Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS

AN INCEPTION REPORT

by

NATURE ENVIRONMENT & WILDLIFE SOCIETY

Funded by

JICA

INCEPTION REPORT

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ORGANIZATION

NATURE ENVIRONMENT & WILDLIFE SOCIETY (NEWS)

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Title of the project:	Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores And the herbivores-carrying capacity in Jaldapara NP, Gorumara NP and Mahananda WLS
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Project work started:	2nd April, 2017
Inception report submitted on:	1st June, 2017

PREFACE

This Inception Report pertains to the agreement between West Bengal Forest and Biodiversity Conservation Society & Nature Environment & Wildlife Society, Kolkata with reference to the Biodiversity Research Project on *the* ***" Impact of habitat management practices, especially canopy manipulation and grassland restoration, on the habitat use pattern of herbivores and the herbivore-carrying capacity in Jaldapara NP, Gorumara NP and Mahananada WLS"*** against NIT no WBFBCP/NIT 11(e)/ 2016-17(2nd Call).

In this report we present the first part of the Deliverables. This is within two months of the commencement of the research project where in we had conducted two preliminary field visits and had discussions with the Forest Officials in all the three PAs under consideration.

The report includes details of the methodology, study sites and the work plan of how the project will be carried forward. To enable an easy understanding of the project, the report is heavily loaded with GPS Maps, Graphs, Tables and Photographs.

The Principal Investigator and his team are fully aware of the scientific investigations needed and hope to provide a sustainable and realistic recommendation for the implementation in the final analysis.

The Organisation records its sincere gratitude of appreciation to the Agency for giving us a chance to conduct this research project not only in the interest of these three PAs, but which could be useful for all other PAs in West Bengal.

ACKNOWLEDGEMENTS:

We are grateful to the West Bengal Forest and Biodiversity Conservation Project (WBFBCP) and JICA for generous funding of this project and especially for the support given by Mr. Prasanta Pandit, Dr Faiji, Mr. Goutam Chatterjee. We also thank Mr. Pradip Vyas, Former Principal Chief Conservator of Forests, Wildlife, West Bengal for according us the permission to work within the forest core areas. We also thank Mr. Murli, CCF, Mr. Bhaskar JV, DFO Jaldapara National Park, Ms. Nisha Goswami, DFO, Gorumara National Park, Mr. Dharamdeo Rai, DFO, Mahananda Wildlife Sanctuary for providing us the necessary permission, logistic support, documents related to the project and forest staff in each of the PAs under consideration.

We thank Mr. Bimal Debnath, AWLW, Jaldapara National Park, Mr. Badal Debnath, ADFO, Gorumara National Park, Mr. Jayanta Mandal, ADFO, Mahananda Wildlife Sanctuary for unconditional help and support. Mr. Dipak Kumar Bal, Ranger, Nilpara Range, Jaldapara National Park, Mr. Kaji Chetri, Ranger, Sukna Range, Mr. Barendra Dubey, FR, West Range, Mahananda Wildlife Sanctuary, and other rangers who rendered us all help as in when needed.

We also thankful to Mr. Chiranjit Pal, NWC Beat, Mr. Gour Chandra Chanda, Beat Officer, Bendaki Beat, Jaldapara National Park, Ms. Srijana Darnal, DR/Fr, Dhupjhora Beat, Ms. Smriti Rai, DR/Fr, Budhram Beat, Mr. Surijit Oraon, DR/Fr, Gorumara Beat, Mr. Bharat Singh Basumata, Beat Officer, Murti Beat, Gorumara National Park, Mr. Dipen Subba, DR/Fr, Punding Beat, Mahananda Wildlife Sanctuary. And last but not the least Mr Paithu Oraon, Mr. Anukul Chandra Roy, Mr. Provash Roy, Mr. Debjyoti Dutta, Mr. Robin Khawas, Mr. Chandan Pradhan, Mr. Nirmal Das, Mr. Raju Koyal and Mr. Dilip Rai for helping us throughout the field work.

We place on record our gratitude to Mr. Ravikant Sinha, PCCF Wildlife, West Bengal, Mr. Subhankar Sengupta, CF, Wildlife, West Bengal for their constant guidance and support to carry this project forward to its logical conclusion.

CONTENTS:

1. INTRODUCTION

The habitat of any organism is its immediate, physical and biological surroundings which supplies all the elements an animal needs for its survival. A healthy and sustainable wild habitat includes food, cover, water, and space as its basic elements. However, each animal varies in its requirement of these elements. Wildlife populations in forested habitats are dynamic because the forest is always changing. Plant succession, or the gradual replacement of one plant community with another, is an important aspect of wildlife habitat. Every successional plant stage, or habitat type, has a specific community of animals associated with it. Close relationships among animals and environments illustrate how alterations to the habitat dramatically affect wildlife populations.

2. NAME, LOCATION AND BACKGROUND OF THE PROJECT AREAS

2.1 Jaldapara National park

Jaldapara National Park is named after the 'Jalda' community, a proto-australoid tribe, which was once home to them. But now, the tribe has become extinct.

The forests of the region, which were earlier a part of the Buxa Forest Division, were being managed for commercial purposes till 1929.

The Bengal Rhinoceros preservation act came into force in 1932 providing protection to the one-horned Rhino (*Rhinoceros unicornis*).

The area was first declared as a "Game Sanctuary" in the year1941 vide Govt. of Bengal Notification No.10549-For, dated 13th November 1941 read with amendment Notification No. 5238-For, dated 3rd April, 1943.

In the year 1951, the area was transferred to the newly created Cooch-Behar Forest Division. An area of 99.51 sq. km. was managed under sanctuary working circle in the two subsequent Working Plans (1962-63 to 1971-1972 and 1972-73 to 1981-83) of Cooch Behar Division. The game sanctuary was re-notified as Jaldapara Wildlife Sanctuary in 1976 vide a Govt. notification No. 5404-dated 24.6.1976 issued under section 18 of the Wildlife (Protection) Act, 1972 and its area increased to 115.53 sq. km. The Sanctuary was transferred to the administrative control of the Wildlife Division-II on 10.2.1982. Another 100.98 sq. km. was added to the sanctuary from Coochbehar Forest Division vide Govt. Notification No. 7245-For dated 31.8.1990. The sanctuary is located in the flood plains of the River Torsa and other small rivers, which have created large tracts of grasslands sustaining a small population of one horned Rhinos. The area of the sanctuary is 216.51 sq.km. compromising of 12 blocks, 45 compartments, 29 beats and 4 Camps under eight Territorial Ranges, one Eco-Tourism and one Elephant Squad Range.

In May, 2012 this sanctuary was designated as National Park lying in the civil district of Alipurduar between the latitudes 25°58''and27°45''N and longitudes 89°08'' and 89°55''E.

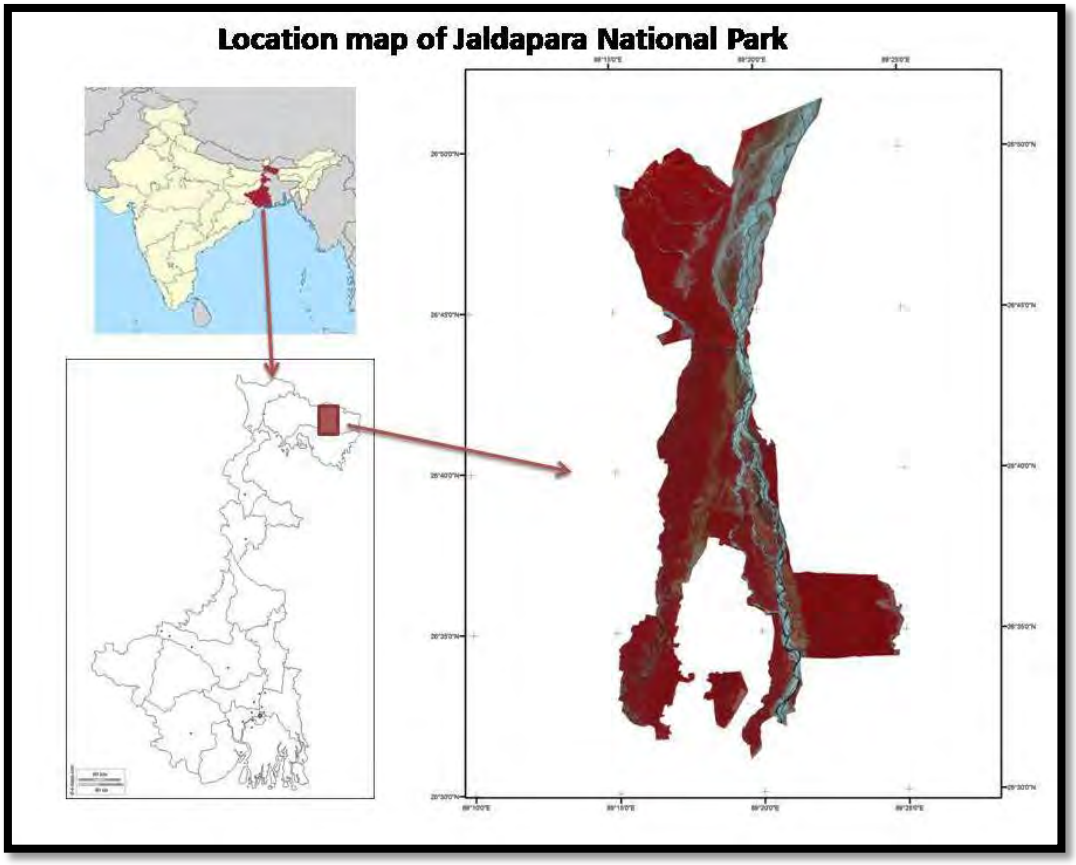


Figure 1: LOCATION MAP OF JALDAPARA NATIONAL PARK

2.2 Gorumara National Park

Gorumara National Park was a reserve forest since 1895 with an area 7 sq. km. under the Forest Act (VII of 1878). Later an area comprising of 8.61 sq. km, was declared as Gorumara Game sanctuary vide Government notification no. 5181-For, Dt. 02.8.49. Subsequently, a notification was issued under the Wildlife (Protection) Act 1972, vide no. 5400-For, dated 24th June, 1876 declaring it as Gorumara Wildlife Sanctuary. During the year 1994, Government Notification No. 319-For, dated 31st January, 1994 was issued with the intention of declaring the sanctuary as Gorumara National Park, with major extension of the existing Gorumara National Park comprising a total area of 79.99 Sq Km.

The Park was declared as the best among the National Parks and Wildlife Sanctuaries in India by Ministry of Environment and Forest for the year 2009. The Parameters used for this include condition of the forest, Wildlife, bush and grassland, performance of eco-tourism, extent of cattle grazing, Socio-economic development of people living in the fringe villages and their Dependency of forest and effective utilization of funds received from the ministry and other sources.

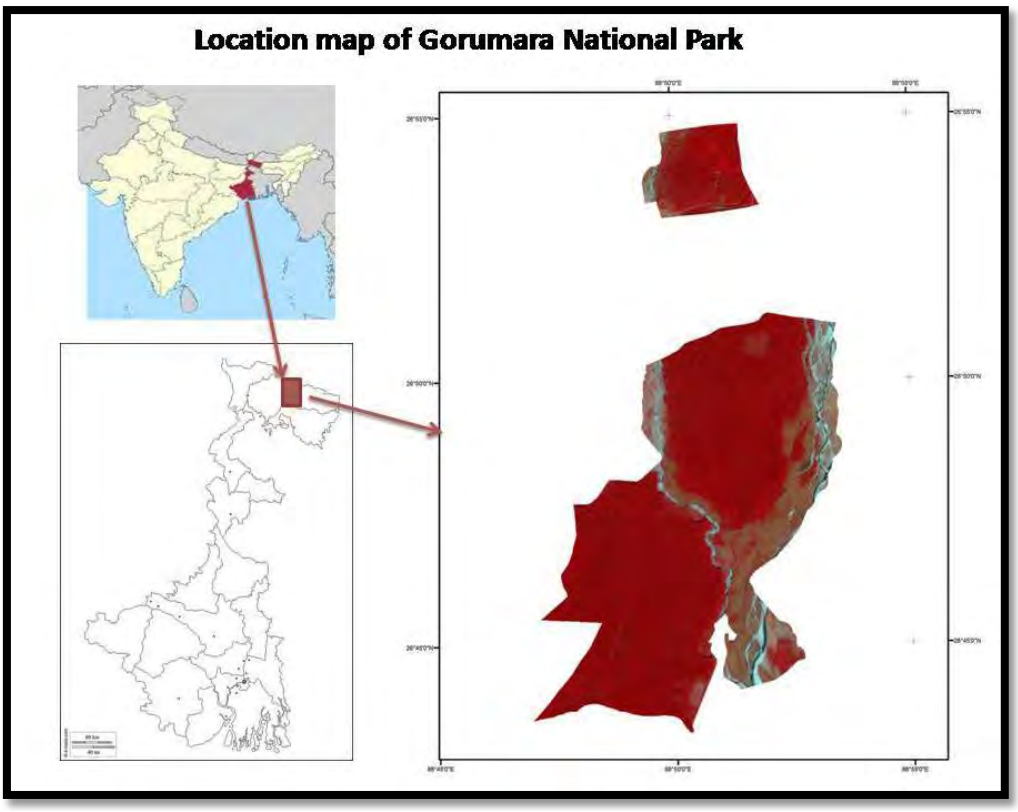


Figure 2: LOCATION MAP OF GORUMARA NATIONAL PARK

2.3 Mahananda Wildlife Sanctuary

The Mahananda Wildlife Sanctuary (MWLS) is situated on the West bank of the River Tista in the Terai region of Darjeeling district that forms a part of the Eastern Himalaya, and located between latitudes $26^0$55´33" N and $26^0$47´54" N and longitude $88^0$33´31" E and $88^0$23´36"E. The notified area of the sanctuary is 127.22 sq. km. It was first notified as a protected area during 1949. "Protection" at that time however was limited only to restrict the hunting of wild animals. The reserved forest in the lower catchment of Mahananda River had been declared as a Wildlife Sanctuary by Government of West Bengal in June 1976, under the administrative control of a Divisional Forest Officer. Major part of the sanctuary was brought under the administrative control of Wildlife Division I, Darjeeling by Principal Chief Conservator of Forests in November 1995, all the notified blocks of MWLS have been placed under the direct management of Wildlife wing on Reorganization of Forest Directorate in September, 1995 (Anonymous 1996).The total area is divided into 33 forest blocks under four ranges viz. East, West, North and South range. The forest blocks are: Punding, Bandar jhora, Jogijhora, Kuni, Choklong, Upper Champasari, Gulma valley, Silihhita, West Sevoke, East Sevoke, North Sevoke,Jhenaikuri, Lower Ghoramara, Upper Ghoramara, Gola, Ruyem, Andera, Chawa, Samaardanga, Lower Champasari, Singimari, Gulma, Mahanadi, Sukna (Part 1), Rongdong, Kaklong, Mohorganj, Panchenai, Hatisar, Kyananuka, Adalpur, Chumta and Laltong.

The area of MWLS comprises of 60 % of the forest in hilly region in the foot hills of the Himalayas, characterized by moderate, steep to precipitous mountain slopes and high ridges towards the north and then sloping to almost flat stretch of the Terai and alluvial plains

towards the south. There are two broad ecological subdivisions, the Hill tract and the Bhabar tract. Conversion of the higher hills into tea estates and Cinchona plantations has fragmented the ecological boundary in the north. River Tista in the east forms a physical barrier against movement of terrestrial wild lives of the Bhabar tract which is gently sloping and covered with sal forests. The river and khola belts act as valuable biotope for wildlife. The sal forest in the south forms an ecological continuum with Laltong block and Baikunthapur Division. Athin strip of forest makes the boundary in the rest of the portion in Hatisar, Mohorganj and Panchenai blocks. There are cultivated fields, labor colonies in the south. In the west, after the junction of Hill Cart Road and River Mahanada, the tea gardens and habitations limit the forest extant. (Anonymous 1996).The sanctuary is spread over varying elevations and across 158.04 sq. km of forest area. The altitude varies from 500ft. at the southern area near Sukna and rising up to 4,300ft towards the northern area near a place called Latpanchar.

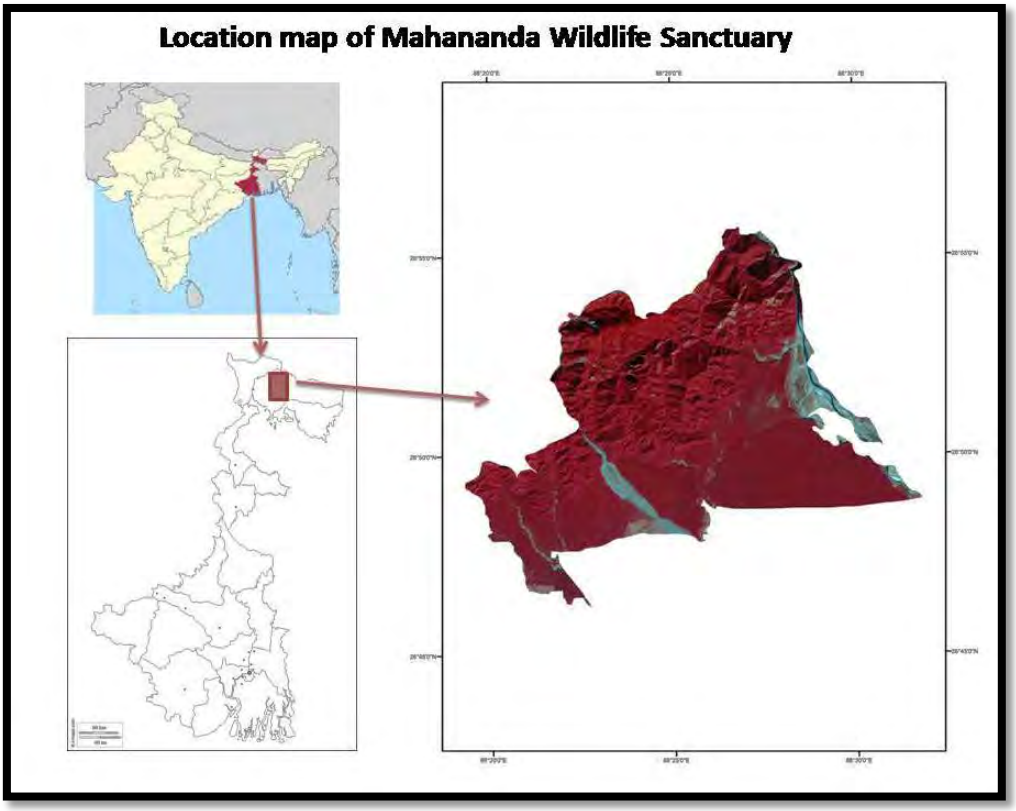


Figure 3: LOCATION MAP OF MAHANANDA WILDLIFE SANCTUARY

Current status of the NPs and WLS areas in three districts of northern part of West Bengal, is Presented in Table-1

Table 1: PROTECTED AREAS UNDER PROJECT

Protected areas	**Area (sq. km.)**	**Bio-geographic zone**	**District**
Wildlife Sanctuary (WLS)			
Mahananda WLS	158.4	7B	Darjeeling
National Park (NP)			
Jaldapara NP	216.51	7B	Alipurduar
Gorumara NP	79.99	7B	Jalpaiguri

3. OBJECTIVE OF THE STUDY

A) To finalise the methodology and selection of study sites in consultation with the client
B) To assess the impact of habitat management practises with emphasis on canopy manipulation and grassland management in Jaldapara NP, Gorumara NP, and Mahananda WL Sanctuary on the habitat use pattern of herbivores (specially all deer species, Rhino, Elephant and Gaur)
C) To assess the herbivore-carrying capacity of these PAs
D) To identify the major weeds in the PAs, assess the occupancy percentage, evaluate the current practises for weed elimination and suggest measures for strengthening effective weed management.
E) To develop habitat management plans for the three Protected Areas in relation to the herbivores, especially in regard to canopy manipulation and grassland management.
F) To incorporate the comments and suggestions of the Wildlife Wing and other field Officers received through the PMU office

4. METHODOLOGY

4.1Assessment of the habitat of the study areas

a) Preparation of GIS map

For wildlife habitat assessment, a general purpose, single- attribute remote sensing land cover map for each PA has been prepared. Images are downloaded from the USGS Earth Explorer and USGS Glovis. When downloading has ensured that the images are completely cloud free.

Table 2: SOFTWARE USED IN LULC CLASSIFICATION

Software	Functions
ERDAS Imagine ™14	Layer stack, Change detection analysis
Arc GIS 10.3	Preparation of thematic map, Analysis, Image classification, Subset, Clipping image, Change detection analysis map, Conversion of KML files to shape files, Accuracy assessment
Google Earth Imagery	Vector layer creation, creating KML files and verifying of GPS generated points

Supervised classification of the 3 PAs has been conducted with six land cover classes including: Wood land, Grass land, Water bodies, Flood plains, Human settlements and

barren land. With this procedure the preliminary map has been prepared. The final map will be produced after incorporating the pre and post-monsoon data to the preliminary map.

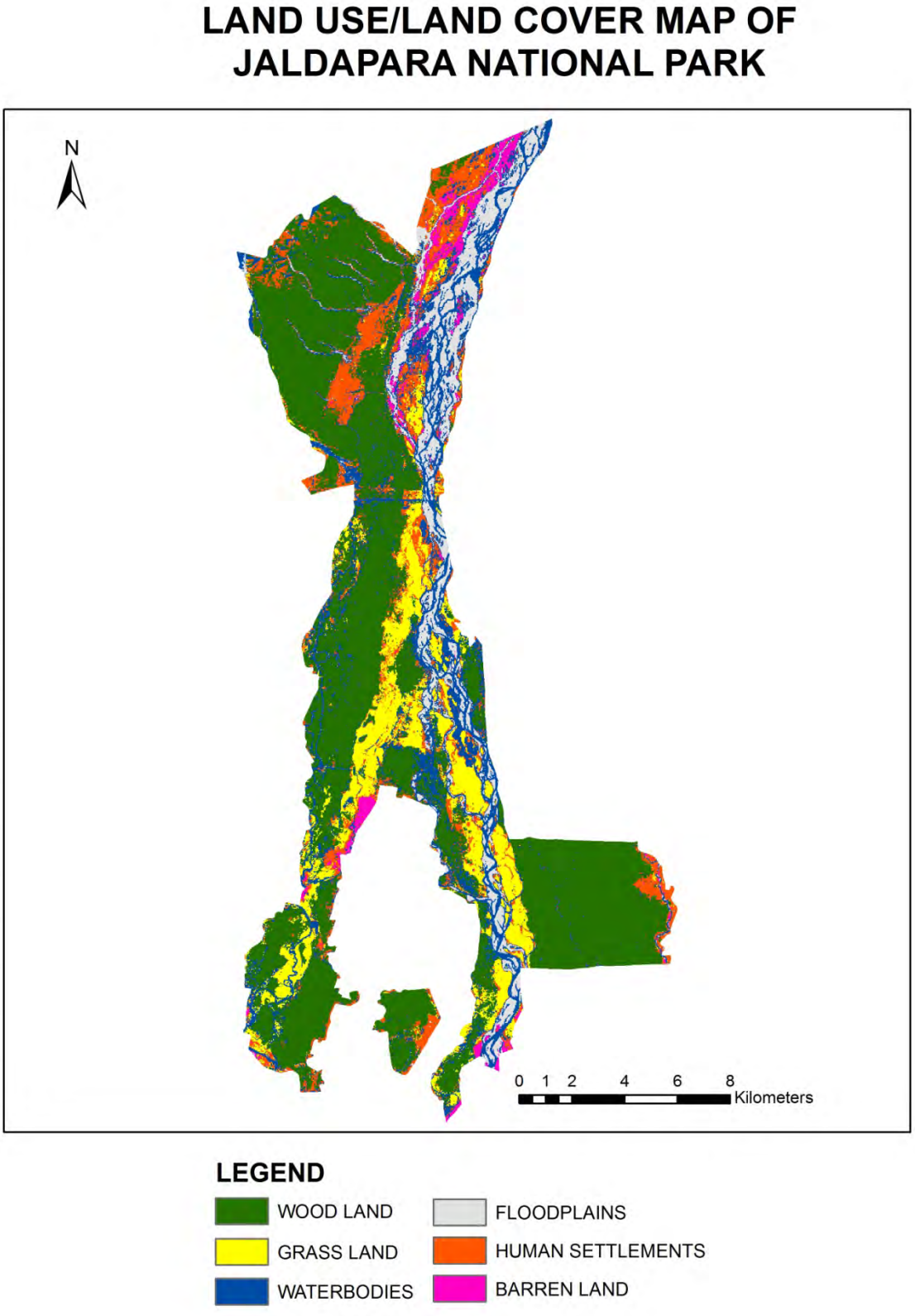


Figure 4: LANDUSE/ LANDCOVER MAP OF JALDAPARA NATIONAL PARK

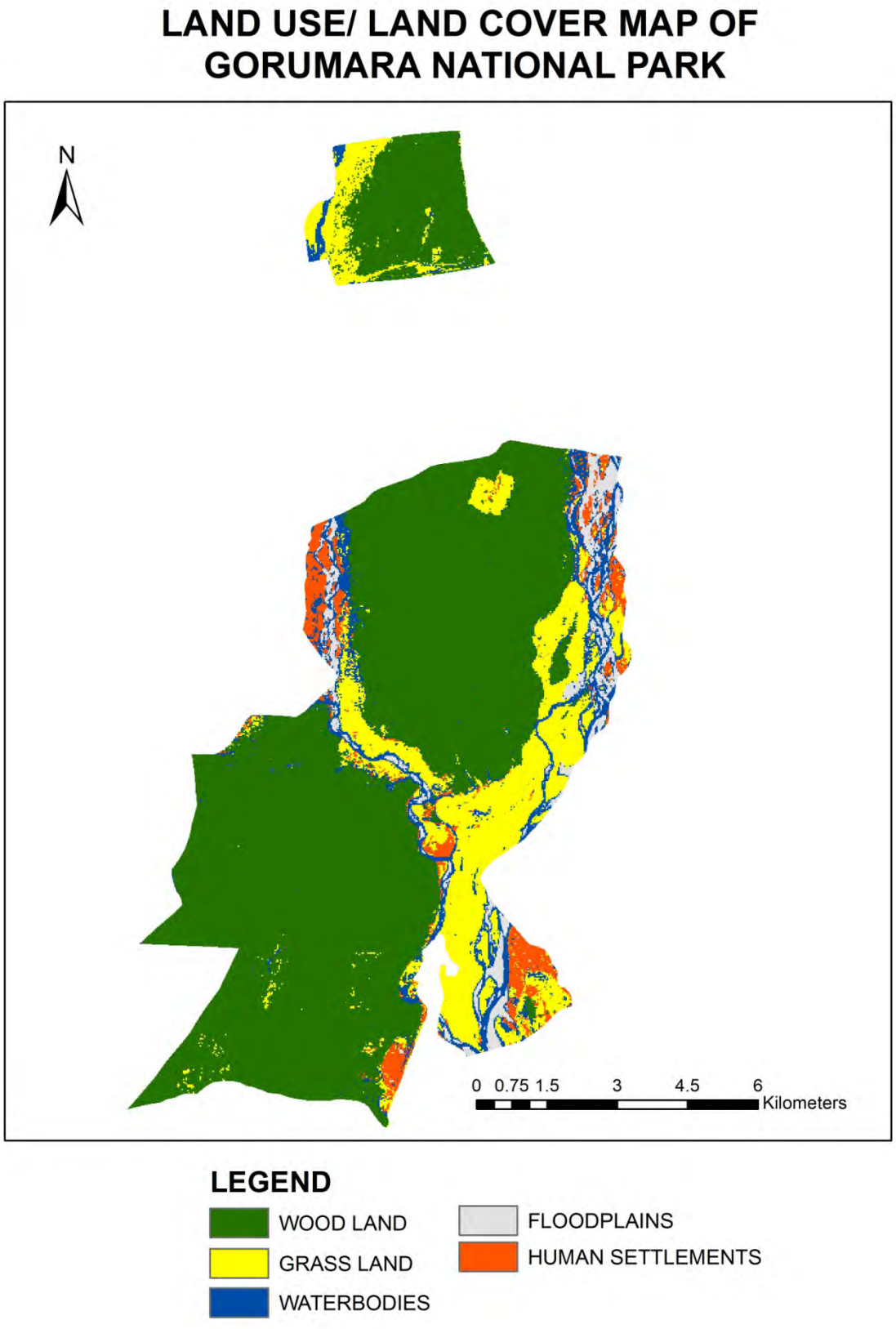


Figure 5: LANDUSE/ LANDCOVER MAP OF GORUMARA NATIONAL PARK

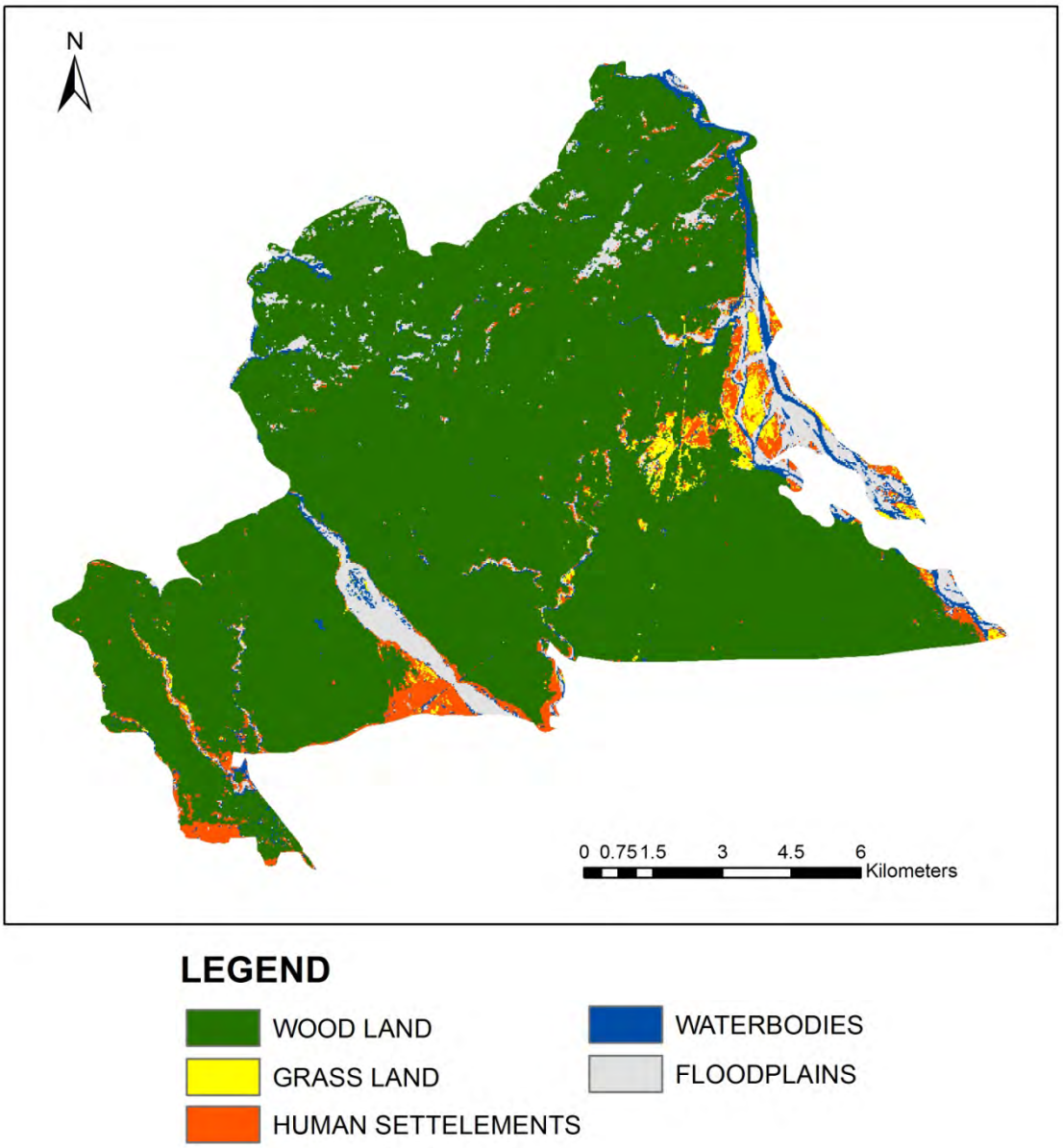


Figure 6: LANDUSE/ LANDCOVER MAP OF MAHANANDA WILDLIFE SANCTUARY

b) Ground Survey

PRILIMINARY FIELD VISITS, INTERACTION WITH THE RESPECTIVE FOREST OFFICIALS, OUR OBSERVATIONS AND SCOPE OF WORK

Two field trips were undertaken during 2nd to 7th April, 2017 and 8th to 14th May, 2017 in Jaldapara N.P., Gorumara N.P. and Mahananda WLS.

The Jaldapara National Park, Gorumara National Park and Mahananda Wildlife Sanctuary are situated in diverse habitat conditions. They have flood plains, hills, forests, grasslands and plantations. Since these areas are under the jurisdiction of the State Forest Department, they have legal protection to a large number of plant species, herbivores, other animals and birds. Despite this, a number of species are only sporadically reported and may face the fate of extirpation.

Among the large and medium sized mammalian herbivores, the Great One–horned Rhinoceros (*Rhinoceros unicornis*) is presently confined to Jaldapara NP and Gorumara NP, while the Indian Elephant (*Elephas maximus*), Wild Boar (*Sus scrofa*), Gaur (*Bos gaurus*), Barking Deer (*Muntiacus vaginalis*), Spotted Deer (*Axis axis*), Hog Deer (*Axis porcinus*) and Sambar (*Rusa unicolor*) are fairly well distributed. Censuses of Elephant, Gaur and Rhinoceros carried by the Forest Department at regular intervals indicate an increasing trend of their population). However, data on the population of wild boar and other species of deer are less conclusive.

Figure 7: GRAZING OF LIVESTOCK WITHIN PROTECTED AREAS

Of late, the multispecies herbivore communities in these protected areas of North Bengal face several anthropogenic stresses that include loss or damage of the corridors, grazing of livestock (Figure7) and uncontrolled fire (Figure 8). In addition, these wildlife habitats are highly susceptible to natural destruction due to changes in the course of different rivers flowing through them, invasion of weedy species into grasslands and the fast growth of weeds and climbers. Both natural and anthropogenic pressures may lead to ecological changes resulting in intra and inter-species competition for food and hiding cover, as well as disturbance in the spatio-temporal utilization of habitat especially by the herbivores. Any perceptible change of the same may set in an irreversible process of degradation. Therefore, for the development of an ecologically sound scientific management plan for the conservation of wildlife of these three

areas in North Bengal, it is necessary to get first-hand knowledge about the population estimates of different species of herbivores, their habitat preference, niches occupied by them, and the carrying capacity of these parks and sanctuary. The present project has been conceived and designed, accordingly.

Figure 8: UNCONTROLLED FOREST FIRE WITHIN THE PROTECTED AREAS

Space

As mentioned earlier each wildlife species requires a certain amount of habitat to move about, avoid or escape potential predators, locate a mate, obtain sufficient food and water for survival, rest especially during the breeding season.

Carrying capacity may be increased by enhancing the quantity and quality of the wildlife habitat components. As for example each tiger requires 60-100 sq. km, whereas tigress requires 20—30 sq. km. A male leopard requires 33-38 sq. km. whereas female one requires 14-16 sq.km. In case of elephant five clans each consisting between 50-200 have home ranges of 105-320 sq. km.

Snags and Cavity Trees

In Jaldapara one major area in core zone had at least 300-400 snag trees on the site of electrical fence on both inside and outside management plot in Siltorsa Beat under Jaldapara Range ($26^0$41’32.2’’N & $89^0$18’53.3’’E)

Figure 9: SNAG TREES WITHIN THE FOREST AREA

Such snag trees in other two PAs namely Gorumara NP & Mahananda WLS were not observe during our two field visits.

Corridors

The main concern about the northern West Bengal elephant population is the increasing trend of human-elephant conflict. The elephants between the Tista and Torsa River are uncertain, mainly due to fragmentation of forest areas in Baikunthapur, Kalimpong, Jalpaiguri and Cooch Behar Forest Division. The elephants are compelled to move through tea gardens, villages agricultural field, High ways, railway tract resulting in increased conflicts. It is also important to protect the elephant corridor between Mahananda Wildlife Sanctuary and Baikunthapur Forest Division along the Tista River, is greatest barrier to removing settlements (Nayabasi) along the corridor. There is also need to re-establish the corridor between North Diana forest and Rheti forest which serves as a link path for herds in the Tonda and Titi forests. In the Terai, the movement of elephants to Nepal does not take place due to fragmentation of forest in the Panighata Range and also due to firing and other attacks on elephants in Nepal.

On the basis of discussion with the Forest Officials in the three Protected Areas, it was seen that from various vantage points (like watchtower etc), beat records the sightings of the major large mammals is presented, for a month vis-a-vis the number of animals in each species. Such graphs are also compared with those from available data during the same month in the previous year. Such analysis will be carried out and an annual assessment will be produced as a final for analysis and recommendation along with the habitats visited by these animals.

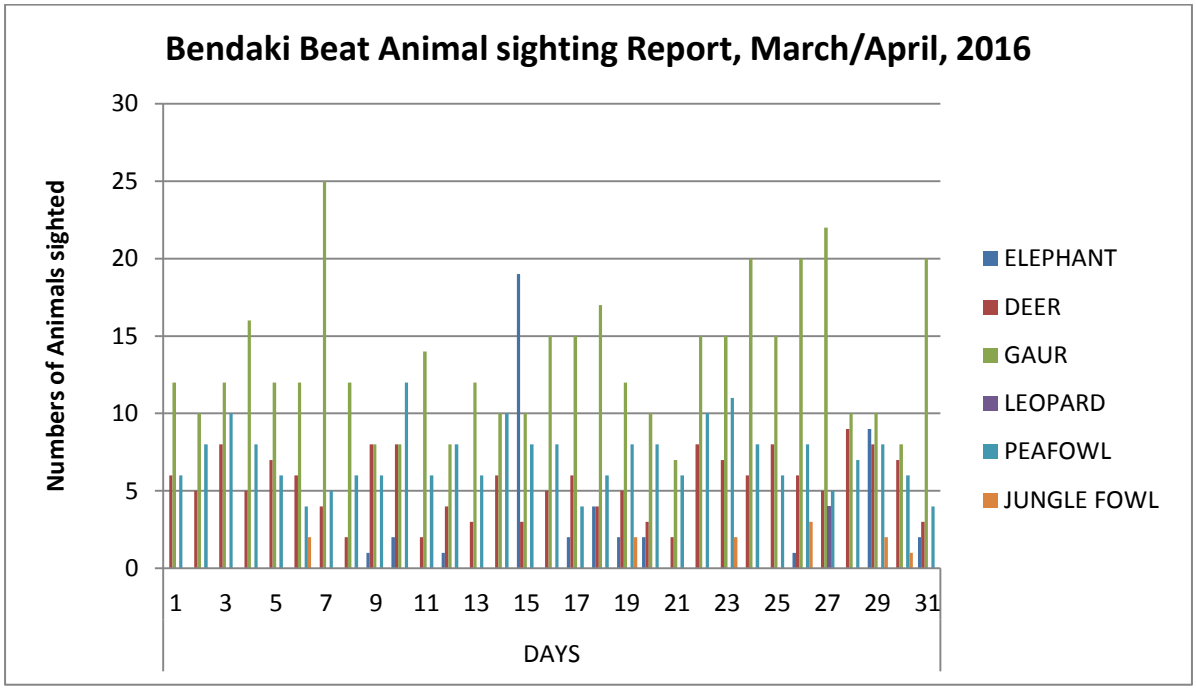


Figure 10: BENDAKI BEAT, JALDAPARA NATIONAL PARK ANIMAL SIGHTING REPORTS, MARCH/APRIL, 2016

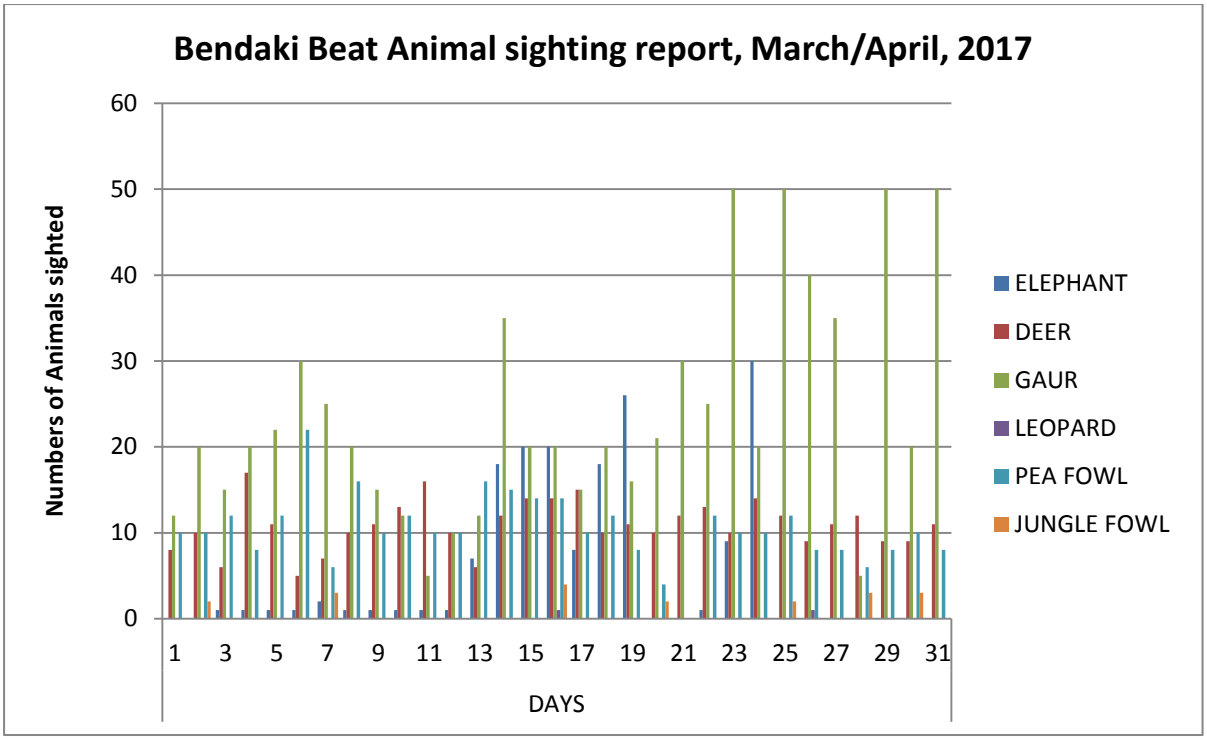
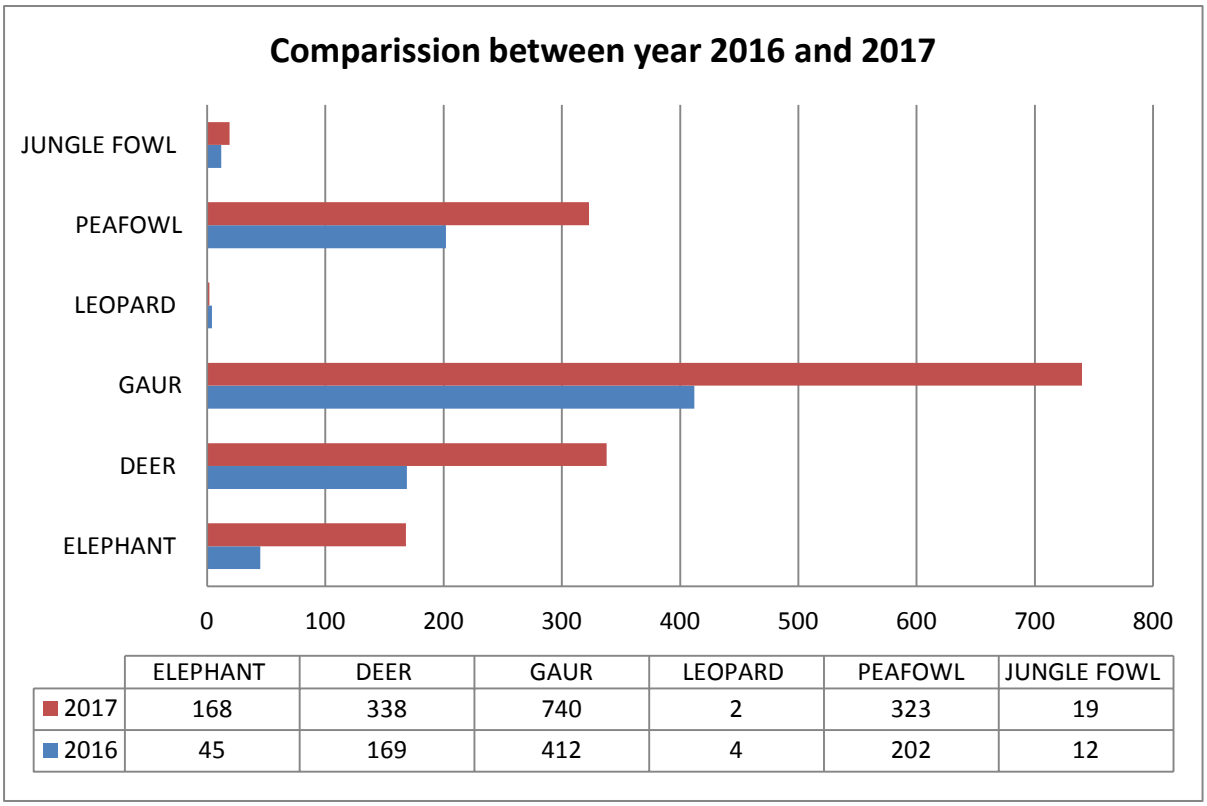


Figure 11: BENDAKI BEAT, JALDAPARA NATIONAL PARK ANIMAL SIGHTING REPORTS, MARCH/APRIL, 2017



	ELEPHANT	DEER	GAUR	LEOPARD	PEAFOWL	JUNGLE FOWL
2017	168	338	740	2	323	19
2016	45	169	412	4	202	12

Figure 12: COMPARISSION BETWEEN ANIMAL SIGHTINGS IN THE SAME SEASON AT BENDAKI BEAT, JALDAPARA NATIONAL PARK

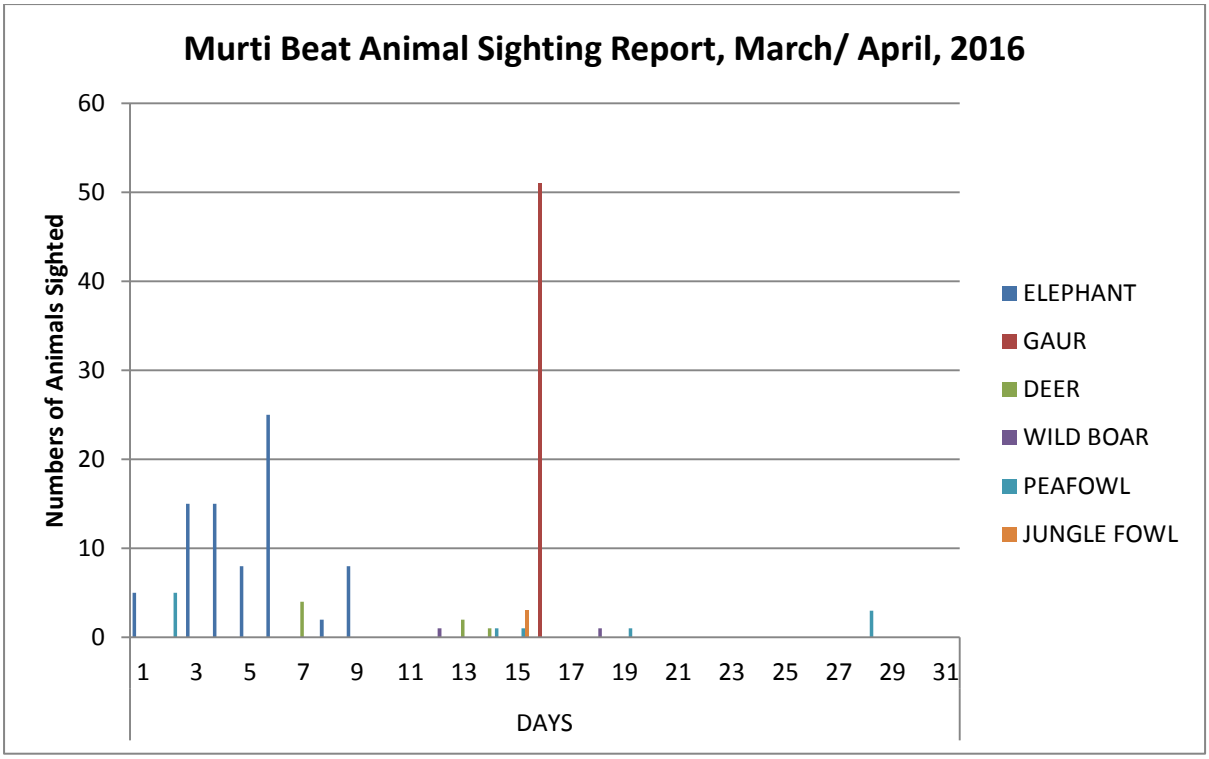


Figure 13: MURTI BEAT, GORUMARA NATIONAL PARK ANIMAL SIGHTING REPOTS, MARCH/APRIL, 2016

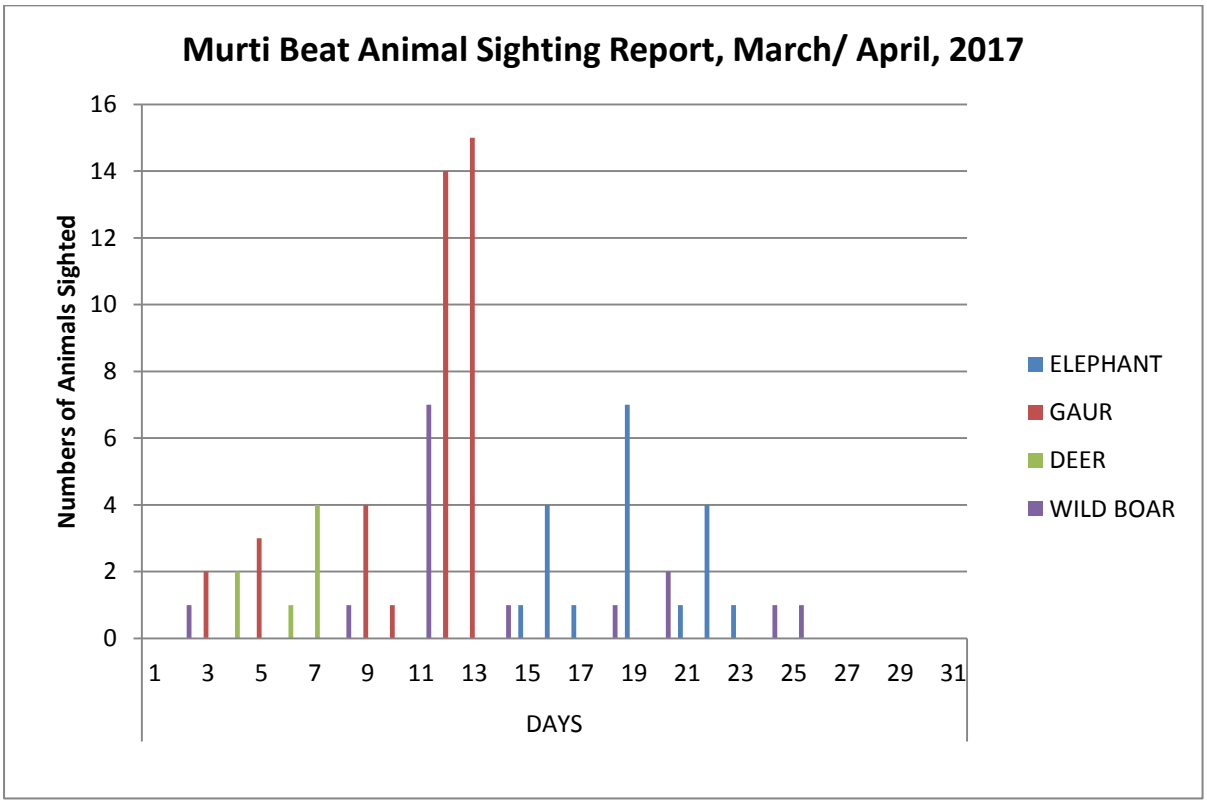
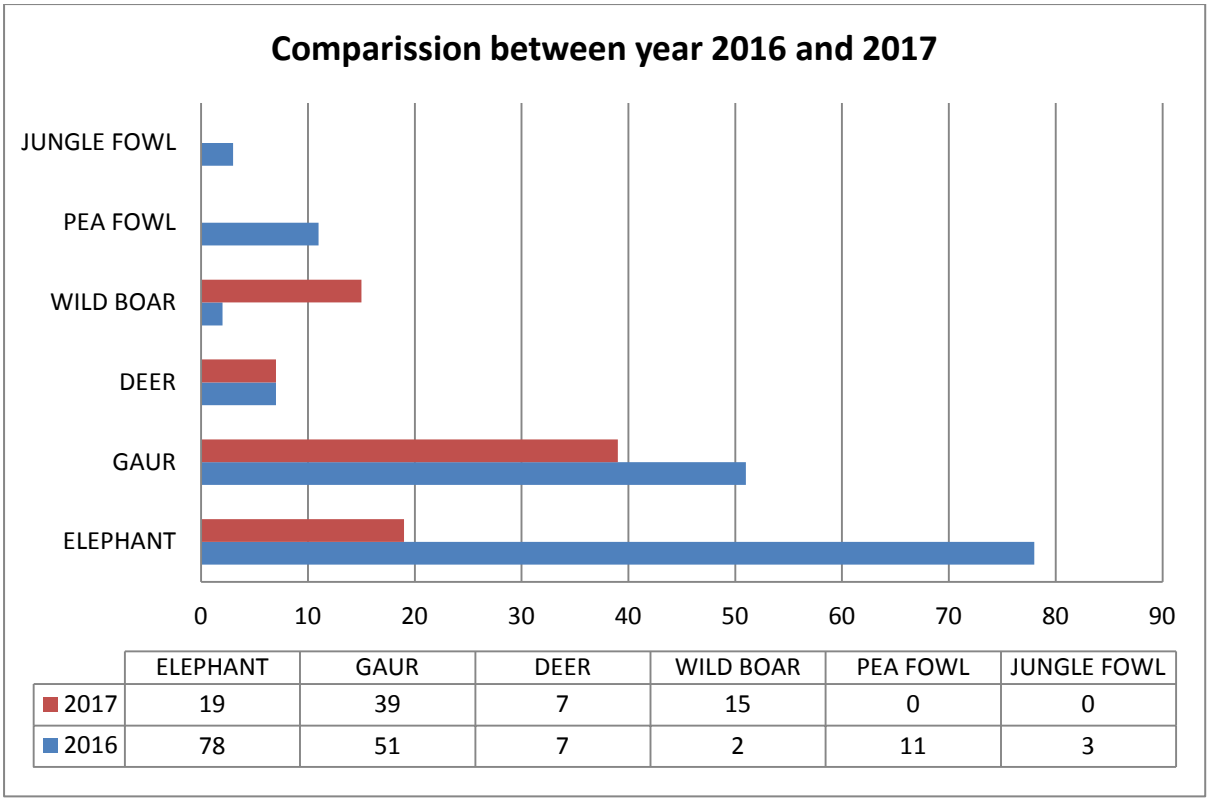


Figure 14: MURTI BEAT, GORUMARA NATIONAL PARK ANUMAL SIGHTING REPORTS, MARCH/APRIL, 2017



	ELEPHANT	GAUR	DEER	WILD BOAR	PEA FOWL	JUNGLE FOWL
2017	19	39	7	15	0	0
2016	78	51	7	2	11	3

Figure 15: COMPARISSION BETWEEN ANIMAL SIGHTINGS IN THE SAME SEASON AT MURTI BEAT, GORUMARA NATIONAL PARK

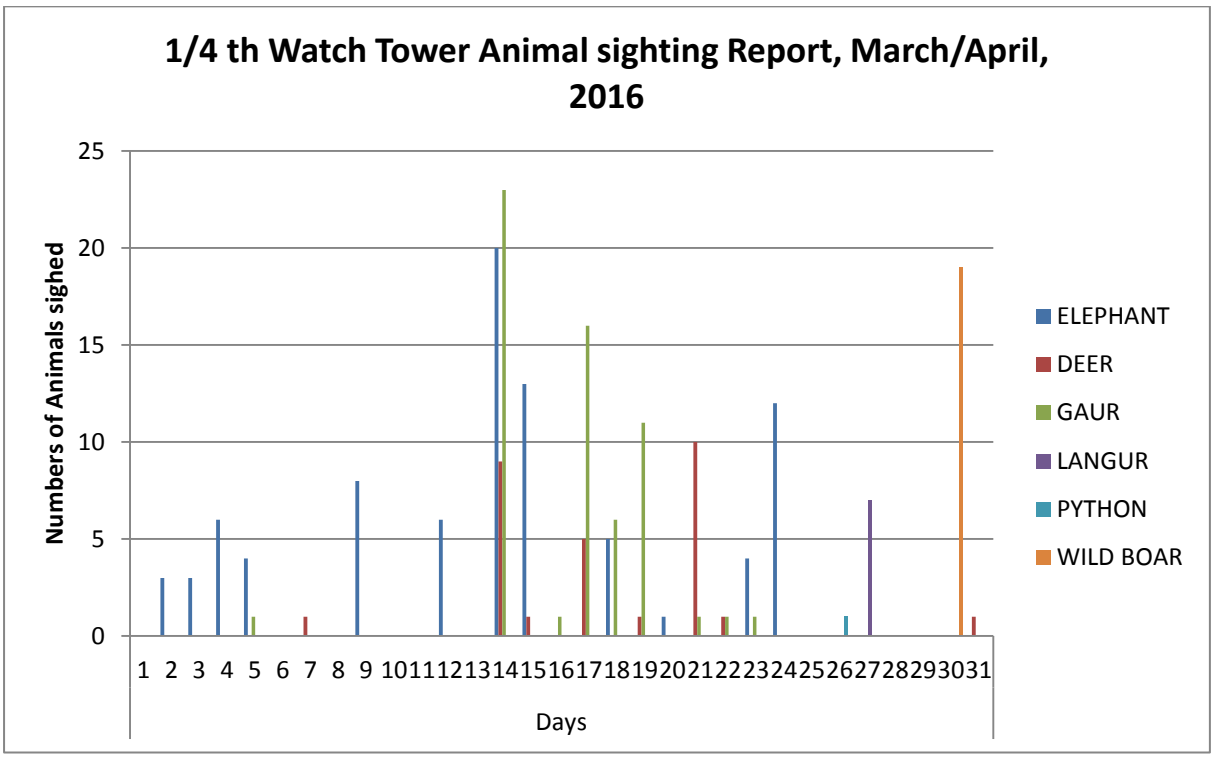


Figure 16: 1/4TH WATCH TOWER, MAHANANDA WILALIFE SANCTUARY ANIMAL SIGHTING REPORTS, MARCH/APRIL, 2016

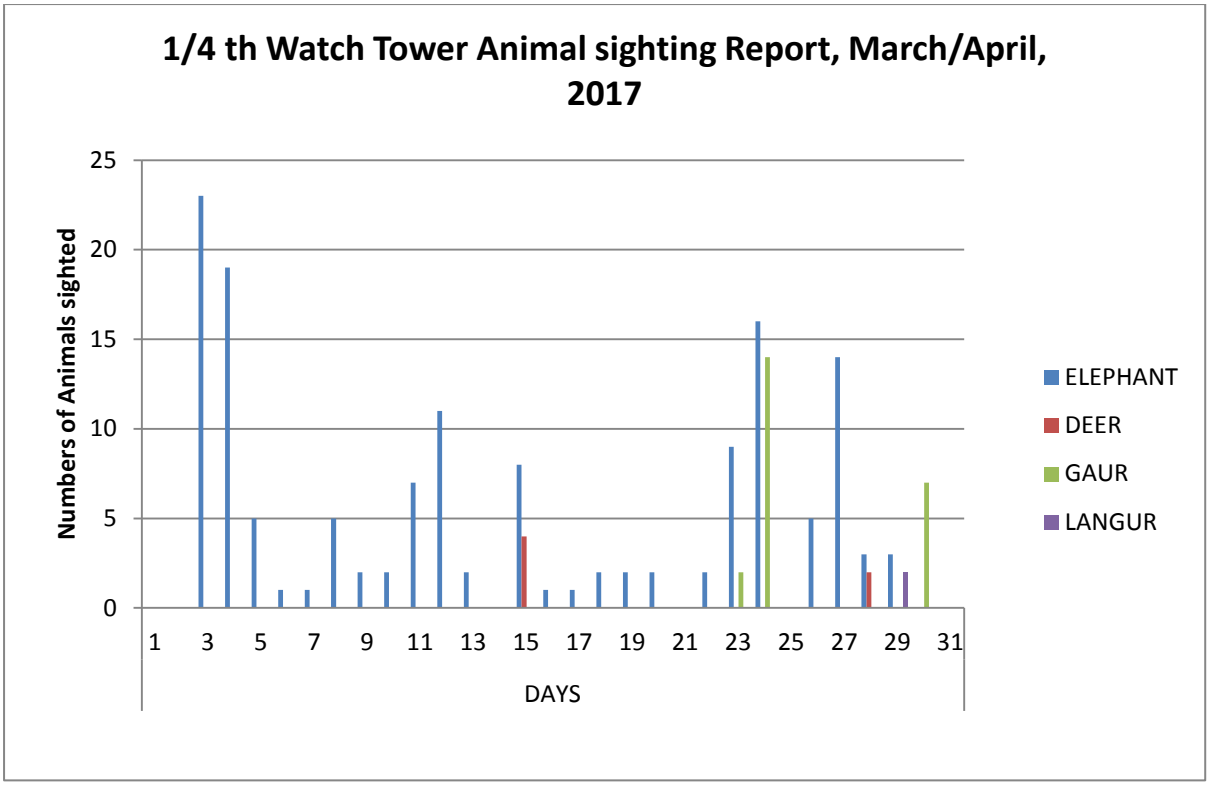
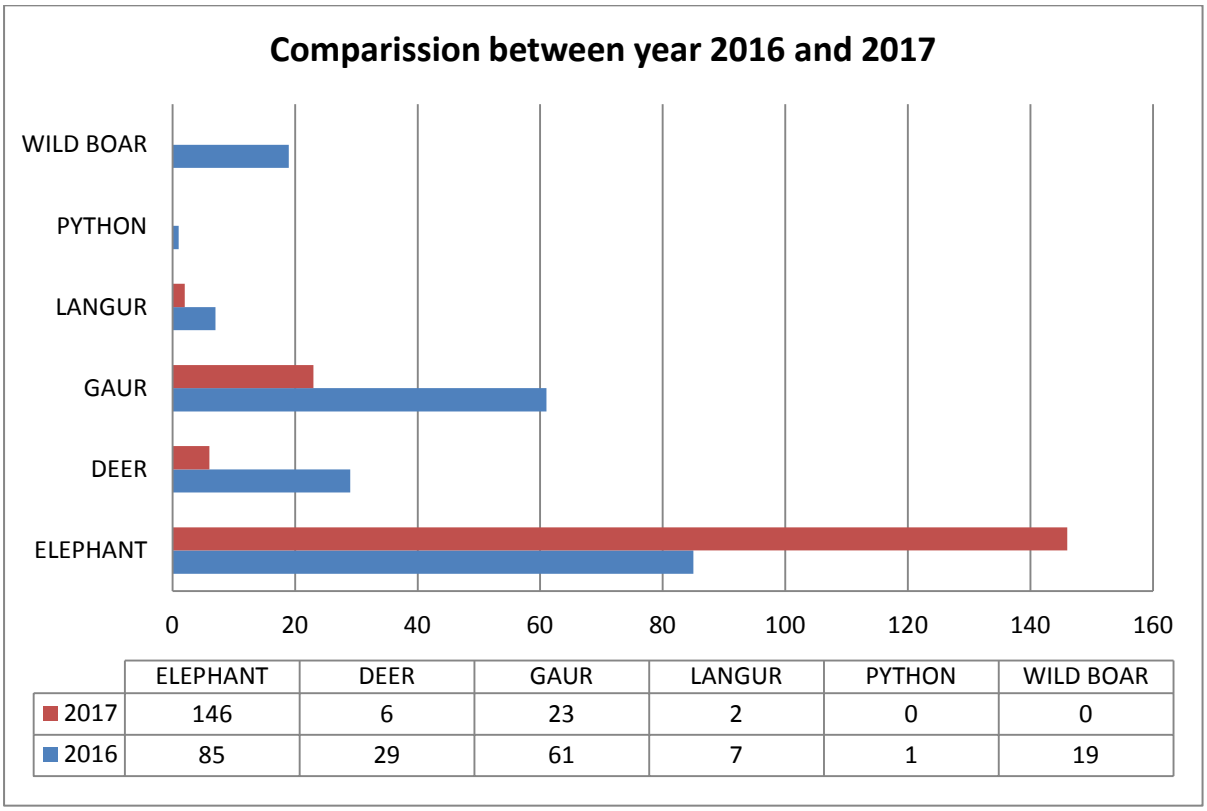


Figure 17: 1/4TH WATCH TOWER, MAHANANDA WILALIFE SANCTUARY ANIMAL SIGHTING REPORTS, MARCH/APRIL, 2017



	ELEPHANT	DEER	GAUR	LANGUR	PYTHON	WILD BOAR
2017	146	6	23	2	0	0
2016	85	29	61	7	1	19

Figure 18: COMPARISSION BETWEEN ANIMAL SIGHTINGS IN THE SAME SEASON AT 1/4TH WATCH TOWER, MAHANANDA WILDLIFE SANCTUARY

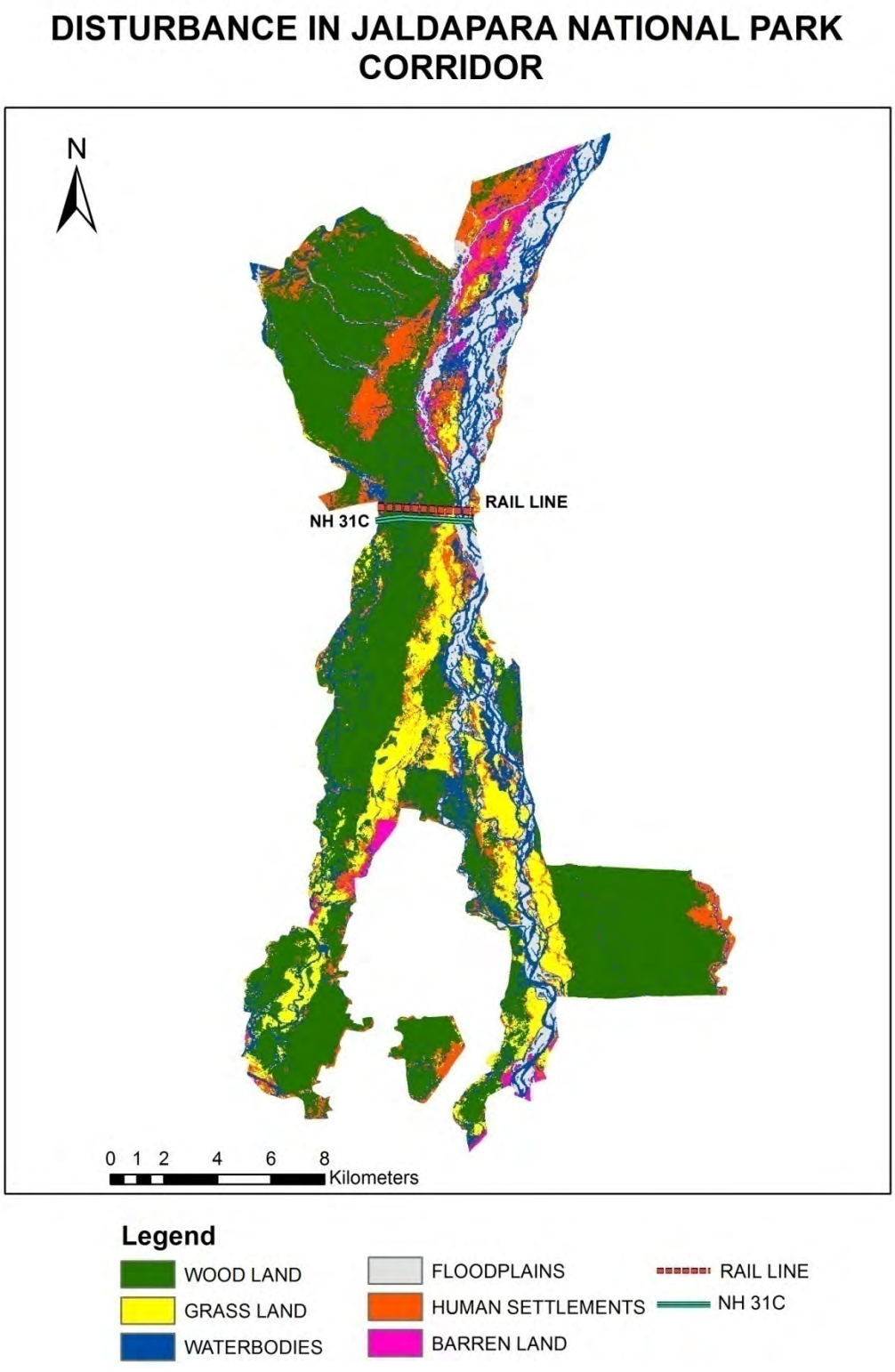


Figure 19: DISTURBANCE IN JALDAPARA NATIONAL PARK WILDLIFE CORRIDOR

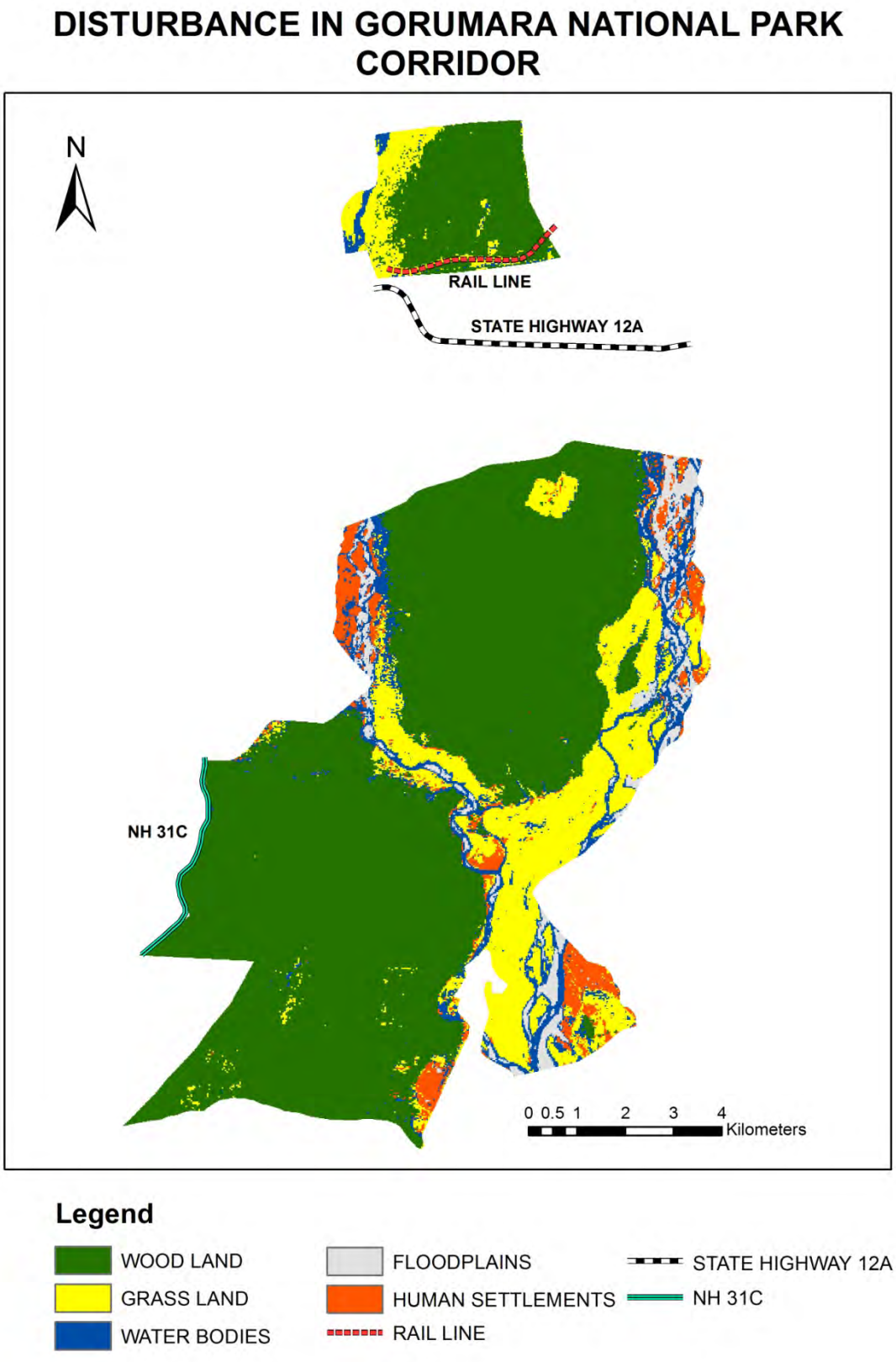


Figure 20: DISTURBANCE IN GORUMARA NATIONAL PARK WILDLIFE CORRIDOR

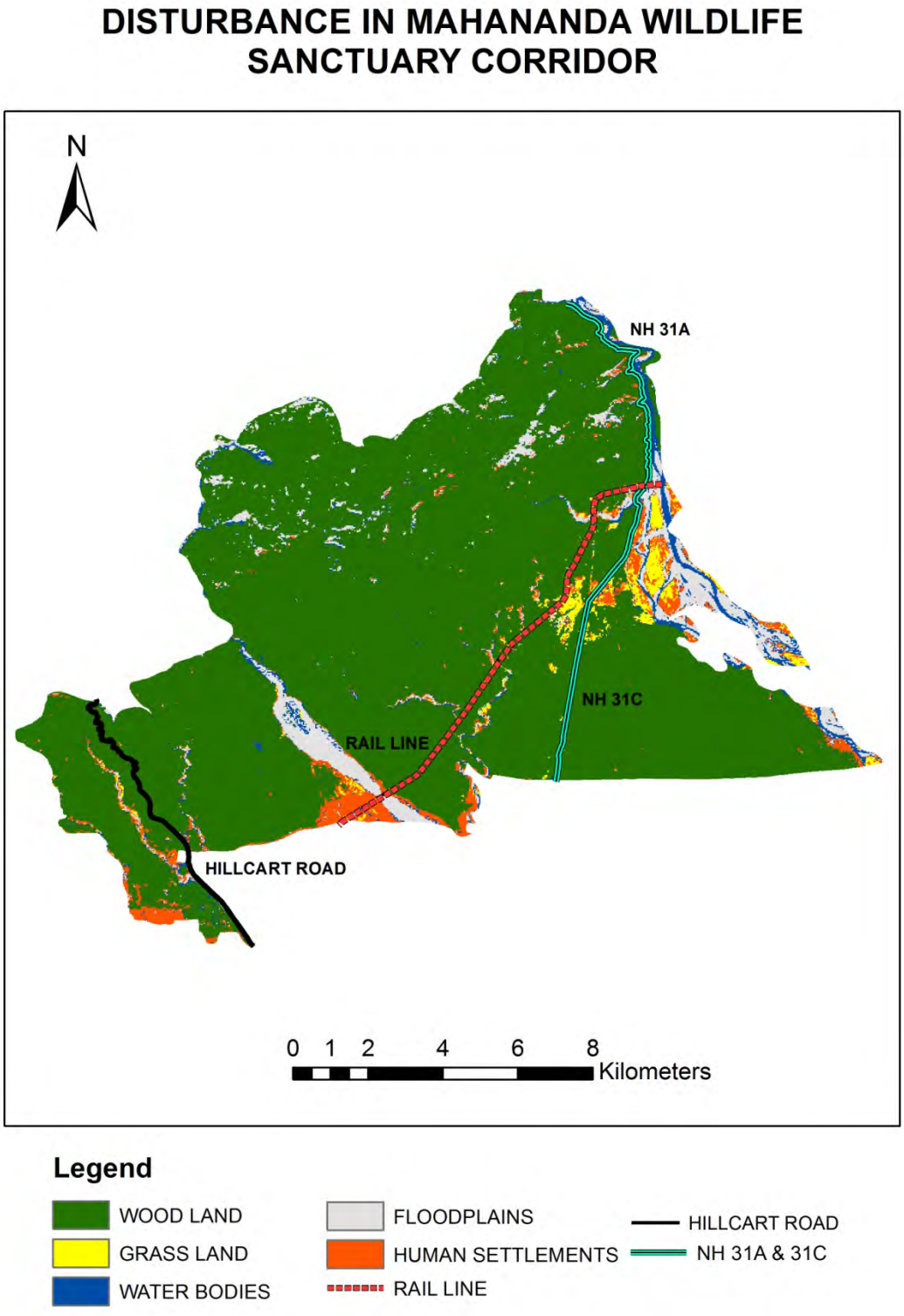


Figure 21: DISTURBANCE IN MAHANANDA WILDLIFE SANCTUARY WILDLIFE CORRIDOR

Canopy manipulation

Canopy manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation. The purpose of canopy manipulation is to increase the quantity and quality of forest for wildlife and/or timber production by manipulating stand density and structure. Canopy manipulation is also used to reduce wildlife hazards, improve forest health, restore natural plant communities, achieve or maintain a desired nature understory plant community for wildlife, grazing, and / or browsing.
The vegetation of the three Pas in this Project comprises of a multi-tiered vegetation assemblage. The most common species among them are:-

Plains: - Sal (*Shorea robusta*), Bahera (*Terminalia champaca*), Champ (*Michelia champaca*), Chilaune (*Schima wallichi*), Gokul (*Ailanthus grandis*), Katus (*Castanopsis indica*), Dudhlali (*Amoora wallichi*), Haralali (*Amoora sp.*), Lasuni (*Aphonomixis portalachea*), Teak (*Tectona grandis*), Jarul (*Lagerstoemia speciosa*), Odal, Satian, Kutkat, Kalikat, Narkeli.

Hills:- Katus (*Castanopsis indica*), Mandane (*Artocarpus fraxinifolius*), Bhalukath (*Talauma hodgsoni*), Phalame (*Walsura tabulata*), Kimbhu (*Morus laevigata*), Panisaj (*Terminalia microcarpa*), Gokul (*Ailanthus grandis*)

It is observed the presence of a wide array of grasses, herbs and shrubs enrich the fodder resources of the forest. The grasses mostly preferred by the wild herbivores are *Imperata cylindrica*, *Arundo donax*, *Themeda arundinacea*, *Phragmites karka*, *Paspalidium punctuatum*, *Panicum maxima*, *Seteria glauca, Oryza sp.*, *Saccharum sp.*, *Andropogon sp.*, *Thysanolana sp.*, *Saccharum narenga*, *and Axonopus compressus.*

With the abundance of dense forests providing plentiful fodder and fruits for herbivores and consequently a large prey base for carnivores, the area should have been an ideal habitat for wild animals. But the faunal variety of PAs faces various hindrances in the path of spatial distribution and thus is limited to a few pockets. It is also observed one of the prime limiting factors is the conversion of natural forests to Teak and Jarul monoculture plantations in many areas during Sixth and Seventh Working Plan Periods before the establishment of the establishment of National and Wildlife Sanctuary. Teak and Jarul plantations occupy 34% of the total plantations in the Protected areas, thus being an uncongenial factor for the wild animals. Further, natural carrying capacity is considerably reduced on account of such adverse changes.

Thus, it can be inferred that the mono culture plantation of Teaks does not favour the wild animals since they do not permit bushy undergrowth and middle storey to provide adequate cover. Dense canopy allows very little sunlight to pass, thus inhibiting the growth of light demanding species of browse value for ungulates. Consequently, congested teak plantations harbor relatively low density of herbivores. Thus, it can be suggested that the old teak plantations should be felled and artificial regeneration of grasslands should be conducted to restore the carrying capacity of the ecosystem.

Figure 22: TEAK AND JARUL PLANTATION

Grassland

During our preliminary field trips we have collected 140 species including 20 species of grasses &14 species of fodder. After identification and preparation of Herbarium it will be categorically arranged in most preferred, preferred, stress-time fodders for Herbivores especially for Rhino. The phenology will also be documented.

Figure 23: RESEARCHERS COLLECTING SAMPLES FROM GRASSLAND

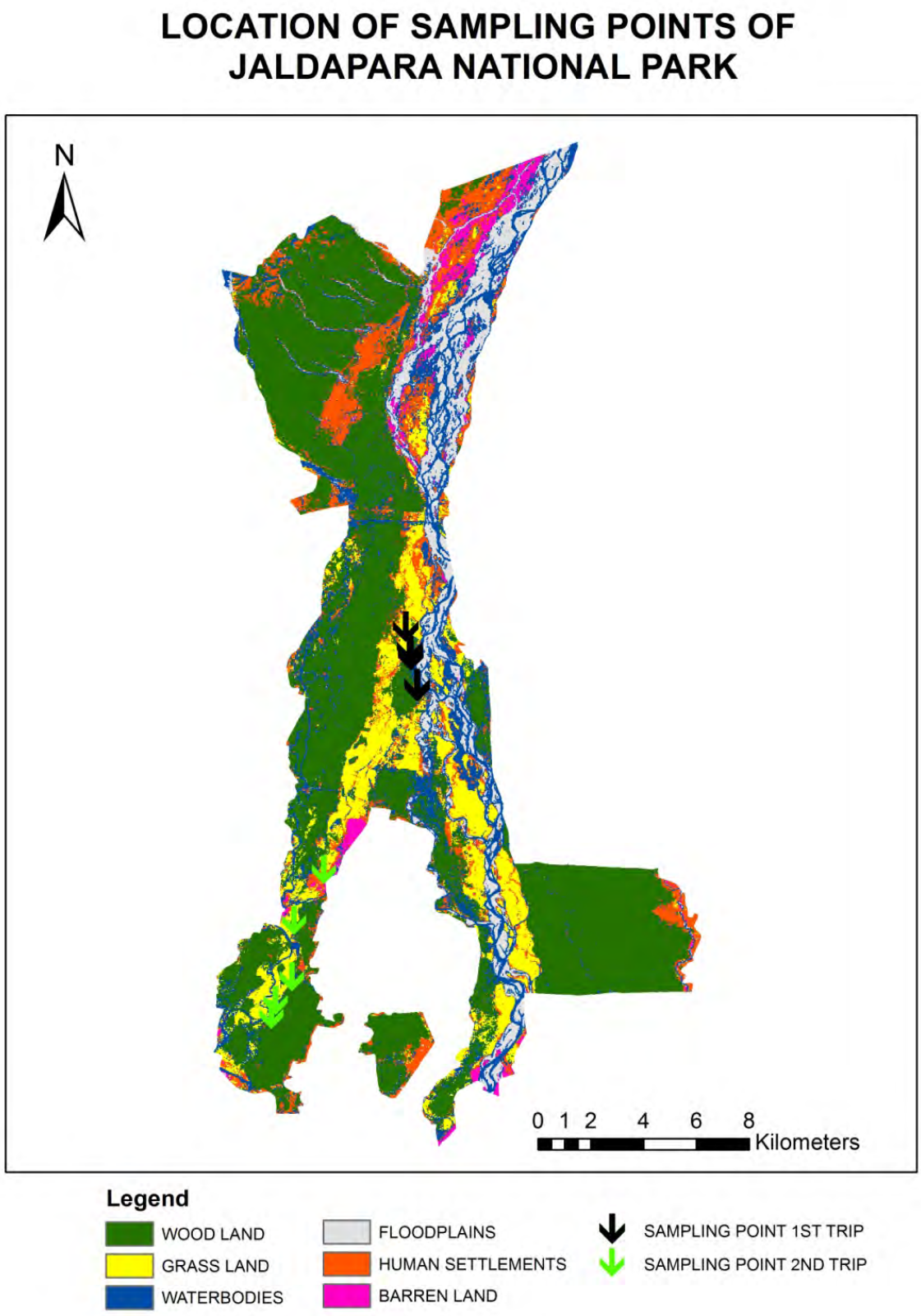


Figure 24: SAMPLING LOCATION MAP OF JALDAPARA NATIONAL PARK

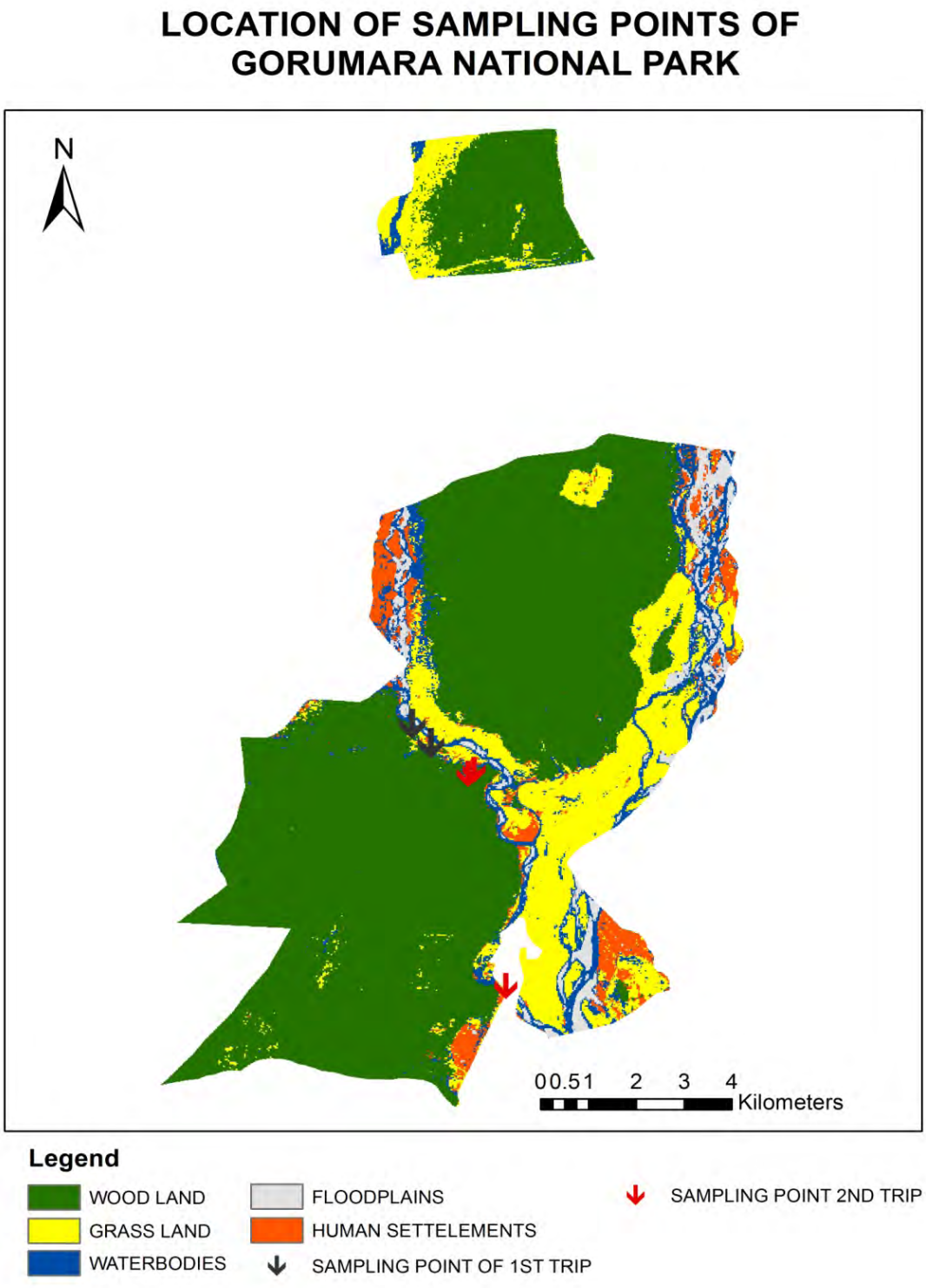


Figure 25: SAMPLING LOCATION MAP OF GORUMARA NATIONAL PARK

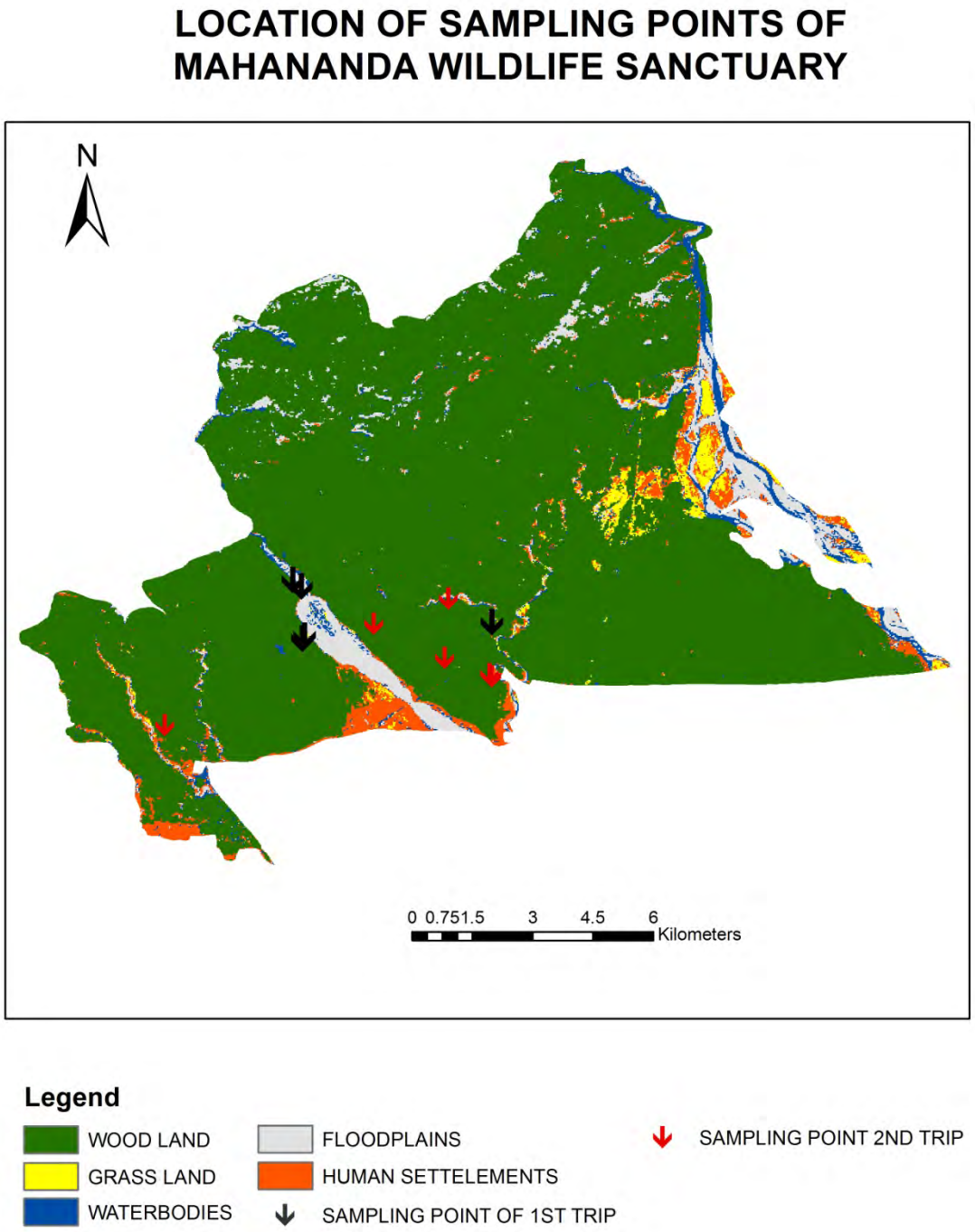


Figure 26: SAMPLING LOCATIONS OF MAHANANDA WILDLIFE SANCTUARY

During our field visits and discussion with Forest Officials, we have identified vacant land for suitable fodder plantation of which, 2 are in Jaldapara NP and 2 are in Mahananda WLS. The selection of species for fodder plantation on seasonal basis will be provided later. Details of the vacant land are in Table: 3

Table 3: VACCANT LANDS OF JALDAPARA AND MAHANANDA

Sl No.	Sanctuary/National Parks	Range	Block	Compartment	Lat/Long	Area
1.	Jaldapara National Park	Jaldapara South Range	Torsa	1	26°36'30.73" N 88°17'18.79"E	69.67 Ha
2.	Jaldapara National Park	Jaldapara South Range	Torsa	1	26°37'19.64" N 88°17'47.64"E	86.95 Ha
3.	Mahananda Wildlife Sanctuary	West Range	Singimari		26°48'46.92" N 88°25'40.73"E	3.52 Ha
4.	Mahananda Wildlife Sanctuary	West Range	Singimari-Gulma Valley		26°49'46.15" N 88°25'17.00"E	6.31 Ha

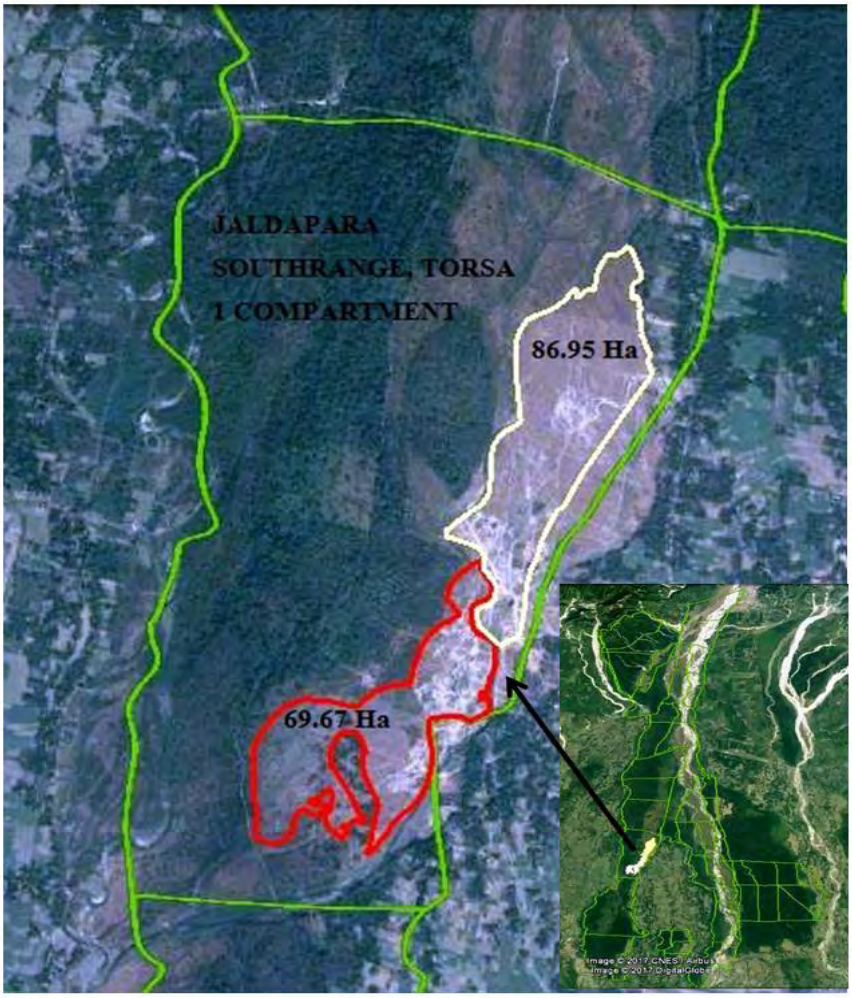


Figure 27: VACANT LAND SUITABLE FOR FODDER PLANTATION IN JALDAPARA NATIONAL PARK

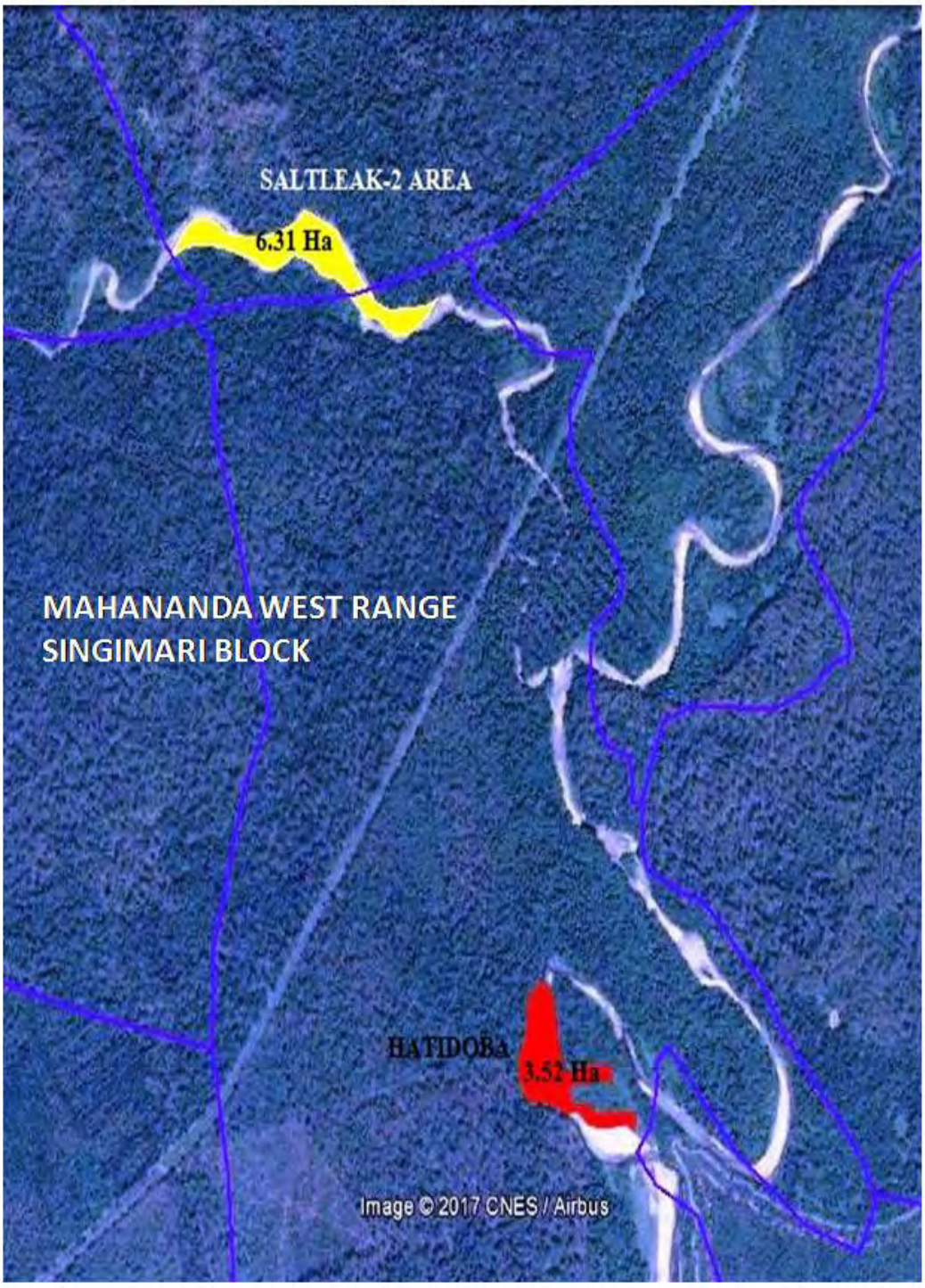


Figure 28: VACANT LAND SUITABLE FOR FODDER PLANTATION IN MAHANANDA WILDLIFE SANCTUARY

Invasive species

During our field visit we have noticed the following invasive species dominated in management area as well as rest of the PA.

a) Lantana camera- Perennial shrub, 2-5m tall seed propagated, woody
Commonly known as Putus

b) Parthenium hysterophorus- Herb, Annual broad leaved, Seed propagated, commonly known as Parthenium weed, Gajar weed

c) Mikania micrantha- It is known as –"mile-a-minute" on the basis of its speed of Its growth, a much branched, perennial, scrambling, twining, slemder- stemmed climber to Semi woody, seed propagated

4.2 Impact of Habitat Management Practices:

The impact of the previous habitat management practices by the forest department we will be assessed by the following methodology:

a) Identify all the managed zone of 3 PAs by the Forest Department with reference to the management plan of each PA and with a questionnaire survey to the forest staffs.
b) In order to assess the impact of habitat management undertaken by the department, especially the canopy manipulation and the grassland restoration, quadrate studies will be done in the managed zone and as well as in the unmanaged forest to assess the conditions which prevailed before the management activities implemented and present situation.
c) The field team will collect the animal sighting data from the managed zone and the unmanaged zone to understand the variability of the animal movement pattern and their feeding habits after manipulation.
d) Identify the impact of the habitat management practices on the animals other than the key stone species especially the arboreal and the nocturnal as well as the animals with other habitat preference such as: Hispid hare, Pigmy Hog, Bengal Florican, Malayan Giant Squirrel and other roosting and resting birds and animals.

4.3 Weed Management:

An effective methodology will be formulated in order to manage the invasive floral species, with a special emphasis to the weeds.

4.4 Inventorization of Flora, Fauna and Microhabitat

4.4.1 Assessment of floral diversity

A thorough survey of the flora of the study areas will be done to ascertain whether there is any introduction of new species especially alien species and whether there is any extinction of a plant species in the areas under study. The data available in the literature or available with the Forest department will be used as reference or background data. The samples will be collected and herbarium specimens of all the plant species will be prepared and kept in the interpretation centre for record and future use.

4.4.2 Assessment of Faunal diversity

The forest staff will be interviewed periodically with the set proforma for collection of data regarding faunal diversity and related aspects. Information regarding population status of herbivores, breeding, sex- age composition, habitat preference along with carnivores and their prey base will be collected from Park Managers and Wildlife Squad. Validation of the collected data in terms of precision and accuracy will be done by the study team by conducting field surveys using standard census methods as well as line transect at random study sites.

Estimation of population density of key herbivores

Estimates of the population densities of rhino, elephant and gaur along with their habitat types will be collected from the Forest Department and existing literature. Line transects method developed by Burnham *et al.* (1980) and modified by Verman and Sukumar (1985) will be used to estimate the population of different species of deer. Transects of suitable lengths depending on actual field situation will be laid and permanently marked. Such transects will be laid in all the different habitats such as forests, grasslands, plantations, banks of the water bodies, fringe areas and others, if any. All the transects will be systematically visited in three different seasons of first and second year. At every sighting, information, such as time, distance, angle of sighting, group size, type of herbivore, habitat and age (if possible) structure will be recorded. Vehicle (4-wheel drive) and elephant of the Forest department will be used for the purpose. The perpendicular distance will be recorded in groups (e.g. 0-5m, 5-10m and so on) and density (D) will be estimated from the following formula (Burnham *et al.* 1980).

$$\boldsymbol{D = nf(o)/2L}$$

Where, n = Total number of animal group
seen L = Length of Transect
f(o) = Probability of density function

Identification and evaluation of microhabitats

Based on direct sightings during transect survey, the areas of distribution will be marked on the maps for each species under study. These areas will be monitored periodically to confirm their presence. The vegetation characteristics such as grass, herb, shrub, tree composition, shade availability, terrain, distance from water bodies/natural saltlicks, will be evaluated to reveal the factors that influence the preference of such micro-habitats

Habitat use pattern and quantification

Habitat use pattern by the herbivores in the study areas will be analyzed by the method followed by Tewari and Rawat (2013) with slight modification. In essence, the method

involves analysis on the basis of direct sightings as well as indirect evidences. Monitoring for direct sightings will be done from vantage/observation points under cover at different habitat categories, *viz*., forests, grasslands, swamps, plantations, fringe areas as already identified in the Management Plans of Forest Dept. (1997, 1997a, 1998) with the help of powerful binoculars and noctavision. All the sightings recorded during dawn to dusk observation along with species identification will be considered for analysis. A continuous ground survey for four different seasons will be conducted with the help of trained elephants. The survey will be carried out in pre-monsoon (March–May), monsoon (June–September), retreating monsoon (October–November) and winter (December–February) seasons to get the seasonal variation of habitat use.

For each sighting, vegetation type, soil characteristics with 10m radius of animal will be noted. A Chi-square goodness-of-fit-test will be carried out to determine whether vegetation types were used according to their abundance or not. To find out the preference and rejection of vegetation type, Bonferroni Simultaneous Confidence Intervals (Marcum *et al.* 1980) will be calculated for the usage proportions by the different species of herbivores. To get data from indirect evidence, 100-200 circular plots of 10m radius representing all the habitats will be laid in each PAs. These plots will be cleared before on set of each season. After 7 days, pellet groups and dung of herbivore species will be counted in each plot along with their identification. The process will be repeated thrice in each season with a gap of 10-15 days.

Identification of species from pellet groups can be done from standard literature (Roberts 1977) and comparing them with the samples from zoos. Analysis of the result will provide a better picture of the seasonal utilization/preference of the different habitats by the herbivores. Seasonal changing pattern of the different parameters of the habitats (tree canopy cover, shrub density, ground cover *viz*., grass, sedge, herbs and water) can also be derived from the analysis of the data. The number of pellet groups of different species in each sampled plot will be converted to pellet group density (Pellet group/m^2) to get further evidences of the population densities of different species.
Hispid hare's habitat pattern study will be conducted at Malangi and Sissamara areas of Jaldapara National Park as the areas support a good number of populations.

The habitat study of Bengal Florican will be conducted at Kunjanagar areas of Jaldapara National Park.

Estimation of herbivore-carrying capacity

The carrying capacity for large ungulate species in three PAs of North Bengal will be calculated from biomass (kg/m^2) of wild ungulates with adult live mass over 15 kg (will be derived from estimated population density), biomass of domestic ungulates (kg/km^2, from sample count of cattle in the fringe villages and data from the Management Plans of the Forest Department 1997, 1997a, 1998), mean annual rainfall (from the Meteorology Dept.) grazing area (data from habitat preference and utilization), soil nutrient availability (by using field kits), and annual plant productivity in grazing and browsing areas, following the procedure of Fritz and Duncan (1994).

Statistical Evaluation of the data

Collected data will be statistically analysed using appropriate method.

5. SITE SELECTION:

It is observed that the three PAs undertaken for the present vary greatly in their sizes. The smallest is Gorumara NP with 79.45 sq. kms, while the largest is Jaldapara NP having an area of 216.51 sq. km. Mahananda WLS has an area of 158 sq. km. Interestingly, the largest of these viz Jaldapara NP has only 12 Blocks, while the smallest Gorumara NP has 13 Blocks. The largest division is found in Mahananda having 34 Blocks.

The site selected for the detailed study will be based on a grid map overlaid on the Blocks. Randomised blocks will be chosen in each of the PA and in each such block a further randomised grids will be identified. These will be based upon the presence of varying habitats, such as natural old growth forests, grasslands, plantations, banks of water bodies, fringe areas and others. In each PA, the randomised grid chosen will have a Habitat Improvement Zone, where manipulation work has already been carried out and along with areas where no habitat improvement is done.

The randomised grid will also be supplemented by the presence of herbivores and their population based on their sighting report and discussion with field staff of the Forest department. In addition to data collected from these sites, line transact method will be used in a few selected grids. All randomised Blocks/Grids will also be representative of all the ecosystems and habitats available in each of these PAs.

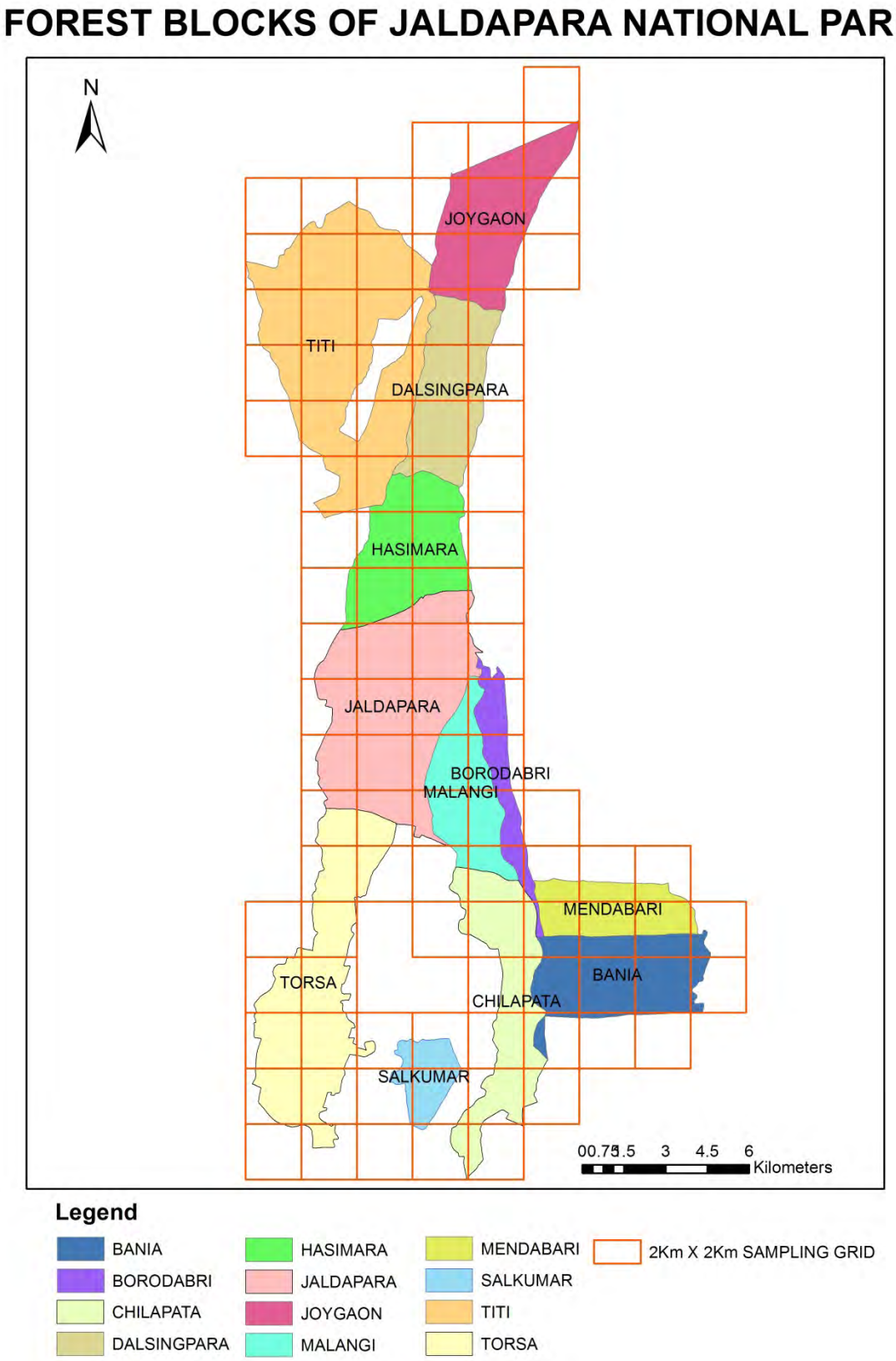


Figure 29: FOREST BLOCKS WITH SAMPLING GRIDS IN JALDAPARA NATIOANAL PARK

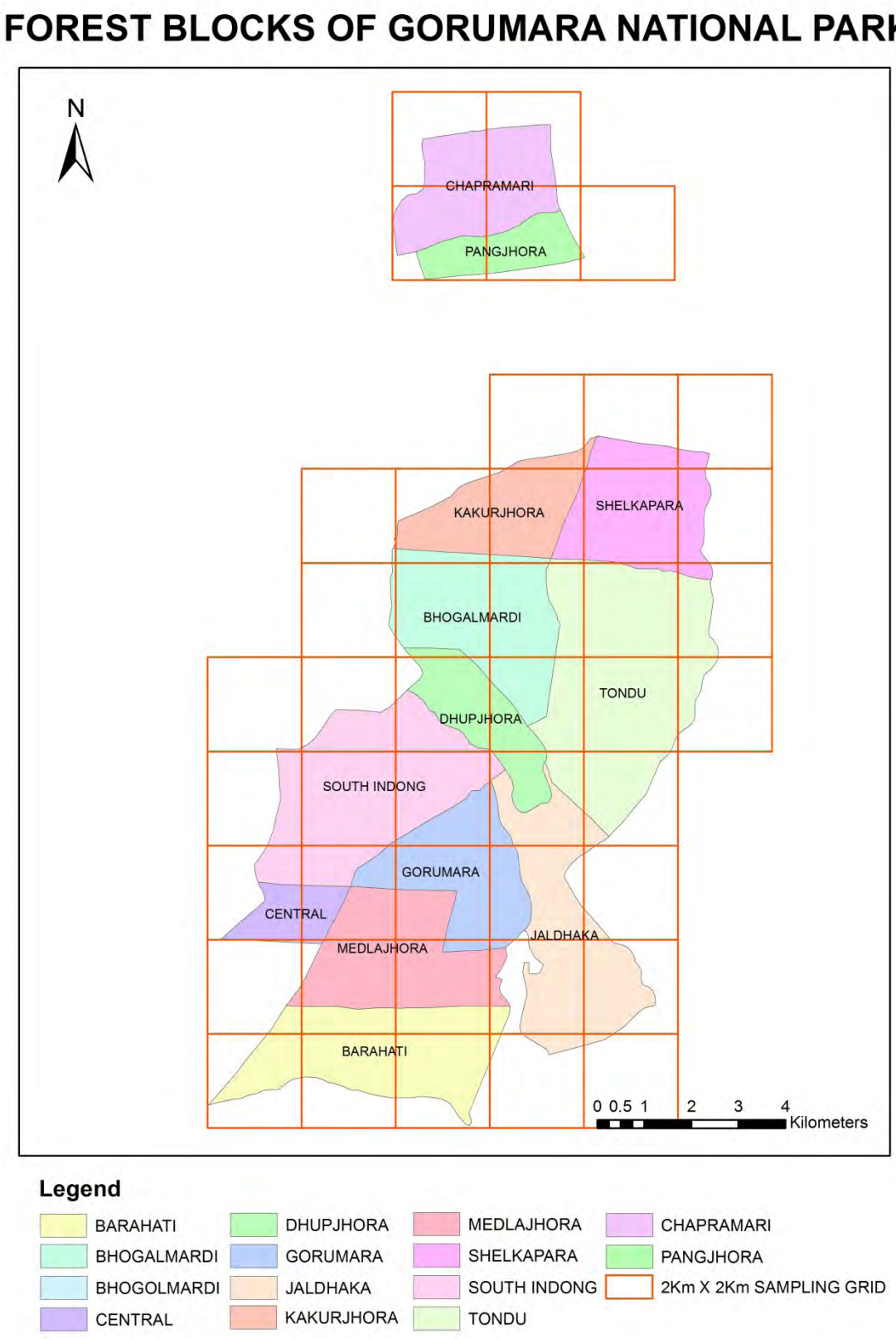


Figure 30: FOREST BLOCKS WITH SAMPLING GRIDS IN GORUMARA NATIONAL PARK

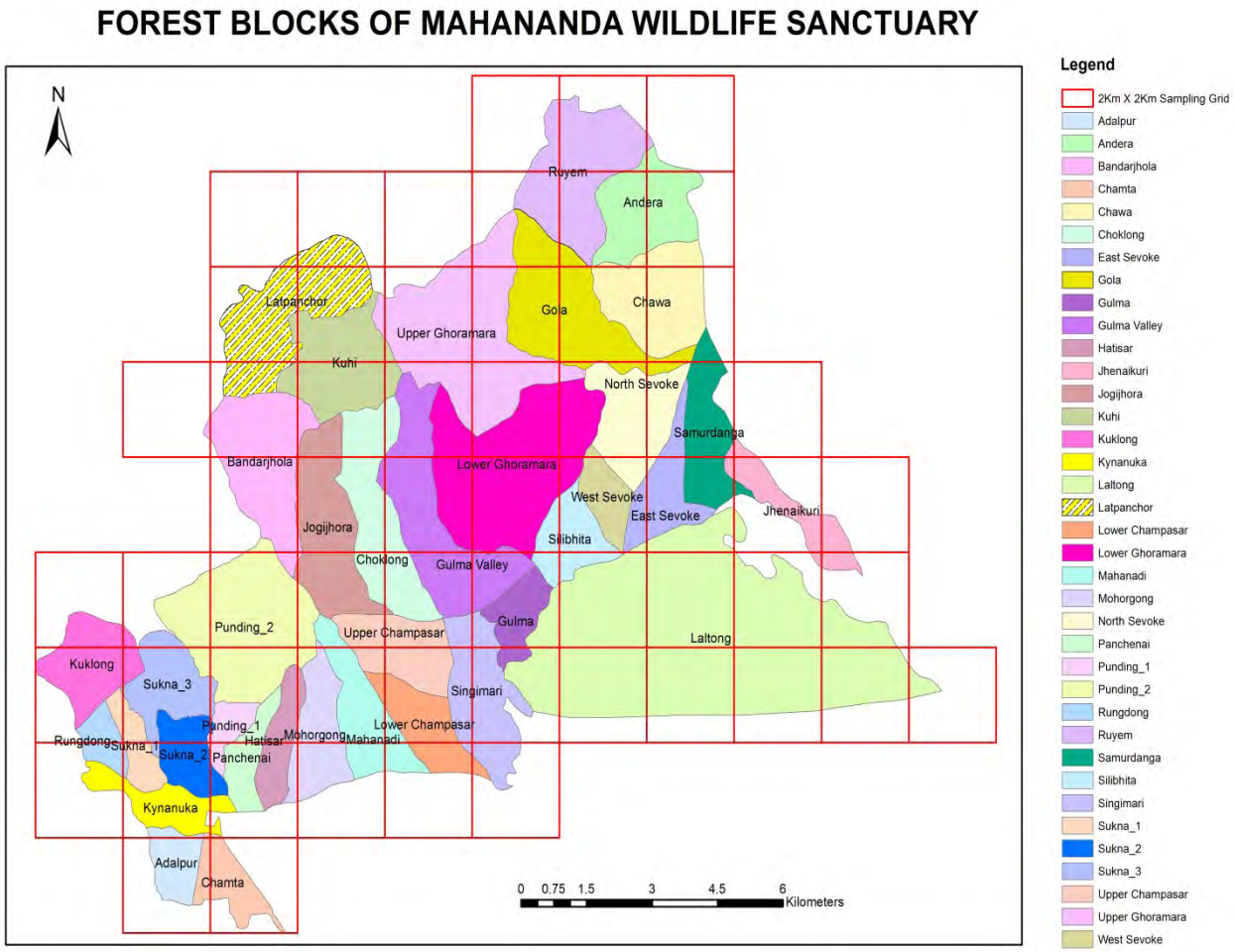


Figure 31: FOREST BLOCKS WITH SAMPLING GRIDS IN MAHANANDA WILDLIFE SANCTUARY

6. WORKPLAN

The study will make a comparison between the Habitat Improvement Zone (HIZ) where works have already been done and the areas where no such habitat improvement work has been undertaken (NHIZ). These two types of areas will represent in 1:1 ratio. The representative sites will be selected and enrolled on the basis of different ecosystems and habitats after consultation with the Forest department.

Quarterly Work Plan:

First Year

Place	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Jaldapara National Park	• Review of literature & records of forest dept. Discussion with forest Department • Study in HIZ area & to note the achievement or shortfall /error • Identification of plant & Collection of plant samples along with invasive species if any with GPS record. • Identification & Collection of grass along with invasive species if any with GPS record. • Documentation of the habitat use pattern of Herbivores. • Documentation of grass/ fodder used take as food by herbivores. • Preparation & submission of the inception report within two months of the commencement of the study. • Documentation of all reports done in 1st quarter.	• Select the site for NHIZ area on the basis of different ecosystem &habitat. • Documentation of food & fodder used by herbivores. • Observation of herbivores carrying capacity. • Observation of habitat use pattern of herbivores. • Collection of plant samples including invasive species and identification of plant collected in previous quarter. • Identification of grass species and collection of the samples. • Preparation of herbarium specimens collected in 1st quarter. • Preparation of2nd quarter and half yearly report.	• Study on Canopy manipulation. • Study on invasive species, documentation of habitat condition of that area. • Collection and identification of plant. • Documentation of food and fodder species used by herbivores. • Studies on herbivores carrying capacity. • GIS-incorporation field survey data after 2nd quarter. • Study on HIZ area & to compare with NHIZ area. • Preparation of herbarium Specimens.	• Study on canopy manipulation. • Study on invasive species, documentation of habitat condition of that area and finalization of the eradication of the harmful weeds. • Collection and identification of plant. • Documentation of food and fodder species used by herbivores. • Studies on herbivores carrying capacity. • Preparation of Annual Report

Second Year

Place	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gorumara National Park	• Review of literature & records of forest dept. Discussion with forest Department • GIS mapping • Study in HIZ area & to note the achievement or short fall /error • Identification of plant & Collection of plant samples along with invasive species if any with GPS record. • Identification • Documentation of the habitat use pattern of Herbivores. • Documentation • Preparation • Documentation of all reports done in 1st quarter.	• Select the site for NHIZ area on the basis of different ecosystem &habitat. • Documentation of food & fodder used by herbivores. • Observation of herbivores carrying capacity. • Observation of habitat use pattern of herbivores. • Collection of plant samples including invasive species and identification of plant collected in previous quarter. • Identification of grass species and collection of the samples. • Preparation of herbarium specimens collected in 1st quarter. • Preparation of 2nd quarter and half yearly report.	• Study on Canopy manipulation. • Study on invasive species, documentation of habitat condition of that area. • Collection and identification of plant. • Documentation of food and fodder species used by herbivores. • Studies on herbivores carrying capacity. • GIS- incorporation field survey data after 2nd quarter. • Study on HIZ area & to compare with NHIZ area. • Preparation of herbarium Specimens.	• Study on canopy manipulation . • Study on invasive species, documentation • Collection • Documentation of food and fodder species used by herbivores. • Studies • Preparation

Third Year

Place	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Mahananda Wildlife Sanctuary	• Review of literature & records of forest dept. Discussion with forest Department • GIS mapping • Study in HIZ area & to note the achievement or short fall /error • Identification of plant & Collection of plant samples along with invasive species if any with GPS record. • Identification & Collection of grass along with invasive species if any with GPS record. • Documentation of the habitat use pattern of Herbivores. • Documentation of grass/ fodder used take as food by herbivores. • Preparation & submission of the inception report within two months of the commencement of the study. • Documentation of all reports done in 1st quarter.	• Select the site for NHIZ area on the basis of different ecosystem &habitat. • Documentation of food & fodder used by herbivores. • Observation of herbivores carrying capacity. • Observation of habitat use pattern of herbivores. • Collection of plant samples including invasive species and identification of plant collected in previous quarter. • Identification of grass species and collection of the samples. • Preparation of herbarium specimens collected in 1st quarter. • Preparation of 2nd quarter and half yearly report.	• Study on Canopy manipulation. • Study on invasive species, documentation of habitat condition of that area. • Collection and identification of plant. • Documentation of food and fodder species used by herbivores. • Studies on herbivores carrying capacity. • GIS- incorporation field survey data after 2nd quarter. • Study on HIZ area & to compare with NHIZ area. • Preparation of herbarium Specimens.	• Study on canopy manipulation. • Study on invasive species, documentation • Collection and identification of plant. • Documentation of food and fodder species used by herbivores. • Studies on herbivores carrying capacity. • Preparation • Preparation of final report.

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8. ANNEXTURE

8.1 Animals and Their Environment

Animals are closely linked to their environment. Both biotic and abiotic components influence their lives. In addition factors such as climate, topography, and geographic location determine the composition and distribution of both plant and animal communities. Plants species help determine the species of wildlife. The, sustainable way to manage wildlife is to manage the habitats in which they live.

8.2 Landscape Ecology

One important concept in habitat management is landscape ecology. Wildlife habitat is usually studied at a relatively small scale, such as an individual forest stand. However, landscape ecology views wildlife habitat on a much larger scale: such as a National Park, a mountain range, or an entire region. The reason for this landscape approach is simple: many wildlife species move regularly across great distances because of seasonal changes in food supply. Hence, changes in habitats over a much wider range affect wildlife populations directly and indirectly.

8.3 Succession

It is difficult to know about wildlife habitat (except carnivores) without discussing plant communities and their succession pattern. Vegetation changes occurring within a forest stand after a fire illustrate such a succession, from grasses and herbs, to shrubs, to saplings, and then to a mature forest stand while old grow this the final stage. As plant communities change from one stage to the next, animal communities change as well. Succession also develops as a result of land management practices, in addition to natural catastrophic disturbances, such as fire, wind, or flood, which occur with relative frequency.

8.4 Carrying Capacity

The basic need of any wildlife is: food, water, cover / shelter, and space. When all these blend together, wildlife not only survives, they thrive, but removal of any one of the four, forces wildlife to migrate to other places to find the missing component. When habitats are isolated or destroyed, wildlife get crowded into smaller areas. Such conditions place wildlife at risk, including vulnerability to predators, accidents, and starvation. However, all wildlife are not very mobile and local populations may be easily extinguished when their habitat is destroyed or significantly altered.

All these lead to the carrying capacity of wildlife in any habitat. Carrying capacity reflects the number of animals a habitat can maintain in a healthy condition. Limiting factors mentioned earlier determine the numbers, types, and locations of wildlife populations.

8.4.1 Limiting Factors

Food

One way to categorize wildlife is by the food they eat. For example, leopard and tiger are primarily meat eaters, or carnivores. Elephant, Rhino, Bison, Deer, Rabbits and Rodents are examples of herbivores; they eat plant material exclusively. Birds eat anything from small mammals (raptors) to grass. Food refers to the season they are present in the habitat, and the quantity available there and easy access to the food. Palatability is the nutritive and digestible quality of food. Wildlife selects and eats palatable foods that they are easily available.

Therefore, food preference directly relates to nutritional quality. Assessing food quality (vegetation) is an important issue when managing herbivores, such as deer. The quality of vegetation relates to the fertility of the soil, and higher the soil fertility, the better the nutritional quality, or palatability, of the vegetation. Many young plant shoots are extremely palatable early in the growing season. Encouraging natural regeneration of native plant species is the best way to improve food resources for wildlife.

Water

Animals require water for their digestion and metabolism, reducing body temperature, and removal of metabolic wastes. Most wildlife can survive a week without food but only a few days without water.

Animals require a permanent source of water or they will abandon the site. Water is seldom a limiting factor for the more mobile terrestrial wildlife species, but some species are restricted in their home range because of their dependence on water for feeding, locomotion, protection, or breeding.

To enable wildlife to occupy in the same area all the year round, managers provide a regular water source. A rule of the thumb guideline is to provide permanent water sources no more than half km. apart. Another important management objective is to keep the watershed (all the area drained by a creek, stream, or river) protected and intact, in the area under consideration.

Cover /Shelter

This is that physical feature that provides an animal with shelter, protection or concealment. Three general types are known:

1) Hiding or escape covers for use by animals seeking protection from predators;
2) Thermal cover, for protection from elements such as wind, rain, and temperature extremes, and
3) Reproductive cover, for use by nesting animals.

Providing cover for wildlife is not without problems. Creating cover for one species may limit the desirable cover for another species. When manipulating the forest environment, the

manager considers vertical (layers within a habitat) as well as horizontal (e.g. distance between and placing side by side cover types) spatial arrangements of cover.

Space

All creatures need space to roam. All wildlife species require a certain amount of habitat to move about, avoid or escape potential predators, locate a mate, obtain sufficient food and water for survival and rest. This type of habitat requirement is called the living space.

This living space is often referred to as the home range of an animal. The amount of space required is largely determined by the quantity and quality of food, cover, and water found in an area. Other factors affecting this space are:

1. The size of an animal (larger animals need more space, but are often generalists that can live in a variety of habitats);
2. Dietary preferences (carnivores need more space than herbivores);
3. How well the animal can withstand crowded conditions. Space requirements (as a function of habitat quality and quantity) essentially determine the carrying capacity, i.e. number of animals the site will support.

8.5 Structural Diversity

The structural diversity of the landscape affects wildlife populations as it dictates the availability and accessibility of food, water, cover. Structural diversity refers to the vertical and horizontal features of the landscape. The layering of canopy and understory vegetation within an individual stand makes up the vertical plane. Different successional stages across the landscape, such as agricultural lands adjacent to a forest, or a river and its floodplain, create the horizontal features. These structural differences influence both the movements and types of wildlife populations living within forest ecosystems.

8.6 Snags and Cavity Trees

Trees can actually provide more habitats for wildlife when they are dead than when they are alive. Standing dead and dying trees, called “snags” or “wildlife trees,” are important to wildlife in both natural and landscaped settings. Such trees could be a result of disease, lightning, fire, animal damage, too much shade, drought, root competition, as well as old age.

Birds, small mammals, and other wildlife use “snags” for their nests, nurseries, storage areas, foraging, roosting, and perching. Live trees with snag-like features, such as hollow trunks, excavated cavities, and dead branches can provide similar wildlife value. Snags occurring along streams and shorelines eventually may fall into the water, adding important woody debris to aquatic habitat. Dead branches are often used as perches; snags that lack limbs are often more decayed and, may have more and larger cavities for shelter and nesting. Snags enhance local natural areas by attracting wildlife species that may not otherwise be found there.

All trees of all sizes are potential snags. Unfortunately, many wildlife trees are cut down without much thought to their wildlife value or of the potential management options that can safely prolong the existence of the tree. Wildlife trees offer a one-stop, natural habitat feature. In short, snags "live on" as excellent wildlife trees for all to enjoy.

8.7 Large, Organic Debris (LOD)

Large, organic debris, also known as coarse, woody debris, is the dead woody material that accumulates on the ground after windstorms, snow slides, timber harvest, and flooding. Although we realize LOD can be a fire hazard, we recognize the importance of this material to the functioning of forest ecosystems. As woody debris slowly decays, it provides a suitable medium for microorganisms and bacteria that aid in the decaying of woody material. As this material is broken down, nutrients return to the soil, where they become available to plants, which in turn provide food for animals.

8.8 Edge

Edge is the area formed between two different successional stages, or plant communities, such as a forest and a meadow. Edges typically are areas of highly diverse wildlife communities. Ecotones, more commonly called edges, are important to wildlife because the boundary between two adjoining habitats contains components of each type and can thus satisfy the needs of a greater diversity of wildlife species than any one habitat type alone can. Some wildlife species live only within the edge, others live both in the edge and the adjoining habitat, while others live exclusively within the interior of a particular habitat type

There are two types of edge, inherent edge and induced edge. Inherent edge occurs as a result of natural features of a site, such as soil, water, and topography. These edges are long lasting, relatively stable features of the landscape. They can be changed rapidly by some catastrophic occurrence or slowly by processes such as erosion. Induced edges exist where two different successional stages abut, and may be created by fire, wind, logging, planting and seeding, and other disturbances. Induced edges are typically short lived phenomena, lasting only a few years or decades before blending into the landscape. There is, obviously, enormous scope for creating induced edge, but potential consequences on wildlife must be considered prior to creating edge.

However, the amount of edge is not the only issue; it is the arrangement across the landscape, which is important. Induced edge increases the numbers and diversity of wildlife species. However, too much edge may have adverse effects on animals that require larger, continuous blocks of forest for survival.

An increase in edge may not be beneficial to all wildlife. For example, forest interior species do not benefit from more edge. Predation and parasitism typically are greater in edge. Therefore, edge sometimes has been called an ecological trap. Further, an improvement in the welfare factors provided by an increase in edge stimulates population growth of selected species, such as deer.

8.9 Forest Fragmentation

Forest fragmentation is a form of habitat fragmentation occurring when forests are cut down in a manner leaving relatively small, isolated patches of forest known as forest fragments or forest remnants. The intervening matrix that separates the remaining woodland patches can be natural open areas, farmland, or developed areas.

8.10 Corridors

Habitat types of value to wildlife must be accessible via connections, or corridors.

Corridors are effective if they protect known travel routes, follow areas of least resistance to movement, and connect seeps, springs, and riparian areas.

Corridors are needed between habitat types so animals can move between them without excessive predation.

Until more information is available regarding the effects of forest fragmentation, corridors can serve as forested "links" between two similar habitat patches. Corridors may provide safe travel routes between habitat "islands," reducing the negative impacts of forest fragmentation on wildlife populations. Corridors provide more continuity to a landscape, and may help managers achieve their management goals.

8.11 Riparian Habitat

Riparian zones are areas that surround water sources. They support high soil moisture and associated moisture-loving vegetation. These areas of high biodiversity often provide the necessary elements for survival food, water and cover in the same location. Changes in soil moisture characteristic of riparian zones promote many different plant communities within a relatively small area. Diverse plant communities support more species of wildlife. Riparian zones are also areas of edge, associated with increased wildlife diversity. The most important consideration in riparian zone management is avoiding stream bank erosion. Soil erosion occurs primarily because of vegetation removal through livestock grazing, road building, or tree harvest. If vegetation is removed, the resulting changes in water chemistry and temperature may harm fish, aquatic invertebrates, amphibians, and many songbirds. Riparian zones are an integral part of entire watersheds. Removal of riparian vegetation impacts water quality downstream and throughout the watershed. Riparian areas may be extremely sensitive to disturbance. Changing riparian habitat impacts a higher proportion of wildlife than is indicated by the amount of area disturbed. Thus, maintaining riparian vegetation communities becomes extremely important in riparian management.

8.12 Canopy manipulation

Canopy manipulation of species composition, stand structure and stocking is by cutting or killing selected trees and understory vegetation. The purpose of canopy manipulation is to

increase the quantity and quality of forest for wildlife by manipulating stand density and structure. Canopy manipulation is also used to reduce wildlife hazards, improve forest health, restore natural plant communities, achieve or maintain a desired nature understory plant community for wildlife, grazing, and / or browsing.

8.13 Grassland restoration

Amongst the many ecosystems, grasslands are one of the most affected systems, which is evident by a sharp decline in its productivity and species diversity. The preeminent causes, which induce the grassland degradation include; overgrazing, soil erosion, nutrient depletion, salinization, pollution, disruption of hydrological systems, and conversion of natural areas into croplands, monoculture plantations and ill-planned developmental activities.

8.14 Invasive species

An invasive species (an introduced species) is a plant, fungus or animal species that is not native to that location and which has a tendency to spread to a degree believed to cause damage to the environment, affecting the economics and human health. Invasive species cause loss of biodiversity including species extinction and changes in hydrology and ecosystem function.

The worst invasive weeds in protected areas include *Lantana camera* (Lantana) , *Acacia auriculiformis* (Akashmani, Australian Babul, Kasia, Soanajhuri), *Parthenium hysterophorus* (Parthenium weed, carrot weed, Chatak Chandani, Gazarghas, Osadi), *Prosopis julifera* (Belarijali, Ganda babul, Ganda babool, Gando bavel, Vilayati babool, Vilayati khejra, Vilayatikikar), *Mikania micrantha* (Mile-a-Minute, Japanihabi), *Grangea maderaspatana etc.*

Invasive species impact plant and animal communities; • Interfere with natural resource management operations; • Reduce threatened and endangered species populations; • Damage cultural and historic resources; • Reduce the value of forest and grazing lands; • Alter fire frequency; • Hybridize with native species; • Lesser timber production;; • Consume ground water, • Increase soil erosion; • Reduce water quality; • Transmit pathogens to other species; • Clog waterways and irrigation systems; • Exclude, parasitize, or attack other species, • Alter nitrogen and carbon cycling; • Impact human health; and • Cause other environmental and economic impacts.

It is apparent from the foregoing discussion that any habitat can be changed by natural and anthropogenic causes, which can impact the distribution and population density of the wild animals. In this context, very little is known about the habitat alteration and its potential effects on wildlife in the National Parks& Wildlife Sanctuaries of North Bengal. The present study has been under taken to bridge the lacuna.

9. PHOTO SECTION

Figure 32: ONE HORNEED RHINO IN ITS GRASSLAND HABITAT IN JALDAPARA NATIONAL PARK

Figure 33: ONE HORNED RHINO IN ITS WOODLAND HABITAT IN JALDAPARA NATIONAL PARK

Figure 34: ELEPHANT IN ITS TYPICAL GRASSLAND HABITAT IN GORUMARA NATIONAL PARK

Figure 35: RESEARCHER DOING VEGETATION SURVEY AND MARK GPS LOCATION ALONG WITH FOREST STAFFS

Figure 36: RESEARCHERS ASSESING THE VACCENT LAND IN JALDAPARA NATIONAL PARK

Figure 37: VACCANT LAND IN MAHANANDA WILDLIFE SANCTUARY

Figure 38: INDIAN BISON OR GAUR IN JALDAPARA NATIONAL PARK

Figure 39: A TUSKER IN GORUMARA NATIONAL PARK

Figure 40: BARKING DEER IN JALDAPARA NATIONAL PARK