Ecology of Elephants (*Elephas maximus*) in North Bengal including population dynamics migratorypattern, feeding habits and human-elephant conflicts

FINAL REPORT

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Ecology of Elephants (*Elephas maximus*) in North Bengal including population dynamics, migratory pattern, feeding habits and human-elephant conflicts

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EXECUTIVE SUMMARY

The Asian elephants, once common in the Indian subcontinent, is now restricted to a few pockets in the region. The North Bengal population with an estimated number of 488 has been facing serious threat from increasing growth of human population. Owing to the imperative of properly managing the species in a human dominated landscape, this study was initiated to understand the ecological needs of the species and to develop a management plan. This three year-long study generated vital information that could potentially help the management authority to safeguard the species.

Our presence-absence survey assessed the distribution of the species which is now restricted to around 1800-2000 sq km out of the 3000 sq km of forested areas in the landscape, including PAs and non-PAs. We sighted 779 elephants in the landscape which includes sighting and re-sightings throughout the study period, however, only 676 individuals were classified to various age and sex. The mean herd size in the landscape was found to be 8.96 ± 1.64, which is similar to other regions in the country. Smaller herds were sighted more in comparison to the bigger herds. Elephants use the riverine forest and grasslands more than any other habitat categories and tend to avoid the monocultures, presumably because of the lack of diverse forage. The elephants tend to move and migrate across the landscape and sometimes crosses over to Nepal and Assam and vice versa throughout the year. This migration is mainly driven by the search for food in the forests and seasonal crops in the nearby villages.

We assessed 14 designated elephant corridors to study their present status and found that most of the corridors are disturbed with increased intensity of human use. We further assessed one new corridor in Darjeeling division. Our study found around 60 species of fodder plants used by elephants in the landscape with various levels of preference. Human-elephant conflict is a growing concern and we recorded 405 incidents of conflict with humans (there were several other incidents that were not officially reported). Crops like maize and paddy attract a lot of elephants to come in contact with human habitations. We further assessed the railway line from Alipurduar junction to New Jalpaiguri and identified potential vulnerable stretches of the route where train collision may happen in future. Our social study findings showed that forest related benefits are not equitably distributed which diminishes the level of community support for the conservation of the species. We also provide a set of recommendations for the improved management of the species in the landscape.

CHAPTER I: ELEPHANTS IN NORTH BENGAL

1.1. BACKGROUND OF THE STUDY

The Asian elephants once distributed across the Indian sub-continent are now confined to a few regions distributed sparsely. Almost everywhere, the populations are facing severe threat from human owing to increased human elephant conflict (HEC), habitat loss, poaching, electrocution, mining and other anthropogenic disturbances. India still holds a population of around 27000 elephants (Govt. of India 2017). Despite their dwindling numbers, considerable studies were conducted on the ecology, HEC pattern and on developing mitigation strategies in India in the past (Daniel, 1980; Ishwaran, 1984 Oliver, 1978; Santiapillai & Suprahman, 1986; Sukumar 1989). However, these studies carried out in the past decades have little significance to present day context with increased human pressure on the animal. In certain regions in India, however the ecology of the elephants is poorly known because of lack of scientific research and available studies are two to three decades old. The Northern Bengal elephant population has drawn national attention in recent years for various reasons, including increased collision with speeding trains in the dooars railway tracks. The existing management strategies by Government of West Bengal need to be redrafted with the changing scenario of Asian elephant and human population in the landscape. Considering the importance of the population and the landscape, this study was commissioned to Aaranyak by the West Bengal Forest and Biodiversity Conservation Project (WBFBCP), assisted by the Japan International Cooperation Agency (JICA).

The future of Asian elephant depends more on what follow up actions are implemented in the coming years. The issues related to Asian elephant conservation are often complex and linked to various layers of inter-disciplinary mechanisms involving a number of different stakeholders. In addition, social, political and administrative issues may also affect elephant population's future. The increased pressure on the species, competition for living space and natural resources, and the rapid economic growth of many countries have resulted in a dramatic loss of forest cover and reduced elephant numbers in the wild, and have rendered many of the populations non-viable in the long term (Sukumar, 2003).This final report presents the details of the three year study and its findings including recommendations for improving the management of the species.

Fig 1. A herd of elephants in Buxa Tiger Reserve

1.2. INTRODUCTION

There were several studies on Asian elephants in the past in India and elsewhere by Daniel, 1980; Ishwaran, 1984; Jackson, 1985; Oliver, 1978; Santiapillai & Suprahman, 1986; Storer, 1981; Sukumar, 1989, particularly in southern India. However, its status and ecology in certain parts of India remain poorly documented. Most of the studies were conducted decades ago and there is urgent need to conduct new studies to understand the ecology including its habitat utilization pattern, seasonal movements, foraging strategy and behavior its range states in India at present. Information on its past status in northern West Bengal can be found in Sukumar, (2003). Of late however it was realized that their current status ought to be assessed and conservation priorities needs to be redrafted owing to large scale changes in habitat and increased conflict with human.

The survival of Asian elephants depends more on our cumulative efforts and conservation practices. As the whole of range countries are witnessing severe conservation issues that readily threaten the existence of elephants. The species is facing severe crisis in certain countries with ever increasing conflict with human. Almost all issues can be attributed to human's indirect impact on the species. In addition, social, political and administrative issues may also affect elephant population (Shaffer *et al.,* 2019). The loss of habitat and fragmentation is perhaps the most important factor having a direct impact on elephants in many parts of Asia (Donlan *et al.*, 2003). As the population density increases in India (Growth rate 1.64%, Govt. of India 2011), the pressure of this expanding population, competition for living space and natural resources, and the rapid economic growth have resulted in a dramatic loss of forest cover and reduced elephant numbers in the wild, and have rendered many of the populations non-viable in the long term (Sukumar, 2003). The Asian elephant population in Northern Bengal has always drawn national attention because of the increased conflicts. The recent population estimation by Project Elephant, Government of India, reported a total of 488 elephants from North Bengal out of 780 elephants from the entire state (MoEFCC, 2018). The elephant habitat in North Bengal stretched from Mechi river in the west up to Sankosh river in the east with nine different forest administrative divisions. Region wise, North Bengal has a total of 3306 sq km forest area (GIS Lab, Aaranyak), out of which 2000 sq km is considered as elephant habitat (Tiwari*etal.,*2017). As per the 2011 census, the average human density in the Duars and the Terai region is 679 persons per sq km (Tiwari *et al.,* 2017). Hence, this region becomes one of the highly human dominated landscapes in the country with increasing trend of human elephant conflict.

The habitat in northern West Bengal is highly fragmented with developmental

Activities like conservation of forests into tea plantations, settlements, agriculture and exploitation of timber in the past and extraction of wood for railway sleepers after cutting the prime natural forest (Lahiri-Chowdhury 1975; Baeua & Bist 1995; Chowdhury *et al.*, 1997; Sukumar *et al.*, 2003; Roy, 2010*).* Encroachment of forests, loss of habitats, habitat degradation, and developmental activities like construction of roads and railway lines and increasing number of both human beings and wild animals, especially wild herbivores, are bringing human and wildlife in close proximity resulting in many human-wildlife conflicts (HWC) in the state. The Northern Bengal region has witnessed severe conflict of elephants with the local people. This conflict had further increased in recent years owing to several developmental projects leading to habitat loss of the elephants.

As mentioned above, this study was commissioned to Aaranyak by the West Bengal Forest and Biodiversity Conservation Project (WBFBCP), assisted by the Japan International Cooperation Agency (JICA). The study was conducted during October 2016 to February 2020.

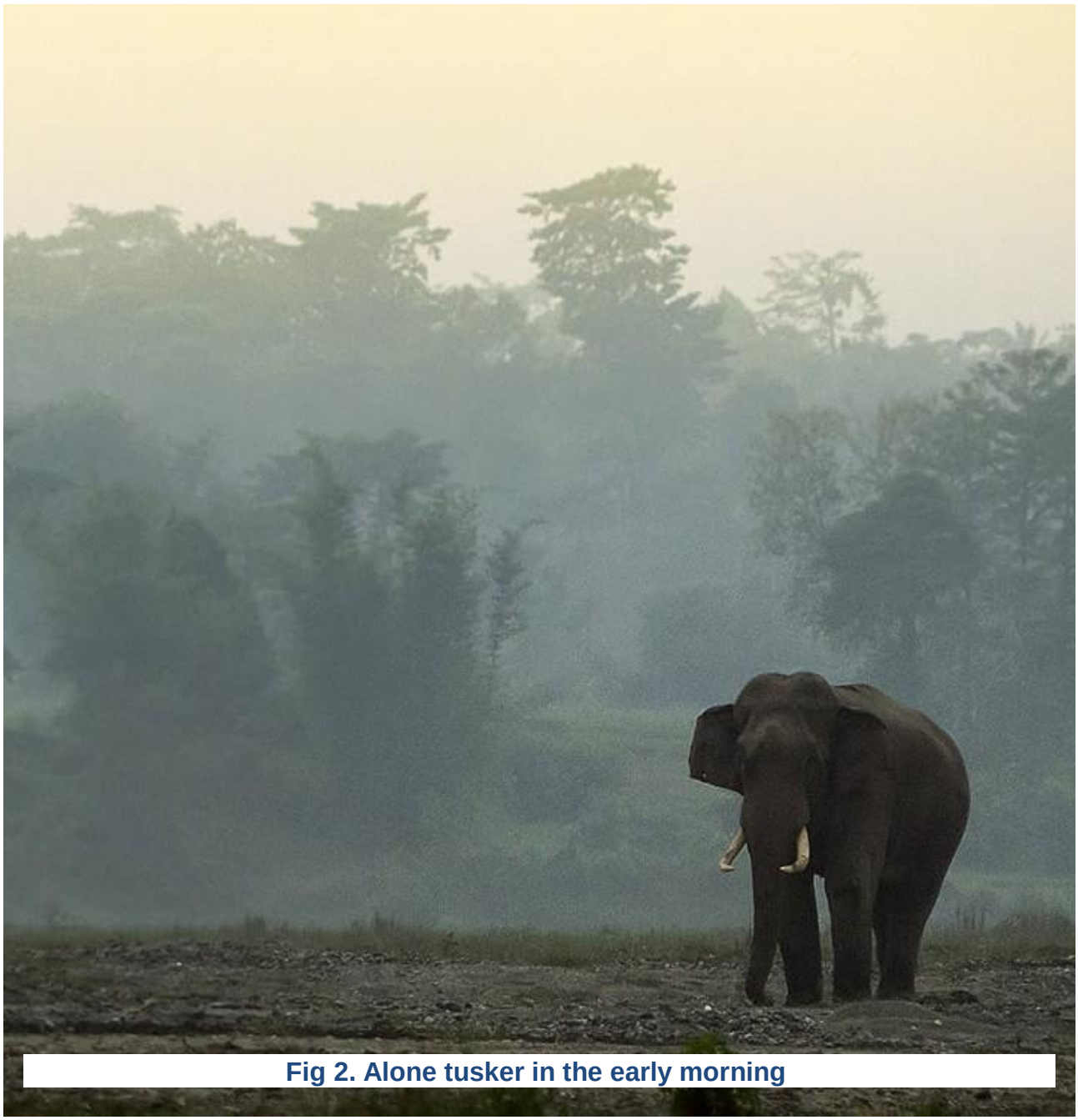


Fig 2. Alone tusker in the early morning

1.1. OBJECTIVES OF THE STUDY

The overall goal of the study was to understand the ecology, HEC and movement pattern of elephants in North Bengal landscape and to develop a management plan for the species for its improved management and to reduce HEC. To achieve the goal, the following objectives were pursued during the three years of the study –

1) To study the elephant ecology in North Bengal landscape

- To assess the population status
- To assess the population dynamics
- To assess the habitat use pattern
- To assess the migratory pattern of elephants in the landscape
- To study the feeding habit of the species

2) To assess the Elephant-carrying capacity in different protected areas of North Bengal

3) To analyze the Human-Elephant conflict in the entire North Bengal landscape

- To assess the present status of human elephant conflict.
- To develop plan for minimizing Human-Elephant conflicts.

4) To develop the management plan of the species with suggestions from the Forest department and concerned authority.

1.2. STUDY AREA

North Bengal landscape encompasses a total geographical area of 12800 sq. km (Source – GIS Lab, Aaranyak) (Fig 3). At least 3306 sq. km of which is forest area and at least 2000 sq. km is considered to be elephant habitat (Source-GIS Lab, Aaranyak). The landscape is divided into five administrative districts *viz.* Darjeeling, Kalimpong, Jalpaiguri, Alipurduar and Coochbehar (Map 1). There are nine forest divisions within the North Bengal landscape. The landscape is criss-crossed by numerous rivers like Mechi, Teesta, Torsa, Raidak, Jainti, Dima, Basra, Diana, Murti, Jaldhaka, Neora, Leesh-Gheesh, Balason *etc.* Our study area covers all these administrative Districts including the protected areas and territorial divisions. The forest types are mostly moist tropical and sub-tropical forests in the Eastern Himalaya with various protected areas like Buxa Tiger Reserve (761km^2), Jaldapara National Park (217 km^2), Gorumara National Park (80km^2), Chapramari Wildlife Sanctuary (9.5km^2), Mahananda Wildlife Sanctuary (158 km^2). As mentioned above, this whole stretch of area from Nepal border with Mechi river in the west to the Sankosh river in the east bordering Assam is a historically known contiguous elephant range (Naha *et al.,* 2019).

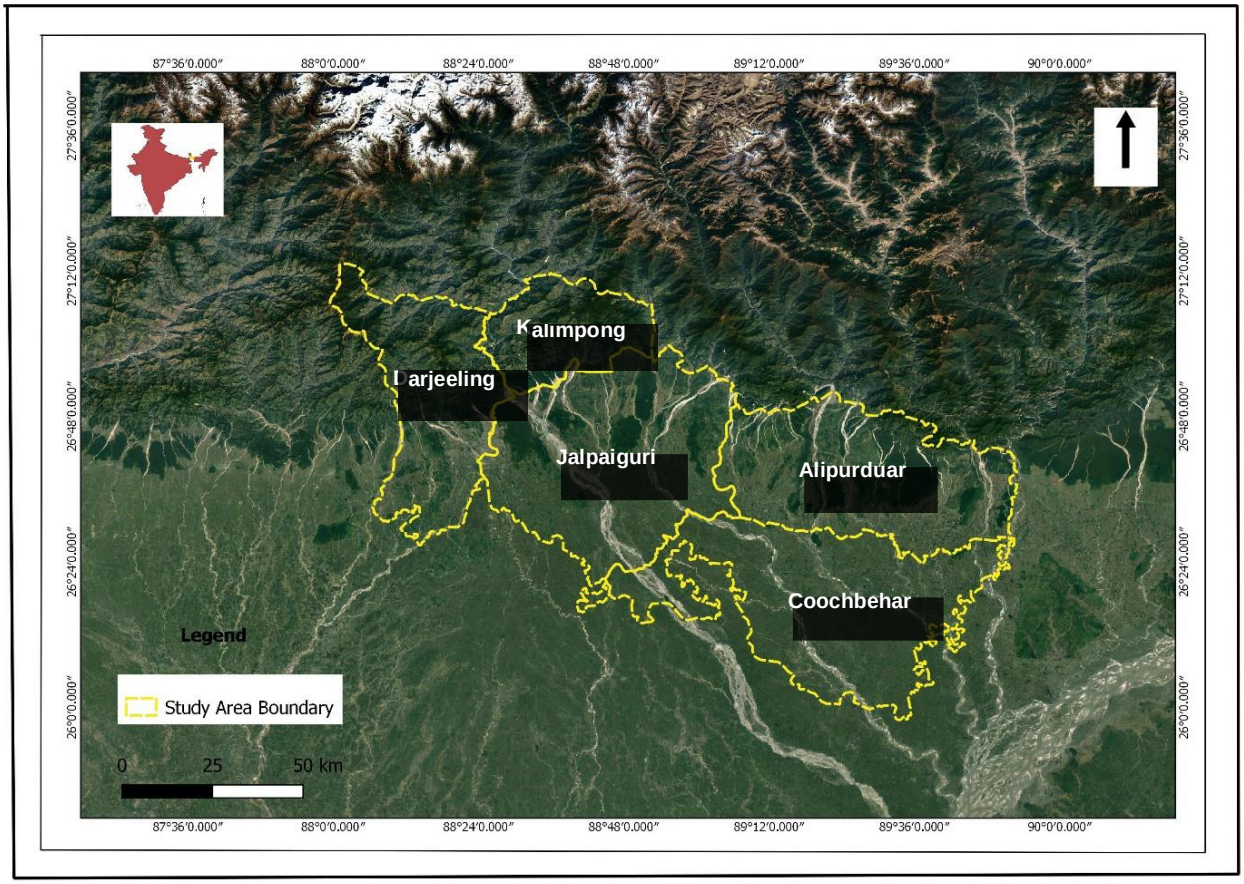
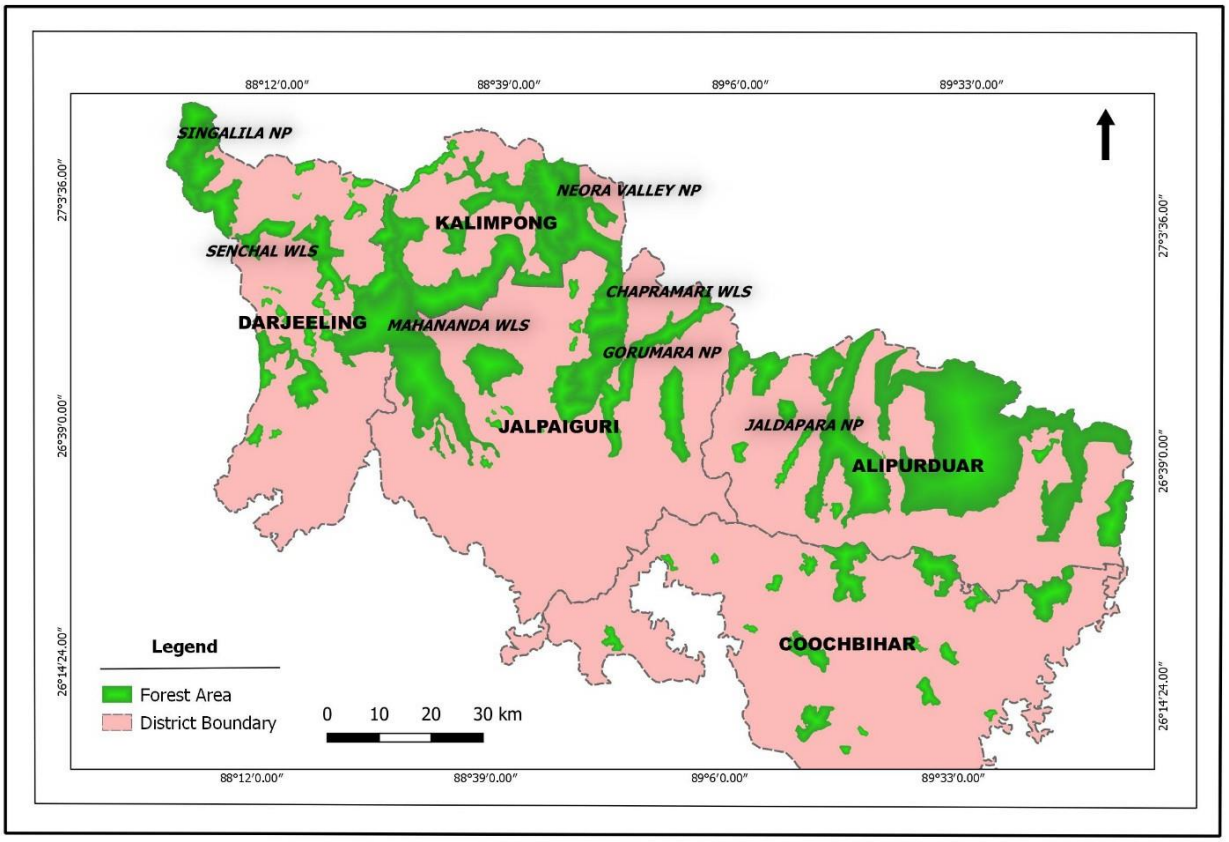


Fig 3. The map of the study area



Map 1: Map of the study area with the protected areas

CHAPTER II: POPULATION STATUS

We decided to do a presence-absence survey at the beginning by covering the entire study area to understand the present distribution of elephants across North Bengal. Our study design was to prepare a sampling protocol by laying line transects in the areas where the elephants are present. Keeping this in mind, we carried out a rapid survey by vehicle to detect animal presence and also collecting secondary information.

2.1. PRESENCE ABSENCE SURVEY

October 2016–December 2016

The whole North Bengal landscape was gridded into 16 sq. km (4 x 4 km) blocks. The total number of blocks was 952 in the entire landscape and only 125 blocks are known to be elephant habitat (2000 sq km).We surveyed at least 230 blocks to detect the elephant presence and reported the presence of elephants from 200 grids (Map2a). Although, we have considered single village in one grid but due to high intensity of human-elephant conflict in some grids, we have surveyed more than one village in a grid for replication purpose. Therefore, among 340 total villages visited with in the ranges of Alipurduar, Jalpaiguri, Cooch Behar and Darjeeling districts combined together there are 13 villages where elephant depredation is totally absent as found during the grid survey in North Bengal. Those villages are *Bindu, Gaurigaon, Jhalung, Samsun paharibsti, Sundarbasti, Lava, Satalibasti, Toshigaon, Lepchaka, Chunabhati, Purba Dawburi and Laphabari.*

December 2017–February 2018

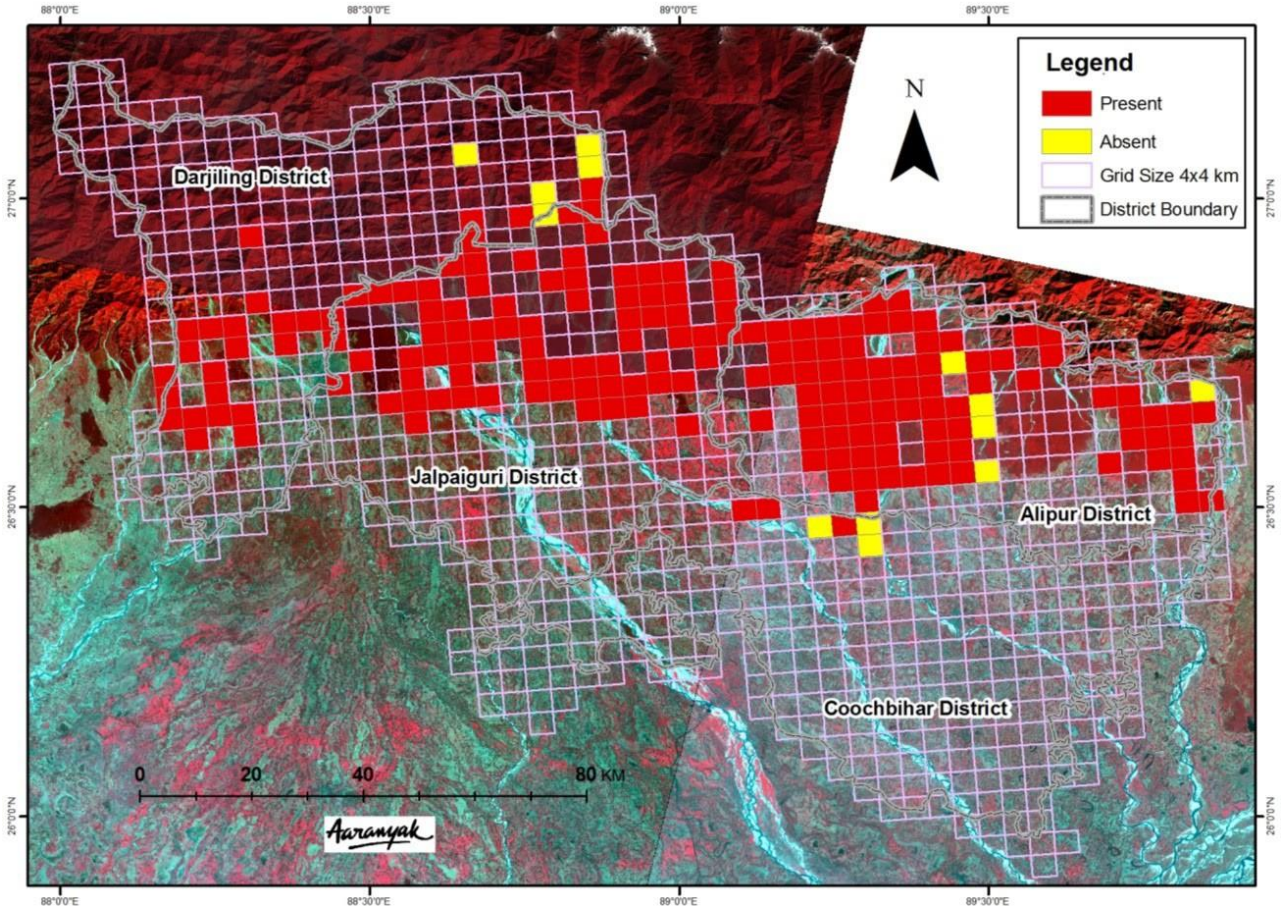
During December to February month 186 blocks were visited and we detected elephants in 174 blocks (Map2b). We could not ascertain elephant presence in 12 blocks. We conducted indirect survey using transect, trail and questionnaire surveys in the blocks to find elephant presence.

2.2.1. Methods followed for presence absence survey

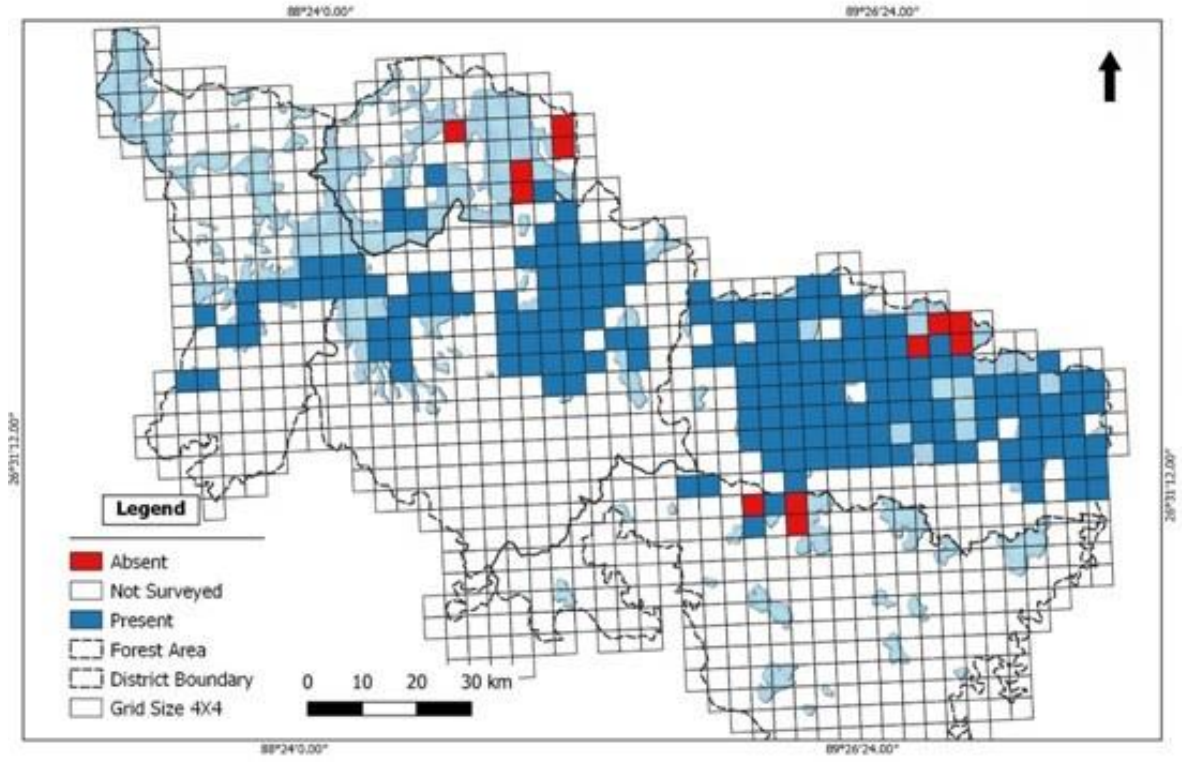
We followed a grid-based sampling protocol covering most of the known elephant range areas in North Bengal. In the sampled grids, we looked for elephant direct sighting or indirect evidence (foot-print, dung, scrape etc) and in those grids that covers human habitation, we conducted interview to the local communities on elephant visit in the area. We also collected three major covariate data (presence of forest cover, distance to forest, distance to water body, distance to human) to ascertain their influence on the presence of elephants.

2.1.2 Results

The naïve occupancy (number of grids where elephant present/total number of grids) estimate changed from 0.21 to 0.19 from the first survey to the second, which means that few areas were avoided by elephants during our course of fieldwork. During the first survey we found 200 grids with elephant presence while during the second survey elephants were detected at 174 grids out of186.



Map 2a.The first grid-based presence-absence survey during October 2016 - December 2016



Map 2b. The second grid-based presence-absence survey during December 2017- February 2018

We conducted two season occupancy modeling to look at the potential influence of any covariates on elephant's presence. However, using models for which occupancy (Ψ) was kept constant, the model without any covariates (Ψ(.),p(.)) was the best model with the lowest AIC. Whilst other left models produced ΔAIC values≥2.This can be explained that none of the four covariates influenced the detection probability of the elephants in this study site. However, we felt that there is scope of improvement to see covariate influence with more environmental variables like climate, rainfall *etc.* Table 1 shows the occupancy results of presence-absence survey.

Model	AIC	ΔAIC	AIC wgt	Model Likelihood	No. Par.	-2*LogLike
Ψ(.),p(.)	100.19	0	0.5872	1	2	96.25
Ψ(.),p(forest_cover)	104.64	3.89	0.1115	0.1963	2	99.62
Ψ(.),p(forest_dis+forest_cover)	105.23	4.53	0.0764	0.1083	3	98.91
Ψ(.),p(water_dis+human_dis)	102.62	4.23	0.0463	0.0982	3	98.89
Ψ(.),p(forest_cover+human_dis)	102.37	5.23	0.0426	0.0863	3	99.48
Ψ(.),p(Water_dis+forest_cover+human_dis)	102.96	4.32	0.0372	0.0574	4	97.91

Table 1. There sults of occupancy survey of elephants in North Bengal

2.2 ALL INDIA SYNCHRONISED ELEPHANT POPULATION ESTIMATION 2017

Project Elephant, Government of India has conducted 'All India Synchronized Elephant Population Estimation 2017' throughout India in 2017. After the population census carried out by the government, it was felt that there is no need of replicating the same estimation process of Asian elephants in the landscape. Hence, during the review seminar held in Siliguri on 20th June 2017 a consensus was reached to drop the objective of population estimation from the initial project objectives Hence we didn't continue the population estimation process. The recent published report from the MoEFCC, Government of India reported a population of 488 elephants from the North Bengal based on direct count during the census. However, Alongside the direct count method, the department has used indirect dung count method to estimate the elephant population. Our research team has also collaborated with the Forest Department in the conduct to the elephant censusin North Bengal The below table 2. Shows the elephant population in last 20 years-

Year	Elephant Population In North Bengal
2001	292
2007	350
2010-11	529
2017	488

Table 2. Elephant population estimates during last two decades in North Bengal (MoEFCC 2017)

2.3. POPULATION STRUCTURE

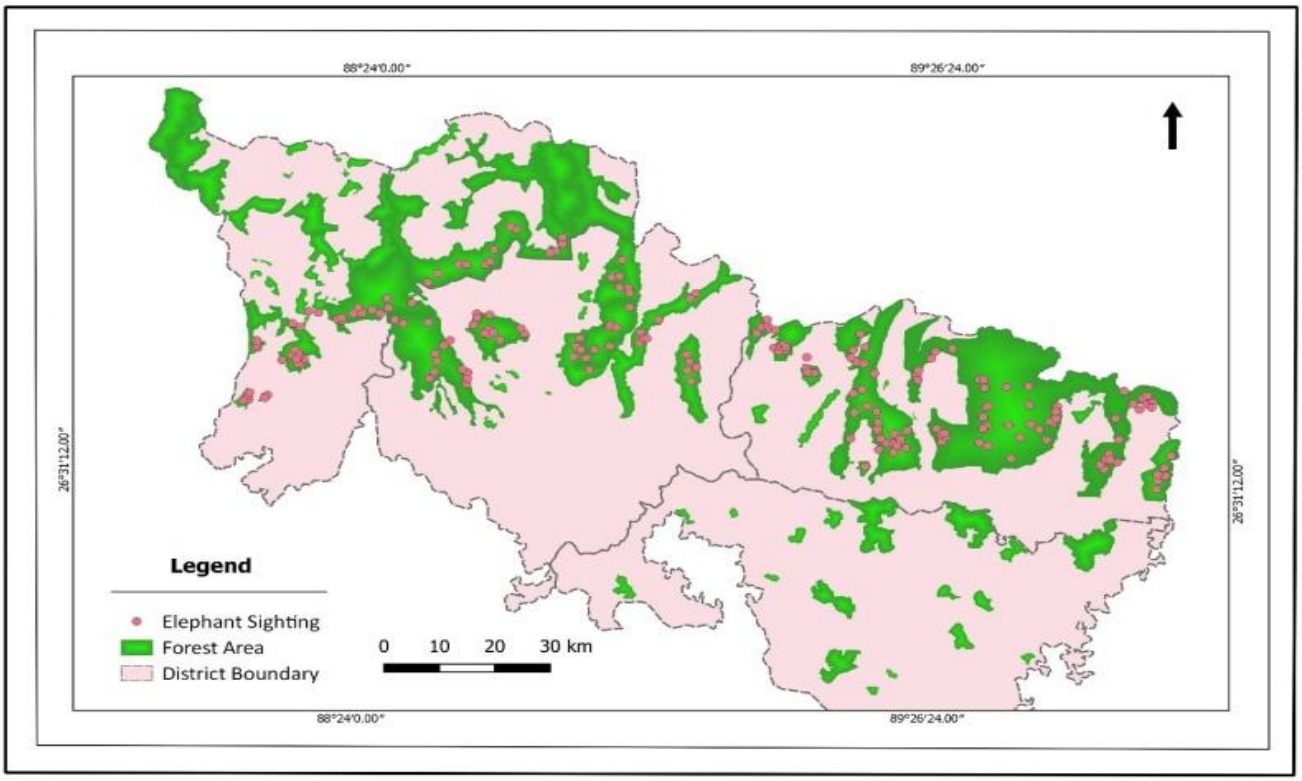
The elephants in north Bengal landscape are widespread across the landscape. The assessment of the population structure is crucial in planning for the conservation of a species (Sukumar *et al.,* 2003). As the past estimates are old, the demography of the North Bengal population needs to be assessed urgently. Sukumar *et al.,* (2003) reported that the North Bengal population ismale-biased. Our study focused on assessing the age-sex class of the existing population and also the size of herds. Herd size and composition provide information on social organization of the species and are often related to environmental conditions (Leuthold and Leuthold, 1975). Social organization of a population such as herd size, composition and structure would generate essential information on population characteristics and trend (McCullough, 1994). Understanding the population dynamics is important for managers if the population is to remain viable (Williams *etal.,*2007).

2.3.1. Methods

The data were collected throughout the study period until Nov 2019. We covered almost 90% of the total study area with regular, systematic, road and waterhole surveys along with the regular transect survey for dung. During these visits, all encounters with elephant herds were documented and required parameters were noted. We followed a random and opportunistic approach for age-sex structure estimation, as the elephant sighting is normally infrequent except the dry winter months, hence the existing methodologies were redesigned to adapt with the prevailing circumstances circumstances. Whenever elephants were sighted, data on age and sex were collected s far as possible. At every sighting, date, vegetation type, age-sex, group size etc. were collected based on Mckay, 1973; Kurt, 1974 and Daniel *et al.,* 1987 (Map3). Age estimation was done based on shoulder height following Sukumar (1985). The sighted elephants were classified into Calf (<5 years), sub-adult (5-15 years), and adult (>15 years). Younger elephants were classified by comparing their height to the oldest adult female in the group (Eisenberg and Lockhart, 1972). Sex differentiation was not possible in certain instances because of poor visibility and group's movement. However, all loner were identified based on characteristics such as trunk musculature, and the social context of the individual. All adult males were classified. However female groups were larger and more difficult to classify than males that were usually solitary in dense vegetation.

2.3.2. Results

A total of 676 individuals of elephants were sighted in 71 sighting instances (sightings and resightings) (Table 3 & Map 3). This includes sighting instances inside the protected area as well as near the forest boundary (in the villages). Resighting instances could not be ascertained because of difficulties in identifying the seen animals in dense forested landscape like Buxa, where sighting frequency peaks in



Map 3. Elephant sighting locations

a particular season and also the chances of resighting of an identified herd is almost nil. There were additional 14 instances of (103 elephants) sighting records that were not included in the final analysis part owing to some doubts and mistakes in the age-sex identification process because of poor visibility. However, these 14 instances of sightings were included for habitat use purpose in chapter III.

The number of adult male sighted in the study area were 77 (95 % CI = 60-94), which The mean herd size encountered was 8.96 ± 1.64 (95 % CI) in the entire landscape. forms 11.39% of the total elephants sighted. There were 22 adult males having tusks which shows that >70 % males were tuskless.

However, there are differences in herd size across different habitats of the study area.

Smaller herds of 1 – 5 elephants were sighted morethan the bigger herds (n=24) (Fig 6). The sex ratio of the population was estimated at 1: 2.17 (male: female) with More than 70% tuskless male. However, we discarded 104 individuals of unidentified sex from the study (mostly calf and juveniles) (Fig 4).

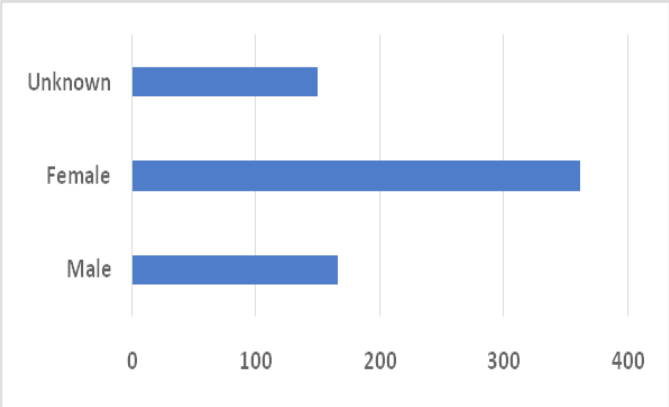


Fig 4. The sex class of the population

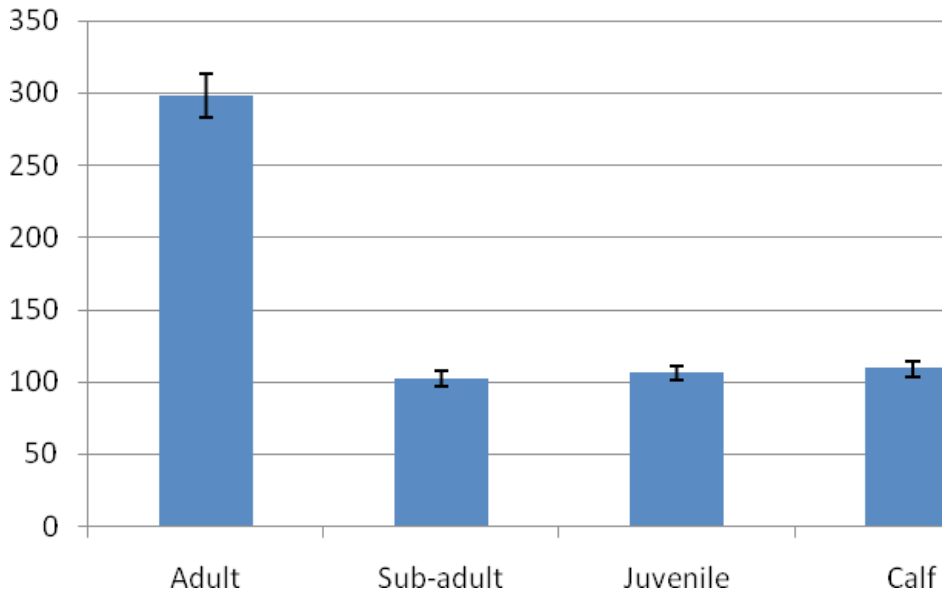


Fig 5. The age class category of the observed elephant herds

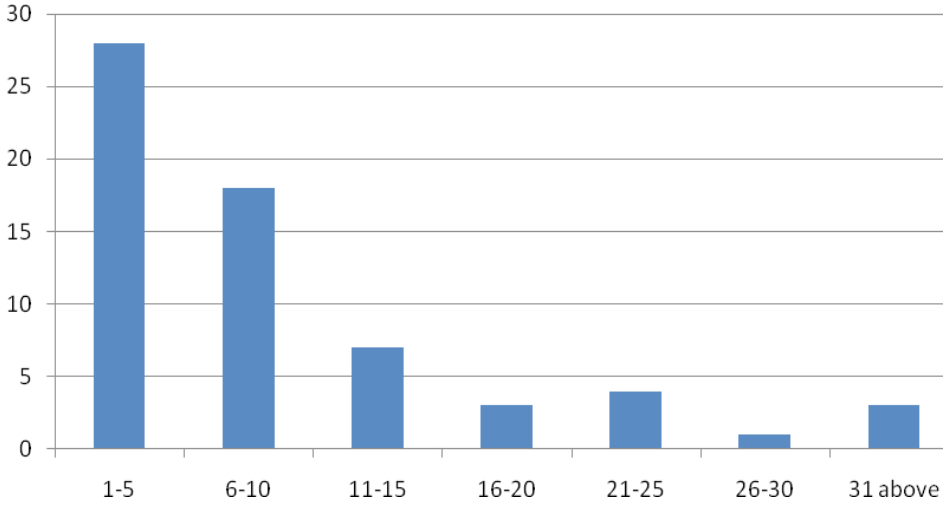


Fig 6.The herd size frequency of the observed elephant groups

Table 3: The sex and age class of the observed herds observed during the study

Sl No.	Total	Sex			Age class			
		Male	Female	Unknown	Adult	Sub-adult	Juvenile	Calf
1	2	2	0	0	2	0	0	0
2	8	0	5	3	5	0	0	3
3	16	3	9	4	6	6	4	0
4	7	0	4	3	4	0	0	3
5	2	2	0	0	2	0	0	0
6	2	1	1	0	2	0	0	0
7	2	0	1	1	1	0	0	1
8	65	16	48	1	46	5	12	2
9	8	0	5	3	5	1	2	0
10	1	1	0	0	1	0	0	0
11	12	4	2	6	4	2	4	2
12	7	0	4	3	3	1	3	0

Sl No.	Total	Sex			Age class			
		Male	Female	Unknown	Adult	Sub-adult	Juvenile	Calf
13	13	2	4	7	4	2	5	2
14	3	1	1	1	2	0	1	0
15	1	1	0	0	1	0	0	0
16	8	0	2	6	8	0	0	0
17	4	0	0	4	2	2	0	0
18	9	0	3	6	3	3	2	1
19	3	0	1	2	1	0	2	0
20	6	0	2	4	3	2	0	1
21	12	4	6	2	5	3	3	1
22	8	3	3	2	3	2	2	1
23	23	7	15	1	5	6	6	6
24	4	1	2	1	2	1	1	0
25	6	3	2	1	2	1	1	2
26	1	1	0	0	1	0	0	0
27	2	1	0	1	1	1	0	0
28	15	7	3	5	3	2	0	10
29	10	5	4	1	3	2	3	2
30	7	2	3	2	2	0	4	1
31	4	2	2	0	1	0	2	1
32	1	1	0	0	1	0	0	0
33	1	1	0	0	1	0	0	0
34	3	1	1	1	1	0	0	2
35	2	1	0	1	1	0	1	0
36	26	8	12	6	3	2	12	9
37	21	5	8	8	1	1	6	13
38	3	1	2	0	3	0	0	0
39	11	2	7	2	7	2	0	2
40	2	2	0	0	2	0	0	0
41	1	1	0	0	1	0	0	0
42	1	1	0	0	1	0	0	0
43	1	1	0	0	1	0	0	0
44	7	1	6	0	5	1	1	0
45	10	1	9	0	5	3	1	1
46	13	3	10	0	6	4	0	3
47	1	1	0	0	1	0	0	0
48	7	2	5	0	5	1	0	1
49	10	2	8	0	8	1	0	1
50	8	3	5	0	6	0	1	1
51	9	3	6	0	5	2	1	1
52	17	4	13	0	14	0	2	1
53	3	0	3	0	1	0	2	0
54	2	2	0	0	2	0	0	0
55	62	9	37	16	45	12	0	5
56	22	4	12	6	9	4	3	6
57	14	3	8	3	6	3	2	3

Sl No.	Total	Sex			Age class			
		Male	Female	Unknown	Adult	Sub-adult	Juvenile	Calf
58	8	2	4	2	1	4	1	2
59	1	1	0	0	1	0	0	0
60	1	1	0	0	1	0	0	0
61	34	7	16	11	12	6	5	11
62	16	3	10	3	4	4	5	3
63	21	4	12	5	4	7	5	5
64	5	1	3	1	1	3	1	0
65	15	3	8	4	7	3	3	2
66	7	2	4	1	4	2	0	1
67	9	2	4	3	5	2	2	0
68	4	1	2	1	3	0	1	0
69	13	3	7	3	7	2	3	1
70	12	3	7	2	6	3	2	1
71	1	1	0	0	1	0	0	0
Total	**676**	**166**	**361**	**149**	**331**	**114**	**117**	**114**

**This table is excluding another 14 instances of sighting of 103 elephants*

Fig 7. A lone tusker in Buxa

CHAPTER III: HABITAT USE ANDMIGRATORY PATTERN OF ELEPHANTS IN NORTH BENGAL

Habitat use means finding relationships between an organism and its habitat and often related to plant communities. It is crucial to understand habitat utilization pattern of elephants in order to understand their requirements. In general, elephants are known to be mixed feeders, with proportions of grass and browse in the diet varying throughout the year. Understanding

3.1. Methods

We assessed indirect evidence and direct sightings of elephants as the major parameter of habitat use. In each visited grid, we assessed the elephant presence based on sighting of dung piles and direct sighting of elephants. Further, for each sighting

3.2. Data Analysis

Achi-squared test was performed to determine whether the habitat use by the elephants was random and differ significantly among different habitats. During the analysis, the habitat categories, where the expected frequencies were less than five, were dropped as these units were rarely selected (Manly *et al.,* 2002). Since, the habitat-use by elephants differed significantly among the habitat types (χ^2 = 519. 697, df=7, P<0.001), the habitat preference was calculated using Manly's standardized preference index, Bi (Manly *et al.,* 2002). The index is based on the selection ratio w

and patterns of habitat utilization by threatened fauna can be critical for informing management and conservation decisions. We roughly stratified the entire study area into the following habitats based on land cover type–Deciduous forest, riverine forest, Mixed vegetation, Sal plantation, Teak plantation, Semi evergreen forest, Grasslands and tea gardens.

Instance the activity (feeding, moving and resting) and time used were recorded. The vegetation structure of the study area was assessed. We conducted vegetation analysis in 728 sample plots of 10m x 10m size in 262 randomly placed transects (Map 4).

$$w_{i,s} = o_{i,s} / \pi_i$$

Where, O = Proportion of the numbers of individuals of species recorded in the habitat units in category i.

And TT = Proportion of the habitats, I among all the habitats sampled.

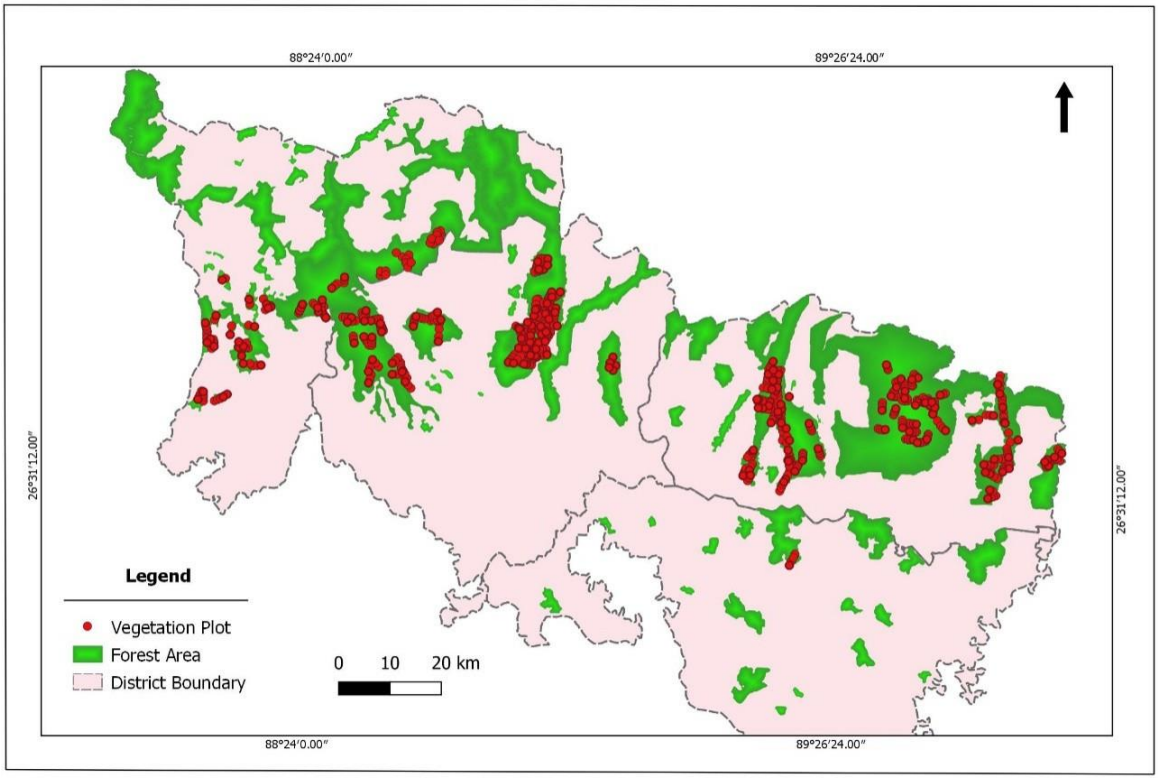
First the W was calculated and then and then the preference index was computed. The preference index was standardised using Manly's standardised equation.

Which is the proportional use of each resource divided by the proportional availability.

Where, H = number of resource habitats units.

$$\text{Bi} = \frac{w_{i,s}}{\sum_{i=1}^{H} w_{i,s}}$$

If the value of the preference index is greater than 1, the habitat is considered to be preferred by the species, and if the value is less than 1 the habitat is considered to be avoided. The value around 1 suggests that habitat was used in proportion to its availability. The mos tpreferred habitats are considered as the key habitats for the species. The data was analysed in program R (R Core Team 2019) using the package and habitat HS (Calenge 2007).



Map 4. The location of the 728 vegetation survey plots in line transects

3.3. Results

We recorded a total of 1356 relatively fresh dung piles and 85 direct sighting of elephant herds (number of elephants = 779). The habitat of the dung piles and the sighted elephant herds were noted. A total of 36. 4 hours of observations were made during the 85 direct sighting records. Fig 8 shows the number of sightings of elephants in different habitat classes. Fig 9 presents the amount oftime spent, in hours, in each habitat type andthe major activity of the group. The elephants most preferred habitats were the riverine Forests (Fig10), followed by the grasslands, both habitat types were used significantly more than their availability (Fig 11). The other habitat types were used less than their availability. The riverine forest might attract the elephants because of palatable riverine grasses and also spent a lot of time in dust bath. While the teak and sal plantations were used considerably low in comparison to their availability in the landscape.

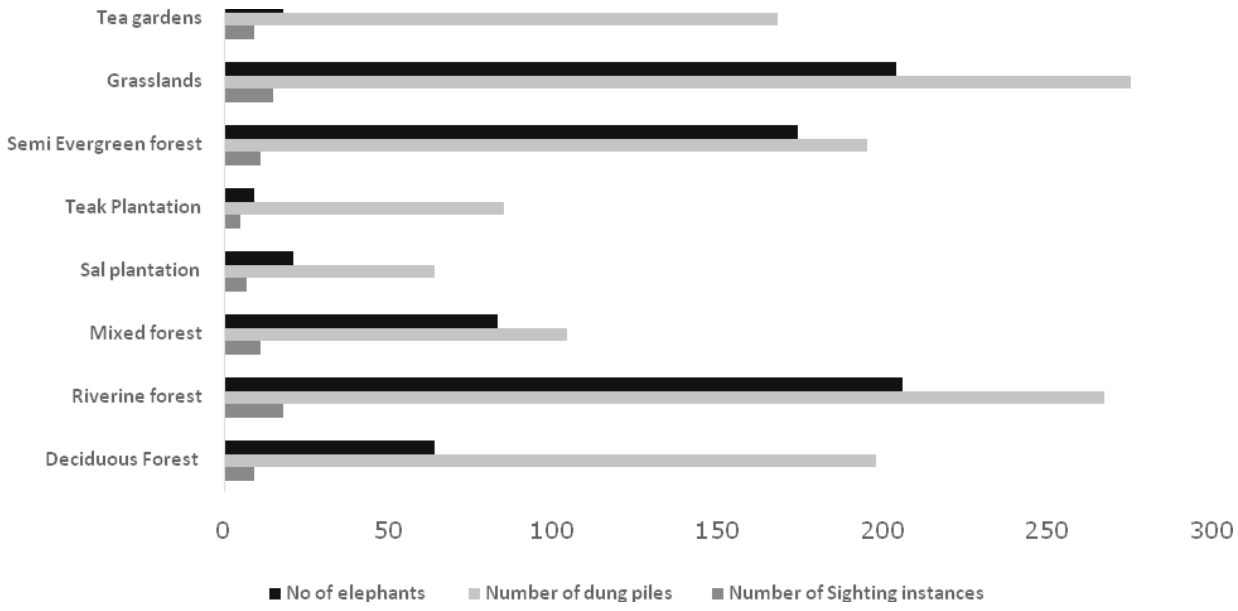
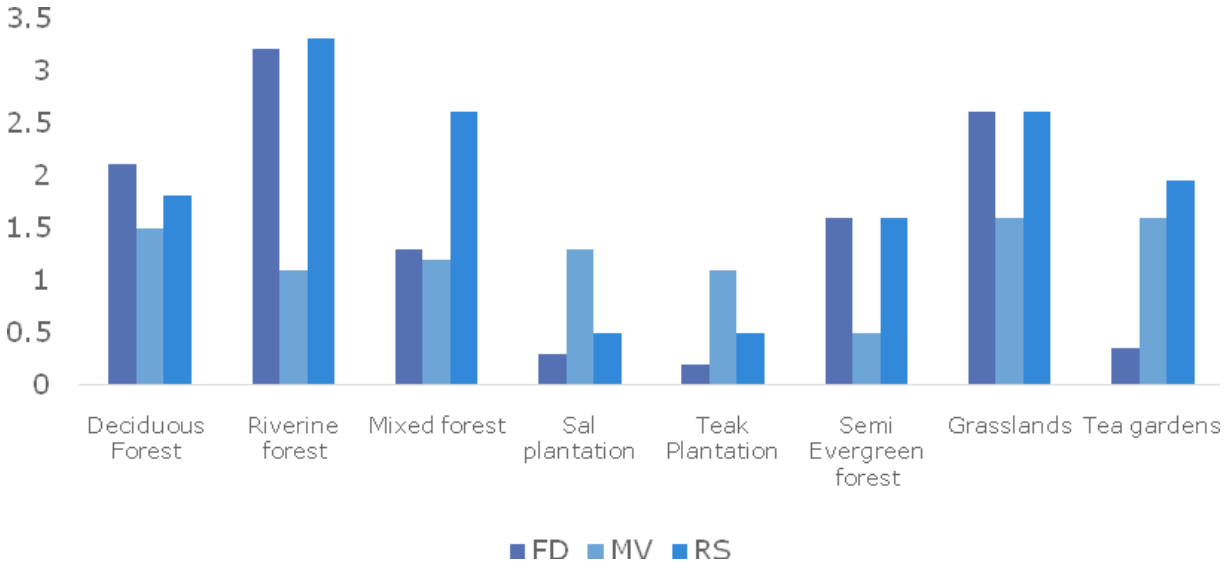


Fig 8. Number of instances of sighting and number of elephants



FD=Feeding,MV=Moving,RS=Resting

Fig 9. The time spent (in hours of observation) on each major activity in the habitat by the herds

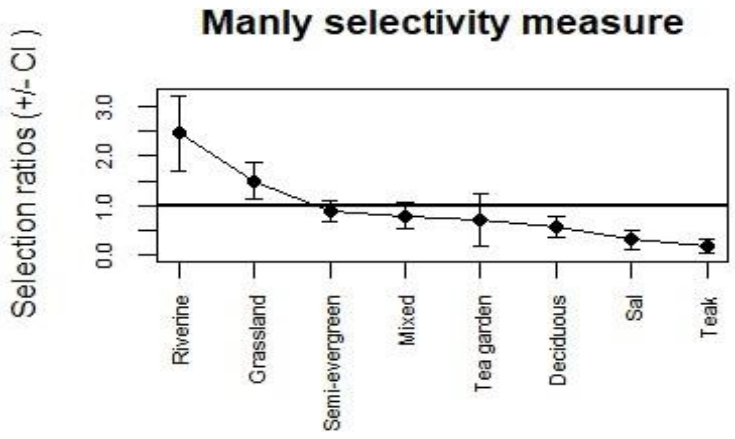


Fig 10.Selectivity measure for each habitat

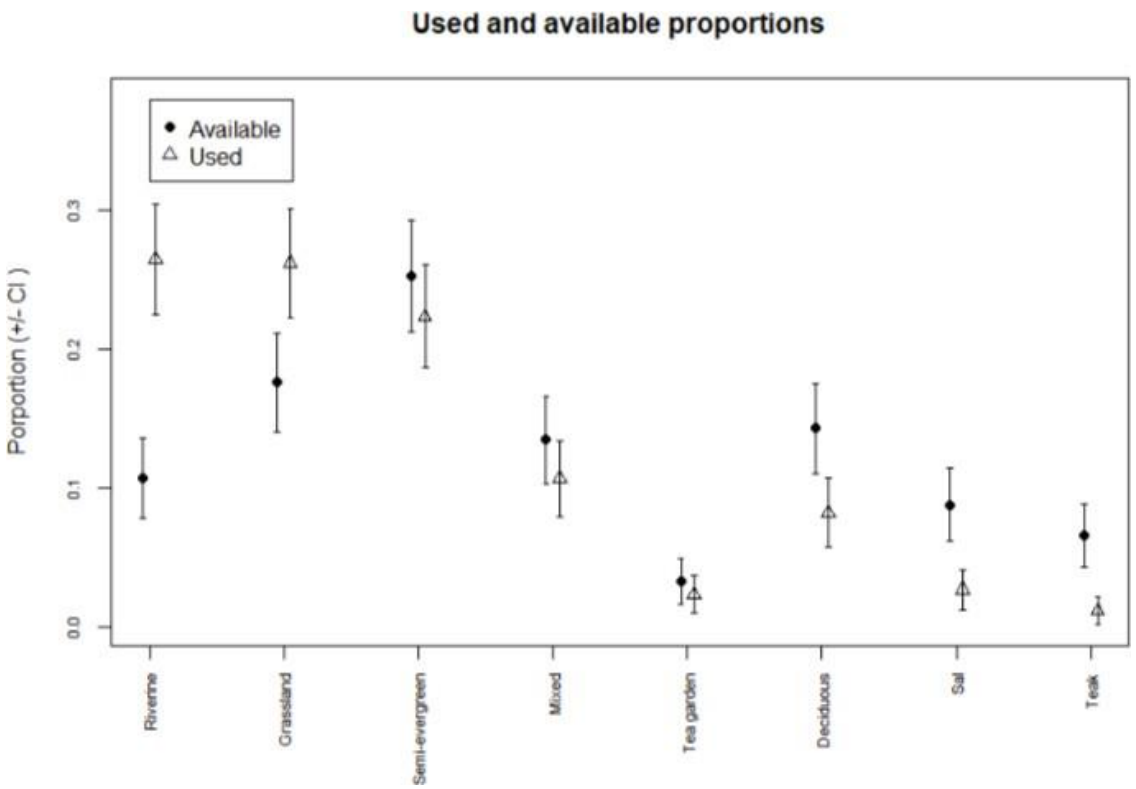


Fig 11. Availability vs use of each habitat

3.4. Discussion

From the results, it is seen that the most preferred habitat is the riverine habitat.This is perhaps because the riverine habitat provides palatable grasses. The other habitat types were used less than their availability. The riverine forest might attract the elephants because of palatable riverine grasses and also spent a lot of time in dust bath. While the teak and sal plantations were used considerably low in comparison to their availability in the landscape.

3.4. MIGRATORY PATTERN

The migration is a seasonal behaviour of elephants across landscapes as the animal is long ranging and often travels to long distances in search of food and shelter. In the past, scientists have used satellite tools to understand the migratory pattern of elephants. However, due to lack of resources, we conducted this activity with the help of local people. At the beginning, we developed an information gathering network across the landscape with support from various people including local youth sand forest staff. We Identified 21 informers including 15 local youths and 6 forest staff distributed across the North Bengal landscape. These informers were stationed across the North Bengal landscape to inform us about any elephant sighting and movement. They were based in Naxalbari, Kolabari, Bagdogra, Sukna, Belakoba, Odlabari, Barodighi, Lataguri ,Nagrakata, Binnaguri, Reiti, Karbala, Telipara, Madarihat, Falakata, Hasimara, Bhutri, Rajabhatkhowa, Buxa, Kartika and Newland TG.

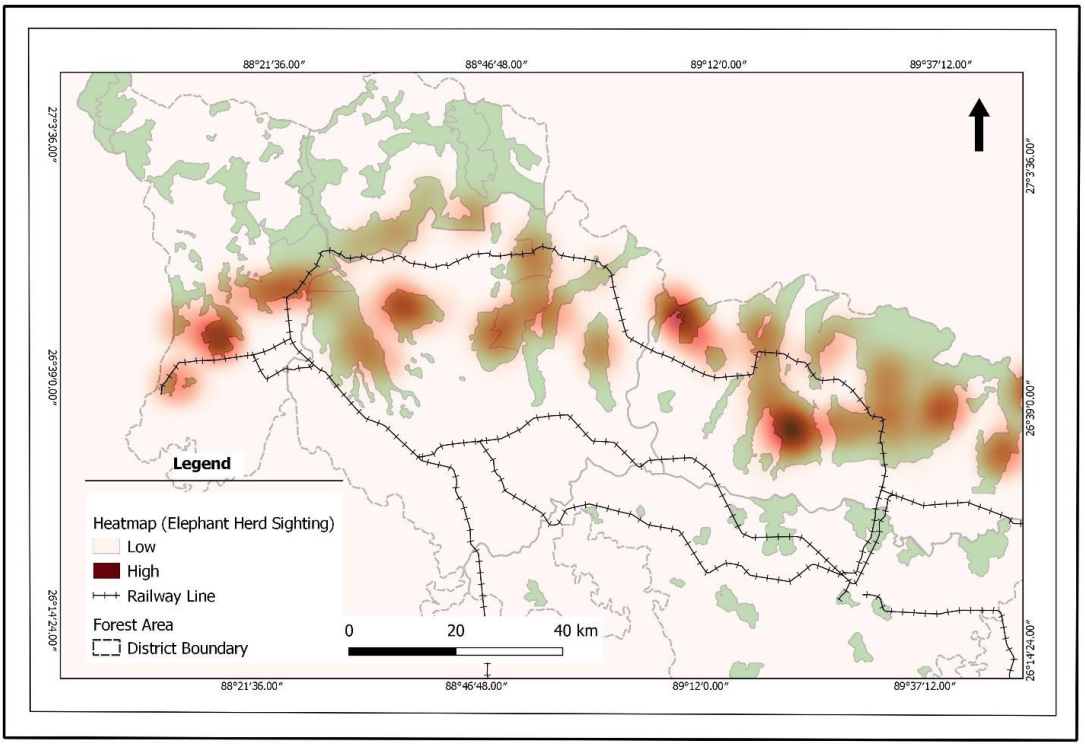
3.4.1. Methods

The local youths were given an orientation on identifying the group movement and inform our field time on each occasion they sight a herd of elephants. All the information from the network from each month were later computed in the map of the study area. We received information on 295 locations based on their phone calls on elephant's movement (Fig 12).They also regularly sent photograph of herds but most of the sightings were during The evening or night time and with cell phone low quality photos in case it was possible to capture during the movement. The month wise distribution of elephants sighting records from the network. Is shown in (fig 12). It shows that there are two peaks of elephant sighting during month of May and November presumably because of harvesting season when the groups moves close the human habitation.

3.4.2. Results

The result showed that elephant herd was sighted more during early winter and early monsoon (Fig 12). Most probably due to cultivation of paddy crops in the duars region by local people. While in the terai stretches of the landscape, the people cultivate maize during early monsoon (Apr-May) and elephants used to raid maize to a great extent.

With further analysis of the data (Map 5), we noted that cultivation of paddy near Kurseong division attracts bigger elephant herds and the herds remain in Kurseong division until harvesting period is over. Presumably the same bigger group then Seems to scatter during January-February and crosses Teesta river to reach Jalpaiguri and Gorumara division. Further we noticed, there are smaller groups distributed across the area for raiding Maize crop during April-May months. Our most of the observations were during this period. During this period the smaller groups congregate in Indo-Nepal border near Mechi river. This herd remains in Kurseong division until the paddy season starts again.



Map 5. Heat map of elephant herd sightings based on information gathering network

Fig 12. The number of sighting of elephants (phone calls) in each month during the study period (combining 26 months)

In the east of North Bengal, we noticed that in Buxa Tiger Reserve, there is a resident population that regularly crosses the Sankosh and visits nearby Kachugaon Forests in Assam. The smaller groups from Buxa are often found to raid crops in near by Rydak, Bholka and Kartika, Kumargram areas. These groups keep travelling from Buxa to Jaldapara NP via Chilapata throughout the year.

In the month of May-June, there is indication of a large congregation of herds in river Dima. In May June, we noticed a large group in Rethi reserve coming from Moraghat, Dhumchi, Dalmore, Gorumara, Diana areas. This herd remains for a month and raid crops in nearby tea gardens and Dalmore, Khas basti, Bhuttabari etc. There is evidence that the groups travel to Bhutan foothills along the Rethi river in search of dolomite.

3.5. STATUS OF ELEPHANT CORRIDORS

Tiwari *etal.* (2017) reported 14 major elephant corridors in North Bengal connecting different forest reserves. These corridors are vital for the migration and movement of the elephant herds and for maintaining genetic connectivity across the landscape. However, due to new settlement areas and other sources most of the corridors are under tremendous human pressure. We studied all the corridors to assess the present status in terms of elephant use and scale of disturbance.

3.5.1. Methods

Based on the survey methods approved for the MIKE programme (Hedge and Lawson, 2006)‘ reconnaissance walks’ were used to follow ‘paths of least resistance’ on each survey. (Lee and Edwards, 2000). The routes were planned using recent GIS map of the corridors so as to maximize the coverage of areas likely to have been, used by elephants. The routes were walked by a team of 3-4 people, at least two project staff and 1-2 local youths. The team walked each route on foot using existing tracks and trails (mostly human/elephant paths) using a GPS to record the start and finish of each reconnaissance walk. Signs of human activities, elephants and other wildlife as well as notable landmarks (*e.g.*teagardens, roads*etc.*) were recorded.

3.5.2. Results

We surveyed all the14corridors inter linking different forest reserves as reported by Tiwari*etal.,* 2017, and listed in table 3.
All these corridors are subjected to the pressure of human activities. Varying number of routes were walked in different corridors in two separate season surveys as given in the table.

Elephant presence: The findings of these surveys indicate that elephants are regularly using these corridors despite increased disturbance. Dung piles of varying ages (from very fresh to weeks old) were found on every survey route. The number of elephants using these corridors is not clear but based on observation of the footprints bigger herds often crosses the corridors (Fig 13).

Human impacts/threats: There are human activities that threaten these corridors at present.

Sl. No.	Corridor Name	Decoded in Map	Number of routes walked (n)	Total effort (in KM)	Mean encounter rate of elephant sign (perKM)	Mean encounter rate of human sign (perKM)
1	Apalchand RF-Mahananda	A	4	8.2	8.8	5.1
2	Apalchand RF- Garumara	D	4	8.4	9.9	8.6
3	Apalchand RF- Kalimpong Division (Via Sylee)	B	5	10.1	4.3	10.6
4	Apalchand RF- Kalimpong Division (Via Meenglass)	C	4	8.3	5.4	9.2
5	Chapramari WLS-Kalimpong Division	E	4	11.5	8.6	4.5
6	Rethi-Moraghat	G	4	5.7	9.4	6.3
7	Rethi-Central Diana	H	4	7.2	7.9	5.9
8	Teti-Rethi via Dhumsi	I	3	6.2	5.5	9.3
9	Moraghat-Central Diana	F	4	8	8.6	6.2
10	Teti-Rethi	J	5	7.3	9.9	5.6
11	Buxa Tetivia Torsha	K	4	7.2	8.3	4.3
12	Buxa Tetivia Barnabari	L	4	5.9	5.7	6.3
13	Nimti-Chilapata	M	4	4.9	7.9	4.6
14	Buxa Ripu (Sankosh)	N	3	4.5	7.3	5.9

Table 3.The mean encounter rate of elephant and human presence signs in the Identified elephant corridor

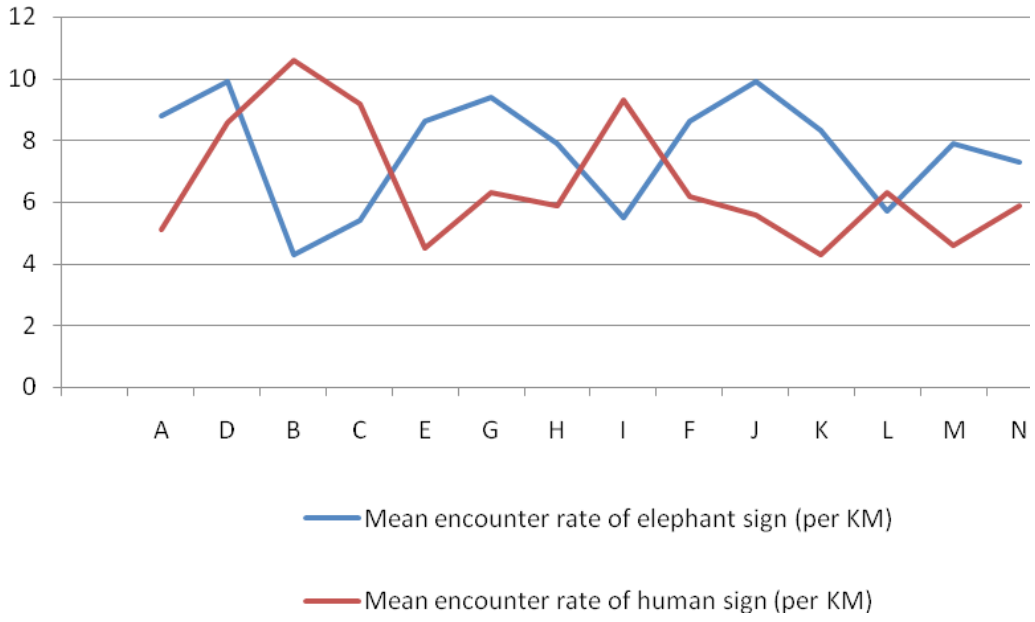
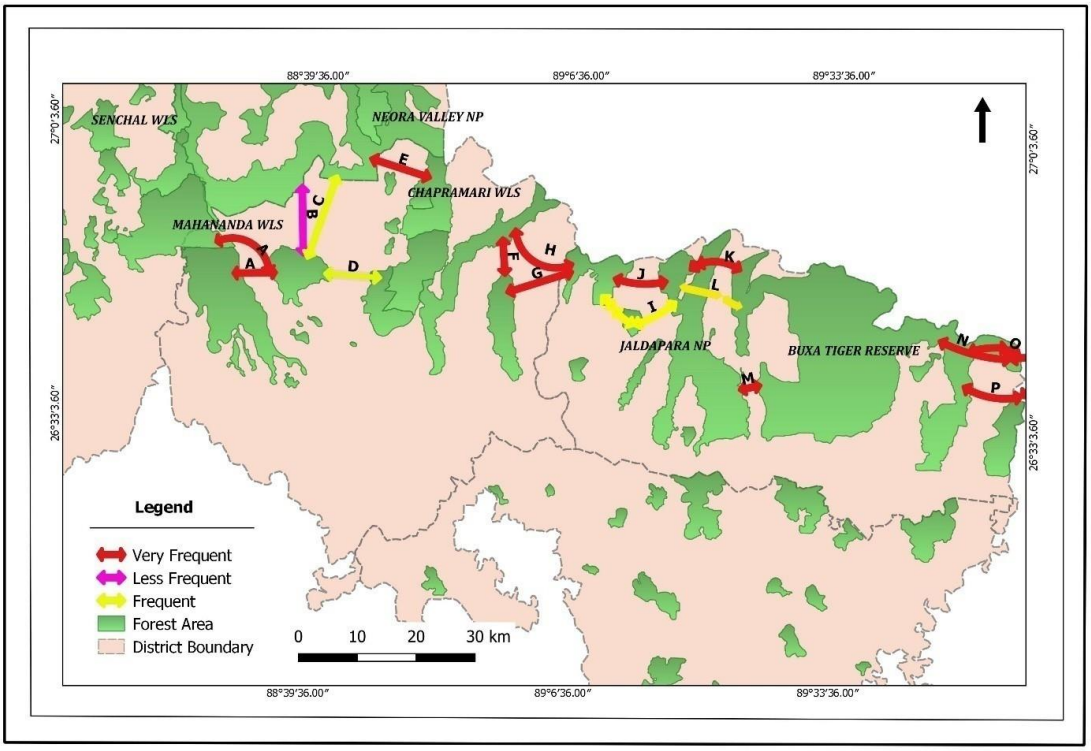
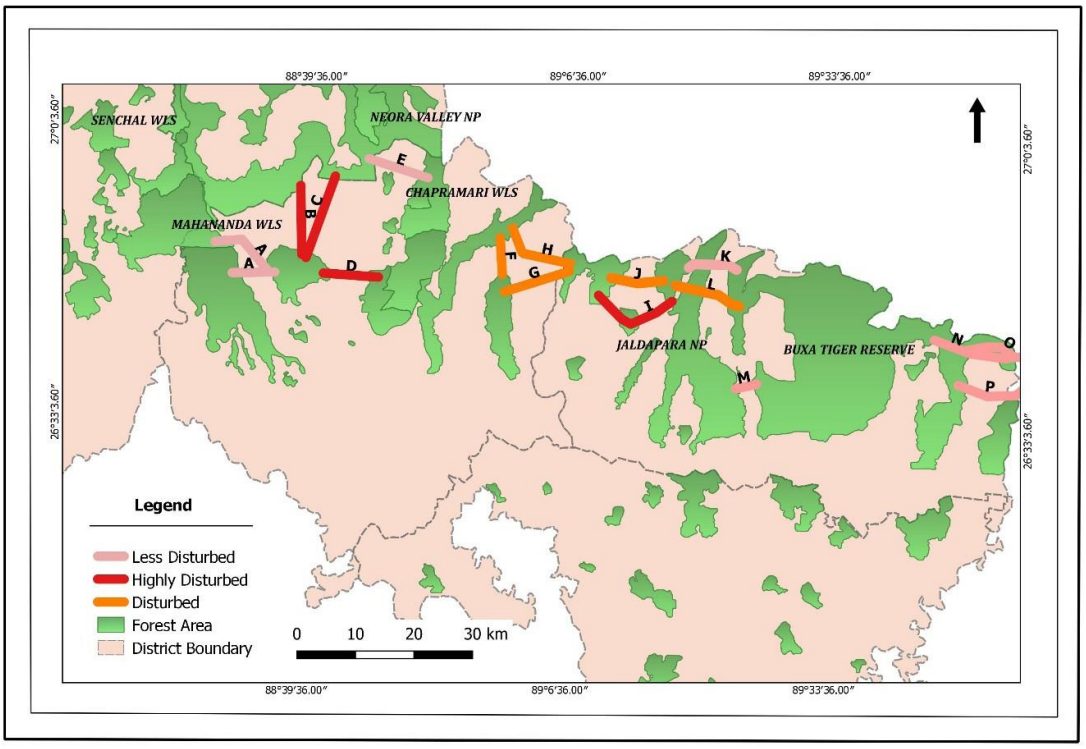


Fig 13. The mean encounter rate of elephant sign and human disturbance sign in each corridor

Although all corridors are used frequently, we found that two corridors Apalchand-Goumara and Teti - Rethi are used more intensively throughout the year (Map 6). The Map 7 shows the level of disturbance to each corridors.



Map 6. Elephant corridors and their frequency of usage (Very Frequent, Frequent, Less Frequent)



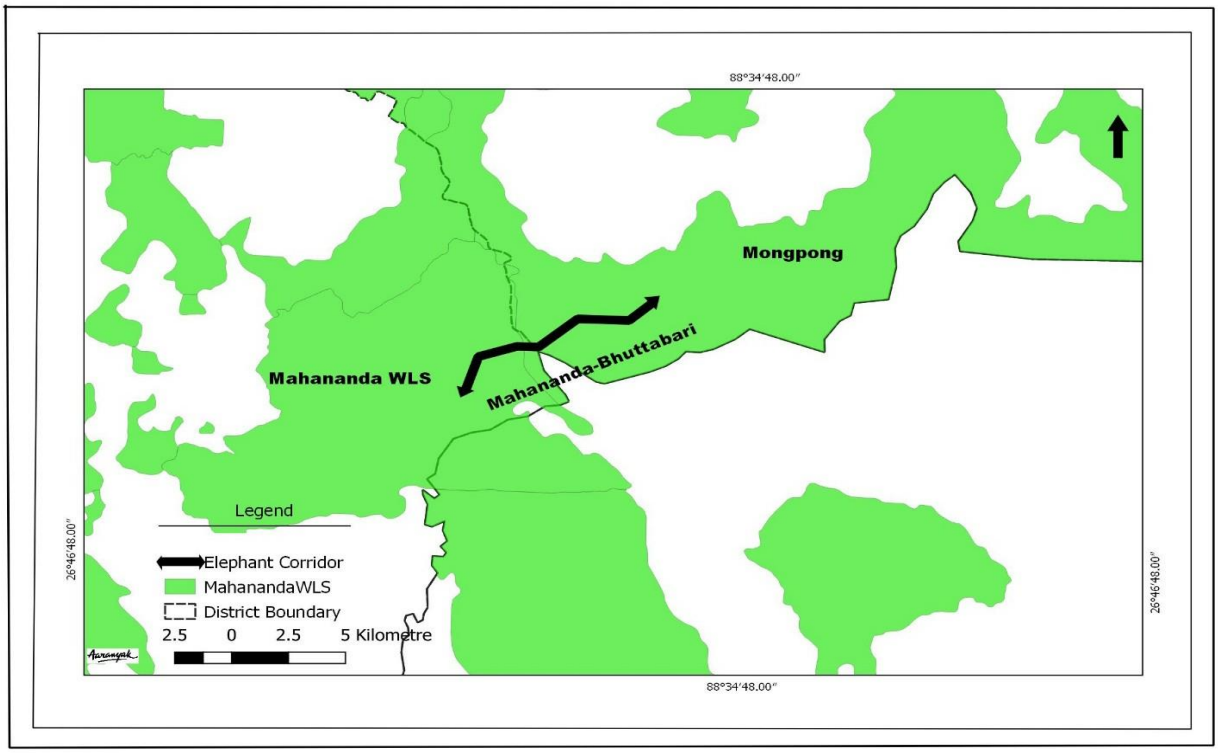
Map 7. Rating of disturbance in the elephant corridors (Highly disturbed, Disturbed, Less Disturbed)

3.5.3. Discussion

Based on the results, it is noted that all the corridors already identified by Tiwari *etal.,* (2017) are still in use by the elephants. Despite the fact that there are increased disturbances, the importance of these corridors cannot be ruled out. The protection and preventing further disturbances are key to permit elephant movements across these corridors.

3.5.4. Evaluation of a new elephant corridor

We have identified a new elephant corridor in the Mahananda WLS (Darjeeling division) to Bhuttabari RF (Mongpong forest, Kalimpong division) (Map 8). The corridor is around 500 m in length and 200 m in breadth. The elephant moves from Bhuttabari RF to Mahananda WLS via Chel, Washabari, Bagrakot area. The forest patch is more or less intact in the corridor area. It appears that this corridor is used throughout the year by elephants rather than seasonal movement. It has been observed that during the paddy season, the elephants tend to raid crops in Mongpong and Rongdongbasti and the herd becomes vulnerable to train hit as the railway track (Siliguri junction to Alipurduar junction) cuts the corridor in one location. There is another threat to the corridor in terms of an army barricade and a National Highway 31C.



Map 8. The identified new corridor

Fig 14. During field survey

CHAPTER IV: FEEDING HABIT

The rapidly declining natural habitat and shrinking of feeding grounds is a serious concern for elephants and for better management purpose, it is essential to identify the plant species eaten by elephants and their abundance in forest. This has direct implication in conservation and in managing habitat for elephants.

4.1. METHODS

We followed direct observation to identify the plant species eaten by elephants. In case the plants were not identified in field, we take photographs of the plants to be identified later by our taxonomist at Aaranyak. Any opportunistic encounter with elephants in the forest was considered to be one sample.

4.1.1. Direct observation and indirect evidence:

We observed elephants through binoculars feeding on in the forest. Once the elephant herd moves away, we try to identify the plant Species or else take photograph of the plants (flowering). A photographic documentation has also been made for the feeding plants including the identified and non-identified species.

4.1.2. Secondary information from Frontline staff and mahouts:

We interviewed 35 mahouts and frontline staff from Jaldapara, Garumara and Buxa Tiger reserve to list the species of elephants fodder plants and their preference level. The details of the staff interviewed are provided in table 4.

Sl. No.	Name	Age	PA	Designation	Work experience (Yrs)
1	Lakhan Rabha	48	BTR, Kalko beat	Mahout	27
2	Anil Karze	45	BTR, West	Mahout	20
3	Nimari Ch Dev	34	Garumara NP (South Range)	Mahout	11
4	Sanjit Ray	38	Garumara NP (Gorati Camp)	Mahout	20
5	Jaydeep Ray	30	Garumara NP (Gorati beat)	Mahout	12
6	Apron Ray	28	Dhupjora beat	Mahout	12
7	Badal Ray	37	Khunia beat	Mahout	13
8	Dinabandhu Barman	49	Garumara	Mahout	30
9	Hasibur Rahman	33	Garumara NP	Pattawala	7
10	Suraj Orang	29	Dhupjhara beat	Pattawala	4
11	Satish ray	45	Dhupjharabeat, Garumara NP	Mahout	21
12	Jugindra Sahoo	35	Dhupjhara beat	Mahout	35
13	Apron Ray	30	Garumara beat	Pattawala	12
14	Jawaharlal Orau	28	Dhupjhora beat	Mahot	10
15	ManjitRay	19	Garumara beat	Pattawala	1month

Sl. No.	Name	Age	PA	Designation	Work experience (Yrs)
16	Dilip Barman	27	Garumara beat	Mahout	9
17	Ramesh Orau	45	Dhupjhara beat	Mahout	25
18	Apu Ray	28	Dhupjhara beat	Pattawalla	11
19	Prakash Ray	29	Garumara beat	Pattawalla	3
20	Parimal Ray	27	Dhupjhara beat	Pattawalla	3
21	Babul Ray	35	Garumara NP	Mahout	10
22	Jogesh Ray	30	Garumara beat	Mahout	12
23	Dulal Ray	35	Dhupjhora beat	Pattawalla	15
24	Kausam Alom	23	Dhupjhora beta	Pattawalla	3
25	Dipok Ray	25	Garaticamp, Garumara NP	Pattawalla	5
26	Ravi Biswa Sharma	40	Jaldapara NP	Mahout	29
27	Durga Orau	45	Jaldapara NP	Mahout	29
28	Sujit Barman	44	Jaldapara NP	Mahout	25
29	Sujit Biswa Sharma	50	Jaldapara NP	Mahout	24
30	Sandel Orau	55	Jaldapara NP	Mahout	20
31	Siblal Orao	36	Jaldapara NP	Mahout	18
32	Ratilal Orau	35	Jaldapara Np	Mahout	20
33	Imul Hoque	48	Jaldapara NP	Mahout	34
34	Arjun Orau	34	Garumarabeat,Garumara NP	Pattawalla	5
35	Ram Bahadur Bhujel	35	Khuniabeat, garumara NP	Pattawalla	5

Table 4. The name of the forest staff interviewed for feeding data collection

4.1.3. Faecal analysis:

We initially planned to do facial analysis of fresh dung piles and collected 55 dung piles. However, we discussed the analysis procedure with experts and it has been confirmed that the process of identifying plant species from dung piles is difficult. As most of the digested plants cannot be separated from dung piles and the preparation of histological slides takes a long time. Hence, the plants can only by identified upto family level. Hence, for practical reasons, we did not continue this method.

4.2. DATA ANALYSIS:

The plant species that were recorded being eaten by elephants were identified by our team, expert taxonomist at Aaranyak and also department staff. All these plant species were listed and later on compared on their of presence in the vegetation survey plots for their presence availability.

We conducted survey for the fodder plants in 728 plots (10m x 10m size) in 262 randomly placed transects across the study

site Based on the availability of the particular species in plots, we estimated the abundance of the species.

The preference of each of these plants were defined as high, med and low based on sighting record.

4.3. RESULTS

We recorded 60 species of plants belonging to 36 families, including trees, grass, shrubs and herbs to be eaten by elephants based on our direct sighting records and secondary Information collected from interviewing 35 forest staff and mahouts on their knowledge on elephant food plants. The data is shown below.

Sl. No.	Species Name	Type	Family	Parts eaten	Abundance (the species occurred in % of plots surveyed)	Preference
1	*Setaria palmafolia*	T	Anacardiaceae	L,f	22%	M
2	*Bauhinia racemosa*	T	Fabaceae	L,f	18%	M
3	*Butea monosperma*	T	Fabaceae	L	8%	L
4	*Cassia fistula*	T	Fabaceae	L,f	4%	L
5	*Dillenia pentagyna*	T	Dilleniaceae	F	15%	M
6	*Gmelina arborea*	T	Lamiaceae	L	24%	L
7	*Grewia tiliifolia*	T	Tiliaceae	L,f	4%	L
8	*Phyllanthes emblica*	T	Phyllanthaceae	L,f	Not found	M
9	*Syzygium cumini*	T	Myrtaceae	L,f	4%	M
10	*Tectona grandis*	T	Lamiaceae	B	34%	L
11	*Ficus sp.*	T	Moraceae	T	27%	M
12	*Acacia catechu*	T	Mimosaceae	T	17%	M
13	*Dilleniai ndica L.*	T	Dilleniaceae	F	18%	H
14	*Albizzia odoratissima*	T	Mimosaceae	B	3%	M
15	*Albizzia procera*	T	Mimosaceae	B	8%	M
16	*Sterculia villosa*	T	Sterculiaceae	B	16%	H
17	*Bombax ceiba*	T	Bombacaceae	B	31%	H
18	*Strobilanthes sp.*	S	Acanthaceae	L,F	5%	L
19	*Grewia abutifolia*	S	Tiliaceae	L,F	Not found	L
20	*Helicteresisora*	S	Malvaceae	L,F	2%	L
21	*Symplocos racemosa*	S	Symplocaceae	L,F,f	Not found	L
22	*Spermacoce sp.*	H	Rubiaceae	L,F,S	5%	L
23	*Desmodium triflorum*	H	Fabaceae	L,F,S	4%	L
24	*Mimosa pudica L.*	H	Mimosaceae	E	14%	L
25	*Musa velutina*	H	Musaceae	E	4%	H
26	*Alpinia allughas*	H	Zingiberaceae	E	11%	H
27	*Urena lobata*	H	Malvaceae	L,F	8%	M
28	*Bambusa arundinacea*	G	Gramineae	E	17%	H
29	*Cynodon dactylon*	G	Poaceae	E	5%	L

Sl. No.	Species Name	Type	Family	Parts eaten	Abundance (the species occurred in % of plots surveyed)	Preference
30	*Cyperus rotundus*	G	Cyperaceae	E	3%	L
31	*Digitaria sp.*	G	Poaceae	E	Not found	L
32	*Dendrocalamus strictus*	G	Poaceae	E	12%	H
33	*Phragmites karka*	G	Poaceae	E	21%	H
34	*Narenga porphyrocoma*	G	Poaceae	E	25%	H
35	*Thysanolaena maxima*	G	Poaceae	E	12%	H
36	*Saccharum procerum*	G	Poaceae	E	18%	H
37	*Saccharum sponataneum*	G	Poaceae	E	27%	H
38	*Acacia pennata*	W	Mimosaceae	T	2%	L
39	*Tinospora cordifolia*	W	Menispermaceae	E	Not found	L
40	*Calamusf loribundus Griff.*	C	Palmae	B	3%	H
41	*Aegle marmelos*	T	Rutaceae	F	2%	H
42	*Mimusops elengi*	T	Sapotaceae	L	1%	L
43	*Carea arborea*	T	Lecythidaceae	L,F	2%	H
44	*Terminalia belerica*	T	Combretaceae	L	2%	H
45	*Musa aurantiaca*	H	Musaceae	E	2%	H
46	*Cayratia japonica*	C	Vitaceae	L	10%	L
47	*Albizzia lucida*	T	Leguminosae	B	15%	M
48	*Clerodendrum viscosum*	Sh	Lamiaceae	E	80%	L
49	*Dendrocalamus stictus*	G	Poaceae	E	10%	H
50	*Mallotus philippensis*	T	Euphorbiaceae	B	10%	H
51	*Eupatorium odoratum*	Sh	Asteraceae	E	50%	M
52	*Curcuma sp.*	H	Zingiberaceae	E	20%	M
53	*Thysolinea maxima*	H	Poaceae	E	10%	H
54	*Setaria palmaefolia*	H	Poaceae	E	12%	L
55	*Musa sp.*	H	Musaceae	E	4%	H
56	*Tinospora cordifolia*	C	Menispermaceae	L	6%	L
57	*Mycania sp.*	Sh	Asteraceae	E	40%	L
58	*Costus speciosus*	H	Costaceae	E	5%	L
59	*Morungai*	T		E	1%	L
60	*Suntala*	Un				

T=Tree, Sh=Shrub, H=Herb, C=Climber
G=Grass, E=Entire, B=Bark, f=fruit, L=Leaf
S=Stem

Table 5. Elephant fodder species, their abundance and the order of feeding preference.

CHAPTER V: HUMAN ELEPHANT CONFLICT

Human-elephant conflict has become a threat to both elephant conservation and human life in elephant areas and the management of such conflict is a primary goal for elephant conservation in range countries. Expansion of human settlements and agricultural field sacross Asia and Africa has resulted in widespread loss of elephant habitat, degraded forage, reduced landscape connectivity, and a significant decline in elephant populations relative to their historical size and overall range (Thouless *Et al*., 2016; Calabrese*etal Et al.,* 2017). This mega-herbivore commonly raids crops, causing economic losses, death and injury to people (Sukumar 1989; Hoare 1995; O'Connell-Rodwell *et al*., 2000). While ivory poaching is a major threat to elephants in Africa, human elephant conflict (HEC) is the most critical threat that the species faces in Asia, a widespread, complex, and intractable challenge to conservation. HEC Can lead to a decline of the population locally and limit meta –population viability by causing negative attitudes within the local communities. Although HEC occurs throughout the species' range (Sukumar, 1991; Mishra, 1997), it is more intense in the areas where there is rapid decline of forest cover and blockage of traditional elephant routes. Unprecedented human population growth in Asia has caused increasing conversion of natural habitat to human dominated landscapes, bringing elephants and humans into greater contact and conflict (Fernando *et al.,* 2005). Confronted with the escalating HEC, the historical respect and reverence for elephants in Asian cultures and societies is rapidly eroding (Fernando *et al.,* 2005). Although the North Bengal landscape supports less than 5% of the total elephant population in India it is one of the most conflict prone areas in the entire country.

5.1. METHODS

Data were collected on conflict incidents including crop-raiding, house damage and human deaths and injuries from October 2016 to Dec 2018 (first two years of the study period). To establish a reliable and independent conflict reporting system (Hoare 1999a), our team visited each conflict incident that has been reported to our team during this period. However, there were numerous unreported cases of conflict which were not possible to visit. The reported incidents within the study area were visited for verification purposes and to to record the location in Universal Transverse Mercator (UTM) coordinates usinga a Garmin GPS12 satellite navigation unit (Garmin Corp., Ulathe, KA). Further details of the incident, such as elephant group size and composition (male groups vs. female-led family groups; cf. Sukumar & Gadgil 1988) and time of incident, were recorded from complainants on a standardized reporting form (Hoare 1999b).Incidents of human death and injury were similarly recorded. The UTM coordinates of each incident were imported into the Arc GIS 9.3 and ERDAS Imagine 9.1 software package for manipulation prior to analysis.

The limitation of the process is that, it was not possible to visit each conflict incident location with the limited man power and vastness of the study area. Additionally, There is enormous amount of HEC incidents occurred throughout the study area. Hence, we collected secondary dataset from the Forest Department.

5.2. RESULTS

We recorded 405 conflict incidents (n=405) during the study period. This included 112 incidents of house-damage, 46 incidents of physical injury/deathand2 47 incidents of crop-raiding (Fig 14b). Elephants raideda number of crops including paddy (*Oryza sativa,)* maize (*Zea mays,)* wheat *Triticum aestivum)* and banana (*Musa paradisiaca)* and many different kinds of vegetables. Conflict occurred throughout the period but intensified during monsoon (November-January) just prior to the paddy harvest and (June-August) during the harvesting time of maize in some areas where maize is grown. The size of crop-raiding elephant groups varied from 1 to 33 (median=1) with 198 incidents involving single elephants and 102 involving female-led family groups. We could not ascertain the identity for 105 incidents..

However, we considered only 182 single elephants (n=182) and 94 female-led family roups (n=94) in the final analysis for the soundness of the dataset.

The incidents were found to be clustered in certain areas signifying that few areas are more affected than others. Map 9 shows the location of crop raids and Map 10 shows the house damage in Buxa TR.

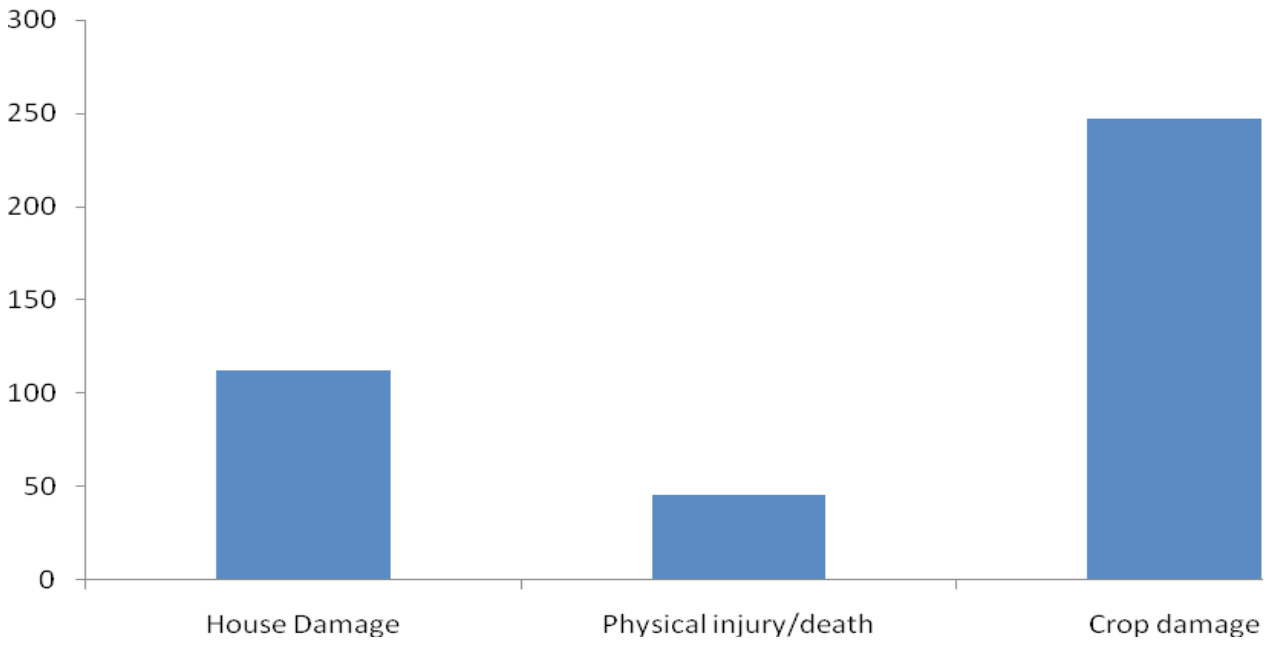
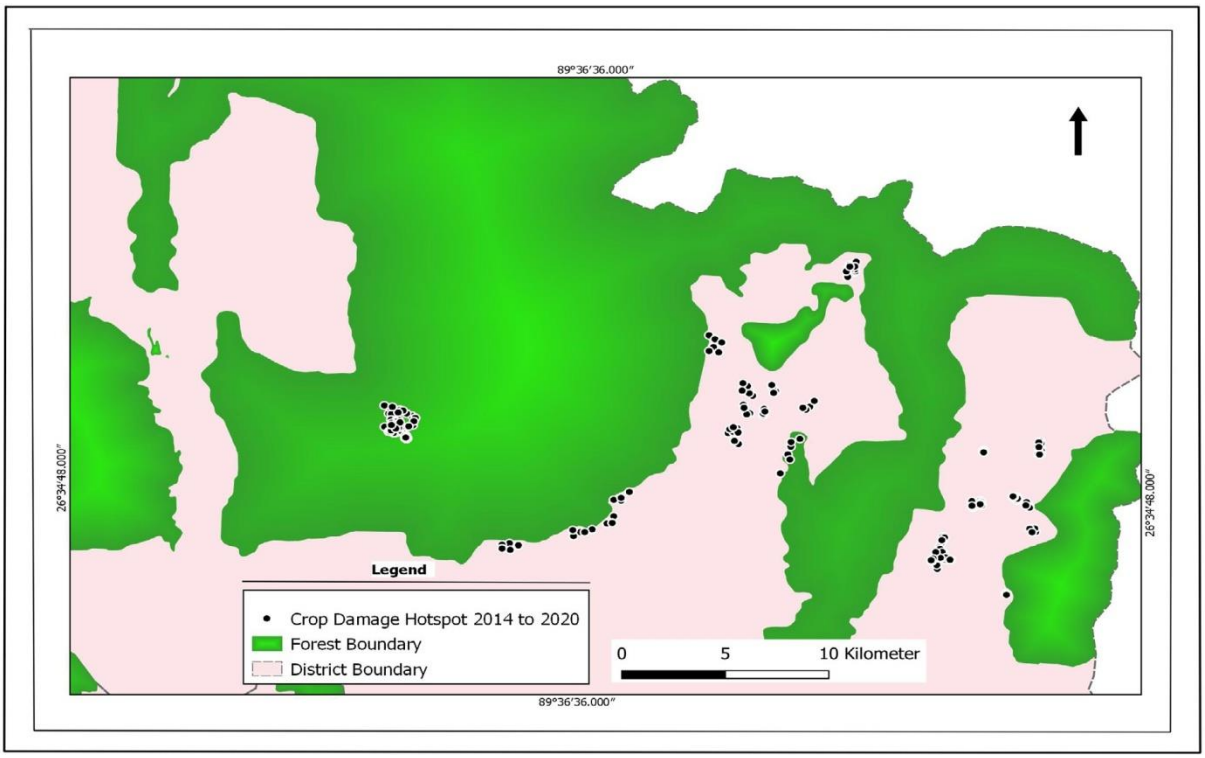
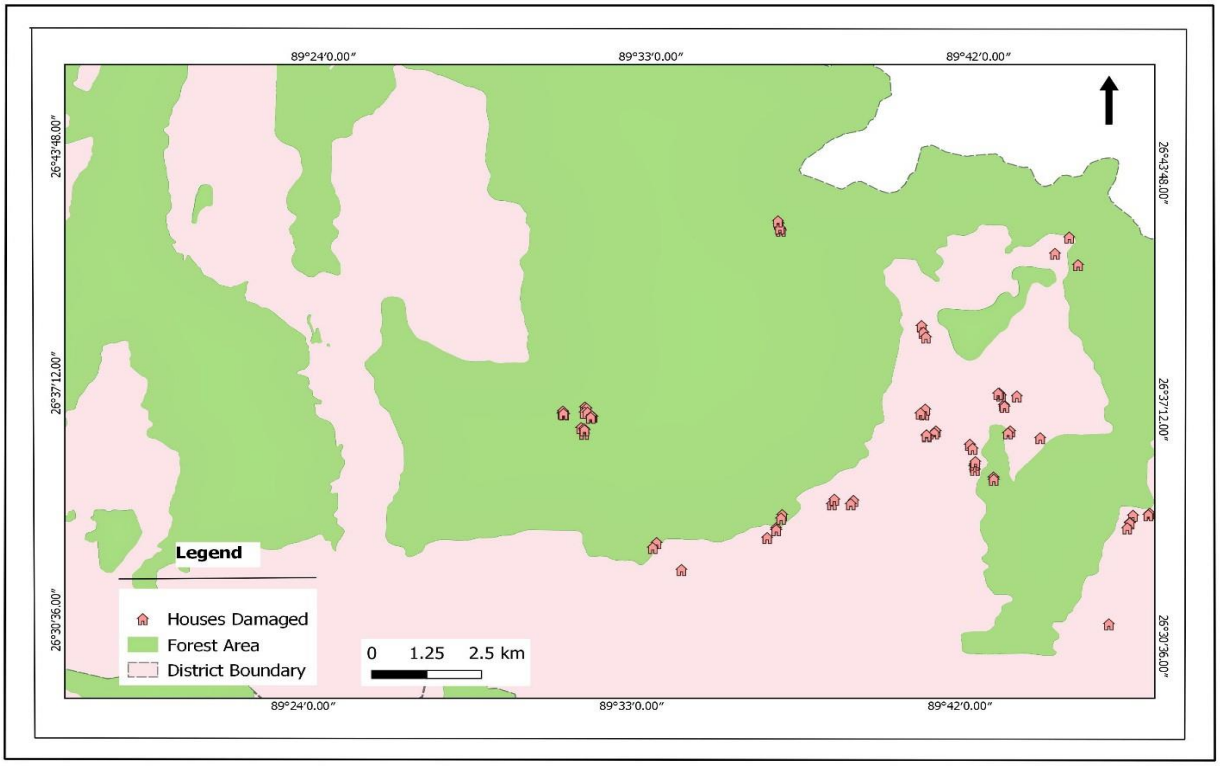


Fig 14. Types and numbers of HEC incidents in the study area during 2016-18



Map 9. The crop raiding incidents in Buxa TR during 2014-20 (with additional data from FD)



Map 10. House damag ing incidents in Buxa TR during 2014-20 (with additional data from FD)

5.3. Secondary information from Forest Department

We collected available data from Forest Department and analysed further. We noticed that, all divisions follow different formats to collect HEC data (crop damage, house damage, human death, elephant death *etc.*) and not very well organised and maintained. We found it extremely difficult to sort out the dataset and collect the required information. For example, the Buxa East and West divisions have information on how many conflict incidents took place in a year along with other related information, while Jalpaiguri division have information only on the area of crop damage by wild elephants but no report on how many incidents.

We strongly believe there should be one common protocol with similar formats for department data collection throughout all the forest divisions in the North Bengal landscape.

From the available secondary dataset, we recorded atleast 16500 incidents of HEC which includes 12281 (n=12281) incidents of crop raid, 3993 incidents (n=3993) of house damage, 162 human death case (n=162), 92 incidents of human physical injury (n=92) and 73 incidents of elephant death (n=73). The below table 6 shows the secondary dataset collected from each division.

Division	Cropraid	Human Death	House Damage	Elephant Death	Human Injury
Buxa TR West		33	215	29	
Buxa TR East	2820	22	484	13	24
Jalpaiguri		11	2577		18
Kurseong	9361	24	855	31	0
Baikunthapur		31	0	0	0
Gorumara		41	77	0	50
Total*	**12181**	**162**	**3993**	**73**	**92**

Table 6. HEC in various divisions during 2013-18 (data obtained from FD)

5.4. FACTORS AFFECTING HEC

Spatial

The spatial analysis were conducted based on the human death and secondary data collected from department. There were at least 128 total death of human from elephant attack during last five years (2013-14 to 2017-18) in the entire landscape. During 2019, we did not collect the Human death data as the HEC objective activity was to be completed by second year.

Most of the death cases (78%) were recorded in the crop fields and the remaining inside the forest. We also noted that that bulls were responsible for more than 90% of the cases.

Our team visited 78 of the human death incidents reported to us (Map 11 & 12) (46 incidents during our study period and the remaining is from the past). We plotted the

Incident location in GIS layers and assessed the distance of each location from the nearest forest and nearest waterbody. The results suggested that the 'distance from forest boundary' is significantly negatively correlated with the human death incidents (R^2=0.784). This indicates that as the distance from forest boundary increases the number of human death decreases which suggests that most of the incidents took place nearer to forests. The R^2 value suggested only 22% other factors may have influence on human death by elephants.

Similarly, we found that the distance from waterbody is also significantly negatively correlated with human death incidents (R^2=0.268) (Fig16). This shows that there are more incidents nearer to a waterbody and death case decreases as the distance from waterbody increases.

We noticed that most people died in the forest when they were visiting for firewood collection or any other purpose (Fig15).

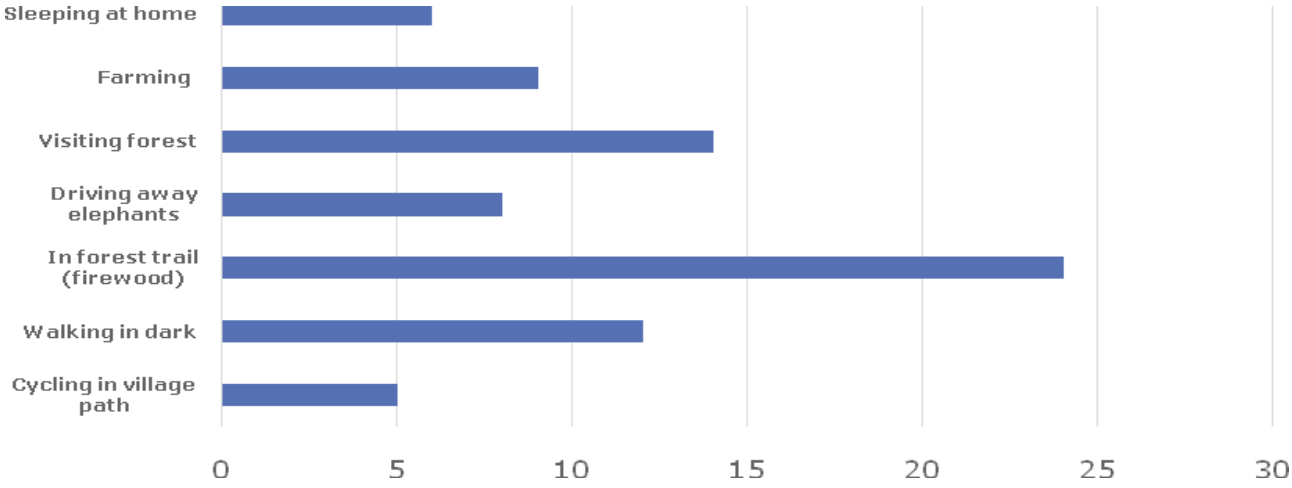


Fig 15. Number of deaths in different categories of activities they were engaged during the accident

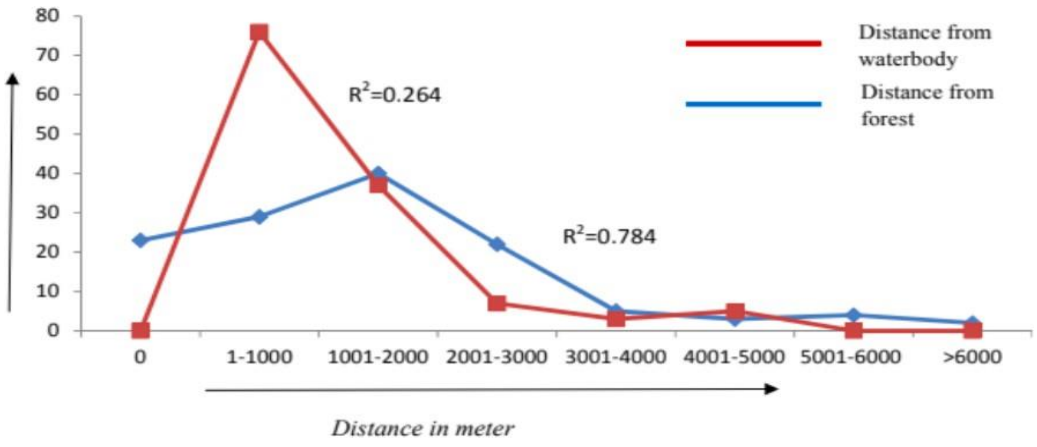
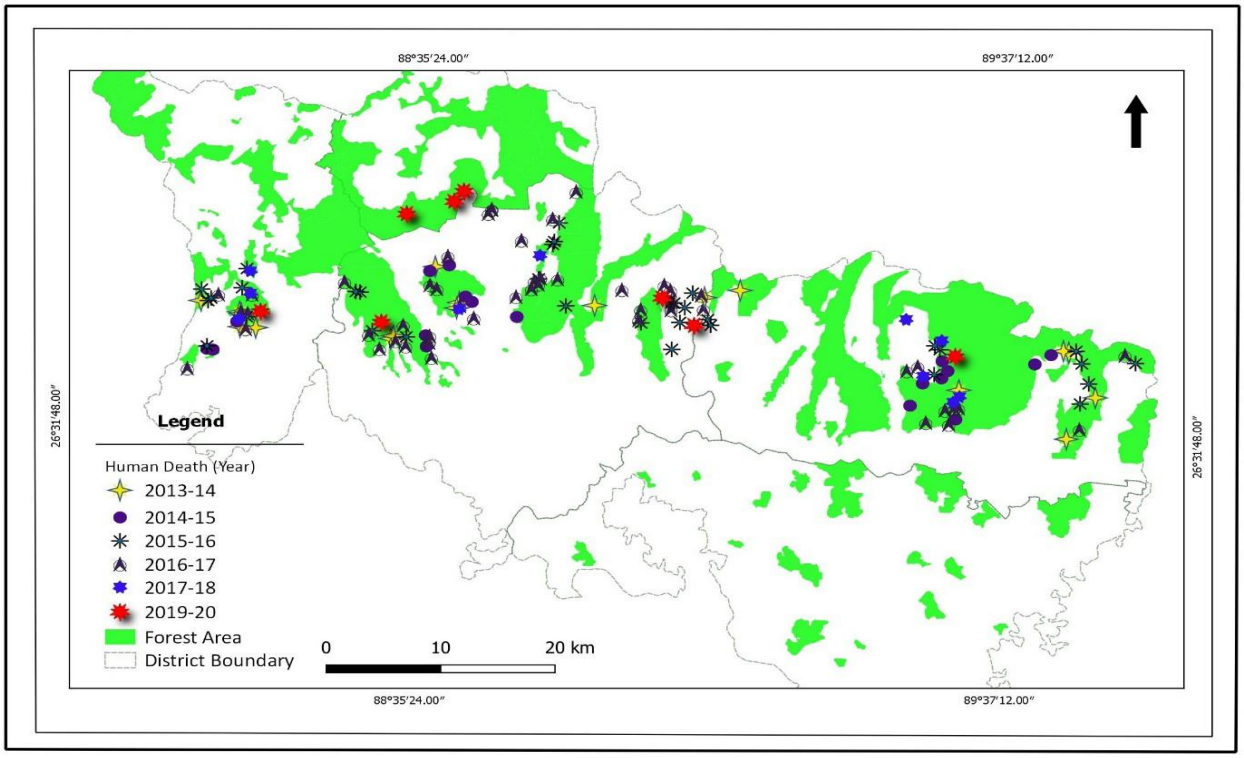
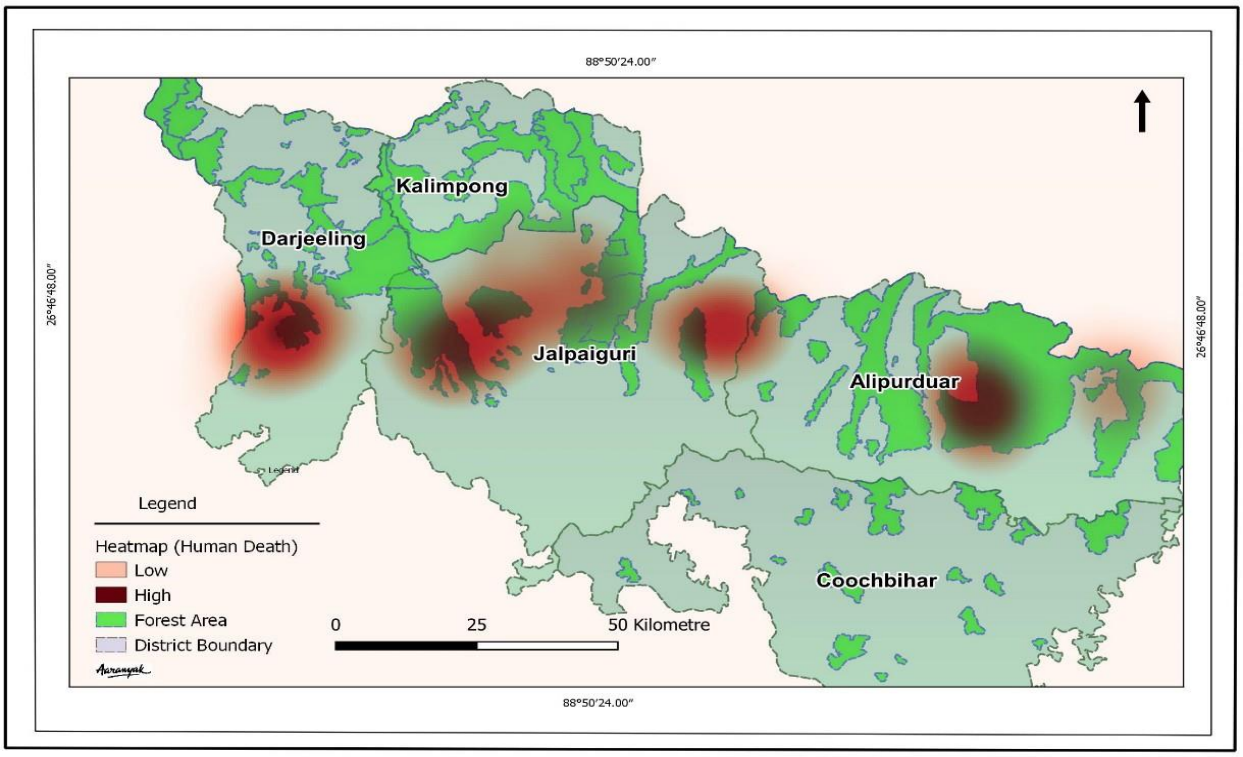


Fig 16. The relationship between human death and distance to forest and waterbodies



Map 11. Locations of the human deaths from HEC from 2013 to 2018 (with additional data from FD)



Map 12. The heat map of HEC human death areas in the landscape

This has significant management implication for the forest department in managing elephants. There should be more patrolling and protection efforts in areas where both crops and waterbodies exist together rather than focusing on the entire area.

5.3. TRAIN COLLISION

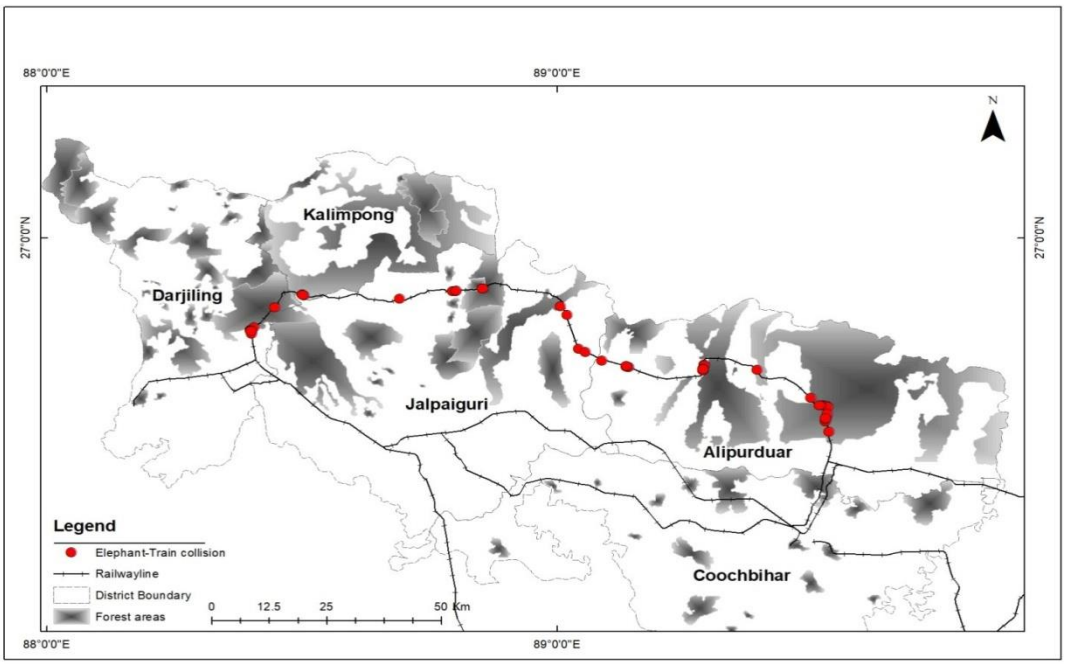
We recorded 42 train accidents resulting in the death of 68 elephants during 2004-2019 (Table 7). The data is collected from various new paper reports, online media searches and department. We assume that this is the minimum number of incidents that took place as we might have missed a few. Based on the number of accidents, we identified five different vulnerable locations.

5.4.1. Results

The Buxa division witnessed highest number of train accidents with elephants (n=10), followed by Mahananda WLS (n=9) and Jalpaiguri (n=8). But in terms of Elephant death, Jalpaiguri division has witnessed highest elephant death (n=22) followed by Buxa (n=17) and Garumara (n=11) (Map 13).

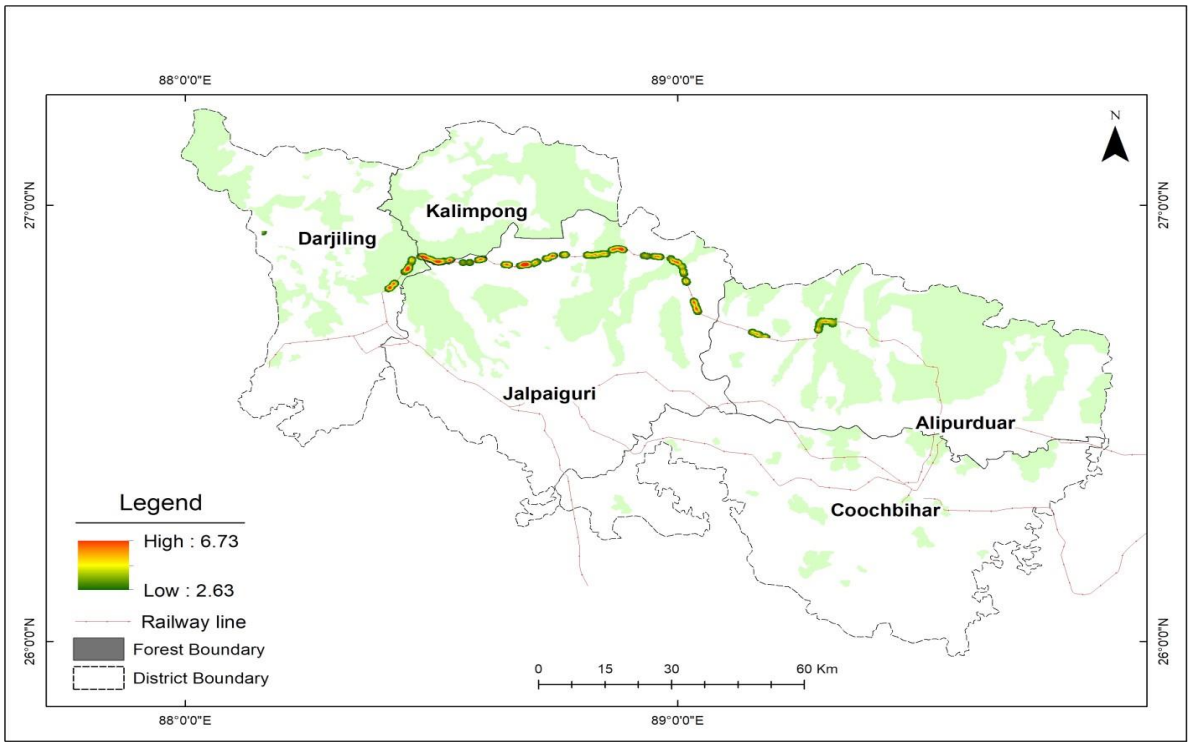
Division	No of Accident	%	No of death	%
Buxa	10	25	16	23.88
Mahananda	9	22.5	9	13.43
Jalpaiguri	8	20	22	32.83
Jaldapara	6	15	5	7.46
Kalimpong	3	7.5	3	4.47
Gorumara	3	7.5	11	16.41
Kurseong	1	2.5	1	1.49
Total	**40**		**67**	

Table 8. Number of elephant deaths by train hit in different forest divisions During 2004-19



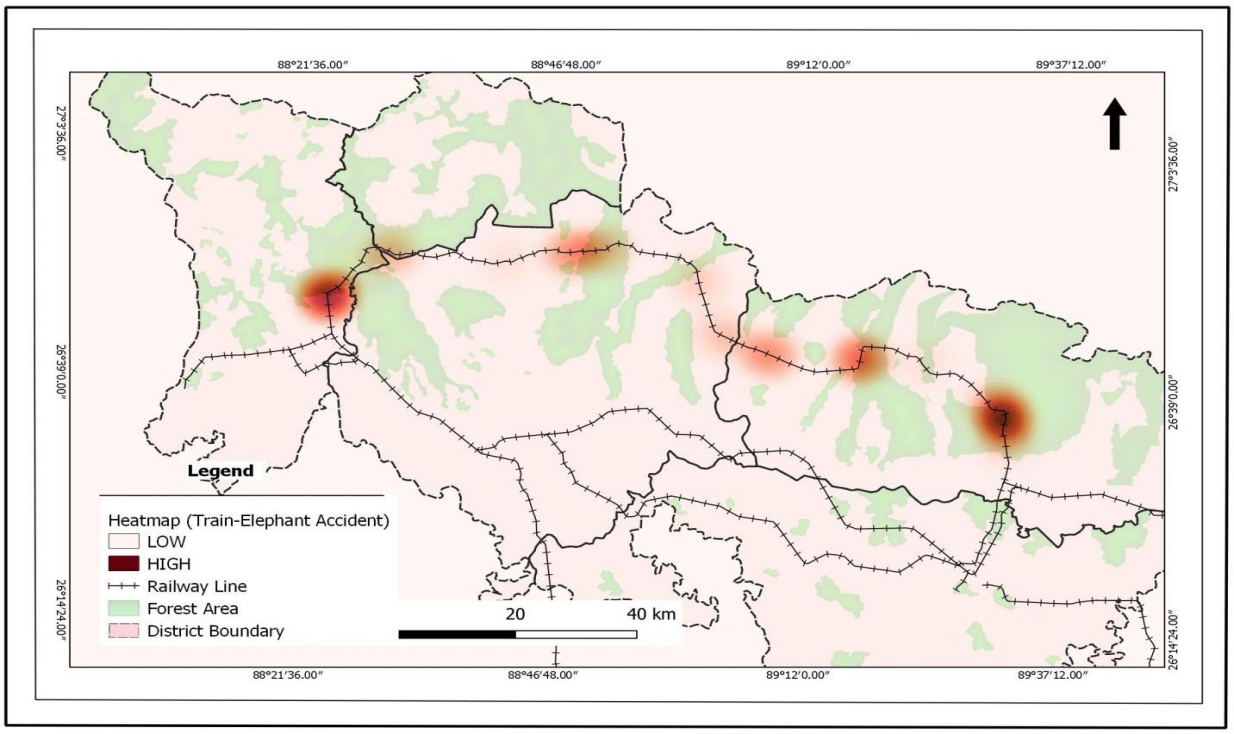
Map 13. The train-elephant accidents locations in the study area during the last 15 years (2004-2019)

Our team walked along the railway track to assess the elephant presence density (Based on Kernal density distribution) from Alipurduar junction to NJP junction (a stretch of 150 km) during Nov-Dec 2018 (Map 14). This has helped us identify the potential locations of train accidents and develop a vulnerability map indicating the susceptible locations (Map 15).



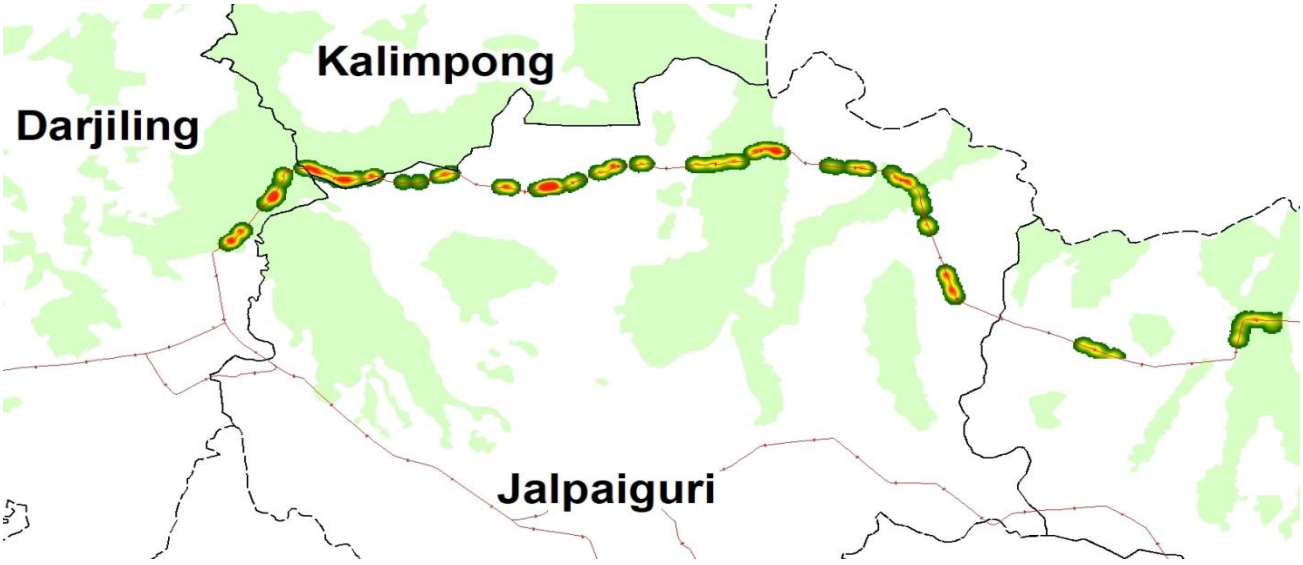
Map 14. The kernel density map of the railway track from ALPD to NJ Pjunction.

(The red highlighted spots are potential locations of elephant-train collision)



Map 15. The potential accident areas based on heat map of train accident spots

Fig 17. The field team during railway line survey



Map 16. Elephant presence in the track co-related with past accident locations.

We noticed that there are certain areas which are more preferred by elephants to cross the railway track. Our kernel density estimation results showed that Alipurduar, Garopara, Damdim, Odlabari, Banarhat, Binnaguri, Garopara, Dalgaon, Chalsa, Nagrakata, Hasimara were to be more vigiled. There were 36 successful crossing while 4 incidents of train accidents recorded during our study timeline. The data on successful crossing were taken from verbal Interaction with forest staff. We found 12 occasions of elephants foraging near tracks with no crossing attempt.

We recommend developing mitigation nmeasures like realignment, developing tunnel at certain stretch of the track (Sevok-Gulma, Kalchini-Rajabhatkhowa) however with limited resources temporary mitigation tactics can be adopted. Details of the recommendation were discussed in later chapter.

5.4. PEOPLE'S PERCEPTION ON ELEPHANTS

We interviewed 502 people from the entire study area using a structured questionnaire; however only 242 respondents' data have been analysed in this report. This is largely due to incomplete and contradictory answers from the remaining participants. The 242 respondents include (male = 217; female = 25, mean age = 40.58 ± 14.07). Of these, 121 individuals were farmers, 30 tea garden labours, 22 daily labour, 10 school teachers, 9 person doing business, 7 person working as mason and 43 others (includes shop owners, carpenters, drivers, tailors *etc.*) out of these, 13 persons were involved in tourism/environment related activity while 228 people were not involved In any environment/conservation activity. The number of male respondents was high as we took household as the sampling unit, and men are the general spokespersons in the community. This constraint in questionnaire-based sampling is reflected in other studies as well (Barua *et al.,* 2010). Further, 102 respondents were from the local Nepali community followed by 78 Adivasi, 32 Rajbanshi, 17 Bengalis and 13 persons from other communities.

Again all questions were not relevant to 242 respondents; for example, 'does PA benefit from tourism?' was only applicable to those living close to PA, which was 155.

5.5.1. TOURISM AND BENEFIT

We found that 14.19% (n=22) of people believe that the nearest protected area (PA) is benefited from tourism while 84.52% (n=131) people said there is no benefit of having the PA nearby. Two people said they are not sure (Fig 18). Only 22.58% (n=35) people think that elephant is important for tourism while 76.77% (n=119) people believe that elephant is not important for tourism.

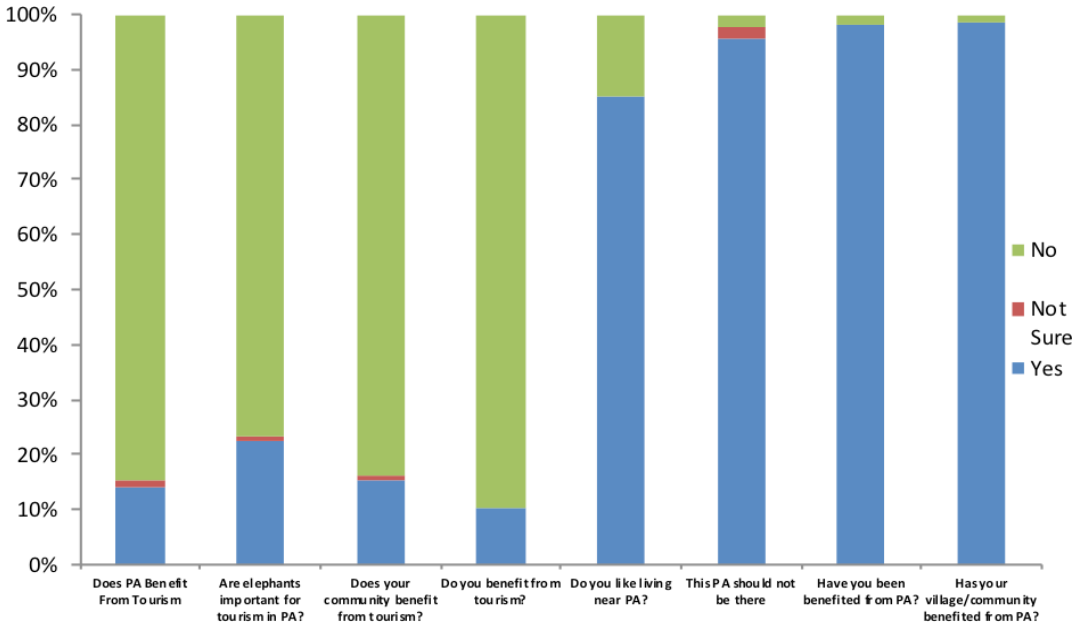


Fig 18. Perception of local people on tourism.

Most people believed that (83.87%; n=130) their community is not benefitted from tourism while only 15.48% (n=24) believed their community is benefitted. When asked about individual benefit, 89.68% (139) people said they are not benefited and only 10.32% (n=16) people benefitted from tourism.

5.5.2. PERCEPTION TOWARDS FOREST

Most people (85.12%; n=206) liked living near the PA or forest while 14.88% (n=36) people did not like living near a PA or a forest. This is because most of the people (94.21%, n=228) benefitted living near the forest and only 5.79% (n=14) people have not benefitted from the PA. The benefits includes firewood/fuelwood (40.42% ,n=213) followed by 31.69% (n=167) other benefit, 25.05% (n=132) from natural resources, 2.85% (n=15) from tourism (Fig 19).

Most of the people believed (98.76%; n=239) their community benefitted from the forests, while only 1.24% 9n=3) people said their community is not benefitted from the forest. This benefits again includes fuelwood (42.87%, n=224), others (30.09%,n =161), natural resources (25.79%, n=138).

Most people (63.22%, n=153) don't want elephants in the forest because of the conflict issues and only 28.93% (n=70) want elephants, while 7.85% (n=19) people were not sure.

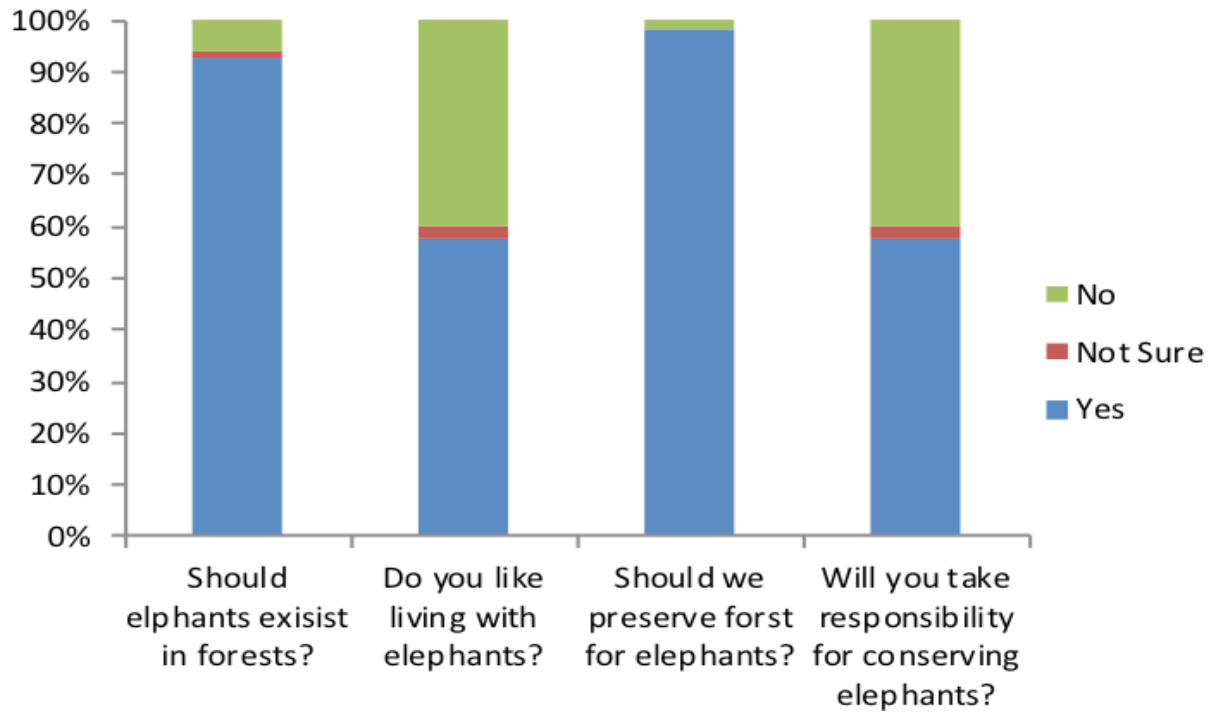


Fig 19. People's perception on elephants and forests

5.5.3. HEC AND COMPENSATION

Almost all respondents said that elephants come to their village (97.93%, n=237) and all respondents faced problem of crop raiding (100%, n=242). Most people (78.51%, n=190) said that elephant raid crops1-10 times per year, 11.57% (n=28) people said that elephants raid crops more than10 times per year (Fig 20).

Half of the respondents (50.27%, n=185) said that most crop raid are done by group elephant and 47.28% (n=174) people said that crop raid are done by loner elephant.

Most people didn't receive compensation (71.07%, n=113) from department while 28.30% (n=45) said they received compensation. Again 57.23% (n=91) people faced problems in getting compensation while 42.77% (n=68) people didn't face any problems.

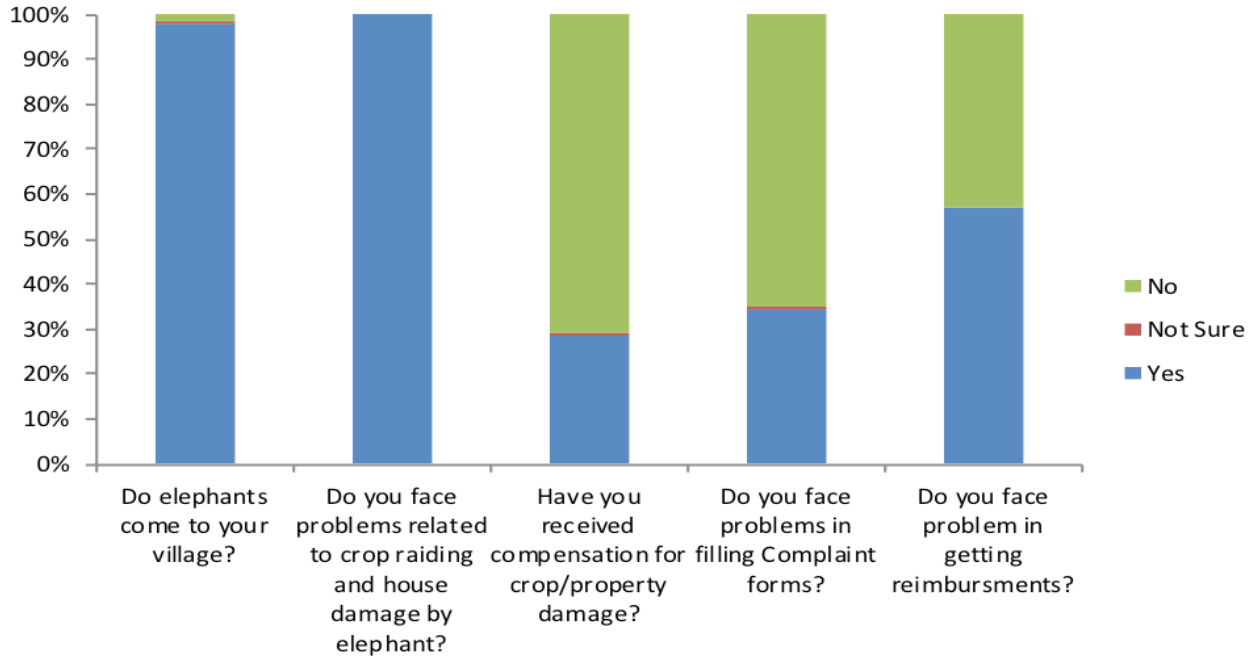


Fig 20. People's perception on HEC and compensation from department

5.5.4. Perception towards elephant

Most people (57.44%, n=139) likes to live near elephant and only 40.08% (n=97) people don't like to live with elephants while 2.48% (n=6) people were not sure. Almost all people (97.93%, n=237) have positive attitude towards the forest and said that they want forest to be preserved for elephants. More than half of the people (57.44, n=139) would like to take responsibility in conserving elephants while 40.08% (n=97) people don't want to take responsibility. Again most people believed that elephant is a property of forest department (50.83%, n=153), followed by national property 21.59% (n=65). Only 11.96% (n=36) people believed that elephant is everyone's property. Most people (79.33%, n=192) believed that forest department should take responsibility of conserving elephants followed by public (27.68%, n=67), and very less responsibility for everyone (4.13%, n=10) (Fig 21).

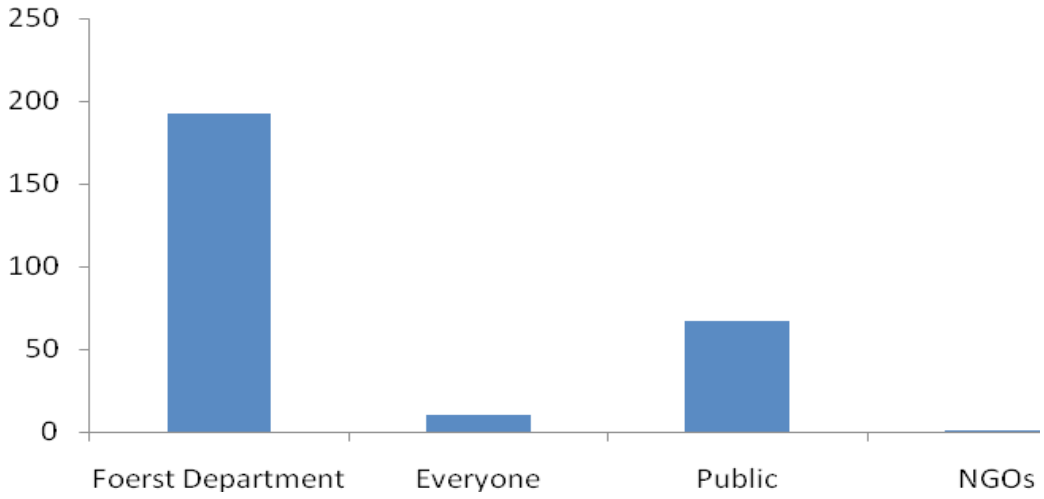


Fig 21. People's perception on who should take responsibility of conserving elephants

5.5.4. MITGATION STRATEGIES

When asked about who is responsible for crop damage, 46.69% (n=113) people said nature is responsible, followed by forest department (42.56%, n=103), elephant (7.02%, n=17). Only 2.48% (n=6) people believed that public/local community is responsible for crop damage. Most people (61.03%, n=202) think that forest department should take responsibility in protecting crops in field, followed by (25.98%, n=crop Field owner) and 12.99% (n=43) by village Community (Fig 22).

Maximum people (27.30%, n=101) think guarding by forest department can be one option in preventing crop raid, followed by electric fencing (23.51% ,n=87), guarding by community (12.97%, n=48) only 4.05% (n=15) people likes to guard by owner himself (Fig 23).

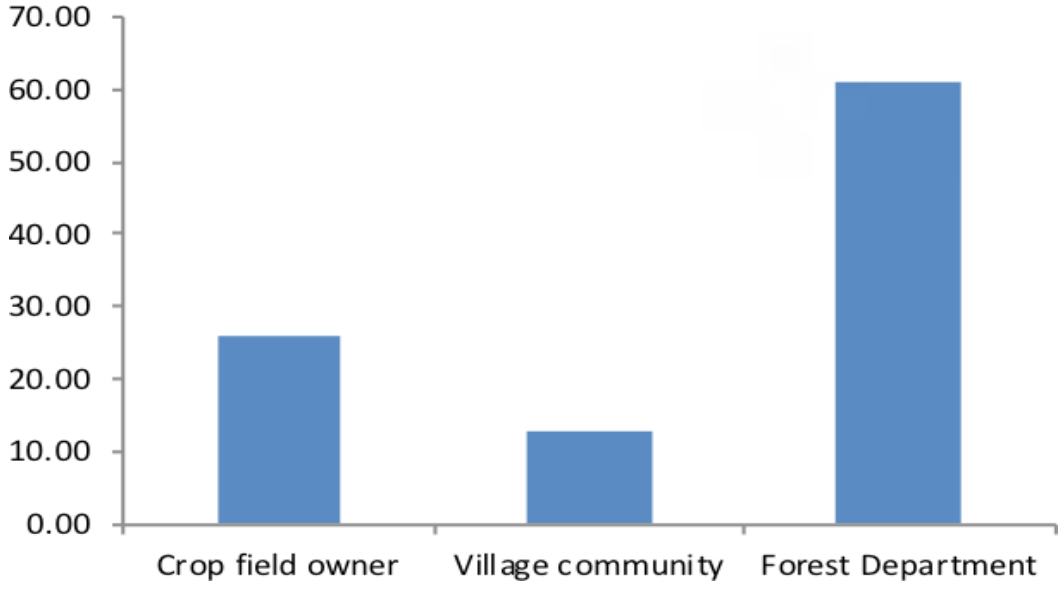


Fig 22. People's perception on who is responsible for crop protection

Overall people had positive attitudes towards elephants but it seems that the benefit from tourism is not equitably distributed among the society. This may create antagonistic attitude of the locals towards forest department.

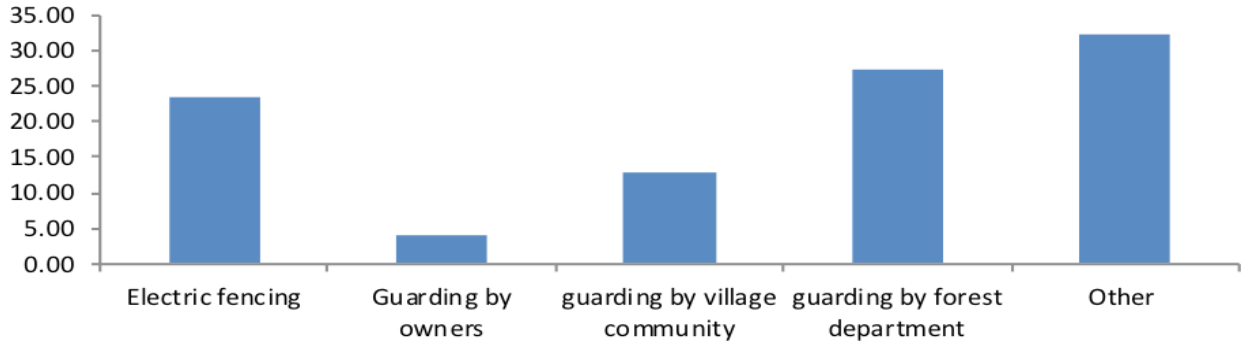


Fig 23. HEC mitigation methods suggested by the respondents

CHAPTER VI: CARRYING CAPACITY

It is assumed that the population of wild elephants in North Bengal has reached a level that has caused concern among managers and conservationists since last few years. Studies in Africa states that when elephants become 'over-populated' in an area, their over utilisation of the resources leads to habitat degradation. The managers and conservationists are often found to be interested to know the maximum number of elephants an area can sustain with its available forest resources. Although it is clear that elephants have an impact on their habitat, it is far from clear whether or not this impact is detrimental. However, there is a huge amount of pressure to reduce elephant population sizes because of the perceived increase in numbers and the subsequent potential effects on human and ecosystem as a whole. There are two major issues that may influence population size –the regulation of elephant population size by density dependent factors and the impact elephants have on their habitat at higher densities before reaching equilibrium levels. By carrying capacity, we mean the availability of resources and competition effectively limiting the number of individuals that a given area can sustain. Basically, density dependence occurs when population size (N) of a species exceeds carrying capacity (K), resources become a limiting factor and bring the population down (through increased mortality or emigration) to below K. Then, because N is less than K, it can again grow. Because the relationship with resources/habitat relates to the density of the species, it is called density dependence. The other possibility is that certain factors that are not mediated by species density (*e.g.,* weather conditions) may influence N. This is called density independence. This is likely to be a less important driver of Asian elephant. This equilibrium cycle has not been historically studied on elephant populations in India as the lifespan of elephants and slow growth rate makes it difficult to assess long-term population data. Hence, we are distantly uncertain on the level at which elephant populations will self-regulate by density-dependent factors. There is no published evidence that survival rates, competition, mortality, body condition or any other potential indicator that populations are above sustainable levels are increasing at the current population levels, despite the fact that these population levels are assumed to be high in North Bengal and in India. Carrying capacity of ecosystem in short is the ratio of productivity of feeding resource to average requirement of an individual (Wallmo *et al.,* 1997).

Sukumar (1986) reported that elephants are generalist feeders requiring about 108 kg fresh (27kg dry) plant fodder per day owing to its enormous size. Hence the yearly requirement for a single elephant 39.42 ton of fodders.

6.1. METHODS

To calculate the carrying capacity of elephants in the North Bengal landscape, we conducted literature review to find out the mean productivity of mixed forest like in North Bengal. Desai (1992) studied the productivity of mixed forest including grasslands and calculated the mean productivity of these forests is around 200 ton per km^2. To estimate elephant carrying capacity in North Bengal, we assumed 10% of total above ground biomass as biomass available for utilization for elephants following (Madugundu *et al.,* 2008). This assumption was based on regeneration capacity of forests (Madugundu*etal. et al.,* 2008). The remaining 90% of the fodder can be removed for regeneration and other herbivores like Gaur, Sambar, other ungulates and also cattle. We measured the carrying capacity by following this formula -

Carrying capacity of elephants = Biomass Available / Annual biomass requirement by elephants

6.2. RESULTS

The total biomass productivity for North Bengal (considering elephant forest habitat area is 1523.50 km^2) is 304700 tones. Now if we take the required 10% of the total biomass, the amount available for elephants will be 30470 tones.

Based on biomass requirement and sustainable biomass available, the carrying capacity of North Bengal is measured as 772 elephants (30470 / 39.42). However, we would like to clarify that this calculation assumes that the social pressure on elephants is zero and that the elephants' dependence on the cultivated food is inconsiderable, and therefore the estimation remains hypothetical. There are methodological constraints in factoring in the high human population density (679/sq km) of the landscape and on the other hand the elephants foray into the agricultural lands for food.

Based on this productivity, we calculate the carrying capacity of elephants in the protected areas in North Bengal (Table 9).

Name of PA and Non PA	Total area (km^2)	Speculated Carrying Capacity
Buxa Tiger Reserve	761	386
Jaldapara	217	110
Gorumara and Chapramari	90	45
Mahananda	158	85
Non PAs	288	146

Table 9. The estimated carrying capacity of elephants in each of the protected areas in North Bengal

6.3. SIGNIFICANCE

The tota lelephant-bearing forest are in North Bengal that can produce biomass is 1523.50 km^2 and this area can potentially support 772 elephants with a density of 1.97 elephants/km^2. In well studied elephant populations in southern India the population density has remained stable at over 2 elephants per km^2 in the past two decades of the investigation (Jathanna *et al.,* 2015). In Africa, 0.37 elephants per km^2 has been postulated as the level above which the elephants would begin to be regulated by density-dependence (Van Aarde *et al.,* 1999, Slotow *et al.,* 2007). Unfortunately such data is lacking for Indian scenario, but it is worth noting that the wetter habitats in Asia (compared to Africa) are able to ecologically support much higher densities. From the long term studies in southern India, it is reported that elephant can occur at a density of 2 elephants/km^2, provided the habitats are unfragmented, well-protected and low anthropogenic pressure (*e.g.,* Nagarahole-Bandipur in Karnataka, Jathanna *et al.,* 2015). Given that incase of North Bengal, with high incidents of human-elephant conflict, fragmented habitats and anthropogenic pressure, we assume the elephant density to be stable at 0.5 elephant per km^2. In a forested landscape of 1523.5 km^2 (existing elephant habitat in North Bengal which includes all Pas and RFs with elephant distribution), we predict that the area can support a population of 761 elephants. This assumption is almost same as the calculate carrying capacity based on biomass available.

The present population size in North Bengal from the recent census carried out by MoEFCC estimated 488 elephants across the landscape. This suggests that the landscape is capable of sustaining another 250-300 elephants. But as the human pressure increases leading to loss of habitat, the ecological carrying capacity will begin to reduce. The analysis also indicates the clustering of elephant distribution in protected areas and patchy distribution outside the reserves. An increased number of elephants may not necessarily result in more conflict with humans. It is seldom that the entire population is involved in human elephant conflicts. Hence, even if the carrying capacity estimation shows slightly more than the present population size in North Bengal, it does not entail more conflicts.

CHAPTER VII: RECOMMENDATIONS

The issues related with human elephant co-existence is challenging and complex as land has become a scarce resource for both growing human population and cornered elephantpopulation.The18kmlongfencinginNepalborderbyNepalgovernmentfromupperTiringto Panitanki, protecting Jhapa district in Nepal has caused severe damage and enhanced HEC incidents.

For management of elephant population in North Bengal, we recommend short term and long-term strategies to be implemented by the department. Based on the identified hotspots of HEC in the region the government may implement following steps:

1. Physical barrier

→ Although HEC is prevalent in the entire stretch from Teesta to Mechi including Kurseong and Jalpaiguri division with highest number of incidents, our study could identify few high conflict zones in the landscape which are listed below as top priority areas.

→ Based on our results, we recommend these sites for top, moderate and low priority for installing urgent permanent or seasonal physical barrier such as solar fencing. The prioritized sites are mentioned below-

TOP

Naxalbari block, Matigarha, Khoribari block (Ketucapur jote, Nirpania, Mallabari, Jharujote, Deomini). The Baikunthapur division (Rangdhemali, Sarugara, Mantadhari, Gajoldhoba 10 No., Mech basti) and Bhutta bari area under Kalimpong division, The Saylee Tea Garden, Ranithera, Noam, Chel), the Chapramari area (Ramsai, Dhupjhora, Batabari, Sulkapara, upper Kolabari basti)

MODERATE

Bhuttabari, Jaldhaka 1, Indong tea garden, Sakam, Diana tea garden, Karbala, Bandapani, Khasbasti, Kathalguri tea garden, the Moraghat area (Sonakhali forest village), Ramjhora tea garden, Dhumthipara tea garden, Garganda tea garden, Lankapara, Holapara, Totopara, the Jaldapara area (Uttar Mendabari forest village, Falakata area, Kodalbasti, Mathura tea garden (under Chilapata), Bharnabari tea garden, Deech tea garden, Dolsinghpara

Hamiltonganj, Pana, Paitkapara, Nimati, Lotabari, East Garam,West Garam, Rajabhatkhowa, 28 mile basti, Santalabari, Kartika, Tiamari, Moinabari, Samuktala, Chitra (South Rydak), Newland tea garden, Kumargram block, Bholka-Balapara, Sankosh beat

2. Seasonal fencing

→ During our survey, the people were keen on the installation of electric fencing as one of the measures to reduce HEC. In few areas like Takimari village (Teesta char), people have installed illegal electric fencing which already injured several elephants.

→ Seasonal solar fencing may be installed in high HEC prone villages. The fencing may surround the paddy field than fencing the movement path of the elephants. This will help in obtaining the confidence of local people and win win situation for both elephant and human.

→ Chilli fencing Preventive measures, such as chilli-fencing have been implemented in various places to reduce HEC (Hedges & Gunaryadi, 2009) and are successful to certain extent. In North Bengal, chilli fencing may work provided department work hand in hand with local communities.

3. Community guarding

→ Community guarding may have the potential to drive away crop raiding elephants, but this has to be more strategic and highly motivated. We encourage forming smaller SHGs (Self Help Group) for crop guarding in this case.

→ ERUs: We suggest about ERUs (Elephants Response Unit) to guard crops like elsewhere. ERUs are basically committed groups of individuals who respond to the presence of wild elephants or a herd near a village and effectively drive the elephant into the forests. However, the compatibility and willingness of the local communities to implement various preventive measures are of utmost necessity to effectively resolve HEC.

4. Early warning system

We propose that the department may engage teams of local youth and train them on early warning system in these areas.

→ The early warning system can be based on App based programs. Existing village level institutions like members of EDC or Village Defense Party may be engaged after an

Orientation on ways and means to reduce HEC and ways and means to control unneeded crowd when elephant stray into civil areas.

5. Management of corridors

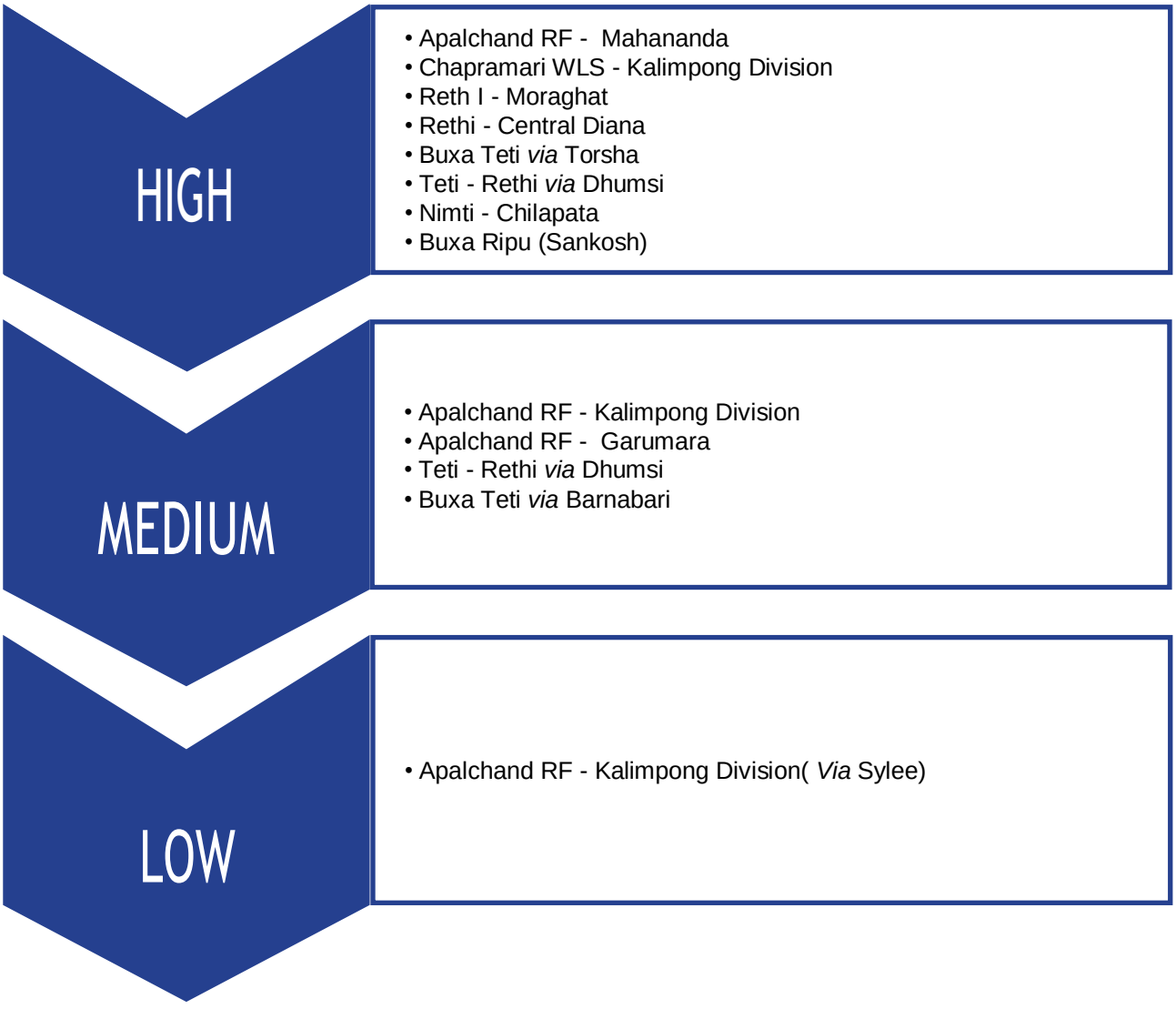
→ The existing corridors can be monitored regularly and should be brought under participatory local protection mechanism.

→ During the seasonal movement, the frontline staff need to patrol the corridor areas and obstruct any human disturbance to facilitate smooth movement.

→ The Apalchand-Bhuttabari, Buxa-Titi, Titi-Dhumsi, Dhumsi-Reiti, Reiti-Moraghat, Reiti-Diana (between tea garden) are still well connected through tea gardens and hence regular monitoring is needed o assist smooth movement.

→ We found the Mahananda-Kolabari corridor is no longer used by elephants due to high disturbances. The Lotabari corridor (Nimati-Chilapata) can be brought under vigilance by department.

→ The order of importance of the corridors in terms of management is given below-



6. Alternative cash crops

→ In the above mentioned highly conflict prone villages, management can encourage alternative cash crops like chilli, lemons, patchouli *etc.* We also recommend cash yielding elephant repellent crops like Homaloma, Ghostchilli, lemon grass, citronella, and wild turmeric for the purpose of producing high cash income for the affected farmers.

→ These products can be termed like"North Bengal Organic Cash Crop Hub' to attract tourists and promote as must buy like the Darjeeling tea.

7. Empowering JFMC and FPCs

→ The existing JFMC/FPCs are not yet fully empowered to assist in reducing elephant depredation. While in Japdapara and Garumara areas the FPCs are doing well in terms of building better communication with locals, in other areas the FPCs are not that proactive.

→ The presently functional Wildlife squad in Buxa TR, Kurseong divn (Bagdogra, Sukna, Belacoba, Ramsai, Malbazar, Khunia, Madarihat) should be accompanied by an educational team to manage local people during field patrolling.

→ These Wildlife squads should be more well equipped with modern tools like GPS and Walki Talkie sets to be able to track the movement of the herds.

→ The development of the Sukna regional office for the squads and the use of the Airawat vehicle is a positive step by government. However, the number of staff in the wildlife squads are low and needs to be strengthened.

8. Building cooperation with Management of Tea gardens

The tea gardens are major refuge and elephants uses this as shelter during daytime.

→ We recommend that the forest department should take the tea garden managements as part of conservation planning to garner their proactive support and create a sense of stewardship among tea management to assist in elephant conservation.

→ We recommend to form Tea garden squad with involvement of local tea garden people and should be trained by department and local NGOS to manage crowd when elephants use the tea gardens or move through it.

→ There are a few small/medium sized tea gardens that are no more functioning in North Bengal. Government can procure these abandoned tea garden lands and can be used for restoration of elephant habitat with fodder plants.

→ The recent elephant driving exercise in Tukriajhar range (Kurseong divn) to drive elephants should be stopped as this may lead to change in animal behavior in future.

9. Army cantonment

→ The army cantonments overlapped with elephant habitat and hence urgent meeting with Army should take place to discuss issues on fencing by army and the defe unneeded nce land at Rohini.

→ The cantonment at Bengdubi, Khaprail (Sukna), Binnaguri are occupying unnecessary huge areas. We found several large water reservoirs inside these cantonments in which elephants have drowned in the in the past. They also use spike to safe guard their food go-downs which causes injury to the elephants.

→ The department may regularly visit and monitor those inside the army cantonments.

→ Regular meeting should be held with armyo fficials (not below the rank of Commanding officer and CF from Forest Department).

10. Habitat management

→ The removal of invasive plant species should be a priority in management for all the protected areas. If existing habitats in North Bengal (NP, WLS and Reserved Forests) are managed scientifically the same habitat may provide needed natural feed to elephants.

→ More research on scientific intervention to assist natural regeneration of elephant Palatable growth to be conducted.

→ The preferred fodder plants (as per our results) should be promoted in infilling and supplement.

11. Compensation

→ One of the government initiatives to mitigate HEC is providing compensation (ex gratia) to the conflictvictims. Through the compensation schemes it is aimed to alleviate the losses to the victims; but in reality, the affected people are not satisfied by the process in many areas (*e.g.* Hamiltonganj).

→ The process of compensation or ex-gratia have to be expedited and relation with local community can be focused in terms of livelihood diversification. During our study, only 28.30% of the respondents had received government compensation for crop and property damage in entire North Bengal. There exists a disparity in receiving the compensation among the people, as our perception survey indicates. The efficiency of the compensation payment has to be improved and the amounts paid have to be enhanced to match the actual losses.

12. Awareness

→ Village level awareness initiatives should be conducted regularly.

→ The department may engage local NGOs and panchayat members as these members

have mass base which need to be used for positive outcome. Close relations with village headman are crucial to address emergency crisis in the villages that could arise from HEC issues.

→ Campaignslike ‘Hastir Bondhu’ or ‘Haati goes to school’ can be initiated in the whole landscape.

13. Train collision

→ We recommend to the railways to reduce the number of avoidable goods trains in this route and shift these to the Dhupguri line. Presently, both forest department and railway staff are using alert systems, however in monsoon these systems are not very effective. Substitutes for these systems need to be used during the challenging seasons.

→ The newly constructing Kalimpong-Sevok tunnel line can be a major problem in future.

→ During our survey, we noticed passengers throwing food items on the tracks that can attract elephant herd to the track and this has to be completely stopped.

→ We already described the high and low potential zones for train accidents in earlier chapter. The high collision zones can be reviewed periodically as the movement may change due to various factors.

→ We recommend to realign the Chapramari-Diana-Moraghat-Reiti stretch as this is the most vulnerable stretch for elephants.

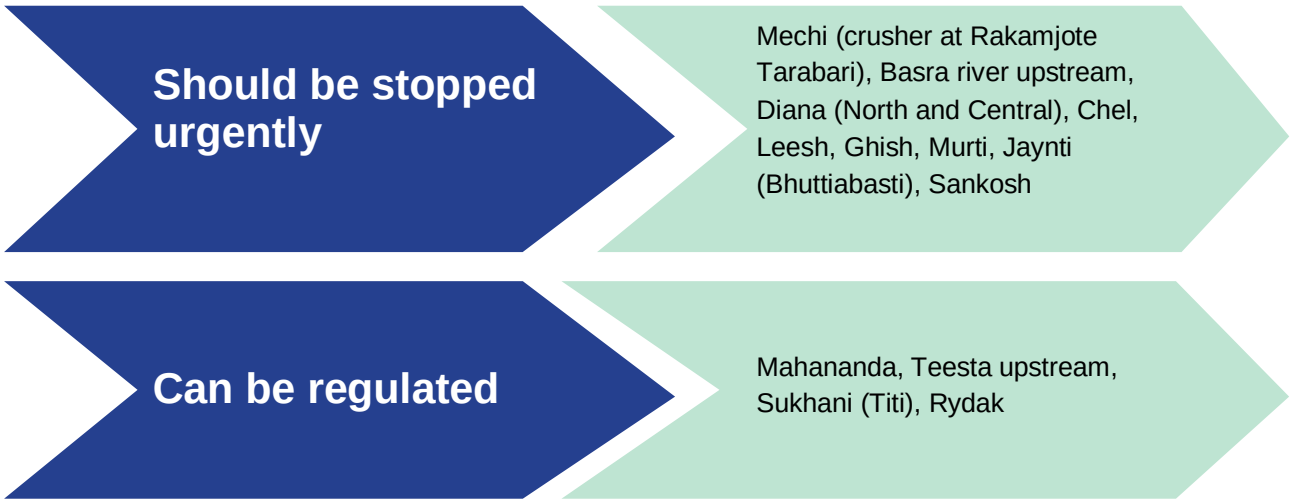
→ To reduce train hit case, Forest officials may engage some local youths especially during winter, by giving them some basic support like monthly mobile phone top up for Rs. 100 per month, blankets or jackets, torch so that these youth group along some key railway track, keep a vigil on movement of elephant herds and alert the nearest railway station master to issue caution notice for train to be passing through the area during that time.

14. Illegal mining

→ The ongoing illegal mining, especially sand mining (using crusher), in the rivers should be stopped or strictly regulated.

→ The extractions are causing upstream water crisis and may eventually contribute to increased HEC. Elephant in the region would obviously try to use low land waterbodies for nutrient requirements and as such bringing some riverine area under eco-sensitive zone may be considered which is likely to help elephant to use these riverine areas.

→ The following chart shows which sites should be stopped immediately-



15. Translocation of problem elephants

→ The identified problem elephants (by wildlife squads) maybe translocated to suitable areas with no conflict within protected areas or outside the state.

→ Inter-state cooperation could be crucial in translocating elephants outside state. As the population is likely to increase in the next 10 years, translocation can be one option.

16. Inter-departmental meeting to garner support

→ It is very much important to keep other allied government agencies fully engaged in mitigation of HEC. HEC issue should not be treated as an issue that only forest department must address.

→ The HEC issues are complex and need proactive understanding of the issue from key government agencies like district administration, police, agriculture department, Veterinary department, BDO and many developmental agencies having plan or projects in the North Bengal landscape.

17. Illegal Electrocution

→ Forest Department should coordinate with Dept of Power to replace the open power supply lines with insulated wire particularly in high conflict areas.

An Elephant Management Plan with detailed provisions for the management of the species has been developed separately using the results of this study.

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PHOTO FROM FIELD

Fig 24: Vegetation surveyat Buxa

Fig 25: During the HEC data collection

Fig 26: Field survey

Fig 27: During the survey along railway track

Fig 28: Elephants in a village in Buxa TR

Fig 29: Dung analysis for feeding evidences

Fig 30: A big herd in Kolabari

Fig 31: During corridor survey

Fig 32: During corridor survey

Fig 33: Railway track inside the protected area

Fig 34: An elephant corridor bisected by a highway

Fig3 5: Vegetation survey at Buxa

Fig 36: An elephant after being electrocuted

Fig 37: Field team surveying villages

Fig 38: A herd of elephant crossing a railway track in Nagrakata

Fig 39: HEC and an elephant

Fig 40: A herd of elephants in Buxa

Fig 41: Army defense area and a wild elephant herd in the background

West Bengal
FOREST DEPARTMENT

West Bengal Forest and Biodiversity Conservation Project,
Government of West Bengal