भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CHHATTISGARH

ELEPHANT - HUMAN CONFLICT IN THE STATE OF CHHATTISGARH, INDIA (2000-2023)

TRENDS, CHALLENGES & INSIGHTS

March 2025

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Acknowledgements

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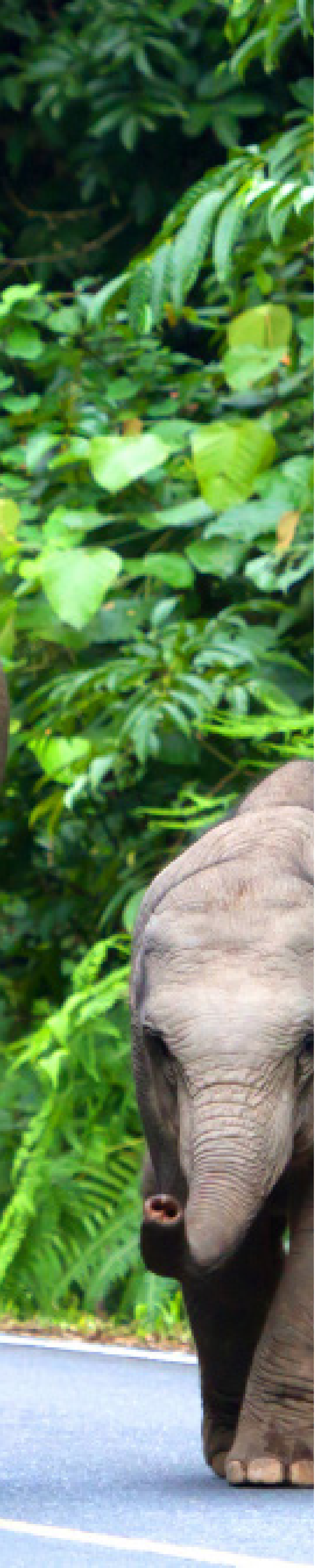

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EXECUTIVE SUMMARY

India holds the largest population of Asian elephants, estimated at approximately 29,964 individuals, representing nearly ~60% of the global population. However, the country's high human population density has led to an increasing frequency of human-elephant conflict. Elephants in India are primarily distributed across Northeast India, the Terai region, southern India, and central states Madhya Pradesh, Maharashtra, Jharkhand and Chhattisgarh. The elephant population in Chhattisgarh, which initially migrated from Jharkhand and Odisha during the 1980s and 1990s, has expanded over time, driven by habitat fragmentation in these neighbouring states. In recent years, deforestation, encroachment, industrialization, and mining have degraded forested areas, forcing elephants to venture in human-dominated landscapes. This shift has also intensified conflicts over the past two decades, driven by agricultural expansion and infrastructure development. The study examined 218 documented elephant mortalities and 828 HEC incidents between 2000 and 2023, identifying key ecological and anthropogenic factors shaping conflict patterns.

Data Collection

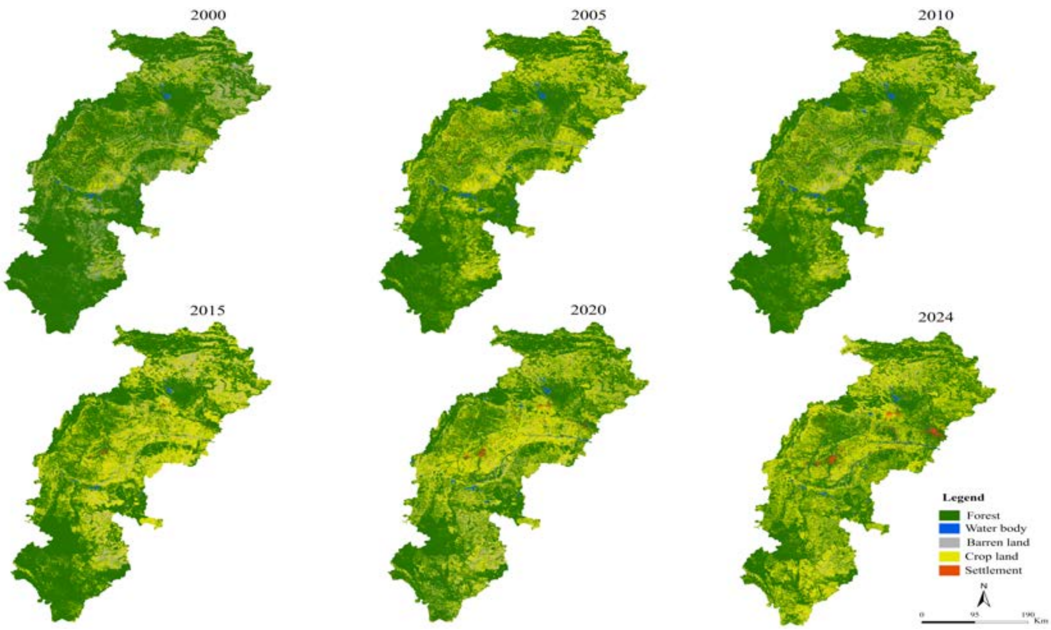
Data collected from **19 FOREST DIVISIONS**

(2000-2023)

- Data segregation: Human Deaths/Injuries and Elephant Mortality
- Temporal trends : Year wise and Seasonal trends of HEC incidents
- Spatial trends and hotspot mapping
- Landscape Drivers and Village level implications

LULC (2000-2024) | **218** Elephant Mortality | **828** HEC incident

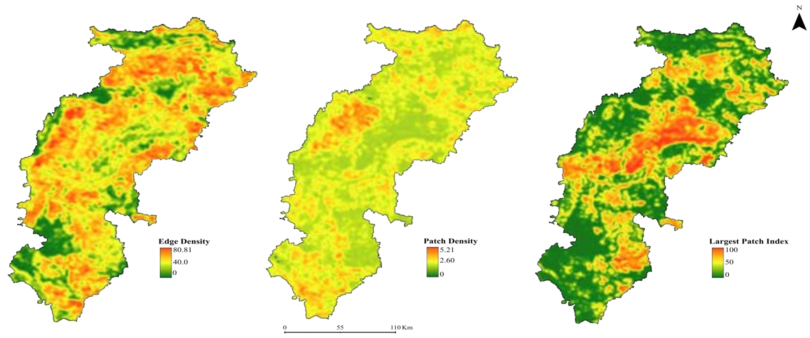
7.26% Change in forest cover



Selected Landscape Matrices (Forest Cover)

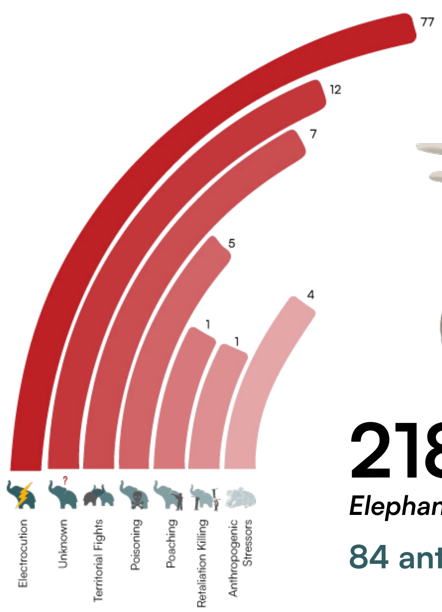
Edge Density
Largest Patch Index
Patch Density

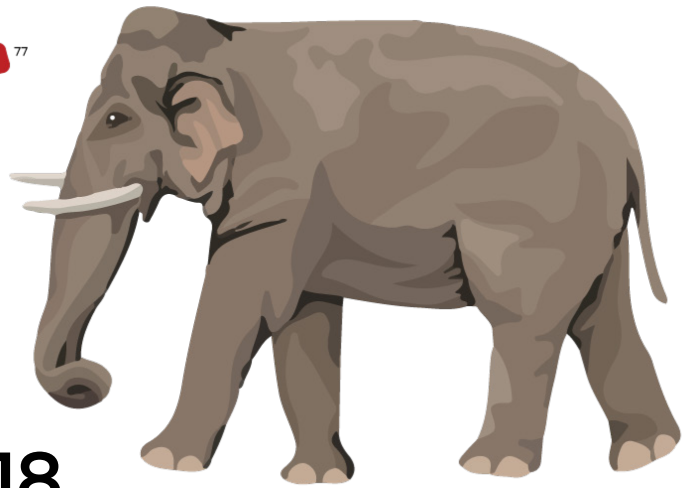
The northern and easter region of Chhattisgarh are highly fragmented with high edge density and patch density. Eastern areas have better forest connectivity with large continuous patch. Central Chhattisgarh is highly fragmented and poses high risk of human elephant conflict.



Elephant Mortality

Findings indicated that electrocution (77 deaths) is the primary cause of elephant mortality, followed by poisoning (5 deaths), poaching (1 death), and retaliatory killing (1 death).





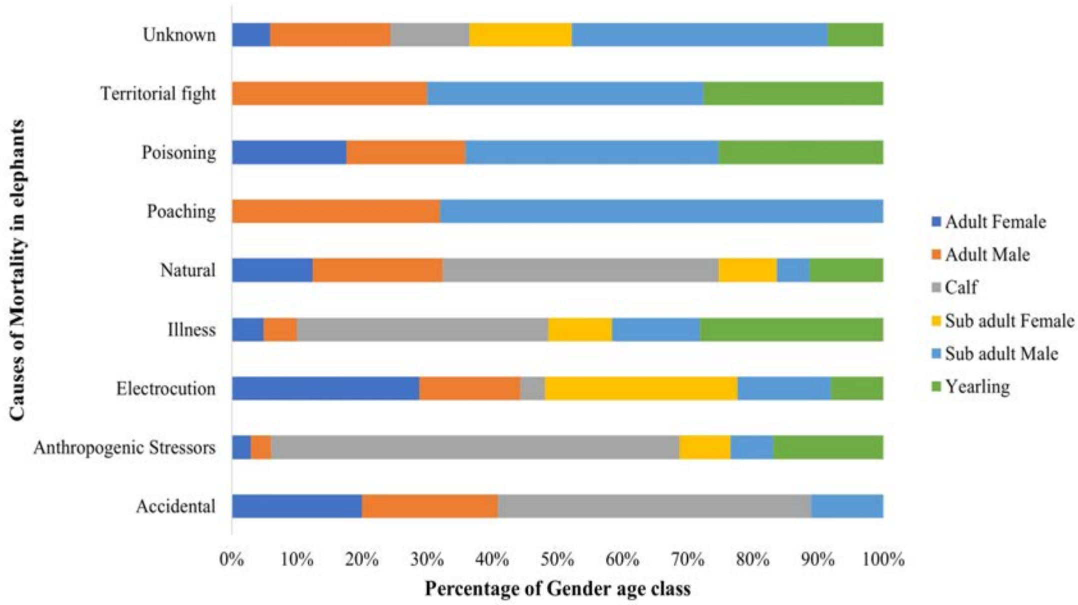
218

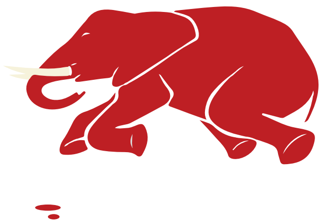
Elephant deaths

84 anthropogenic causes | 134 natural deaths

Age Class Demography

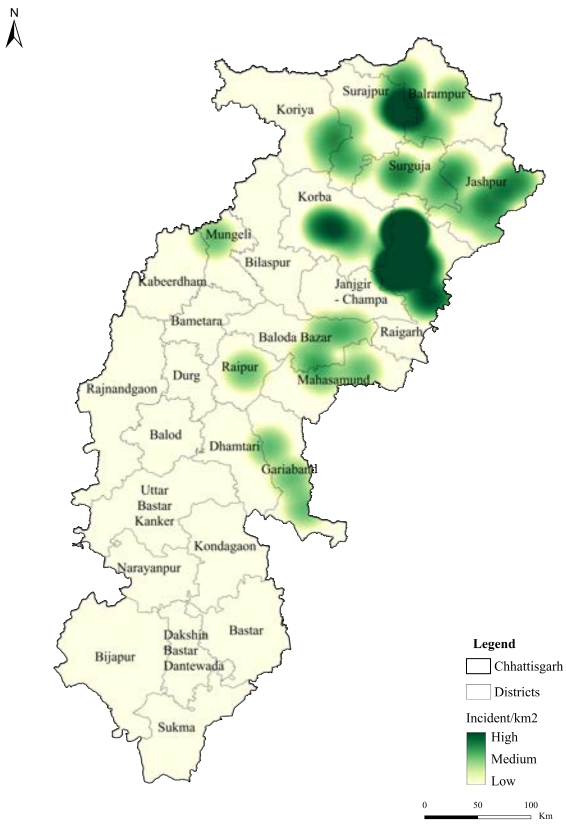
Adult males having the highest numbers of deaths (35), followed by adult female (17), sub adult male (13), sub adult female (4), yearling (5).





Elephant mortality is strongly linked to habitat fragmentation and human activities. Villages located in close proximity to elephant reserves, with higher forest edge density, and greater habitat fragmentation experience more frequent incidents. Additionally, the presence of mining areas further increases risks for elephants. Effective conflict mitigation requires sustainable land-use planning, conservation-focused infrastructure policies, and habitat restoration efforts to promote coexistence between humans and elephants.

Spatial Distribution of Elephant Mortality



Most Affected Divisions:

33 Dharamjaigarh

11 Raigarh

10 Jashpur

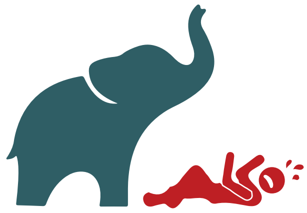
9 Surajpur

Most Affected Villages:

15 Dharamjaigarh

10 Chhal

828
Incidents



737 Human Deaths | 91 Human Injuries

Human Mortality

In 23 years, Chhattisgarh reported 828 HEC incidents, including 737 human deaths and 91 injuries. Fatalities peaked between 2016 and 2018.

Spatial Distribution of Human Casualties
(including fatalities & injuries)

Spatial distribution of conflict hotspots. Among the divisions, Jashpur (152 deaths,19 injuries) emerged as the most severely affected, followed by Dharamjaigarh (135 deaths, 20 injuries), Surajpur (107 deaths, 04 injuries), and Korba (64 deaths, 04 injuries). Proximity to forests, elephant reserves, and protected area is strongly associated with higher conflict occurrences. Elephants prefer habitats near forests and water sources, leading to increased interactions with human settlements close to these areas.

Most Affected Divisions:

171 Jashpur

155 Dharamjaigarh

111 Surajpur

68 Korba

Most Affected Villages:

45 Amandon

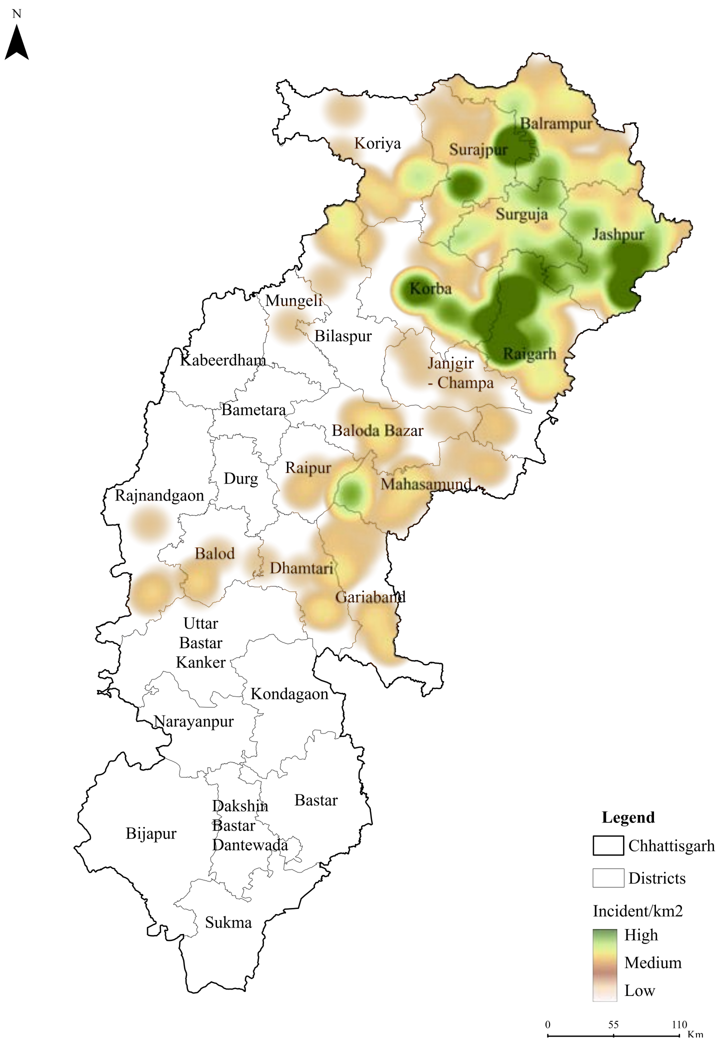
42 Chhal

36 Dharamjaigarh

32 Sajbahar

25 Katghora

24 Surajpur

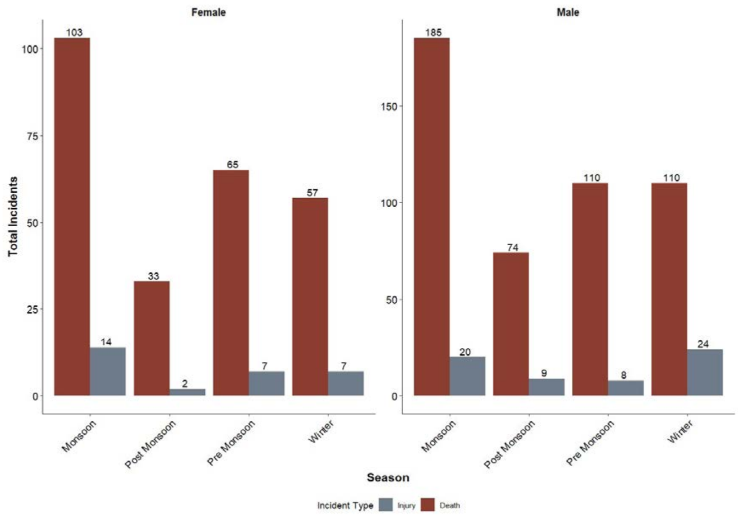


Seasonal variation in gender distribution of human casualties caused by HEC

Seasonal variation in human fatalities by gender revealed that the fatality and injury rates were significantly higher in males (540 cases) compared to females (288 cases). Seasonal patterns emerge as a significant driver of conflict, with the monsoon season witnessing heightened incidents of human fatalities and injuries. During this period, increased agricultural activities coincide with the seasonal movements of elephants.

Male victims were significantly more prevalent across all seasons.

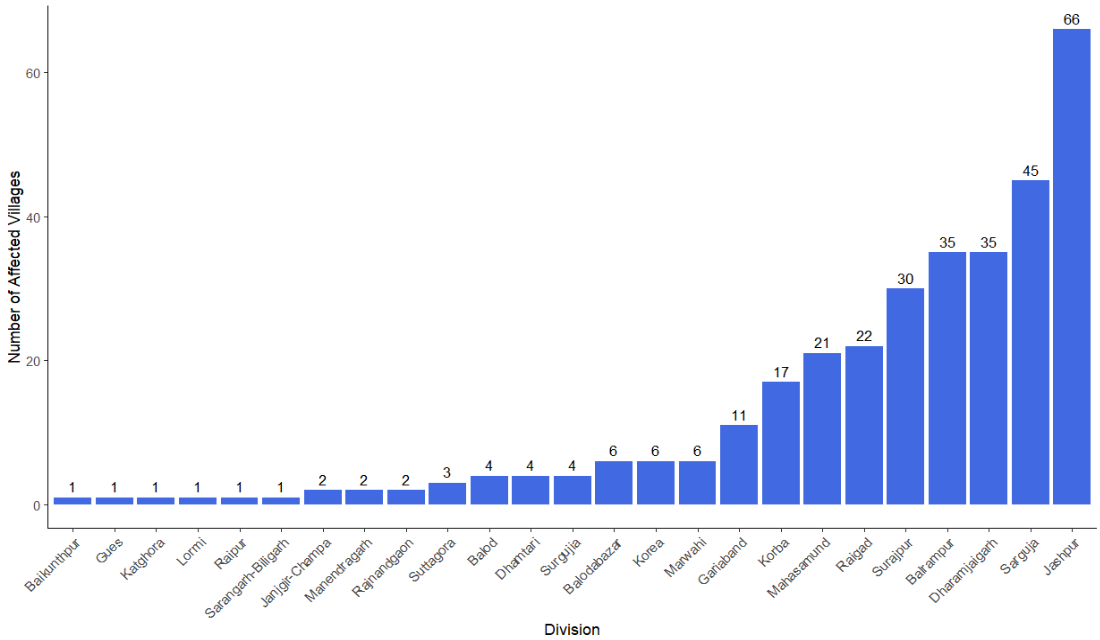
Seasonal data indicated that monsoon accounted for the highest conflict incidents.



Villages affected by HEC, categorized by divisions

Human-elephant conflict affected 321 villages, with Jashpur (66) being the most impacted. Surguja followed with 45 villages, while Dharamjaigarh and Balrampur each reported conflicts in 35 villages.

321 villages



Categorization of incident villages

ELEPHANT MORTALITY

HIGH: 10-15	1 INCIDENT
MEDIUM: 5-10	1 INCIDENT
LOW: 0-5	46 INCIDENTS

Elephant mortality in Chhattisgarh is concentrated in 48 villages, with the highest deaths in Dharamjaigarh (15), Chhal (10), Amandon & Goreapipar (4 each), and Katghora & Raigarh (3 each). High-mortality villages have greater built-up density and cropland expansion.

HUMAN MORTALITY

HIGH > 20	6 INCIDENTS
MEDIUM: 11-20	5 INCIDENTS
LOW: 1-10	310 INCIDENTS

A total of 321 villages experienced HEC, with Jashpur (66), Surguja (45), Dharamjaigarh (35), and Balrampur (35) are the most affected. High-conflict areas have more built-up, less water, and high in forest cover.

In Chhattisgarh, human-elephant conflict is predominantly concentrated in high-risk villages such as Dharamjaigarh, Chhal, Amandon, and Raigarh, where infrastructure development, habitat fragmentation, and human activities intensify the severity of interactions. The primary causes of elephant mortality include electrocution, vehicular accidents, poaching, and poisoning, necessitating targeted mitigation measures. Strictly prohibiting the use of distribution lines for fencing, insulating power lines, increasing their height, and implementing solar-powered microgrids to prevent illegal power tapping are essential measures to mitigate the risk of electrocution. Anti-poaching efforts emphasize strengthening patrolling units, community involvement, and GPS tracking of elephant movements. To prevent vehicular collisions, measures such as speed limits, warning signage, and underpasses are proposed, while alternative cropping practices, chili fences, and rapid compensation mechanisms can help mitigate retaliatory poisoning. Additionally, habitat restoration, enforcement of land-use regulations, and strategic conservation planning are crucial to reducing anthropogenic stressors. The study also highlights the importance of early warning systems, elephant corridors, and community-based conservation programs to manage human casualties. Identified key elephant corridors, such as Badalkhol-Tamor Pingla, Lemru Elephant Reserve, and Dharamjaigarh Corridor, are critical for mitigating HEC. Addressing these challenges through an integrated approach combining policy interventions, technological solutions, and community participation is essential for fostering coexistence between humans and elephants in Chhattisgarh.

CHAPTER 1:
Elephant Mortality in the State of Chhattisgarh (2000-2023)

1.1. Introduction

Asian elephants have attracted global attention as their number has reduced by ~50% over the past three generations, along with rapid shrinkage of their habitat. The increase of human settlements and agricultural practices in Asia has led to widespread destruction of elephant habitats, reduced connectivity within the landscape, and significant decline in elephant populations (Shaffer *et al.*, 2019a; Lanka, 2023; Jarungrattanapong and Olewiler, 2024). Asian Elephants are at risk of being affected by habitat deterioration due to conflicts, especially in areas outside of Protected Areas (PAs), notably along the edges (Gubbi *et al.*, 2014a; Calabrese *et al.*, 2017). In the last decade, the issue of human- elephant conflict (HEC) has become a major problem in several Asian countries (Montez *et al.*, 2021; Shaffer *et al.*, 2019b; Wilson *et al.*, 2015). These clashes have led to economic reparations, as well as casualties and fatalities to both humans and elephants (Bhagat *et al.*, 2017; Köpke *et al.*, 2024). Given the frequent overlap and encroachment of human activities into elephant habitats, HECs are a critical concern for ensuring elephant survival and persistence in countries within their native range (Billah *et al.*, 2021; Shameer *et al.*, 2024). It is therefore vital to gain a deeper understanding of how dynamic land-use changes at these interfaces, as well as an integrated management approach both inside and outside PAs, are crucial to elephant conservation in landscapes where HECs are prevalent.

India, home to the largest population of Asian elephants with a count of 29,964 nearly 60% of the population of the species also has the highest human population globally (Baskaran *et al.*, 2011). This demographic dynamic has resulted in increasing casualties among both humans and elephants, with the trend continuing to rise (Pandey *et al.*, 2024b). Deforestation, urbanization, linear infrastructure development, and activities in the energy and mining sectors have been found to be the major causes of human-elephant conflict (HEC) in India (Savino, 2024). The distribution of Asian elephant has undergone significant changes over time. At present, elephants are distributed in northeast India, Terai region, southern India and including central regions in the state of Madhya Pradesh, Maharashtra and Chhattisgarh. Historical records and writings from the Mughal emperors of the 16th and 17th centuries (Baskaran *et al.*, 2011).There is evidence that elephants were once widely distributed across central India, ranging from southern Uttar Pradesh through Madhya Pradesh to Chhattisgarh (Baskaran *et al.*, 2011). Although they eventually disappeared from these areas, they have recolonized Chhattisgarh. The elephant habitat of Central India is spread over an area of 21000 sq. km in the states of Jharkhand, Odisha Chhattisgarh and part of southern West Bengal (Menon *et al.*, 2017). Most of the elephant occupied forest habitat patches are degraded and highly fragmented due to intensive agriculture, mining, shifting cultivation and linear infrastructure (Menon *et al.*, 2017; Sukumar 2011). Subsequently, Human-elephant conflict is also very high in this landscape. Though the area supports less than 10% of the elephant population of the country, it accounts for almost 45% of all human deaths due to elephants in India (Menon *et al.*, 2017). Chhattisgarh has a small population of elephants that initially travelled from Jharkhand and Odisha in the 1980s and 1990s. Over the past few decades, the forested areas in these two states have experienced degradation due to activities such as illicit logging, encroachments, industrialization, and mining (Singh, 2002) . Due to the decline in the quality of their habitat, elephants have been compelled to engage in extensive and confused travels, utilizing smaller forest patches as a means to reach larger forest regions (Debata *et al.*, 2013). This is a primary factor contributing to the movement of elephants into Chhattisgarh and extending into Madhya Pradesh. According to Forsyth's historical account from 1889, elephants were once present in northern Chhattisgarh. Nevertheless, they experienced local extinction throughout the early years of the 20th century (Singh, 2002). Due to the deterioration of their habitat, elephants have been forced to undertake extensive and erratic journeys, using smaller forest patches as stepping stones to access larger forest areas of Chhattisgarh. According to Forsyth's historical account from 1889, elephants were once present in northern Chhattisgarh. However, they experienced local extinction throughout the early years of the 20th century (Singh, 2002). As reported, only 18 elephants moved into Chhattisgarh in 1988, but from 1998 onwards, the population gradually increased, reaching 247 individuals by 2017 (MoEF&CC, 2017). The incidence of human-elephant con flict has been on the rise since 2000 due to the steady increase in the number of migratory elephants entering Chhattisgarh (Singh, 2002). Presently, this population occupies about 3625 km² of forest area in northern Chhattisgarh, encompassing the districts of Surguja, Korba, Raigarh, Jashpur, Surajpur, Mungeli, and Korea (Natarajan *et al.*, 2025).

The issue of human-elephant conflict presents a substantial hindrance to conservation endeavors and rural livelihoods in various regions of India, including Chhattisgarh. The state has experienced an increase in incidence of human-elephant conflict in recent years (Natarajan *et al.*, 2025). This conflict is marked by elephants inflicting damage to crops, property, and also resulting in human and elephant casualties. The elephant population is already under pressure due to habitat fragmentation and poaching. To comprehend the intricacies of HEC in Chhattisgarh, a detailed understanding of the fundamental elements propelling these disputes is necessary. Therefore, understanding the dynamics of HEC in Chhattisgarh requires a comprehensive analysis of the underlying factors driving these conflicts. This includes examining demography of deceased animal in the conflict and changes in land use patterns. Studies have indicated that the demise of adult elephants, especially those holding prominent social positions such as matriarchs, can considerably disturb the social hierarchy within elephant herds and result in heightened conflict (Douglas-Hamilton *et al.*, 2006). The presence of adult elephants is critical for maintaining herd integrity and transmitting vital survival skills to younger members. The loss of these key individuals can disrupt the herd's social structure, resulting in diminished cohesion, unpredictable behaviour, and increased incidences of human-elephant conflict as well as intra-herd aggression. Previous studies have found that elephant herds affected by culling, which removed a significant number of adults, exhibited disruptions in their social behaviours. In contrast, stable herds with intact social systems and no history of such disturbances maintained cohesive interactions. The study also highlighted the importance of experienced adult elephants in guiding herd behaviour and decision-making. Their absence not only increases instability and conflict but also disrupts the transmission of essential social and survival skills within the group (Shannon *et al.*, 2013) . Therefore, in the present study, we investigate the changes in elephant mortality causes and their spatial distribution in Chhattisgarh over the past two decades (2000-2023). The specific objectives are as follows: (i) How did the causes of elephant mortality and their spatial distribution in Chhattisgarh change over past two (2000-2023) decades?

(ii) Is there any significant association between the age and demography of deceased elephants and specific causes of mortality, particularly focusing on anthropogenic stressors?

(iii) How landscape and anthropogenic features over the same periods, potentially influence these mortality patterns?

1.2. Study Area

The study was conducted in Chhattisgarh, India which lies between 17°46'N to 24°05'N and 80°15'E to 84°20'E. Chhattisgarh has a total geographical area of 135,192 km^2, of which 55,547 km^2 (41.09%) has forest cover. It has a hot and humid tropical climate with three distinct seasons: summer (March to May), rainy (June to October), and winter (November to February). Summer maximum temperatures range from 30°C to 45°C, while winter low temperatures range from 8°C to 25°C. The region receives an average of 1292 mm of rainfall each year, with the most precipitation happening in July and August. Chhattisgarh is separated into three main zones: Northern Hill, Bastar Plateau, and Chhattisgarh Plains. The Northern Hills and Bastar Plateau areas are covered with natural forests while Chhattisgarh Plains are primarily used for agriculture. The steep southwest sections of the Bastar Plateau are part of Central India's Satpura hills, specifically the Maikal Range. Champion and Seth write that there are twelve distinct types of forests in Chhattisgarh, with the two main groupings being tropical moist deciduous forest and tropical dry deciduous forest. According to data spanning from 2016 to 2017, Chhattisgarh was the leading supplier of non-cooking coal in India, accounting for an astounding 23.9% of the country's total supply (Bhavan, 2018). Over three decades, the districts of Korba and Raigarh witnessed the growth of coal mines, urban areas, and water bodies, while the areas covered by forests decreased by 212.87 km² and 711.3 km², respectively.

Being an important migratory route for elephants, though not traditionally an elephant habitat, Chhattisgarh supports the corridors with habitats drastically reducing in the neighboring states of Odisha and Jharkhand (Sukumar, 2006). Northern districts of Surguja, Jashpur, and Raigarh connect Simlipal forests of Odisha and Dalma Wildlife Sanctuary of Jharkhand and act as crucial corridors that allow the easy movement of elephants into Chhattisgarh (Johnsingh and Williams, 1999b). Forests in Chhattisgarh, primarily of Sal (*Shorea robusta*) and mixed deciduous types, carry resident and migratory populations of elephants. Critical corridors include the Hasdeo-Arand forests and the Mahanadi Wildlife Sanctuary, which are under severe threat from mining and deforestation (Jogi, 2024a). A western Chhattisgarh extension of the Satpura Range also sweeps into Madhya Pradesh, opening habitats for longer elephant movements. Habitat fragmentation forces elephants into human-dominated landscapes, thus further increasing the prospects of human-elephant conflict (Johnsingh and Williams, 1999b) .The state's ecological diversity is complemented by a relatively moderate climate and seasonal precipitation patterns, with rainfall typically ranging between 1,200 mm to 1,600 mm annually. This varying precipitation affects both the forest cover and the agricultural landscapes, making certain areas more prone to human-elephant encounters during the monsoon season when elephants may move into agricultural fields in search of food. The population density of Chhattisgarh, which is around 270 people per square kilometer, also poses a challenge for conservation efforts, as human settlements are encroaching on these critical wildlife corridors. These pressures, exacerbated by habitat fragmentation, force elephants into human-dominated landscapes, increasing the likelihood of human-elephant conflict (Johnsingh and Williams, 1999b).

The Koriya district had an increase in coal mines of 5.68 km^2 between 1990 and 2010, however this later decreased to 2.85 km^2, along with an increase in built-up areas and a decrease in forest cover of 251.31 km^2 in 2020. Between 1990 and 2020, the Surguja district saw the growth of built-up areas and coal mines. In 2010, the forest area declined by 160.21 km^2, but by 2020, it had recovered. Coal, iron ore, bauxite, limestone, and other abundant mineral resources contribute considerably to the state of Chhattisgarh's GDP. However, environmental issues like water pollution, land degradation, and deforestation have been brought on by mining operations (Jogi, 2024b). Furthermore, the human population of approximately 31.53 million in 2023 has steadily increased from 25.5 million in 2011, and the literacy rate has been rising over time to stand at 70.28%, this surge is explained by both natural population expansion and urban migration seeking work opportunities (Green, 2006; Bara and Turner, 2016). There are still many districts and villages like Jashpur which are home to several tribal communities, the majority of which rely on forest and agricultural resources for their subsistence. The prevalence of HEC has a negative impact on people's socioeconomic status and means of sustenance, which makes conservation difficult (Bhagat *et al.*, 2017b).

1.3. Methods

1.3.1. Data Analysis

We prepared the database with 218 elephant mortality cases over 23 years. For each mortality incidence, we categorised the data for:

(1) Cause of death

(2) Time of incident (year, month and season) (monsoon, post-monsoon, summer and winter);

(3) division wise list;

(4) age and demography of the dead elephant.

The causes of death were further recorded and classified (see table 1.2), elephant deaths brought by natural calamities and unprecedented accidents like drowning, lightning strikes, and fall from hills were included in accidental deaths. Age groups were categorized as calf (0-1 year), juveniles/ yearlings (1-5 years), sub-adults male and female (6-15 years), and adult male and female (16+ years) (Arivazhagan and Sukumar, 2008). Logistic regression models were applied to determine the probability of specific causes of death (*e.g.*, poaching, electrocution, human-elephant conflict) relative to the age group and region. This analysis aimed to identify age groups most vulnerable to threats.

Table 1.2: Causes of elephant deaths reported in the state of Chhattisgarh from 2000-2023.

Causes of Elephant deaths	Indirect/ Direct sources	Categories
Still birth, old age, heart attacks, Malnourishment, heat stroke, dehydration	Natural	Natural
Drowning, lightning strikes, fall from hills	Natural calamities, accidents	Accidental
Poisoning pesticide poisoning,	Retaliation killing, HEC	Poisoning
Poaching	HEC	Poaching
Illness	Spreading of diseases	Illness
Territorial fights	Natural behavior, Interspecies conflict, decrease in territorial space	Territorial fights
Stuck in drains, falling into canals and wells, electrocution	Anthropogenic climate change, stress due to human infrastructures	Anthropogenic stressors

1.3.2. Land use land cover change and factors influencing Elephant mortality

Data was divided into five-year intervals (2000-2005, 2005-2010, 2010-2015, 2015-2020, 2020-2023). LULC change analysis was conducted using Landsat 5 TM and Landsat 8 OLI imagery (2000-2024) with a 30 m spatial resolution (Fig. 1.1). Chhattisgarh falls within UTM Zone 46. Six bands (blue, green, red, NIR, and two SWIR) were used for classification, while the QA band was applied for cloud and shadow masking. We collected 1,250 random points for RF classifier training and validation, with 70% used for training and 30% for validation in each iteration. Accuracy assessment quantified classification effectiveness. Google Earth Engine (GEE) handled image processing and classification, while ArcGIS Pro was used for sub-setting, fragmentation analysis, distance calculations, and map preparation. A supervised pixel-based RF algorithm classified the Landsat dataset. The GEE was chosen for its robust accuracy and ability to handle large, high-dimensional datasets. RF classifiers applied to Landsat imagery in GEE effectively mapped five LULC categories: (1) forest, (2) water, (3) barren land, (4) agriculture, and (5) settlement. This study used the RF classifier from the "smileRandomForest" library. Using the forest cover class from the LULC maps, we extracted Patch Density (PD), Edge Density (ED), and Largest Patch Index (LPI) with FRAGSTATS v.4.2. Elephant death distribution was analyzed with kernel density estimation in ArcGIS to identify mortality patterns across divisions and villages. Generalized Linear Models (GLMs) with a binomial distribution in R (version 4.3.1) was employed to predict the influence of ecogeographical and anthropogenic variables on elephant mortality incidents. Mortality incidents (excluding natural deaths) were coded as 1, while pseudoabsence locations (coded as 0) were generated using a two-step approach: random point generation and selection of locations from a spatial map to ensure representation of landscape.

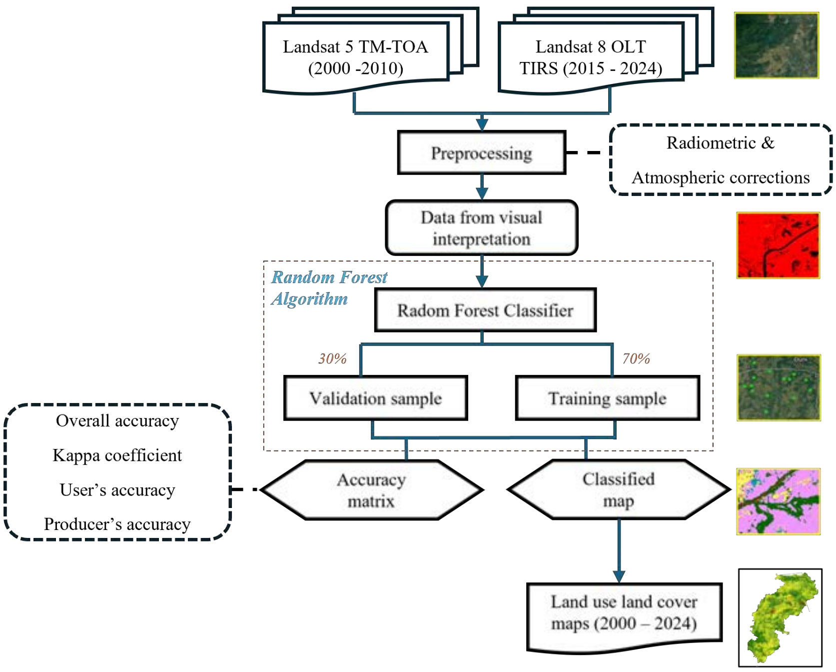


Figure 1.1: Land use and land change pattern methodology flowchart for the state Chhattisgarh

The GLM analysis included 12 explanatory variables: distances to forests, croplands, built-up areas, roads, railways, mines, water sources, protected areas, and elephant reserves, along with edge density, patch density, and largest patch index from FRAGSTATS. Supporting hypotheses for each variable were generated (Table 1.3). Model performance was evaluated using AIC, with models having ΔAIC ≤ 2 considered well-supported (Burnham and Anderson, 2002). The "MuMIn" package in R was used for model ranking.

Table 1.3: Factors Influencing Elephant Mortality in Chhattisgarh: A Priori Hypotheses

Feature	Variables	Source	A-priori Hypothesis
Landcover	Distance from Built-up (db)	Different landcover types (built-up, cropland, forest, waterbodies) are extracted from classified landcover data. Distance between conflict points and landcover were calculated using the Near Table tool (ArcPro 3.0.0).	Closer proximity to built-up areas may increase elephant mortality due to accidents, retaliatory killings, and habitat loss.
	Distance from Cropland (dc)		Higher elephant mortality is expected near croplands due to conflict arising from crop raiding and retaliatory actions.
	Distance from Forest (df)		Mortality may be lower near forests but increase at forest edges due to human-elephant interactions and habitat fragmentation.
	Distance from Waterbodies (dw)		Mortality risk may be higher near waterbodies, especially during dry seasons when elephants cluster around limited water sources, increasing human encounters.
Anthropogenic	Distance from Roads (dr)	Shapefiles ware obtained from OpenStreetMap and processed in GIS.	Proximity to roads may increase elephant mortality due to vehicle collisions and restricted movement corridors.
	Distance from Railways (drail)		Closer distance to railways may elevate mortality due to train collisions, a significant cause of elephant deaths.
	Distance from Mines (dmn)	Mining areas were mapped using satellite imagery and GIS datasets.	Mining areas may contribute to elephant mortality due to habitat destruction, pollution, and accidental falls into pits.
Protected Areas	Distance from Protected Areas (dpa)	Protected areas, Elephant Reserves were mapped using shapefiles from the Elephant Cell of WII.	Mortality may be higher at PA boundaries where elephants move into human-dominated landscapes, facing poaching or retaliation.
	Distance from Elephant Reserves (der)		Higher mortality may occur near reserves as elephants disperse into unprotected areas with human activity.
Landscape Metrics	Edge Density (ed)	Calculated using landscape metrics in FRAGSTATS.	Increased edge density may elevate mortality due to fragmented habitats forcing elephants into high-risk areas.
	Patch Density (pd)		Higher patch density may correlate with increased mortality by restricting movement and increasing conflict zones.
	Largest Patch Index (lpi)		Larger continuous patches may reduce mortality by offering safer movement corridors, while fragmented areas may heighten risks.

1.3.3. Analysis of landscape fragmentation

Landscape fragmentation was examined using FRAGSTATS (v4.2), which calculated landscape metrics. The input data for this analysis, derived from the LULC maps, consisted of forest and non-forest data. The LULC maps for 5 years were reclassified into forest and non-forest classes using the ArcGIS Spatial Analyst tool. Among the many landscape metrics available, we selected those that best capture the important features of the landscape. This helps to avoid duplicate information and makes the metrics more useful for analysing the landscape. Class-level metrics were used in this study because they measure the abundance, spatial distribution, and pattern of a particular LULC class in the landscape, in this study, patch matrix for Patch Density (PD), Edge Density (ED) and Largest Patch Index (LPI) used respectively. These metrics are examined using moving window analysis of fixed size of 7km based on average elephant movement. The window moves across the landscape and return the value to the centre cell and thereby create a continuous surface.

Table 1.4. Landscape Metrics: Definitions and Computational Formulas

Landscape metrics	Description	Formula
Patch density (PD)	Number of patches per unit area.	$PD = \frac{N}{A} (10{,}000) (100)$
Edge density (ED)	Reports edge length on a per unit area.	$ED = \frac{\Sigma_{k}^{m}=1^{e}ik}{A} 1000$
Largest patch index (LPI)	Quantifies the percentage of total landscape area comprised by the largest patch.	$LPI= \frac{max_{j}^{n}=1^{a}ij}{A} 100$
N= Number of patches in the landscape A = Total landscape area(m^2)		

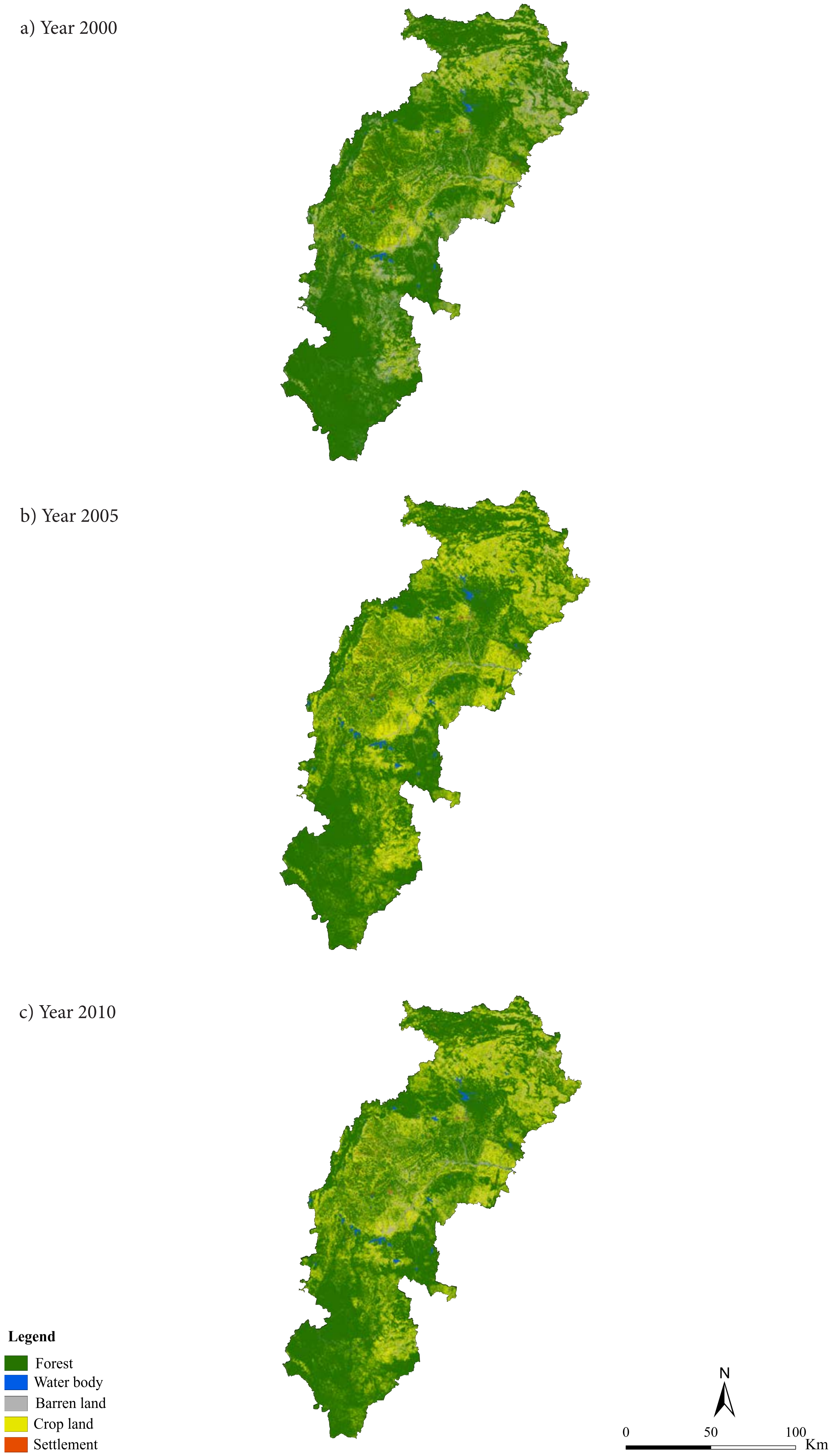
1.3.4. Village Categorization for Elephant mortality

To assess elephant mortality distribution in Chhattisgarh, we categorized villages into three groups: low (0—5 deaths), medium (5—10 deaths), and high (more than 10 deaths). This classification helps identify environmental factors influencing mortality, such as forest percentage, crop percentage, mines percentage, water density, built-up percentage, road density, railway density. Understanding these patterns allows targeted mitigation efforts, focusing on high-risk areas for habitat restoration, conflict management, and infrastructure improvements. The village boundaries were obtained from the ArcGIS Online, shapefile : Indian Administrative Layer 2024.

1.4. Result

1.4.1. Land Use Land Cover

The land use and land cover changes (2000 - 2024) showed changes in forest cover, water bodies, barren land, cropland, and built-up areas (Fig. 1.2 a-f, Table. 1.3). There has been a decrease of 7.26% in forest cover, with a decline observed in 2005 (-2.47%), 2010 (-5.84%), 2020 (-1.02%), and 2024 (-1.76%). Barren land exhibited variation over years, peak increase followed by a decline in 2024 (19%). while Urbanization has shown an upward trend. Forest cover was converted mainly to cropland (22.16%), built-up areas (5.77%), and barren land (0.79%), while cropland was converted particularly into built-up areas (2.29%).


a) Year 2000
b) Year 2005
c) Year 2010
Legend
Forest
Water body
Barren land
Crop land
Settlement
N
0
50
100
Km

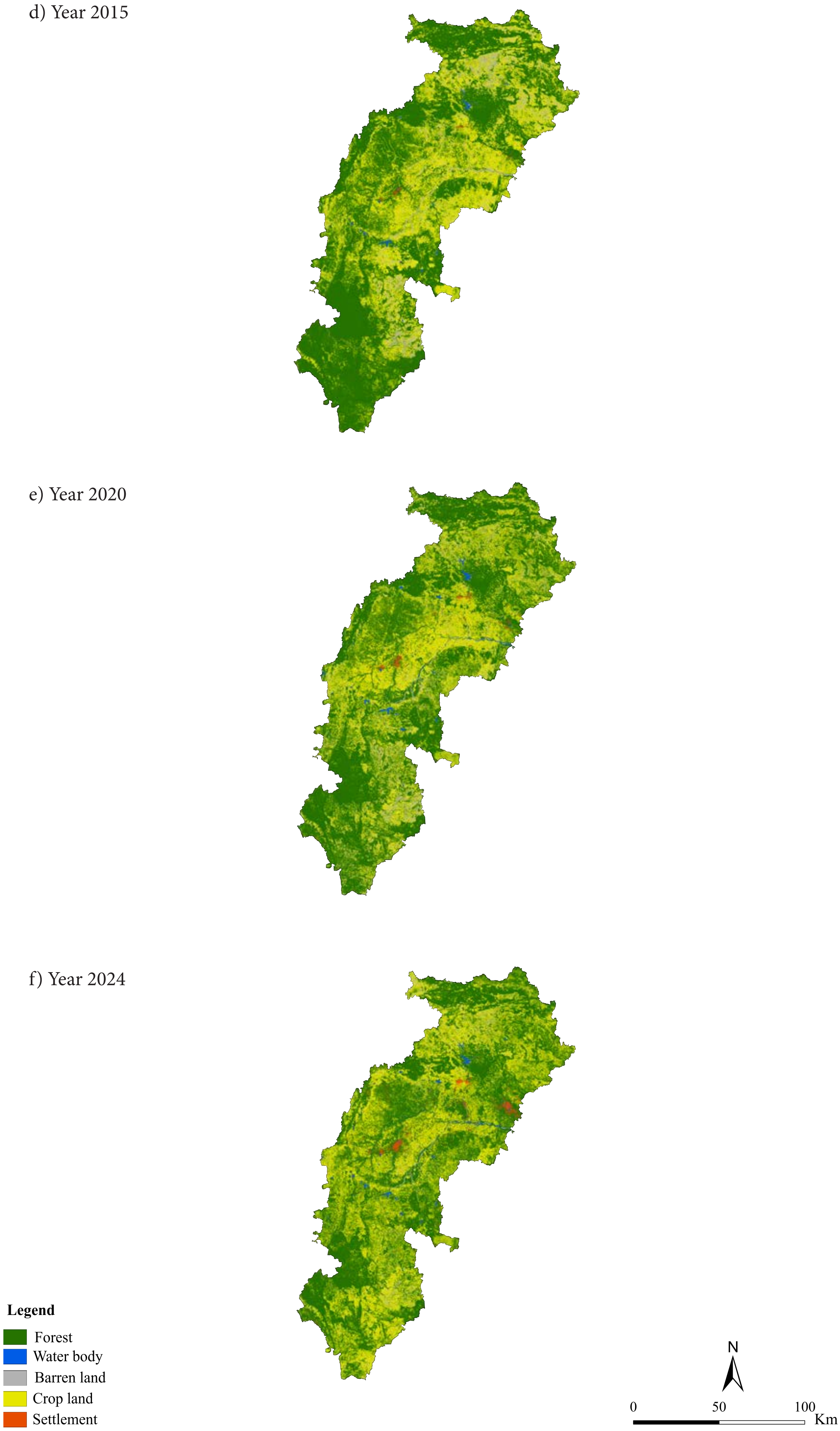


Figure 1.2: Land Use Land Cover (LULC) of Chhattisgarh from year 2000-2024 (a-f respectively).

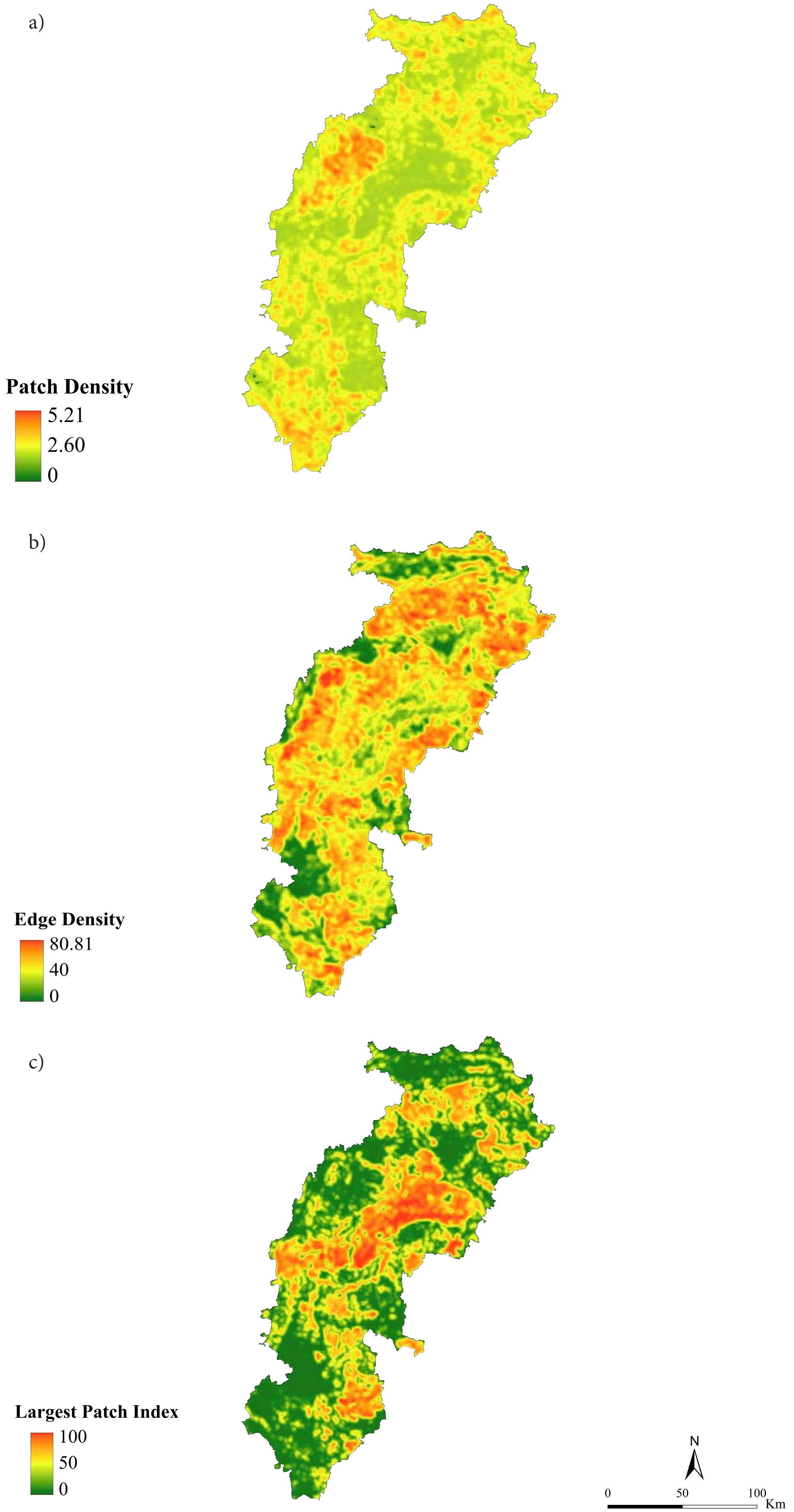
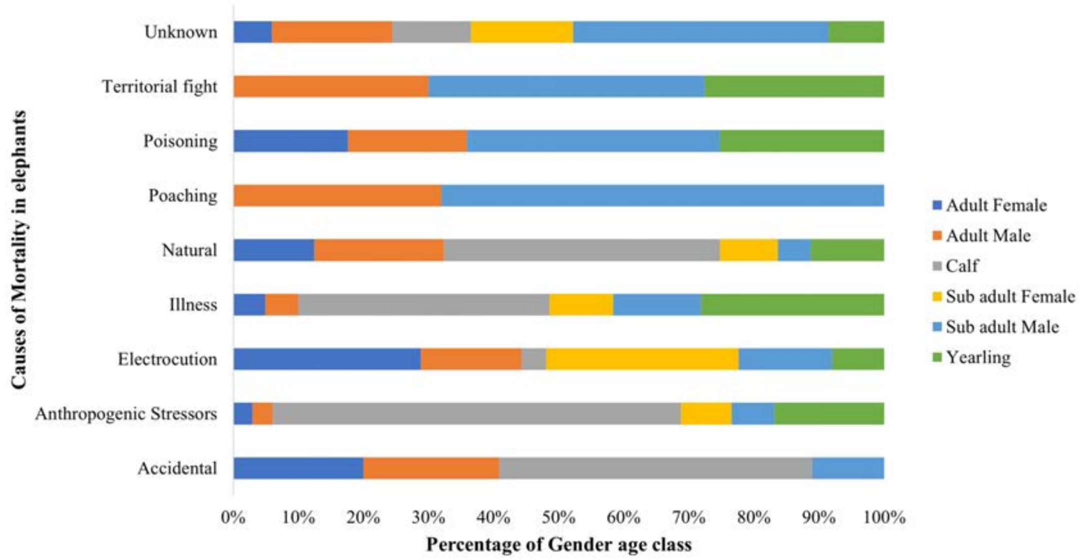


Figure 1.3 (a-c): Spatial Distribution of Forest Patch Density, Edge Density, and Largest Patch Index in Chhattisgarh respectively.

1.4.2. Temporal and age demography

In last 23 years, a total of 218 elephant's deaths have been reported. The highest number of deaths was recorded in 2022 (20 deaths). Out of these 134 were Natural deaths [including natural cases (77), illness (31), unknown (12), territorial fight (7)] while 84 anthropogenic causes including electrocution (76 deaths), poisoning (5 deaths), Poaching (2), retaliation killing (1). Electrocution emerged as the main reason of the elephant death out of the anthropogenic causes (χ^2 = 11.468, df = 1, p-value = 0.00). Distribution of death across age group due to anthropogenic causes differed significantly (χ^2 = 118.59, df = 5, p-value < 2.2e-16), with adult males having the highest numbers of deaths (35), followed by adult female (17), sub adult male (13), sub adult female (4), yearling (5) (Fig.1.4). Among seasons, elephant deaths have been occurred most in monsoon season (26 deaths) (χ^2 = 5.101, df =3, p = 0.164), followed by post monsoon (20), winter (21) and the least deaths in pre monsoon (12). Highest elephant mortalities were recorded in Dharamjaigarh (33, all attributed to electrocution. Other divisions with notably elephant mortality included Raigarh (11 deaths), Jashpur (10 deaths) and Surajpur (9 deaths).



. Figure 1.4: Age demography and relation to cause of deaths in elephants in Chhattisgarh

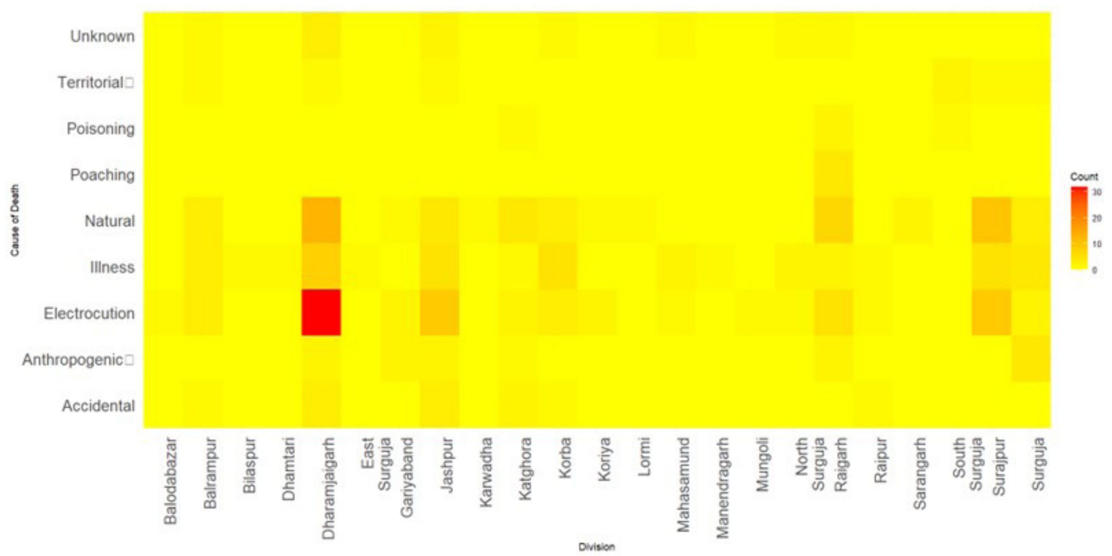


Figure 1.5: Heatmap showing spatial distribution pattern of Elephant mortality in different divisions of Chhattisgarh

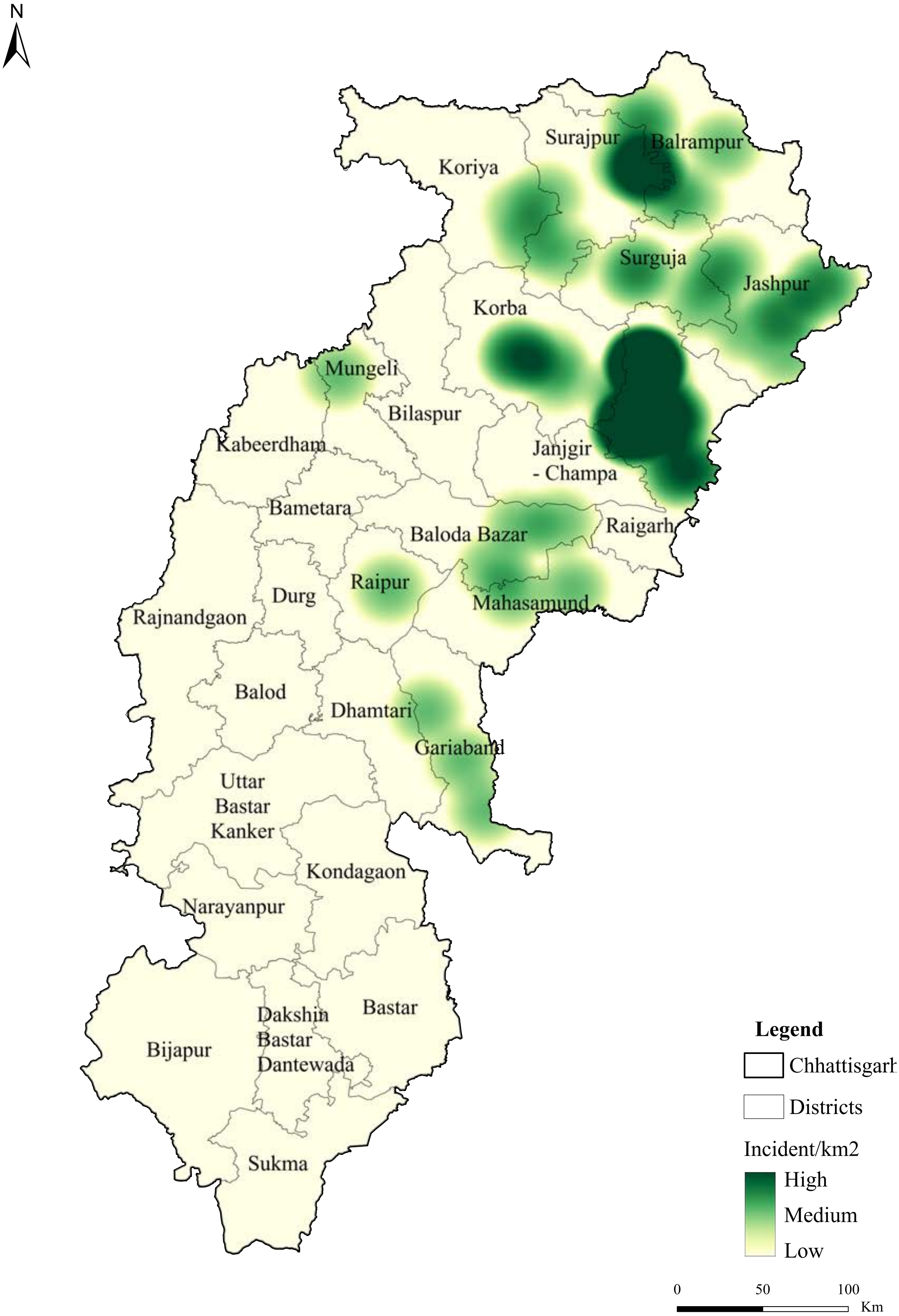


Figure 1.6: Asian Elephant mortality hotspot in Chhattisgarh (2000—2023).

1.4.3. Natural cases of elephant mortality in Chhattisgarh

Out of 218 recorded elephant mortalities in Chhattisgarh, 134 were attributed to natural causes. This included 108 cases of natural deaths (such as old age, drowning, illness, heart attacks and stillbirths), 12 cases of unknown causes, and 7 fatalities from territorial fights. Adult males (39) and adult females (16) had the highest mortality, followed by calves (39), sub-adult males (6), sub-adult females (11), unknown (6), and yearlings (18). Territorial fights resulted in 7 deaths, primarily in adult males (3) and calves (1), with sub-adult males (1) and yearlings (2) also affected. In 12 unknown mortality cases, adult males (5) and adult females (2) were the most impacted, followed by calves (2), sub-adult males (2), unknown (1), and no recorded yearling fatalities (Fig. 1.8).

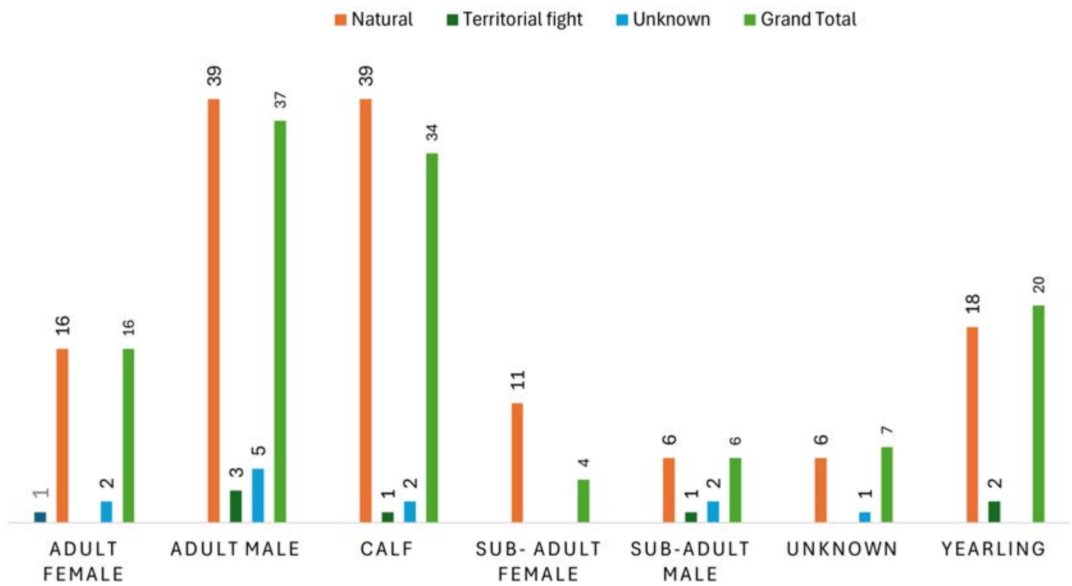


Figure:1.7 Age class- distribution in Natural deaths category for elephant deaths in Chhattisgarh

1.4.4. Village-level analysis of elephant mortality and its influencing factors

A total of 48 villages have been identified where elephant mortality has occurred (Appendix 1). With the highest in Dharamjaigarh (15 deaths), Chhal (10 deaths), Amandon and Goreapipar (4 deaths) and Katghora (3 deaths), Raigarh (3 deaths). High-incident villages have higher built-up percentage, while non-incident villages show the lowest levels (χ^2 = 8.8701, p = 0.03107). Water availability remain relatively stable across all village categories (χ^2 = 7.9816, p = 0.04639). Cropland cover is substantially higher in high-fatality villages (χ^2 = 9.2361, p = 0. 02631) (Fig. 1.9). Post hoc Dunn's test revealed specific pairwise differences, as shown in Table 1.5. However, Mines (χ^2 = 0.13617, p = 0.7121) and Railway (χ^2 = 0.48813, p = 0.9215) showed no significant variation. The Road variable (χ^2 = 7.1148, p = 0.06833) indicated a possible trend, but it was not strong enough to be considered statistically significant Elephants' deaths are significantly influenced by habitat and human-induced factors. distance to cropland (β = -1.237, p = 0.016) and distance to elephant reserves (β = -1.357, p = 0.001) were strong predictors. Additionally, landscape features like largest patch index (LPI) (β = -0.984, p = 0.001) and edge density (ED) (β = -0.676, p = 0.009) showed significant negative relationship. Distance to built-up areas (β = -0.461, p = 0.074) and distance to mines (β = -0.510, p = 0.064) were marginally significant.Distance to forest (β = 0.487, p = 0.031) and distance to protected areas (β = 0.364, p = 0.182) showed a positive trend. Distance to water (β = -0.607, p = 0.096) and distance to roads (β = -0.133, p = 0.594) did not exhibit significant relationships with mortality risk. (Table 1.6 & 1.7, Fig. 1.10)

Table 1.5: Post hoc Dunn's Test for Significant Kruskal-Wallis results for different land-use variables and adjusted p-values

Variable	Comparison	p-value	Adjusted p-value
Water	Incident vs. Low Incident	0.0186	0.111
Built-up	Incident vs. Medium Incident	0.0146	0.0876
Crop	Incident vs. Medium Incident	0.0157	0.0944
Crop	Medium Incident vs. Low Incident	0.0245	0.147

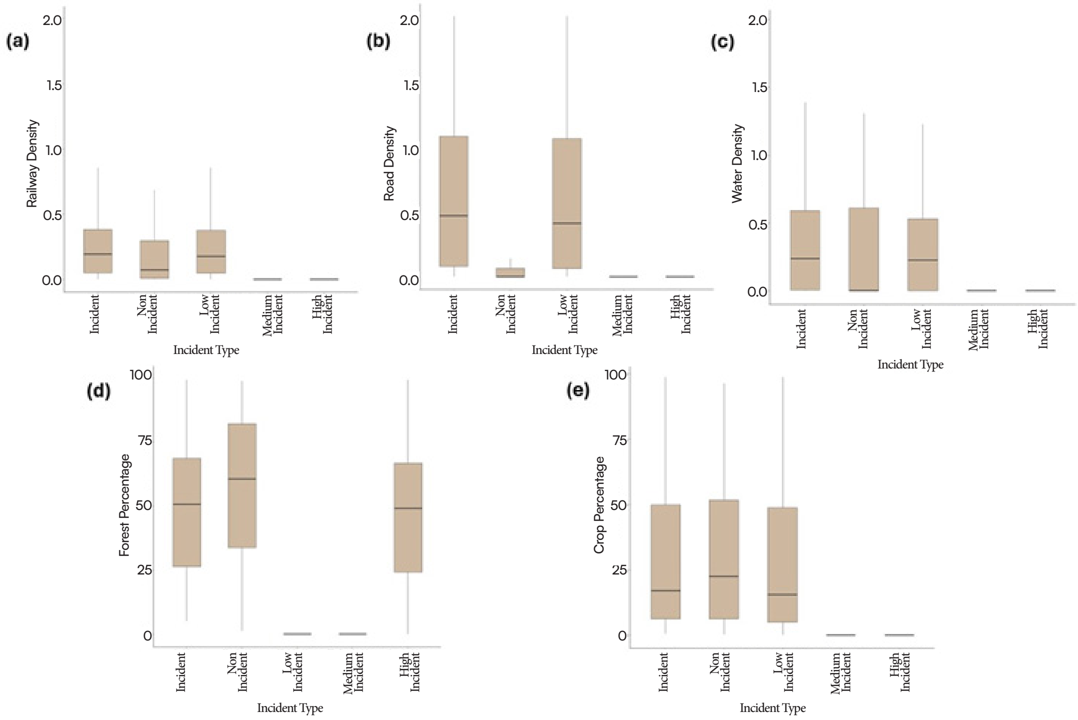


Figure 1.8: Box plot showing the built-up density, road density, railway density, crop percentage, forest percentage and mining percentage in non-incident, low-incident, medium-incident and high-incident villages in Chhattisgarh.

Table 1.6: Summary statistics loglikelihood (LogL), degrees of freedom (df), Akaike Information Criteria (AICc), relative support for hypothesis (Δ AICc), Akaike weights (Wi) of candidate regression model explaining elephant mortality in Chhattisgarh.

Model	LogL	df	AICc	ΔAICc	Wi
dw + dr + df + dc + db + der + dpa + dmn + lpi + ed	-69.484	11	162.577	0.000	0.181
df + dc + db + der + dpa + dmn + lpi + ed	-71.842	9	162.767	0.190	0.165
dw + dr + df + dc + db + der + dpa + dmn + lpi + pd + ed	-68.857	12	163.629	1.052	0.107
df + dc + db + der + dpa + dmn + lpi + pd + ed	-71.363	10	164.060	1.483	0.086
dr + df + dc + db + der + dpa + dmn + lpi + ed	-71.435	10	164.204	1.627	0.080
df + dc + der + dmn + lpi + ed	-75.065	7	164.796	2.219	0.060
df + dc + der + dpa + dmn + lpi + ed	-74.024	8	164.910	2.333	0.056
dr + df + dc + db + der + dpa + dmn + lpi + pd + ed	-70.764	11	165.138	2.561	0.050
dc + db + der + dpa + dmn + lpi + pd + ed	-74.274	9	167.632	5.055	0.014
dw + dr + df + dc + db + der + dpa + dmn + lpi + pd	-73.023	11	169.655	7.078	0.005
df + dc + der + lpi + ed	-78.802	6	170.102	7.524	0.004
db + der + dpa + dmn + lpi + pd + ed	-77.028	8	170.918	8.340	0.003
der + lpi + ed + dmn	-80.811	5	171.976	9.399	0.002
der + dpa + dmn + lpi + pd + ed	-79.392	7	173.451	10.874	0.001
der + dpa + lpi + ed + dpa + dmn + pd	-79.392	7	173.451	10.874	0.001
null (Intercept only)	-121.983	1	245.988	83.411	0.000

Table 1.7. Parameter estimates effect (β) and probabilities of ecological and anthropogenic variables in determining mortality of Asian elephant due to various anthropogenic activity

Predictor	Beta	Z_value	P_value	Significance
(Intercept)	-0.378	-1.555	0.120	
Distance to Waterbodies (dw)	-0.607	-1.663	0.096	.
Distance to Roads (dr)	-0.133	-0.533	0.594	
Distance to Forests (df)	0.487	2.152	0.031	*
Distance to Cropland (dc)	-1.237	-2.413	0.016	*
Distance to Built-up (db)	-0.461	-1.784	0.074	.
Distance to Elephant Reserve (der)	-1.357	-4.529	0.001	***
Distance to Protected Areas (dpa)	0.364	1.334	0.182	
Distance to Mines (dmn)	-0.510	-1.852	0.064	.
Largest Patch Index (lpi)	-0.984	-3.616	0.001	***
Edge Density (ed)	-0.676	-2.599	0.009	**

** Indicate the statistical significance of a result.*

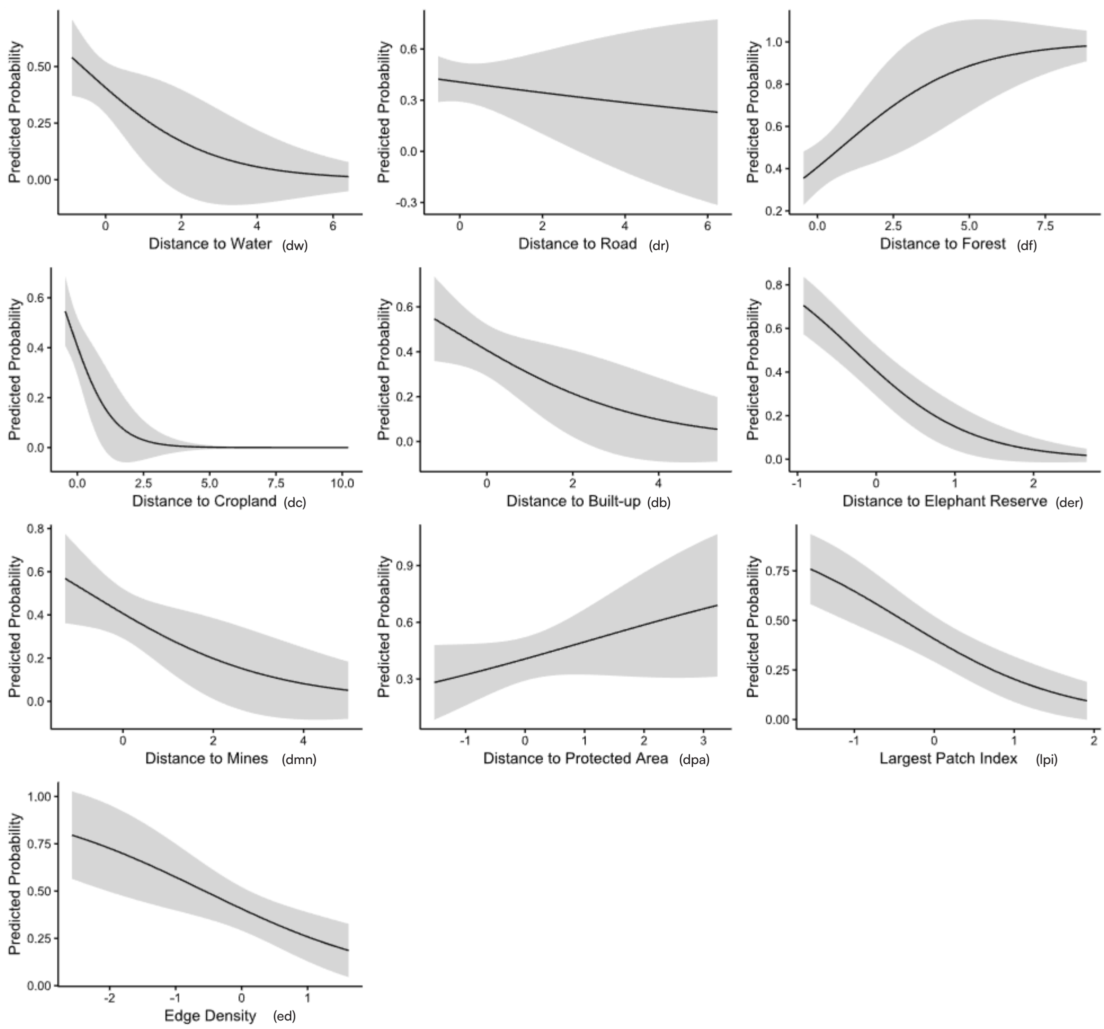


Figure 1.9: Graphs showing the probability of elephant mortality in relation to the different ecological and anthropogenic variables in Chhattisgarh

1.5. Discussion

1.5.1. Land Use Land Cover

The land cover change analysis from 2000 to 2024 showed notable changes in forest cover, water bodies, barren land, cropland, and built-up area. Forest cover shown a constant decline, decreasing from 48,440 sq.km in 2000 to 41,194 sq.km in 2024. Barren land varied over time, peaking in 2015 before declining significantly by 2024. Cropland expanded significantly, peaking at 41,628 sq.km in 2015 (+23.36%) before falling to 29,239 sq.km in 2024 (-1.76%). Built-up areas demonstrated continuous expansion, increasing from 2000 to 2024, with the highest surge observed between 2020 and 2024 (+93.34%). Additionally, transition matrix highlighted the conversion of forest cover primarily to cropland (33.2%), built-up areas (1.17%), and barren land (1.3%), while cropland has been converted to built-up areas (7%) and other land categories. LULC changes in Chhattisgarh reflect significant human-driven transformations. A decline in forest cover, particularly in Korba and Raigarh, due to expanding coal mines and urbanization (Bhagat et. al, 2024). Other studies found that rapid urban growth in Raipur had replaced agricultural and open lands. Deforestation threatens biodiversity, disrupts carbon sequestration, and reduces water availability, while the conversion of cropland into built-up areas raises concerns on food security (Khan et al., 2016) . Fluctuations in water bodies may be linked to reservoirs and land reclamation, while barren land changes indicate cycles of degradation and restoration. Urbanization, driven by population and economic growth, demands better land-use planning to balance development and sustainability. These findings are consistent with previous research, projecting significant land use and land cover (LULC) changes in the Mahanadi River basin, forecasting a decline in grasslands and an increase in croplands (Sahu *et al.*, 2024). Other study documented rapid urban expansion in Raipur, leading to the conversion of agricultural and open lands into built-up areas. Implementing sustainable land management strategies is essential to address these challenges effectively (Khan *et al.*, 2016).

1.5.2. Spatial and Temporal patterns

The findings highlight electrocution as the predominant cause of elephant mortality across divisions, particularly in areas with extensive electrical infrastructure. The concentration of fatalities in Dharamjaigarh, Raigarh, Jashpur, and Surajpur suggests a strong link between unprotected power lines, illegal fencing, and elephant movement patterns. These findings align with previous studies highlighting electrocution as a significant cause of elephant deaths in India, particularly in regions with expanding human settlements and electrical infrastructure (Ladue *et al.*, 2012; Baskaran *et al.*, 2013; Gubbi *et al.*, 2014b). The high mortality in Dharamjaigarh suggests a direct correlation between dense electrical networks and elephant deaths, a trend similarly observed in other elephant landscapes in Karnataka and Tamil Nadu (Ladue *et al.*, 2012) .Poorly insulated power lines and illegal electrical fencing are major contributors to this pattern (Gubbi *et al.*, 2014b).Our study reveals a significant pattern in elephant mortality due to anthropogenic causes, with adult male elephants exhibiting the highest mortality rates, followed by adult females and sub-adult males. This trend aligns with findings from northern West Bengal, where adult males were more frequently involved in elephant-train collisions, indicating a higher risk of mortality from human activities. This increased vulnerability may be attributed to adult males' behaviour, especially during musth, which leads them to wander into human settlements or along railway tracks, increasing their chances of fatal encounters. (Roy *et al.*, 2017). The expansion of the human population has resulted in encroachment upon elephant habitats, compelling elephants to forage in agricultural fields. This behaviour is particularly prevalent during the harvest season, a time when elephant raids are most frequent (Pradhan *et al.*, 2013; Palei *et al.*, 2014).

1.5.3. Drivers of Elephant Mortality and Village level implications

Our findings indicated that elephant mortality is significantly influenced by habitat and human-induced factors. These results align with previous research highlighting the impact of habitat fragmentation and human activities on elephant mortality. For instance, a study on the influence of habitat changes on elephant mortality in Sri Lanka found that both anthropogenic (*e.g.*, forest cover loss) and natural (*e.g.*, water availability, temperature) changes were associated with elephant mortality (Ladue *et al.*, 2021). Similarly, research on the impacts of landscape fragmentation on human-elephant interaction in Botswana demonstrated that land use and land cover changes, leading to habitat fragmentation, significantly influenced human-elephant interactions (Moeng *et al.*, 2022). Furthermore, a study on suitable habitats shifting toward human-dominated landscapes in Africa noted that the progressive dispersal of elephants from reserves due to habitat fragmentation and loss has led to increased overlap between their habitats and human-dominated regions, escalating the frequency of human-elephant conflicts (Yu *et al.*, 2024).

Our study underscores the profound influence of land-use changes on elephant mortality in Chhattisgarh, with agricultural expansion and urbanization playing a crucial role in escalating human-elephant conflict. These findings are consistent with previous research showing that habitat fragmentation and land conversion heighten interactions between humans and elephants, increasing the risk of fatalities (Anand *et al.*, 2017; Gubbi *et al.*, 2014c).The spread of croplands and built-up areas not only reduces available elephant habitat but also attracts elephants with easily accessible, high-energy food sources, which in turn leads to greater conflict and retaliatory killings (Baskaran *et al.*, 2013; Shaffer *et al.*, 2019c). Water availability remained stable across different village categories, suggesting it is not a major factor influencing elephant mortality. However, infrastructure development appears to be an emerging concern. The impact of mining and railways on elephant mortality appears to vary regionally, as previous studies suggested that their influence depends on local environmental and infrastructural factors (Chakraborty *et al.*, 2021). In contrast, the near-significant link between elephant mortality and road networks suggests that expanding infrastructure could pose an increasing threat to elephant populations. Similar patterns have been observed in other landscapes, where roads facilitate human access, intensify conflicts, and contribute to direct mortality (Laurance *et al.*, 2009; Vanak *et al.*, 2010).

1.6. Conclusion

Over the past 23 years, elephants in Chhattisgarh have faced increasing threats from human-elephant conflicts, habitat loss, and electrocution. Adult males are especially vulnerable due to territorial fights, accidents, and poaching, while the monsoon season witnessed the highest mortality rates due to increased movement and environmental hazards. Certain villages, including Dharamjaigarh, Chhal, Amandon, Goreapipar, Katghora, Kunkri, and Raigarh, are key areas of concern for elephant mortality. Understanding the environmental characteristics surrounding these villages such as habitat fragmentation, proximity to corridors, and human activity is crucial for effective mitigation. Identifying potential corridors and assessing where fragmentation is most severe can help create safer movement pathways for elephants. To reduce conflicts and protect elephants, key measures include insulating power lines, restoring forests, and maintaining migration corridors. Community-driven initiatives like early warning systems and compensation programs can help prevent retaliation. Technological advancements like AI-based predictive models, infrared surveillance, drones, and satellite tracking, successfully tested in Nagaland, can monitor elephant movement and reduce conflicts. GPS-enabled smart collars with geofencing can alert forest officials and communities in real time. Training forest officials on AI-based monitoring (DAS and IDS) and community engagement is crucial for effective conservation. Long-term success depends on stronger policies, better land-use planning, and collaboration between stakeholders. Ongoing research and adaptive strategies will be essential to ensuring elephants and humans can coexist safely.

CHAPTER 2:
Human Fatalities in the State of Chhattisgarh (2000-2023)

2.1. Introduction

Human-elephant conflict (HEC) is among the major issues challenging both the conservation of wildlife and human livelihoods across the globe. In Asia and Africa, elephants frequently come into contact with humans due to habitat fragmentation, the expansion of agricultural areas, and a decline in natural food sources (Sukumar, 2006). These conflicts results in crop raiding, property damage and, more critically, human and elephant fatalities (Fernando *et al.*, 2005). The level of conflict differs spatially and temporally depending on a multitude of factors including resource distribution, agricultural practices, land use by humans, seasonal climatic conditions, and habitat connectivity (Bal *et al.*, 2011; Cook *et al.*, 2015; Goswami *et al.*, 2015a; Wilson *et al.*, 2015b; Mumby and Plotnik, 2018). Similarly, in Africa, the encroachment of human into elephant habitats has resulted in frequent and often fatal encounters (Johnsingh and Williams, 1999a). Presently, HEC has also become a serious conservation concern in India. The country comprises the largest population of the world's wild Asian elephants, mainly distributed over the states of Karnataka, Assam, Kerala, Tamil Nadu, and Odisha. These high forest cover areas have human habitations and cultivation interspersed, making the scene most conducive to conflict (Choudhury, 2004a). India harbors the largest population of Asian elephants, with an estimated 25,000—30,000 individuals occupying approximately 163,000 km² of diverse habitats. However, frequent human-elephant interactions occur, particularly in the east-central region, which includes Chhattisgarh, Odisha, and West Bengal. This conflict results in high human casualties and elephant mortality, making the environment increasingly hostile for humans and elephants (Shaffer *et al.*, 2019d). Human-elephant conflict resulted in an average of 450 human deaths annually across India (2009—2020), with the east-central region (including Chhattisgarh) suffering the highest number of fatalities (Pandey *et al.*, 2024c). India has taken significant steps to protect its elephant while addressing human-elephant conflict. One of the most important initiatives is Project Elephant, launched in 1992, which focuses on safeguarding elephants, preserving their habitats, and maintaining crucial corridors that connect their movement pathways. Subsequently, 33 Elephant Reserves have been established across 14 states, covering 80,777 km². Unlike traditional protected areas, these reserves take a landscape approach, ensuring that elephants can move safely even outside protected areas. Strong legal protections, such as the Wildlife (Protection) Act of 1972 and the Forest (Conservation) Act of 1980, help regulate habitat destruction and infrastructure development, making conservation efforts more effective. These combined strategies reflect India's commitment to balancing conservation with coexistence (Pandey *et al.*, 2024c).

Chhattisgarh, a state in central India, including parts of the Eastern Ghats and Satpura range providing an important refuge for elephants, has a unique case that is evolving in many ways. Historically, this tract was the elephant homeland, and throughout the greater part of the 20th century, there was hardly any resident population (Johnsingh and Williams, 1999b). The late 20th and early 21st centuries have marked a remarkable change with the re-emergence of elephants in the Chhattisgarh landscape. Traditionally, elephants were mainly found in the northeastern states, southern regions, and parts of central India (Menon *et al.*, 2017). Though the state is dominated by dense forests and tribal populations, this place did not have much of an elephant population until the late century (Johnsingh and Williams, 1999b). The reappearance of elephants in Chhattisgarh could be associated with deforestation and mining in Odisha and Jharkhand, which have forced them to seek new habitats (Paleiet. al., 2019). The state's forests provide natural corridors that facilitated this migration, settling resident elephant populations in places like Surguja, Jashpur, and Raigarh (Natarajan *et al.*,2024). Over the years, agricultural expansions into forested areas, combined with mining and logging activities fragmented these corridors, forcing elephants to venture into human-dominated landscapes (Sukumar, 2006). This has drastically altered the ecology and led to frequent human-elephant conflicts due to the presence of this mega herbivore (Choudhury, 2004a).

Conflicts majorly lead to human fatalities and injuries as well as elephant fatalities. Several human deaths and injuries from elephant encounters strain the human-wildlife relationship (Talukdar *et al.*, 2024). Elephant damage houses granaries and infrastructure, human injuries and fatalities thus escalating the conflict (Choudhury, 2004b). Several factors have been identified to aggravate the HEC problem in Chhattisgarh. Large-scale agricultural expansion and development projects reduce the elephant habitats, increasing the encounters (Sukumar, 2006). However, none of these driving forces have been quantified at the landscape scale in terms of HEC management and mitigation. In recent years, the fragmentation of forests disrupts the natural elephant movement and increases the chances of contact with humans (Choudhury, 2004b). Conflict mitigation strategies have been inadequate and ineffective, failing to prevent or reduce conflicts, which remain an ongoing challenge (Kochprapa *et al.*, 2024). Similarly, HEC has significant socio-economic impacts on local communities, including psychosocial stress, displacement, and migration. The continuous danger posed by elephants causes psychosocial stress and trauma among affected communities (Nyumba *et al.*, 2020). If these conflicts persist, some families even migrate, hence breaking their social and economic stability (Bhagat *et al.*, 2017b). One of the critical factors that influence HEC in Chhattisgarh is the rapid expansion of open-cast mining (Singh, 2002). The expansion of mining has led to extensive deforestation and habitat fragmentation. As such, with more land being cleared for open-cast mining, elephants are deprived of their natural habitats and thus are compelled to enter human-dominated landscapes in search of food (Bhagat *et al.*, 2017b). It is, therefore, common to have frequent encounters with elephants causing substantial property damage. The financial toll of these conflicts can be overwhelming, particularly for smallholder farmers who rely heavily on their land for both sustenance and income. The destruction of crops and property can leave them vulnerable, as their livelihoods are directly tied to the agricultural output, they are able to produce (Barua *et al.*, 2013). This has in most cases led to loss of property, relegating such families to poverty, thereby creating a cycle of conflict and hatred for elephants in general (Acharya *et al.*, 2016) .To summarize, forest fragmentation caused by mining, road construction, and urbanization has disrupted elephants' migration routes, forcing them through human settlements and agricultural fields. This increased reliance on human resources has led to more frequent and deadly encounters, escalating the human-elephant conflict and further tension (Ram *et al.*, 2021). Another major cause of HEC in Chhattisgarh is the ineffectiveness of mitigation strategies. Though plans for establishing elephant corridors have been made, they are often ineffective or poorly implemented. These corridors are supposed to be protected routes that enable elephants to travel between patches of forests; however, human activities such as agriculture, settlements, and mining often encroach on these corridors, obstructing elephant movement. This encroachment reduces the available spaces for safe elephant passage, increasing the conflict. Furthermore, community awareness programs designed to foster coexistence are often narrow in scope and fail to address the needs of all communities. These programs are typically not comprehensive enough to engage the entire population in efforts to rescue conflict and promote sustainable coexistence (Ram *et al.*, 2021).

In the current study, we tried to understand the spatial and temporal dynamics of HEC in Chhattisgarh and identify key ecological and anthropogenic drivers influencing conflict intensity and distribution. The key objectives are as follows: a) to analyze the temporal variation in human fatalities, and injuries across the study period, b) to examine the spatial distribution of conflict hotspots using kernel density estimations to identify divisions and villages with high conflict intensity c) Investigate seasonal & gender-based variations in human fatalities and injuries to understand demographic disparities in conflict impact d) to determine the influence of landscape features such as proximity to forests, protected areas, roads, water bodies, crop fields, and built-up areas on HEC occurrence. The outcome of this study would provide insights into the ecological and anthropogenic drivers of HEC to inform targeted conflict mitigation and management strategies in high-risk areas.

2.2. Methods

2.2.1. Collection of HEC occurrences

Human-elephant conflict (HEC) data from 2000 to 2023 were collected from 19 Divisional Forest Offices in Chhattisgarh, detailing incident locations, division name, date of the incidents, human fatalities and injuries (with gender). Surveys conducted in high-conflict villages, in collaboration with forest officials, to collect more precise and detailed information on the incidents.

2.2.2. Land use land cover, HEC Spatial Patterns, and Forest Fragmentation

The human-elephant conflict (HEC) records include 828 documented incidents of human deaths and injuries between 2000 and 2023. The incidents were grouped into five-year intervals: 2000—2005, 2006—2010, 2011—2015, 2016—2020, and 2021—2023. Each incident was classified by type (death or injury), gender of the affected individuals, year, season, forest division, and whether it occurred within or outside protected areas. A kernel density estimation approach was used to map conflict hotspots. The HEC occurence of this was stratified into three levels of intensity: high (more than 20 incidents), medium (11—20 incidents), and low (1—10 incidents). Moreover, the frequency of occurrences was further calculated to examine the temporal and spatial patterns of HEC at village levels within their corresponding forest divisions. The village boundaries were obtained from the ArcGIS Online, shapefile : Indian Administrative Layer 2024.

A LULC map of Chhattisgarh was generated for the years 2000, 2005, 2010, 2015, 2020, and 2024, using satellite images from Landsat 5 TM and Landsat 8 OLI. Landscape fragmentation was analysed through key landscape metrics calculated using FRAGSTATS (v4.2). The LULC maps were reclassified into forest and non-forest categories using ArcGIS Spatial Analyst tools. To capture the critical landscape features, important metrics such as Patch Density (PD), Edge Density (ED), and Largest Patch Index (LPI) were computed. A 7 km moving window analysis was done based on average elephant movement, generating a continuous surface that ensured ecologically meaningful results (Cushman *et al.*, 2010). This analysis provided a comprehensive understanding of the relationship between land cover changes, fragmentation, and HEC incidents.

2.2.3. Variables influencing human casualties

To investigate the factors contributing to HEC, spatial data were analysed for variables such as distances to forests, croplands, built-up, roads, rivers, protected areas, elephant reserves, and mining operations. Fragmentation metrics like Patch Density (PD), Largest Patch Index (LPI), and Edge Density (ED) were computed to assess landscape structure and fragmentation. The selection of these variables, along with the underlying hypotheses, is summarized in Table 2.1. Land Use Land Cover (LULC) data, including forest, crop, and urban land types over 24 years, were obtained from satellite imagery, converted to vector format, and matched with conflict locations for each relevant year. Using the "Generate Near Table" function in GIS, distances from conflict points to these landscape features were calculated. These distance measurements, along with fragmentation metrics, were then treated as predictor variables, while human fatalities and injuries served as the response variable. We applied Generalized Linear Models (GLMs) to identify the factors contributing to conflict, and for model selection we used R package "MuMIn". The models were built based on theoretical assumptions, ensuring that variables with known relevance to HEC were included. Prior to model construction, all variables were standardized (z-transformed), and multicollinearity was checked. Each HEC event involving human fatalities/injuries was marked as 1, while pseudo-points (representing areas without conflict) were randomly assigned a value of 0. These pseudo-points were generated near actual conflict zones within the study area using ArcGIS Pro to maintain spatial accuracy. Furthermore, at the village scale, the Kruskal-Walli's test was conducted to evaluate significant differences in the aforementioned ecological and anthropogenic variables across villages classified as low, medium, and high conflict.

Table 2.1: Variables and a-priori hypotheses for analysing factors influencing Human-Elephant Conflict in Chhattisgarh

Feature	Variable	Description and Source	A-priori Hypothesis
Landcover	Distance from Built-up Areas (dba)	Distance between conflict points and built-up areas is calculated using the Near Table tool in ArcPro 3.0.0. Built-up areas are extracted from classified land cover data.	Proximity to built-up areas may negatively impact HEC due to higher human activity and potential habitat loss for elephants.
	Distance from Cropland (dc)	Distance between conflict points and croplands is calculated using the Near Table tool in ArcPro 3.0.0, based on classified land cover.	Proximity to cropland is expected to increase HEC due to crop damage and competition for resources.
	Distance from Forest (df)	Distance between conflict points and forests is calculated using the Near Table tool in ArcPro 3.0.0, based on classified land cover.	Proximity to forest may increase HEC as elephants may venture into human settlements in search of food and habitat.
	Distance from Waterbodies (dw)	Distance between conflict points and waterbodies is calculated using the Near Table tool in ArcPro 3.0.0. Waterbodies are extracted from classified land cover.	Proximity to waterbodies may increase HEC, particularly during the dry season when elephants move closer to human settlements in search of water.
	Distance from Mines and Quarries (dmn)	Distance between conflict points and mines/ quarries is calculated using Google Earth Pro for digitization and the Near Table tool in ArcPro 3.0.0.	Mining activities significantly influence the occurrence of HEC by disrupting elephant habitats; areas close to mines may show a higher likelihood of conflict.

Anthropo-genic	Distance from Roads (dr)	Distance between conflict points and roads is calculated using OpenStreetMap data and the Near Table tool in ArcPro 3.0.0.	Proximity to roads may elevate HEC due to increased human activity, habitat fragmentation, and infra-structure development.
	Distance from Protected Areas (dpa)	Distance between conflict points and pro-tected areas is calculated using shapefiles from WII's Elephant Cell and the Near Table tool in ArcPro 3.0.0.	Proximity to protected areas is expected to influence HEC, with potential increase in conflict near edges where human activities are more prevalent.
	Distance from Elephant Re-serves (der)	Distance between conflict points and ele-phant reserves is calculated using the Near Table tool in ArcPro 3.0.0.	Proximity to elephant reserves will impact HEC, as increased elephant movements around reserves may lead to more frequent conflicts near settlements.
Landscape Metrics	Patch Density (pd)	Patch density is calculated using the Patch Analyst tool in ArcGIS, based on landcover data from classified imagery.	Higher patch density, indicating more fragmented landscapes, may lead to increased conflict due to disrupted habitats and movement corridors for elephants.
	Edge Density (ed)	Edge density is calculated using the Patch Analyst tool in ArcGIS, focusing on bound-aries between different land cover classes (*e.g.*, forest/cropland, forest/built-up).	Higher edge density may increase HEC by creating more interfaces between habitats and human set-tlements, where elephants are more likely to cross paths with humans.
	Largest Patch Index (lpi)	Largest patch index is calculated using the Patch Analyst tool in ArcGIS, measuring the size of the largest continuous patch of a particular land cover type (*e.g.*, forest).	A larger largest patch index may indicate a more stable habitat for elephants, potentially reducing HEC; however, fragmentation of the largest patches could lead to more conflicts.

2.3. Results

2.3.1. Temporal pattern and Seasonality

In 23 years, Chhattisgarh reported 828 HEC incidents, including 737 human deaths and 91 injuries (Appendix 2). Fatalities peaked between 2016 and 2018, with the highest number of incidents recorded in 2019 (Fig. 2.1). Among the divisions, Jashpur (152 deaths,19 injuries) emerged as the most severely affected, followed by Dharamjaigarh (135 deaths, 20 injuries), Surajpur (107 deaths, 04 injuries), and Korba (64 deaths, 04 injuries; Fig. 2.2). Spatial analysis of conflict hotspots, derived from kernel density estimations, revealed concentration in these high-conflict divisions (Fig. 2.3). Seasonal variation in human fatalities by gender revealed that the fatality and injury rates were significantly higher in males (540 cases) compared to females (288 cases) ($\chi^2 = 76.69$, df = 1, p = 2.2e-16). However, there was no significant association between gender and seasons ($\chi^2 = 3.04$, df = 3, p = 0.38). Seasonal data indicated that monsoon accounted for the highest fatalities and injuries ($\chi^2 = 14.35$, df = 3, p = 0.002; 205 males, 117 females) (Fig. 2.4). A total of 321 villages were affected by HEC, with Jashpur being the most impacted (66 villages), followed by Surguja (45 villages), Dharamjaigarh, and Balrampur (35 villages each) (Fig. 2.5)

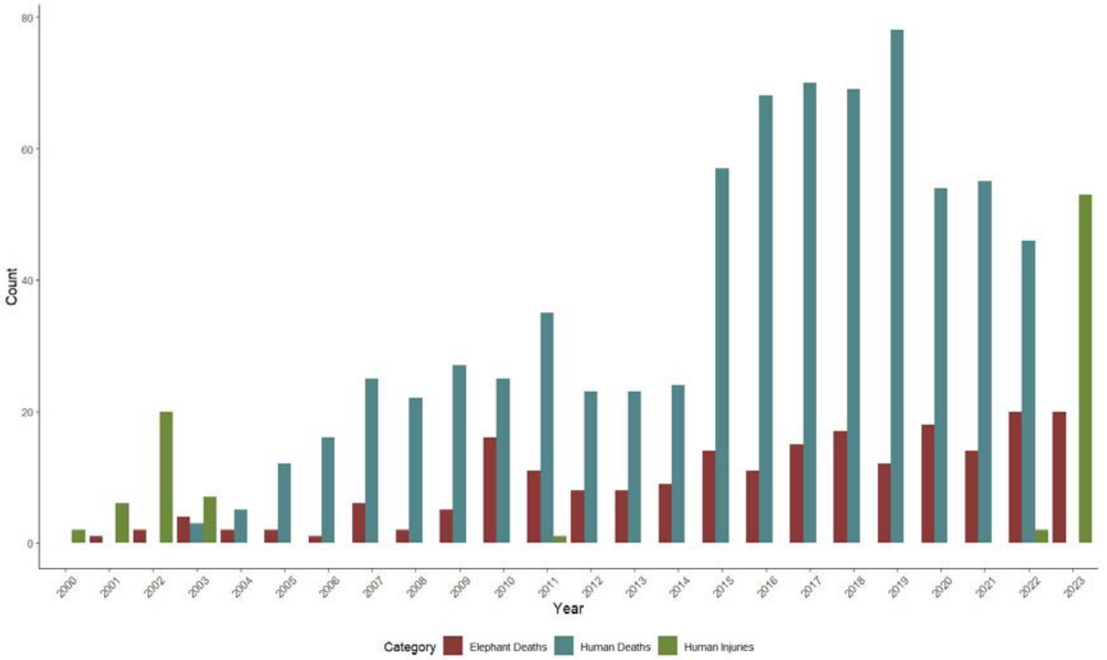


Figure 2.1: Trends in human fatalities and injuries resulting from human-elephant conflict in Chhattisgarh over a 23-year period (2000-2023)

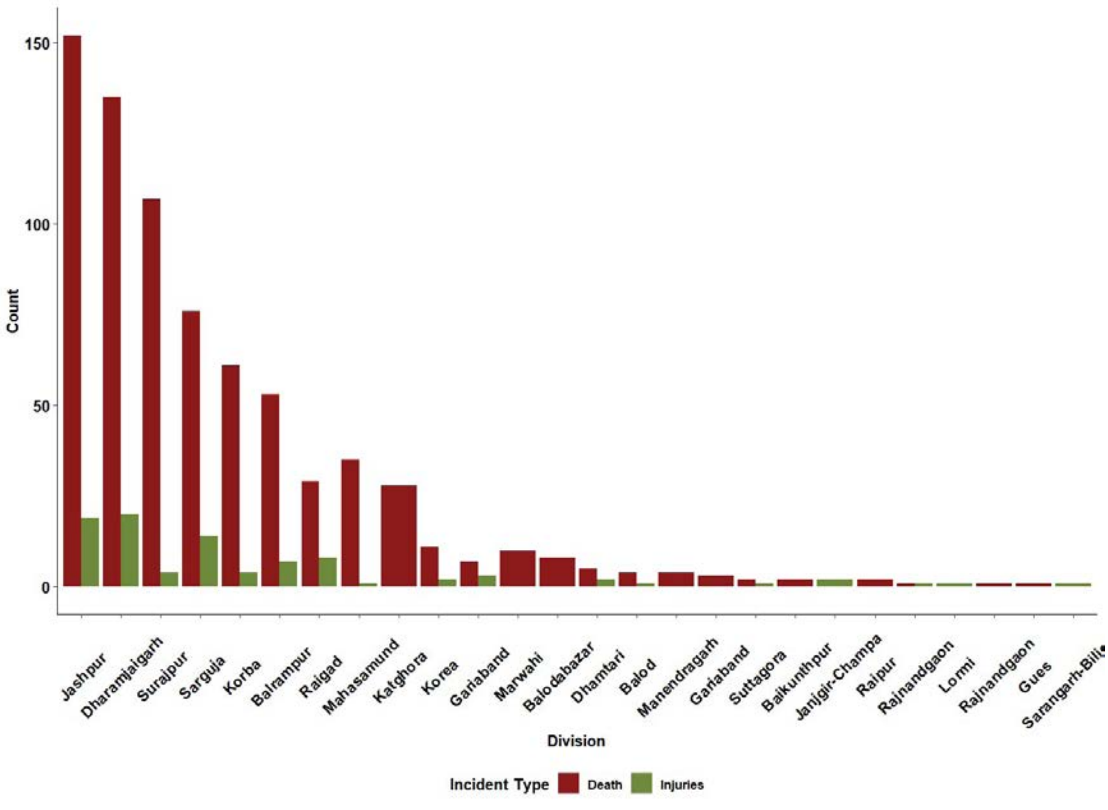


Figure 2.2: Division-wise patterns of human (fatalities & injuries) in Chhattisgarh over the past 23 years (2000-2023)

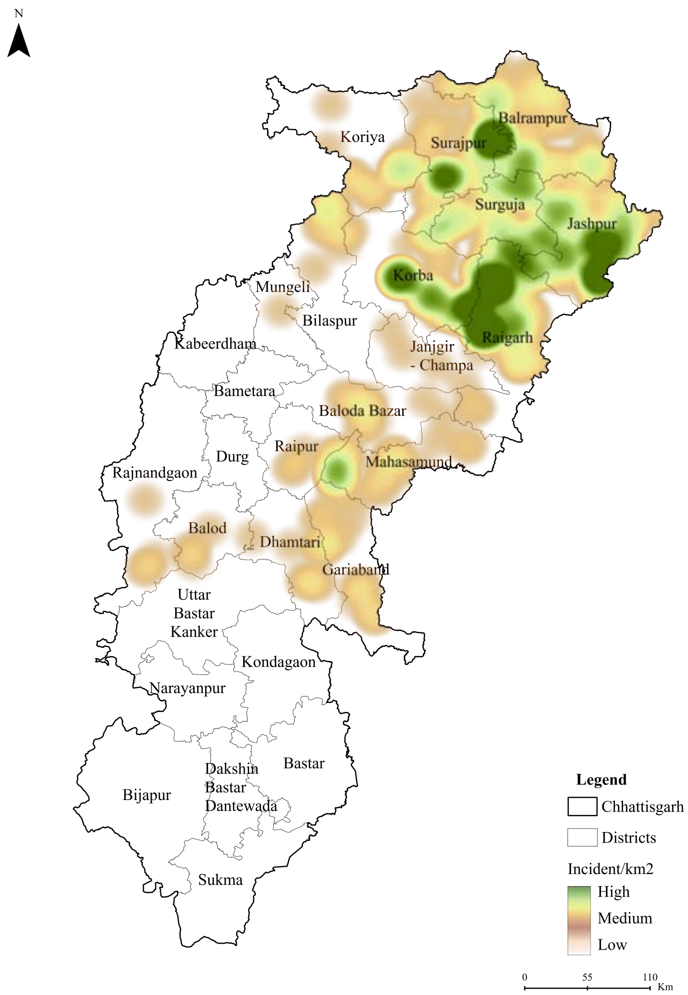


Figure 2.3: Kernel Density map visualizing the intensity and distribution, highlighting areas with higher HEC occurences in Chhattisgarh (2000—2023).

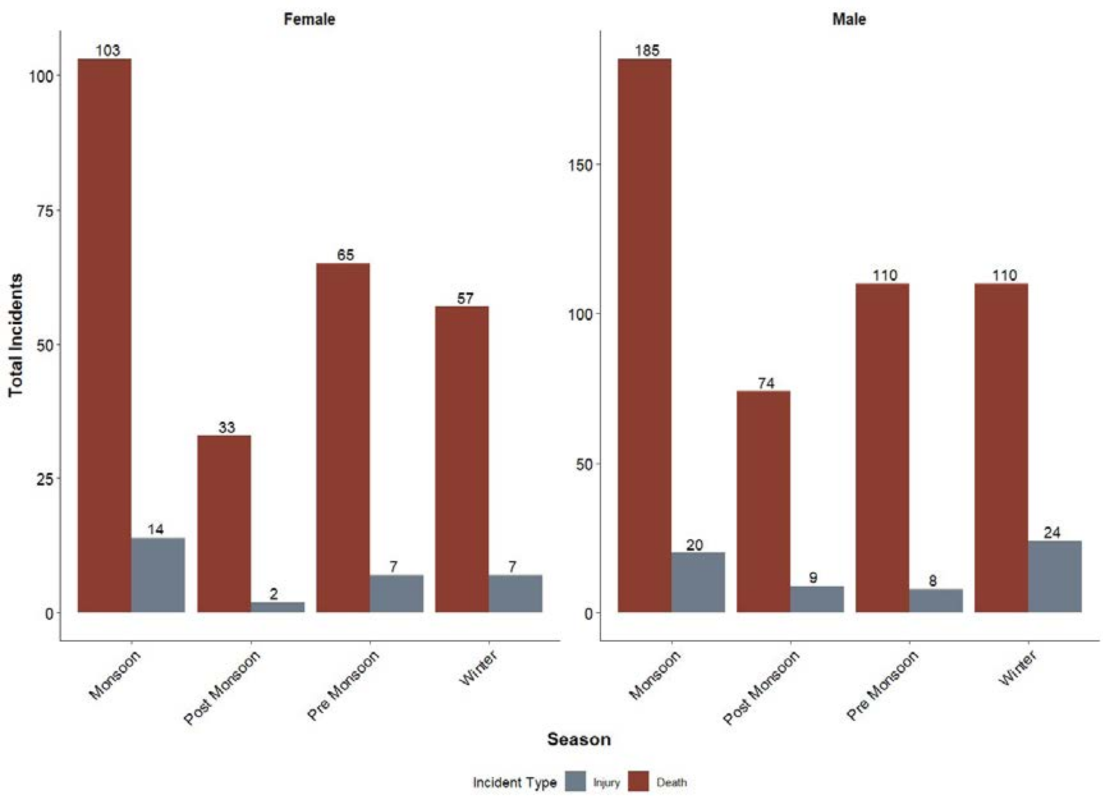


Figure 2.4: Seasonal patterns of human fatalities and injuries (male and female) in Chhattisgarh from 2000 to 2023

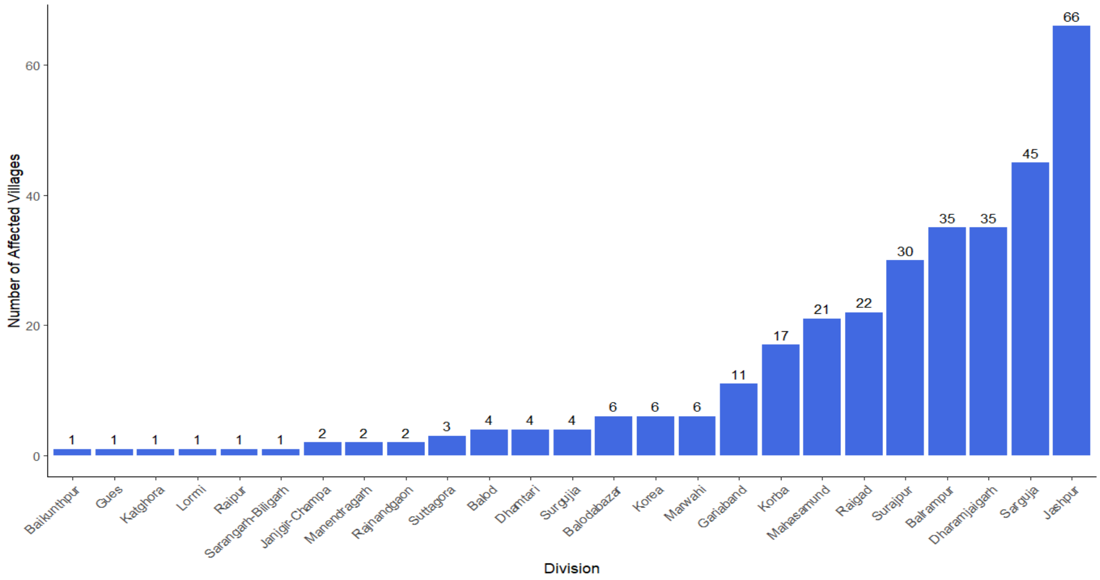


Figure 2.5: Distribution of Conflict-Affected Villages (human fatalities & injuries) in Chhattisgarh from 2000 to 2023.

2.3.2. Village-Level Analysis of Ecological and Anthropogenic Variables

A comprehensive examination of ecological and anthropogenic variables at the village level highlights distinct patterns across varying conflict intensity categories. High-conflict areas exhibit a wider range of built-up percentages, medium-conflict zones have the lowest built-up percentage, and low-conflict zones showed greater variability (Fig. 2.6a, Kruskal-Walli's: χ^2 = 3.21, df = 2, p = 0.20). High-conflict areas show lower crop cover percentages with less variability, while medium- and low-conflict zones exhibit broader variability (Fig. 2.6b, χ^2 = 0.11, df = 2, p = 0.94). Forest cover percentages are higher in high incident zones, with medium-conflict zones having the lowest median forest cover and low-conflict zones showing greater variability (Fig. 2.6c, χ^2 = 1.40, df = 2, p = 0.49). High conflict areas exhibit low water availability. Medium-and low-conflict zones show moderate water availability (Fig. 2.6d, χ^2 = 4.51, df = 2, p = 0.1046). Road density is higher in non-incident zones compared to incident zones (Fig. 2.6e, χ^2 = 14.87, df = 2, p = 0.0005). High-conflict areas exhibit low mining percentages, suggesting minimal mining activity in regions with intense human-elephant conflicts. Medium- and low-conflict zones show moderate mining percentages (Fig. 2.6f, χ^2 = 0.28, df = 2, p = 0.86).

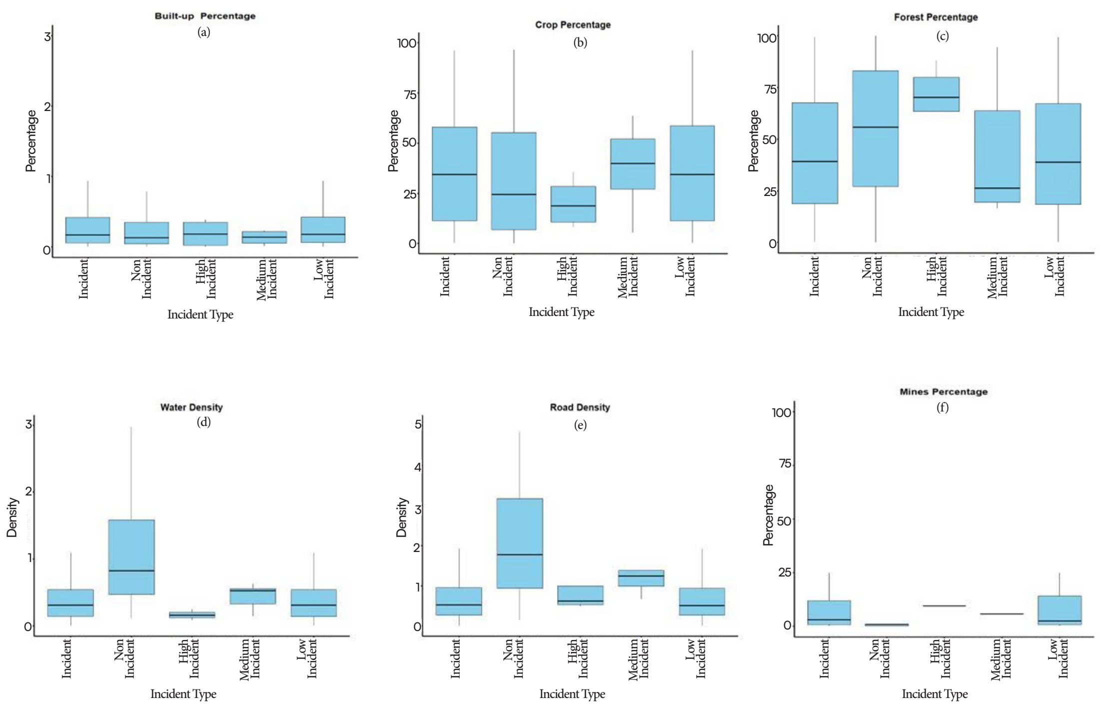


Figure (2.6a-2.6f). Comparison of ecological and anthropogenic variables across differnt incident types and non-incidence villages of Chattisgarh

2.3.3. Key Predictors of HEC

HEC patterns are strongly influenced by the interplay of natural landscapes and human-modified surroundings. Probability of conflict decreases with increasing distance from water bodies (β = -0.14, p = 0.048), roads (β = -0.54, p < 0.001), cropland (β = -1.80, p < 0.001), built-up area (β = -0.40, p < 0.001), mines (β = -0.13, p = 0.068) and elephant reserve boundary (β = -0.83, p < 0.001). In contrast decreases with increasing distance to forest patches (β = 1.48, p < 0.001) and protected areas (β = 0.233, p = 0.002). Additionally, conflict incidents show a decreasing trend in areas with larger forest patches (LPI) (β = -0.31, p < 0.001; Table 2.2 & 2.3).

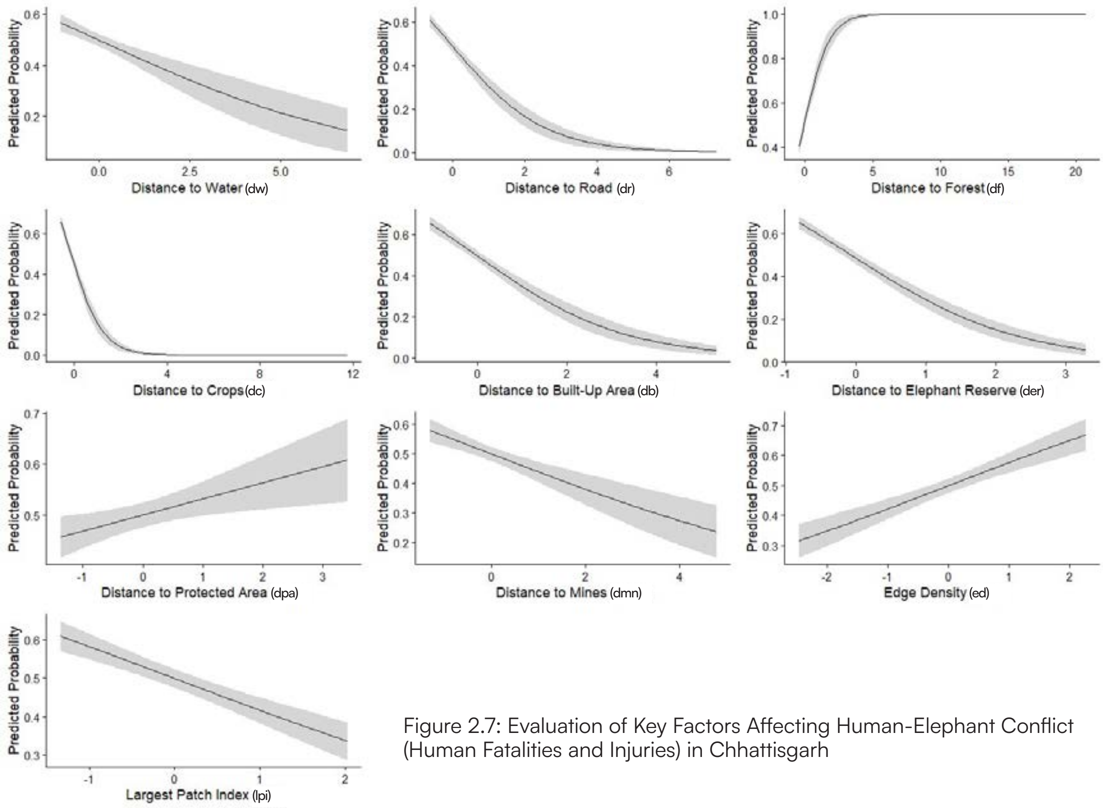


Figure 2.7: Evaluation of Key Factors Affecting Human-Elephant Conflict (Human Fatalities and Injuries) in Chhattisgarh

Table 2.2: Summary statistics loglikelihood (LogL), degrees of freedom (df), Akaike Information Criteria (AICc), relative support for hypothesis (Δ AICc), Akaike weights (Wi) of candidate regression model explaining HEC in Chhattisgarh.

Model Description	LogL	df	AICc	ΔAICc	Wi
dw + dr + df + der + dmn + dpa + lpi + dc + db + ed	-763.168	11	1548.498	0	1.00
dw + dr + df + der + dmn + dpa + lpi + db + ed	-834.876	9	1687.863	139.364	0.00
dw + dr + df + der + dmn + dpa + lpi + db + ed	-834.206	10	1688.547	140.049	0.00
dr + df + der + dmn + dpa + lpi + db + ed	-836.748	9	1691.606	143.10	0.00
dw + dr + df + der + dmn + lpi + db + ed	-839.639	9	1697.388	148.8	0.00
dr + df + der + dmn + dpa + ed	-863.386	7	1740.84	192.342	0.00
dr + df + der + dmn + dpa + lpi + ed	-863.24	8	1742.581	194.083	0.00
dw + df + der + ed	-911.323	5	1832.684	284.185	0.00
dr + df + dmn + db + ed	-945.620	6	1903.293	354.794	0.00
dr + dpa + dc + ed	-976.108	5	1962.254	413.755	0.00
dw + dr + df + dpa + lpi + ed	-990.935	7	1995.939	447.44	0.00
der + db + ed	-995.645	4	1999.316	450.817	0.00

dw + der + dmn + lpi + ed	-995.061	6	2002.174	453.675	0.00
dw + df + dmn + ed	-1029.534	5	2069.105	520.607	0.00
dw + dpa + lpi + db + ed	-1057.123	6	2126.298	577.799	0.00
dw + dr + lpi + ed	-1060.648	5	2131.333	582.835	0.00
intercept-only model (null model)	-1147.851	1	2297.706	749.20	0.00

Table 2.3: Parameter estimates effect (β), standard errors (S.E), and probabilities of ecological and anthropogenic variables in determining the human elephant conflict in Chhattisgarh

Predictor	Beta_Coefficient (β)	Std_Error	Z_value	P_value	Significance
(Intercept)	-0.4083	0.0793	-5.144	0.0001	***
Distance to water (dw)	-0.1422	0.0720	-1.974	0.05	*
Distance to road (dr)	-0.5432	0.0879	-6.177	0.0001	***
Distance to forest (df)	1.4871	0.1190	12.493	< 2e-16	***
Distance to elephant reserves (der)	-0.8362	0.0840	-9.947	< 2e-16	***
Distance to mines (dmn)	-0.1339	0.0734	-1.824	0.07	
Distance to protected areas (dpa)	0.23	0.0755	3.084	0.0001	***
Largest Patch Index (lpi)	0.3138	0.0780	4.02	0.0001	***
Distance to crops (dc)	-1.8024	0.1869	-9.641	< 2e-16	***
Distance to built-up (db)	-0.4081	0.0758	-5.382	0.0001	***
Edge Density (ed)	0.0987	0.0730	1.352	0.17262	

** Indicate the statistical significance of a result.*

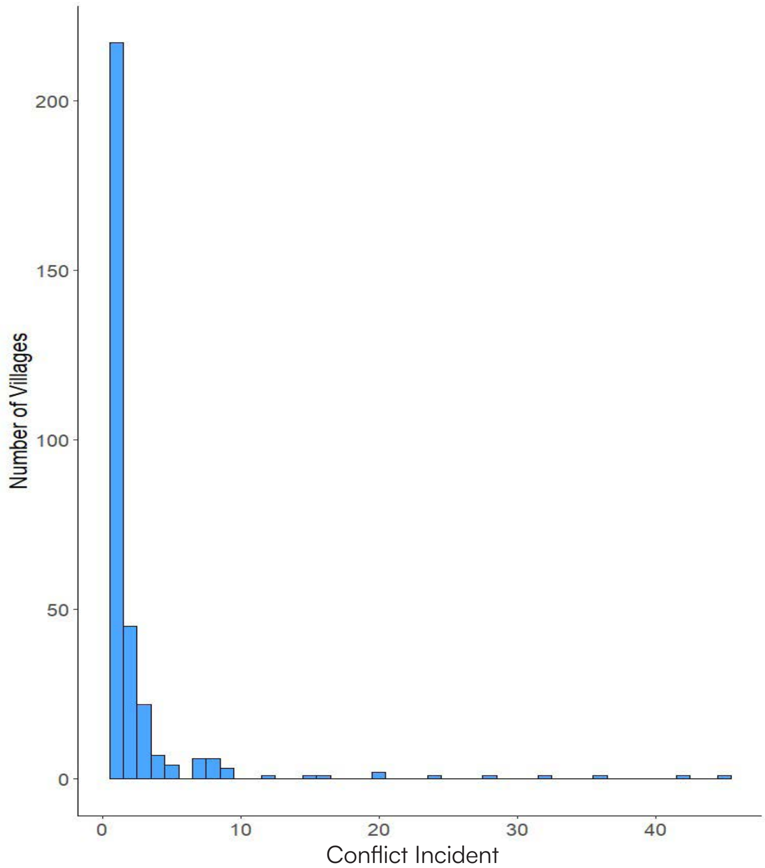


Figure 2.8 Distribution of Human (fatalities & injuries) Conflict Incidents Across Villages in Chhattisgarh

2.4. Discussion

In Chhattisgarh, various factors influencing the overall pattern of HEC, particularly leading to incidents of human fatalities and injuries. Developmental activities including infrastructure projects, agricultural expansions, deforestation have caused substantial habitat loss for elephants, which in turn has intensified the occurrence of HEC (Choudhury, 2004a; Palei, 2013; Guru and Das, 2021a). Over the years, Dharamjaigarh, Surguja, and Jashpur have become HEC hotspots, mirrors patterns observed in the neighbouring state of Odisha, where deforestation and urbanization are linked to higher rates of conflict (sarkar and Bhattacharya, 2023). As elephants migrate into human-dominated areas, the likelihood of conflict increases, often resulting in agricultural damage and heightened risks for local communities (Mago *et al.*, 2022). In regions like Nepal, Sri Lanka, and Kenya, the expansion of farmlands has led to habitat fragmentation, making elephants more likely to raid crops and come into conflict with humans (Okello *et al.*, 2014; Gunawansa *et al.*, 2023; Tiller *et al.*, 2025). A similar trend is observed in Chhattisgarh, where agricultural expansion is increasing at a rate of 9.25 percent annually. HEC incidents in Chhattisgarh show seasonal variations, often peaking during the monsoon season. This trend is consistent with observations from North Bengal, where a rise in crop-raiding incidents during the monsoon season, is attributed to the abundance of crops that draw elephants into human settlements (Naha *et al.*, 2019).

Our analysis of HEC in Chhattisgarh highlights the intricate relationships between ecological conditions and human-driven activities. Villages with low conflict levels tend to have low infrastructure percentages, indicating that areas with less human interference are less prone to HEC. However, high-conflict villages are often located near regions with moderate infrastructure development, suggesting that elephants may avoid highly developed built-up areas with high human activity and noise pollution, but still encounter conflicts near transitional zones. Previous studies also reported that roads and human settlements disrupt elephant migration routes and fragment their habitats, exacerbating the frequency and severity of HEC (Shaffer *et al.*, 2019d) .Forest cover also plays a pivotal role in influencing conflict levels; while intact forests act as buffers, fragmented forests often lead to high-conflict zones due to elephants entering human settlements in search of resources. These findings emphasize the importance of minimizing habitat fragmentation to maintain elephant corridors and reduce HEC intensity (Rani *et al.*, 2024). Water availability is another key factor; areas with ample water sources tend to have fewer conflicts, as elephants are less likely to enter human settlements when water is readily available in their natural habitat. This is consistent with findings from other regions, where water scarcity in conflict zones is a key driver behind elephants' movements into agricultural and urban areas, increasing the potential for conflict (Shaffer *et al.*, 2019d; Dutta, 2020). Human-altered landscapes, including agricultural lands and urban areas, also contribute to conflict. Conflict often occurs when there is intensive agriculture, particularly nutrient-enriched crops such as rice and maize, attracting elephants to the area to raid crops (Webber *et al.*, 2011). This study found a positive correlation between the percentage of crops in conflict areas and the intensity of the conflict, as elephants are drawn to these areas in search of food. Other regions have reported similar findings where agricultural land has been the main factor that pushes elephants into human settlements (Dorji and Thapa, 2024).

Proximity to forests, elephant reserves, and protected areas is strongly associated with higher conflict occurrences. Elephants prefer habitats near forests and water sources, leading to increased interactions with human settlements close to these areas (Palei, 2013). Increasing distances from roads, crop fields, and built-up areas are linked to lower conflict levels. Human-modified landscapes, such as infrastructure and agricultural expansion, disrupt elephant habitats and migration routes. Elephants tend to avoid areas with high road density and human activity, which act as deterrents to movement (Anoop *et al.*, 2023). Water bodies had a weak but significant effect on conflict, as elephants are drawn to them during water scarcity, particularly in dry seasons. This is consistent with findings identifying proximity to water as a key factor in elephant habitat suitability (Wilson *et al.*, 2015b). Larger continuous habitat patches (indicated by a higher Largest Patch Index, LPI) showed a negative relationship with conflict. Intact habitats reduce edge effects and human-elephant interactions, mitigating conflict (Rani *et al.*, 2024). Edge density showed a positive but non-significant relationship with conflict, indicating that boundary complexity may influence elephant movement patterns (Gubbi *et al.*, 2014b). Mining activities were weakly associated with conflict, suggesting their impact is less significant compared to roads or agricultural expansion. Mining contributes to habitat degradation but has a less direct correlation with human-elephant conflict (Tripathy *et al.*, 2021).

In Chhattisgarh, efforts must be particularly targeted to decrease human-elephant conflict especially in the worst-affected villages. Priority should be given to high-conflict villages such as: Amandon (45 incidents), Chhal

(42 incidents), Dharamjaigarh (36 incidents), Sajbahar (32 incidents), Katghora (28 incidents), and Surajpur (24 incidents). In addition, in the medium-conflict village category are Kunkuri (20 incidents), Kudmura (20 incidents), Korba (16 incidents), Godhi Khurd (15 incidents), and Mahasamund (12 incidents), which require urgent attention to prevent escalations of the same. Finally, low-conflict villages (total number of 310) have fewer events; these are integral parts of broader strategies to ensure long-term success and prevent new outbreak areas. There is a comprehensive and stratified strategy across all the levels of conflicts, which would encourage harmonious living and consequently minimize human-elephant conflicts in the region. Mining activities, particularly in regions like Korba, have exacerbated habitat degradation, contributing to landscape fragmentation and intensifying human-elephant interactions. The expansion of mining operations not only destroys critical habitats but also increases human presence in ecologically sensitive areas, further elevating conflict risks. These disruptions are compounded by agricultural activities in the vicinity of forested regions, as farmlands with crops like rice and maize serve as major attractants for elephants. To mitigate HEC in Chhattisgarh, a multi-pronged strategy is essential. The escalating human-elephant conflict reflects the growing pressures of habitat fragmentation and unprotected corridors, as observed across the east-central region (Pandey *et al.*, 2024a). With rapid infrastructure expansion and mining disrupting traditional elephant pathways, communities find themselves at increasing risk of tragic encounters. Safeguarding and restoring these critical corridors are not just about conserving wildlife but also about protecting lives and fostering coexistence between humans and elephants (Pandey *et al.*, 2024a). First, enhancing landscape connectivity by restoring degraded habitats and protecting critical elephant corridors is imperative. This includes regulating land-use changes near key habitats, particularly those impacted by mining, linear infrastructure, and agricultural expansion. Subsequently, developing water resources within elephant habitats may help reduce conflict. Second, prioritization of high-conflict areas is crucial. Villages such as Amandon, Chhal, and Dharamjaigarh must be the focus of mitigation interventions. Specific strategies such as early warning systems, and community-based patrolling can significantly reduce conflict in these zones. Furthermore, the use of physical barriers such as trenches, and solar fencing should be re-evaluated at the village level to ensure they do not exacerbate conflicts. These barriers must be strategically placed, avoiding critical elephant corridors. Seasonal interventions during the monsoon, such as visibility improvement measures and increased monitoring of elephant movements, are particularly important for reducing risks. Third, community involvement is vital in ensuring the success of mitigation measures. Training local communities in conflict mitigation, resource management, and monitoring elephant movements can enhance their capacity to manage conflict effectively. Additionally, promoting alternative livelihoods and implementing fair compensation schemes can alleviate the economic burden on affected communities.

Finally, stricter governance and collaborative efforts among forest departments, local governments, and NGOs are necessary to address illegal mining, enforce land-use regulations, and develop adaptive conflict management frameworks. Infrastructure planning, particularly in ecologically sensitive areas, should include wildlife-friendly measures like underpasses and overpasses to maintain connectivity. By integrating ecological, socio-economic, and governance-based approaches, we can foster coexistence between human communities and elephants while addressing the root causes of conflict in Chhattisgarh. Long-term monitoring of conflict trends and the use of predictive spatial models can further inform proactive interventions, ensuring sustainable management of human-elephant interactions in the region.

CHAPTER 3:
Suggested Measures to minimize Human-Elephant Conflict in the State of Chhattisgarh

Over the past 23 years, human-elephant conflict (HEC) in Chhattisgarh has become a rising concern, affecting both elephants and humans. This includes 84 elephant mortalities, 737 human fatalities, and 91 injuries. This study highlights the spatial and temporal patterns of conflict and the key environmental and human-related factors that influence its severity and distribution. The analysis identifies certain villages, such as Dharamjaigarh, Chhal, Amandon, Goreapipar, Katghora, Kunkri, and Raigarh, as high-risk areas for elephant deaths. Out of a total of 48 villages, 95.83% had low elephant mortality, while only a small percentage of villages fell into the medium (2.08%) and high (2.08%) categories. The analysis also revealed a strong link between human activities and conflict levels. Among the 321 villages affected by HEC, 96.58% experienced very low conflict levels, primarily in areas with minimal infrastructure, suggesting that lower human interference correlates with reduced conflict. In contrast, high-conflict villages (1.87%) are typically situated near moderately developed areas, indicating that while elephants generally avoid densely built-up regions with high human activity and noise, conflicts persist in transitional zones. Targeted solutions in these high-risk areas and better prevention measures in low and medium risk areas are crucial to reducing human fatalities. Based on the factors influencing elephant mortality and human elephant conflict, it is essential to adopt different mitigation measures for specific causes to ensure most effective risk reduction.

3.1. Recommendations for managing Elephant Deaths in Chhattisgarh

To address and mitigate elephant mortality, it is crucial to analyse the demographic and geographic characteristics of the affected areas. The primary causes of elephant mortality include electrocution, vehicular accidents, anthropogenic stressors (drowning in dam and drain) and poisoning.

3.1.1. Electrocution

Multiple elephant deaths due to electrocution have been reported in Dharamjaigarh, Chhal, Amandon, Banhar, Kunkuri, Jashpur, and Goreyapipar. Electrocution-related elephant mortalities often result from human negligence, including unauthorized power connections, delays in reporting damaged power lines, and the illegal use of electricity from distribution lines for fencing. Such practices must be strictly monitored by the village development authority at the panchayat level in collaboration with the forest department to prevent further incidents. Enhancing community awareness through village-level workshops, radio broadcasts, posters, and social media can improve electrical safety in elephant habitats. A comprehensive study on elephant habitat use and movement ecology can help identify high-risk areas where elephants encounter power lines while foraging or traversing fragmented landscapes. Insulating power lines and elevating them to a minimum height of 6—7 meters can significantly reduce direct contact and mitigate electrocution risks. Additionally, power poles should be strategically placed to minimize elephant interactions, as elephants may push against them, causing structural failures. Using concrete or steel poles with tilt-proof designs, anchored deeply with steel braces, can enhance durability, while placing poles outside elephant corridors, identified through telemetry data, may further reduce conflicts. Regular inspections of power lines in elephant habitats are crucial to identifying and addressing potential hazards such as broken or sagging cables. Promoting alternative energy solutions, including solar power and deep-cycle solar batteries, can reduce reliance on high-voltage transmission lines in elephant corridors. Establishing localized microgrids powered by renewable energy sources such as solar and biomass can provide rural electrification while minimizing the need for illegal power tapping, a significant contributor to electrocution incidents. Additionally, subsidized legal electricity connections can deter unauthorized tapping and enhance safety. Strengthening policy interventions by enforcing strict penalties for illegal power use and implementing rigorous environmental impact assessments (EIA) before approving new power projects in elephant corridors can ensure that infrastructure development does not compromise wildlife conservation.

3.1.2. Poaching

Poaching leads to a severe threat to elephant populations in regions like Raigarh and Gharghoda. Strengthening anti-poaching patrols and intelligence networks is essential. Community involvement and stricter law enforcement can further help in conservation efforts.

The specific recommendations are as follows:
Strengthening Anti-Poaching Units (APUs) through well-equipped forest guards using GPS tracking

devices, night vision cameras, and drones can enhance real-time monitoring and prevent illegal activities. Providing advanced intelligence training further improves their response capabilities. Establishing Rapid Response Teams (RRTs) with mobile squads, vehicles, and first-aid kits ensures timely intervention in poaching incidents and the rescue of injured elephants, while inter-state coordination helps combat organized wildlife crime. Community engagement through education on wildlife laws, conservation ethics, and school programs fosters awareness and reduces poaching incentives. Additionally, promoting alternative livelihood programs can provide sustainable economic opportunities. Implementing GPS and RFID tracking of elephant movements enables authorities to predict migration patterns, take proactive conservation measures, and integrate tracking data with early warning systems to mitigate conflicts and poaching risks.

3.1.3. Vehicular Accident

In Dharamjaigarh, vehicular accidents on roads intersecting elephant corridors have become a serious concern, requiring urgent mitigation measures. To reduce elephant-vehicle collisions, installing reflective and electronic warning signage at crossing points, particularly in conflict-prone areas like Dharamjaigarh, can alert drivers, especially at night. Enforcing strict speed limits (30—40 km/h) in wildlife zones further mitigates risks. Constructing underpasses and overpasses, as recommended by WII-linear infrastructure guidelines, facilitates safe elephant movement across fragmented habitats. Engaging local communities through "Elephant Watch" groups enhances roadside monitoring and accident prevention. Additionally, deploying thermal imaging cameras and AI-powered motion sensors along highways helps detect elephant presence, triggering flashing lights and alarms to warn drivers in advance.

3.1.4. Poisoning

In Raigarh, Katghora, Gharghoda, and Goreyapipar, retaliatory poisoning often in response to crop raiding, continues to pose a significant threat to elephant populations. Implementing less palatable crops in affected villages by replacing highly attractive crops like paddy and sugarcane with alternatives such as citrus, chili, garlic, and ginger can help reduce elephant crop raids. Multi-layer farming, where deterrent crops form an outer buffer, further minimizes crop damage. Chili-infused rope fences, leveraging capsaicin's irritant properties, serve as an effective non-lethal deterrent, while thorny plants like agave or euphorbia and chemical repellents such as neem and citrus-based sprays provide additional protection. Ensuring timely compensation through rapid response teams that assess losses and provide payouts within 48 hours, along with GPS-enabled mobile apps and community-managed insurance schemes, reduces economic hardship and discourages retaliatory actions against elephants. Additionally, promoting community-based conservation through eco-tourism initiatives and village elephant monitoring teams offers sustainable livelihoods while enhancing wildlife protection.

3.1.5. Other Anthropogenic Activity

Urban expansion, deforestation, and industrial encroachment fragment elephant habitats, increasing human-elephant conflicts. To mitigate this, habitat restoration through reforestation with native species, assisted natural regeneration, and agroforestry can create buffer zones and support wildlife. Additionally, regulating human activities by enforcing land-use policies, restricting deforestation and mining, and integrating elephant corridors with protected areas can help reduce conflicts and protect critical habitats.

3.2. Recommendations for managing Human deaths and injuries in Chhattisgarh.

This alarming rise in HEC highlights the need to examine the demographic and geographic factors that contribute to HEC. The highest numbers of casualties are reported in villages such as Amandon (45 cases) and Chhal (42 cases), followed by Dharamjaigarh (36 cases) and Sajbahar (32 cases). Factors such as population density, household numbers, and the degree of urbanization significantly influence the frequency of HEC incidents. Areas with higher human population, particularly those adjacent to fragmented elephant habitats, are more vulnerable to conflict. These findings show the importance for location-specific, integrative mitigation strategies that incorporate ecological, socio-economic, and infrastructural components.

Early Warning Systems: Implementing early warning systems is crucial for preventing unexpected encounters between humans and elephants. Technological solutions, such as sensor-based alerts and mobile applications, can inform communities of nearby elephant movements.

Elephant Corridors and Habitat Restoration: Restoring and maintaining elephant corridors is essential to facilitate safe movement for elephants and reduce their movement into human settlements. Details on villages that are within or adjacent to corridors and require specific habitat restoration and alternative livelihoods are provided in Table 3.1.

Community-Based Patrols and Conflict Response Teams: Educating local communities to actively participate in monitoring and managing elephant movements can enhance the effectiveness of HEC mitigation. Establishing community-based patrols and training local teams to coordinate with forest departments to conflict management.

Alternative Cropping Practices: Adopting agricultural practices that deter elephants can significantly reduce crop raiding incidents. Cultivating crops less palatable to elephants, such as chili, garlic, and citrus, has been recommended. This approach not only safeguards farmers livelihoods but also promotes coexistence.

Physical Barriers: The use of physical barriers, including solar-powered electric fences and bio-fencing with thorny plants, serves as a deterrent to elephants entering agricultural areas. Studies indicate that non-lethal electric fences around villages have been widely implemented to mitigate HEC. However, any physical barrier can alter elephant movement, potentially causing conflicts in new areas where elephants were previously absent. Therefore, a detailed study of elephant behaviour is essential before implementing deterrents, particularly in regions that have historically been part of elephant corridors.

Compensation and Insurance Schemes: Providing timely compensation for losses due to HEC is crucial for maintaining community support for conservation efforts. Implementing efficient compensation mechanisms for crop damage, property loss, and human casualties helps to reduce the economic burden on individuals.

Awareness and Capacity Building: Educating communities on elephant behaviour and safe practices is fundamental to reducing HEC incidents. Awareness programs and capacity-building initiatives equip local populations with the knowledge and tools necessary to coexist with elephants safely.

3.3. Elephant Corridors Near High-Conflict Villages

Table 3.1 The following key elephant corridors, as identified in the “Right of Passage” and “Elephant corridors of India” report, are critical for mitigating human-elephant conflict:

Corridor Name	Connected Areas	Conflict Villages
Badalkhol-Tamor Pingla Corridor	Badalkhol Wildlife Sanctuary — Tamor Pingla Wildlife Sanctuary	Goreyapipar, Jashpur, Kunkuri
Lemru Elephant Reserve	Korba District, Chhattisgarh	Katghora, Banhar
Guru Ghasidas-Tamor Pingla Corridor	Guru Ghasidas National Park — Tamor Pingla Wildlife Sanctuary	Jashpur, Goreyapipar
Raigarh Forest Corridor	Raigarh District	Raigarh, Gharghoda, Dharamjaigarh, Chhal
Dharamjaigarh Corridor	Dharamjaigarh Forest Region, Chhattisgarh	Dharamjaigarh, Chhal, Banhar
Jashpur-Kunkuri Corridor	Jashpur and Kunkuri Forest Areas	Jashpur, Kunkuri

Table 3.2 Human-elephant conflict hotspots: Villages where both elephant mortality and human casualties occurred with count

Elephant mortality count	Human casualty count	Village Name	Division
4	45	Amandon	Surajpur
10	42	Chhal	Dharamjaigarh
15	36	Dharamjaigarh	Korba
1	32	Sajbahar	Jashpur
3	28	Katghora	Gariaband
1	20	Kudmura	Mahasamund
2	20	Kunkuri	Dharamjaigarh
1	16	Korba	Dharamjaigarh
1	12	Mahasamund	Mahasamund
4	9	Gharghoda	Jashpur
1	8	Bagicha	Surajpur
2	8	Jashpur	Elephant Reserve Surguja
1	8	Sitapur	Raigad
1	8	Baikunthpur	Dharamjaigarh
1	7	Wadrafnagar	Raigad
1	7	Kansabel	Raigad
3	5	Raigarh	Korba
2	4	Goreyapipar	Dharamjaigarh
1	3	Lahraud	Dharamjaigarh
1	3	Taraimar	Jashpur
1	3	Himmatpur	Jashpur
1	2	Bagchaba	Dharamjaigarh
1	1	Surata	Dharamjaigarh
1	1	Malgaon	Surajpur
1	1	Kudumkela	Jashpur
1	1	Reserve Forest	Sarguja
1	1	Todgaon	Raigad
1	1	Gersa	Raigad
1	1	Bansajhar	Korea
1	1	Sapanai	Katghora

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Appendix 1: Details of Villages which witnessed Elephant Mortality in the state of Chhattisgarh from 2000-2023

S.No.	Elephant Mortality Count	Village Name	Division	Administrative level	Rural / Urban	Household	Population	Male%	Female%	Area (Ha)
1	15	Dharamjaigarh	Dharamjaigarh	Town	Urban	3369	14354	50.7106	49.2894	3324.006
2	10	Chhal	Dharamjaigarh	Village	Rural	772	3341	50.13469	49.86531	966.0039
3	4	Amandon	Surajpur	Village	Rural	256	1201	51.62365	48.37635	209.8626
4	4	Gharghoda	Raigarh	Town	Urban	2244	9455	51.07351	48.92649	1431.995
5	3	Raigarh	Raigarh	Town	Urban	32658	150019	51.23684	48.76316	3492.181
6	3	Katghora	Katghora	Town	Urban	4825	22690	50.63464	49.36536	2024.253
7	2	Banhar	Dharamjaigarh	Village	Rural	250	1121	48.34969	51.65031	849.3661
8	2	Goreyapipar	North Surguja	Village	Rural	94	411	49.39173	50.60827	315.0305
9	2	Kunkuri	Jashpur	Town	Urban	2988	13846	49.61722	50.38278	709.7753
10	2	Jashpur	Jashpur	Town	Urban	6128	28301	50.66252	49.33748	1123.49
11	1	Nawapara	Raigarh	Village	Rural	113	432	49.53704	50.46296	131.8407
12	1	Dhawalpurdih	Gariyaband	Village	Rural	673	2456	50.93648	49.06352	391.4522
13	1	Surata	Surajpur	Village	Rural	875	3704	51.70086	48.29914	2692.945
14	1	Bagchaba	Dharamjaigarh	Village	Rural	138	658	49.84802	50.15198	263.8794
15	1	Korba	Korba	Town	Urban	51187	224680	51.88935	48.11065	8591.67
16	1	Songudha	Korba	Village	Rural	363	1339	51.53099	48.46901	1079.512
17	1	Sajbahar	Jashpur	Village	Rural	207	865	49.59538	50.40462	396.2368
18	1	Arjunpur Alias Amkhoh	Surajpur	Village	Rural	402	1707	50.49795	49.50205	1735.052
19	1	Chandora	Surajpur	Village	Rural	265	1099	51.50136	48.49864	1029.218
20	1	Malgaon	Gariyaband	Village	Rural	381	1657	47.43512	52.56488	1944.481
21	1	Giraud	Balodabazar	Village	Rural	603	2869	48.17009	51.82991	695.0379
22	1	Mahasamund	Mahasamund	Town	Urban	12198	54413	49.79141	50.20859	1388.063
23	1	Kudumkela	Raigarh	Village	Rural	1549	5914	50.01691	49.98309	2945.23
24	1	Lahraud	Mahasamund	Village	Rural	385	1598	49.93742	50.06258	211.6013
25	1	Narsinghpur	Balrampur	Village	Rural	319	1572	51.27226	48.72774	1451.696
26	1	Bagicha	Jashpur	Town	Urban	2451	10427	52.30651	47.69349	1850.092
27	1	Wadrafnagar	Balrampur	Town	Urban	1258	6048	51.24008	48.75992	2084.664

28	1	Taraimar	Dharam-jaigarh	Village	Rural	104	423	49.64539	50.35461	707.3581
29	1	Todgaon	Elephant Reserve	Village	Rural	254	1343	49.06925	50.93075	514.7046
30	1	Budha Bagicha	Dharam-jaigarh	Village	Rural	385	1964	54.9389	45.0611	223.2704
31	1	Kudmura	Korba	Village	Rural	357	1557	48.68337	51.31663	1436.933
32	1	Nawapara	Prabandh sanchalak	Village	Rural	118	455	47.25275	52.74725	222.1325
33	1	Khudiya	Mungoli	Village	Rural	865	3688	49.59328	50.40672	12718.3
34	1	Gersa	Dharam-jaigarh	Village	Rural	356	1664	49.27885	50.72115	1269.941
35	1	Kansabel	Jashpur	Village	Rural	1196	5289	47.17338	52.82662	697.0463
36	1	Natkela	Jashpur	Village	Rural	296	1235	48.50202	51.49798	820.1036
37	1	Basna	Dharam-jaigarh	Town	Urban	2318	10345	49.74384	50.25616	644.6341
38	1	Deori	Surajpur	Village	Rural	190	946	50.73996	49.26004	849.7624
39	1	Himmat-pur	Dharam-jaigarh	Village	Rural	29	103	58.25243	41.74757	5504.505
40	1	Bansajhar	Dharam-jaigarh	Village	Rural	235	962	48.7526	51.2474	410.5559
41	1	Sondiha	Jashpur	Village	Rural	159	602	49.33555	50.66445	245.9476
42	1	Pratappur	Surajpur	Town	Urban	1093	5635	50.57675	49.42325	1303.018
43	1	Sitapur	Surguja	Town	Urban	1928	9361	50.30445	49.69555	1485.741
44	1	Sapanai	Raigarh	Village	Rural	116	503	52.08748	47.91252	516.8686
45	1	Nandbhan	Koriya	Village	Rural	100	422	50.23697	49.76303	214.172
46	1	Baikunth-pur	Koriya	Town	Urban	6289	28431	51.87647	48.12353	4035.915
47	1	Balrampur	Balrampur	Town	Urban	972	4456	52.28905	47.71095	1055.369

Appendix 2: Details of Villages which witnessed Human Mortality by Elephants in the state of Chhattisgarh from 2000-2023

S.No.	Human Casu-alties Count	Village Name	Division	Admin-istrative level	Rural / Urban	House-hold	Popula-tion	Male%	Female%	Area (Ha)
1	45	Amandon	Surajpur	Village	Rural	256	1201	51.62365	48.37635	209.8626
2	42	Chhal	Dharam-jaigarh	Village	Rural	772	3341	50.13469	49.86531	966.0039
3	36	Dharam-jaigarh	Dharam-jaigarh	Town	Urban	3369	14354	50.7106	49.2894	3324.006
4	32	Sajbahar	Jashpur	Village	Rural	207	865	49.59538	50.40462	396.2368
5	28	Katghora	Katghora	Town	Urban	4825	22690	50.63464	49.36536	2024.253
6	24	Surajpur	Surajpur	Town	Urban	4397	20189	51.6618	48.3382	1854.462
7	20	Kudmura	Korba	Village	Rural	357	1557	48.68337	51.31663	1436.933
8	20	Kunkuri	Jashpur	Town	Urban	2988	13846	49.61722	50.38278	709.7753
9	16	Korba	Korba	Town	Urban	51187	224680	51.88935	48.11065	8591.67
10	15	Godhi Khurd	Dharam-jaigarh	Village	Rural	234	1036	48.64865	51.35135	392.1877
11	12	Mahasa-mund	Mahasa-mund	Town	Urban	12198	54413	49.79141	50.20859	1388.063
12	9	Duldula	Jashpur	Village	Rural	992	4354	47.58842	52.41158	1759.837
13	9	Gharghoda	Raigad	Town	Urban	2244	9455	51.07351	48.92649	1431.995
14	8	Bagicha	Jashpur	Town	Urban	2451	10427	52.30651	47.69349	1850.092
15	8	Dumardih	Sarguja	Village	Rural	178	835	51.13772	48.86228	570.8949
16	8	Rajpur	Balrampur	Town	Urban	987	4838	46.5895	53.4105	1475.254
17	8	Jashpur	Jashpur	Town	Urban	6128	28301	50.66252	49.33748	1123.49
18	8	Sitapur	Sarguja	Town	Urban	1928	9361	50.30445	49.69555	1485.741
19	8	Baikunthpur	Korea	Town	Urban	6289	28431	51.87647	48.12353	4035.915
20	7	Kamleshwar-pur	Sarguja	Village	Rural	216	1036	62.64479	37.35521	1028.894
21	7	Lundra	Sarguja	Village	Rural	260	1232	48.45779	51.54221	430.8056
22	7	Wadrafnagar	Surajpur	Town	Urban	1258	6048	51.24008	48.75992	2084.664
23	7	Dharampur	Surajpur	Village	Rural	319	1486	51.88425	48.11575	1018.035
24	7	Kansabel	Jashpur	Village	Rural	1196	5289	47.17338	52.82662	697.0463
25	7	Pathalgaon	Jashpur	Town	Urban	3424	16613	50.2799	49.7201	2572.442

26	5	Raigarh	Raigad	Town	Urban	32658	150019	51.23684	48.76316	3492.181
27	5	Pidiya	Korba	Village	Rural	493	1722	48.31591	51.68409	1813.675
28	5	Kanakula	Dharam-jaigarh	Village	Rural	51	176	50	50	4134.628
29	5	Kusmi	Balrampur	Town	Urban	1505	7448	50.63104	49.36896	1090.451
30	4	Bakaruma	Dharam-jaigarh	Village	Rural	336	1516	49.14248	50.85752	1156.895
31	4	Mudapara	Jashpur	Village	Rural	619	3133	48.96266	51.03734	930.3931
32	4	Goreyapipar	Elephant Reserve Surguja	Village	Rural	94	411	49.39173	50.60827	315.0305
33	4	Kachhar	Korba	Village	Rural	137	515	50.67961	49.32039	351.9804
34	4	Babusajba-har	Jashpur	Village	Rural	297	1179	50.63613	49.36387	611.5022
35	4	Tara	Dharam-jaigarh	Village	Rural	287	1291	49.65143	50.34857	3132.807
36	4	Ambikapur	Sarguja	Town	Urban	24080	121071	51.85057	48.14943	3681.836
37	3	Girjapur	Balrampur	Village	Rural	58	262	52.29008	47.70992	426.8075
38	3	Tapkara	Jashpur	Village	Rural	1076	4624	51.08131	48.91869	717.2312
39	3	Lahraud	Mahasa-mund	Village	Rural	385	1598	49.93742	50.06258	211.6013
40	3	Sanna	Jashpur	Village	Rural	1190	5397	49.47193	50.52807	2596.242
41	3	Raghunath-nagar	Surajpur	Village	Rural	658	2882	52.49827	47.50173	1042.595
42	3	Ghatbarra	Sarguja	Village	Rural	310	1395	50.89606	49.10394	2251.474
43	3	Taraimar	Dharam-jaigarh	Village	Rural	104	423	49.64539	50.35461	707.3581
44	3	Nonbirra	Korba	Village	Rural	707	2689	50.79955	49.20045	896.022
45	3	Charmar	Korba	Village	Rural	183	761	49.01445	50.98555	476.207
46	3	Sithara	Dharam-jaigarh	Village	Rural	590	2608	50.30675	49.69325	1953.138
47	3	Baratapali	Dharam-jaigarh	Village	Rural	365	1488	49.12634	50.87366	1062.624
48	3	Manora	Jashpur	Village	Rural	602	2886	49.7921	50.2079	1420.101
49	3	Bhitghra	Jashpur	Village	Rural	646	2835	49.94709	50.05291	2033.631
50	3	Sainda	Korea	Village	Rural	162	828	50.12077	49.87923	690.0666
51	3	Biharpur	Surajpur	Village	Rural	280	1255	50.43825	49.56175	486.426
52	3	Himmatpur	Dharam-jaigarh	Village	Rural	29	103	58.25243	41.74757	5504.505
53	3	Pondi	Surajpur	Village	Rural	164	646	51.70279	48.29721	364.839
54	3	Manen-dragarh	Manen-dragarh	Town	Urban	7008	33071	51.76439	48.23561	1069.191
55	3	Bodal Ba-hara	Dhamtari	Village	Rural	61	208	48.55769	51.44231	2821.053
56	3	Madhuwa-nala	Udanti Sitanadi TR Garia-band	Village	Rural	72	252	51.5873	48.4127	6853.358
57	2	Karouli	Balrampur	Village	Rural	362	1735	50.317	49.683	373.5156
58	2	Bagchaba	Dharam-jaigarh	Village	Rural	138	658	49.84802	50.15198	263.8794
59	2	Lemroo	Korba	Village	Rural	449	1685	52.52226	47.47774	2189.565
60	2	Sajapani	Jashpur	Village	Rural	325	1305	48.19923	51.80077	1261.645
61	2	Nagri	Dhamtari	Town	Urban	3093	13308	49.96243	50.03757	1578.484
62	2	Dalli Rajhara	Balod	Town	Urban	11018	44363	50.0958	49.9042	620.1461
63	2	Lalitpur	Sarguja	Village	Rural	442	1976	50.05061	49.94939	1804.451
64	2	Kerju	Sarguja	Village	Rural	696	3372	49.7331	50.2669	1445.268
65	2	Jarhi	Surajpur	Town	Urban	1513	7228	52.10293	47.89707	767.8101
66	2	Sarga	Sarguja	Village	Rural	474	2281	50.54801	49.45199	1497.4

67	2	Rewati	Surajpur	Village	Rural	381	1676	54.23628	45.76372	1575.792
68	2	Rakhi 1 Rakhi	Raipur	Village	Rural	310	1877	49.92009	50.07991	484.7323
69	2	Kandora	Jashpur	Village	Rural	387	1925	50.18182	49.81818	940.8051
70	2	Keshaldih	Mahasa-mund	Village	Rural	55	277	50.18051	49.81949	4584.304
71	2	Katangdih	Raigad	Village	Rural	178	709	48.378	51.622	937.9475
72	2	Shiwari	Surajpur	Village	Rural	222	793	49.68474	50.31526	363.3241
73	2	Dharasiv	Balodaba-zar	Village	Rural	600	3254	51.0756	48.9244	327.0566
74	2	Baidpali	Mahasa-mund	Village	Rural	239	1078	49.53618	50.46382	353.9894
75	2	Baloda Bazar	Balodaba-zar	Town	Urban	5407	26632	50.61956	49.38044	1211.573
76	2	Tolum	Rajnand-gaon	Village	Rural	131	648	47.83951	52.16049	932.8411
77	2	Dahejwar	Balrampur	Village	Rural	356	1399	50.96497	49.03503	386.3327
78	2	Lawa	Balrampur	Village	Rural	211	1035	51.49758	48.50242	1533.246
79	2	Kartala	Korba	Village	Rural	603	2316	49.30915	50.69085	1404.07
80	2	Khadgaon	Dharam-jaigarh	Village	Rural	464	2110	48.24645	51.75355	1264.236
81	2	Bandhanpur	Dharam-jaigarh	Village	Rural	228	925	50.16216	49.83784	277.5409
82	2	Kuma	Dharam-jaigarh	Village	Rural	206	750	48.8	51.2	1047.246
83	2	Ludeg	Jashpur	Village	Rural	1150	5130	50.76023	49.23977	1392.362
84	2	Lodam	Jashpur	Village	Rural	686	3126	49.87204	50.12796	779.2619
85	2	Bimda	Jashpur	Village	Rural	427	1874	50.58698	49.41302	1252.154
86	2	Saraipani	Jashpur	Village	Rural	552	2487	50.06031	49.93969	1376.504
87	2	Kudargarh	Surajpur	Village	Rural	163	676	49.26036	50.73964	10112.83
88	2	Simda	Jashpur	Village	Rural	395	1678	50.47676	49.52324	1355.909
89	2	Akshyapur	Surajpur	Village	Rural	168	759	46.77207	53.22793	589.5002
90	2	Tangargaon	Jashpur	Village	Rural	763	3054	48.52652	51.47348	1576.732
91	2	Sarangarh	Raigad	Town	Urban	3311	14954	49.61883	50.38117	1088.956
92	2	Pasan	Marwahi	Village	Rural	984	3951	50.74665	49.25335	2656.497
93	2	Mahavirganj	Balrampur	Village	Rural	832	4077	51.11602	48.88398	2373.213
94	2	Tatijhariya	Sarguja	Village	Rural	342	1623	50.33888	49.66112	1656.977
95	2	Sewari	Balrampur	Village	Rural	421	1934	49.89659	50.10341	990.4413
96	2	Kete	Sarguja	Village	Rural	124	561	52.76292	47.23708	1359.322
97	2	Karraghati	Balrampur	Village	Rural	126	510	48.23529	51.76471	960.8262
98	1	Badra Tola	Dhamtari	Village	Rural	262	1274	49.76452	50.23548	447.4634
99	1	Khokhra	Surajpur	Village	Rural	1520	7506	51.9984	48.0016	1704.713
100	1	Lohjhar	Gariaband	Village	Rural	384	1528	49.47644	50.52356	774.7951
101	1	Parasghat	Rajnand-gaon	Village	Rural	155	732	48.36066	51.63934	330.1287
102	1	Bidora	Gariaband	Village	Rural	165	601	53.0782	46.9218	263.5562
103	1	Badesajapali	Mahasa-mund	Village	Rural	721	2814	50.21322	49.78678	479.545
104	1	Sankara	Gariaband	Village	Rural	179	839	46.72229	53.27771	474.888
105	1	Kalmidadar	Mahasa-mund	Village	Rural	207	951	48.37014	51.62986	560.908
106	1	Bagbahara	Mahasa-mund	Town	Urban	4326	19529	50.16642	49.83358	745.8247
107	1	Khamhariya	Mahasa-mund	Village	Rural	368	1561	49.71172	50.28828	426.7868
108	1	Pendarkhi	Surajpur	Village	Rural	350	1528	51.76702	48.23298	648.1363
109	1	Khopali	Mahasa-mund	Village	Rural	281	1202	51.08153	48.91847	335.298
110	1	Surata	Surajpur	Village	Rural	875	3704	51.70086	48.29914	2692.945
111	1	Gaurmudi	Raigad	Village	Rural	78	274	48.90511	51.09489	422.88

112	1	Punjipathra	Raigad	Village	Rural	81	381	52.49344	47.50656	1026.956
113	1	Bhalmundi	Dharam-jaigarh	Village	Rural	80	305	51.47541	48.52459	10789.59
114	1	Kanchanpur	Raigad	Village	Rural	443	1750	48.57143	51.42857	781.6124
115	1	Dondi	Balod	Town	Urban	1810	8042	49.77618	50.22382	1267.629
116	1	Korkoma	Korba	Village	Rural	650	2703	50.24047	49.75953	1037.451
117	1	Mohali	Balrampur	Village	Rural	390	1541	52.43348	47.56652	5277.385
118	1	Kaliba	Jashpur	Village	Rural	375	1671	49.43148	50.56852	1446.51
119	1	Raghunath-pur	Sarguja	Village	Rural	218	939	51.5442	48.4558	178.9508
120	1	Kunjara	Jashpur	Village	Rural	189	824	53.8835	46.1165	366.3848
121	1	Kersai	Jashpur	Village	Rural	1076	4618	49.45864	50.54136	2132.408
122	1	Patkura	Sarguja	Village	Rural	378	1725	50.26087	49.73913	2459.608
123	1	Mayur Nacha	Jashpur	Village	Rural	515	2125	48.94118	51.05882	2091.033
124	1	Balachhapar	Jashpur	Village	Rural	144	665	49.02256	50.97744	619.7729
125	1	Narayanpur	Jashpur	Village	Rural	261	1221	47.58395	52.41605	427.3781
126	1	Hariharpur	Sarguja	Village	Rural	62	298	50.67114	49.32886	447.8421
127	1	Lormi	Achanak-mar Tiger Reserve	Town	Urban	3197	15156	50.48166	49.51834	1102.183
128	1	Khutera	Jashpur	Village	Rural	351	1392	49.13793	50.86207	1660.81
129	1	Lakhanpur	Sarguja	Town	Urban	1388	6270	50.59011	49.40989	914.7906
130	1	Jamjhariya	Sarguja	Village	Rural	99	430	51.62791	48.37209	581.9019
131	1	Malgaon	Gariaband	Village	Rural	381	1657	47.43512	52.56488	1944.481
132	1	Achhola	Mahasa-mund	Village	Rural	676	3369	49.45088	50.54912	1634.122
133	1	Bendridih Viran	Mahasa-mund	Village	Rural	5	21	76.19048	23.80952	261.4107
134	1	Kauwajhar	Mahasa-mund	Village	Rural	369	1516	50.46174	49.53826	364.4145
135	1	Kirkima	Sarguja	Village	Rural	138	606	45.70957	54.29043	252.9405
136	1	Harramar	Sarguja	Village	Rural	314	1556	50.06427	49.93573	662.1739
137	1	Sattipara	Surajpur	Village	Rural	154	812	51.47783	48.52217	411.5419
138	1	Piparchhedi	Mahasa-mund	Village	Rural	223	1059	49.38621	50.61379	413.6464
139	1	Barbaspur	Balodaba-zar	Village	Rural	110	375	48.26667	51.73333	228.7647
140	1	Samdama	Jashpur	Village	Rural	150	553	48.10127	51.89873	494.3821
141	1	Lotapani	Jashpur	Village	Rural	78	384	50.78125	49.21875	3441.051
142	1	Gadakata	Jashpur	Village	Rural	371	1671	50.20946	49.79054	1470.049
143	1	Murki	Mahasa-mund	Village	Rural	136	601	47.92013	52.07987	366.4146
144	1	Katangjor	Jashpur	Village	Rural	209	1036	49.90347	50.09653	1033.416
145	1	Amadiha	Jashpur	Village	Rural	415	1588	48.48866	51.51134	1454.681
146	1	Baloda	Janj-gir-Cham-pa	Town	Urban	2931	13630	50.60895	49.39105	1551.595
147	1	Rajankatta	Gariaband	Village	Rural	255	1182	48.73096	51.26904	313.0651
148	1	Balod	Balod	Town	Urban	5308	23648	49.89005	50.10995	1224.836
149	1	Chitaud	Balod	Village	Rural	643	2976	49.49597	50.50403	559.03
150	1	Deogaon	Raigad	Village	Rural	331	1237	50.28294	49.71706	553.0506
151	1	Barbahara	Gariaband	Village	Rural	192	813	48.33948	51.66052	224.788
152	1	Behramar	Dharam-jaigarh	Village	Rural	439	1941	48.11953	51.88047	1069.156
153	1	Kudumkela	Dharam-jaigarh	Village	Rural	1549	5914	50.01691	49.98309	2945.23
154	1	Kurludih	Balrampur	Village	Rural	496	2622	50.6865	49.3135	1196.914

155	1	Duppi	Balrampur	Village	Rural	228	1098	48.99818	51.00182	665.16
156	1	Ara	Balrampur	Village	Rural	349	1850	50	50	647.1192
157	1	Rouni	Jashpur	Village	Rural	328	1510	46.49007	53.50993	3019.079
158	1	Betara	Jashpur	Village	Rural	146	618	47.73463	52.26537	595.2732
159	1	Bariyon	Balrampur	Village	Rural	897	3863	52.05799	47.94201	894.7004
160	1	Matasi	Jashpur	Village	Rural	151	641	52.5741	47.4259	300.3749
161	1	Charaimara	Jashpur	Village	Rural	90	345	49.27536	50.72464	158.9827
162	1	Nawapara Tenda	Raigad	Village	Rural	367	1543	49.9676	50.0324	754.4844
163	1	Rede	Jashpur	Village	Rural	455	1927	48.46912	51.53088	1436.693
164	1	Barima	Sarguja	Village	Rural	447	2115	50.59102	49.40898	1299.856
165	1	Narbadapur	Sarguja	Village	Rural	1583	6516	49.95396	50.04604	3554.606
166	1	Udari	Sarguja	Village	Rural	863	3658	49.09787	50.90213	1349.414
167	1	Baratangar	Raigad	Village	Rural	58	228	49.12281	50.87719	347.8691
168	1	Lamgaon	Sarguja	Village	Rural	482	2200	50.22727	49.77273	588.9373
169	1	Badgari	Sarguja	Village	Rural	300	1053	50.04748	49.95252	158.9462
170	1	Kharsia	Raigad	Town	Urban	4006	18939	51.48107	48.51893	720.008
171	1	Amaljharia	Dharam-jaigarh	Village	Rural	27	104	45.19231	54.80769	1222.56
172	1	Pusaudera	Dharam-jaigarh	Village	Rural	43	219	49.77169	50.22831	19028.57
173	1	Amlidih	Raigad	Village	Rural	300	1333	50.93773	49.06227	540.2596
174	1	Baikona	Surajpur	Village	Rural	370	1904	49.0021	50.9979	579.082
175	1	Dumarkher-awa	Marwahi	Village	Rural	142	515	47.18447	52.81553	283.2146
176	1	Semharadih	Saran garh-Biligarh	Village	Rural	116	500	52	48	293.1522
177	1	Lavan	Balodaba-zar	Town	Urban	1760	8984	49.17631	50.82369	1666.398
178	1	Kotmi Kalan	Marwahi	Village	Rural	569	2252	50.35524	49.64476	514.2795
179	1	Todgaon	Raigad	Village	Rural	254	1343	49.06925	50.93075	514.7046
180	1	Khardi	Marwahi	Village	Rural	456	1525	49.31148	50.68852	1655.585
181	1	Dhanpur	Gues	Village	Rural	482	1644	48.35766	51.64234	958.3112
182	1	Gindola	Balodaba-zar	Village	Rural	447	2093	49.25944	50.74056	404.0465
183	1	Sona Silli	Mahasa-mund	Village	Rural	465	2266	47.74934	52.25066	864.2848
184	1	Kendai	Suttagora	Village	Rural	609	2467	51.76328	48.23672	517.4427
185	1	Mendhari	Balrampur	Village	Rural	432	1764	49.71655	50.28345	1376.428
186	1	Pindra	Elephant Reserve Surguja	Village	Rural	134	534	54.11985	45.88015	155.0614
187	1	Chainpur Kerta	Balrampur	Village	Rural	166	759	49.80237	50.19763	773.4501
188	1	Champa	Korba	Village	Rural	316	1265	49.24901	50.75099	803.1411
189	1	Jogipali	Korba	Village	Rural	258	970	50.10309	49.89691	623.0038
190	1	Junwani	Korba	Village	Rural	399	1447	49.41258	50.58742	357.3993
191	1	Badmar	Korba	Village	Rural	263	879	46.87144	53.12856	1382.063
192	1	Pasarkhet	Korba	Village	Rural	225	883	50.39638	49.60362	1003.085
193	1	Rajgamar	Korba	Town	Urban	2315	11544	51.21275	48.78725	1960.763
194	1	Amapali	Dharam-jaigarh	Village	Rural	163	811	49.69174	50.30826	519.5103
195	1	Bulekera	Dharam-jaigarh	Village	Rural	72	336	48.5119	51.4881	368.6849
196	1	Balpeda	Dharam-jaigarh	Village	Rural	200	783	48.27586	51.72414	1317.582
197	1	Putukachhar	Dharam-jaigarh	Village	Rural	391	1602	50.99875	49.00125	571.3293

198	1	Udauda	Dharam-jaigarh	Village	Rural	577	2158	47.68304	52.31696	3001.133
199	1	Gersa	Dharam-jaigarh	Village	Rural	356	1664	49.27885	50.72115	1269.941
200	1	Tejpur	Dharam-jaigarh	Village	Rural	200	749	49.3992	50.6008	880.2316
201	1	Boro	Dharam-jaigarh	Village	Rural	285	1077	48.56082	51.43918	943.5091
202	1	Kamosin-dand	Dharam-jaigarh	Village	Rural	150	610	51.80328	48.19672	14568.34
203	1	Koilar	Dharam-jaigarh	Village	Rural	239	1011	47.9723	52.0277	853.0516
204	1	Phutaha Munda	Raigad	Village	Rural	120	508	48.8189	51.1811	922.9612
205	1	Kusumtal	Jashpur	Village	Rural	288	1363	51.3573	48.6427	886.6106
206	1	Jumai Kela	Jashpur	Village	Rural	374	1896	48.68143	51.31857	1065.831
207	1	Marga	Jashpur	Village	Rural	100	478	52.92887	47.07113	519.3066
208	1	Bartoli	Jashpur	Village	Rural	73	382	48.42932	51.57068	297.8692
209	1	Gattibuda	Raigad	Village	Rural	333	1279	50.11728	49.88272	695.7366
210	1	Kopa	Jashpur	Village	Rural	390	1698	49.88221	50.11779	1439.306
211	1	Karma	Jashpur	Village	Rural	248	1132	47.87986	52.12014	577.2235
212	1	Rengale	Jashpur	Village	Rural	305	1206	50.16584	49.83416	727.3684
213	1	Bhurkoni	Mahasa-mund	Village	Rural	440	1879	49.70729	50.29271	1772.998
214	1	Kotadol	Korea	Village	Rural	296	1083	51.80055	48.19945	901.6416
215	1	Tejpur Alias Tendua	Sarguja	Village	Rural	353	1747	51.34516	48.65484	616.0745
216	1	Sangra	Dharam-jaigarh	Village	Rural	96	373	56.30027	43.69973	318.3567
217	1	Bansajhar	Dharam-jaigarh	Village	Rural	235	962	48.7526	51.2474	410.5559
218	1	Tamki	Surajpur	Village	Rural	147	832	50.72115	49.27885	1731.252
219	1	Kharra	Surajpur	Village	Rural	381	1570	51.33758	48.66242	1510.119
220	1	Moharsop	Surajpur	Village	Rural	335	1524	53.08399	46.91601	7185.358
221	1	Mayapur	Surajpur	Village	Rural	497	2112	49.9053	50.0947	385.2518
222	1	Kurhatepna	Jashpur	Village	Rural	61	302	48.34437	51.65563	9066.483
223	1	Mathpahard	Jashpur	Village	Rural	167	728	47.93956	52.06044	670.1686
224	1	Amdi	Sarguja	Village	Rural	237	992	49.39516	50.60484	510.2473
225	1	Rajpuri	Sarguja	Village	Rural	344	1548	52.71318	47.28682	762.0588
226	1	Kalaru	Jashpur	Village	Rural	114	571	48.68651	51.31349	514.446
227	1	Charaidand	Jashpur	Village	Rural	453	2068	50.72534	49.27466	982.7162
228	1	Kalyanpur	Surajpur	Village	Rural	772	3846	50.36401	49.63599	1030.348
229	1	Gotgawan	Surajpur	Village	Rural	292	1350	49.77778	50.22222	631.5872
230	1	Patratoli	Jashpur	Village	Rural	327	1384	49.56647	50.43353	699.4538
231	1	Bamhan-mara	Jashpur	Village	Rural	125	473	49.26004	50.73996	514.5649
232	1	Sikirima	Jashpur	Village	Rural	193	783	48.91443	51.08557	736.761
233	1	Dumardih	Sarguja	Village	Rural	503	2125	51.71765	48.28235	1040.684
234	1	Shivnathpur	Sarguja	Village	Rural	278	1419	49.18957	50.81043	1332.515
235	1	Rajauti	Sarguja	Village	Rural	541	2452	49.55139	50.44861	857.7168
236	1	Baro	Jashpur	Village	Rural	268	1086	50.55249	49.44751	601.4931
237	1	Sonwahi	Surajpur	Village	Rural	191	921	47.77416	52.22584	680.9424
238	1	Langda Sand	Sarguja	Village	Rural	103	513	50.68226	49.31774	249.4803
239	1	Kilkila	Jashpur	Village	Rural	282	1326	49.84917	50.15083	315.6159
240	1	Kurkunga	Jashpur	Village	Rural	312	1343	49.14371	50.85629	533.531
241	1	Erand	Sarguja	Village	Rural	243	1136	50.17606	49.82394	941.3481
242	1	Padouli	Sarguja	Village	Rural	254	1213	50.94806	49.05194	606.7787

243	1	Bansajhal	Sarguja	Village	Rural	373	1637	51.6799	48.3201	1136.057
244	1	Sendrim-unda	Jashpur	Village	Rural	265	1180	47.88136	52.11864	904.1267
245	1	Remate	Jashpur	Village	Rural	175	644	50.15528	49.84472	336.8869
246	1	Riri	Sarguja	Village	Rural	122	503	52.48509	47.51491	1015.697
247	1	Dandgaon	Sarguja	Village	Rural	368	1680	50.77381	49.22619	590.6942
248	1	Laxmipur	Elephant Reserve Surguja	Village	Rural	171	817	47.85802	52.14198	405.7473
249	1	Kishunpur	Sarguja	Village	Rural	129	601	50.91514	49.08486	326.3542
250	1	Hansuli	Sarguja	Village	Rural	195	780	50.76923	49.23077	161.5479
251	1	Kanchanpur	Sarguja	Village	Rural	263	1124	50.97865	49.02135	506.0937
252	1	Sakalo	Sarguja	Village	Rural	431	2056	49.51362	50.48638	556.4419
253	1	Parsa	Sarguja	Village	Rural	746	3313	51.5243	48.4757	1252.443
254	1	Sundarpur	Korea	Village	Rural	279	1339	52.87528	47.12472	570.6327
255	1	Chuhkimar	Dharam-jaigarh	Village	Rural	169	662	51.96375	48.03625	597.1308
256	1	Sapanai	Raigad	Village	Rural	116	503	52.08748	47.91252	516.8686
257	1	Khond	Surajpur	Village	Rural	1157	4899	52.68422	47.31578	297.4743
258	1	Shivpur Charcha	Korea	Town	Urban	5063	23514	51.82019	48.17981	5173.867
259	1	Jodhpur	Balrampur	Village	Rural	246	956	52.61506	47.38494	228.9433
260	1	Surmi	Korea	Village	Rural	97	392	51.78571	48.21429	200.2854
261	1	Palgi	Surajpur	Village	Rural	506	2509	52.17218	47.82782	1217.392
262	1	Tamnar	Raigad	Village	Rural	1307	5465	50.70448	49.29552	1193.847
263	1	Semara	Balrampur	Village	Rural	172	728	50.82418	49.17582	582.6357
264	1	Patrapara	Balrampur	Village	Rural	307	1558	52.24647	47.75353	1045.687
265	1	Baidhi	Balrampur	Village	Rural	225	993	51.46022	48.53978	419.1514
266	1	Lau	Balrampur	Village	Rural	567	2573	49.70851	50.29149	2026.608
267	1	Gajadharpur	Balrampur	Village	Rural	421	1929	50.85537	49.14463	1284.971
268	1	Gamhardih	Sarguja	Village	Rural	193	831	51.26354	48.73646	860.2303
269	1	Sargadi	Balrampur	Village	Rural	187	786	50.89059	49.10941	1217.235
270	1	Chitma	Surajpur	Village	Rural	125	576	50.17361	49.82639	2626.407
271	1	Kuniya Kalan	Sarguja	Village	Rural	245	978	49.48875	50.51125	270.4102
272	1	Pidiya	Sarguja	Village	Rural	311	1272	48.97799	51.02201	589.3542
273	1	Parsagudi	Balrampur	Village	Rural	746	3371	51.85405	48.14595	1103.379
274	1	Achholi	Mahasa-mund	Village	Rural	441	2228	49.4614	50.5386	823.2062
275	1	Gopalpur	Mahasa-mund	Village	Rural	136	664	50.75301	49.24699	199.5659
276	1	Dhelwadih	Suttagora	Village	Rural	1204	5355	51.55929	48.44071	382.8709
277	1	Amgaon	Janj-gir-Cham-pa	Village	Rural	684	3143	50.39771	49.60229	1010.51
278	1	Marghati	Dharam-jaigarh	Village	Rural	524	2095	52.07637	47.92363	987.7588
279	1	Vijaynagar	Balrampur	Village	Rural	1119	5715	50.95363	49.04637	2010.883
280	1	Dadhakhar	Balodaba-zar	Village	Rural	39	184	44.02174	55.97826	3216.812
281	1	Udaipani	Gariaband	Village	Rural	9	46	50	50	3085.23
282	1	Ganjimuda	Gariaband	Village	Rural	62	248	54.03226	45.96774	11264.55
283	1	Kharibahar	Jashpur	Village	Rural	235	951	48.15983	51.84017	880.4497
284	1	Jambahar	Jashpur	Village	Rural	305	1360	48.82353	51.17647	957.6841
285	1	Gobara	Balrampur	Village	Rural	205	1036	51.44788	48.55212	738.714
286	1	Girwani	Balrampur	Village	Rural	770	3224	50.21712	49.78288	2635.658
287	1	Seoni	Marwahi	Village	Rural	787	3103	50.85401	49.14599	1004.883
288	1	Sapghara	Jashpur	Village	Rural	222	860	51.74419	48.25581	472.712

289	1	Harri	Jashpur	Village	Rural	128	604	50.82781	49.17219	777.0059
290	1	Kulador	Jashpur	Village	Rural	161	811	50.43157	49.56843	1688.125
291	1	Sinharpur Tukda	Mahasa-mund	Village	Rural	41	176	55.68182	44.31818	1082.186
292	1	Adbahal	Raigad	Village	Rural	111	418	50.95694	49.04306	291.6726
293	1	Kelhari	Manen-dragarh	Village	Rural	296	1277	53.56304	46.43696	523.9548
294	1	Ramanujganj	Balrampur	Town	Urban	2319	11893	52.08106	47.91894	873.7946
295	1	Karimati	Balrampur	Village	Rural	96	478	51.88285	48.11715	1546.39
296	1	Kanakpur	Balrampur	Village	Rural	443	2310	49.5671	50.4329	2490.736
297	1	Abadi	Balrampur	Village	Rural	88	495	47.07071	52.92929	1138.324
298	1	Ramchan-drapur	Balrampur	Village	Rural	309	1386	52.52525	47.47475	1669.407

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