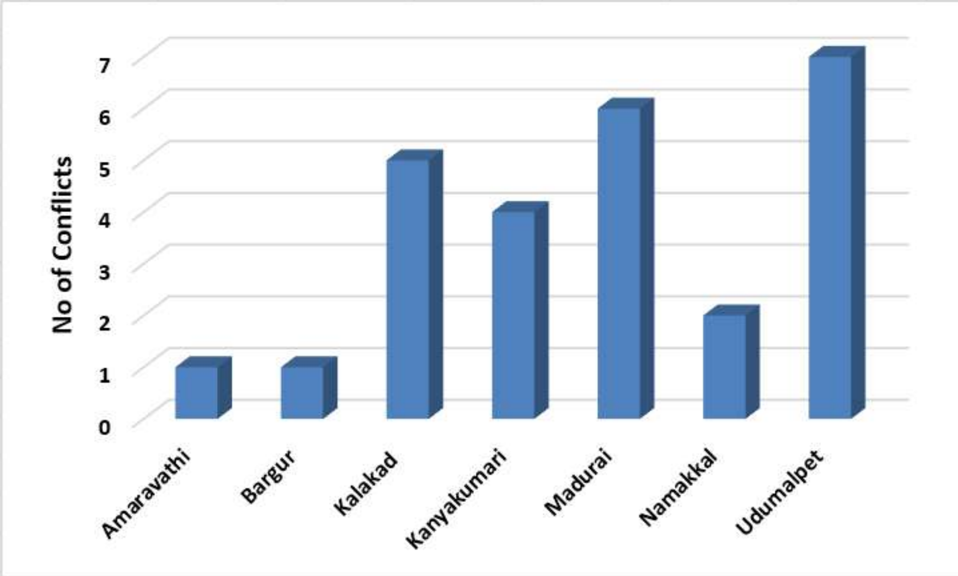
- From the above study, we have observed that elephant conflict has been rising for the past few years. From the collected secondary data, it seems there are **9477** elephant conflict records in the state. Out of these, the maximum number of conflicts was found to be in **Hosur division (4395**) followed by **Coimbatore (1899**). The lowest number of conflicts was found in the Amaravathy (1) and Bargur divisions (1) etc. [Fig – 29, 30, 31]
- **Denkankottai range (1539**) was observed to be highest in elephant conflict, followed by **Hosur range (1284**) and **Jawalagiri range (858**). [Fig –32, 33, 34]



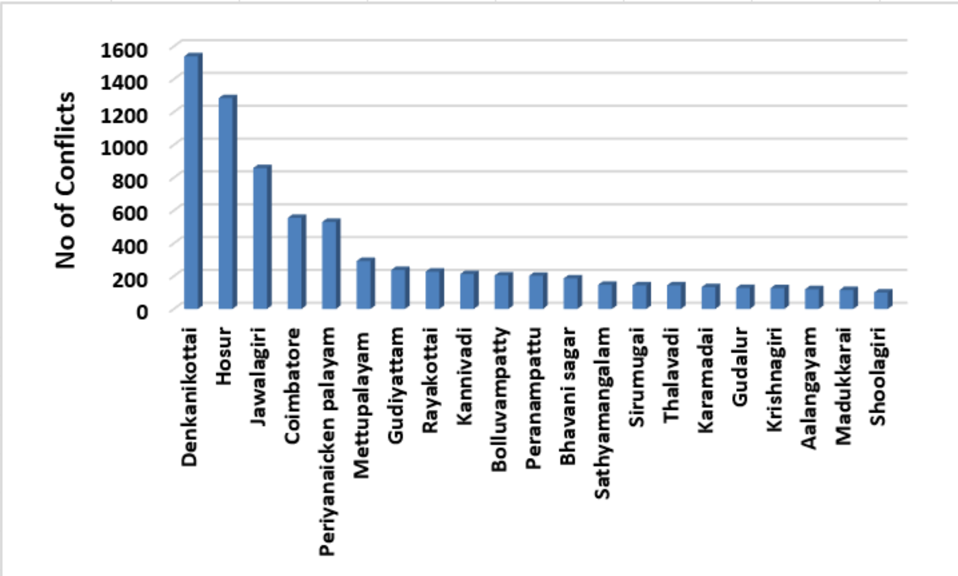

**[Fig - 29] shows the frequency of the HEC in Forest divisions (on a scale of 100 - 4500).**



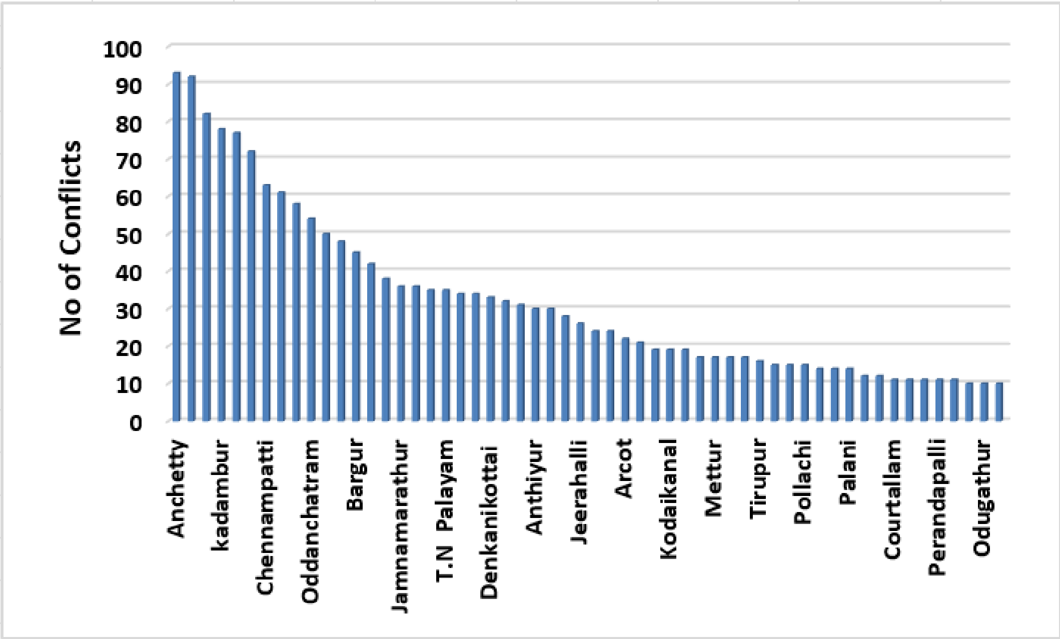

**[Fig - 30] shows the frequency of the HEC in forest divisions (on a scale of 10 - 100).**



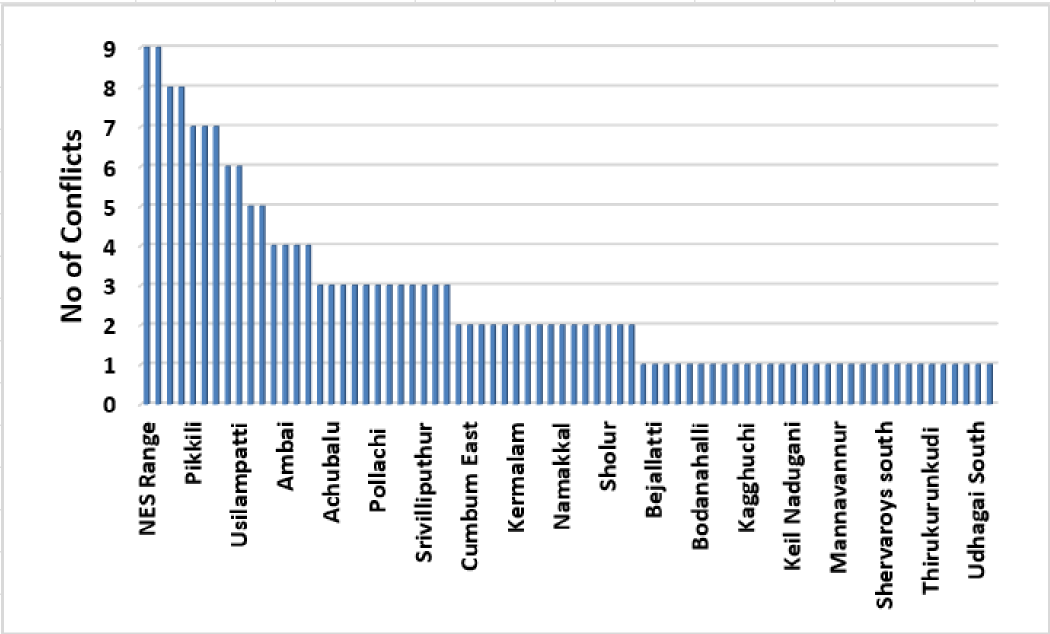

**[Fig - 31] shows the frequency of the HEC in forest divisions (on a scale of 0 - 10).**




**[Fig - 32] shows the frequency of the HEC in forest ranges (on a scale of 100 - 1600).**



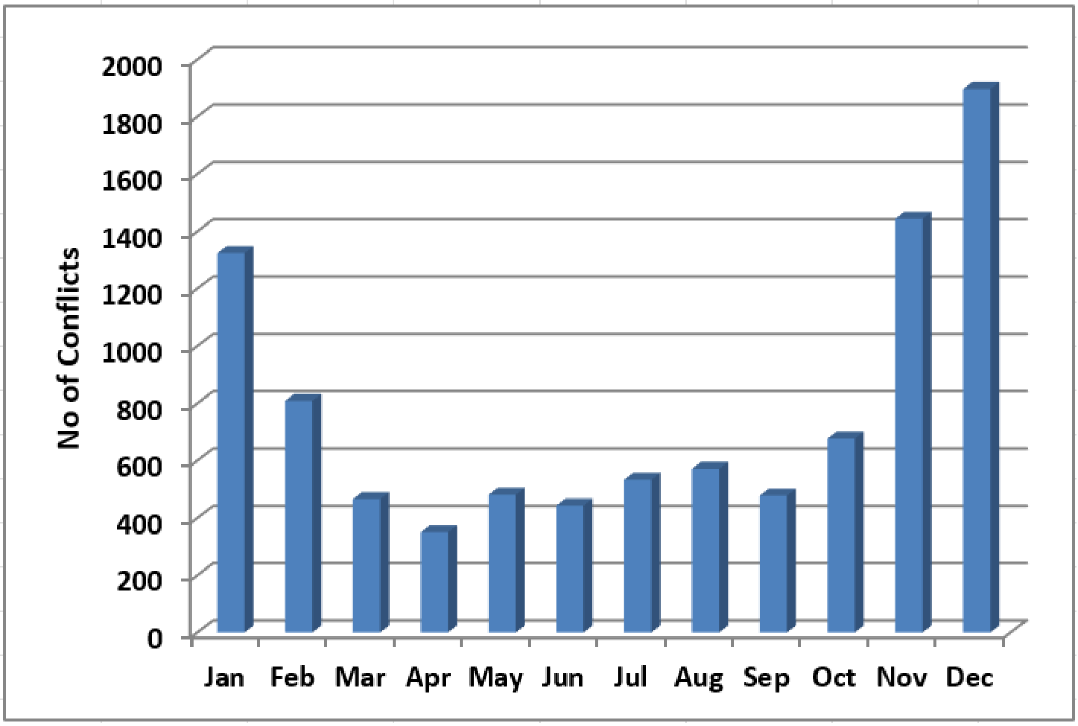

**[Fig - 33] shows the frequency of the HEC in forest ranges (on a scale of 10 - 100).**



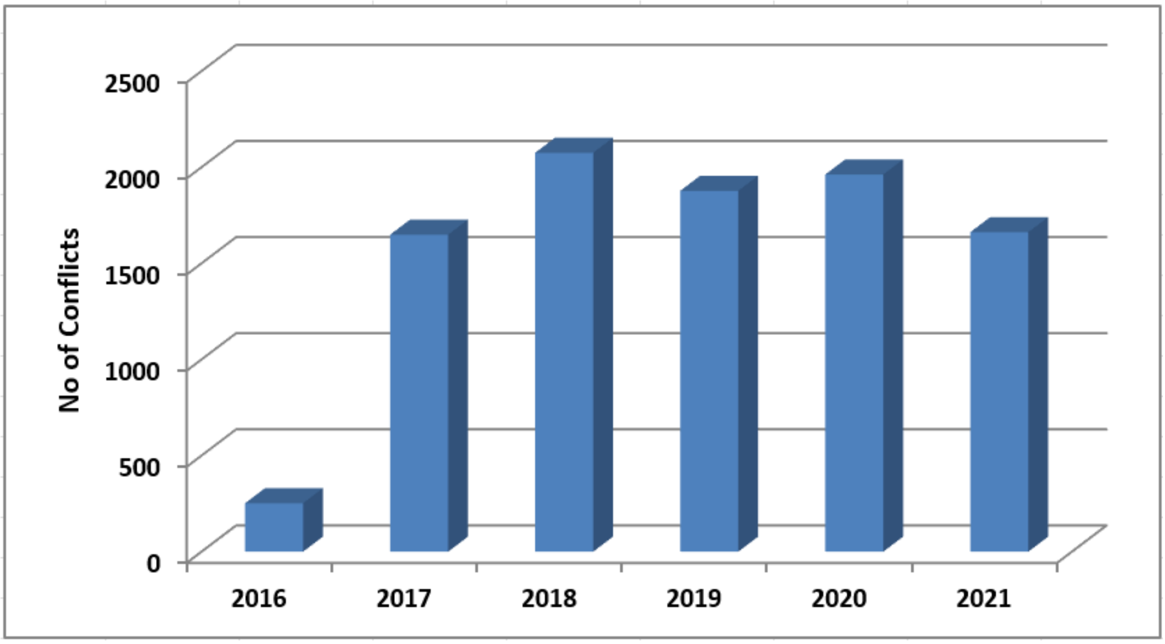

**[Fig - 34] shows the frequency of the HEC in forest ranges (on a scale of 0 - 10).**

### 7.1.2 Temporal Analysis

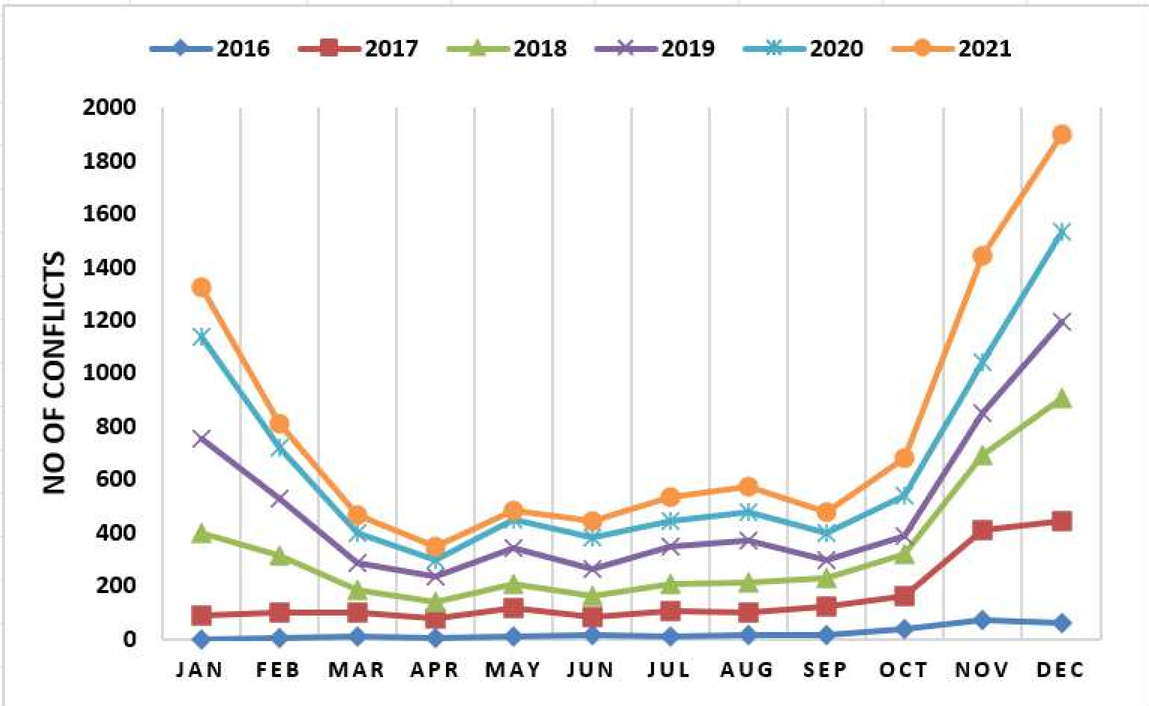
- Overall, the conflict was high for the past few years (2016–2021) in the month of **December**, followed by **November** and **January** [Fig - 35]. The February and October months showed a moderate number of conflicts. April was the least conflicted month followed by June and March. While comparing the year-wise data, the same trends were observed. Out of 5 years of data taken, the year 2018 saw the highest conflict [Fig - 36].




**[Fig - 35] shows the overall temporal pattern of HEC (2016–21).**



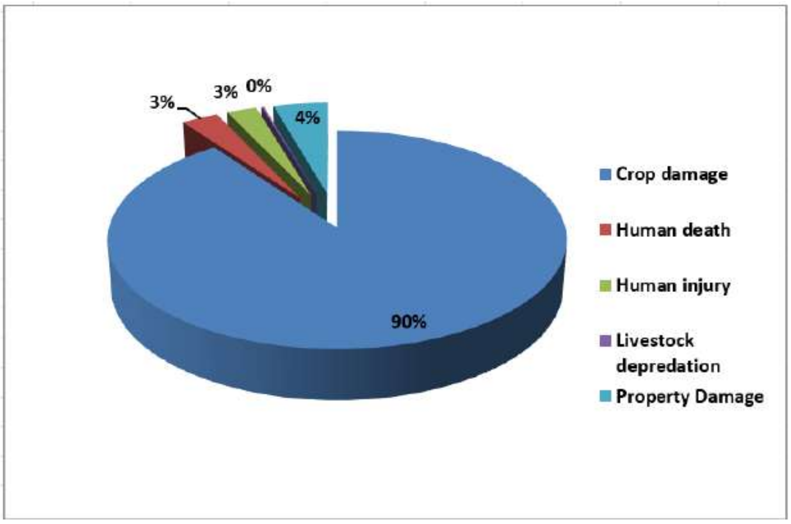

**[Fig - 36] Showing the year-wise HEC pattern.**



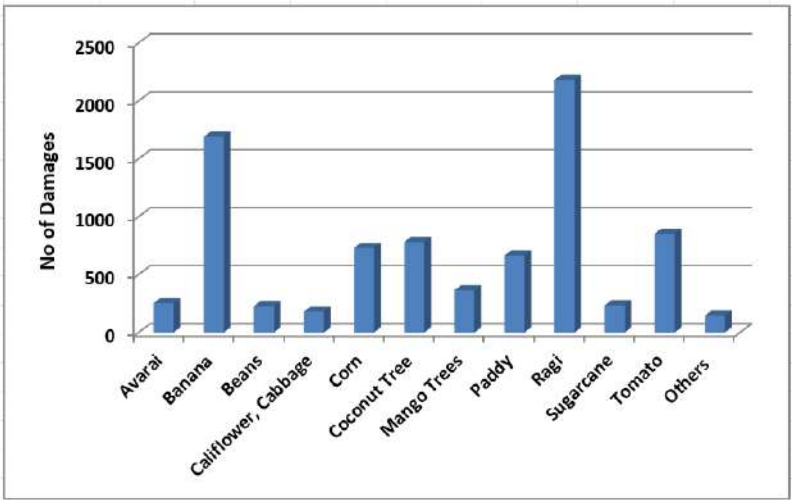

**[Fig - 37] shows the trend in HEC both month and year wise.**

### 7.1.3 Conflict Analysis:

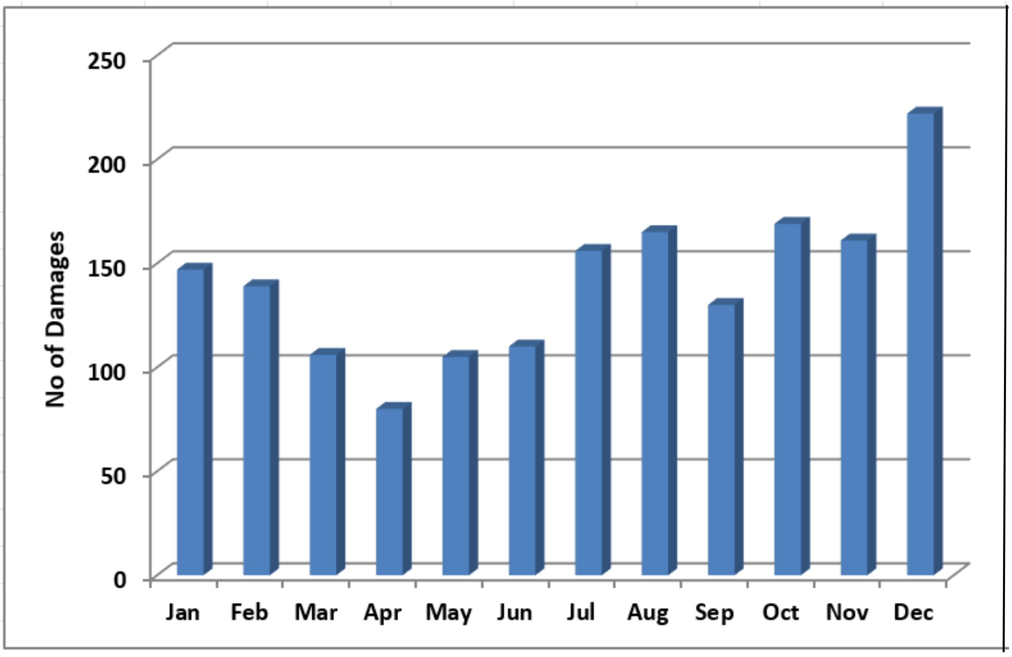
- Out of all conflict incidents elephants found to be mostly involved with **crop damage (8530)** followed by **property damage (418)**, **human death (281**), and **human injury (230)** [Fig - 38]**.** In the crop damage category, out of all the crops being damaged, 15 crops were damaged in a significant amount; other crops were not preferred mostly. Crop **raagi (2182 times**) was damaged most, followed by **banana (1690 times)**, **tomato (854 times**) and **coconut (782 times**) [Fig - 39].




**[Fig - 38] Showing the frequency of different types of conflicts in HEC.**

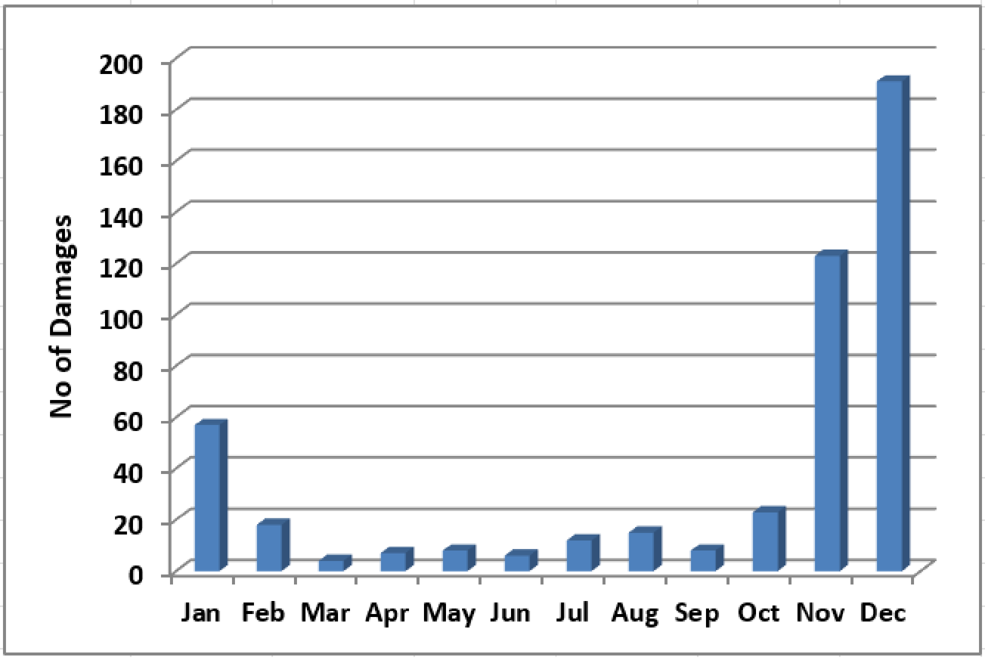



**[Fig - 39] Showing the crop wise frequency of crop damage from HEC.**



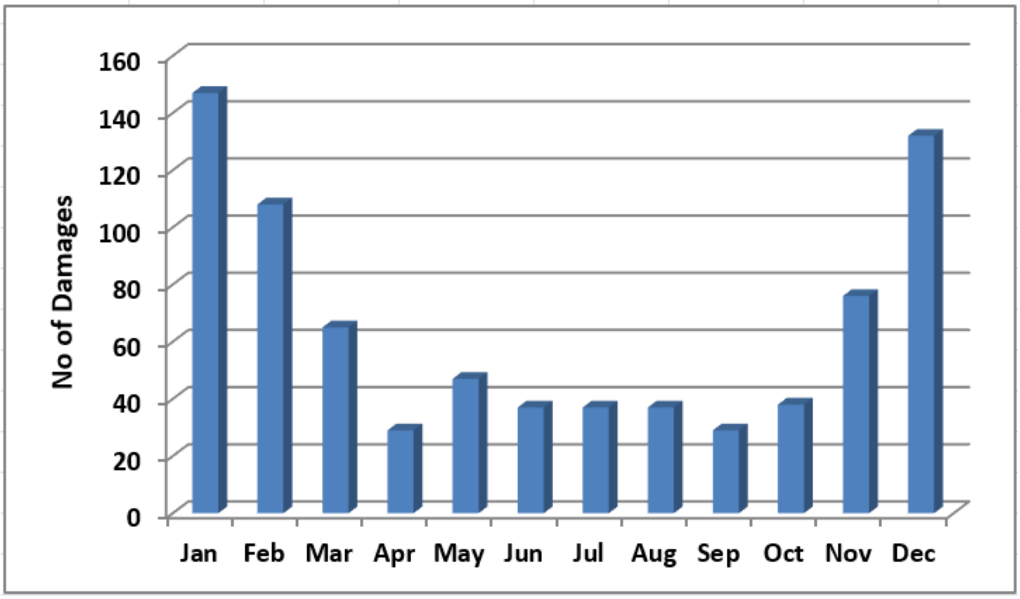

**[Fig - 40] Showing the temporal analysis damage of a banana tree**

The above graph depicts a temporal analysis of the banana crop which reveals that the crop is being damaged in Dec, followed by Oct and Aug months.



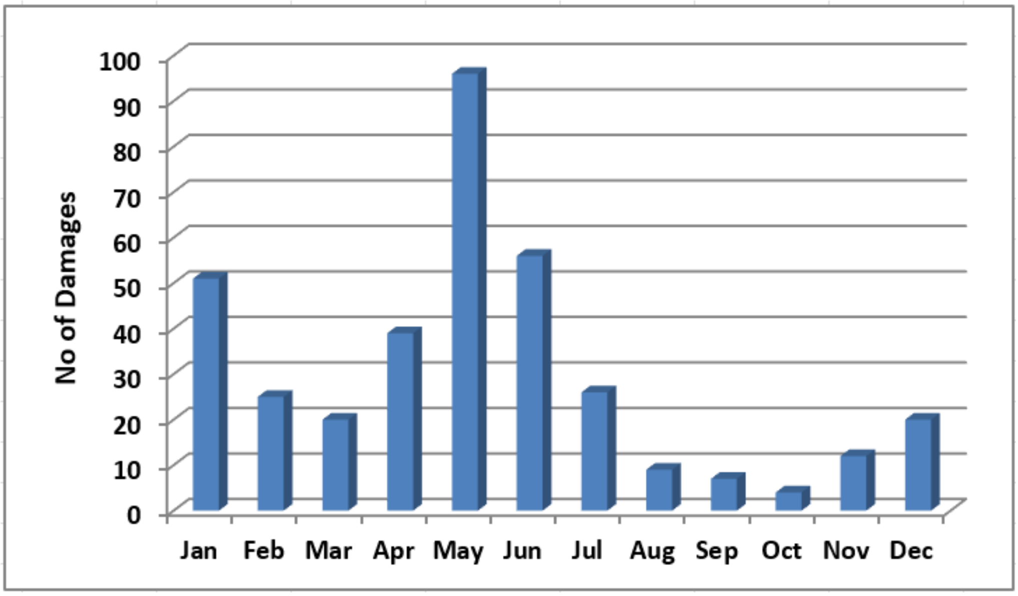

**[Fig - 41] Showing the temporal analysis damage of corn.**

The above bar graph depicts that the corn is favoured mostly in the month of Dec, followed by Nov and Jan months.



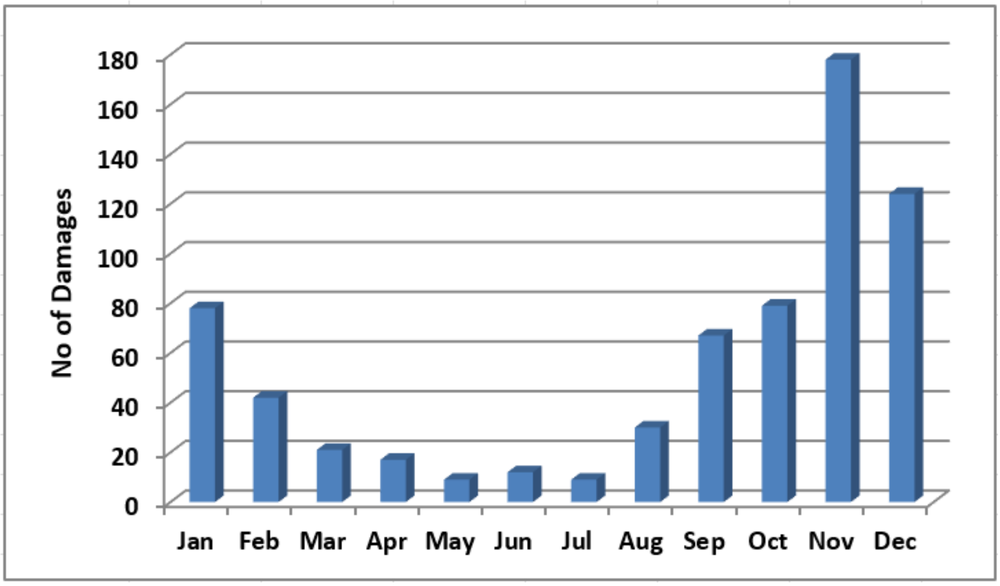

**[Fig - 42] Showing the temporal analysis damage of coconut**

The above graph shows that the coconut crop is damaged highest in the months of Dec and Jan, followed by Feb and Nov months.



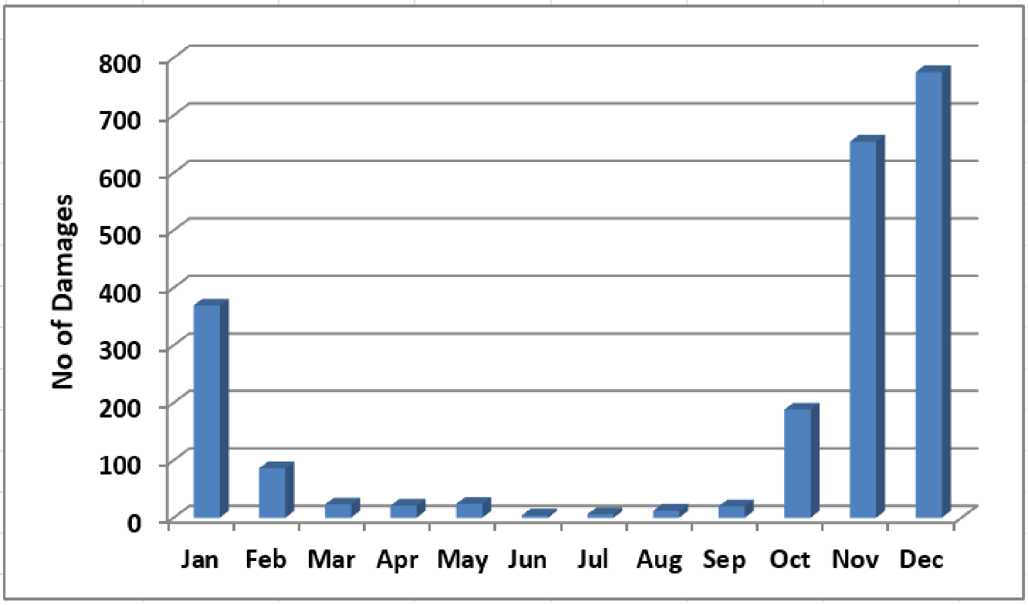

**[Fig - 43] Showing the temporal analysis of the Mango crop damage.**

The above bar graph shows that the crop mango gets damaged mostly in the month of May, followed by June and Jan months.



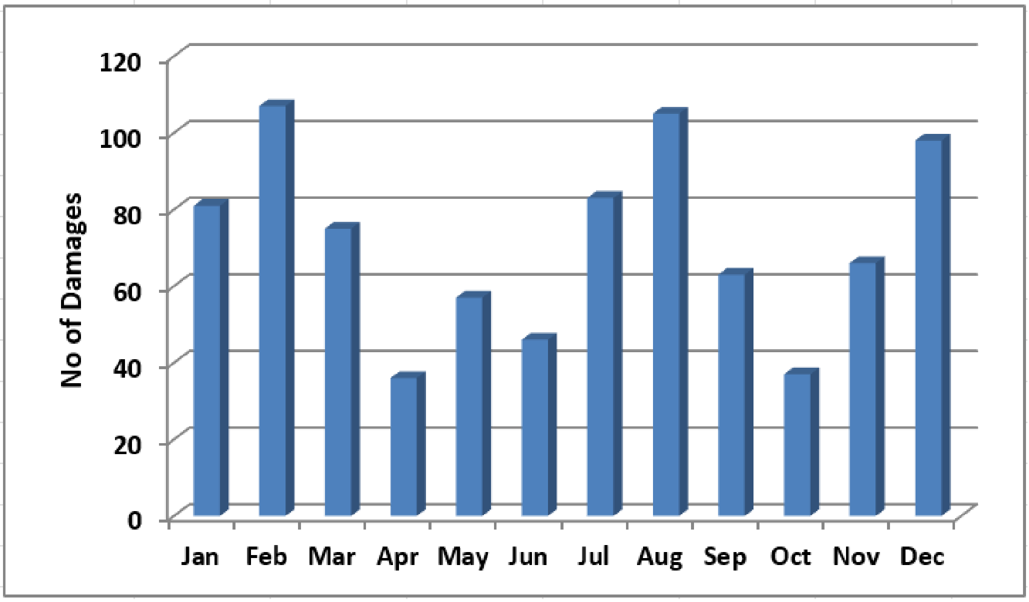

**[Fig - 44] Showing the temporal analysis damage of the Paddy crop.**

The above graph shows the pattern of paddy crop damage which clearly shows that the crop mostly gets attacked in the month of Nov, followed by Dec, Oct and Jan months.




**[Fig - 45] Showing the temporal analysis damage of the ragi crop**

The graph concludes that the ragi crop is being damaged mostly from Nov till Jan month.

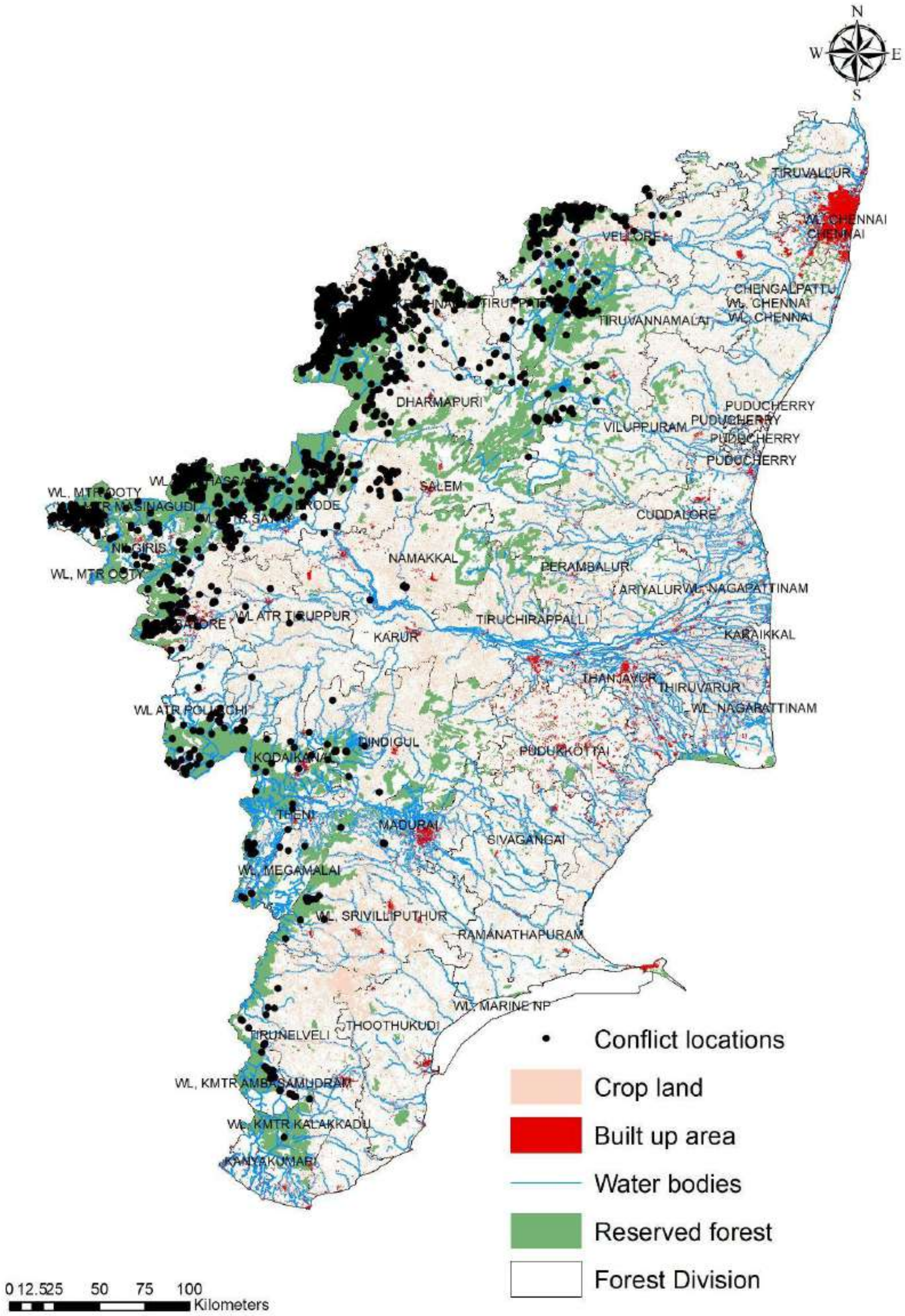



**[Fig- 46] Showing the temporal analysis damage of the tomato crop.**

The above graph shows that the crop tomato gets damaged throughout the year, and most conflicts happen for this crop in the months of Feb, Aug.

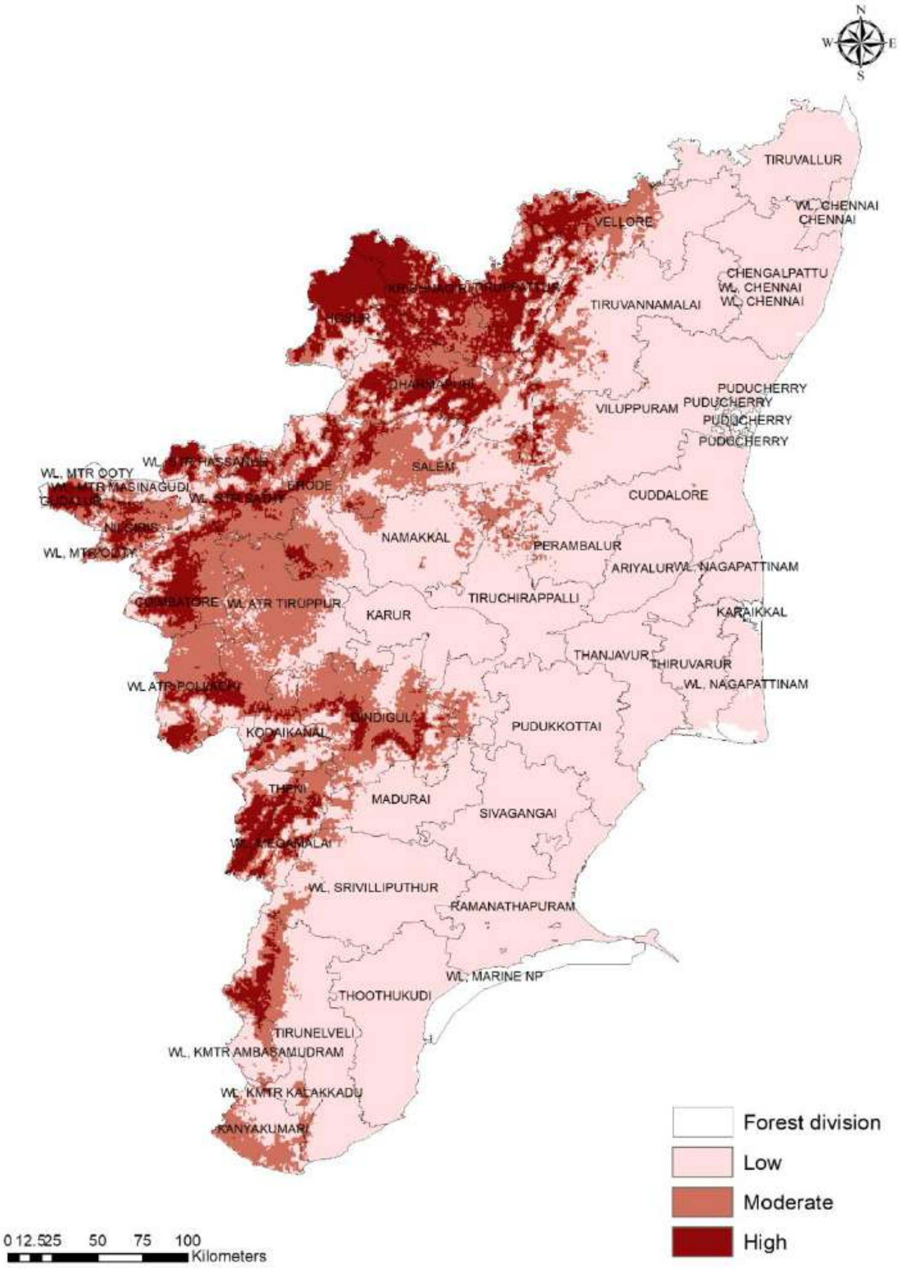
**7.2. Compensation Payments:**

- Total of **9083** elephant conflict incident claims were settled as compensation by the state Govt **(176454885/-)** in a period of **5 years (2016 – 21**).
- Out of which **77675000/-** paid by Govt in accordance with human death (**227** incidents) by elephants and **9012659/-** settled for human injuries caused by elephants.
- Total of **362600/-** paid for livestock and property damages, and **86950958/-** settled for all the crop raids caused by elephants.
- Total of **2453668/-** settled for property damage by elephants.



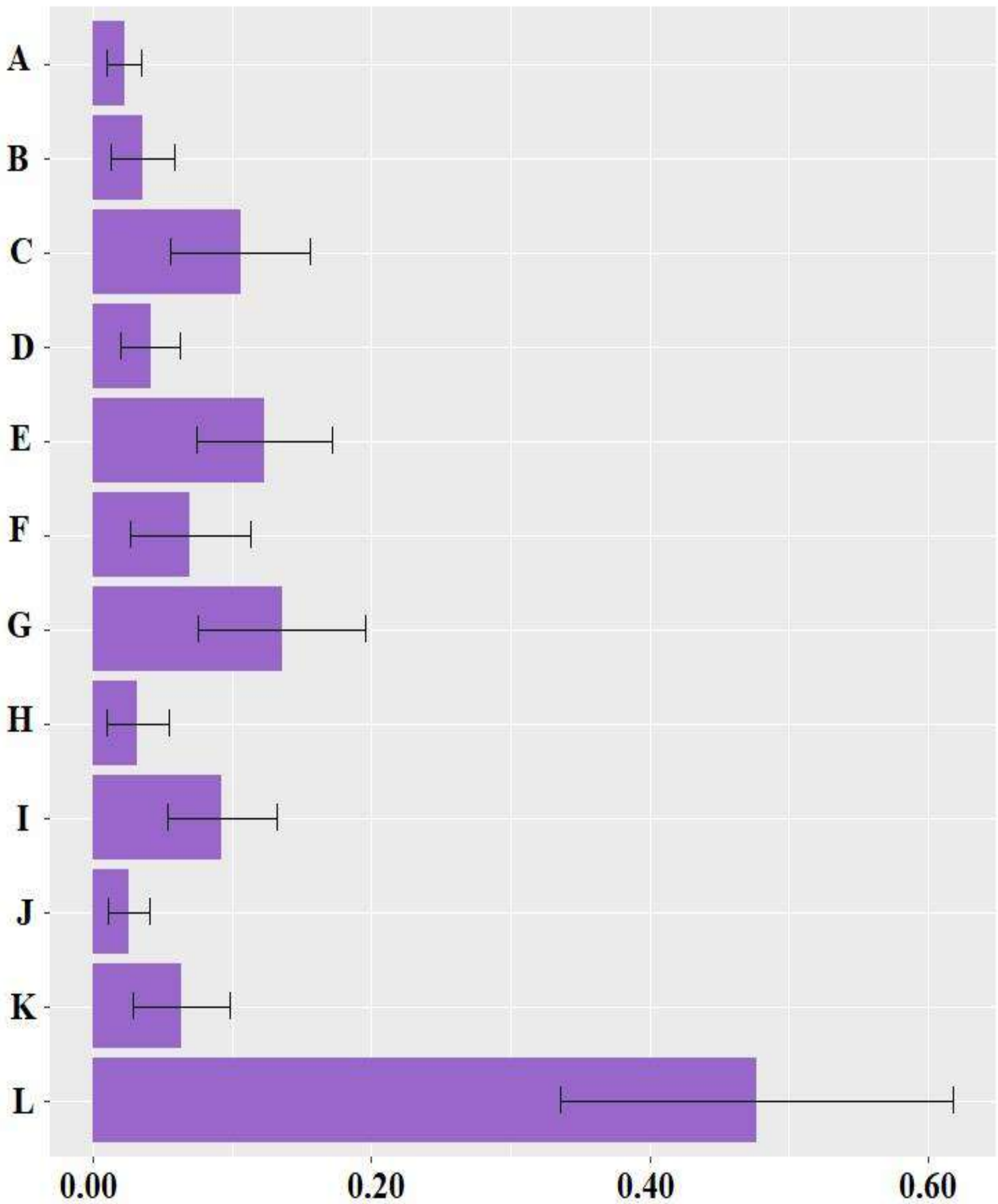

**[Fig – 47] Showing the conflict locations of Elephant conflict in Tamil Nadu.**

The above map shows that more conflicts happened in the North West and West directions of the state.




**[Fig - 48] Map showing likelihood based predicted conflict risk zones of HEC in the forest division of Tamil Nadu Red colour indicates high conflict risk zones.**

The spatial hotspot map shows high density at Dharmapuri, Krishnagirir, Tirupattur, Hosur, Coimbatore, Gudalur, Nilgiris, Dindigul, Pollachi and Megamalai Forest divisions. As per the modelling around **16446 Km 2** area comes under high conflict zone.




**[Fig - 26] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Normalised vegetation index, E. Human modification index, F. Distance to forest cover, G. Digital elevation model, H. Distance to crop land, I. Distance to build up area, J. Isothermality, K. Annual precipitation, L.  Mean annual temperature.**

The above graph shows that the mean annual temperature has contributed maximum to the HEC risk modeling followed by Digital elevation model and Human modification index.

## 7.3. Discussion:

The above study shows distribution of HEC among the forest divisions and ranges. It is clearly shown that the divisions **(Coimbatore, Hosur)** and ranges **(Denkankottai, Hosur, Jawalagiri)** show high HEC as these divisions provide ample options of crops, enough water resources etc. **[Fig - 29, 30, 31, 32, 33, and 34]**. Additionally, they have common crops that elephants prefer, such as rice, sugarcane, jackfruit, mango etc. The highest contributor to the total HEC cases, crop damage seems to be the type of conflict with max contribution followed by property damage **[Fig - 38]**. Property damage is caused by elephants while they come raiding houses for food. Out of the overall crop damage cases, majorly few crops are being targeted more often than others. These crops are such as banana, sugarcane, corn, paddy, ragi, mango, coconut and tomato crops **[Fig - 39]**.

The geographical layout of these regions significantly influences the occurrence of conflicts. The presence of U-shaped valleys between distinct habitats often necessitates elephants to traverse human settlements, leading to conflicts (Maheswari 2013). For example, elephants migrate from the Western Ghat or Mukurthi stretch to find food in the low-lying areas. These migrations take place through the elephant corridors which nowadays are being modified into several agricultural lands; and while migrating they frequently encounter agricultural crops and raid them for sustenance. In some instances, herds have even become residents in the area and regularly raid crops as they adapt to the landscape. These conflicts arise due to the unavoidable overlap between human settlements and elephant habitats, causing challenges for both communities.

From the above data we can observe the overall temporal pattern of conflict caused by elephants. As the highest contributor to the overall HEC is crop damage **[Fig - 38]**, Similar studies on HEC reported the same by (Yadav. 2007). Most conflict happens during crop harvesting time that is the winter season and around Nov to Feb **[Fig - 35]**. Similar studies concluded that frequency of HEC is higher in the rainy season as it's the season of crop maturation which are nutritious and palatable (Joshi and Singh. 2008). The winter season sees the peak of crop raids as it provides easily accessible food (Sukumar. 2003). Studies have shown that the distance of crop lands from the protected areas boundary influences the conflict positively; however these giants have been seen to travel up to several kms (3 km to 3000 km) to raid crops (Gubbi. 2012).

While we can observe the overall crop damage temporal pattern, it is crucial to take into account that these monthly patterns can vary according to different crops. It is evident that the banana crop gets damaged highest in Oct to Feb mostly because of the harvesting and ripening time. However, the elephants do raid these crops even at a young stage as the young trees have much preferred soft inner core, pseudo stem which are full of nutrition and moisture. elephants prefer these young shoots, followed by mature fruits as well. That is why we can see high crop raids in July and Aug months as well **[Fig - 40]**. On the other hand, corn crop is being damaged mostly during Nov to Jan months. Normally harvesting of corn takes place Aug through Oct however that may vary region and variety of corn wise. We can see that max damage has happened after the harvesting period or during harvest **[Fig - 41].**

Similarly, we can see temporal patterns of major crops that are being damaged by elephants. Coconut is one of such crops. After analysing the data, we found that the coconut crop is being damaged mostly during Nov to Feb months. Again, during the early harvesting time, the coconuts will be tender and juicy which is nutritious as well as tasty for the elephants **[Fig - 42].** Mango is a summer fruit and it gets harvested and ripens in summer months, which is evident by the data that the crop gets damaged highest during April, May, June months **[Fig - 43].** Paddy crop is a winter season crop, which is harvested during winter so the pattern of damage seems to be during Oct to Jan months **[Fig - 44].** Similarly, Raagi crop also gets damaged during harvesting time which lies between Nov to Jan **[Fig - 45].** Unlike these crops tomato crop shows fluctuating temporal pattern of being damaged. Max no of damages being done in the months of Feb, Aug, and Dec. The pattern showed that during Nov to Mar there was high raiding then drop was seen in the months of April and then again, a spike was seen in tomato crop raiding till Sep. **[Fig - 46].**

As the map **[Fig – 47]** shows conflict locations of HEC across the state and it clearly shows that the intensity of conflict is higher in the North, North West and West directions which constitutes densely populated districts like Vellore (4,566,538), Krishnagiri (2,180,766), Erode (2,612,248), Coimbatore (4,011,678), andDharmapuri (1,748,089). These districts grow higher cash crops such as banana, raagi, coconuts, and corn. Veggies like Tomatoes, fruits like mangoes, which matches our data of crops damaged by elephants. These factors contribute to higher occurrence of HEC in these districts as human population and having vast cultivation areas attracts the elephant population in the forest fringes to raid crops. As the map **[Fig - 25]** shows the risk prediction of the HEC in the state, we can conclude that bright red-coloured divisions require more focus in aspects of HEC management.

The Human Elephant Conflict in Tamil Nadu is one of the major concerns. Both government and conservationists' efforts are being proven to be not effective. Elephants are intelligent herbivores. During their mating season the male tuskers become very aggressive and often feel threatened by human presence and try to act on a self-defence which results in fatal consequences for humans. Sometimes to prevent crop raiding and conflicts humans go for mitigation measures and that sometimes act antagonistically, as some elephants get electrocuted and the whole ecosystem gets impacted. The major reason that elephants come into human contact is in search of food or mates. They can travel long distances and during different weathers they like to move to different locations finding suitable environment according to their convenience.

### 7.4. Management Implications for HEC:

HEC management is a multifactorial phenomenon that involves different aspects of social and economic impacts. The problem remains that elephants are intelligent mega herbivores and can figure out mitigation measures with ease. While the initial stages of mitigation are able to hold them off, they immediately find a loophole to overcome them. In order to have a long lasting and effective solution, it is crucial to understand the socioeconomic factors and elephant behaviours as well.

Globally HEC is of a major concern and there are several mitigation measures being implemented. One such example would be beehive fences which are being proven very effective and sustainable as it is cost effective and honey from the hives could provide livelihood for the local population (Enukwa, 2017). Community-based crop-guarding also proved effective in keeping elephants away (Gunaryadi et al. 2017). Fences work somewhat effectively however elephants learn quickly that their tusks don't conduct electricity so they use it to damage the fencing (Graham et al. 2009a; Mutinda et al. 2014). Bio acoustics such as yelling, hitting metal objects and fire crackers and light deterrents such as flaming torches, flash lights etc works moderately effective (Nyhus et al.2000; Fernando et al. 2005). studies reveals that agriculture based deterrents are able to scare them away, these alternative crops such as coriander, mint, ginger, onion, garlic, lemongrass, and citrus tree along with deterring the elephants provide a financial support to the farmers (Gross et al. 2016; Gross et al. 2017). Similar studies show that chilli-based deterrents were able to successfully repel the elephants from invading the crop land and mitigating HEC (Karidozo and Osborn. 2015). Furthermore, measures such as translocation, early warning systems are being implemented. Although these measures come with their own flaws, especially with translocation, these elephants seem to migrate back to their origin. In some instances, they seem to cause deliberate killing and damage to properties at the release area while returning to their home (Pinter-Wollman, 2009; Fernando et al. 2012). In Odisha there has been a new measure being taken by the local joint forest management group that is seeds of fresh bamboo (Dendrocalamus sp.) are rolled into unreachable parts of forest areas. This has helped in developing the food reserves inside the forests, further limiting the elephants in their wild habitats (Chakraborty et al. 2021).

Current efforts to mitigate HEC are mostly human centric measures and offer unbalanced solutions discarding the underlying drivers of HEC (Mumby HS and Plotnik JM. 2018). The existing mitigation measures in the state include EPTs (elephant proof trenches), fencing, electric fencing, solar and solar hanging fencing, Armstrong fencing, double layered fencing, an early warning system, monitoring, awareness through WhatsApp groups (TADAM, Elephant info etc.), and chasing. Despite their initial promise, some of these measures have shown limited effectiveness. Through our interactions with farmers and forest officials, it became evident that while EPTs are effective in preventing elephant invasion, a lack of maintenance has made them less efficient. We learned that maintaining EPT is costly, and the fund flow for maintenance is provided on a per-kilometre basis, which proves counterproductive. Sometimes the elephants were seen moving the soil to fill the trench and crossing through it. Fencing seems to be effective to a certain extent. Among the different types of fencing, electric fencing is not that dominant nowadays as a result of preventing the electrocution of elephants. After our evaluation, it is clear that the chasing and monitoring, Armstrong fencing, double-layered fencing, and hanging solar fencing demonstrate satisfactory performance. Last but not least, the WhatsApp group, including the local farmers and forest officials, proved to be helpful in coordinating and monitoring the elephants' movements, which further aids in chasing them in time and minimising the conflicts to the maximum level.

Elephant death as a result of human induced pressure is another part of the HWC which is often ignored. During our field visit (**Madukkarai Range**) we assessed the railway track accidents that caused elephant deaths (11 deaths till the date we visited 12th Dec, 2022) and spoke to forest officials. The major reason would be the track crossing through the Reserved Forests (Track A goes 1.7 km inside RF and Track B goes 2.8 km inside RF) and nearby water sources providing optimum site for the elephant's visit. However, the forest department along with the Railway department has come up with a system where they monitor the animals through WhatsApp group (TADAM) and communicate the milestone numbers that are placed alongside the tracks to intimate the path of elephants. As the railway department slows down the train speed up to 45 km/ hr to give a chance to these animals to cross the track safely. In addition to this the department has installed CCTV cameras alongside the tracks to monitor the wildlife crossing the track and its efficacy is good. Underway passage is being constructed to provide the elephants a safe passage through the railway track. Tracking their movement pattern is crucial in order to chase them away from human settlements. Researchers have been working on developing deterrents to deter them from a particular pathway. Although the early warning system has been found to be effective against direct confrontation between humans and elephants, it fails to solve other types of conflicts.

For E.g., geographical barriers such as Penstocks in Theni district also play a great role in diverting their pathway into the human settlements. These penstocks were constructed to transport water from higher areas like Kerala to the low-lying areas such as Theni districts, however during the pilgrim season observed in Kerala, in order to avoid human disturbance some population started to migrate downwards. Their migratory path gets blocked by these huge penstocks going through the hills. There have been proposals from the department to construct bridges at the low penstock points and at the high going point’s underground pathways for these giants to cross smoothly. We recommend identifying these points and initiate constructing different pathways for elephants. There have been instances of elephants accidentally damaging properties, while chasing them away. Sometimes they get scared and try to escape the situation and, in that process, they end up unwantedly damaging human lives and properties. Specific elephants also cause conflicts on a regular basis. Karappan tusker (Thalavady range), Radhakrisnan tusker (Ovelly range) are examples of such problem elephants, these tuskers seem to deliberately attack humans and damage crops. Managing the certain tusker named Karappan became difficult day by day; he seemed to raid many crop lands in one night which makes it tricky to chase them away from farms. Relocation of this tusker has been a major task for the forest officials. In addition, these kinds of scenarios end up creating conflict in other croplands, as in if we chase them from one farm; they end up in raiding another farm.

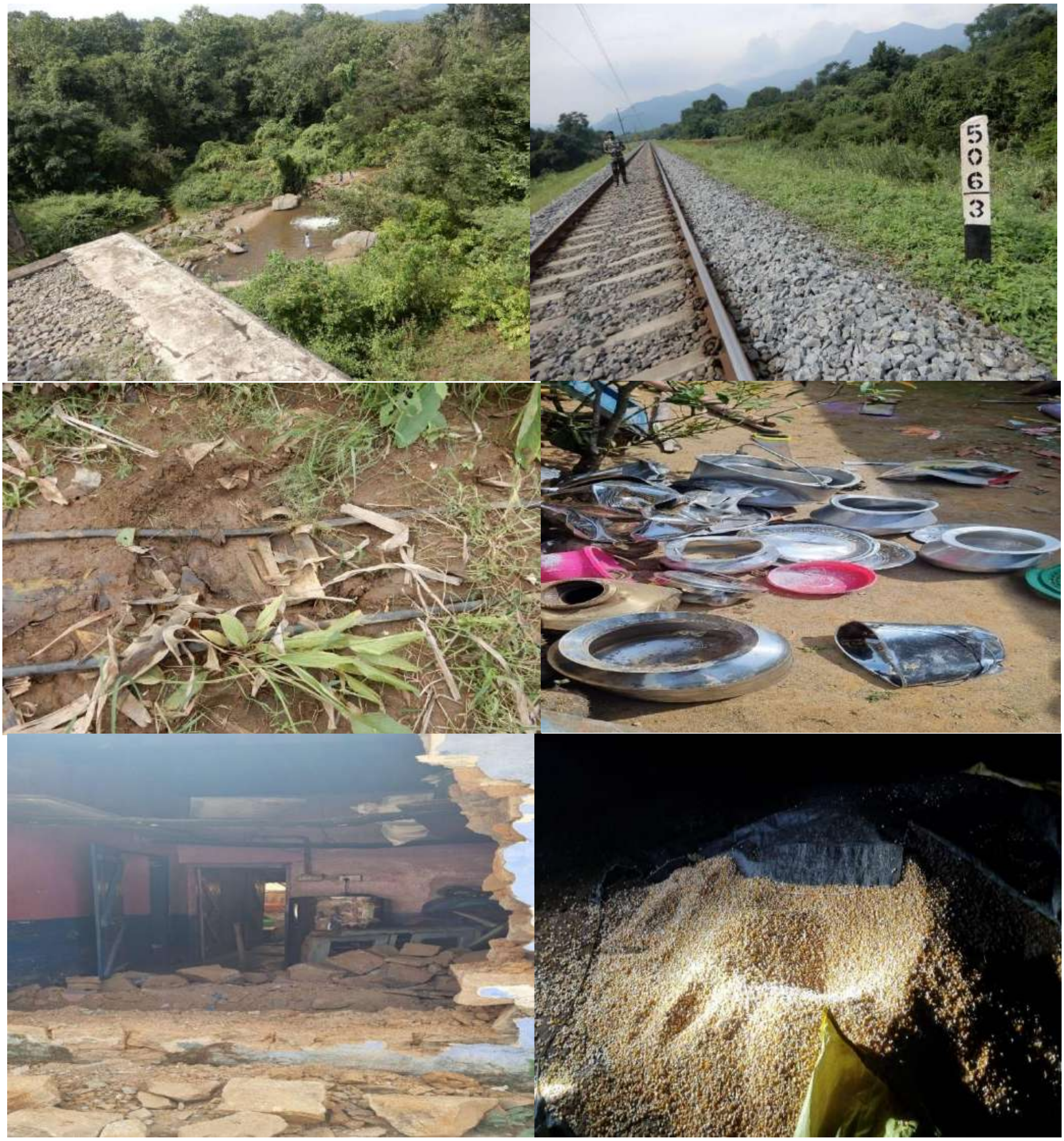
We came across many underlying challenges in managing human wildlife conflicts, especially HEC. Loopholes such as a lack of manpower, logistics and timely financial assistance can make it difficult for forest officials to manage HWC cases efficiently. Currently, the forest department has uniform fund allocations for all the forest ranges. We need to take the nuances of the cases and severity of them in forest ranges. As we observed, some ranges are seeing high human deaths due to elephant attacks, and some ranges see high crop raiding. The ranges that see high crop raiding will require less compensation compared to the ranges that see high human death cases. Additionally, there are many other factors influencing the issues, such as encroachments, etc. As we know that chasing is one of the most effective measures against HEC, we need to take into account the logistics, fuel, and manpower necessary to perform it efficiently. Many forest ranges are too large to handle and manage effectively, which is why the government has fabricated the large ranges and sections into several small entities. Many ranges have been fabricated into several sections as per administrative purposes and effective management; however, the same staffs are expected to handle the newly fabricated sections. There are many vacancies as forest guards, etc., get promoted to foresters, but there is no new recruitment. The ground level staff became insufficient for managing HWC cases. Another drawback would be the remuneration of the field officers, or APWs, who are the front-line staff of HWC. We suggest revised, site-specific fund allotment for more complex HWC prone ranges, and field and logistics need to be modified after a thorough assessment of the range's requirements.

Suggestions such as systematic research on both demographic as well as individual level behaviours is needed, as to understand their tendency to raid crops and their age correlation (Chiyo et al. 2011, 2012). Behaviour study such as their cognitive analysis capacity and risk propensity associated with their demographic profile can provide a better image of their personality on an individual as well as population level. Along with that, studying their decision-making process such as their search for food and shelter, risk taking mentality and the factors influencing these decisions would help us identify the groups and develop group of elephant specific solutions to mitigate the HEC (Plotnik et al. 2014; Von Durckheim et al. 2018; Yasui et al. 2012; Seltmann et al. 2018). Overall having a deeper level of understanding of elephants' decision-making process and cognition ability and the factors influencing these, would help us develop modified long term preventive measures instead of coming up with mitigation measures to stop the mere symptoms of the conflict. Accordingly, we can influence their desire and decision-making process which would promote coexistence in the long run. It further would help us predict these conflict cases and take preventive measures ((Mumby HS and Plotnik JM. 2018).

Hence, we suggest building the capacity of local people through collaboration with multiple local stakeholders such as panchayats, the Agri department, the police department, etc. to make it easier to manage. Translocations should be taken under rigorous learning about their behaviour and any underlying disease and terrain information as well, with proper guidelines.

Farmers claim that their compensation claims are getting delayed, so we suggest coordination with other departments to give wildlife conflict cases an upper hand.

**7.5. PHOTOS OF THE FIELD VISITS**




**[Fig – 50] Figures depicting railway track encounters, crop damage. (The water source explains why elephants come near railway track)**


**[Fig – 51] Figures depicting crop and property damaged by elephant.**

**[Fig – 52]Figure showing property damage by elephant.**

**[Fig – 53] Figure showing the penstock situated in Gudalur range**.

**[Fig – 54] Some glances of team members discussing with villagers and forest officials.**



**[Fig – 55] Pictures of team members visiting conflict location and assessing the terrains and mitigation measures with forest officials**

**[Fig – 56] Pictures of team members visiting conflict location and discussing with forest officials and farmers.**

# CHAPTER – 3

## HUMAN – GAUR CONFLICT

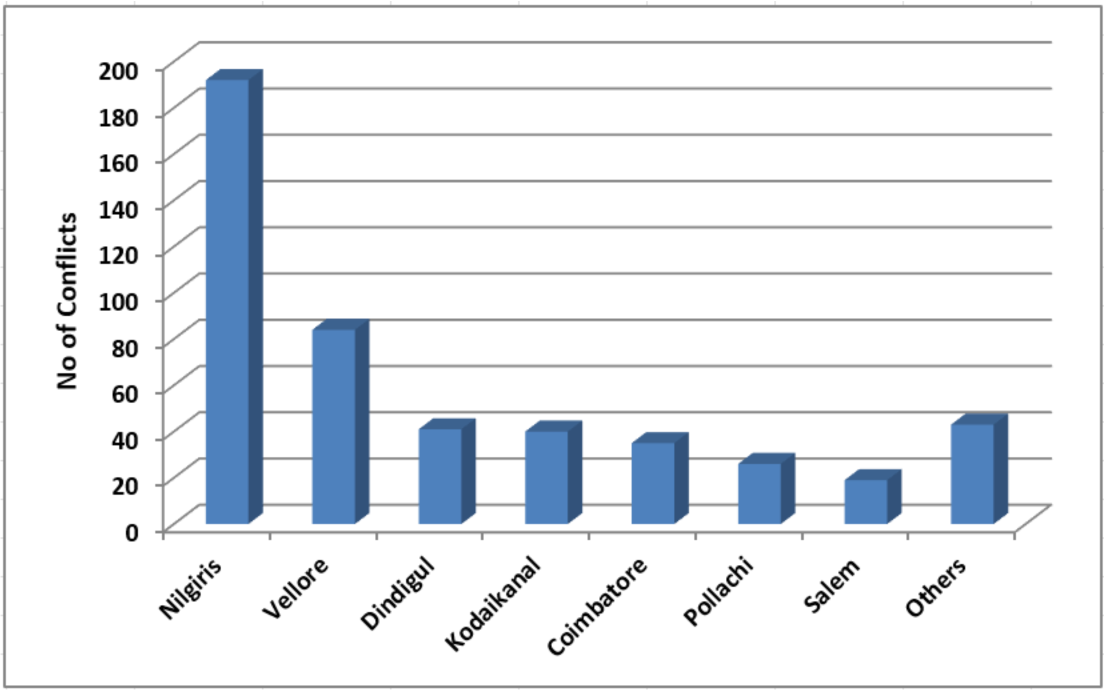
# 8. CHAPTER 3: HUMAN GAUR CONFLICT (HGC)

Human-Gaur conflict has contributed a significant number of cases to the whole HWC case in India as well as in Tamil Nadu. These huge herbivores prefer forested places; they inhabit almost all of the Tiger Reserves and surrounding areas. They cause a significant amount of damage to the farmlands, causing huge economic losses to the farmers. Although these animals are herbivores, they occasionally seem to attack humans when they feel cornered or threatened. Their presence near human settlements poses a threat to human security. The government has been taking many initiatives to mitigate the conflict, such as early warning systems, fencing, raising awareness, etc. It is necessary to understand their behaviour in order to reduce their conflict with humans. To promote better coexistence between humans and these giant herbivores, it is the need of the hour to understand their movement patterns and feeding patterns so as to suggest less preferred crops to farmers.

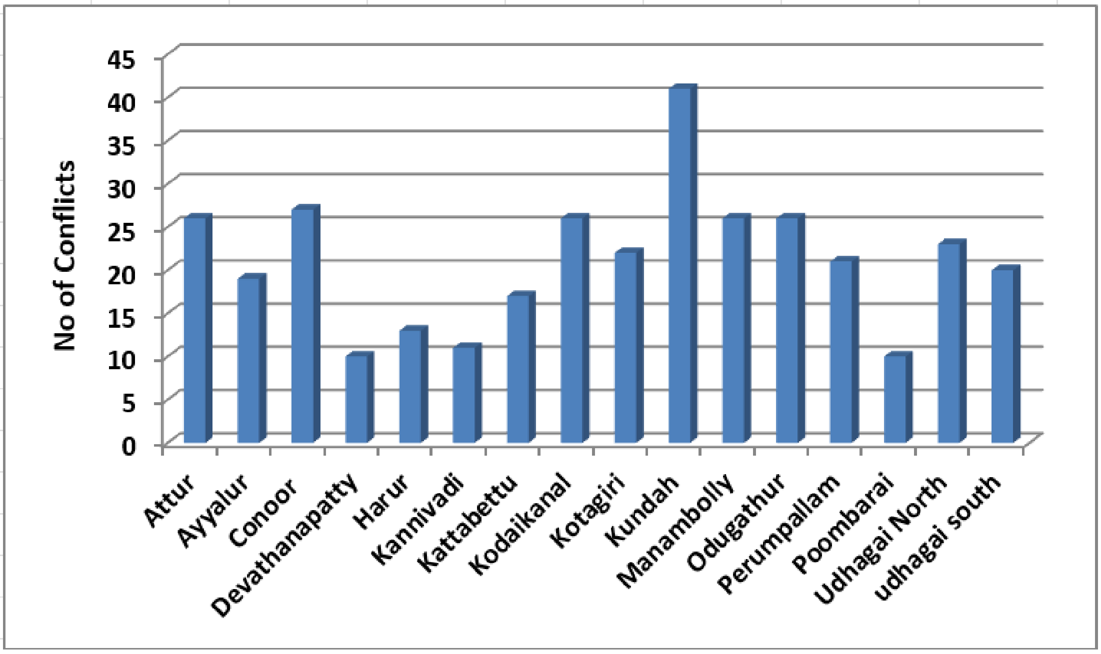
## 8.1. Results

### 8.1.1. Frequency analysis:

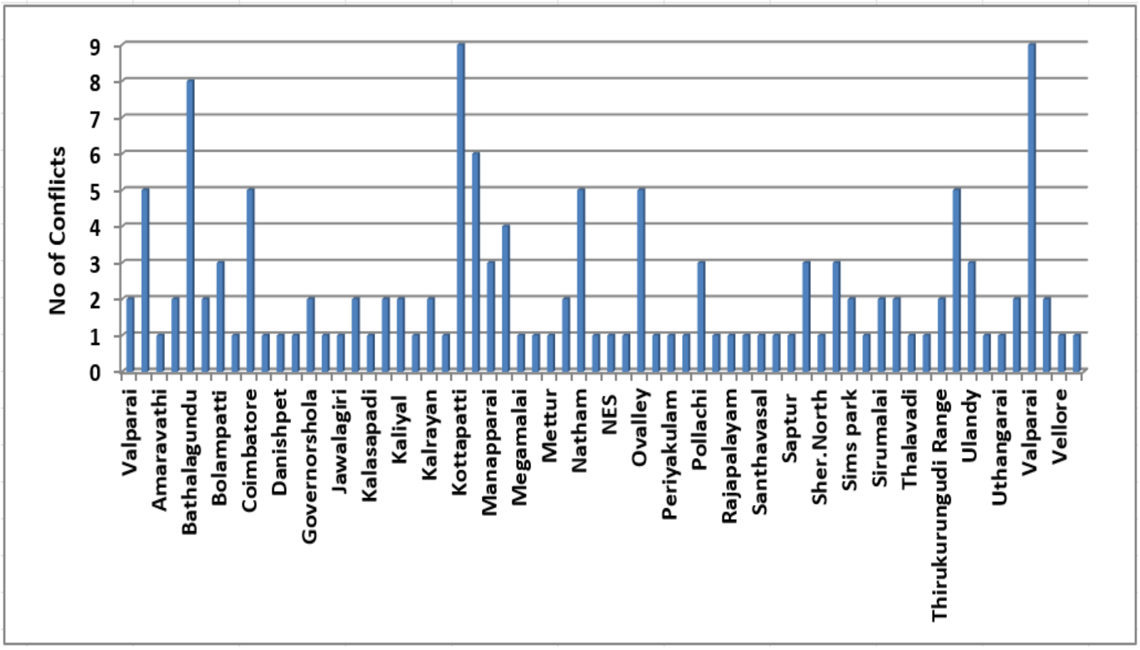
- From the above study, we have observed that gaur conflict has been contributing to the total HWC cases for the past few years. From the collected secondary data, it seems there are **480** Gaur conflict records in the state. Out of these, the maximum number of conflicts was found to be from **Nilgiris division (192**) followed by **Vellore (84**). The lowest number of conflicts was found in the Hasanur (1) and Valparai divisions (1) etc. **[Fig - 57]**
- **Kundah range (41**) was observed to be highest in gaur conflict, followed by **Manamboly range (26**) and **Odugathur range (26**) etc. **[Fig -58, 59]**




**[Fig - 57] Showing the frequency of the HGC (Human Gaur Conflicts) Division wise.**



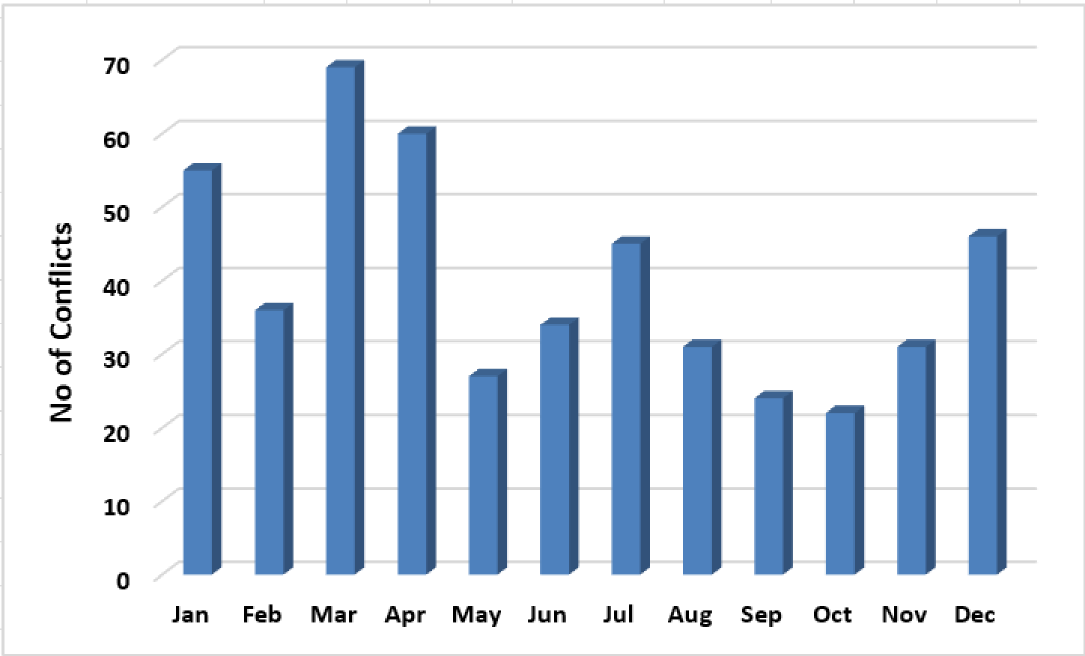

**[Fig - 58] Showing the frequency of HGC forest range-wise (10 - 50).**



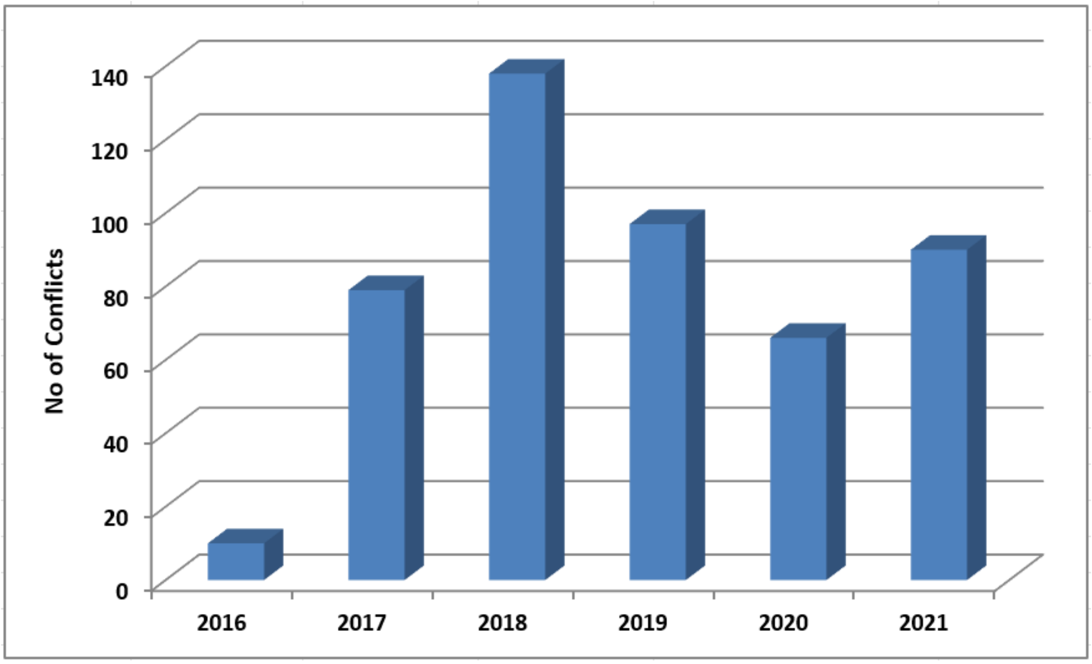

**[Fig - 59] Showing the frequency of HGC forest range-wise (0 - 10).**

### 8.1.2. Temporal Analysis

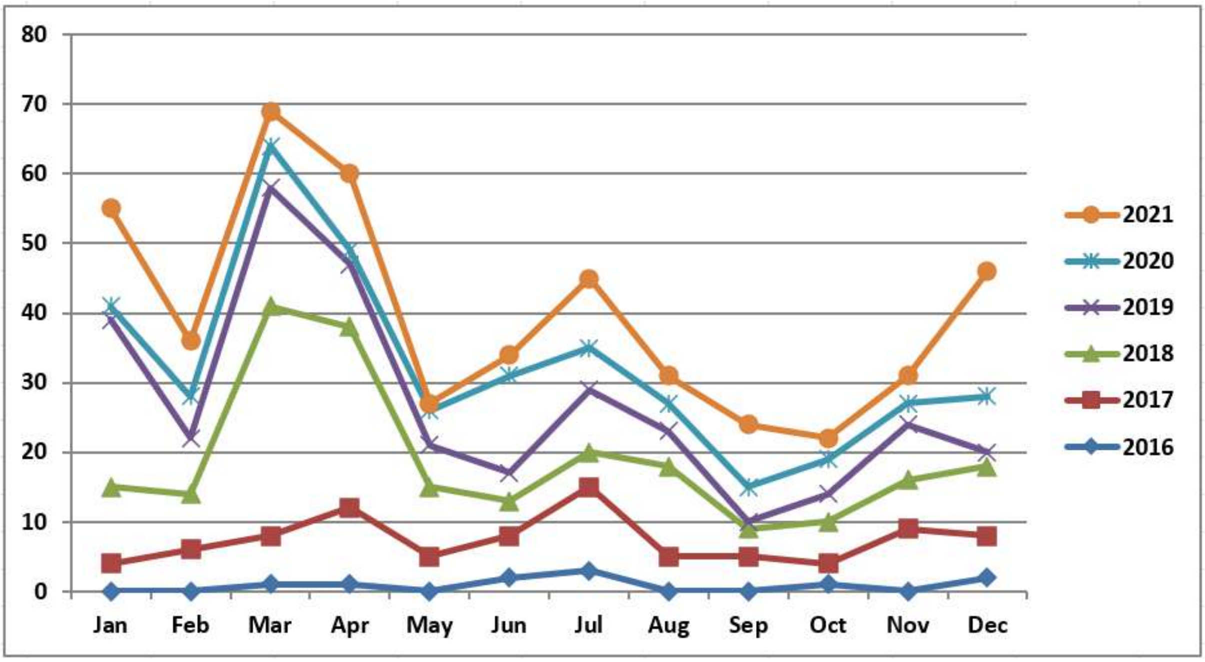
- Overall, the conflict was high for the past few years (2016–2021) in the month of **December**, followed by **November** and **January [Fig - 60]**. The February and October months showed a moderate amount of conflict. April was the least conflicted month, followed by June and March. While comparing the year-wise data, the same trends were observed. Out of 5 years of data taken, the year 2018 saw the highest conflict **[Fig - 61].**




**[Fig - 60] shows the overall temporal analysis of HGC (2016 - 21).**



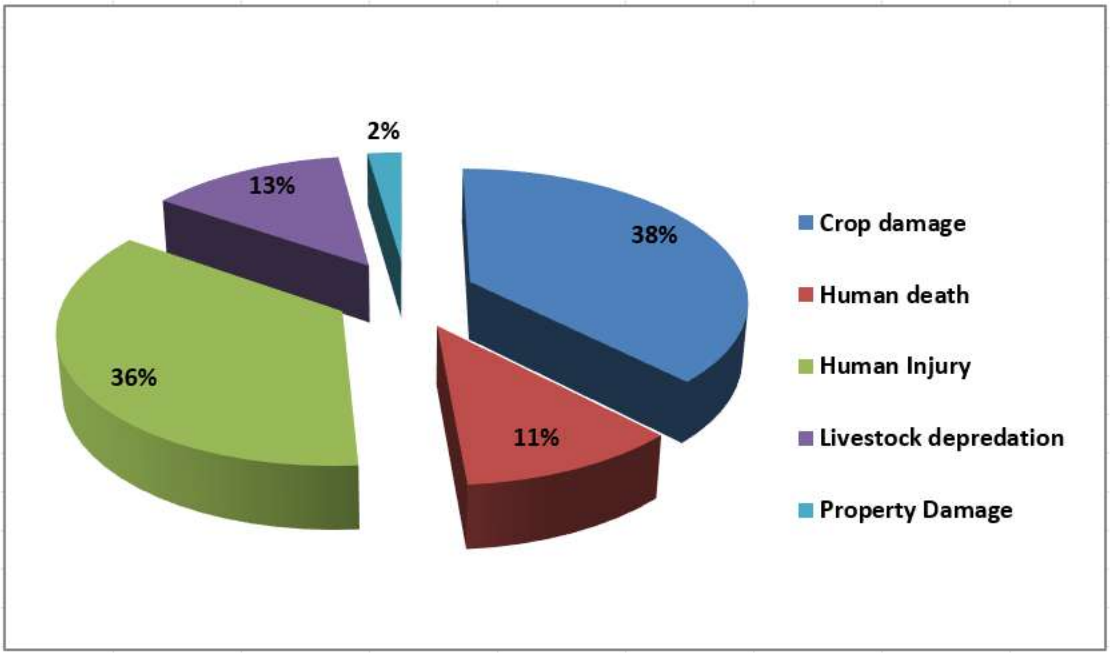

**[Fig - 61] Guar conflict frequency year wise.**



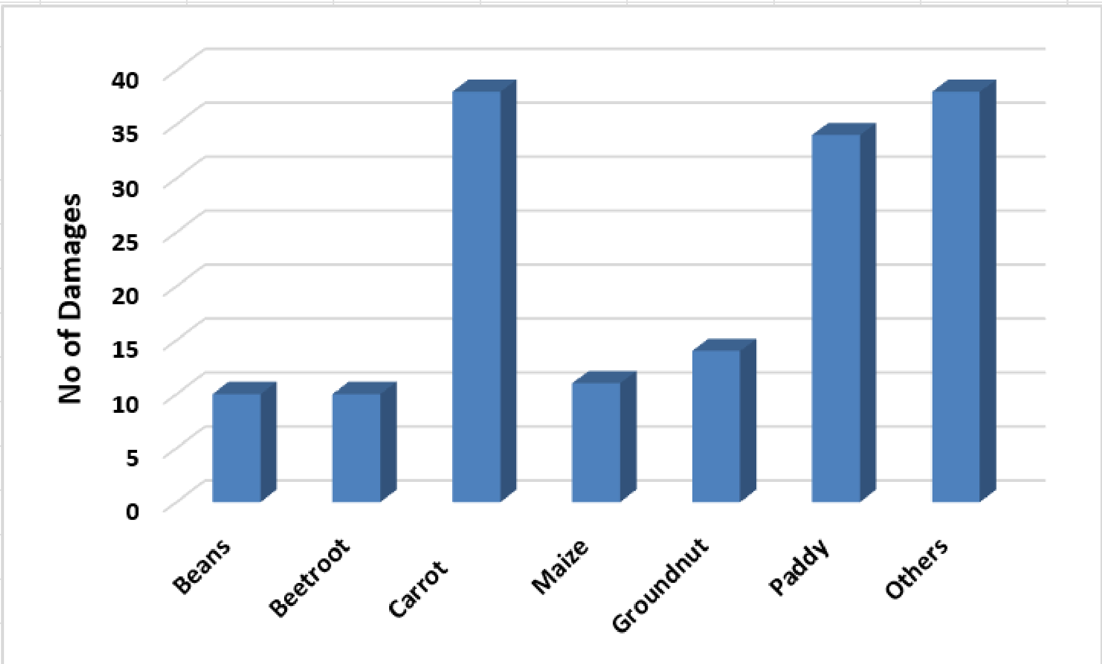

**[Fig - 62] Shows the temporal analysis of HGC both month and year wise.**

**8.1.3. Conflict Analysis:**

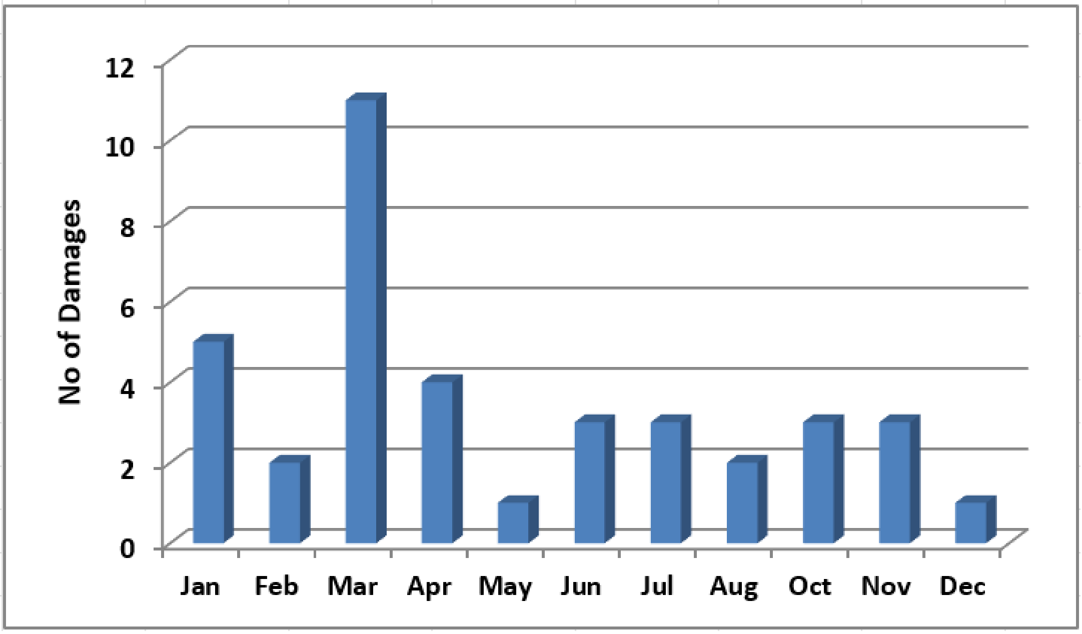
- Out of all conflict incidents Gaurs found to be mostly involved with **crop damage (181)** followed by **human injury (172)**, **livestock depredation (63), human death (53**), and **property damage (11) [Fig - 63].** In the crop damage category, out of all the crops being damaged, 15 crops were damaged in a significant amount; other crops were not preferred. Crop **carrot (38 times**) was damaged most, followed by **paddy (34 times)**, **groundnut (14 times**) and **beans and beetroot (10 times each**) **[Fig - 64].**




**[Fig - 63] Shows different types of conflict frequencies.**

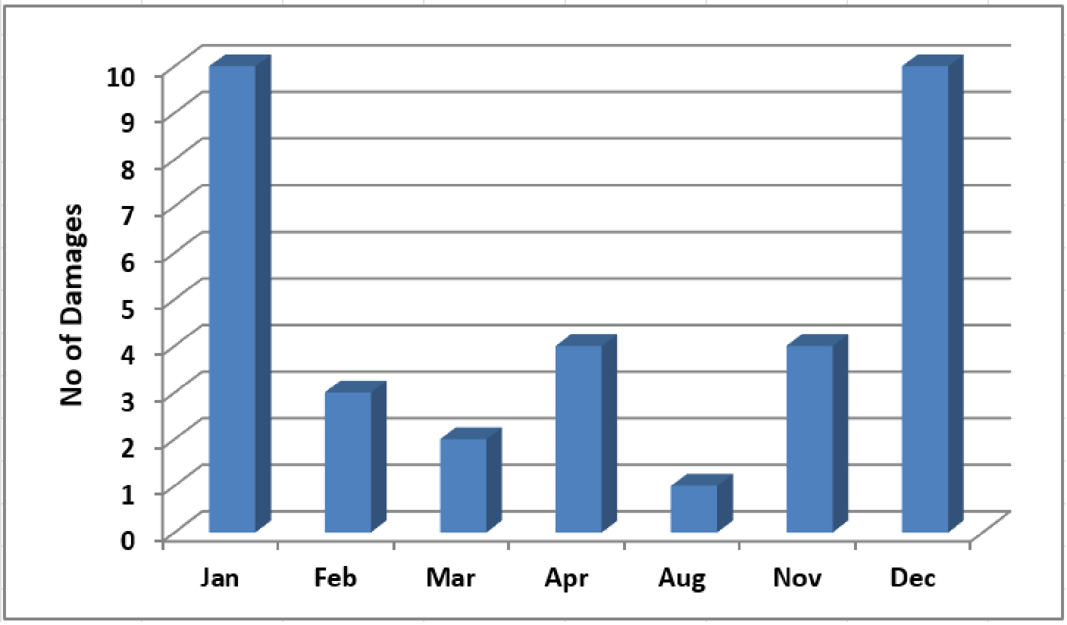



**[Fig - 64] Shows the Crop wise analysis of crop damage conflict by Gaur.**




**[Fig - 65] Shows the temporal analysis of carrot crop damage.**

We can see the pattern that the carrot crop gets damaged highest in the month of March followed by Jan, as carrots get harvested during Jan to Mar months.

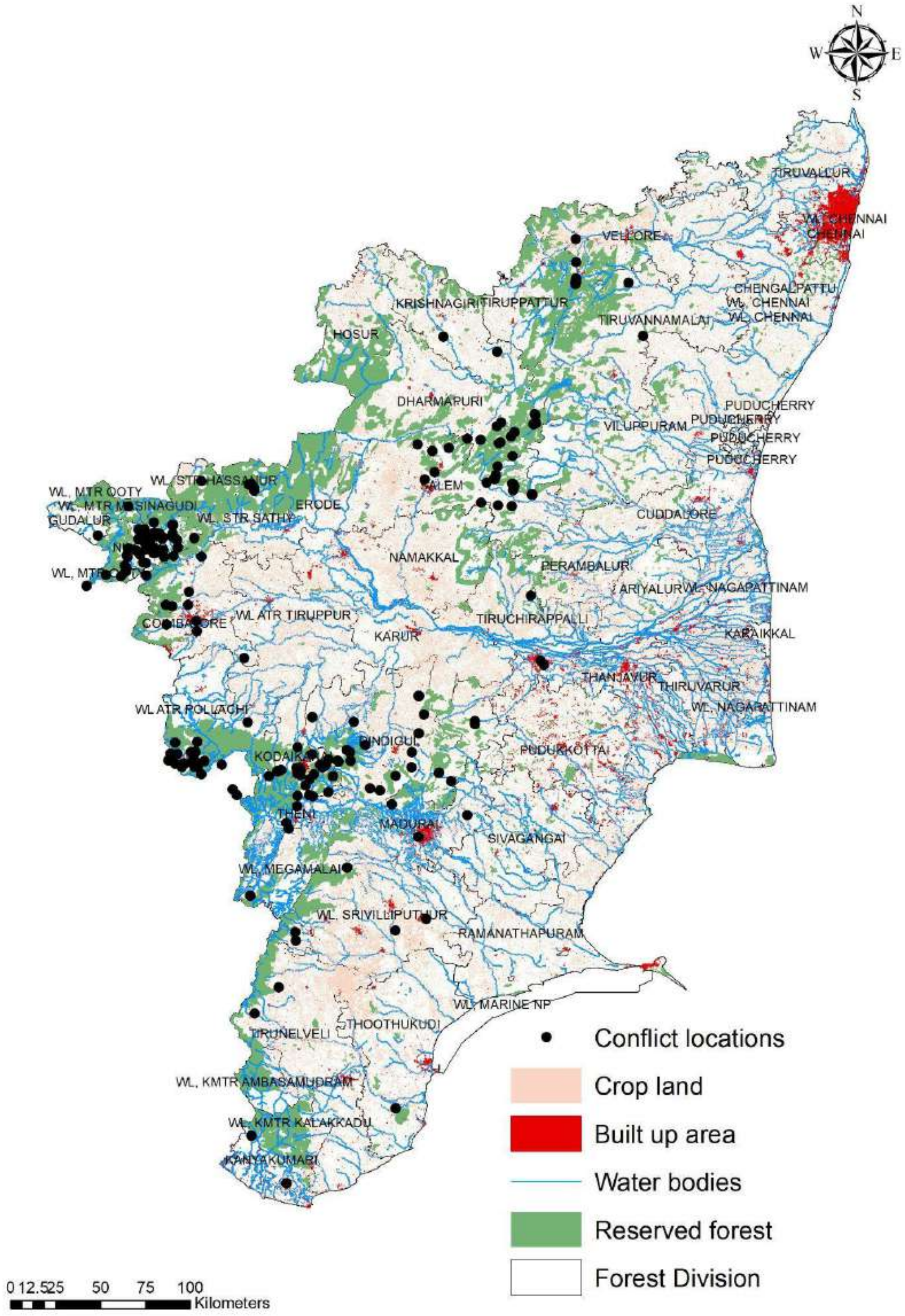



**[Fig - 66] Depicts the temporal analysis of paddy crop damage.**

As we can observe that the graph shows peaks in December and January, we know it's the harvesting time of the Paddy crop, which attracts Gaurs during that time.

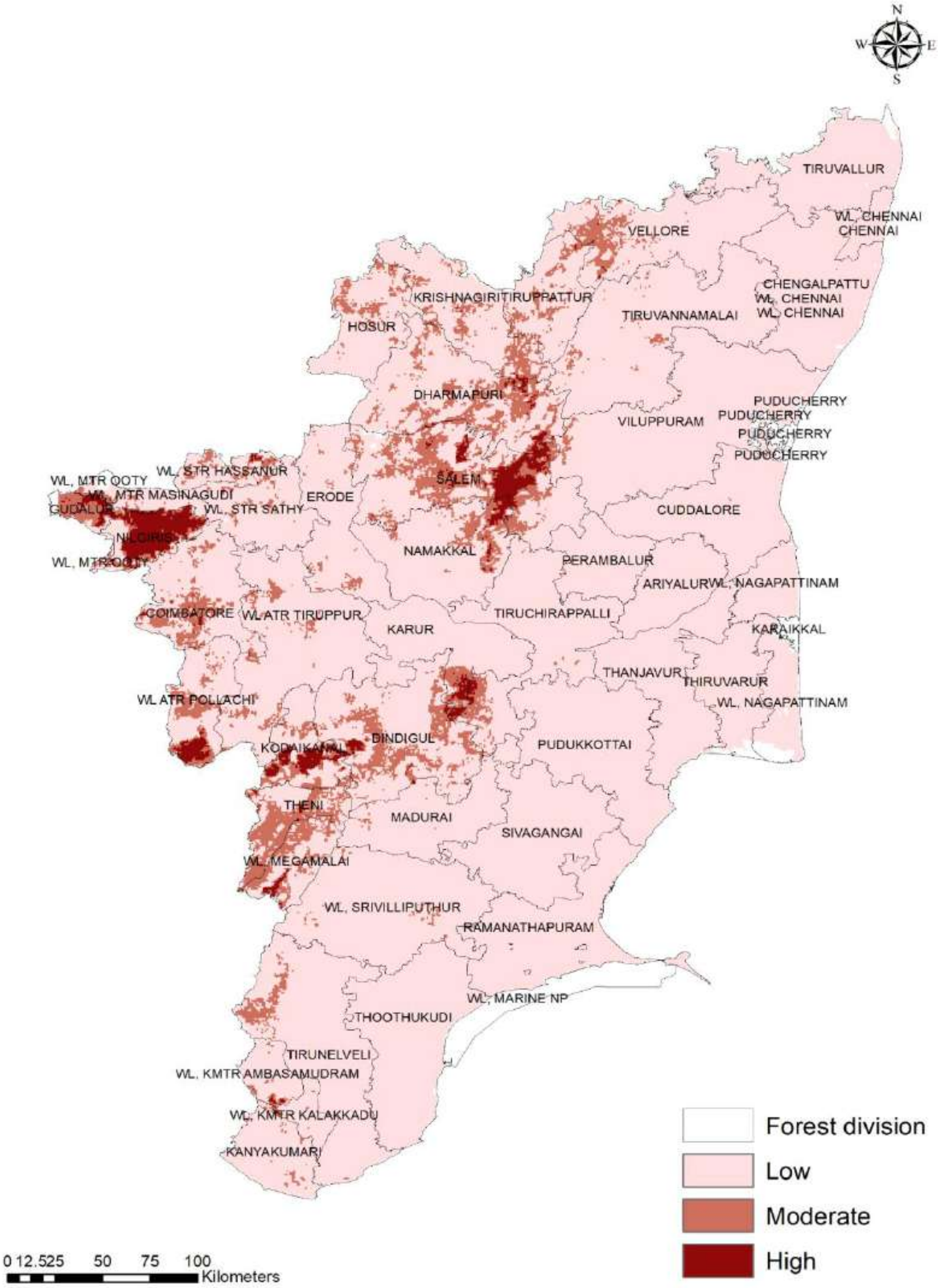
### 8.2. Compensation Payments:

- A total of **411** Gaur conflict incident claims were settled as compensation by the state Govt**(21012772/-)** in a period of **5 years (2016–21**).
- Out of which **1834396/-** settled for all the crop raids caused by Gaurs (**169** incidents).
- Out of which **12400000/-** paid by Govt in accordance with human death (**40** incidents) by gaurs and **5612976/-** settled for human injuries caused by gaurs.
- Total of **119400/-** paid for livestock damages, and **46000/-** settled for property damage by gaurs.



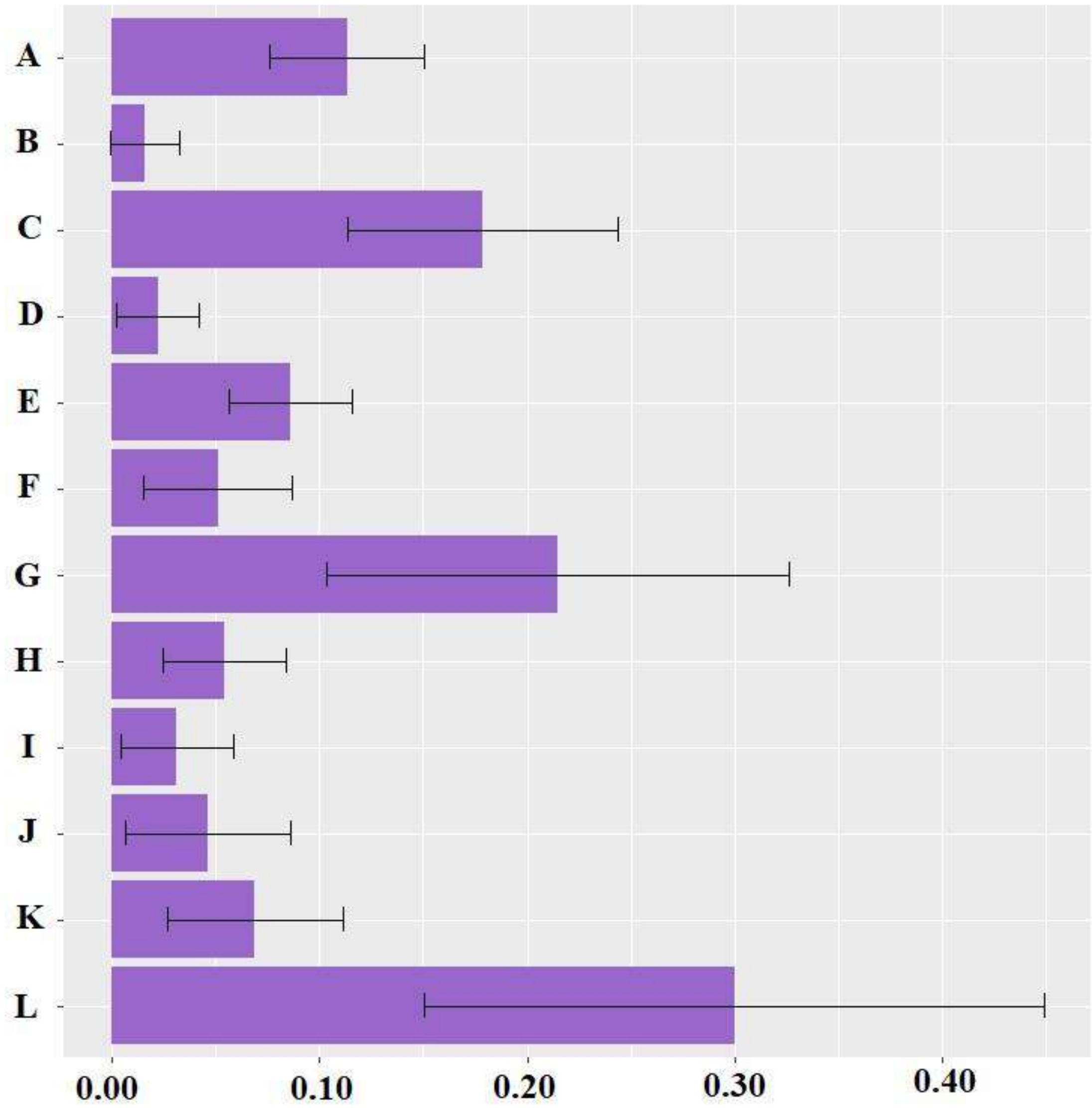

**[Fig - 67] Showing spatial distribution of the conflict locations contributing to HGC**

The above map shows that more conflicts happened in the South West and West directions of the state.




**[Fig - 68] Map showing likelihood based predicted conflict risk zone of HGC in forest division of Tamil Nadu. Red colour indicates high conflict risk zones.**

The spatial hotspot map shows high density at Nilgiris, Gudalur, Kodaikanal, Pollachi and Salem Forest divisions. As per the modelling **2869 km 2** areas comes under high conflict zone.




**[Fig - 69] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Normalised vegetation index, E. Human modification index, F. Distance to forest cover, G. Digital elevation model, H. Distance to crop land, I. Distance to built up area, J. Isothermality, K. Annual precipitation, L. Mean annual temperature.**

The above graph shows that the mean annual temperature has contributed maximum to the HGC risk modeling followed by Digital elevation model and Distance from road.

## 8.3. Discussion:

We made an attempt through our study to show the distribution of HGC across the state of Tamil Nadu. Our spatial analysis clearly showed that the **Nilgiris and Vellore** divisions and **Kundah, Conoor and Manambolly** ranges contribute more to the overall HGC **[Fig –57, 58, 59]**. As these divisions and ranges provide optimum atmosphere and resources for the Gaurs to thrive. Additionally, these places are dominated by patchy forests fragmented by huge coffee and tea plantations, reducing their food and shelter into mere patches, these ungulates are bound to wander off to the human settlements. Since these giant herbivores go for natural vegetation, grazing on grasses and shrubs, they normally feed on these, but occasionally they wander off to human settlements and come across crops. As we can see that the highest contributor to the total HGC cases is crop damage **[Fig - 63]**, we analysed the type of crop they damage majorly in order to suggest alternative crops. Gaurs mostly go for carrot, paddy, groundnut, beans and beetroot types of crops **[Fig - 64]**. Human Injury comes second highest in the contributors of conflicts as these animals tend to get aggressive while coming in contact with humans, they charge towards humans while on roads and while attempting to shoo them away from the crop fields. Occasionally travellers going on roads also get attacked by these giants as they mistake it as being threatened.

We can observe the overall temporal pattern of conflict caused by gaurs. The highest conflict occurs in Mar and followed by Apr, and Jan. We can conclude the range that conflict occurs is from Dec to Apr and in between Jul also sees an increase in conflict. As we take the numbers of conflicts in our overall temporal analysis, we can say that throughout the years the conflict happens **[Fig - 60]**. To understand the conflict patterns and crop damage trends, we need to understand the crops temporal pattern of damage as well. The most targeted crop is carrot and paddy. The temporal analysis for the carrot crop showed that the highest damage has been done in the month of March followed by Jan and April. We can conclusively say that the damage ranged from Jan to April **[Fig - 65]**. Few varieties of carrot are cultivated in high altitude places such as Nilgiris and Kodaikanal which attracts HGC in these places. The variety of carrot can significantly impact the harvesting timeline of the crop as well. Some of the varieties mature around Oct to Feb range, which justifies the temporal graph of the crop carrot. The March peak shows that the crop damage by gaurs usually happens around the harvest season. The crop paddy also gets damaged predominantly by gaurs. The crop is usually harvested in the winter season as it's a winter crop. This justifies the temporal graph of the crop Paddy, as we can see that the peaks are ranging from Nov to Feb **[Fig - 66]**. Other than these two crops, there are other three crops which are being damaged as well but not dominantly. These are such as groundnut, beans, and beetroot having peak damage in Aug, Dec, and Mar respectively.

Human Gaur Conflict in Tamil Nadu has become another feather in the HWC crown. Gaurs are large and powerful herbivores, which often come in contact with humans. These large herbivores show some behaviours such as territorial and protecting their young ones etc. These behaviours result in conflict incidents and eventually lead to fatal consequences for both parties. These giants tend to act aggressively when they feel threatened, or cornered. While going on the road they cause significant damage to the travellers. There have been instances of human injuries by Gaurs as well as the vice versa. Conservation efforts on the prey species and lack of predators in the forest habitats has caused a shrinkage of natural fodder for these herbivores which compels them to come out of the protected areas (Manoj et al.). Additionally, the outbreak of invasive species further damages their habitat quality turning it into a food scarcity for gaurs, which is why they wander off into human settlements (Milda et al.). These giant herbivores are mostly grazers and need an optimum number of grasslands in order to thrive, due to anthropological impacts, grasslands have been reducing in the western and Eastern Ghats stretch causing them to wander off to human settlements

(Joshi and Sankaran Ratnam, 2018). Additionally, encroachment and cultivation practices in forest lands that have been privately owned, adjacent to the forest landscape, are seen to catalyse the conflict in the fringe areas of Nilgiris and Kodaikanal landscapes (Indira, 2019). These herds come for the grass cover in the patches of forest modified plantations (Indira, 2019; Sankar et al. 2020; Chaiyarat et al. 2021). These modified lands with patches of forests become the major land of conflict for local people who have become vulnerable to these grazers (Indira, 2019; Sankaret al. 2020). Huge expansion of tea plantations in the Nilgiris biosphere reserve associated with pockets of human settlements has become a shelter for these ungulates (Madhusudan and Mishra, 2003). Further lack of predator species such as tiger population being significantly low compared to gaur population on high altitude places, may have caused their population to overshoot (Ramesh et al. 2012a, 2012c). Additionally, waste management in Kodaikanal and Nilgiris seem to be improperly managed, which ends up attracting these gaur herds into the settlements and human contact (Sankar et al. 2020).

As the map **[Fig – 67]** shows conflict locations of HGC across the state and it clearly shows that the intensity of conflict is higher in the North, North West and West directions which constitutes densely populated districts like Coimbatore (4,011,678), The Nilgiris (853,131), Dindigul (2,505,555) and Dharmapuri (1,748,089). These districts grow higher cash crops such as carrot and paddy that attracts the gaurs, which matches our data of crops damaged by gaurs. These factors contribute to higher occurrence of HGC in these districts as human population and having vast cultivation areas attracts the elephant population in the forest fringes to raid crops. As the map **[Fig - 68]** shows the risk prediction of the HGC in the state, we can conclude that bright red coloured divisions require more attention in aspects of HGC management.

### 8.4. Management Implications for HGC:

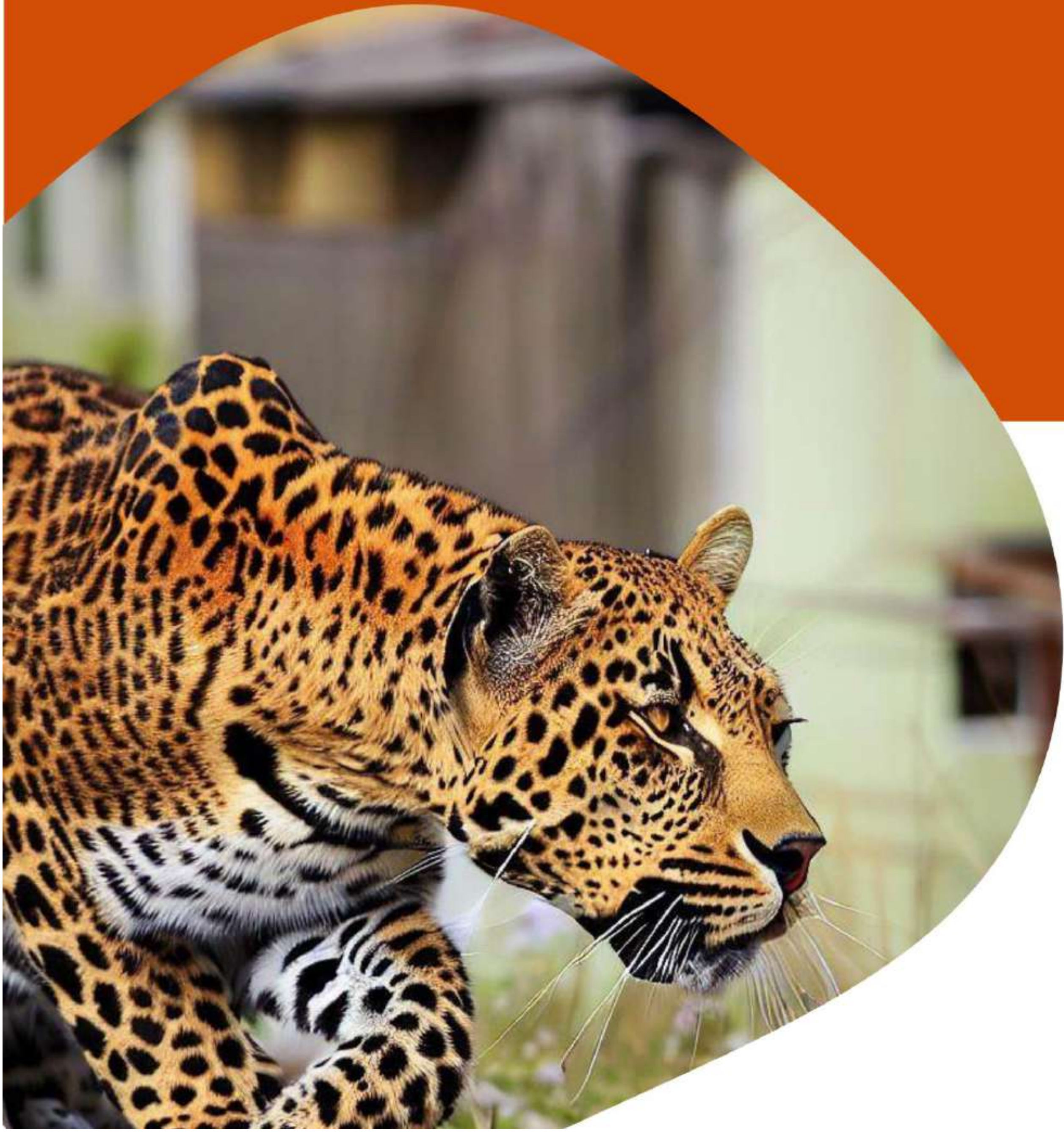
Like any other HWC cases, HGC management is also a multifactorial process. This involves various aspects of social and economic impacts. Currently we have awareness, fencing and chasing as a way of mitigation against Gaur. More behaviour-based study and awareness campaigns in layman's language to make people understand the effect of the Gaur aggressive behaviours would be further helpful in making people see the impact. These huge animals possess higher strength and power which causes humans to fall prey to their aggressive charge. Understanding their behaviour will further enhance our mitigation strategies accordingly. Systematic research to understand their movement patterns and their conflict pattern is needed in order to develop site and conflict specific strategies to handle HGC cases in the state. Till now HGC cases are not that predominant, but lack of appropriate efforts can lead it to explode like HEC or HWPC. Involving multiple stakeholders such as the traffic police department as well as smooth fund flow would be helpful in this case. Additionally, electric fencing and habitat restoration could also give an upper hand to minimising HGC cases.

## 8.5. PHOTOS OF THE FIELD VISITS


**[Fig - 70]Figures depicting Gaur mitigation measures, few conflict cases, and gaur spotted on the roads of kodaikanal.**

# CHAPTER - 4

## HUMAN - LEOPARD CONFLICT



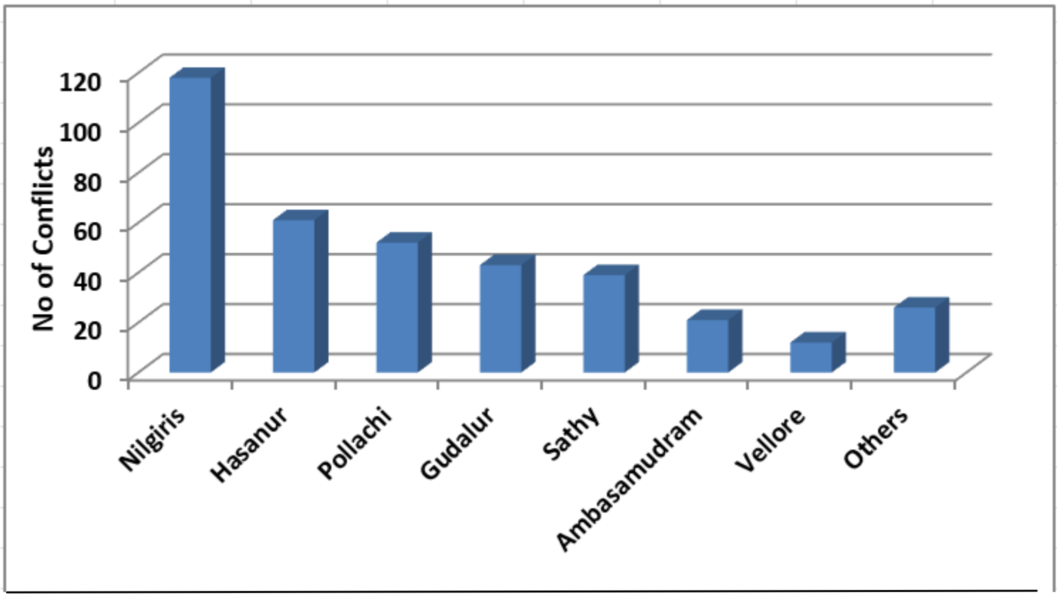
# 9. CHAPTER 4: HUMAN LEOPARD CONFLICT

Human carnivore conflict is one of the major concerns among HWC specialists as this mostly causes livestock and human fatalities or injury. Among carnivore conflicts Leopards, Tigers and Sloth bears are major species to be involved in conflicts. In this chapter we will learn about the Leopard conflicts and the spatial and temporal trends involved. Leopards seem to be comfortable in human settlements and surrounded by human movements. One of the major drivers of leopards to wander off into human settlements is the availability of easy prey near human settlements. They prefer livestock depredation over hunting for prey in the wild. leopards go for mostly cows, calves and goats as well. Cows would be sufficient for them to feed on for days, and calves and goats also become easy targets for them. People have been using the watchdog as a mitigation measure but sometimes they prefer dogs as well. This requires us to go deeper and understand their behaviour as well as predation patterns.

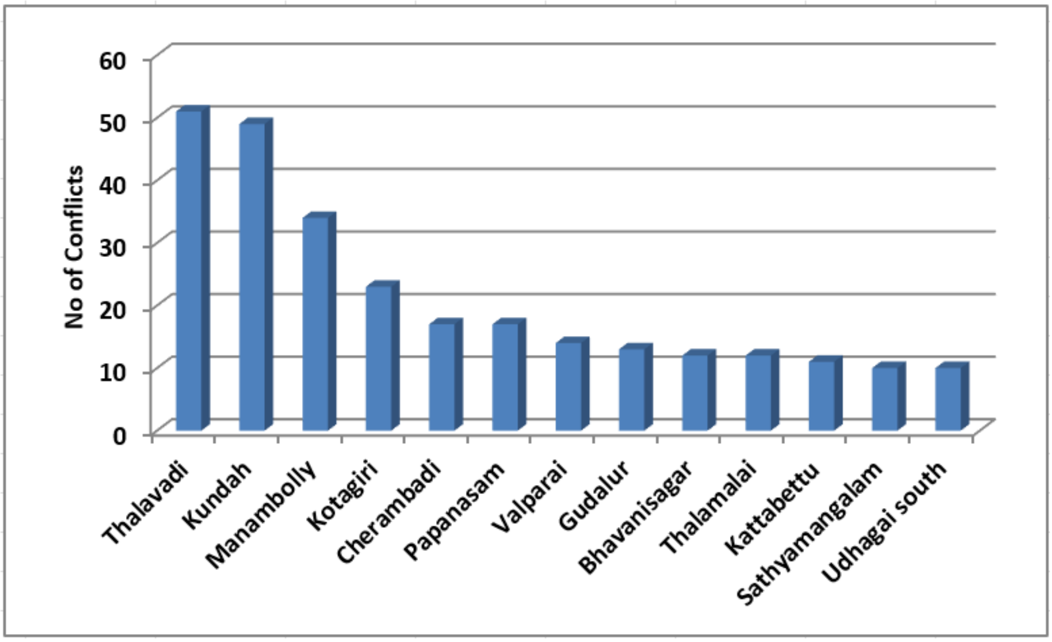
## 9.1. Results

### 9.1.1. Frequency analysis:

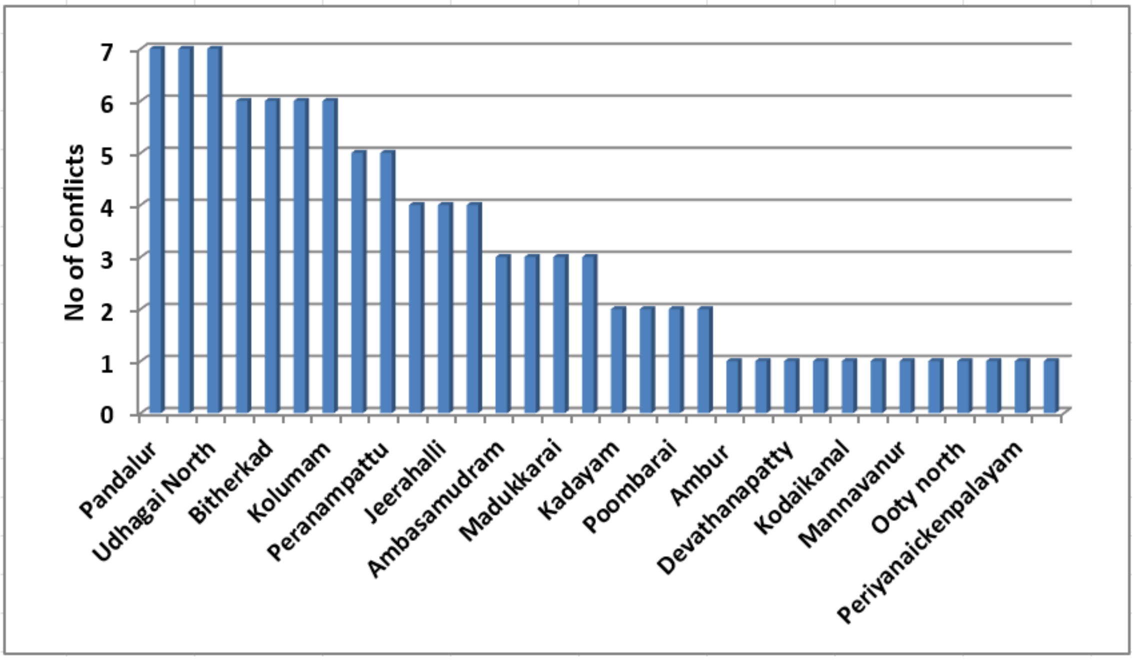
- From the above study, we have observed that Leopard conflict has been contributing to the total HLC cases for the past few years. From the secondary data collected, it seems there are **372** Leopard conflict records in the state. Out of these, the maximum number of conflicts was found to be in the **Nilgiris division (118),** followed by **Hasanur (61**). The lowest number of conflicts was found in the Theni (1) and Tirunelveli (1) divisions, etc. **[Fig - 71]**
- **Thalavadi range (51**) was observed to be highest in leopard conflict, followed by **Kundah range (49**) and **Manamboly range (34**) etc. **[Fig –72, 73]**




[Fig - 71] Showing the frequency of the HLC (Human Leopard Conflicts) Division wise



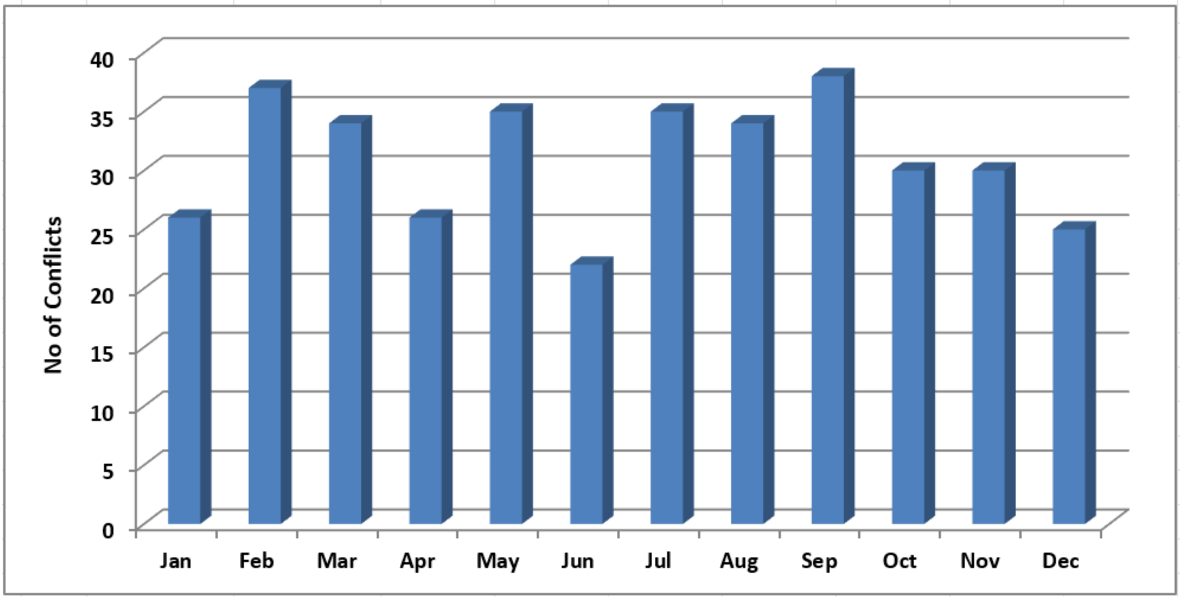

[Fig - 72] shows the frequency of HLC forest range-wise (10 - 60).



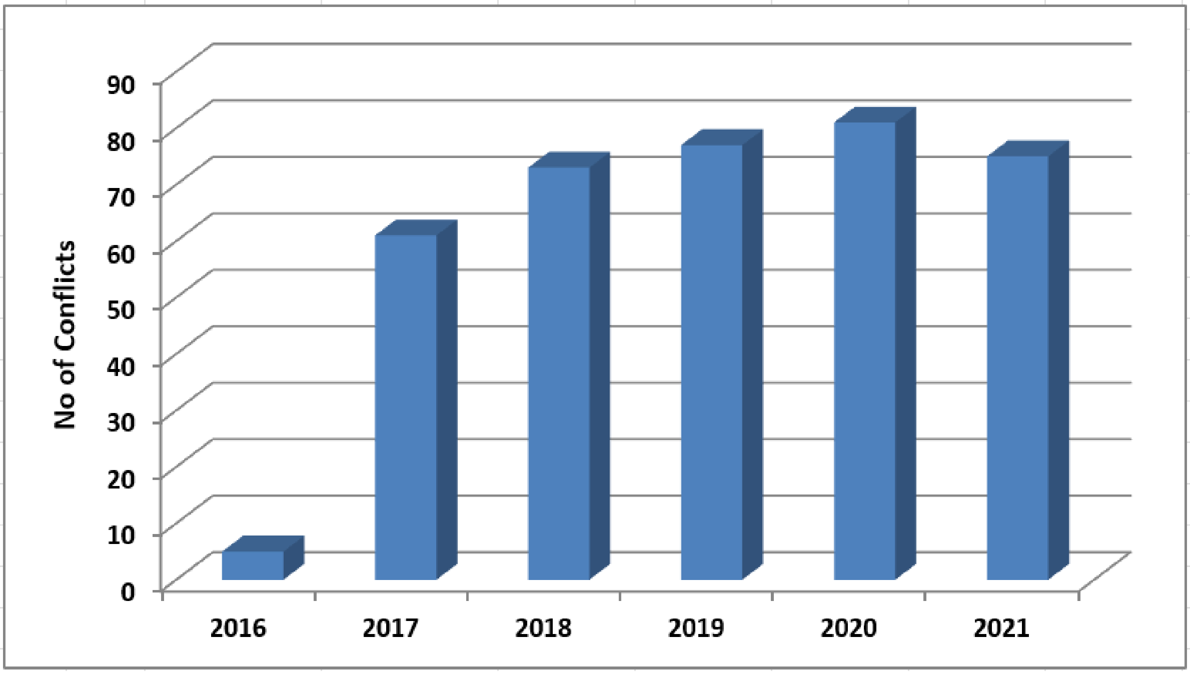

**[Fig - 73] shows the frequency of HLC forest range-wise (0 - 10).**

### 9.1.2. Temporal Analysis

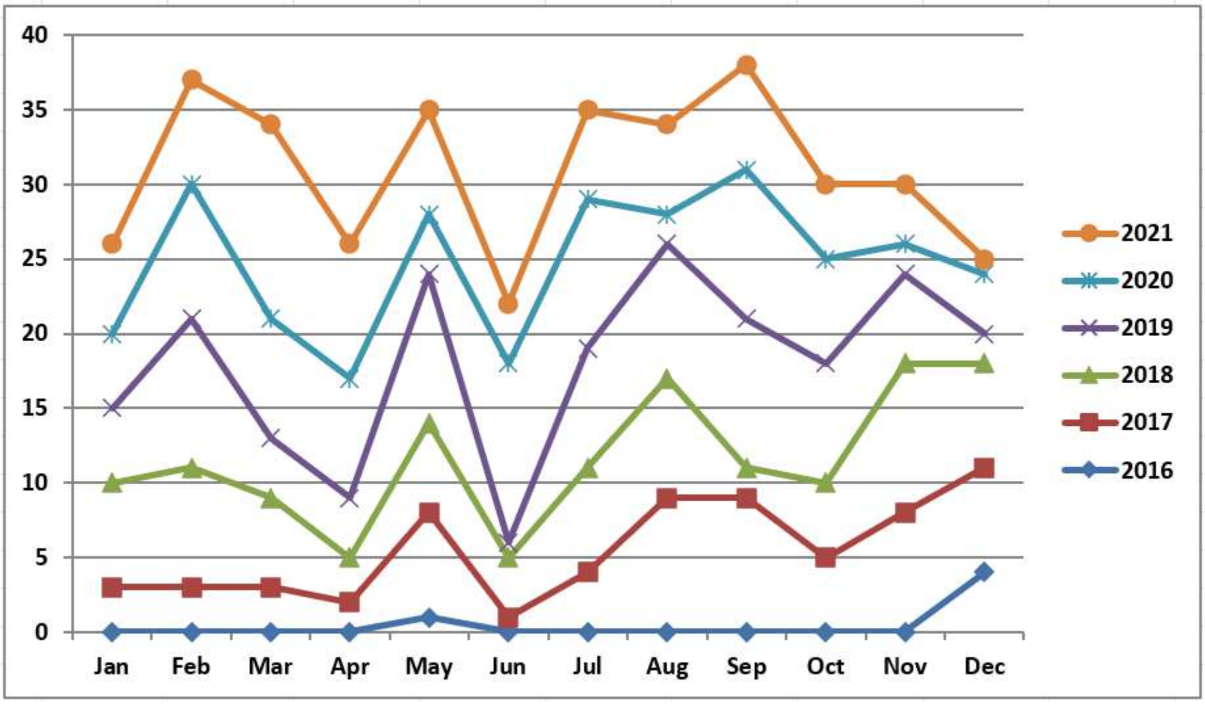
- Overall, the conflict was high for the past few years (2016–2021) in the month of **September**, followed by **February [Fig - 74]**. Throughout the year all the months witness a similar amount of conflicts, which infers that the livestock damage caused by leopards are not influenced by seasonal variation. While comparing the year-wise data, the same trends were observed. Out of 5 years of data taken, the year **2020** saw the highest conflict **[Fig - 75].**




**[Fig - 74] shows the overall temporal analysis of HLC (2016 - 21).**



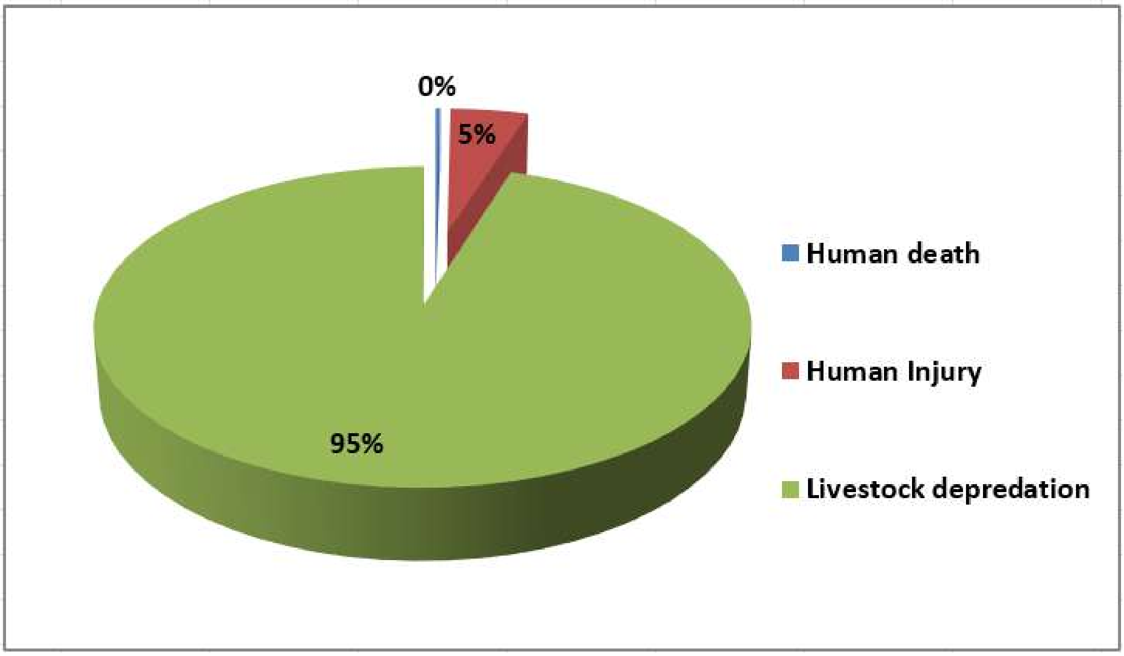

**[Fig - 75] shows the HLC frequency year wise**



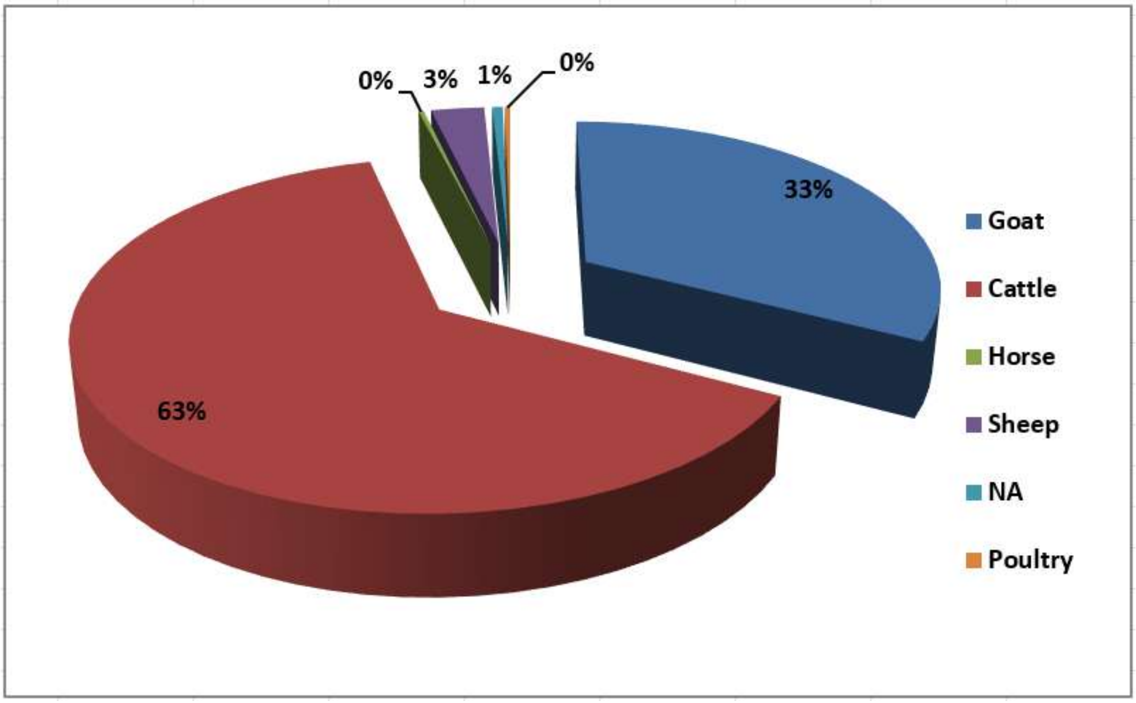

**[Fig - 76] shows the temporal pattern of HLC both month and year wise.**

**9.1.3. Conflict Analysis:**

- Out of all conflict incidents, leopards were found to be mostly involved with **livestock depredation (354),** followed by **human injury (17)** and **human death (1**) **[Fig - 77].** In the livestock depredation category, out of all livestock, **10 types** were attacked most frequently. **Cattle (225)** were attacked most, followed by **Goats (116) [Fig - 78]**.



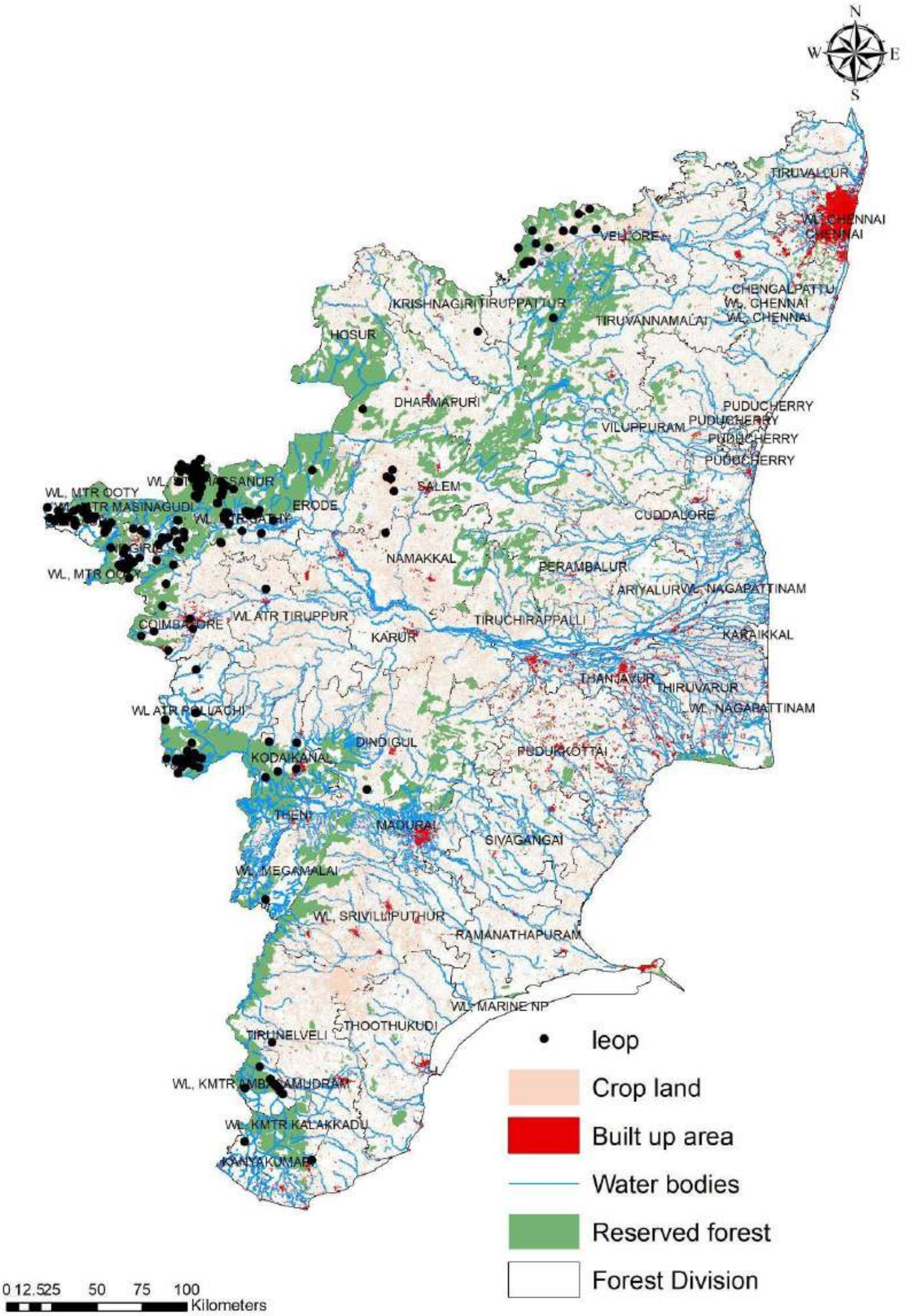

**[Fig - 77] Shows the frequency analysis of conflict types.**




**[Fig - 78] Shows the types of livestock killed by leopards.**

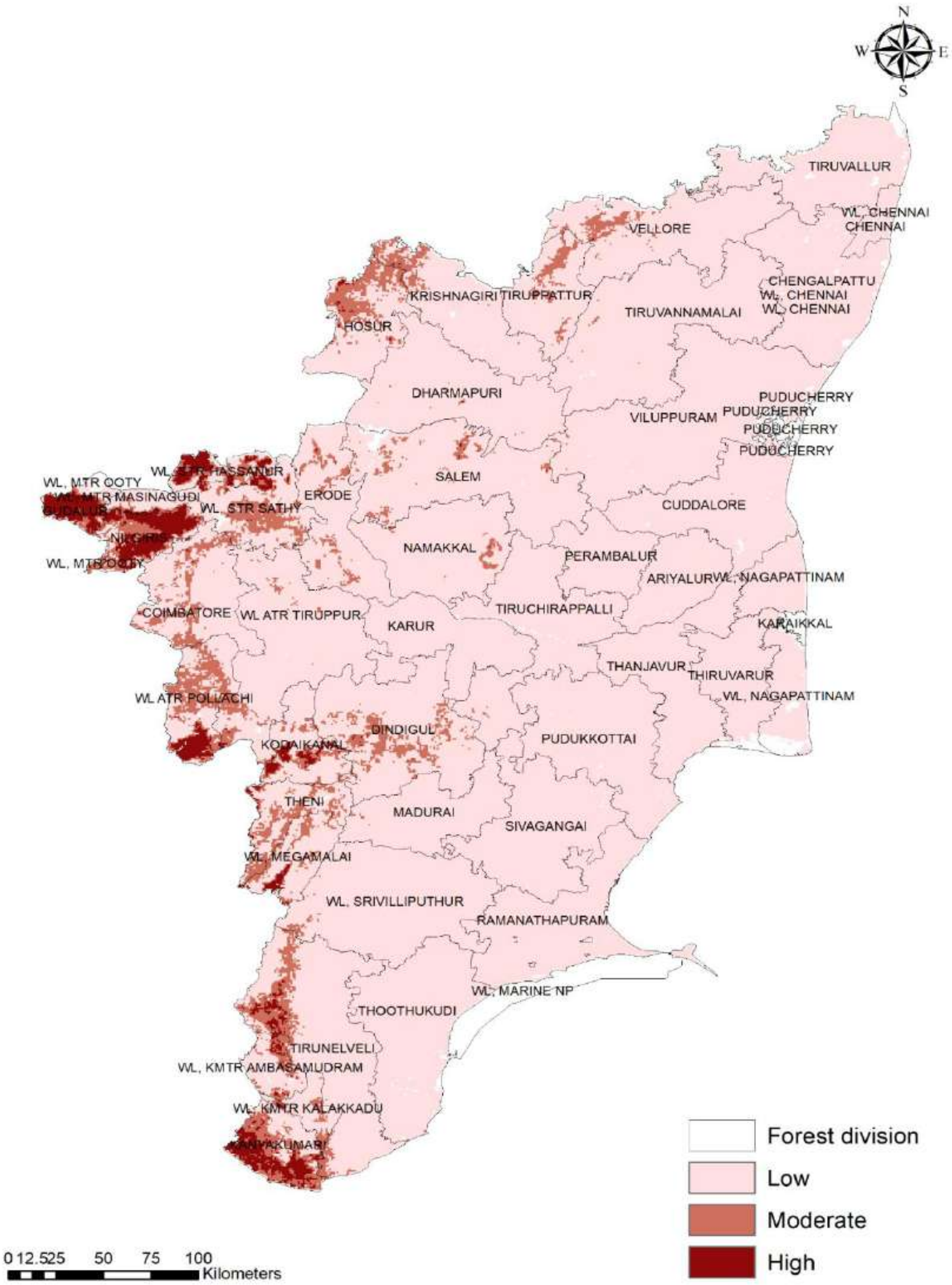
### 9.2. Compensation Payments:

- A total of 342 Leopard conflict incident claims were settled as compensation by the state Govt**(4973000/-)** in a period of **5 years (2016–21**).
- Out of which **4143700/-** settled for livestock damages **(325 incidents**), **400000/-** paid in accordance with human deaths (**1** incident) by leopards, and**429300/-** settled for human injuries caused by leopards.



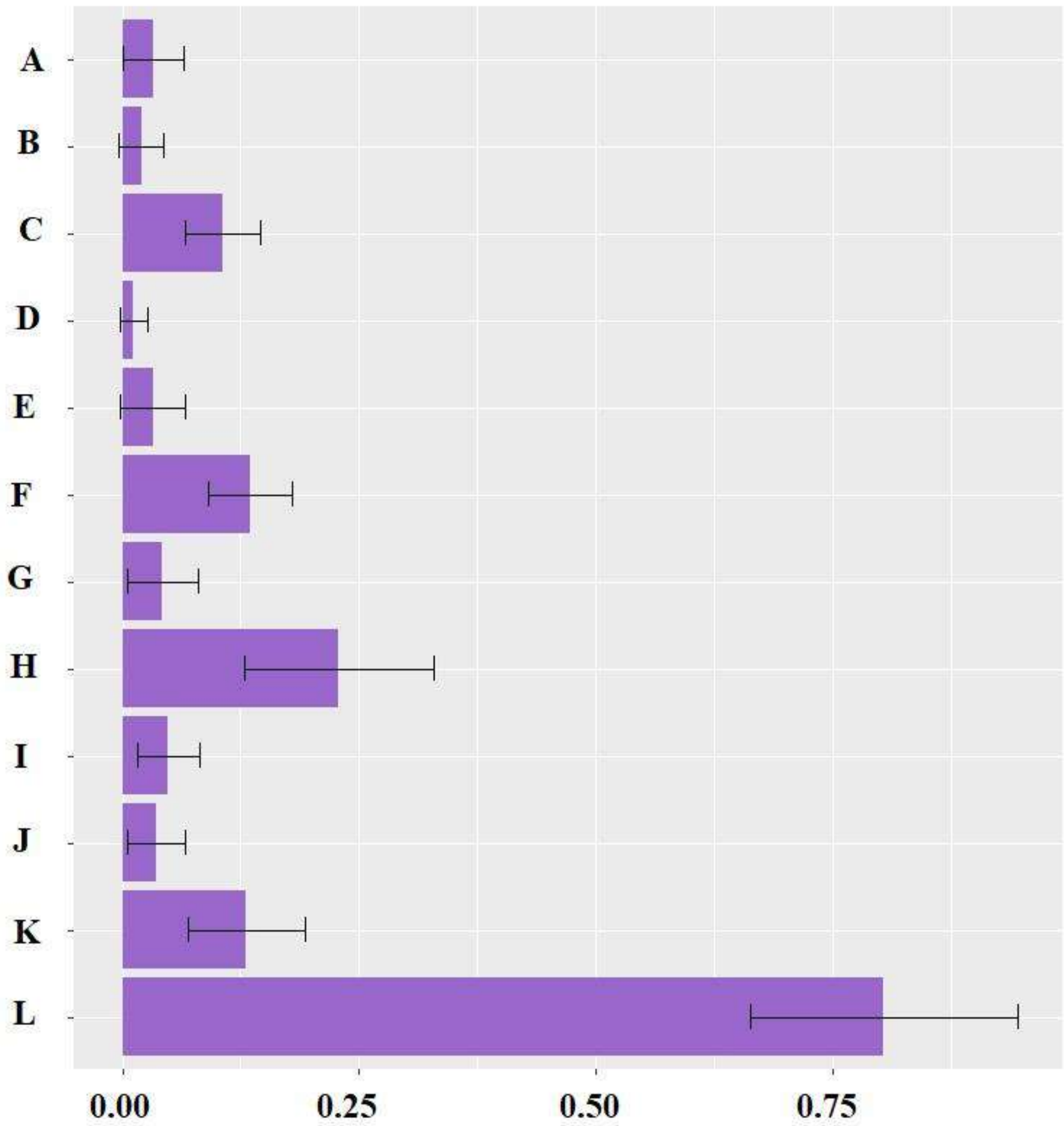

**[Fig - 79] shows the spatial distribution of HLC in the forest divisions of Tamil Nadu**

The above map shows that more conflicts happened in the West and few in the South West direction of the state.




**[Fig - 80] map showing likelihood based predicted conflict risk zone of HLC in forest division of Tamil Nadu. Red colour indicates high conflict risk zones.**

The spatial risk map shows high density at Nilgiris, Gudalur, Kodaikanal, Pollachi and STR Hasanur Forest divisions. According to the modeling, around **3316 km 2**areas come under high conflict zones.




**[Fig - 81] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Night light, E. Normalised vegetation index, F. Human modification index, G. Distance to forest cover, H. Digital elevation model, I. Distance to built up area, J. Isothermality, K. Annual precipitation, L. Mean annual temperature.**

The above graph shows that the mean annual temperature has contributed maximum to the HLC risk modeling followed by Digital elevation model and Human modification index.

### 9.3. Discussion:

In the above study, we analyzed the spatial and temporal analysis of Human Leopard Conflict across the state of Tamil Nadu. We can clearly observe that the HLC cases are high in the **Nilgiris** and **Hasanur** divisions and the **Thalavadi** and **Kundah** forest ranges [Fig – 71, 72, 73]. These divisions and ranges provide an optimum environment for these predators to live and thrive. They encounter vulnerable opportunities in the form of livestock bred within human settlements, particularly noticeable in the Thalavady range. Within this expanse, abandoned quarries have transformed into roosting sites for both leopards and sloth bears. These predators sporadically set their sights on livestock within the surrounding areas. Among the various causes of human-leopard conflicts (HLC), livestock depredation emerges as a prominent contributor, owing to its relative ease compared to hunting in the wild. Our investigation delved into the specific livestock most susceptible to attacks, aiming to propose species-specific awareness strategies. Leopards exhibit a preference for targeting cows, goats, and calves. The second most prevalent factor in the overall HLC cases in Tamil Nadu stems from incidents of human injury. These big cats often feel threatened when they come into close proximity with humans, especially during pursuits. Research indicates that following a livestock attack, the victim's family sometimes consumes the carcass, depriving the predator of its kill and prompting it to seek another within weeks (Lamichhane et al. 2018). Studies have established a correlation between the likelihood of predation by large carnivores and the density of vegetation cover (Miller et al. 2015; Kolowski et al. 2006; Beattie et al. 2020). However, leopards have showcased adaptability, thriving near human settlements and successfully hunting in areas with lesser vegetation cover (Athreya et al. 2016). Heterogeneous landscapes, featuring grazing lands interspersed with settlements, patches of forest, and scrub lands, appear to offer improved prey accessibility for leopards (Sidhu et al. 2017; Naha et al. 2018). The fringes of protected areas have consistently proven to be hotspots for carnivore conflicts (Woodrofe et al. 1998; Inskip& Zimmermann 2009). Leopards are particularly active in such areas, especially within the interface of forested tracts and agricultural expanses (Rostro-García et al. 2016). They adeptly inhabit altered forest zones adjacent to agricultural lands or settlements (Yadav et al. 2020). Their hunting strategy predominantly involves stealthy stalking and ambushes in proximity to forest reserves (Jacobson et al. 2016; Odden et al. 2014). The underlying drivers of HLC within these fringes predominantly encompass habitat degradation and the decline of natural prey populations within these Reserved Forests (RF) (Baral et al. 2021). Our findings underscore that human injuries contribute significantly to the overall HLC incidents. In these cases, leopards exhibit a preference for targeting young individuals over adults, in alignment with previous research (Naha et al. 2018). This behaviour is reasoned by the fact that older leopards or those with cubs tend to opt for hunting young children, as it demands less energy (Bhatia et al. 2017).

The overall temporal trend of leopard conflict shows that conflicts occur throughout the year irrespective of the seasonal months, which can be a result of the residential population residing in the locality. To understand the trends in HLC, we need to go deeper into the behavioural aspects of leopards and their hunting instincts. Rigorous monitoring and behavioural studies need to be carried out in the leopard habitats of the state and on their movements and preying habits. A thorough awareness should be given to the local communities as to where the leopard dominated landscapes are and their frequent movements, so they can avoid grazing their livestock in those leopard prone areas. This will help the farmers circumvent the attacks by leopards.

As the map **[Fig – 79]** shows conflict locations of HLC across the state and it clearly shows that the intensity of conflict is higher in the West and south west directions which constitutes districts with population as such Coimbatore (4,011,678), The Nilgiris (853,131), and Dindigul (2,505,555). These districts fall among the protected areas such as MTR, ATR etc.

with substantial forest cover, which provides these predators an optimum atmosphere to thrive. Unfortunately, continuous encroachment and habitat fragmentation has led them to come in close contact with humans and their livestock. These factors contribute to higher occurrence of HLC in these districts as human population and having varied options of easy prey along the forest fringes. As the risk map **[Fig - 80]** shows the risk prediction of the HLC in the state, we can conclude that bright red-coloured divisions require more attention in aspects of HLC management.

### 9.4. Management Implications for HLC:

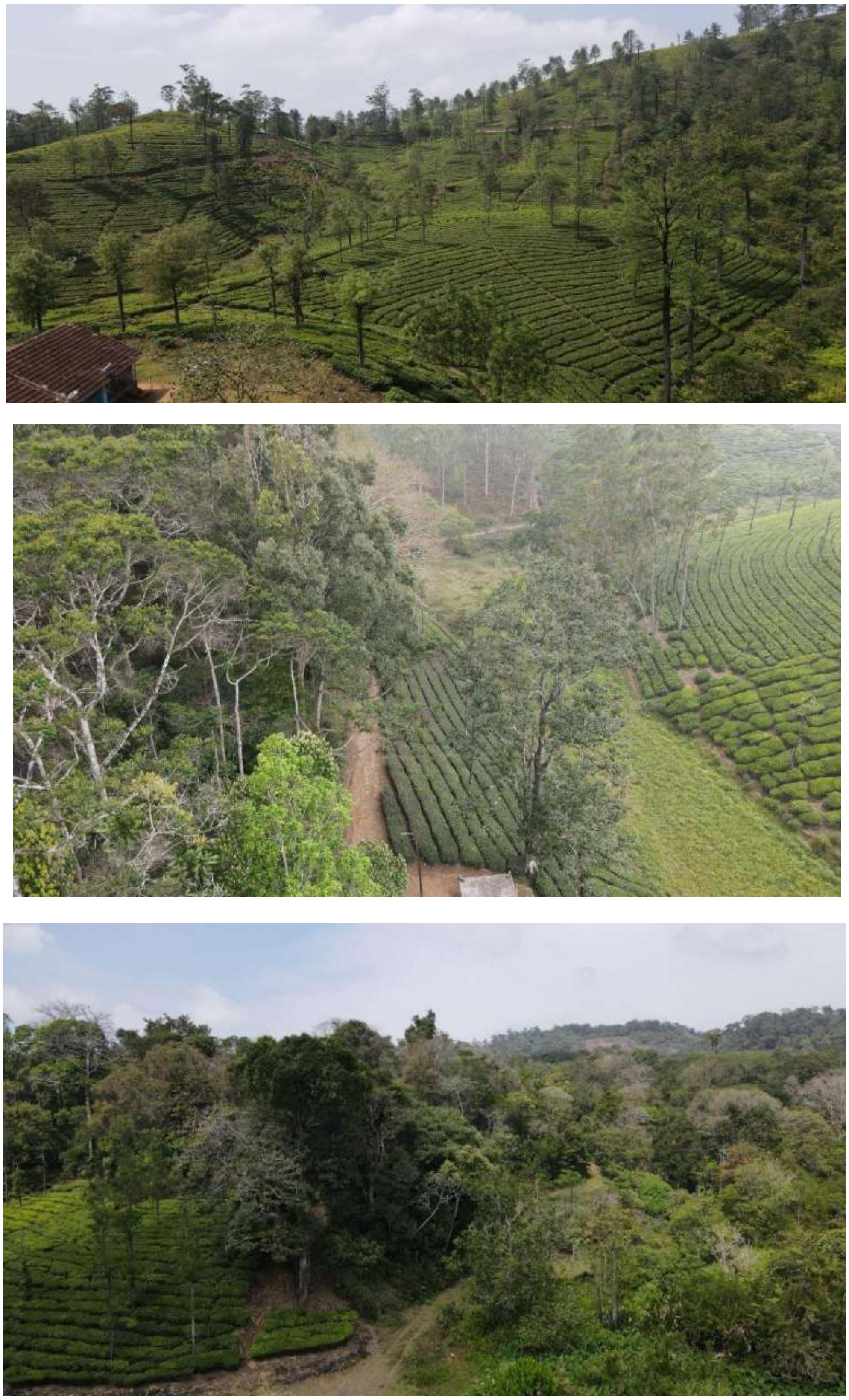
Human Carnivore Conflict, like any other conflict, depends upon awareness and outreach among local communities. Currently, for leopard conflict, various mitigation measures are being implemented, such as awareness, strengthening the livestock fences, monitoring, scary lights and sounds, and chasing away. Mostly, awareness is being proven effective in cases of Leopard conflict. Rigorous monitoring and patrolling would help identify their frequent movement patterns, which could help locals avoid those places for grazing their livestock to avoid loss. Strengthening the houses or fences used for livestock would be another additional measure against leopards. Globally mitigation measures such as projectiles, gas exploders, chemical deterrents (Bangs, 2006) have been proven to be effective against carnivores like leopards. Additionally, measures such as watch dogs or guarding animals, fences and irregular alarms (Ausband, 2013) can be tested in the state on a trial-and-error basis. Issues such as problems in compensation claim in case the predator completely indulges the livestock, farmers cannot produce the picture as evidence if there is no animal left. These kinds of exceptional cases should be looked into thoroughly in order to let the farmers claim their compensation smoothly.

Similar studies show that prey species as well as leopard habitat management, assessment of leopard and prey species current population status would help mitigate human leopard conflicts in the state (Baral et al. 2022). Studies also show that mitigation measures to reduce human leopard conflict involve effective compensation for livestock loss, better protection for livestock and encouraging social acceptance to share space with carnivores. However reactive solutions such as translocation have seemed to increase the conflict as they try to return back to their home and that causes more chaos (Athreya et al. 2011). Similar studies inferred that attacks on humans by leopards cause more negative responses such as retaliation towards carnivores rather than livestock killing. Through genetic analysis the author concluded that the leopard prosecuted by villagers was the same one that killed the victim (Manandhar et al.). HLC cases were mostly recorded from high human modified forest lands, forests that have been modified into agricultural fields or settlements (Yadav et al.). Further maintaining the dispersal between leopard habitats is the key to sustaining their population inside RFs and avoiding potential HLC cases (Swanepoel et al. 2013).

Leopards like any other big cats try to avoid human interaction, but unfortunately lack of resources and mutual sharing of spaces has compelled these felines to face humans. There has been a success story from Bhopal, where these felines and humans share spaces in the heart of the city. There is better urban planning that the city and its people have adapted to micro manage the timings of exposure to certain places that's common between these leopards and humans. We need more study on their movement pattern in specific time periods of the day in the leopard occupancy landscapes, and the landscape can be shared with people in different timings.

## 9.5. PHOTOS FROM THE FIELD


**[Fig - 82]Pictures showing livestock predation by leopards, few field pictures from forest officials and some pug marks spotted around the conflict location**



**[Fig - 83]Location shots of leopard conflict locations which gives us insights of their habitat selection of patchy forests interspersed with lands modified as plantations as discussed in the discussion**

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**[Fig - 84] Drone shots of leopard sighting locations with water sources and abandoned quarries that provide shelter and roosting spots for leopards.**

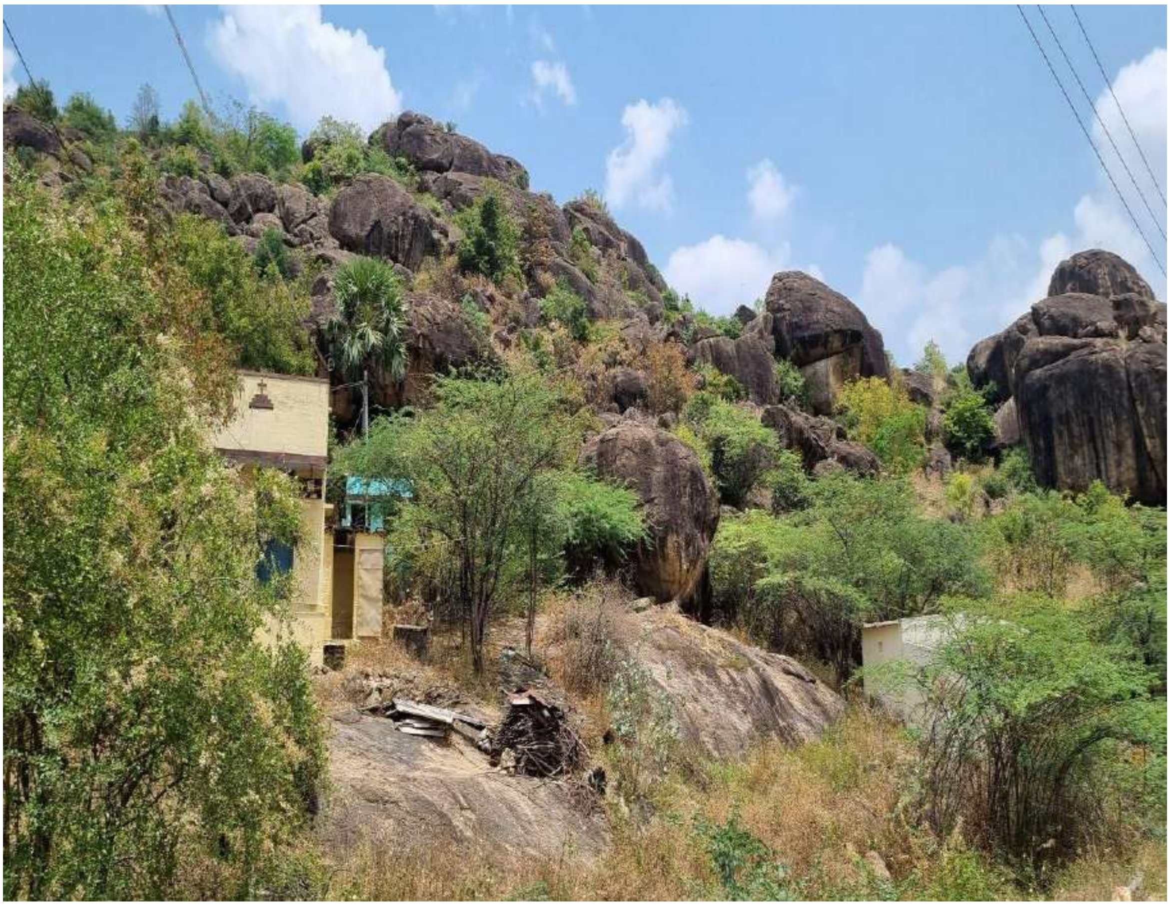
**[Fig – 85] Drone shots of leopard movement area, encroached with human settlements and plantations.**

**[Fig – 86] Team members interacting with victims and forest officials while visiting conflict locations.**

**[Fig – 86] Team members interacting with victims and forest officials while visiting conflict locations.**

**[Fig – 87] First locations that shows the livestock attack by leopards andas a prevention the cattle shed has been moved to new and stronger enclosure (second location).**

**[Fig – 88] Livestock depredation locations, leopard capturing cage, picture showing cattle going inside RFs for grazing which further escalates conflict as mentioned in the discussion.**



**[Fig -89] Leopard roosting place in Papanasam range.**

# CHAPTER – 5
## HUMAN - TIGER CONFLICT

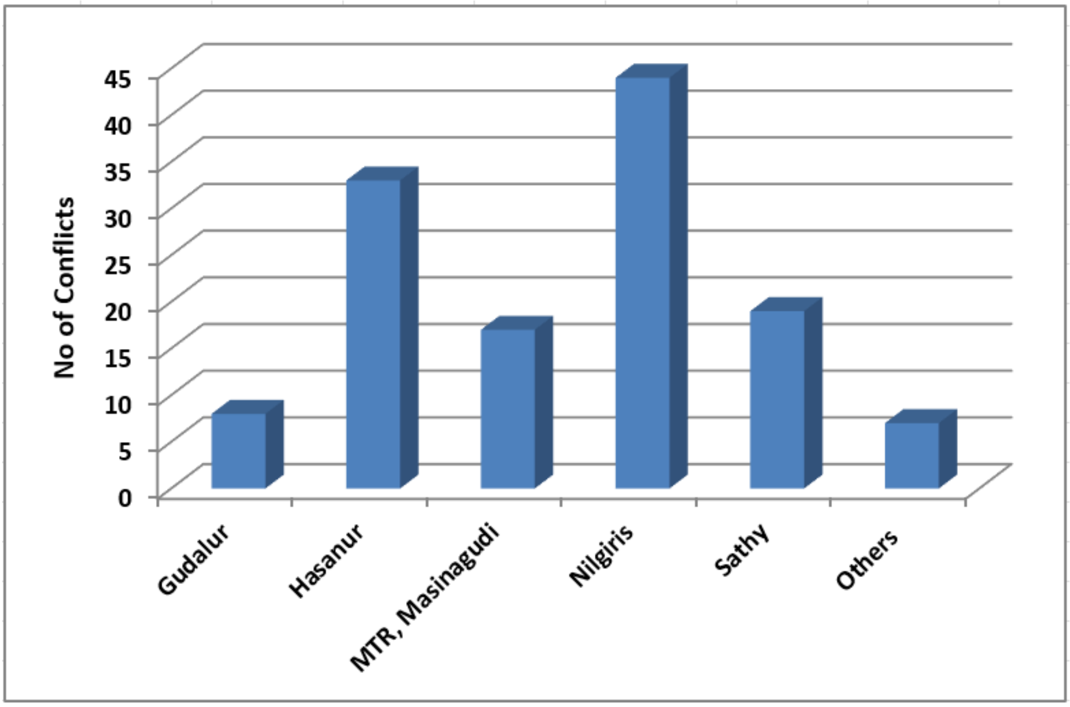
## 10. CHAPTER 5: HUMAN TIGER CONFLICT

Tamil Nadu is a biodiverse state located in the southern part of India, sharing its border with the western ghats provides a mega biodiverse landscape for its communities and wildlife. Among these biodiversity rich landscapes, big cats such as Tigers stand tall as apex predators. The communities here have shared an intricate bond with these majestic predators. However, as the human population continues to expand, encroachment into the tiger's natural habitat becomes inevitable. Rapid urbanisation, agricultural expansion, and infrastructural development have led to fragmented tiger habitats, isolating these magnificent cats and restricting their roaming grounds. As a consequence, tigers are forced to venture closer to human settlements in search of food and shelter, which further intensifies these fatal encounters. In order to address this, issue a multifaceted approach needs to be taken. Increased conservation efforts and heightened public awareness campaigns, establishing more protected areas and tiger corridors should be ensured for these big cats' critical habitats to be kept intact.

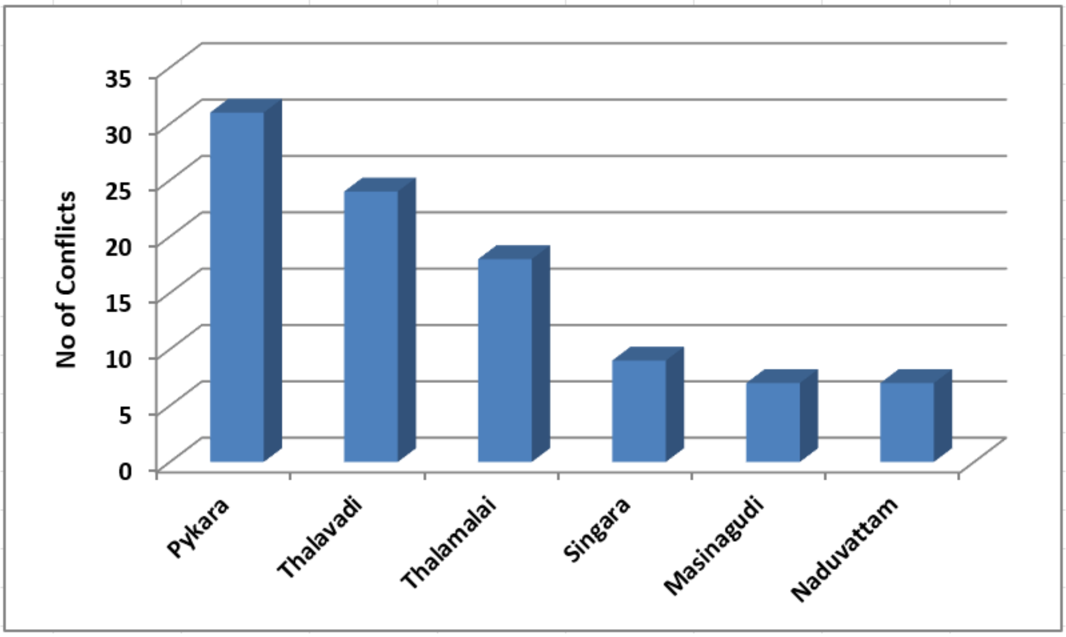
### 10.1. Results

#### 10.1.1. Frequency analysis:

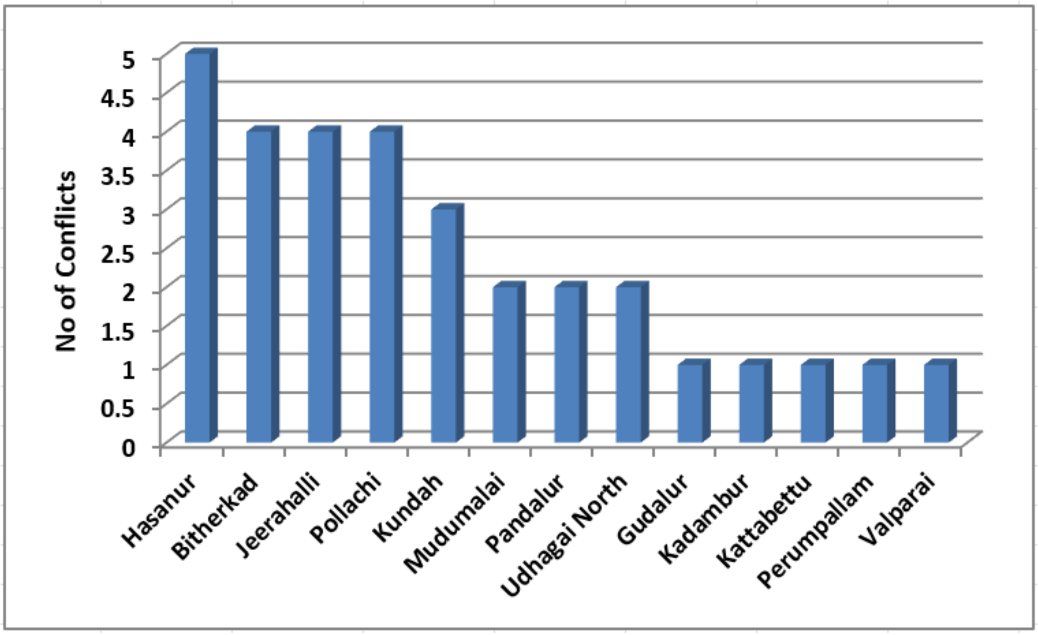
- From the above study, we have observed that Tiger conflict has been contributing to the total HWC cases for the past few years. From the secondary data collected, it seems there are **127** Tiger conflict records in the state. Out of these, the maximum number of conflicts was found to be in the **Nilgiris division (44),** followed by **Hasanur (33**). The lowest number of conflicts was found in the Kodaikanal (1) and MTR, Ooty (1) divisions, etc.**[Fig - 90]**
- **Pykara range (31**) was observed to be highest in tiger conflict, followed by **Thalavady range (24**) and **Thalamalai range (18**) etc. **[Fig –91, 92]**




**[Fig - 90]Showing the frequency of the HTC (Human Tiger Conflicts) Division wise**



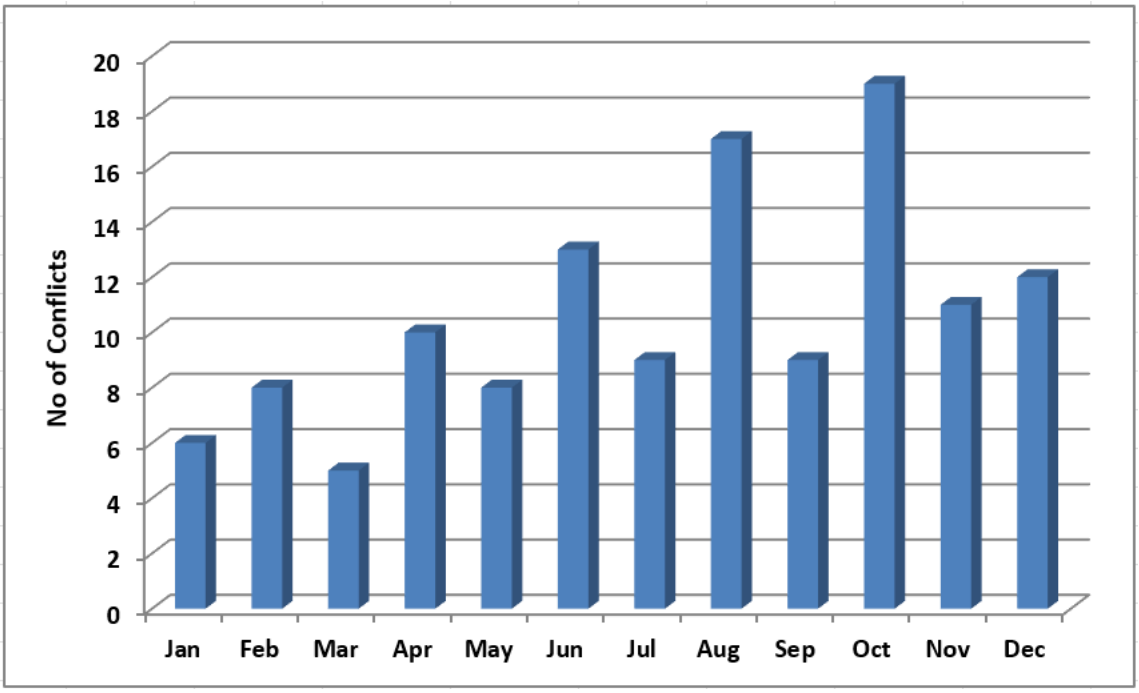

**[Fig - 91]Showing the frequency of HTC forest range-wise (5 - 35)**.



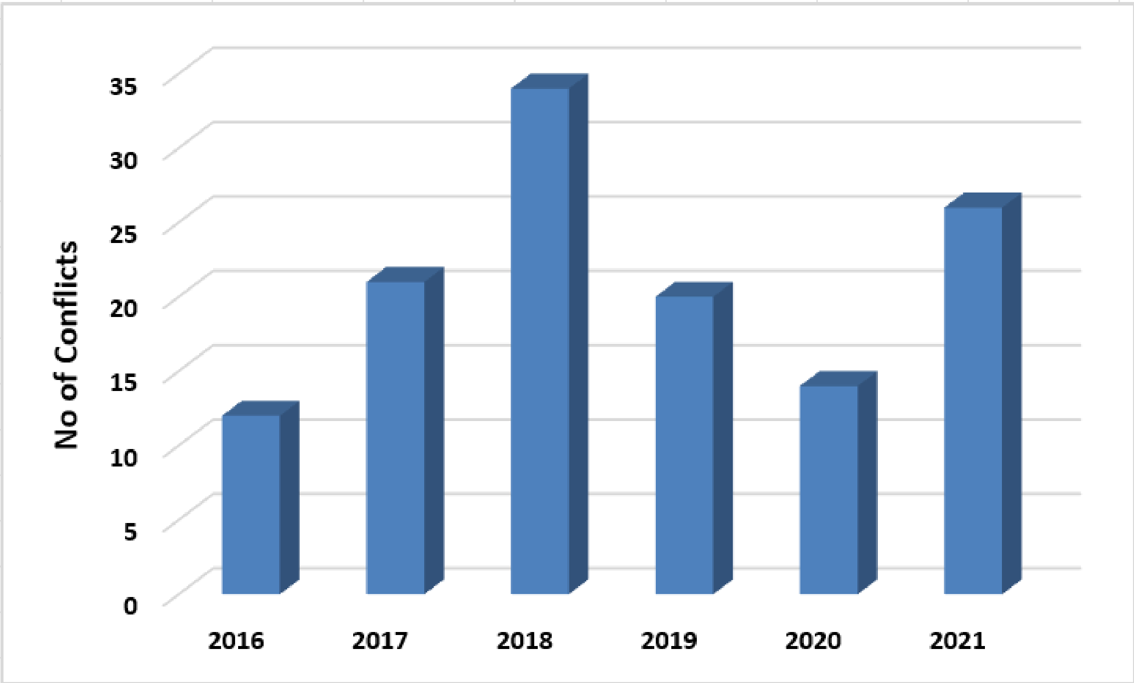

**[Fig - 92]Showing the frequency of HTC forest range-wise (0 - 5)**.

### 10.1.2. Temporal Analysis

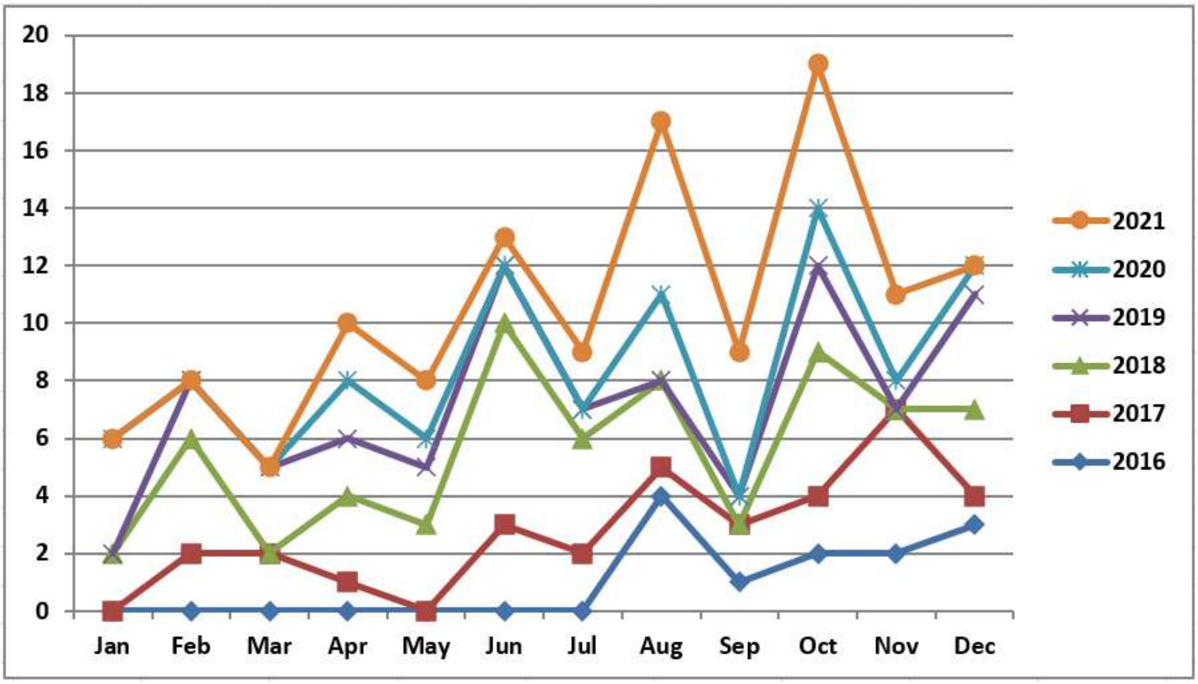
- Overall, the conflict was high for the past few years (2016–2021) in the month of **October**, followed by **August[Fig - 93]**. June, November and December months saw moderate amounts of conflicts, and March saw the least amount of conflict. While comparing the year-wise data, the same trends were observed. Out of 5 years of data taken, the year **2018** saw the highest conflict **[Fig - 94].**




[Fig - 93] Shows the overall temporal pattern of HTC



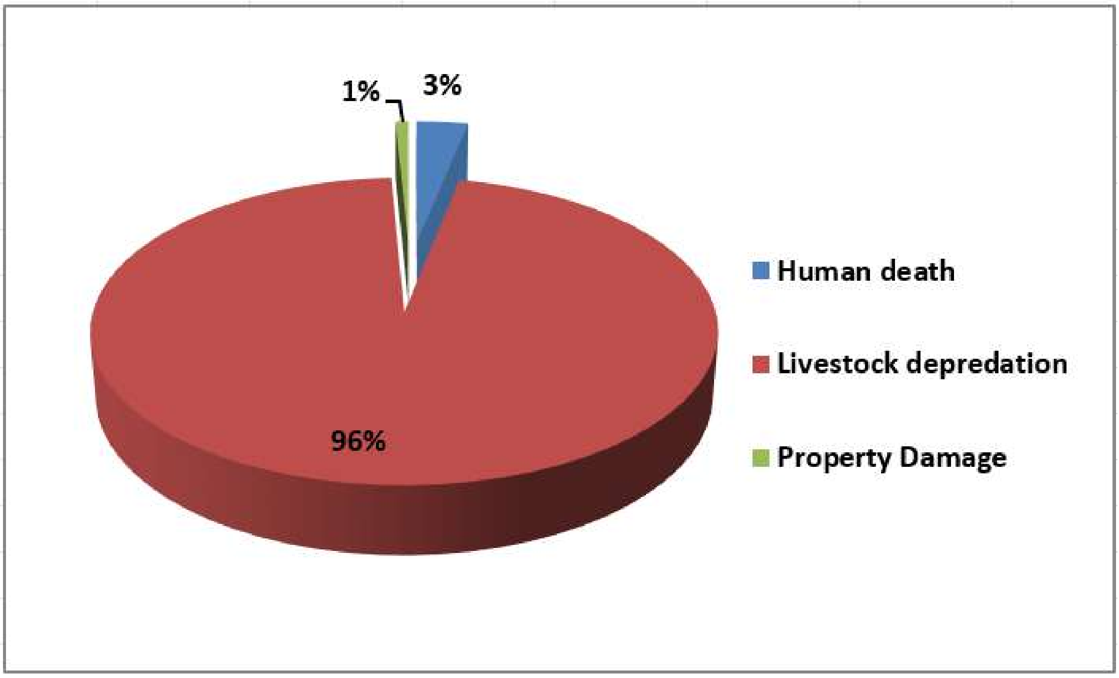

[Fig - 94] Shows the year wise pattern of HTC



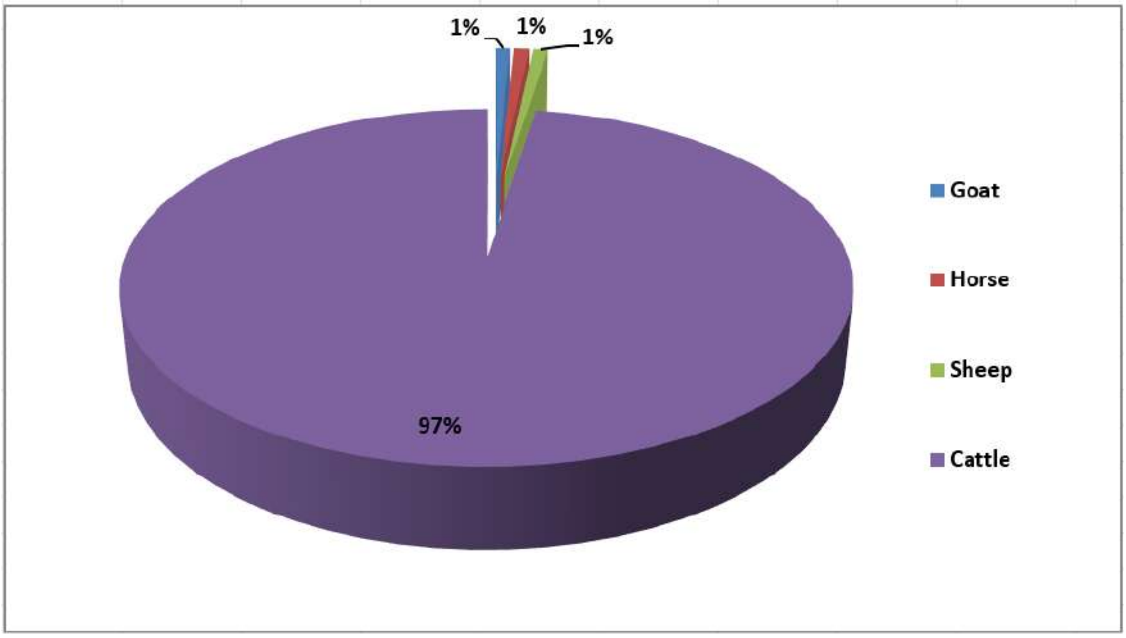

**[Fig - 95] shows the temporal pattern of HTC both month and year wise.**

### 10.1.3. Conflict Analysis:

- Out of all conflict incidents, tigers were found to be mostly involved with **livestock depredation (122),** followed by **human death (4**) **[Fig - 96].** In the livestock depredation category, out of all livestock, **07 types** were attacked most frequently. **Cattle (199)** were attacked most, followed by others **[Fig - 97]**.



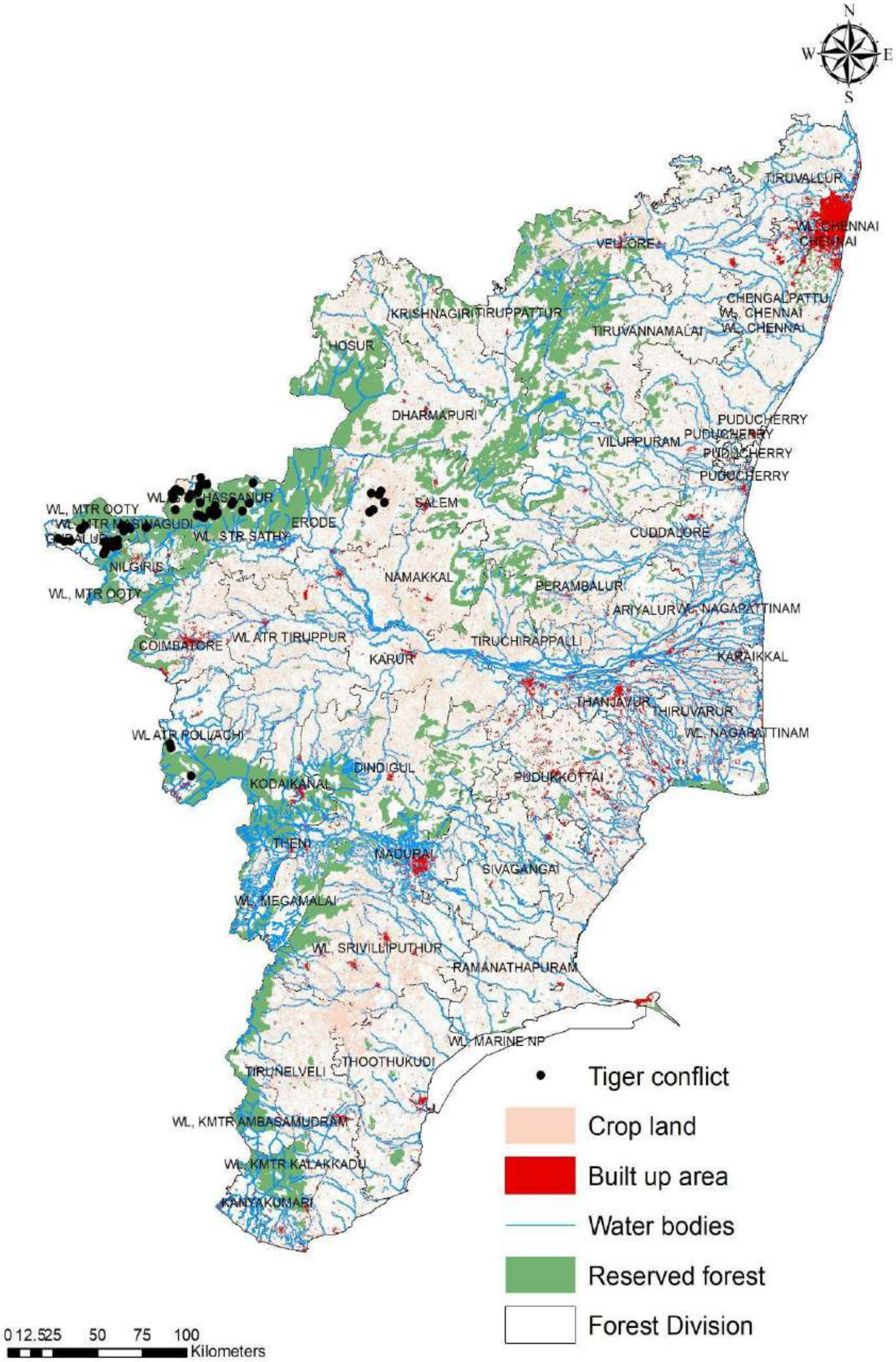

[Fig - 96] shows the pattern of conflict type wise killed by Tiger.




[Fig - 97] shows the pattern of livestock killed by Tiger.

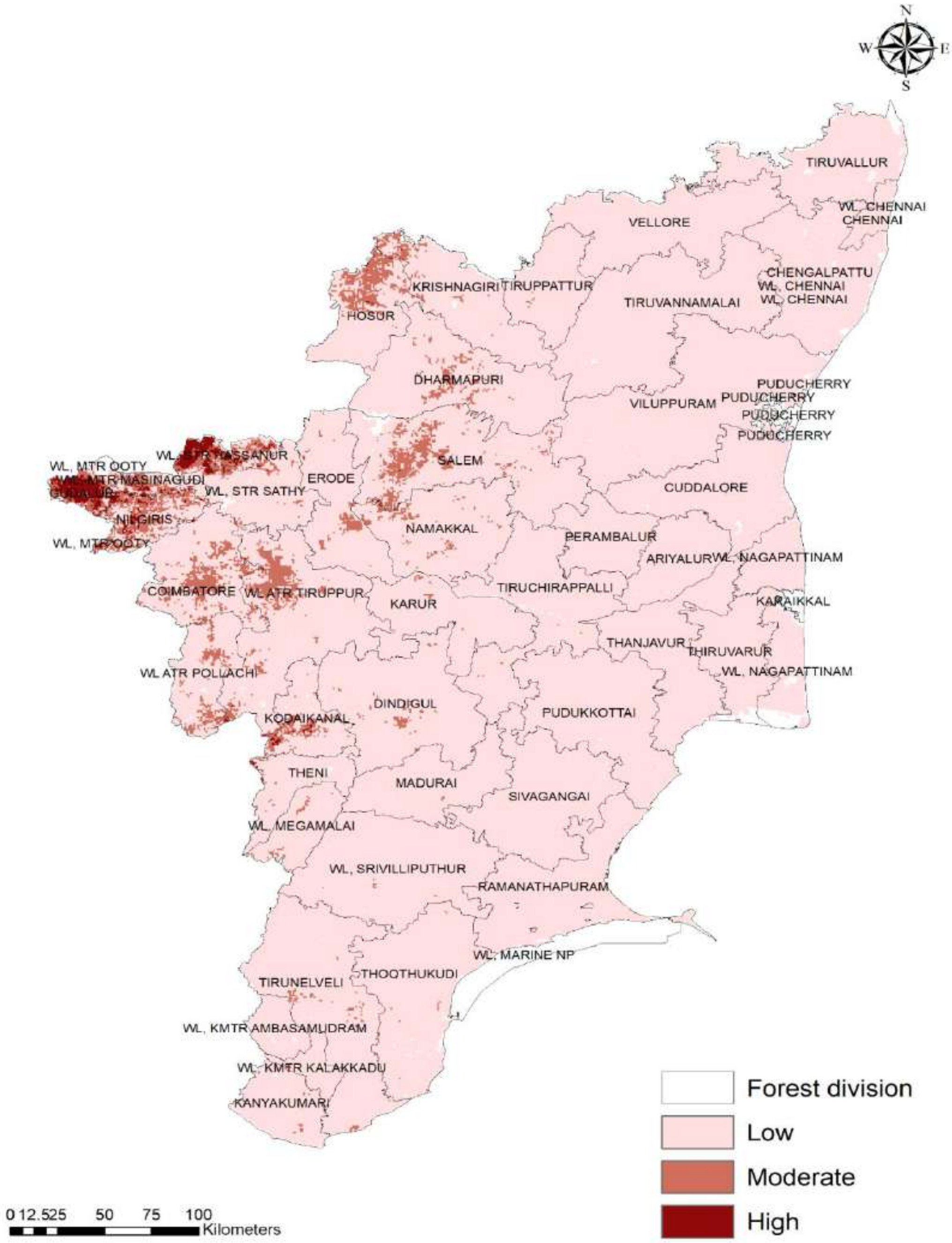
**10.2. Compensation Payments:**

- A total of **120** Tiger conflict incident claims were settled as compensation by the state Govt**(2437000/-)** in a period of **5 years (2016–21**).
- Out of which **2430500/-** settled for livestock damages **(119 incidents**), **1600000/-** paidin accordance with human deaths (**4** incidents) by tigers and**6500/-** settled for property damage caused by tigers.



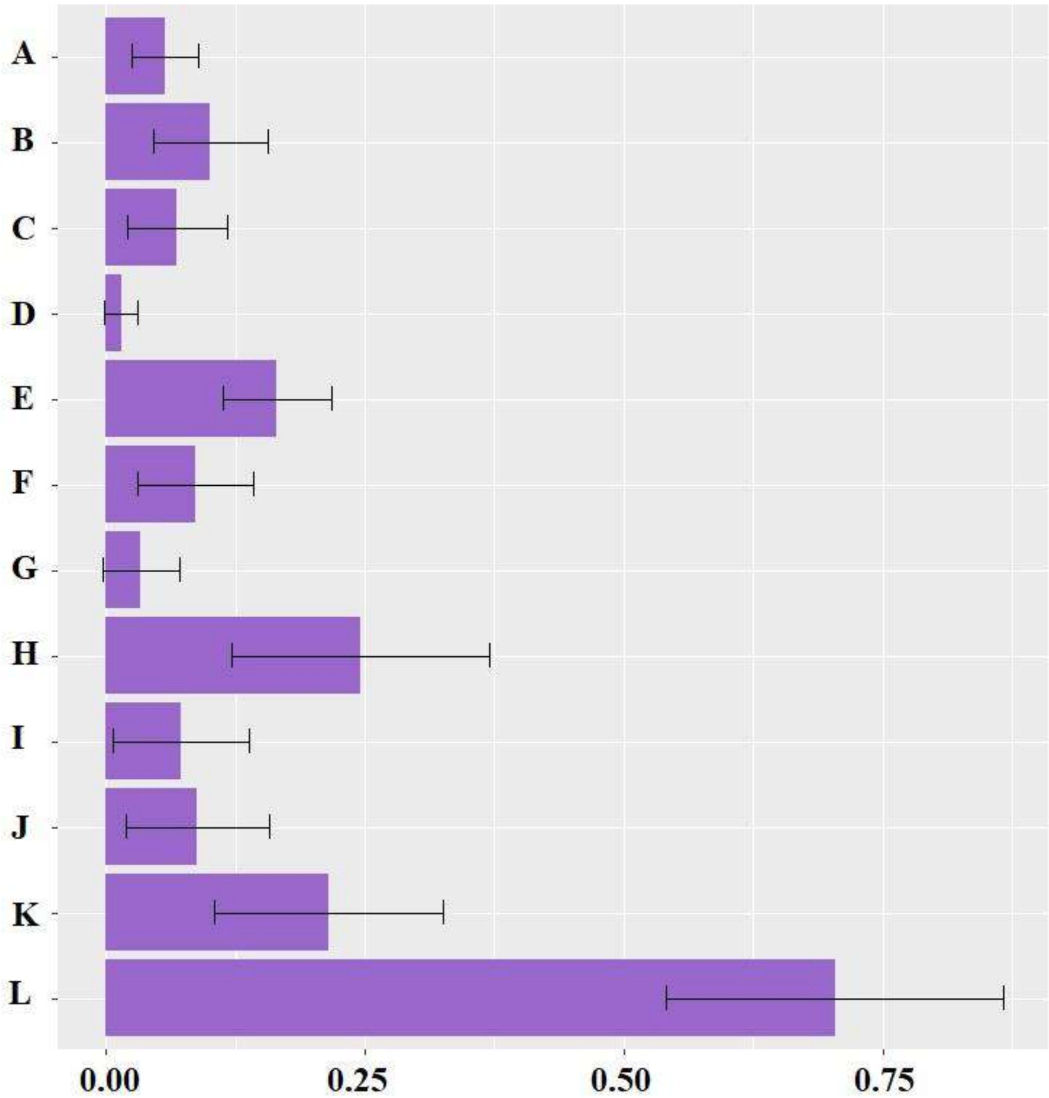

**[Fig - 98] Map showing the conflict locations of Tiger conflict cases.**

The above map shows that conflicts pretty much concentrated to the West of the state.




**[Fig - 99] map showing likelihood based predicted HTC risk zone in forest division of Tamil Nadu. Red colour indicates high conflict risk zones.**

The spatial risk map shows high density at Nilgiris, Gudalur, MTR and STR Hasanur Forest divisions. According to the modelling around **982 km2** has been identified as high conflict zones.




**[Fig - 100] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Night light, E. Normalised vegetation index, F. Human modification index, G. Distance to forest cover, G. Digital elevation model, H. Distance to built-up area, I. Isothermality, J. Annual precipitation, K. Mean annual temperature.**

The above graph shows that the mean annual temperature has contributed maximum to the HTC risk modeling followed by Distance to built-up area and Annual precipitation.

**10.3. Discussion:**

The entire study focuses on spatial and temporal analysis on HWC cases across Tamil Nadu. The Human Tiger Conflict also caught a few attentions these days. as it is observed that the HTC cases are highly reported from **Niligiris** and **Hasanur** divisions and **Pykara** and **Thalavady** ranges [Fig – 90, 91, 92]. These divisions near Tiger reserves can give us an appropriate reasoning of these fatal encounters between tigers and local communities. In Nilgiris there have been many modifications to the large scale forest coverage, such as transformation to tea, coffee, cardamom plantations. Some of these areas have been abandoned as well which is now being used by various prey species like sambar deer, barking deer and mouse deer etc. as a result the predators started invading these plains as well. After the predators' arrival the prey population decreased gradually, but these big cats had found an easy alternative by that time, and went for livestock for sustenance. Some instances narrated by forest officials were that they killed these livestock as a way of transferring the skill of hunting to their cubs. The buffer zone of these tiger reserves has local communities living, and lacking prey or in search of easy targets, these majestic predators wander off into the human settlements and eventually end up causing these unfortunate incidents. Most of the HTC conflict cases were under livestock depredation categories, and within that category, most livestock such as cattle and calves have been killed. Human death contributed second highest of the conflict type analysis, which may be a result of their defensive behaviours around humans. Studies show that tigers seem to eat the dead carcasses of humans which show them being familiar to humans as prey (Dhungana et al. 2017). Seidensticker and McDougal (1993) argued that tigers don't generally prefer humans as prey, since they look so different from ungulate prey and also have necks at a distance which is their target for hunting. Even so they might attack when they feel threatened or not finding any suitable prey to hunt to satisfy their hunger (Gurung et al. 2008; Karanth and Gopal 2005). Overall research shows that these big cats generally avoid humans (Karanth et al. 2017). Similar studies also reveal that juvenile and sub adult tigers may tend to move away from core reserves to find and establish new home ranges at the fringe areas for themselves, where there's ample agricultural and livestock resources available (Karanth and Gopal 2005; Smith 1993).

The overall temporal trend of tiger conflict shows that conflicts occur throughout the year irrespective of the seasonal months, which can be a result of the residential population residing near the protected areas as mostly the high conflict areas are tiger reserves fringes. To understand the trends in HTC, we need to go deeper into the behavioural aspects of tigers and their hunting instincts. Rigorous monitoring and behavioural studies need to be carried out in the tiger habitats and protected areas such as tiger reserves to understand their movements and preying trends. A thorough awareness should be given to the local communities as to where the tiger movement landscapes are and their frequent movements, so they can avoid grazing their livestock in those tiger prone areas. This will help the farmers circumvent the attacks by tigers.

As the map **[Fig – 98]** shows conflict locations of HTC across the state and it clearly shows that the intensity of conflict is higher in the West directions which constitutes with populated districts such as The Nilgiris (853,131), and Erode (2,612,248). These districts fall among the protected areas such as MTR and STR, with substantial forest cover, which provides these predators an optimum atmosphere to thrive. Unfortunately, continuous encroachment and habitat fragmentation has led them to come in close contact with humans and their livestock. These factors contribute to higher occurrence of HTC in these districts as a high human population and having varied options of easy prey along the forest fringes. As the risk map **[Fig - 99]** shows the risk prediction of the HTC in the state, we can conclude that bright red coloured divisions require more attention in aspects of HTC management.

### 10.4. Management Implications for HTC:

Big cats, such as tigers, are territorial animals and often avoid coming into contact with human face to face. However, rapid destruction and fragmentation of tiger habitats have led them to come into close contact with humans. These interactions seldom end up with fatal consequences for both parties. There are various mitigation measures being taken in the state, such as awareness and monitoring, which have been proven to be effective so far. One of the key strategies to mitigate HTC cases is isolating activities in case of time and space between humans and tigers. Furthermore, identification of problem animals, suitable compensation for the loss caused by HTC, sharing of financial benefits of tourism among all the local stakeholders and alternative livelihood options that reduce dependency on forest resources can be proven effective (Bhattarai et al. 2019). Another strategy being followed is killing or removing the problem animal, which does not prove effective in reducing the number of HTC cases (Dhungana et al. 2017). Scientists also argue that relocating the problem animal to another location might increase competition between relocated and residential tigers (Treves and Karanth 2003) and also between other predator species (Harihar et al. 2011; Odden et al. 2010). Banning grazing livestock inside the park can be effective against livestock depredation and replacing the stock with breeds that are lower in numbers but productive can provide close supervision and less manpower to protect and guard (Gurung et al. 2009). Globally, a few mitigation measures are also being proven effective and can be implemented on a trial-and-error basis. These measures include conditioned aversion to some chemicals or any deterrents (gas exploders, irregular alarms, etc.) (Lorand et al. 2022), which can be tested in a site-specific location for trial in Tamil Nadu. Along with these, our current mitigation measures can also be modified and strengthened further, such as monitoring and chasing, which should be rigorous. For these modifications, a large amount of manpower as well as ample logistics are necessary. With the help of monitoring, the tiger movement zones can be identified, and the locals can be made aware to avoid those places during peak tiger movement times.

### 10.5. PHOTOS OF FIELD VISITS

**[Fig – 101] Showcasing the landscape of Masinagudi range with cattle grazing, which explains livestock depredation by tigers and highest being cows**


**[Fig – 102] Locations showing tiger pug mark spotted in Kilipi RF and Masinagudi, few livestock attack and landscape shots that shows the habitat of tigers and a picture of team members discussing with the forest officials**

# CHAPTER - 6

## HUMAN - SLOTH BEAR CONFLICT

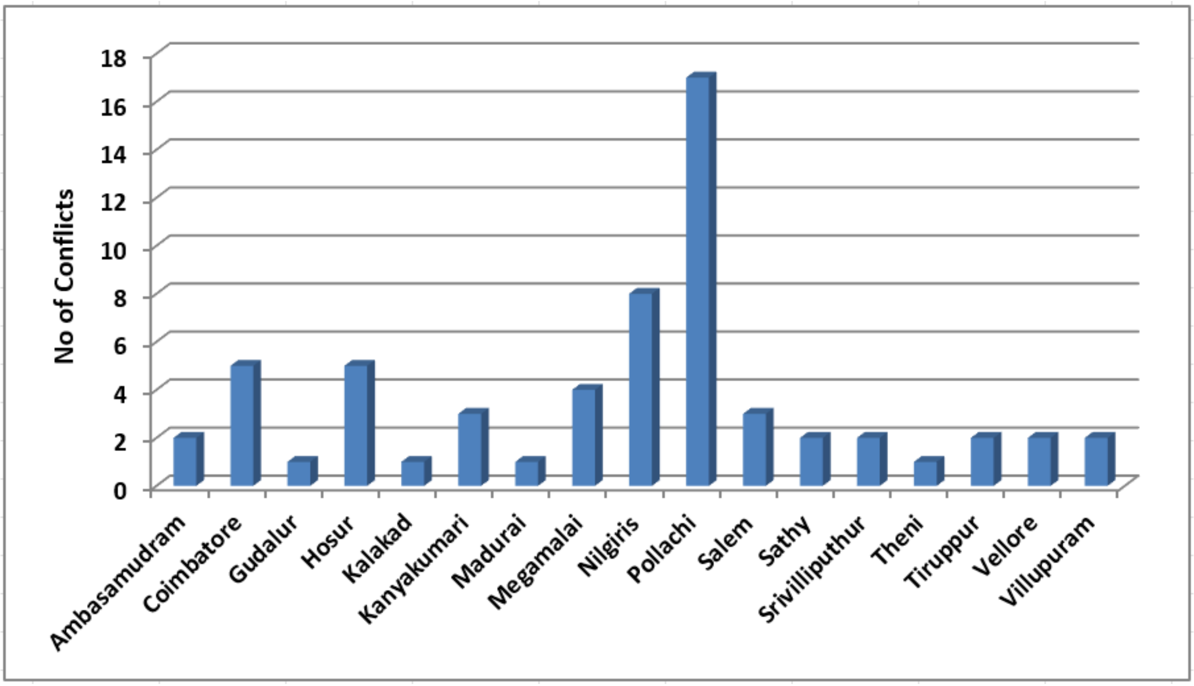
# 11. CHAPTER 6: HUMAN SLOTH BEAR CONFLICT

Tamil Nadu is a biodiversity rich state located in the southern part of India. Sharing its boundary with the Western Ghats surely provides it with an optimum atmosphere for its diverse wildlife to live and thrive. Carnivores such as big cats and canines are its major predators. As the human population expands and agricultural activities extend further into forested territories, the chances of encounters between humans and sloth bears increase. These encounters can lead to conflicts, as both parties compete for resources and the protection of their territories. The human-sloth bear conflict is a prevalent issue, particularly in regions where human settlements encroach upon the natural habitats of these bears. Sloth bears, being territorial and shy creatures, may feel threatened by the presence of humans and react defensively, resulting in potential harm to humans or their property. Conversely, humans may view sloth bears as threats to their crops, livestock, and personal safety, leading to retaliatory actions against the bears.

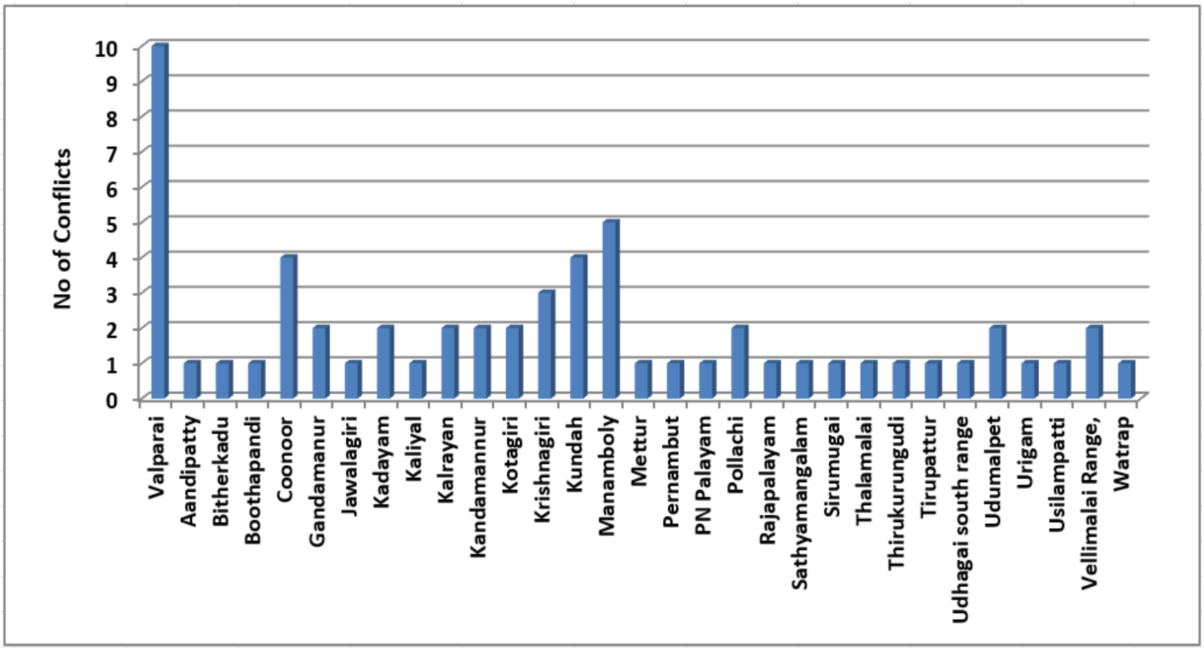
## 11.1. Results

### 11.1.1. Frequency analysis:

- From the above study, we have observed that Sloth bear conflict has also been contributing to the total HWC cases for the past few years. From the secondary data collected, it seems there are **61** Sloth bear conflict records in the state. Out of these, the maximum number of conflicts was found to be in the **ATR Pollachi division (17),** followed by **Niligiris division (08**). The lowest number of conflicts was found in the Kalakkadu (1) and Theni (1) divisions, etc. **[Fig - 103]**
- **Pykara range (31**) was observed to be highest in bear conflict, followed by **Valparai range (10**) and **Manambolly range (05**) etc. **[Fig - 104]**



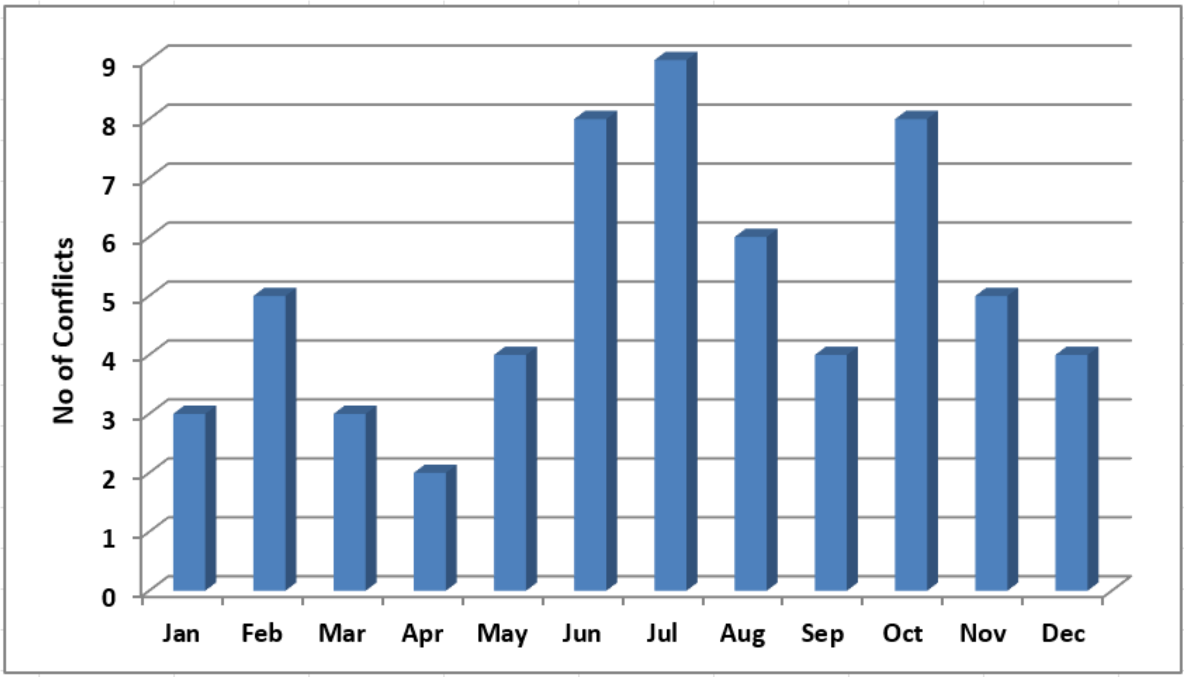

**[Fig - 103]Showing the frequency of the HSBC (Human Sloth Bear Conflicts) Division wise**



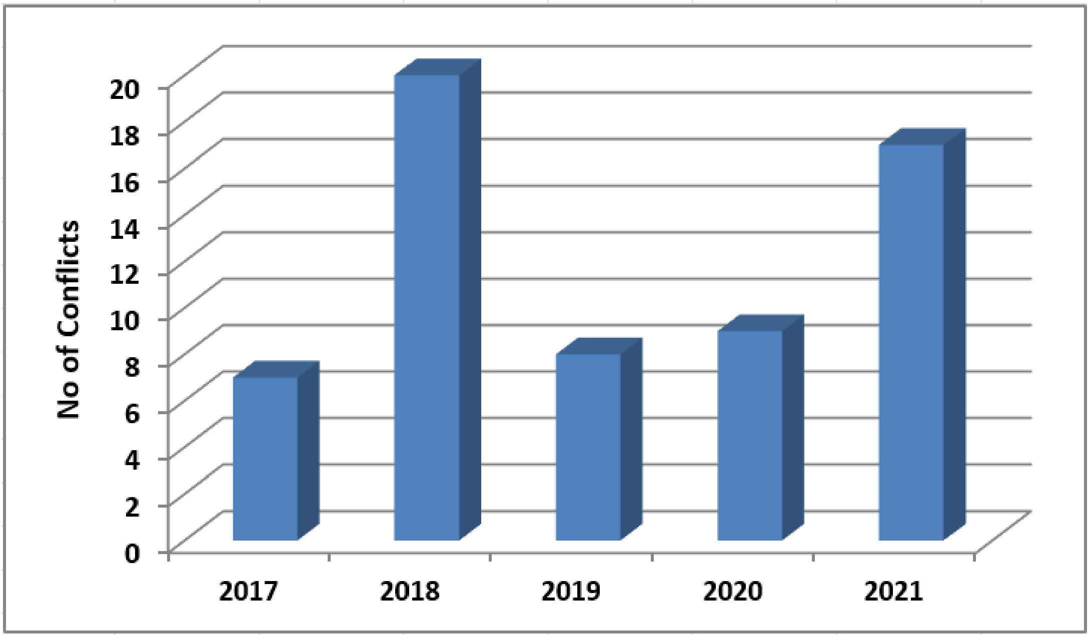

**[Fig - 104]Showing the frequency of the HSBC range wise**

### 11.1.2. Temporal Analysis

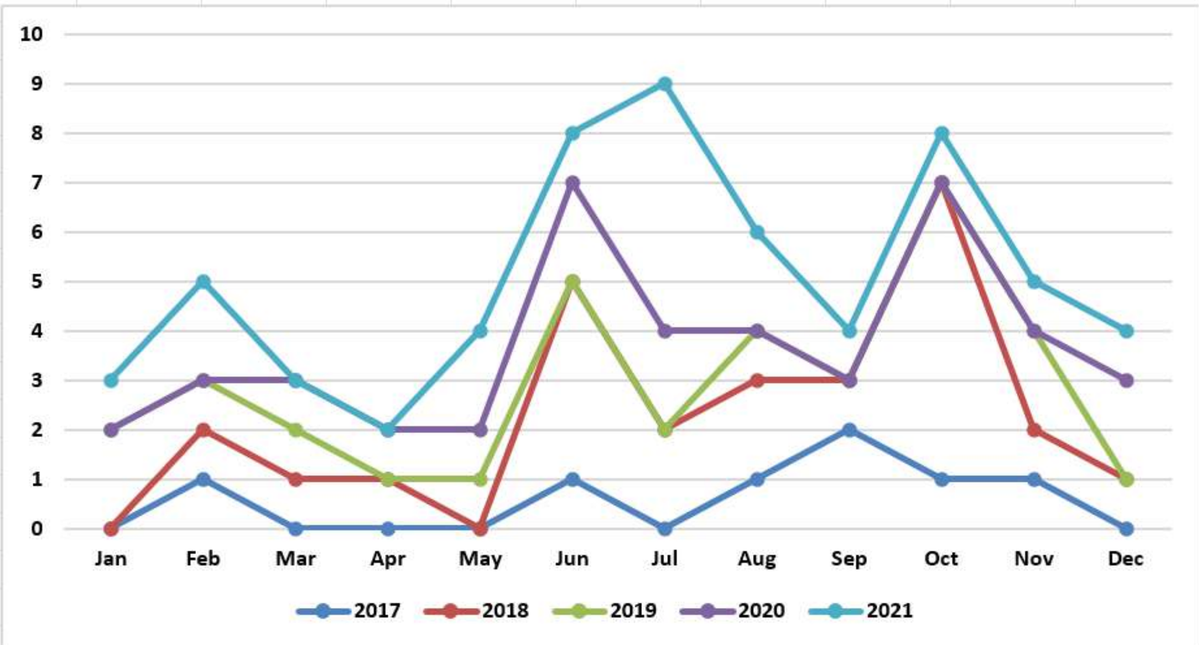
- Overall, the conflict was high for the past few years (2016–2021) in the month of **July**, followed by **June** and **October [Fig - 105]**. August, February, and November months saw moderate amounts of conflict, and April saw the least amount of conflict. While comparing the year-wise data, the same trends were observed. Out of 5 years of data taken, the year **2018** saw the highest conflict **[Fig - 106].**




**[Fig - 105]Showing the Overall temporal pattern of the HSBC.**



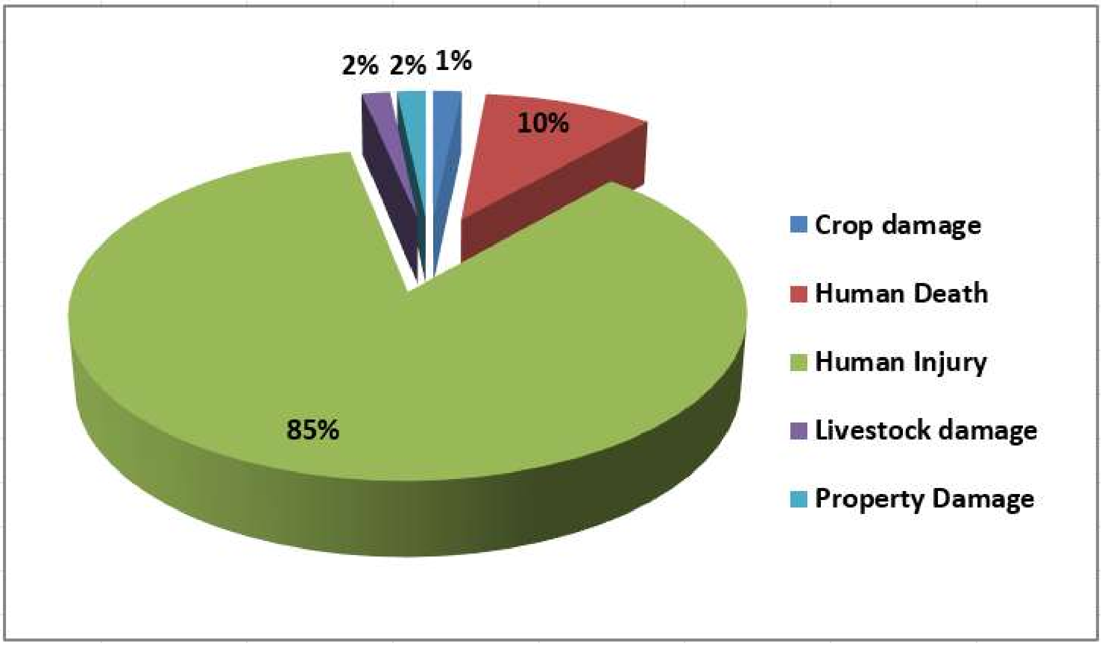

**[Fig - 106]Showing the pattern of the HSBC year wise**



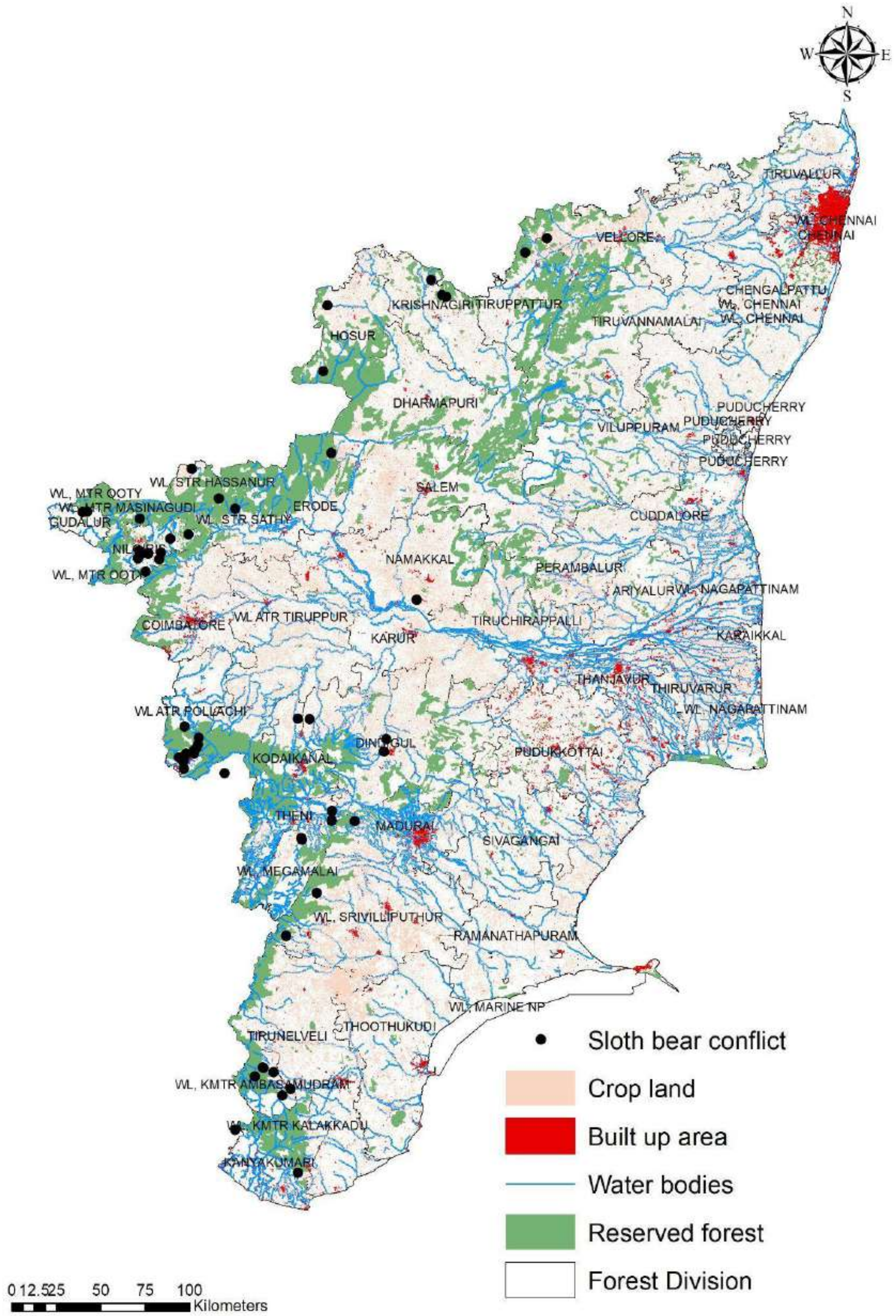

**[Fig - 107]Showing the pattern of HSBC both year and month wise.**

### 11.1.3. Conflict Analysis:

- Out of all conflict incidents, tigers were found to be mostly involved in **human injury (52),** followed by **human death (6**) [Fig - 108]**.** Other categories of conflicts were not found to be as prevalent in the case of HSBC in the state.

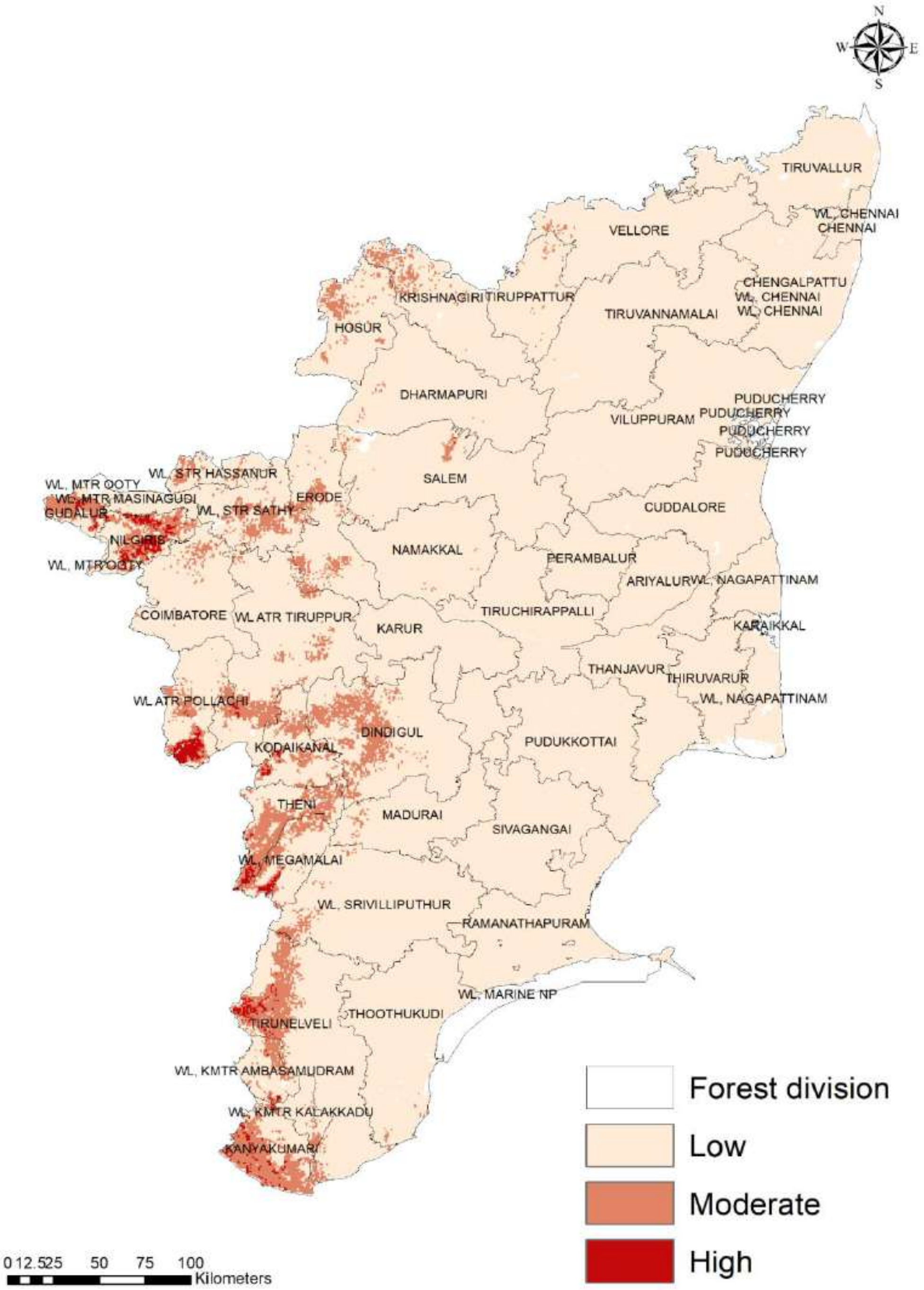



**[Fig - 108]Showing the frequency of the HSBC conflict type wise.**



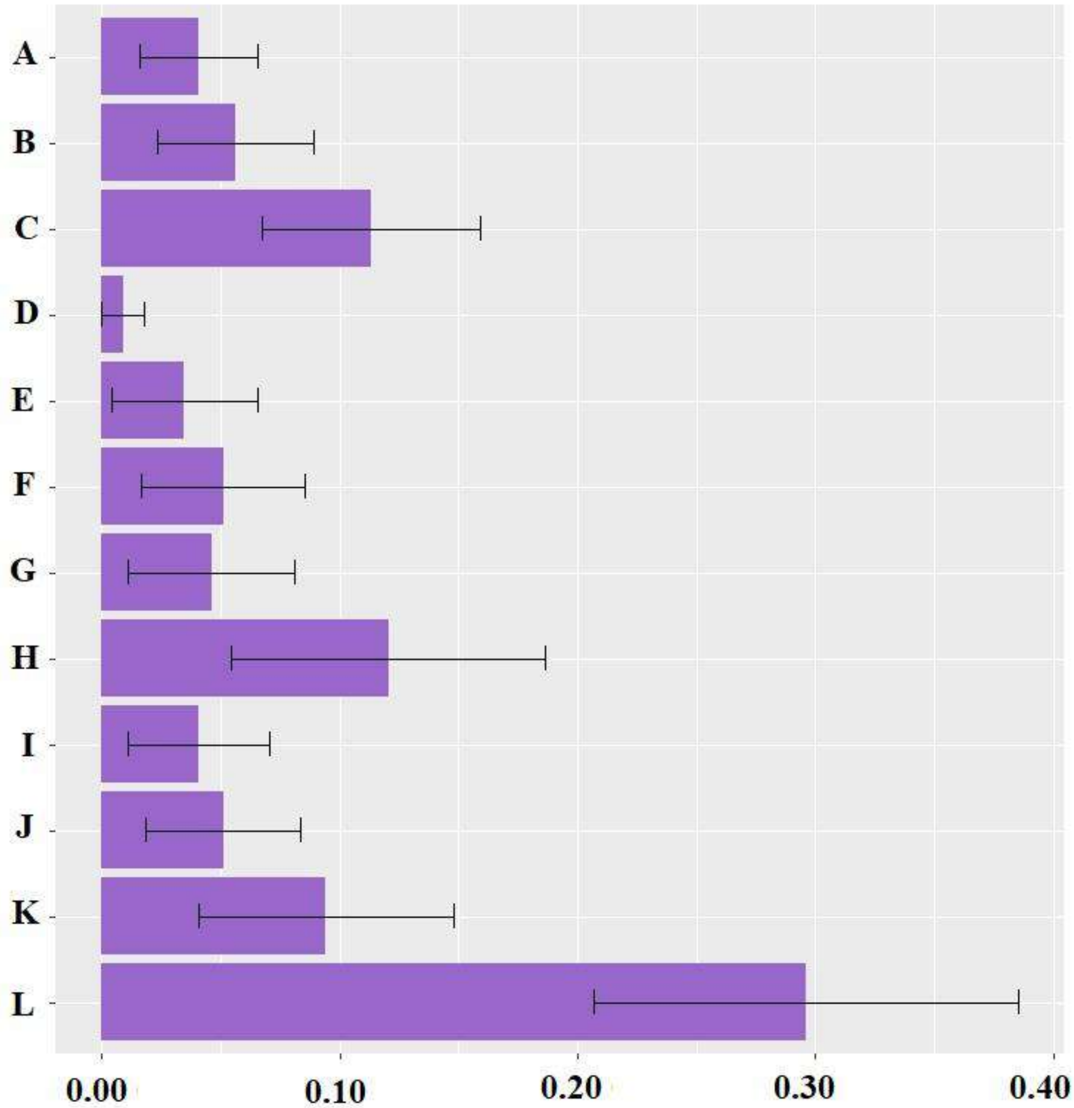

**[Fig - 109] Map showing the spatial distribution of HSBC in Tamil Nadu.**

The above map shows that conflicts occurred mostly in the West, South and South West of the state.




**[Fig - 110] map showing likelihood based predicted conflict risk zones of HSBC in the forest division of Tamil Nadu. The red colour indicates high conflict risk zones.**

The spatial risk map shows high density at Nilgiris, ATR Pollachi, Dindigul, Theni, Megamalai and Tirunelveli Forest divisions. According to the modelling around **968 km2** the area has been identified as high conflict zones.




**[Fig - 111] A, Distance to water, B. Terrain ruggedness index, C. Distance to road, D. Night light Normalised vegetation index, F. Human modification index, G. Distance to forest cover, H. Digital elevation model, I. Distance to built up area, J. Isothermality, K. Annual precipitation, L. Mean annual temperature.**

The above graph shows that the mean annual temperature has contributed maximum to the HSBC risk modeling followed by digital elevation model and Distance to road.

### 11.2. Discussion:

The objective of the project is to identify the hotspots of HWC in the state. In this report, we attempted to provide both overall and major species wise spatial and temporal analyses as well. In this Sloth bear conflict segment, it is observed that HSBC cases are highly reported from the **ATR Pollachi** and **Nilgiris** divisions and **Valparai** and **Manambolly** range [Fig – 103, 104]. As evident all these ranges are highly modified lands with tea and coffee plantations and settlements interspersed with patches of forests. These divisions and ranges fall near the state tiger reserves, giving an appropriate explanation for the frequent conflict cases. The buffer zones with human settlements attract sloth bears towards the garbage and household items. There have been incidents of bears raiding houses in search of food; in the process, they come into contact with humans and end up attacking them as a response of self defence or feeling threatened. Being very powerful and aggressive (Singh et al. 2018), sloth bears can maul humans to death. These instances of human attacks have contributed to the highest number of human injury cases, with human death being the second highest contributor. Bears tend to attack a single individual rather than a group of individuals, their attack seems to be aggressive with less numbers of individuals and vice versa (Ratnayeke et al. 2014; Pokharel et al. 2022). Similar studies have reported that single individuals involved in some chores are more prone to being attacked and mostly single female mother bears with cubs are predicted to attack (Singh et al. 2018). Human injury in the form of bear mauling is prevalent around bear habitats that has been modified and encroached by human settlements, as a result of high anthropogenic pressure, bears come in contact with humans (Bargali et al. 2005; Dhamorikar et al. 2017). In order to minimize these unfortunate encounters, it is recommended to learn about the behavioural aspects of sloth bear attacks and the drivers of the conflict. One of the major characteristics of bear attack is sudden encounters inside the RF, which happens often as the local people depend on forest products such as NTFP (Non-

Timber Forest Products). This requires them to go separately and silently inside the forest to collect these while these unfortunate incidents take place (Dhamorikar et al. 2017; Singh et al. 2018). Some suggest that this dependency on forest products also lead to bear habitat destruction and exploitation, and it was reported that bear attacks males more than females as males move in single and are generally associated with outdoor chores (Gaurav et al. 2022). Sloth bears seem to opt for disturbed habitat with moderation of resources such as food and water etc. A rugged terrain has been reported to provide optimum resting and hiding sites, as well as to protect their cubs from predators like tigers etc as they can hide them easily (Akhtar et al. 2007; Bargali et al. 2012; Baskaran et al. 2015). These omniverse also seem to feed on agricultural crops in human dominated landscapes where high human modification has happened (Mewada, 2015; Paleiet al. 2020). Additionally, invasive alien species such as lantana camara along the roadside reduce visibility and provides hiding site for bears, which further escalates the HSBC cases (Debata et al. 2017; Sharp et al. 2020; Singh et al. 2018).

The overall temporal pattern of Sloth bear conflicts reveals that there was a slight inclination towards the monsoon season (June, July, and August), similar observations were evident from (Pokharel et al. 2022; Singh et al. 2018), other than that the conflict occurred throughout the year irrespective of seasonal variations. This can infer that these sloth bear populations might be residential and reside in nearby forests or human settlements. These trends can vary according to the availability of food sources or accessibility. Community involvement can be helpful in avoiding these interactions. As the bears come to the house in search of food, more efficient chasing techniques and deterrents are needed. Multiple stakeholder involvement will be helpful in circumventing these cases near the protected area fringes. As evident bears do not hunt on large mammals, it's not a part of their diet, however they have been seen scavenging on large mammals at times (Garshelis et al. 1999). Additionally, studies conclude that running triggers a chase response in bears (Herrero 1985), cases of chasing, catching and mauling humans are prevalent (Sharp and Sonone 2011) as the victim's running response is the spontaneous reaction to a sudden encounter with a bear.

As the map **[Fig – 109]** shows conflict locations of HSBC across the state and it clearly shows that the intensity of conflict is higher in the West, South and South west directions which constitutes districts such as The Nilgiris (853,131), Theni (1,445,367), and Tirunelveli (3,569,898). These districts fall among the protected areas such as MTR, KMTR and STR, with substantial forest cover, which provides these predators an optimum atmosphere to thrive. Unfortunately, continuous encroachment and habitat fragmentation has led them to come in close contact with humans and their households. These factors contribute to higher occurrence of HSBC in these districts as a high human population and having varied options of food sources from garbage cans and wastage dumps of the settlements. As the risk map **[Fig - 110]** shows the risk prediction of the HSBC in the state, we can conclude that bright red-coloured divisions require more attention in aspects of HSBC management.

### 11.3. Management Implications for HSBC:

Dealing with powerful omnivores like Sloth bears, which have a penchant for raiding human households and food, poses significant challenges for forest officials and local communities. While various mitigation measures, such as translocation and chasing, are being implemented in the state, they come with several drawbacks. The translocation process, in particular, can be complex and risky, especially when dealing with bear cubs and their protective mothers. This can result in unintended captures and damages to the lives and property. To effectively address this issue and ensure the safety of both bears and people, a multifaceted approach is essential. First and foremost, community awareness and education are crucial components of mitigating conflicts. By informing and educating the local population about bear behaviour and ways to prevent conflicts, we can reduce the likelihood of unfortunate encounters.

Furthermore, habitat protection and restoration play a vital role in minimizing human-bear interactions. Global practices such as shock collars, chemical deterrents can be tested on a landscape basis. (Hawley, 2009). Several global nonlethal practices like irregular alarms, guarding animals and gas exploders can also be tested here with proper supervision. (Garrote, 2012). Studies have also suggested measures like bear spray diversionary feeding and ceasing small mammal poisoning as mitigation for HSBC (Yunchuan et al. 2020). Several approaches like avoiding bears direct sighting and restricting activities near forest during the day (Debata et al. 2017) has been proven to be effective. Studies have recommended keeping their livestock protected, and thorough monitoring of bear population status might be effective against bear conflict (Akhtar and Chauhan. 2008). Poor waste management in few places of Kotagiri range seems to attract bears into the settlements. As evident from a field visit, a huge waste dump was seen near some human settlements and while bears come in contact with humans, eventually lead to conflict.  Similar findings have been reported by studies where the researcher talked about how these trash bins are the reason for people's negative attitudes towards bears which could further lead to retaliatory killing (Prajapati et al. 2021). We suggest effective waste management in and around bear habitats could be helpful in avoiding these negative interactions between bears and humans. Studies also recommend obtaining detailed location data and categorising conflict types uniformly and strengthening the conflict regulations around conflict hotspots is necessary for mitigating these HSBC cases (Mordo et al. 2008). Since it has become evident that maximum conflict happens in close proximity of human settlements, relocating the people from the core zone should be a priority for managers in order to reduce HSBC, and manage wildlife population and habitat (Lasgorceix and Kothari, 2009; Jhala et al. 2021). The issue becomes less complicated as people inside RF in some cases are willing to be relocated cause of these HWC cases, lack of basic facilities and reduced forest productivity (Harihar et al. 2014). Geographical profiling of conflict hotspot villages would help facilitate relocation process and securing their livelihood would make sure that they sustain (Bargali et al. 2005; Dhamorikaret al., 2017; Dhamorikar et al. 2018). However, some studies also suggest that installing camera traps would help monitor human activities inside RFs which could be analysed on a long-term basis to come up with a long-term solution (Miller et al. 2017). Reducing local's dependency on forest products and educating them about the importance of the ecosystem services and sustainability would help in promoting coexistence and reducing HWC (Pokharel et al. 2022; Lamichhane et al. 2018). As stated in several studies, sloth bears tend to have larger territory and greater movement between habitats, which can be inferred from the gene flow among meta populations (Dutta et al. 2015; Thatte et al. 2020). Studies on tigers show that corridors facilitate dispersal which is essential for these large mammals' population growth (Subedi et al. 2021; Thapa et al. 2017, 2018). As sloth bears and tigers co-occur in several landscapes, although the direct predation risk from tigers is seemingly low, tiger centric conservation plans may disturb bears habitat (Joshi et al. 1999). Studies like (Sharp et al. 2020) provide insights into few measures to reduce or avoid bear encounters. These techniques would be making noise to alert bears, protecting head and neck if attacked, practising year-round bear safety. Conflicts happen in low visibility, especially during dark hours so to avoid moving in bear territories during these times. Avoiding single movements and preferring groups are safer. Carrying a 2m stick, possibly modified with bells ("GhantiKathi") and seeking refuge if available or playing dead, can help survive.

**11.4. PHOTOS**

**Fig - 112 Showing huge waste dump in Kotagiri range which is a major driving factor of Sloth bear interaction in the neighbourhood.**

**Fig - 113 Pictures of sloth bear hiding spot and bear scat found on the conflict locations, Bear foot print found in Kilipi RF, and a picture of a watch dog raised by villagers in Kotagiri for alerting the bears movement, however hilariously, according to them he has made friends with the bears now.**

**[Fig – 114] Sloth bear attack human injury location, as discussed these kind of roads provide less visibility which results in sudden encounters with bears.**

**[Fig – 115] Picture of team members interacting with locals and forest officials at a sloth bear property damage location.**

# 12. Chapter 7: Overall conclusion

Human-wildlife conflicts (HWC) in Tamil Nadu encompass a complex interplay between natural ecosystems and human activities, leading to clashes between wildlife species and local communities. The study of conflicts involving wild pig, elephant, gaur, leopard, and sloth bear provides valuable insights into the spatial and temporal patterns of these interactions. The key findings and scientific conclusions from this study, along with potential strategies for mitigation, are summarized below:

## 12.1. Understanding Conflict Hotspots:

- The analysis reveals specific geographic divisions and ranges where conflicts are more pronounced for each species.
- Forest fringes and modified landscapes with human settlements are particularly susceptible to HWC due to resource availability and proximity to wildlife habitats.

## 12.2. Species-Specific Drivers:

- Different species exhibit distinct behaviours and motivations for conflict, such as wild pigs targeting crops for sustenance and elephants searching for food and mates.
- Understanding these species-specific drivers is crucial for effective conflict mitigation strategies.

## 12.3. Temporal Patterns:

- Conflicts occur year-round, highlighting the persistent nature of HWC.
- Seasonal variations in crop harvesting, availability of natural prey, and animal behaviours influence the temporal patterns of conflicts.

## 12.4. Livelihood Impact:

- Human injuries and loss of livestock often result from conflicts, posing threats to human lives and livelihoods.
- Socioeconomic impacts on local communities necessitate holistic approaches to conflict resolution.

## 12.5. Habitat Fragmentation and Modification:

- Anthropogenic activities, such as habitat destruction and encroachment, contribute to conflicts by forcing wildlife to adapt to modified landscapes.
- Encroachment disrupts natural predator-prey dynamics and exacerbates resource competition.

## 12.6. Management Strategies:

- Mitigation efforts should focus on protecting and restoring natural habitats, ensuring prey availability for predators, and promoting wildlife corridors.
- Awareness campaigns and education initiatives can empower communities to adopt proactive measures and avoid conflict-prone areas.

## 12.7. Human Behaviour and Practices:

- Human actions, such as waste mismanagement and improper livestock management, contribute to conflicts by attracting wildlife to settlements.
- Effective waste disposal, responsible livestock practices, and reducing human-wildlife encounters are crucial components of conflict reduction.

**12.8. Conservation and Coexistence:**

- Successful conflict management involves striking a balance between conserving wildlife and ensuring human safety and livelihoods.
- Implementing innovative technologies, such as early-warning systems and deterrents, can reduce the frequency of conflicts.

**12.9. Interdisciplinary Approach:**

- Resolving HWC requires collaboration among ecologists, wildlife biologists, social scientists, policymakers, and local communities.
- Holistic solutions should address ecological, socioeconomic, and behavioural factors contributing to conflicts.

**12.10. Adaptive Management and Research:**

- Continuous monitoring, research, and adaptive management are essential for assessing the effectiveness of conflict mitigation strategies.
- Long-term studies can provide insights into evolving wildlife behaviours and help refine management approaches.

**12.11. Ecosystem Dynamics and Conservation:**

- The study highlights the complex interplay between human activities, habitat modification, and wildlife behaviour.
- Conservation efforts should focus on maintaining and restoring natural habitats, especially along the forest fringes, to reduce human-wildlife interactions.

**12.12. Behavioural Studies:**

- In-depth behavioural studies of the studied species (wild pig, elephant, gaur, leopard, sloth bear) are crucial to understanding their movement patterns, feeding habits, and responses to human presence.
- Such studies can guide the development of effective mitigation strategies that respect the ecological needs of these species.

**12.13 Habitat Connectivity and Corridor Protection:**

- Protecting and creating wildlife corridors between fragmented habitats is essential for the long-term survival of these species.
- Collaborative efforts between local communities, government bodies, and conservation organizations are needed to secure these corridors.

**12.14. Livelihood Diversification:**

- Engaging local communities in alternative livelihood options, such as eco-tourism and sustainable agriculture, can reduce dependency on forest resources and minimize conflicts.

### 12.15. Crop and Livestock Management:

- Implementing better crop protection measures, such as fencing and scare tactics, can reduce crop damage by wildlife.
- Livestock protection measures, like improved animal husbandry practices and better livestock housing, can mitigate losses and prevent retaliatory killings.

### 12.16. Public Awareness and Education:

- Public awareness campaigns about wildlife behaviour, conflict avoidance, and responsible behaviour can foster understanding and tolerance among local communities.
- School and community programs can play a pivotal role in creating a culture of coexistence.

### 12.17. Early Warning Systems:

- Developing and implementing early warning systems can help alert communities about wildlife presence and reduce potential conflicts.

### 12.18. Collaborative Governance:

- Strengthening collaboration between government agencies, conservation organizations, researchers, and local communities is essential for effective conflict management.
- Involving local stakeholders in decision-making processes ensures that solutions are culturally and contextually relevant.

### 12.19. Capacity Building and Training:

- Training local forest officials, rangers, and volunteers in conflict mitigation techniques and wildlife behaviour can improve conflict resolution outcomes.

### 12.20. Technological Solutions:

- The use of technology, such as GPS collars, camera traps, and remote sensing, can provide valuable data for understanding wildlife movements and designing targeted conservation strategies.

### 12.21. Long-Term Monitoring:

- Continuous monitoring of conflict incidents, ecological changes, and conservation interventions is crucial for adaptive management and refining strategies over time.

In conclusion, the study underscores the urgent need for a comprehensive and interdisciplinary approach to address human-wildlife conflicts in Tamil Nadu. Balancing the needs of local communities with wildlife conservation is a complex challenge, but with strategic planning, community engagement, scientific research, and collaborative efforts, it is possible to foster coexistence between humans and the diverse wildlife that inhabits the region. By adopting a holistic approach, Tamil Nadu can serve as a model for successful human-wildlife conflict management, contributing to the broader goal of biodiversity conservation and sustainable development.

## 13. Overall Management implications:

### 13.1. Fund Flow and Allocation:

- Current uniform fund allocation for all forest ranges.
- Need for nuanced fund allocation based on severity and nature of HWC cases.
- Ranges experiencing high human deaths require more financial support.
- Ranges with significant crop damages may require less compensation.

### 13.2. Manpower and Recruitment:

- Vacancies in watcher and guard positions.
- Promotions without subsequent recruitment for lower level positions.
- Insufficient ground level staff for managing HWC cases.

### 13.3. Range Size and Management:

- Larger forest ranges are being divided for effective management.
- Existing staff expected to manage newly fabricated sections.
- Discrepancy between range size and available resources.

### 13.4. Logistics and Chasing:

- Chasing is an effective measure against HWC (human wildlife conflict).
- Need for adequate logistics, fuel, and manpower for efficient chasing.

### 13.5. Local Tribe Involvement and Education:

- Initiative to train and involve local tribes in conservation efforts.
- Formation of committees to promote conservation and sustainability.
- Education of children about wildlife conservation and engagement as guardians.

### 13.6. Underlying Challenges and Loopholes:

- Challenges in managing HWC cases due to lack of manpower, logistics, and timely financial assistance.
- Uniform fund allocations don't consider case nuances and severity.
- Factors influencing HWC include encroachments and other issues.

### 13.7. Recommendations and Suggestions:

- Revise fund allocation for complex HWC prone ranges based on specific needs.
- Modify field and logistics strategies after thorough assessment.
- Address remuneration concerns for field officers and frontline staff (APWs).
- Technology and innovation for developing better deterrents

- Capacity building and training and multiple stakeholder involvement
- Habitat protection and restoration, data based research to be done to come up with better and long-term solutions.

### 13.8. Species-specific conflict mitigation strategies:

#### 13.8.1 Wild Pig Conflict:

- Implement community-driven cloth fencing initiatives to prevent wild pig intrusion.
- Explore alternative measures like insurance or subsidies for farmers to mitigate losses.
- Emphasize the importance of community involvement and coordinated fencing efforts.
- Focus on preventing conflicts from escalating and displacing into new areas.

#### 13.8.2 Elephant Conflict:

- Develop and expand non-lethal methods such as beehive fences and crop guarding.
- Address socioeconomic factors alongside elephant behaviour for long-lasting solutions.
- Prioritize habitat protection and corridors to facilitate natural elephant movement.
- Consider human behaviour in conflict-prone areas to ensure effective mitigation.

#### 13.8.3 Gaur Conflict:

- Conduct behaviour-based research to understand gaur conflicts better.
- Raise awareness through targeted campaigns to reduce gaur-related conflicts.
- Strengthen livestock fences and improve waste management in gaur habitats.
- Restore and manage gaur habitats to minimize human-wildlife interactions.

#### 13.8.4 Leopard Conflict:

- Enhance community awareness programs about leopard behaviour and safety.
- Implement effective livestock protection measures to minimize losses.
- Investigate and trial non-lethal deterrents and innovative conflict reduction methods.
- Conduct systematic research to understand leopard movement patterns and behaviour.

#### 13.8.5 Tiger Conflict:

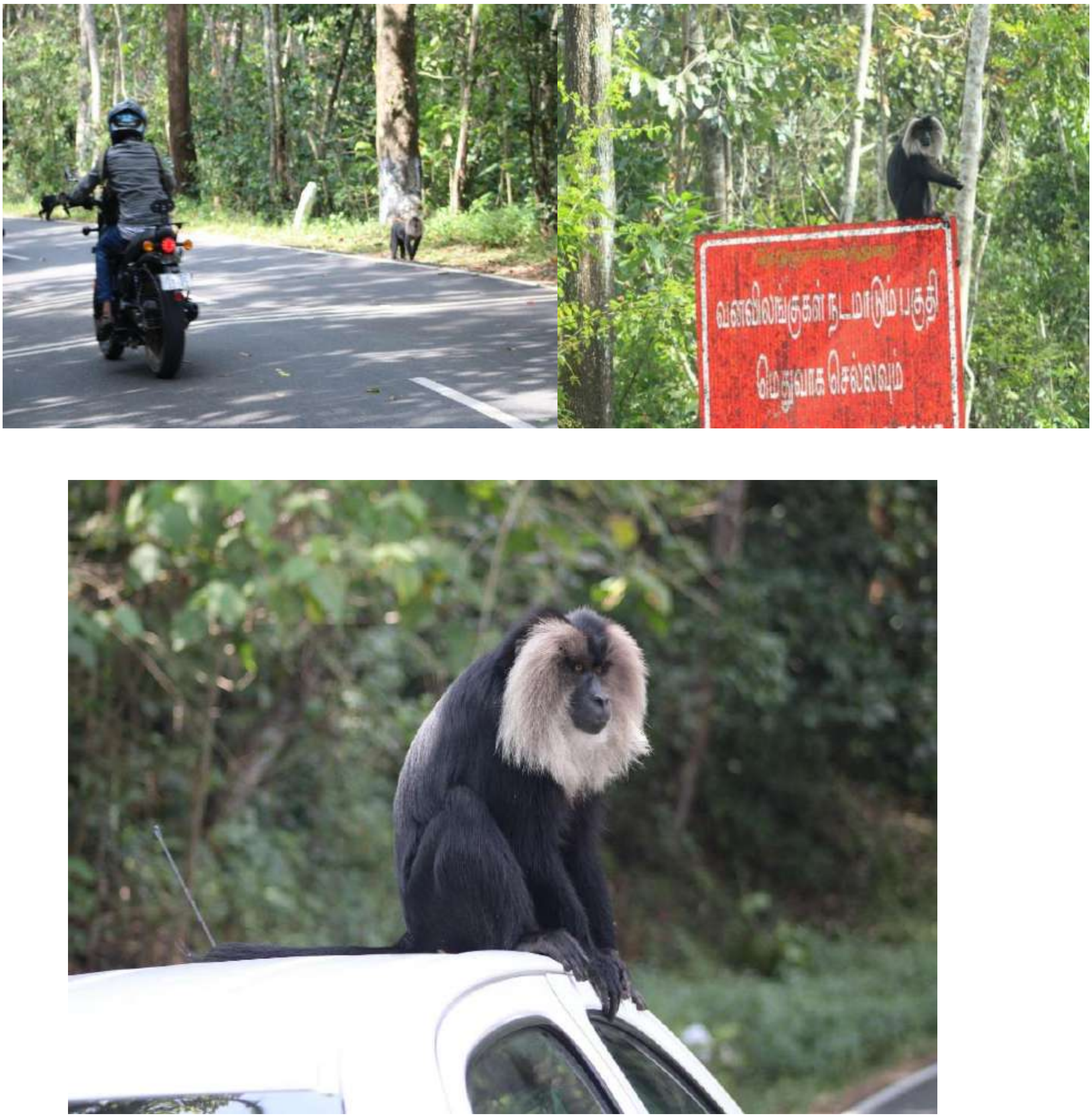
- Prioritize habitat protection and restoration to prevent fragmentation.
- Conduct extensive community education campaigns about tiger behaviour and coexistence.
- Implement proactive measures to minimize human-tiger conflicts in time and space.
- Develop strategies for identifying and managing problem tigers.
- Promote alternative livelihoods to reduce dependency on forest resources.
- Involve local stakeholders in sharing benefits of wildlife tourism for conservation support.
- Avoid reactive solutions like translocation that can lead to more conflicts.
- Develop adaptive management plans considering changing ecological and social dynamics.

### 13.8.6 Sloth Bear Conflict:

- Establish comprehensive community education programs to minimize sloth bear conflicts.
- Encourage proper waste management practices to reduce attractants for sloth bears.
- Promote coexistence by maintaining habitat connectivity and discouraging fragmentation.
- Use non-lethal methods such as noise deterrents and protective measures.
- Conduct behavioural studies and collaborate with stakeholders for effective management.
- Develop long-term strategies that adapt to changing ecological and socioeconomic factors.

In all cases, the overarching approach is to strike a balance between conservation, human livelihoods, and sustainable development for harmonious coexistence with these species.

In conclusion, managing human-wildlife conflicts in Tamil Nadu requires a comprehensive strategy that addresses the unique characteristics of each species, involves local communities, integrates scientific research, and embraces technological innovations. By fostering understanding, coexistence, and proactive measures, Tamil Nadu can serve as a model for successful conflict resolution and biodiversity conservation. Overall, the discussion highlighted the importance of tailored fund allocation, recruitment strategies, efficient logistics, involvement of local communities, and a comprehensive approach to managing human-wildlife conflicts based on the unique challenges faced by different forest ranges.




**[Fig - 116] Few pictures of threats faced by Lion tailed macaques, speed of the vehicles poses a severe risk on their population.**

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