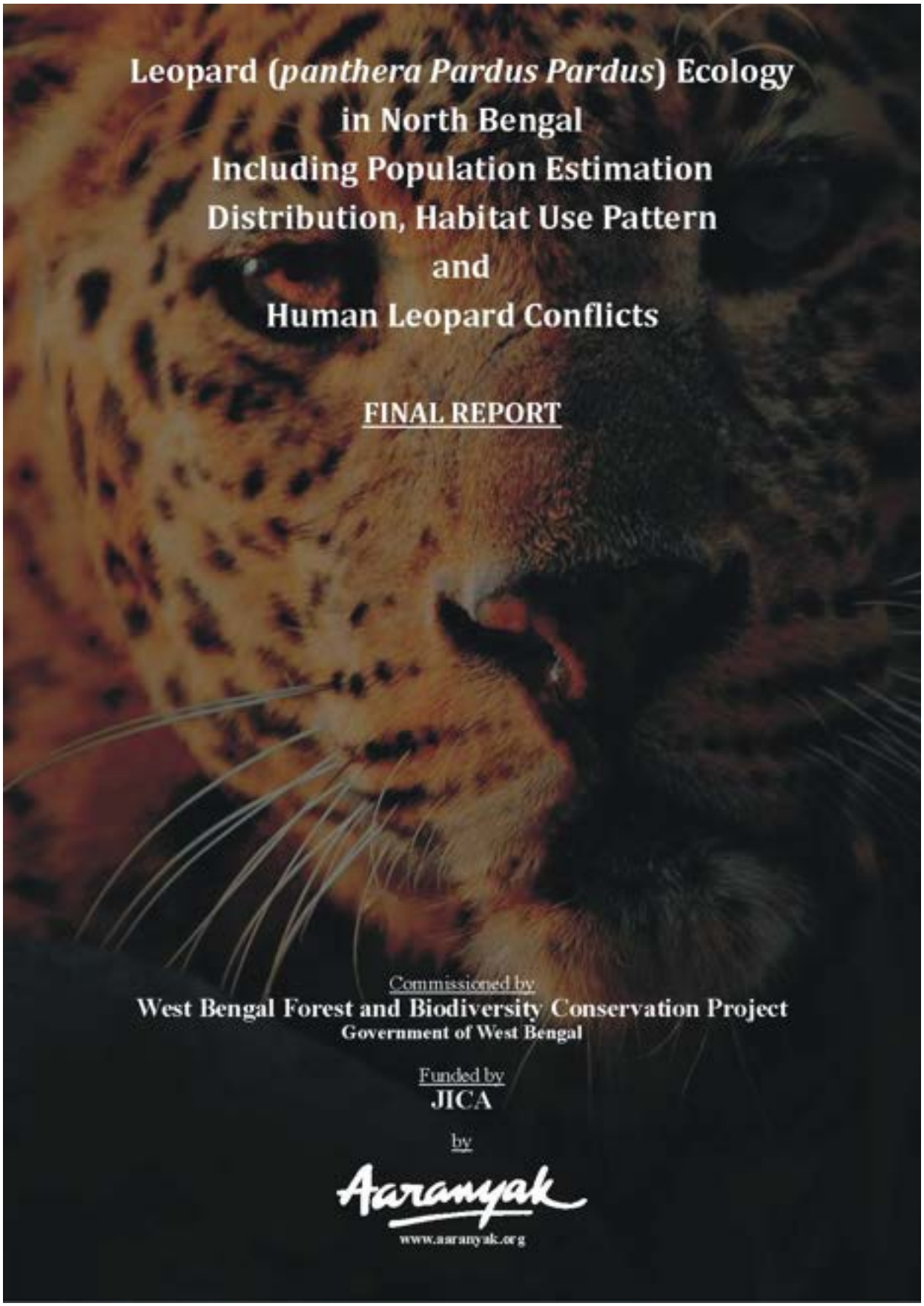

Leopard (*panthera Pardus Pardus*) Ecology in North Bengal Including Population Estimation Distribution, Habitat Use Pattern and Human Leopard Conflicts

FINAL REPORT

Commissioned by

West Bengal Forest and Biodiversity Conservation Project

Government of West Bengal

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Leopard (*Panthera pardus*) ecology in North Bengal including population estimation, distribution, habitat use pattern and human-leopard conflicts

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EXECUTIVE SUMMARY

Leopard (*Panthera pardus*) is a globally threatened species which has experienced a rapid decline in population size across its distribution range. The species is highly adaptive to a diverse type of habitat and can adapt very well to human dominated landscapes. This however often brings the species in conflict with human, due to attacks on human and their livestock as well as retaliatory killing by human. In the North Bengal landscape, human-leopard conflict instance are on a rise in recent years resulting in casualties on both sides. While the increase in human-leopard conflict in North Bengal is attributed to the changes in land use patterns over the past century, no systematic appraisal on the population of leopard, people's perception towards leopards and dietary preference of leopards have so far been carried out at the landscape level.

As part of the present study we carried out a systematic appraisal of status of human-leopard conflict intensity, people's perception towards leopards, their presence across the protected area network of North Bengal along with population status and dietary preference of the species. The human-leopard conflict intensity and people's perception towards leopards was evaluated through semi-structured questionnaire survey while the presence of leopards in the protected areas of North Bengal was determined through sign survey and molecular identification of carnivore scats. We further estimated the population size and density of leopard in the protected areas of North Bengal through genetic sampling, conducted sign survey and line transects to determine prey presence and encounter rate and conducted dietary analysis of scats to estimate frequency of occurrence and relative biomass of prey consumed by leopards.

The land use and land cover map generated from the project shows total forest cover of 3462.15 sq km in the North Bengal Landscape. Our questionnaire survey covered 27.7% of the total 916 grids (4 km x 4 km) spanning the entire North Bengal landscape in which a total of 1696 participants took part. The questionnaire survey showed a high dependency of 53.71% of the respondents on forest resources. No clear trend on increase or decrease of human-leopard conflict in the landscape could be observed during the survey. As 70.40% of the respondents did not take any precautionary measures to avoid depredation of their livestock, there is a clear need of creating

awareness among people on preventive measures for leopard attacks on livestock outside protected areas. Despite predatory attacks on livestock overall a positive attitude was observed towards leopard among the participants of the questionnaire survey.

The estimated population size of leopards in protected areas of North Bengal was observed to be 111 with highest leopard density of 32.6 per 100 Km^2 in Senchal Wildlife Sanctuary while lowest density of 8.2 per 100 Km^2 in Buxa Tiger Reserve. We also recorded a healthy female to male ratio which ranged between 3 to 1 (Senchal Wildlife Sanctuary) to 1.2 to 1 (Buxa Tiger Reserve) across protected areas of the North Begal Landscape. Grazing inside protected area was evident from the high cattle sign encounter rate of 1.52 to 7.27 per 10 km observed across the sampled area as well as results of dietary analysis which showed high percentage of cattle biomass in leopard diet across most of the protected areas.

To ensure the long term conservation of leopard in the human dominated landscape of North Bengal a holistic approach is highly desirable by undertaking conservation awareness programmes and measures to build confidence among local communities on the human-leopard conflict mitigation measures that are being undertaken by the authorities.

1. BACKGROUND AND OBJECTIVES

Large carnivores have been receiving both public attention as well as priority in global conservation through focus on research and management. Based on both symbolic and functional ground, they receive the status of the flagship and umbrella species (Caro and O'Doherty 1999; Linnell and Strand 2000). The leopard is the fourth largest of the seven large cats, which include tigers, lions, leopards, cougars (puma), jaguars, cheetahs and snow leopards. It forms part of the family Felidae under order Carnivora. They are exceptionally strong and lithe and are capable of climbing trees while carrying prey up to three times its own weight (du Plessis and Smit 2001).

Leopards inhabit in a wide range of habitat which include tropical rain forests to deciduous forests, temperate forests and coniferous forests up to an altitude of 2500 meters above sea level. They historically lived across much of Africa, and Asia from the Middle East to the Pacific Ocean covering an area of nearly 35,000,000 km^2 but now are confined to only 25% of its historical distributional range. Despite the efforts given for conservation of leopard, its global population size is in decline similar to the other large carnivore species such as tiger (Ripple et al. 2014). The key threats to the survival of leopards include loss of natural habitat, fragmentation, depletion of prey base, unsustainable hunting for trophy, poaching for body parts, and indiscriminate killing (Jacobson et al. 2015). Leopard is recognised as “Vulnerable” under the IUCN Red List of Threatened Species (Stein et al. 2020) and is also listed in Appendix I of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. In India, the Leopard is provided with highest level of protection under the Wildlife (Protection) Act (1972) and is listed as schedule I species. The Indian leopards are distributed throughout India, Nepal, Bhutan, Bangladesh and parts of Pakistan. In the Indian subcontinent, the Indus River acts as the topographical barriers to the dispersal of leopard in the west and the Himalaya in the North while in the east, the lower course of the Brahmaputra and the Ganges Delta form natural barriers to the distribution of the Indo-Chinese leopard.

Human wildlife conflict is of growing concern for conservationists and wildlife managers across the globe because it threatens the survival of many wildlife species, especially,

large felids, most of which are highly threatened due to anthropogenic causes and conflict with human accounting for the highest mortality (Loveridge et al. 2010). Such unresolved conflicts may hinder management goals and can cause determent in conservation objectives. Leopard often occur outside forests even in human-use landscapes where they prey upon livestock and occasionally attack humans leading to human-leopard conflict (Seidensticker et al. 1991; Daniel 2009).

In North Bengal, human-leopard conflict has been reportedly increased in recent years with reports of straying of leopards into human habitation, attacks on human being by stray individuals and loss of human lives as well as deaths of leopards in retaliatory actions (Manoj et al. 2013; Vyas and Sengupta 2014; Chakraborty 2015). The increase in human-leopard conflict in North Bengal has often been attributed to the changes in land use pattern over the past century (Manoj et al. 2013; Vyas and Sengupta, 2014). The North Bengal landscape has undergone large scale alterations in the late 1800s when British tea planters cleared vast stretches of forests for tea cultivation resulting in the present landscape of small and fragmented forest patches connected via tea plantations and livestock depredation due to leopard attacks in fringe villages are often common (Bhattacharjee and Padhy 2013; Kshettry et al. 2017 and Kshettry et al. 2018).

The current scenario of human-leopard conflict in North Bengal warrants for immediate implementation of measures which will ensure mitigation of human-leopard conflict as well as conservation of existing leopard population in its natural habitats. In the present study the distributional status of leopards, its population size, prey base, dietary habits and habitat use pattern in the North Bengal Landscape was evaluated using noninvasive genetic tools along with other conventional ecological methods. The noninvasive genetic tools have been successfully used across India for monitoring of wild populations of large carnivores, especially, in the low density areas where conventional methods requires a huge amount of investment in terms of logistic requirements, time and requirement of skilled personal (Reddy et al. 2012; Borthakur et al. 2013; Sharma et al. 2013). The study further assessed the present scenario of human-leopard conflict along with peoples' perception towards the species through semi-structured questionnaire survey.

Objectives

The objectives of the present study were:

1. To evaluate the human-leopard conflict intensity in North Bengal.
2. To determine the presence of leopards in protected areas of North Bengal through sign encounter rate survey and use of noninvasive genetic tools.
3. Estimation of population size and population density of leopard in protected areas of North Bengal.
4. Estimation of prey abundance of leopard.
5. Diet analysis of leopard scats for estimation of relative biomass and number of prey consumed by leopard.

2. STUDY AREA

The present study was conducted in the northern part of the state of West Bengal comprising of the districts of Alipurduar, Cooch Behar, Jalpaiguri, Darjeeling and Kalimpong. It represents a unique mosaic of Eastern Himalayan region, sub-montane terai region and alluvial plains which are dissected by numerous rivers and their tributaries. Of the total land mass of North Bengal 5583 km^2 are estimated to be forest areas (Forest Survey of India, 2015) comprising of various forest types such as, tropical wet ever green forests, sub-tropical semi ever green forests, moist deciduous forests, sub-tropical broad leaved forests, Himalayan wet temperate, moist temperate and sub-alpine forests along with grasslands covering vast areas of alluvial plains and montane regions (Sanyal et al. 2012).

The present study encompassed the protected area (PA) network of North Bengal (Figure 1) which include four National Parks (NP) viz., Singalila NP, Neora Valley NP, Gorumara NP and Jaldapara NP along with three Wildlife Sanctuaries (WLS), viz., Senchal WLS, Mahananda WLS and Chapramari WLS and the Buxa Tiger Reserve (Buxa TR) (Figure 2). Administratively, the Chapramari WLS is managed under the Gorumara NP.

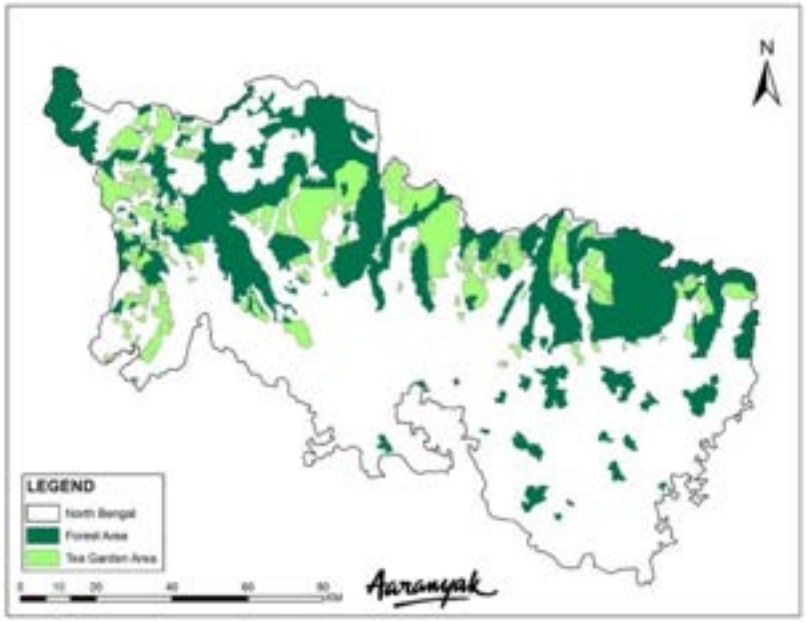

Figure 1: Map showing forest and tea garden areas of North Bengal

Although, leopards are known to use tea garden areas in North Bengal landscape, in the present study tea gardens have not been included in any of the sampling sessions.

2.1. Singalila National Park

The Singalila National Park (87°58′ - 88°05′ E to 27°01′ - 27°13′ N) is situated in the administrative district of Darjeeling. It extends over an area of 108.8 km^2 with altitudinal gradient ranging from 2400 m to 3636 m. The park encompasses four distinct forest types which include temperate oak forests, temperate broad leaf deciduous forests, subalpine broadleaf coniferous forests and subalpine coniferous forests. The Singalila NP is famous for red panda (*Ailurus fulgens*) distribution. Apart from red panda other mammalian species that have been reported from Singalila NP include leopard (*Panthera pardus*), clouded leopard (*Neofelis nebulosa*), leopard cat (*Prionailurus bengalensis*), Himalayan black bear (*Ursus thibetanus*), takin (*Budorcas taxicolor*), Himalayan serow (*Capricornis sumatraensis thar*), barking deer (*Muntiacus vaginalis*), wild boar (*Sus scrofa*) etc.

2.2. Neora Valley National Park

The Neora Valley National Park (88°41′--88°46′ E to 26°58′--27°09′ N) is situated at the Kalimpong District of West Bengal covering an area of 88 km^2. The altitudinal range of Neora Valley NP ranges between 300 m to 3100 m. The subtropical mixed broadleaf, temperate evergreen, temperate mixed broadleaf and Rhododendron forests of Neora Valley NP support a wide variety of floral and faunal diversity. The major mammalian species recorded from Neora Valley NP include tiger (*Panthera tigris*), leopard (*P. pardus*), clouded leopard (*N. nebulosa*), golden cat (*Catopuma temminckii*), leopard cat (*P. bengalensis*), red panda (*A. fulgens*), Himalayan black bear (*U. thibetanus*), sloth bear (*Melursus ursinus*), wild boar (*S. scrofa*), Himalayan goral (*Naemorhedus goral*), Himalayan serow (*C. sumatraensis thar*), Himalayan tahr (*Hemitragus jemlahicus*) and deer species such as barking deer (*M. vaginalis*) and sambar (*Rusa unicolor*).

2.3. Gorumara National Park

The Gorumara National Park (88°47′-88°53′ E to 26°43′-26°51′ N) comprises of 79.99 km^2 of area and is located at the in the sub-montane terai belt of the Eastern Himalayas in the Jalpaiguri district of West Bengal. The vegetation of Gorumara NP mainly consists of sal forests, bamboo groves, terai grasslands and tropical riverine reeds along river Murti, Garati, Indong and Jaldhaka. Gorumara NP is known for its rich mammalian diversity and is inhabited by species such as leopard (*P. pardus*), greater one-horned rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), sloth bear (*M. ursinus*), wild boar (*S. scrofa*) and deer species including chital (*Axis axis*), sambar (*R. unicolor*), barking deer (*M. vaginalis*) and hog deer (*Axis porcinus*).

2.4. Jaldapara National Park

Jaldapara National Park (89°10′ - 89°25′ E to 26°30′ - 26°52′ N) is situated in the Alipurduar district of West Bengal in the flood plains of river Torsa. It covers an area of 216 km^2. The vegetation of Jaldapara NP consists of moist-dry deciduous forest, semi evergreen forests and savannah grasslands. The Jaldapara NP is rich in herbivore and carnivore species. The major herbivore species found in Jaldapara include greater one-horned rhinoceros (*R. unicornis*), Asian elephant (*E. maximus*), gaur (*B. gaurus*), chital (*A. axis*), sambar (*R. unicolor*), barking deer (*M. vaginalis*), hog deer (*A. porcinus*), wild boar (*S. scrofa*) etc.

The major carnivore species found in Jaldapara is leopard (*P. pardus*). Although, there were past records of tiger (*P. tigris*) presence from the national park, it has not been reported in the past few decades.

2.5. Senchal Wildlife Sanctuary

Senchal Wildlife Sanctuary (88°13′ - 88°20′ E to 26°57′ - 27°02′ N) is located in the Darjeeling district of West Bengal covering an area of 28.6 km^2. The altitudinal gradient of Senchal WLS varies from 1500 m to 2600 m. The sub-tropical and temperate oak forests in Senchal WLS are known to house mammalian species such as leopard (*P.*

pardus), leopard cat (*P. bengalensis*), barking deer (*M. vaginalis*), Himalayan serow (*C. sumatraensis thar*), wild boar (*S. scrofa*), Himalayan palm civet (*Paguma larvata*), large Indian civet (*Viverra zibetha*), Himalayan crestless porcupine (*Hystrix brachyura*), Yellow throated marten (*Martes flavigula*) and Assamese macaque (*Macaca assamensis*).

2.6. Mahananda Wildlife Sanctuary

The Mahananda Wildlife Sanctuary (88°19′ - 88°31′ E to 26°46′ - 26°55′ N) is located in the terai region of Eastern Himalayas on the bank of River Teesta in the Darjeeling district of West Bengal. The vegetation of Mahananda WLS comprises of alluvial grasslands, Khair-Sissoo forests, sal forests and dry-wet mixed forest. The Mahananda WLS is known to house a number of mammalian species which include leopard (*P. pardus*), clouded leopard (*N. nebulosa*), jungle cat (*Felis chaus*), leopard cat (*P. bengalensis*), jackel (*Canis aureus*), Himalayan black bear (*U. thibetanus*), small indian civet (*Viverricula indica*), Asian elephant (*E. maximus*), gaur (*B. gaurus*), chital (*A. axis*), barking deer (*M. vaginalis*), Himalayan goral (*N. goral*) etc.

2.7. Chapramari Wildlife Sanctuary

The Chapramari Wildlife Sanctuary (88°49′ - 88°51′ E to 26°53′ - 26°54′ N) is a small PA covering 9.6 km^2 of forest situated north of Gorumara NP in the Jalpaiguri district of West Bengal. The Chapramari WLS primarily consists of dry mix forests which is known to sustain good population of mammalian species such as leopard (*P. pardus*), Asian elephant (*E. maximus*), gaur (*B. gaurus*), chital (*Axis axis*), sambar (*R. unicolor*), barking deer (*M. vaginalis*), wild boar (S. scrofa) etc.

2.8. Buxa Tiger Reserve

Buxa Tiger Reserve (88°22′ - 89°53′ E to 26°29′ - 26°50′ N) is located in the Alipurduar District of West Bengal. The altitudinal gradient of Buxa TR varies from 60 m to 1700 m and is spread over an area of 760 km^2 comprising of 385 km^2 of core area and 375 km^2 of buffer zone. The vegetation of Buxa TR primarily comprises of tropical moist deciduous forest, sub-montane semi-evergreen forest, tropical evergreen forest, Bhabar

and Terai Sal forest, savannah woodland and grasslands. A total of 73 mammalian species have been reported from Buxa TR which include carnivore species such as tiger (*P. tigris*), leopard (*P. pardus*), clouded leopard (*N. nebulosa*), leopard cat (*P. bengalensis*), jungle cat (*Felis chaus*), fishing cat (*Prionailurus viverrinus*), Asiatic wild dog (*Cuon alpinus*), hog badger (*Arctonyx collaris*), jackal (*Canis aureus*), Indian fox (*Vulpes bengalensis*) and herbivores such as Asian elephant (*E. maximus*), gaur (*B. gaurus*), sambar (*R. unicolor*), chital (*A. axis*), hog deer (*A. porcinus*), barking deer (*M. vaginalis*), wild boar (*Sus scrofa*) and hispid hare (*Caprophagus hispidus*).

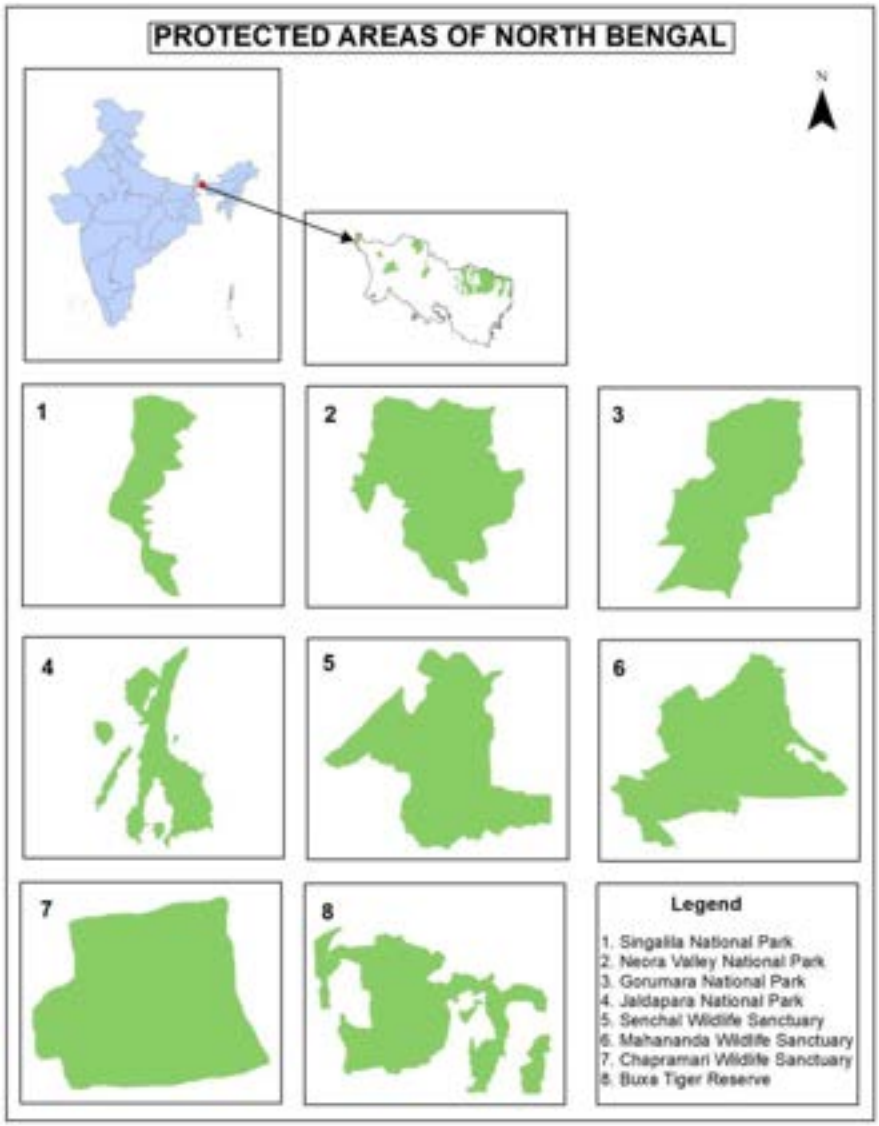

Figure 2: Map showing the protected areas of North Bengal

3. MATERIALS AND METHOD

3.1. Stratification of The Study Area on The GIS Platform and Preparation of Land Use Land Cover (LULC) Map of North Bengal

Based on the land use and land cover patterns the entire study area was divided into different zones through unsupervised classification in a GIS environment. Further stratification of each zone was carried out based on the forest covers, large agricultural areas, hillocks with scanty human settlements etc. The entire PA network was then divided into 2 km x 2 km grids using GIS platform. Such 2km x 2km grids within the PA boundary were considered as sampling unit for sign survey and leopard signs were collected in selected grids. Further, to carry out questionnaire survey, the entire North Bengal landscape was divided into 4 km x 4 km grids and was considered as sampling units.

We prepared a land use and land cover (LULC) map of North Bengal through supervised classification after field survey and ground truthing. GPS points were collected from different Land use and land cover classes. From each GPS location the following information was recorded: (a) Latitude and longitude (b) elevation (c) types of vegetation and other land use classes. A survey of literature published about the region and interaction with the local forest departments was carried out to enhance capability of understanding the unique land use and land cover types. We used recent Sentinel 2A satellite imageries with a pixel resolution of 10 meter.

For Image enhancement, we applied DOS1 (Dark Object Subtraction) atmospheric correction (carried out for all the years) was applied using QGIS software. This procedure of atmospheric correction corrects brightness values converted to radiance values required for eliminating seem lines and reducing radiometric problems (Jensen 2009; Chander et al. 2009). All the satellite imageries are projected into UTM WGS 84 with zone 45 N projection system. As the study area lies in four adjacent satellite imageries, mosaicing was carried out to get the whole area coverage into a single satellite image and subseting of satellite image was done by using Area of Interest (AOI) district boundaries of the study area using ERDAS software.

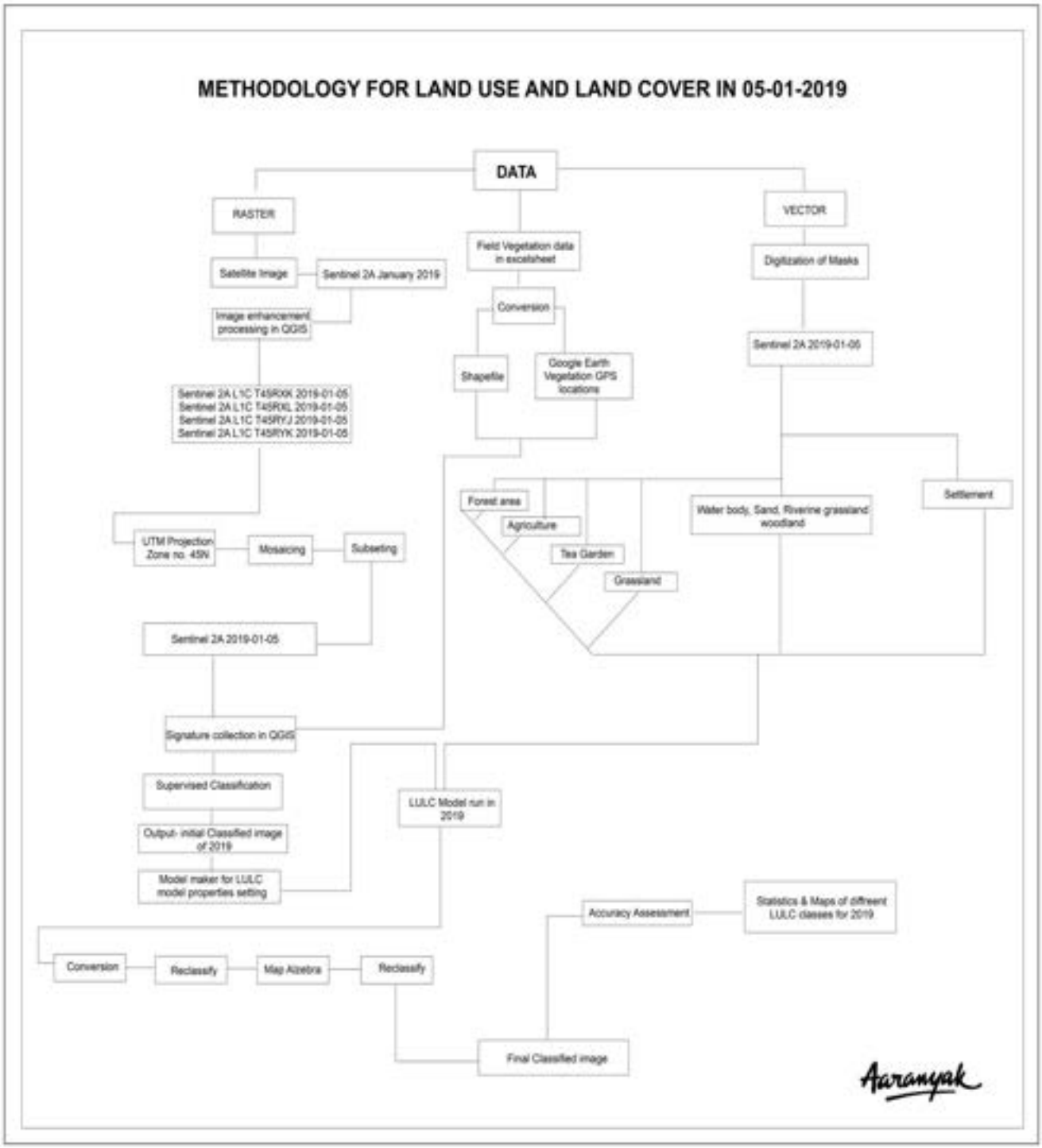

Figure 3: Flowchart showing methodology of LULC map preparation

Both visual and digital classifications were used for analysis using QGIS, ERDAS and Arc GIS software. The supervised classification technique under the digital classification approach was utilized in the present study (Lillesand et al. 2004). The training sites were collected from the satellite scene based on ground truthing data and Google earth image to get better information for inaccessible areas. Delineation of masks in the study area which consisted of water body, sand, riverine grassland, woodland and tea gardens, was carried for 2017 in ArcGIS software with scale 1:25,000. Due to misclassification in certain areas and to rectification a model maker tool was created and run to get better result which eliminates the misclassification from the classified image of 2019 by using Arc GIS software. Area of land use and land cover classes were calculated in square kilometers (sq km) and percentage cover.

A Biogeography Branch's Sampling Design tool for Arc GIS is downloaded and created stratified random points assigned to 30 points for individual class with altogether 240 points for each year. Finally, using excel spread sheet, calculated the total ground truth points in each class, Ground truth percentage, Comission, Omission, Produce accuracy, User Accuracy, Overall accuracy and Kappa Coefficient were calculated for 2019 classified images.

3.2. Questionnaire Survey on Peoples' Perception

In order to obtain information on leopard presence, frequency of leopard sightings, status of human-leopard conflict and study various socio economic factors driving peoples' perception towards leopards and leopard conservation and management efforts the Aaranyak team conducted questionnaire survey in villages in North Bengal landscape. Field data were collected using qualitative method of semi-structured interviews conducted in local language which formed the main data source. The questionnaire survey was primarily conducted by the same members of the research team to maintain uniformity and reduce individual bias while scoring of the answers. A family was treated as the basic unit for the purpose of this study, with only one respondent from a family was interviewed. The respondent was treated as a representative of the family unit.

The questionnaire consisted of five main sections: demographic and socio-economic characteristics of respondents, human–carnivore conflict experience, perceptions towards carnivores, and tolerance towards carnivores.

3.3. Sign Encounter Rate Survey

The survey team conducted sign survey in roads, river beds or trails made by other animals as travel routes. Three to five-member survey teams comprising of Aaranyak team and West Bengal Forest staff traversed through such trails/roads/riverbed in selected grids of respective PAs during the survey time. The grids for sign encounter rate survey were selected based on feasibility as well as prior consultation with the PA managers.

The survey team collected data on signs of leopard such as pugmark, scratch, rake, scat etc., following Karanth and Nichols (2002). During sign survey, each trail was divided into one kilometer sampling unit and data on signs of leopard were collected in every alternate kilometer. GPS coordinates of each of the data point were recorded systematically in datasheets. The sign encounter rate was calculated in terms of number of “encounters” per 10 kilometer walked by the survey team.

3.4. Genetic Sampling for Confirmation of Leopard Presence

To confirm the presence of leopards in the North Bengal Landscape, we further employed a noninvasive genetic sampling technique. We collected all the carnivore scats encountered during the sign encounter rate survey. Such scat samples act as a source of DNA from leopard and other major carnivore species that are found in the respective PAs. All the samples were collected in ziplock bags and transferred to the Wildlife Genetics Laboratory of Aaranyak located in Guwahati, Assam. Information’s on sampling location, Beat, Range, sample age were recorded for each of the scat sample collected in separate datasheet for future reference.

3.4.1. Laboratory Work

3.4.1.1. DNA Extraction

The DNA from scat samples were extracted following Boom et al. (1990) with minor modifications (Das et al. 2015) standardized at Wildlife Genetics Laboratory, Aaranyak.

The detailed protocol is as followed,

a. Approximately 250 mg of the faecal sample was added to 1000 µl of L6 lysis solution (5 M Guanidine isothiocyanate, 100 mM Tris, pH 6.4, 20 mM EDTA, pH 8.0, and 1.3% Triton X-100) in a sterile 1.5 ml microcentrifuge tube (MCT).
b. The mixture was incubated overnight at room temperature with intermittent vortexing to thoroughly suspend the faecal pellets. The mixture was centrifuged at 8,000 rpm for 1 minute to pellet the faecal debris, the next morning.
c. The supernatant was transferred to a fresh sterile 1.5 ml MCT, and 100 µl of 10% polyvinyl polypyrrolidone (PVPP) solution was added to it and mixed by gentle inversion.
d. The setup was left to stand at room temperature for 30 minutes, and then centrifuged at high speed 12,000 rpm for 2 minutes.
e. The pellet was discarded while the supernatant was transferred to a new 1.5 ml MCT and mixed with 50 µl of 6% silica solution by gently inverting the tubes. The setup was incubated at room temperature for about 30 minutes to allow the positively charged silica matrix to bind with the negatively charged phosphate backbone in the DNA molecules.
f. The mixture was then centrifuged at 12,000 rpm for 1 minute to pellet the silica matrix containing the embedded DNA.
g. After discarding (decanting) the supernatant, the pellet was washed twice with 500 µl of L2 Solution (5 M Guanidine isothiocyanate, 100 mM Tris, pH 6.4, and 20 mM EDTA, pH 8.0.
h. The pellet was then washed twice more with 500 µl of Ethanol wash buffer (100 mM Tris, pH 7.5, 100 mM sodium chloride, 1 mM EDTA, pH 8.0, and 60% ethanol).

i. This was followed by one wash with 500 µl of ice-cold 80% Ethanol and then 500 µl with ice-cold Acetone.

All washing steps were performed at 12,000 rpm for 1 minute.

j. The washed pellet was then air dried at 55°C for about two to three minutes, and 75 µl of 1X TE buffer (10 mM Tris, 1mM EDTA, pH 8.0) was added to the now dried pellet. The suspension was mixed by tapping or vortexing the tube and incubated at 55 °C for 10 minutes.

k. The eluted DNA was recovered from the silica suspension by centrifugation at 12,000 rpm for 3 minutes. About 65 µl of the 1X TE buffer containing the eluted DNA was gently aspirated out using a micropipette, taking care not to pick up loose silica pellet dislodged at the bottom of the tube.

l. The DNA was transferred to a sterile 1.5 MCT and stored at 4 °C.

3.4.1.2. Identification of Scats of Leopard Origin

For reliable identification of leopard scats we employed a PCR based species identification method. In this method the species identity of the carnivore scat sample is primarily determined on the basis of presence or absence of PCR products of specific size which can be resolved through Agarose gel electrophoresis by comparing with known size markers.

In the present study we employed the leopard specific mitochondrial cytochrome b gene based marker system (Ppo-CbF: 5′-GTAAATTATGGCTGAATTATCCGG-3′; Ppo-CbR: 5′-CATAACCGTGAACAATAATACGAC-3′) designed by Sugimoto et al. (2006) which produces a product of 156 base pair size. The DNA obtained from faecal samples is often low in quantity and quality and therefore, species-specific primers that amplify a region of the mitochondrial DNA are ideal for such low quality/ quantity DNA samples owing to high mitochondrial copy number (Mukherjee et al. 2007).

All the PCR reactions were carried out using QIAGEN Multiplex PCR Kit (QIAGEN, Germany) following standard kit protocol for reagent concentration with 0.5 µM of each primer and 2.5 µl of DNA in a reaction volume of 10 µl. The PCR reaction conditions were set at initial denaturation at 95° C for 15 minutes followed by 40 cycles of

denaturation at 94° C for 30 sec, annealing at 60° C for 30 sec and extension at 72° C for 45 sec and a final extension at 72° C for 10 minutes.

3.4.1.2.1. Visualization of PCR Products in Agarose Gel

All the PCR products were run on 2% (w/v) Agarose gel (Amresco make) in 0.5X Tris-Borate-EDTA (TBE) buffer (Merck make). 5µl of the PCR products were mixed with1µl of 6X loading dye (Fermentas make) and were loaded on to the gel. After electrophoresis, the gel was stained with Ethidium Bromide and visualized over an UV Transilluminator.

3.4.1.3. Confirmation of Species Identity of Leopard Scats through Sequencing

As per recommendations of the Review meeting of the Monitoring Committee on "Biodiversity Research Studies" dated 6th September 2019, the species identities of the leopard scats were further verified using DNA sequencing technique. For this, partial sequences of mitochondrial Cytochrome C Oxidase I (COI) gene were generated using universal COI markers developed and standardized in Wildlife Genetics Laboratory, Aaranyak.

For amplification of partial COI gene sequence, polymerase chain reaction (PCR) was performed using QIAGEN Multiplex PCR Kit (QIAGEN, Germany). The PCR products were then gel purified using QIAEX® II Gel Extraction Kit (QIAGEN Ag., Germany) and cycle sequenced using the BigDye® Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, USA). Electrophoretic separation and detection of the sequencing reaction products was then performed using ABI3130 Genetic Analyzer (Applied Biosystems). To test possible amplification of nuclear pseudogene copy we examined presence of intermediate stop codons in the generated partial COI sequences using web based tool EMBOSS Transeq (EMBL-EBI). Then, sequence similarity search was performed using web based tool GenBank BLAST at NCBI applying default settings of the software package.

3.5. Estimation of Leopard Population Size

3.5.1. Genetics Sampling Strategy for Population Estimation

Genetic sampling for estimation of population size of leopards in the PAs of North Bengal was carried out during the months of December 2020 to February 2021. For this, we adopted a single session sampling-based capture-recapture sampling strategy following Borthakur et al (2011). In this method, samples collected at the same time and location (coordinates) was considered as a single observation. For collection of scats, 2 km x 2 km grids were selected based on results of leopard presence study. Aaranyak field team comprising of three to five members surveyed the respective PAs by walking on the jungle trails or by using elephants as well as vehicles as mode of transportation whenever required in presence of the Forest Department staffs. The leopard scats collected during leopard sign survey were not included in the population estimation as the single session sampling-based capture-recapture sampling strategy was not followed while collecting those scat samples.

All the scats collected during field survey were stored in air tight zip-pouch containing silica gel (desiccant). Sampling locations of all the samples collected during survey were recorded using a GPS system.

3.5.2. Laboratory Work for Population Estimation

3.5.2.1. DNA Extraction

The DNA from scat samples were extracted following Boom et al. (1990) with minor modifications (Das et al. 2015) standardized at Wildlife Genetics Laboratory, Aaranyak as mentioned in section 4.4.1.1.

3.5.2.2. Species Identification from Scats

The species identity of the scats collected were determined through DNA sequencing. The method has been described in section 4.4.1.3.

3.5.2.3. Individual Identification from Leopard Scats

Once the genuine leopard scats are identified through genetic analysis, we used the polymorphic microsatellite markers panels designed by Mondol et al. (2009) to identify the number of leopard individuals present in the collected leopard scats.

Multiplex PCRs was carried out using QIAGEN Multiplex PCR Kit (QIAGEN, Germany) following standard kit protocols for reagent concentration and reaction and cycle conditions as described by Mondol et al. (2009). To minimize electropherogram stutter patterns and prevent allele drop-out, dedicated microsatellite PCR kits (Multiplex PCR Kit, QIAGEN, Germany) were employed.

Each sample and loci were typed for three replicates following Navidi et al. (1992) and consensus genotypes were created based on the results of these repeats. Allele sizing was carried out using a combined approach of automated allele calling and visual inspection of microsatellite electropherograms of each sample. This process provides a balance between the efficiency and consistency of automated allele calling software (GENEMAPPER v3.7, Applied Biosystems, USA) and the accuracy provided by human inspection in detecting novel alleles outside of the expected range of a locus, stochastic amplifications within the size range, and potential mistypes due to stutter or large-allele dropout.

Further, consensus genotypes were generated and genotyping error rates were estimated using software GIMLET v 1.3.3 (Valiere 2002). To identify the unique multilocus genotypes i.e., the individual leopards from the multi-locus genotypic data we used the software CERVUS (Marshall et al. 1998).

3.5.2.4. Gender Identification from Leopard Scats

The sex of the genuine leopard scat samples was identified using primers to amplify the Y chromosome linked SRY (sex determining region) loci as demonstrated in the domestic cat individualization panel, MEOWPLEX (Butler 2002; Butler et al. 2002).

3.5.3. Data Analysis for Population Estimation

The population size of leopards was estimated in a single session sampling scheme using software CAPWIRE (Miller et al. 2005). The software uses two models *viz.,* the *Even Capture Model* (ECM) which assumes that, there is no capture heterogeneity in the data set and the *Two Innate Rates Model* (TIRM) which assigns individuals as having either a high or a low capture probability. We used both the models of capture probability incorporated in CAPWIRE to derive population estimates with 95% confidence intervals with parametric bootstrap of 10,000 replicates. Further, we used the *Likelihood Ratio Test* (LRT) incorporated in CAPWIRE to select one of the two models of capture probability. The samples collected at the same time and location (coordinates) were considered as a single observation, as adopted by Zhan et al. (2006). This method of estimation of population size has been successfully demonstrated in case of other carnivores such as tiger in studies conducted in Orang National Park (Borthakur et al. 2011) and Buxa Tiger Reserve (Borthakur et al. 2013).

3.6. Population Density Estimation

The leopard density was calculated using information about area sampled and the maximum distance moved by individual leopards based on locations of the samples following Karanth et al. (2006).

The density (D) of leopards in the study area was estimated using the equation-

D = N / (A (W))

[where **D**- estimated density, **N**- estimated population size, (**A** (**W**))- effectively sampled area] (Karanth and Nichols, 1998 & 2002).

However, instead of using camera trap locations as suggested in the original methodology description (Karanth and Nichols, 1998 & 2002), the effectively sampled area (**A**) will be calculated by drawing a polygon connecting the outermost leopard sample locations and adding a strip width (**W**) to this polygon. The strip width will be calculated using half of the *Mean Maximum Distance Moved* (MMDM) by individual

leopards between sampled locations. These areas will be calculated using GIS software ERDAS Imagine 9.0 and Arc GIS 9.0.

3.7. Prey Abundance Estimation

To estimate the densities of prey species in the study area we employed line transect method (Eberhardt 1968; Burnham et al. 1980; Buckland et al. 1993). The method has been effectively used to determine animal densities under similar tropical conditions (Karanth and Sunquist 1992, 1995).

For each sighting on transects, the following parameters were recorded:

a) Sighting angle (with a compass)

b) Sighting distance (visually estimated)

c) Group size

d) Sex and age class of the individuals (whenever it was possible to classify them)

Along with line transect, the survey team also conducted sign survey in all the PAs to assess the leopard prey population. The survey teams comprising of Aaranyak team and West Bengal Forest staff traversed through trails/roads/riverbed in selected grids of respective PAs during the survey time and collected data on all the recognizable signs of leopard prey such as hoofmarks, scratch, rake, dung, direct sighting etc., following Karanth and Nichols (2002). GPS coordinates of each of the data point were recorded systematically in datasheets. The sign encounter rate was calculated in terms of number of “encounters” per 10 kilometers walked by the survey team.

3.8. Diet Analysis of Leopard from Scats

The leopard scats identified through genetic species identification were further used for dietary analysis. Hairs from the scats were sampled following Mukerjee et al (1994a) and were compared with reference slides of prey species. The identification of hair samples was based on the general appearance of the hair, colour, length, width, medullary structure, medullary width/hair width ratio and cuticle pattern (Mukerjee et al.,

1994b). Quantification of the diet was based on frequency of occurrence and percentage occurrence following Ackerman et al. (1984)

3.9. Estimation of Relative Biomass and Number of Preys Consumed by Leopard from Scat Analysis Using Correction Factor

Frequencies of identifiable prey remains in scats do not give a representative picture of the consumed proportion of different prey species when the prey types vary in size to a considerable extent (Biswas and Sankar, 2002). Smaller prey species, having more hair per unit body weight produce more scats per unit prey weight consumed, leading to an overestimation of smaller prey species in the carnivore diet (Ackerman et al. 1984). Therefore, to overcome this problem we adopted a correction factor (Y) in order to correct the over representation of smaller prey by multiplying it with the observed frequency of occurrence data (A). The details of this method have been discussed by (Ackerman et al. 1984; Karanth and Sunquist 1995) and others in details. The average weights (X) of different prey species were taken based on the available literature. For species like cattle, Gaur, sambar etc the body weights of calves and sub adults were considered for analysis following Kshettry et al (2018).

4. RESULTS

4.1. Stratification of the Study Area

The entire land use and land cover of the study area was categorized into nine classes viz., grassland, dense forest, open forest, degraded area, water body, sand area, tea garden, agriculture land and human settlement and home gardens based on spectral signatures of satellite imagery along with GPS-based field data of different land use land cover classes and by delineation of dense and open forest mask to run the final analysis in model builder (Table 1 and Figure 4).

The present study shows that forest covers an area of total 3462.15 km^2 of the North Bengal landscape comprising of 2406.27 km^2 of Dense Forest, 667.72 km^2 of Open Forest and 388.16 km^2 of Grasslands. A total of 1417.23 km^2 of area is covered with tea plantation while 5810.64 km^2 of area is used for other agricultural practices.

Table 1: Table showing land use land cover class and its area

Sl. No.	Classes	Area (Km^2)
1	Grassland	388.16
2	Dense Forest	2406.27
3	Open Forest	667.72
4	Degraded Area	130.75
5	Water Body	304.62
6	Sand Area	572.82
7	Tea Garden	1417.23
8	Agriculture Land	5810.64
9	Human settlement and home garden	1058.67
	Total	**12756.88**

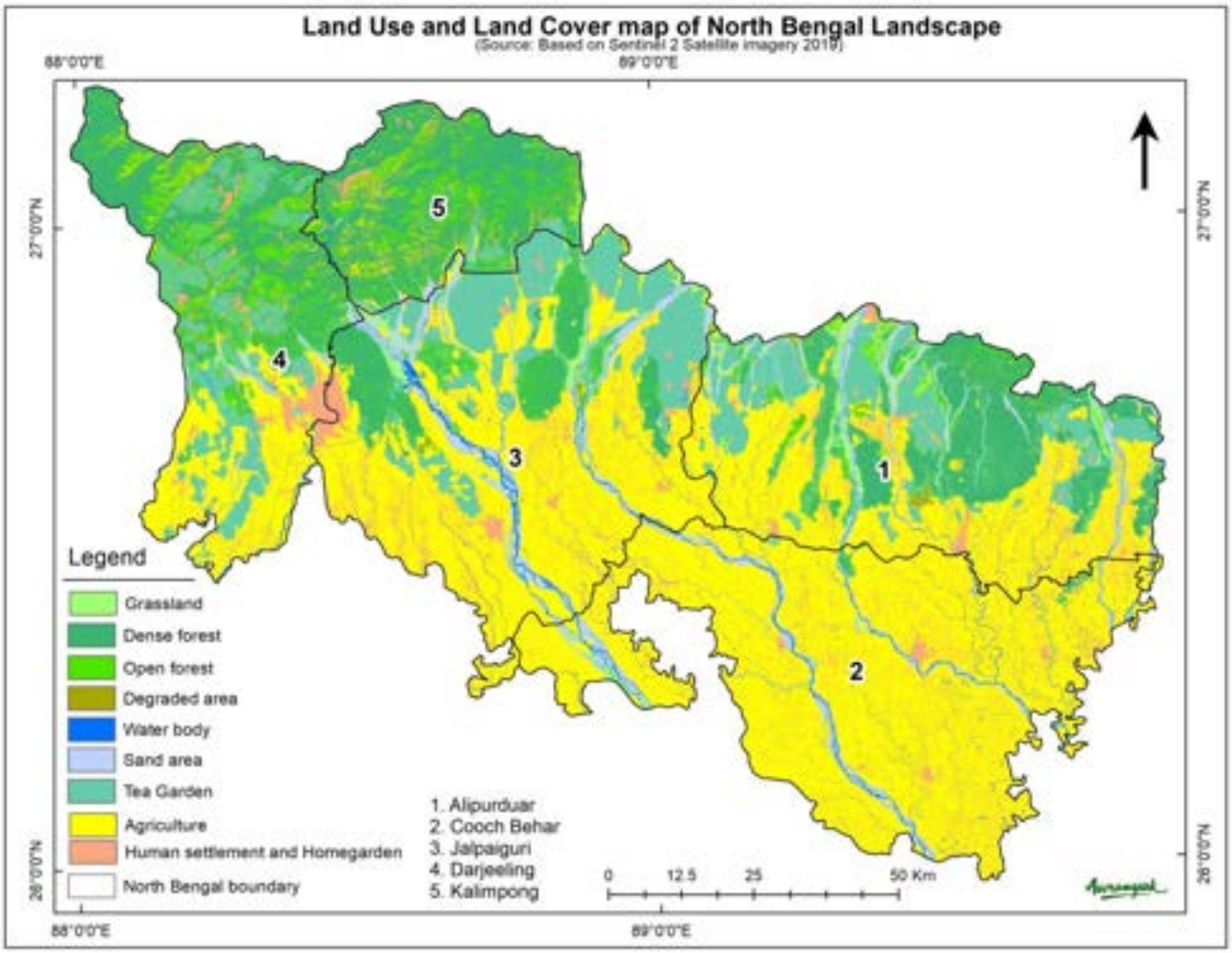

Figure 4: The land use land cover map of North Bengal landscape

4.2. Questionnaire Survey

The entire North Bengal Landscape was divided into 4 km x 4 Km grids in a GIS platform (Figure 5) and semi-structured questionnaire survey was conducted in selected human dominated grids. The questionnaire was primarily designed to understand the demographic and socio-economic characteristics of the respondents, human–leopard conflict situation, people's perceptions towards human-leopards conflict, and tolerance towards leopards.

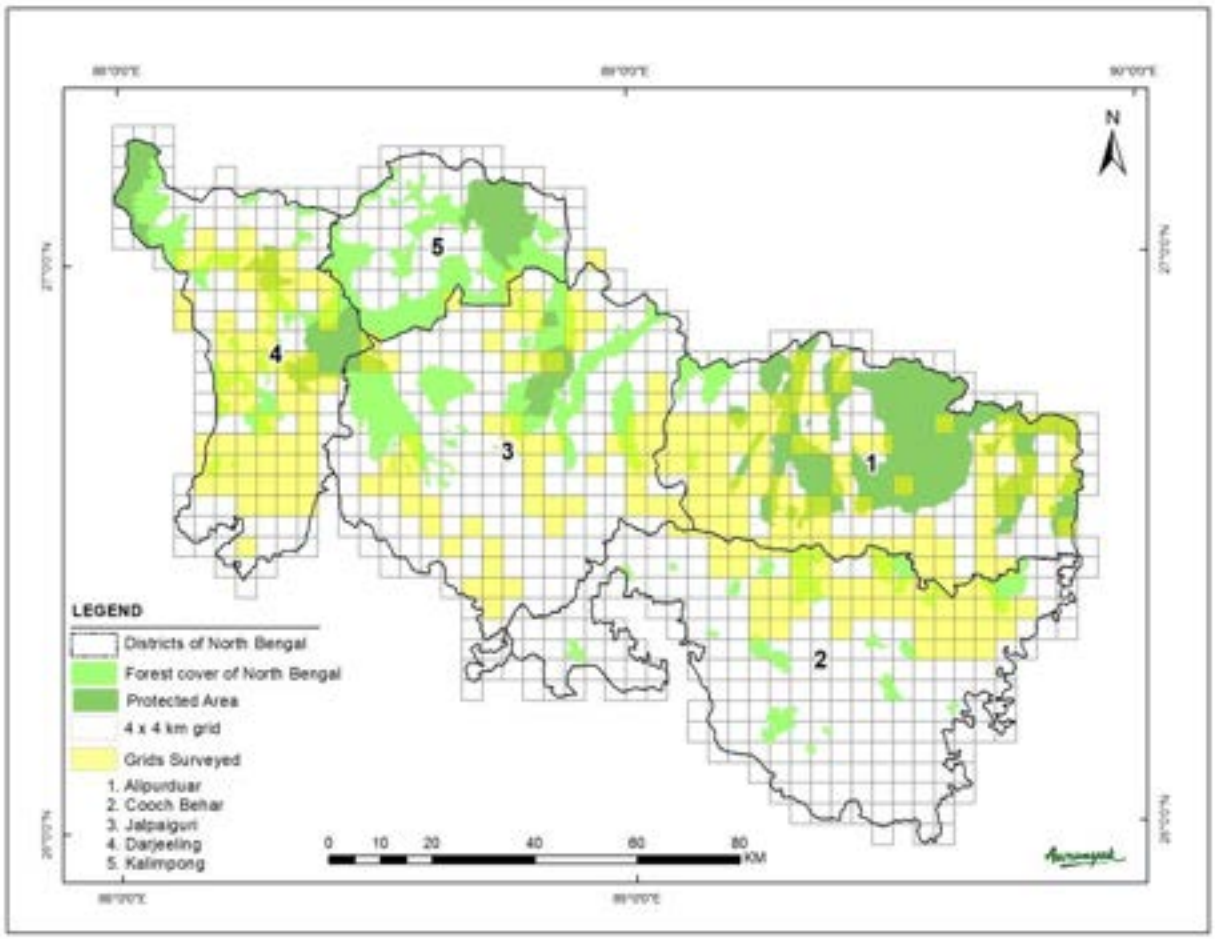

Figure 5: Map showing study area for questionnaire survey divided into 4 Km x 4 Km grids

The questionnaire survey covered 27.7% of the total grids (4 km x 4 Km) in the north Bengal Landscape. A total of 1696 respondents participated in the questionnaire survey. Of the total respondents 20.05% were female and 79.95% were males grouped together in four age classes viz., 15-34 years (34.49%), 35-54 years (48.29%), 55-74 years (16.45%) and 75-94 years (0.77%) (Figure 6 and Figure 7).

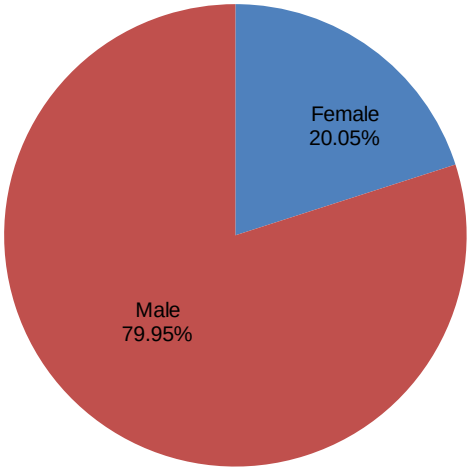

Figure 6: Percentage of male and female respondents in questionnaire survey

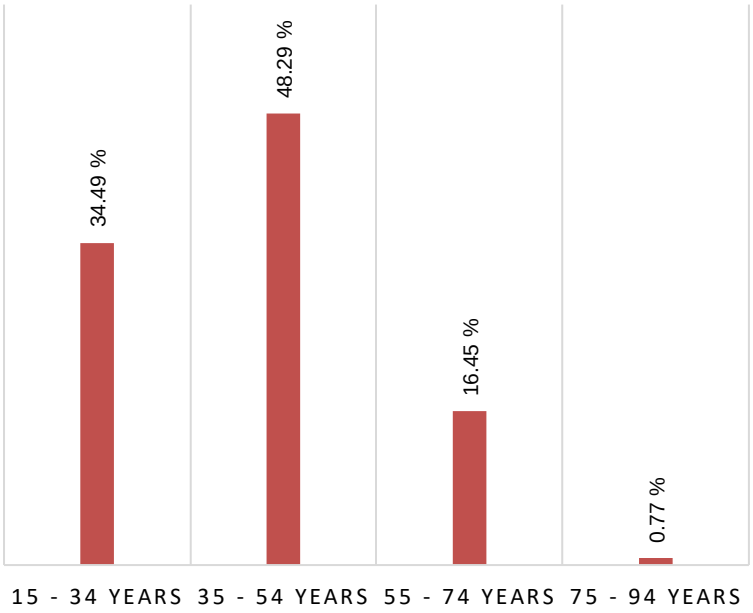

Figure 7: Percentage of Respondents According to Age Class

49.88% of the total respondents were living within 500 meter radius from PA boundaries, followed by 13.62% in less than 1km, 5.19% in less than 2km, 5.72% in less than 5km and 25.59% in 5km or more than 5km radius from PA boundaries (Figure 8). Of the total respondents 53.71% of the respondents were dependent on forest

resources (in terms of firewood, fodder for livestock and food such as vegetables and fruits) showing high dependency on forest (Figure 9).

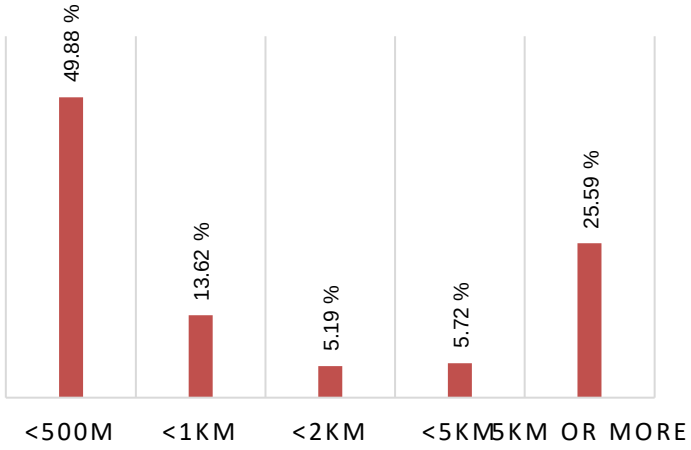

Figure 8: Distance of respondents' residence from forest

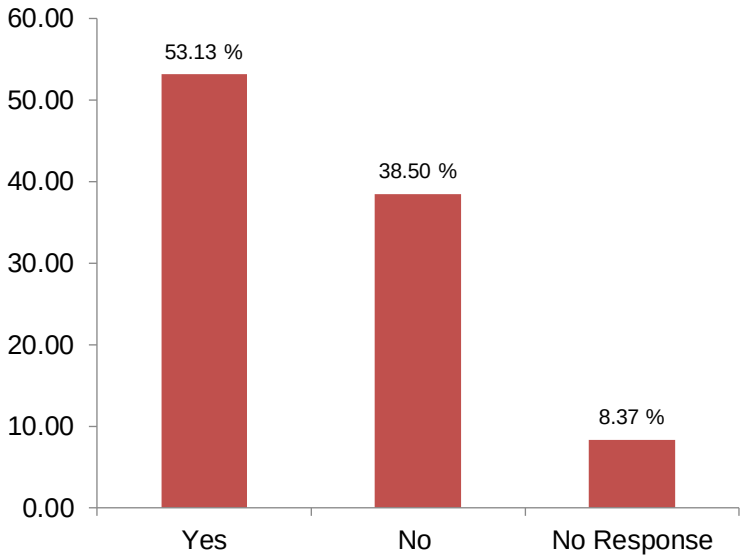

Figure 9: Dependency of respondents' on forest resources

It was also observed that 75.06% of the respondents had livestock such as cow, buffalo, goat, pig, poultry etc., of which 36.14% were pen fed and 38.92% were self-grazing (Figure 10). It is interesting to note that 70.40% of the respondents did not take any precautionary measures to avoid depredation of their livestock while rest adopted

measures such as keeping livestock in animal shades with proper fencing, watchman to repel leopards, threatening etc. to protect their livestock from leopard attack (Figure 11).

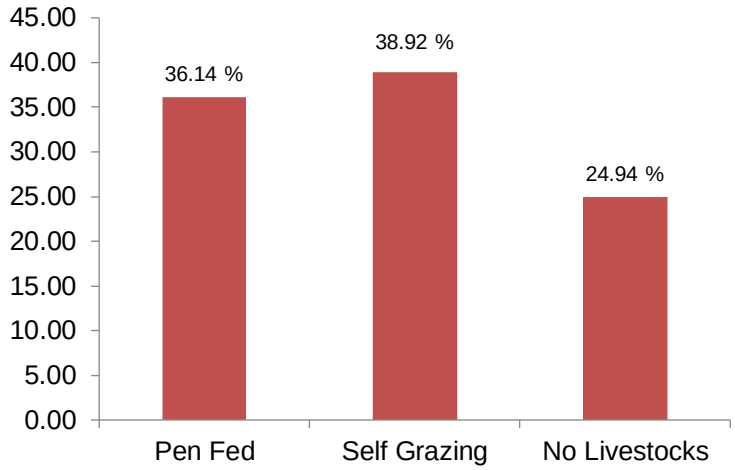

Figure 10: Estimates of livestock categories

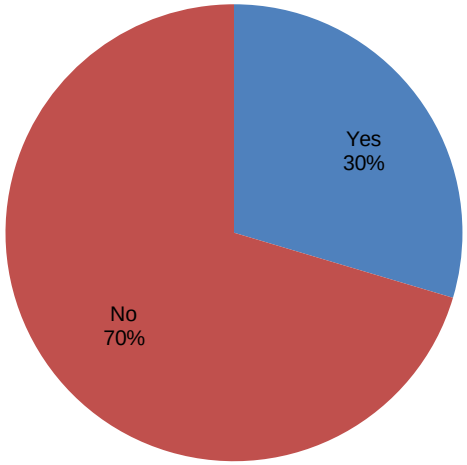

Figure 11: Measures adopted against leopard attack

During questionnaire survey 667 respondents out of 1696 reported predatory attack by leopard on their livestock. However, no clear pattern of time of attack on livestock was observed with 18.51% responding most of the predatory attacks occurring at night, 12.15% at day time while 25% of the respondents were of the view that there was no

pattern (Figure 12). However, it is important to note that 44.34% of the respondents did not respond to the question.

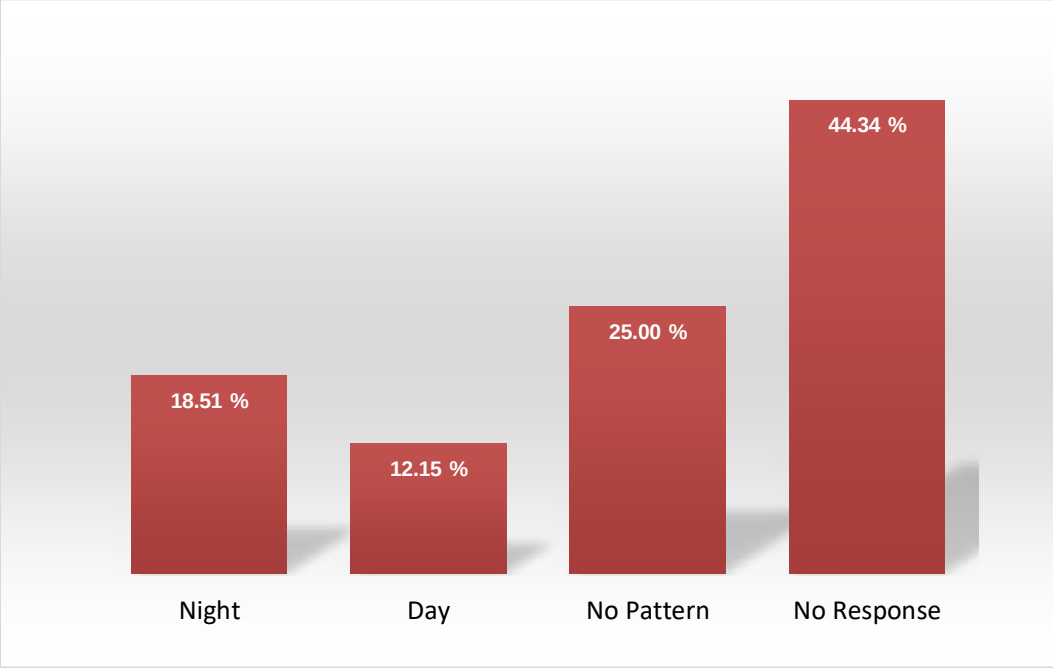

Figure 12: Most Common Time of Predatory Attacks

Similarly, no clear pattern of place of occurrence of predatory attack was observed during the questionnaire survey. Of the total respondents 19.40% were of the view that most attacks occurred inside forest, 18.57% responded that attacks occurred outside forest areas while 14.50% of the respondents were of the view that predatory attacks occurred both inside and outside the forest (Figure 13). Majority of the areas where incidences of predatory attack by leopard on livestock were reported by respondents during the questionnaire survey were observed to be located within 0-10 km radius of forested area including fringe villages surrounding PAs as well as other forested areas, tea garden and areas with human habitation.

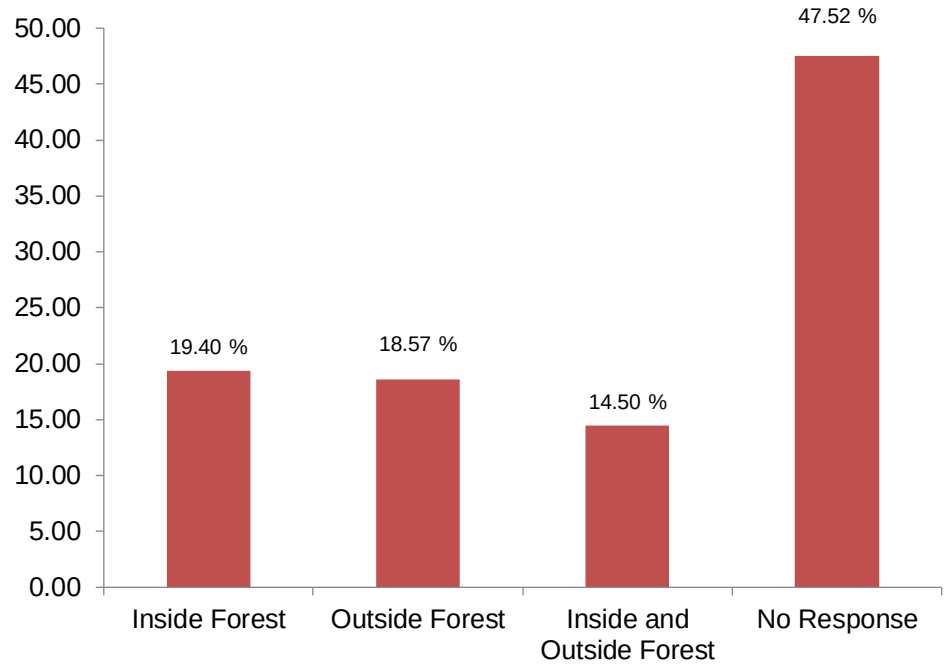

Figure 13: Place of Occurrence of Predatory Attacks by Leopards

It is interesting to note that 33.96% of the respondents believed that human-leopard conflict has increased in their area. However, 27.48% did not agree to it whereas 38.56% of the respondents were not sure if instances of human-leopard conflict have increased in their area over the years (Figure 14).

Further, it was observed that 34.20% of the respondents believed that livestock depredation due to predatory attack of leopards have increased in their area in the last five years. However 27.12% respondents did not agree to it while 38.68% respondents were unsure if livestock depredation has increased in last five years (Figure 15).

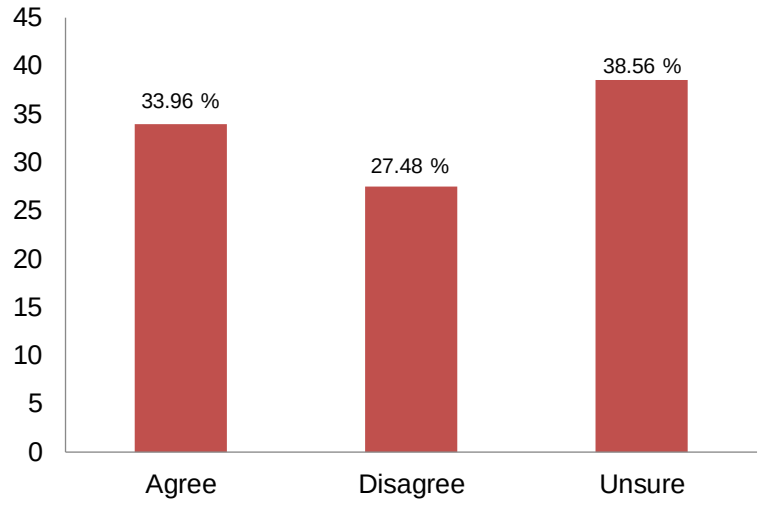

Figure 14: Views of the respondents (in percentage) on increase in human-leopard conflict in North Bengal

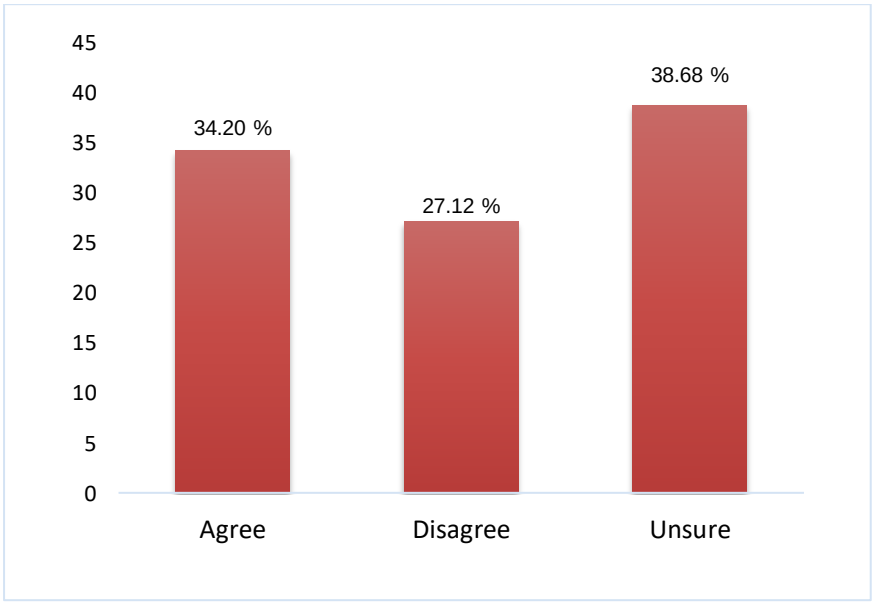

Figure 15: Views of the respondents (in percentage) on increase in livestock depredation in North Bengal due to predatory attack of leopards

To analyse the people's perception, views of the respondents on increase in leopard population (35.02%), less availability of food in wild (43.10%), preference for easy prey (45.75%), habitat destruction (36.62%), agricultural fields as hiding place (18.51%) and relocation from other areas (5.66%) as probable reasons for human-leopard conflict were obtained. However, it was observed that high percentage of respondents were not sure of possible reasons of human-leopard conflict (Figure 16).

During questionnaire survey, peoples view on possible management strategies to reduce human-leopard conflict was also obtained. Majority of the respondents were of the view that improvement of leopard habitat (16.86%), prey base (10.14%) and improvement of both leopard habitat and prey base (30.78%) as possible management strategy to reduce human-leopard conflict. Whereas it was observed that some of the respondents were in favour of capturing and relocating (7.37%) or repelling conflict causing leopard individuals using disrupting stimulant (2.24%) as possible management strategy to reduce human-leopard conflict (Figure 17).

Although, there are cases of livestock depredation due to predatory attack by leopard along with instances of leopard attacking human being the respondents of the questionnaire survey in general showed tolerance and empathy towards leopards. It was observed that 70.28% of the respondents were of the view that Leopards are important for ecosystem (Figure 18.a). 56.96% of the respondents did not have any problem with leopards being present in nearby forest areas (Figure 18.b). 48.41% of the respondents agreed that leopards need conservation (Figure 18.c) while 31.96% of the respondents agreed to participate in future leopard conservation efforts (Figure 18.d).

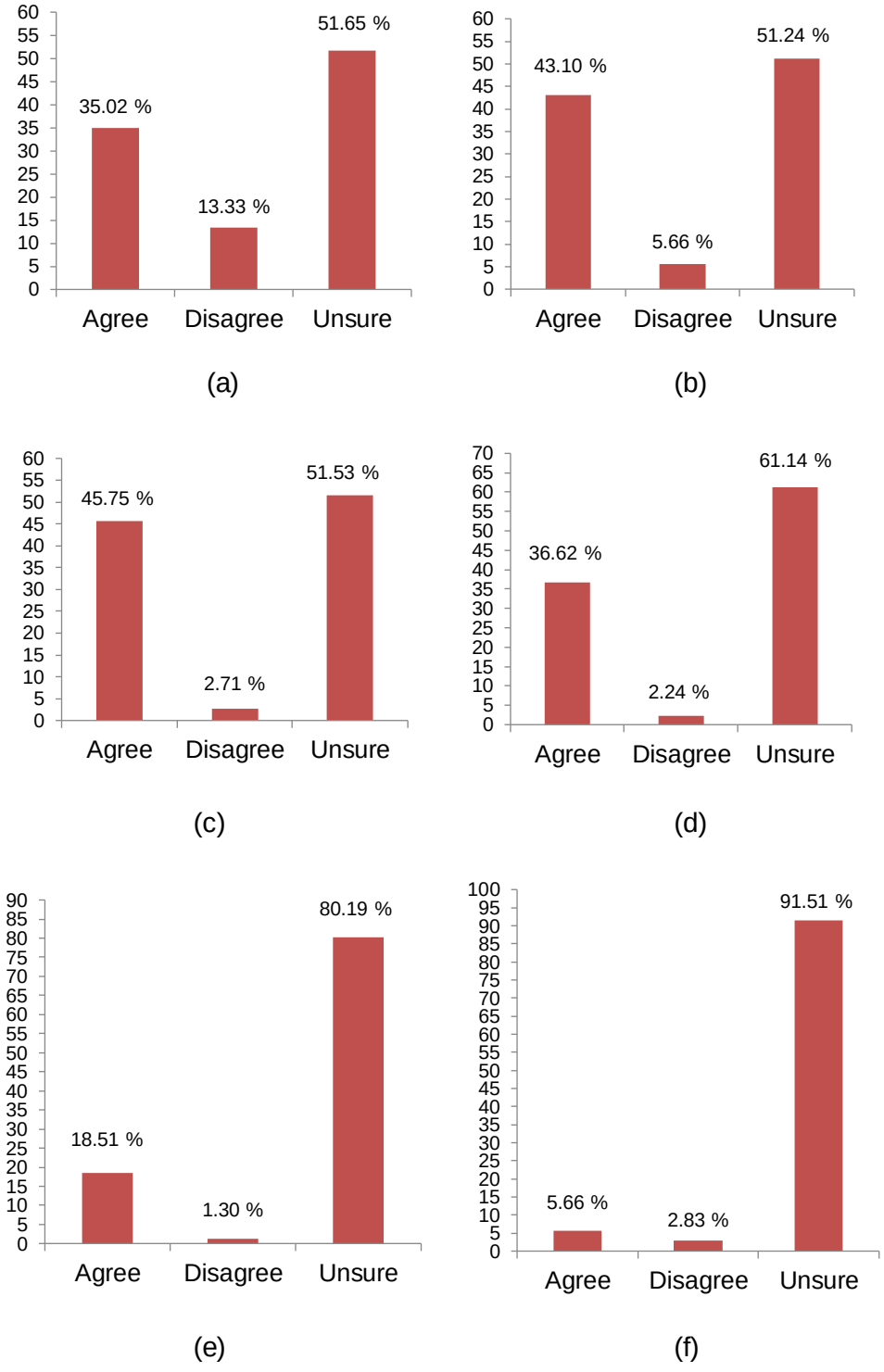

Figure 16: View of the respondents on the probable reason for human-leopard conflict; (a) increase in leopard population, (b) less availability of food in wild, (c) preference for easy prey, (d) habitat destruction, (e) agricultural fields as hiding place and (f) relocation from other areas

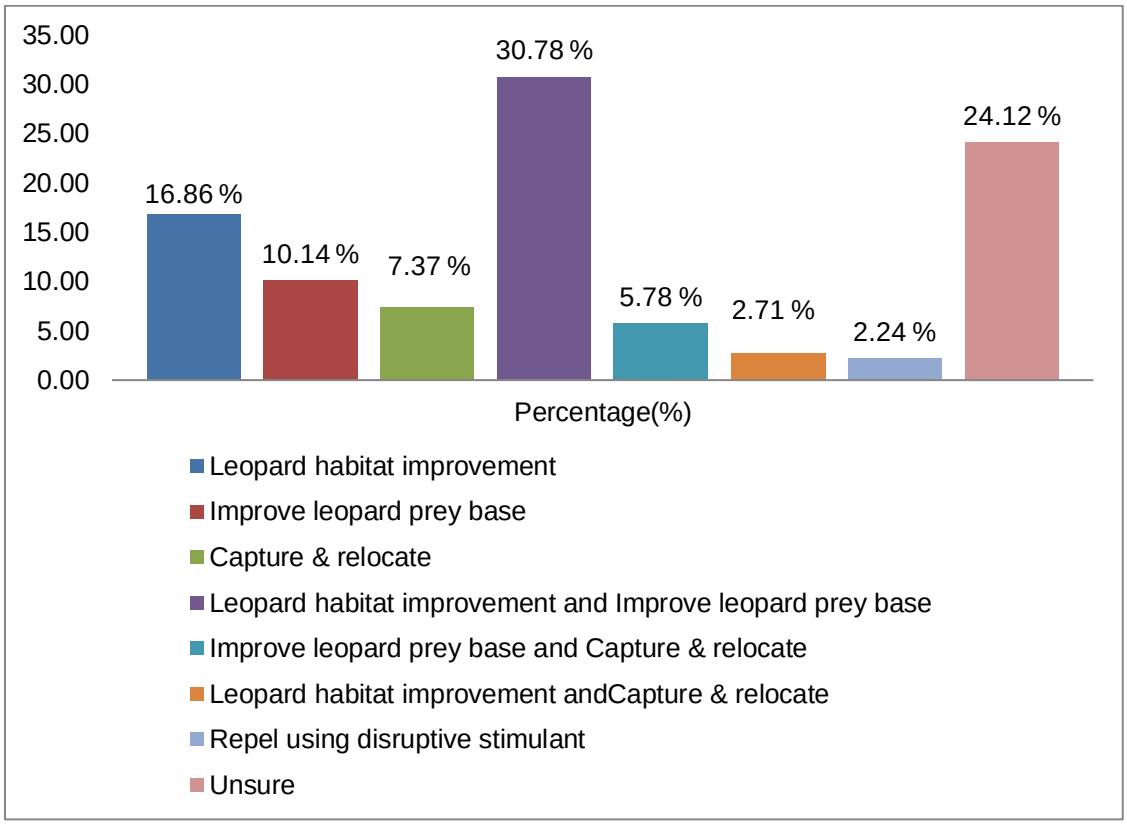

Figure 17: View of respondents on possible management strategies to reduce human- leopard conflict

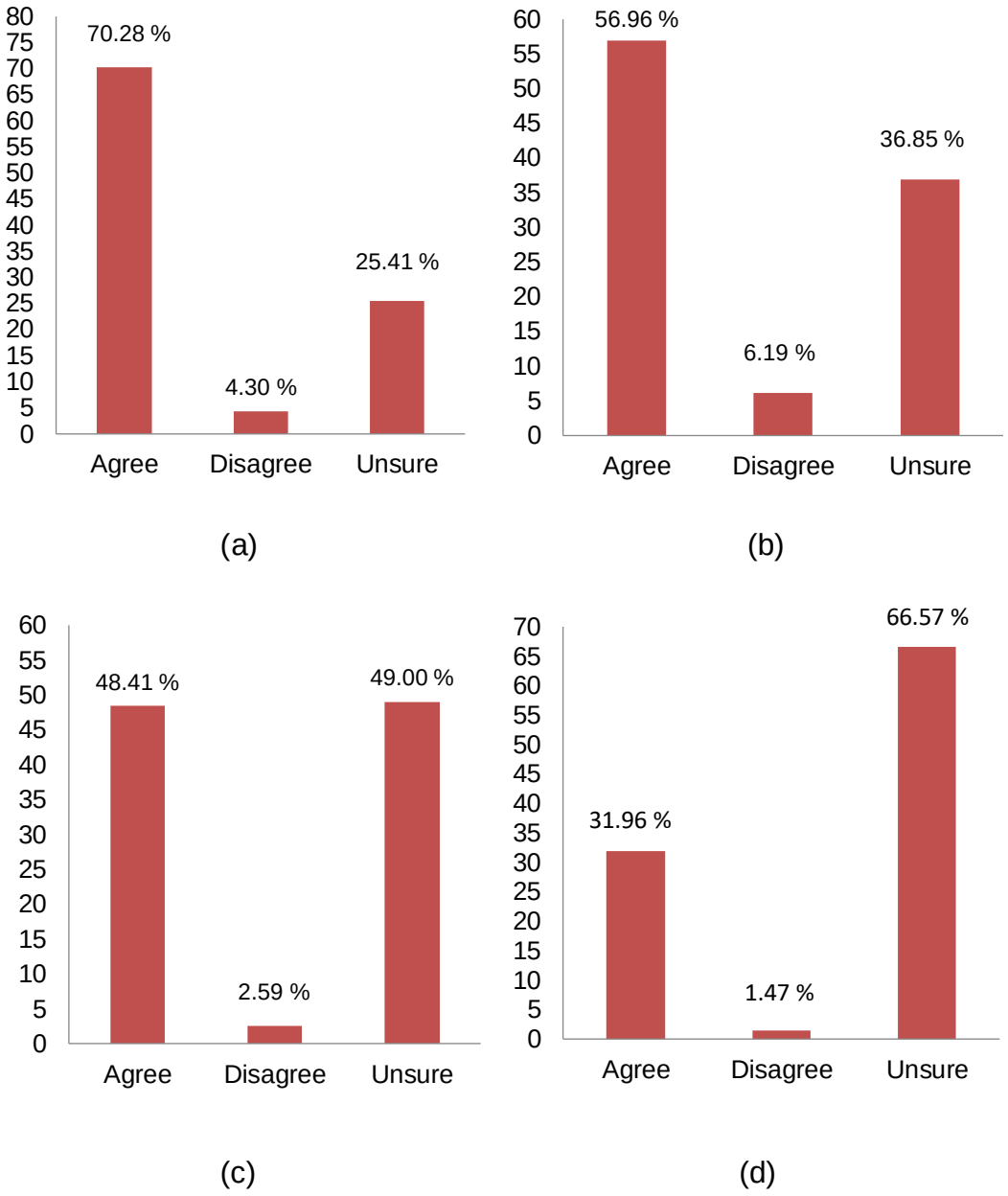

Figure 18: Peoples empathy towards leopards in North Bengal; (a) leopards are important for ecosystem, (b) I am fine with leopards in my forests, (c) leopards needs conservation and (d) participate in leopard conservation

The views of the respondents on the existing mechanism to mitigate human-leopard conflict were also obtained during the questionnaire survey. It was observed that 16.98% of the respondents believed that the role of the forest department in human-leopard conflict mitigation was dissatisfactory while 19.81% were of the view that it could improve. 10.26% of the respondent found it satisfactory. It is important to note that more than 50% of the respondents did not respond to the query (Figure 19).

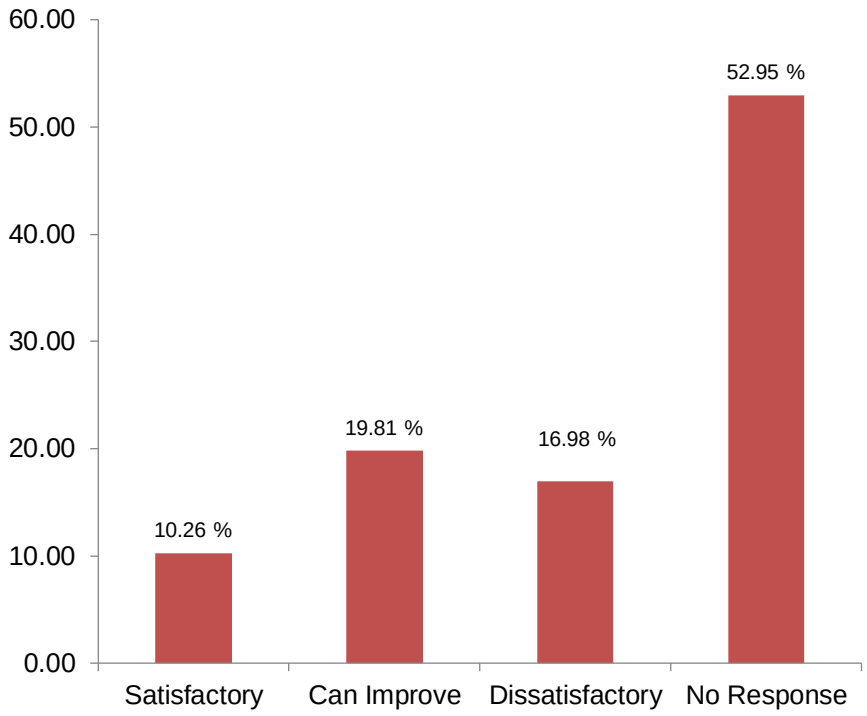

Figure 19: View of the respondents on role of forest department in resolving human- leopard conflict

It was also observed that many of the human-leopard conflict instances go unreported owing to complicated and lengthy procedure, lack of awareness regarding compensation procedure as well as inadequate compensation in case of livestock depredation (Figure 20).

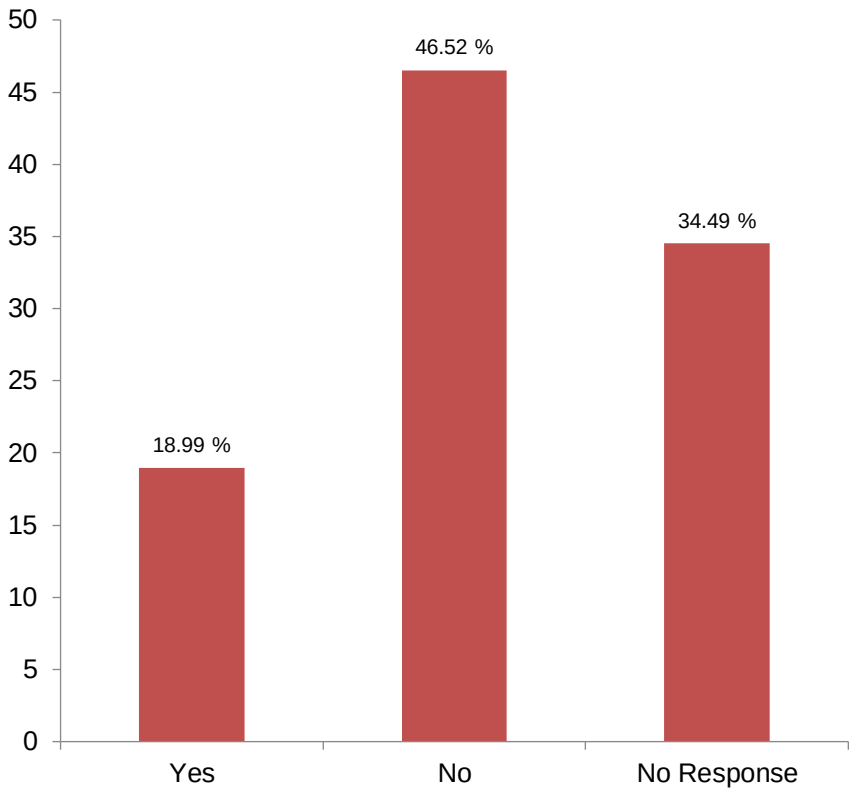

Figure 20: Response of the participants on whether all incidences of human-leopard conflict being reported to the forest department

Interestingly, 39.68% of the respondents were not aware of compensation being given in case of livestock depredation due to leopard attack (Figure 21). The respondents of the questionnaire survey also believed that there is a need to improve the compensation process in terms of hassle free reporting, adequate compensation and speedy procedure (Figure 22).

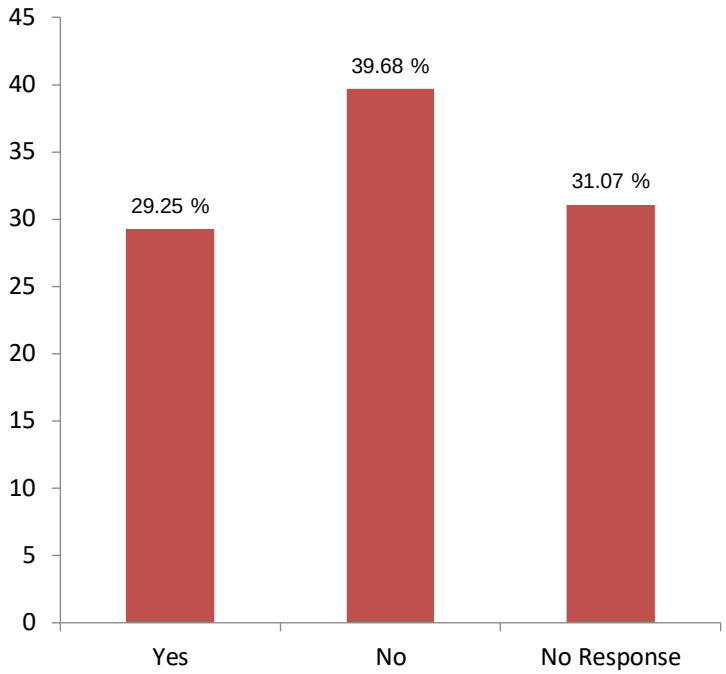

Figure 21: Awareness among respondents on compensation procedure in case of livestock depredation due to leopard attack

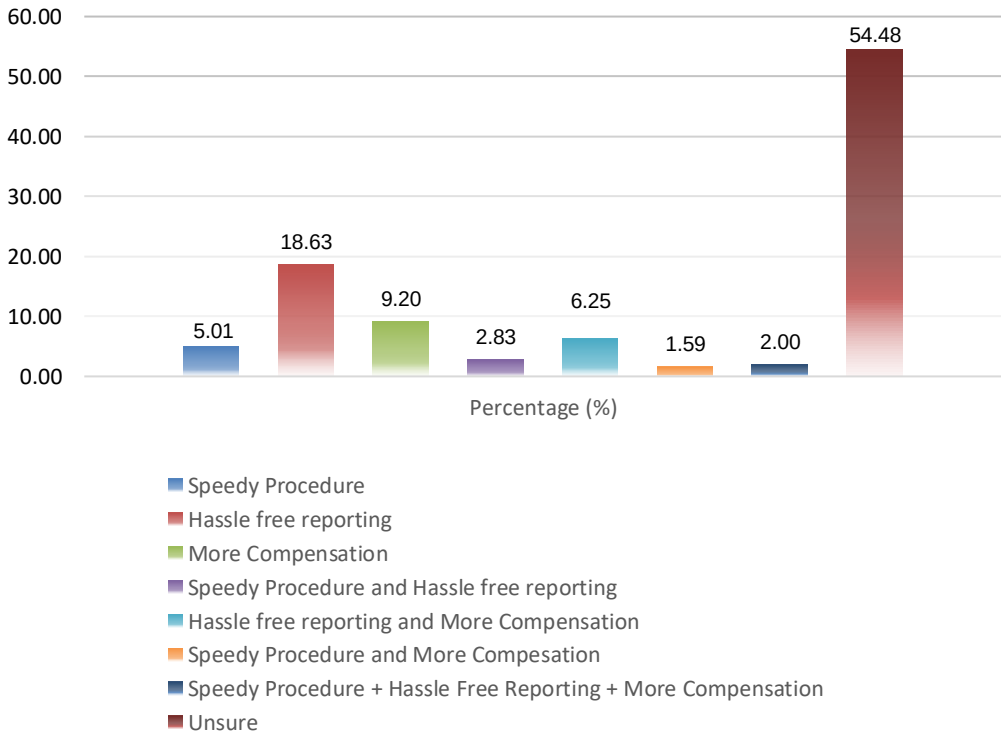

Figure 22: Suggestion from respondents for improvement of compensation process

4.3. Sign Encounter Rate

In the present study, sign survey was conducted in seven PAs (Table 2) which include Gorumara NP, Jaldapara NP, Neora Valley NP, Mahananda WLS, Senchal WLS, Chapramari WLS and Buxa TR to detect the presence of leopards.

Table 2: Protected areas, Ranges and Beats surveyed during sign survey

Sl. No.	Protected Area	Range	Beat
1	Neora Valley NP	Upper Neora	Rachilla
		Lower Neora	Gagune
2	Gorumara NP	North Range	Murti and Khunia
		South Range	Budhuram, Bichabhanga, Gorumara and Dhupjhora
3	Jaldapara NP	Jaldapara West	Holong, Moiradanga, and TEC
		Jaldapara North	Siltorsa, Hasimara and NWC
		Jaldapara South	Salkumar
		Kodalbasti	Mantharam, Kodalbasti and Mendabari
		Madarihaat	Dumchi, North Khairbari and South Khairbari
		Chilapata	Chilapata and Bania
		Nilpara	Nilpara, Titi
		Lankapara	Holapara,Lankapara, Bhagatjyote
4	Senchal WLS	Senchal East	6thmlle, Rambi
		Senchal West	Jorebunglow, Rangeroo and Sonada
5	Mahananda WLS	SuknaRange	Chamta and Sukna
		West Range	Koklong, Punding and Gulma
		North Range	Sevoke
		South Range	Toribari
6	Chapramari WLS		Chapramari beat
7	Buxa Tiger Reserve	RBK	WRBK
		Hamilton	Bhanawari and Rangamati
		Nimati	West Poro, East Nimati and West Nimati
		East RBK	Gadadhar, North Panbari and South Panbari
		Jainti	Jainti North, Jainti South and Bhutiabasti
		Hatipota	Hatipota, Chuniajhora and Phaskhowa
		North Rydak	Mainabari and Tiamari
		Central Rydak	Kartika
		South Rydak	South Rydak (Samuktala), Chipra, Marakhata, Narathali
		Kumargram	Sankosh, Kumargram and Newland
		Bholka	Barobhisa, Balapara, Ghoramara and Chengmari

Signs of leopard were observed in all the PAs surveyed during the present study. The details of the sign encounter rate for the respective PAs surveyed are given in the table 3 below.

Table 3: Sign encounter rates observed during leopard sign survey in respective protected areas of North Bengal

Sl. No.	Protected Area	Total Sign	Total Km	Sign/10 km
1	Neora Valley NP	0	21	0
2	Gorumara NP	44	43	9.72 *
3	Jaldapara NP	51	61	8.57 *
4	Senchal WLS	25	10	25
5	Mahananda WLS	72	40	18
6	Chapramari WLS	6	5	12
7	Buxa Tiger Reserve	32	76	4.16 *

* Extrapolated at arithmetic rate

Although, encounter rate was observed to be zero in Neora Valley NP, leopard signs were recorded during opportunistic sampling.

4.4. Genetic Determination of Leopard Presence from Scats

A total of 223 numbers of carnivore scat samples were collected during the sign survey to genetically determine the presence of leopards in the respective PAs. The results of the genetic species identification of the carnivore scats are given in the table 4.

Table 4: PA wise number of scats collected and scats of leopard origin

Sl. No.	Protected Area	No. of Scat Collected	No. of Scats of Leopard Origin
1	Neora Valley NP	8	1
2	Gorumara NP	58	51
3	Jaldapara NP	50	22
4	Senchal WLS	52	40
5	Mahananda WLS	10	8
6	Chapramari WLS	20	11
7	Buxa Tiger Reserve	25	17
Total		**223**	**150**

4.5. Leopard Population Estimation

For estimation of population size of leopard the field team of Aaranyak visited eight PAs of North Bengal viz., Singalila NP, Neora Valley NP, Gorumara NP, Jaldapara NP, Senchal WLS, Mahananda WLS, Chapramari WLS and Buxa TR during December 2020 to February 2021 and carried out field sampling following a single session sampling-based capture-recapture sampling strategy. As Chapramari WLS is managed together with Gorumara NP under the North Range of the National Park, all the analysis were performed considering both the PAs as one.

During field survey a total of 346 carnivore scat samples were collected of which maximum number was obtained from Gorumara-Chapramari (76) followed by Jandapara NP and Senchal WLS (71), Buxa TR (45), Mahananda WLS (37), Singalila NP (24) and Neora Valley NP (22). Out of these 346 carnivore scats 287 were found to be of leopard origin.

Out of the 287 leopard scats, usable microsatellite genotype data were obtained for 227 samples with a success rate of 79.09% across all the PAs. A total of 97 individual leopards were identified from different PAs of North Bengal (Table 5). The female to male ratio were observed to be 1.5 in Singalila NP, 2.5 in Neora Valley NP, 1.85 in Gorumara-Chapramari, 2.8 in Jaldapara NP, 3 in Senchal WLS, 2.33 in Mahananda WLS and 1.2 in Buxa TR respectively.

The estimated population size was found to be highest in Gorumara-Chapramari with 27 (95% CI, 24-31) individuals within effective sampling area of 117 km^2 followed by Jaldapara NP (23; 95% CI, 21-26; Effective Sampling Area 103 km^2), Buxa TR (16; 95% CI, 14-21; Effective Sampling Area 193.4 km^2), Neora Valley (13; 95% CI, 9-26, Effective Sampling Area 62.1 km^2), Mahananda WLS (13; 95% CI, 11-17; Effective Sampling Area 77.9 km^2), Senchal WLS (12; 95% CI 12-12; Effective Sampling Area 36.7 km^2) and Singalila NP (7; 95% CI, 6-10, Effective Sampling Area 41.7 km^2) (Table 5).

4.6. Leopard Density Estimation

In the present study, highest density of leopard (Table 5) was found in Senchal WLS (32.6 per 100 Km^2) followed by Gorumara-Chapramari (23 per 100 Km^2), Jaldapara NP (22.3 per 100 Km^2), Neora Valley NP (20.9 per 100 Km^2), Singalila NP (16.7 per 100 Km^2), Mahananda WLS (16.6 per 100 Km^2) and Buxa TR (8.2 per 100 Km^2).

Table 5: PA wise number of leopards identified, estimated population size, male female ratio and density

Sl. No.	Protected Area	No. of Leopard individual Identified	Female	Male	Unidentified	Female to male ratio	Estimated Population Size	CI (95%)	Effective Area A(W) (Km^2)	Density N/A(W)
1	Singalila NP	6	3	2	1	1.5	7	6-10	41.7	0.167
2	Neora Valley NP	9	5	2	2	2.5	13	9-26	62.1	0.209
3	Gorumara NP & Chapramari WLS	24	13	7	4	1.85	27	24-31	117	0.230
4	Jaldapara NP	21	14	5	2	2.8	23	21-26	103	0.223
5	Senchal WLS	12	9	3	0	3	12	0	36.7	0.326
6	Mahananda WLS	11	7	3	1	2.33	13	11-17	77.9	0.166
7	Buxa TR	14	6	5	3	1.2	16	14-21	193.4	0.082

The estimate of total leopards within PAs studied was then obtained by extrapolating the leopard density estimate to the total area of each of the PA at arithmetic rate (Table 6).

Table 6: Extrapolated estimate of total leopards within protected areas studied

Sl. No.	Protected Area	Total Estimate of Leopard
1	Singalila NP	18
2	Neora Valley NP	18
3	Gorumara NP & Chapramari WLS	27*
4	Jaldapara NP	48
5	Senchal WLS	12*
6	Mahananda WLS	26
7	Buxa TR	62

*not extrapolated as entire Gorumara NP & Chapramari WLS and Senchal WLS were covered during sampling

4.7. Distribution of Leopard Signs

Within PAs majority of the leopard signs during survey (including sign encounter rate survey, emergent sampling and scats sampling) were observed in dense forest areas with high canopy cover. A considerable percentage of leopard signs were also observed in grass lands, open forest areas as well as river beds (Table 7).

Table 7: Percentage of leopard signs (including data of sign encounter rate survey, emergent sampling and scats sampling) observed in different types of land use within protected area boundary.

Sl. No.	Protected Area	Dense Forest (%)	Open Forest (%)	Grassland (%)	Degraded Land (%)	River bed (%)
1	Singalila NP	93.75	0	0	6.25	0
2	Neora Valley NP	89.47	10.53	0	0	0
3	Gorumara NP	35.71	15.58	33.77	0.65	14.29
4	Jaldapara NP	44.29	5	37.86	1.43	11.42
5	Senchal WLS	90.53	9.47	0	0	0
6	Mahananda WLS	48.67	18	10	0.66	22.67
7	Chapramari WLS	37.5	33.33	29.17	0	0
8	Buxa TR	53.85	1.1	17.58	0	27.47

During questionnaire survey, 81 grids (4 km x 4 km; Figure 23) were identified where predatory attacks by leopards on livestock were reported by the respondents (Figure 23) which are located within a radius of 0-10 km from forested areas including fringe villages surrounding PAs as well as other forested areas, tea garden and areas with human habitation.

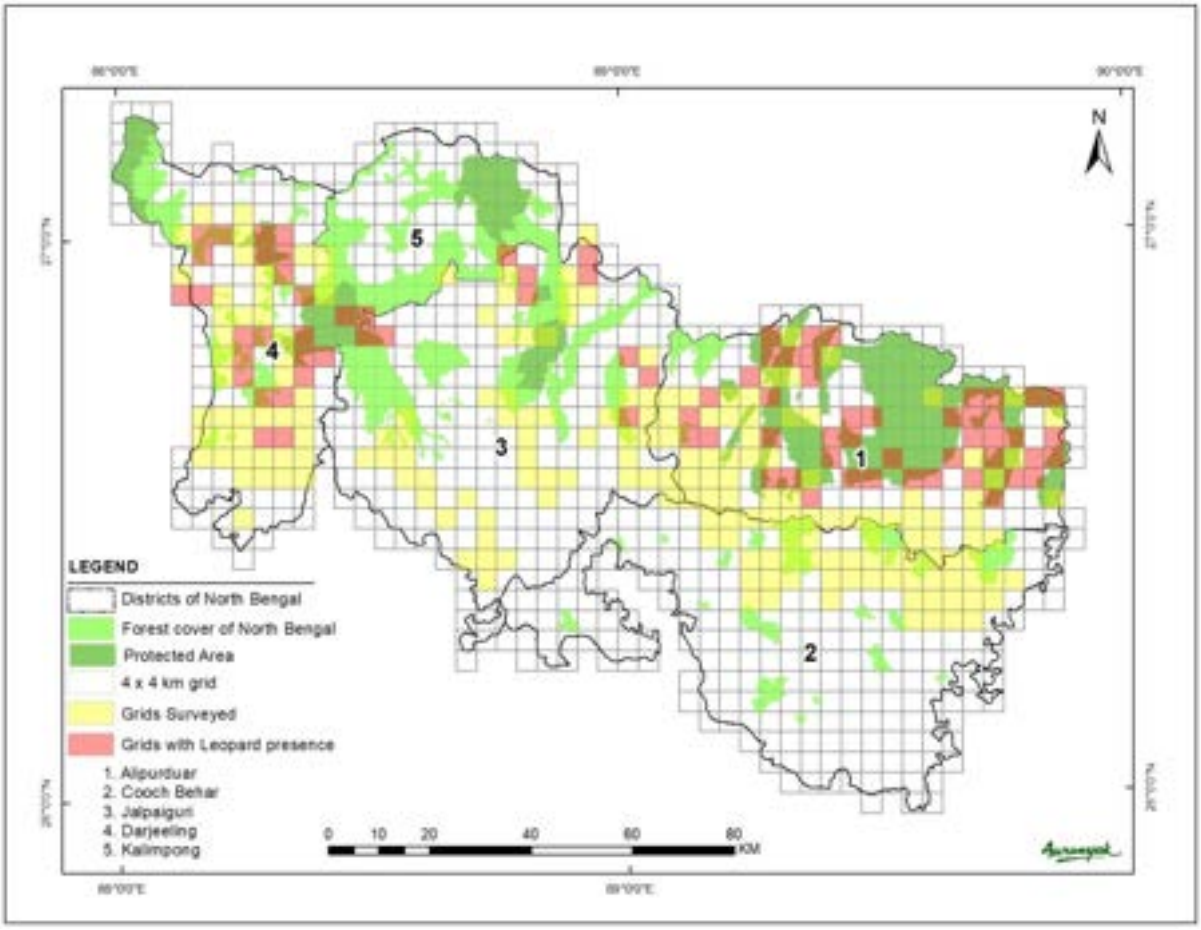

Figure 23: Map showing questionnaire survey grids (4 km x 4 km) where incidences of predatory attack by leopards were reported by respondents

4.8. Prey Density Estimation

In the present study although line transects of 1 km lengths were laid in four of the PAs, the sighting records were very poor and was not sufficient for prey density estimation. However, during the carnivore scat sampling session field team simultaneously

collected signs of leopard preys in all the PAs concerned and the results of the sign survey are detailed below.

Highest number of prey signs was observed in Jaldapara NP (37.16 per 10 km) followed by Neora Valley NP (33.74 per 10 Km), Senchal WLS (31.74 per 10 Km), Mahananda WLS (29.1 per 10 Km), Buxa TR (27.57 per 10 Km), Gorumara-Chapramari (26.43 per 10 km) and Singalila NP (23.31 per 10 Km). Signs of barking deer and wild boar were observed highest among wild prey species (Table 8). However, it was interesting to observe presence of high number of cattle inside the forested area in almost all the PAs surveyed.

Table 8: Results of leopard Prey Sign Survey

Sl. No.	Species	Total Sign	Km observed	Signs/10 KM
Singalila NP				
1	Cattle	3	19.73	1.52
2	Goat	1		0.51
3	Barking Deer	22		11.15
4	Wild Boar	4		2.03
5	Horse	6		3.04
6	Himalayan Tahr	1		0.51
7	Himalayan Serow	1		0.51
8	Yak	8		4.05
	Total	46		23.31
Neora Valley NP				
1	Cattle	30	45.35	6.62
2	Gaur	7		1.54
3	Barking Deer	55		12.13
4	Wild Boar	48		10.58
5	Himalayan Serow	8		1.76
6	Khalij Pheasant	3		0.66
7	Porcupine	2		0.44
	Total	153		33.74
Gorumara NP and Chapramari WLS				
1	Cattle	19	54.11	3.51
2	Gaur	32		5.91
3	Chital	13		2.40
4	Sambar	17		3.14
5	Barking Deer	20		3.70

6	Wild Boar	28		5.17
7	Rhesus Macaque	4		0.74
8	Hare	1		0.18
9	Peafowl	7		1.29
10	Red Jungle Fowl	2		0.37
	Total	143		26.43
Jaldapara NP				
1	Cattle	21	49.52	4.24
2	Gaur	37		7.47
3	Chital	2		0.40
4	Sambar	26		5.25
5	Barking Deer	20		4.04
6	Hog Deer	1		0.20
7	Wild Boar	48		9.69
8	Hare	8		1.62
9	Rhesus Macaque	5		1.01
10	Peafowl	13		2.63
11	Red Jungle Fowl	3		0.61
	Total	184		37.16
Senchal WLS				
1	Barking Deer	79	46.31	17.06
2	Wild Boar	55		11.88
3	Hare	4		0.86
4	Khalij Peasant	4		0.86
5	Himalayan Serow	5		1.08
	Total	147		31.74
Mahananda WLS				
1	Cattle	24	32.99	7.27
2	Gaur	12		3.64
3	Chital	9		2.73
4	Sambar	5		1.52
5	Barking Deer	12		3.64
6	Hare	11		3.33
7	Rhesus Macaque	7		2.12
8	Wild Boar	16		4.85
	Total	96		29.1
Buxa TR				
1	Cattle	23	56.59	4.06
2	Gaur	26		4.59
3	Chital	13		2.30
4	Sambar	8		1.41
5	Barking Deer	21		3.71
6	Wild Boar	35		6.18

7	Rhesus Macaque	5		0.88
8	Hare	2		0.35
9	Peafowl	19		3.36
10	Red Jungle fowl	4		0.71
	Total	156		27.57

4.9. Diet Analysis of Leopard from Scats

Most of the scats used in the dietary analysis contained single prey type. However, some of the scats in all the PAs were found to contain more than one prey items resulting in average prey items per scat values of 1.25, 1.41, 1.12, 1.09, 1.23, 2.48 and 1.21 in Singalila NP, Neora Valley NP, Gorumara-Chapramari, Jaldapara NP, Senchal WLS, Mahananda WLS and Buxa TR respectively. Moreover, grass and varying amount of soil were also observed in many of the leopard scat samples that were analysed for dietary composition. Although, all the samples were collected inside the protected are domestic animals such as cattle, goat and dog were often recorded in the scats which constituted a major portion of their diet in all the PAs (Table 9). Among wild animals' macaque, barking deer, rodents form major part of the leopard diet (Table 9).

4.10. Estimation of Relative Biomass and Number of Preys Consumed by Leopard from Scat Analysis Using Correction Factor

Based on the dietary analysis of the genetically identified leopard scats (n=287), 15 different prey species were identified. The relative biomass and number of prey consumed were estimated following Ackerman et al (1984). The results are presented in the table 9.

Table 9: Percentage of Occurrence, Frequency of occurrence (A), relative biomass consumed (D) and relative number of prey individuals consumed (E) by leopard in different PAs (Percent occurrence is represented as number of times a specific item was found as percentage of all items; frequency of occurrence is represented as percentage of total scats in which an item was found; Y= correction factor as described by Ackerman et al., 1984; D and E estimated following Ackerman et al., 1984).

Sl.No	Species	Percent Occurrence	Freq of Occurrence (A)	Avg. Body Weight (X)	Y (Kg/Scat)	Relative Biomass (D)	Relative Number of Prey (E)
Singalila NP							
1	Yak	5.00	6.25	60	4.08	6.84	0.37
2	Cattle	20.00	25.00	60	4.08	27.38	1.56
3	Goat	10.00	12.50	25	2.86	9.59	1.29
4	Dog	5.00	6.25	18	2.61	4.38	0.82
5	Barking Deer	20.00	25.00	20	2.68	17.98	3.06
6	Pig	15.00	18.75	40	3.38	17.01	1.46
7	Rodent	15.00	18.75	0.5	2.00	10.06	68.39
8	Bird	10.00	12.50	1	2.02	6.78	23.05
Neora Valley NP							
1	Cattle	12.50	17.65	60	4.08	18.77	1.31
2	Goat	8.33	11.76	25	2.86	8.76	1.48
3	Dog	20.83	29.41	18	2.61	20.00	4.68
4	Domestic Cat	4.17	5.88	4.5	2.14	3.28	3.08
5	Barking Deer	16.67	23.53	20	2.68	16.43	3.46
6	Civet	8.33	11.76	40	3.38	10.36	1.27
7	Macaque	12.50	17.65	6	2.19	10.07	7.09
8	Rodent	8.33	11.76	0.5	2.00	6.13	59.71
9	Bird	8.33	11.76	1	2.02	6.19	26.11
Gorumara NP and Chapramari WLS							
1	Cattle	24.39	27.40	60	4.08	33.10	3.34
2	Goat	12.20	13.70	25	2.86	11.60	2.79
3	Dog	8.54	9.59	18	2.61	7.41	2.49
4	Gaur	1.22	1.37	60	4.08	1.66	0.18
5	Chital	2.44	2.74	55	3.91	3.17	0.36
6	Samber	2.44	2.74	60	4.08	3.31	0.36
7	Barking Deer	7.32	8.22	20	2.68	6.52	2.00
8	Pig	9.76	10.96	40	3.38	10.97	1.64
9	Macaque	17.07	19.18	6	2.19	12.44	12.55
10	Hare	2.44	2.74	2	2.05	1.66	5.03
11	Rodent	4.88	5.48	0.5	2.00	3.25	39.42

12	Bird	7.32	8.22	1	2.02	4.92	29.84
Jaldapara NP							
1	Cattle	20.00	21.88	60	4.08	27.87	2.02
2	Goat	11.43	12.50	25	2.86	11.16	1.98
3	Dog	5.71	6.25	18	2.61	5.09	1.23
4	Gaur	1.43	1.56	60	4.08	1.99	0.13
5	Chital	1.43	1.56	55	3.91	1.90	0.13
6	Samber	4.29	4.69	60	4.08	5.98	0.44
7	Barking Deer	5.71	6.25	20	2.68	5.23	1.14
8	Pig	11.43	12.50	40	3.38	13.19	1.45
9	Macaque	17.14	18.75	6	2.19	12.82	9.42
10	Hare	2.86	3.13	2	2.05	2.00	4.40
11	Rodent	7.14	7.81	0.5	2.00	4.88	42.96
12	Bird	11.43	12.50	1	2.02	7.88	34.68
Senchal WLS							
1	Cattle	11.59	14.29	60	4.08	18.01	0.95
2	Goat	4.35	5.36	25	2.86	4.73	0.6
3	Dog	17.39	21.43	18	2.61	17.27	3.03
4	Barking Deer	8.70	10.71	20	2.68	8.86	1.39
5	Pig	10.14	12.50	40	3.38	13.05	0.98
6	Macaque	20.29	25.00	6	2.19	16.91	8.91
7	Hare	5.80	7.14	2	2.05	4.52	7.14
8	Rodent	10.14	12.50	0.5	2.00	7.72	48.8
9	Bird	11.59	14.29	1	2.02	8.92	28.19
Mahananda WLS							
1	Cattle	8.70	12.90	60	4.08	13.10	0.95
2	Goat	15.22	22.58	25	2.86	16.07	2.77
3	Dog	17.39	25.81	18	2.61	16.76	4.03
4	Domestic Cat	2.17	3.23	4.5	2.14	1.72	1.65
5	Chital	2.17	3.23	55	3.91	3.14	0.26
6	Samber	2.17	3.23	60	4.08	3.28	0.22
7	Barking Deer	10.87	16.13	20	2.68	10.76	2.34
8	Pig	6.52	9.68	40	3.38	8.14	0.87
9	Macaque	17.39	25.81	6	2.19	14.07	10.17
10	Hare	4.35	6.45	2	2.05	3.29	7.14
11	Rodent	8.70	12.90	0.5	2.00	6.42	55.58
12	Bird	4.35	6.45	1	2.02	3.24	14.03
Buxa TR							
1	Cattle	20.00	24.32	60	4.08	27.44	3.20
2	Goat	13.33	16.22	25	2.86	12.83	3.55
3	Dog	11.11	13.51	18	2.61	9.75	3.76

4	Domestic Cat	2.22	2.70	6	2.19	1.63	1.88
5	Gaur	2.22	2.70	60	4.08	3.05	0.35
6	Chital	4.44	5.41	55	3.91	5.85	0.77
7	Samber	2.22	2.70	60	4.08	3.05	0.35
8	Barking Deer	4.44	5.41	20	2.68	4.01	1.39
9	Pig	6.67	8.11	50	3.73	8.37	1.18
10	Macaque	24.44	29.73	6	2.19	18.01	20.89
11	Rodent	4.44	5.41	0.5	2.00	2.99	41.64
12	Bird	4.44	5.41	1	2.02	3.02	21.03

Amongst the domestic prey, dog was the most frequent prey species (29.48, Neora Valley NP), while cattle composed highest relative biomass (33.1, Gorumara NP and Chapramari WLS) of prey consumed in any of the PAs (Table 9). Amongst the wild prey, macaque most frequent prey species (29.73, Buxa TR), also contributing highest relative biomass (18.01, Buxa TR) in any of the PAs (Table 9). Across all the PAs, domestic prey biomass varied from 50.81% (Neora Valley NP) to 65.2% (Singalila NP) (Fig. 24).

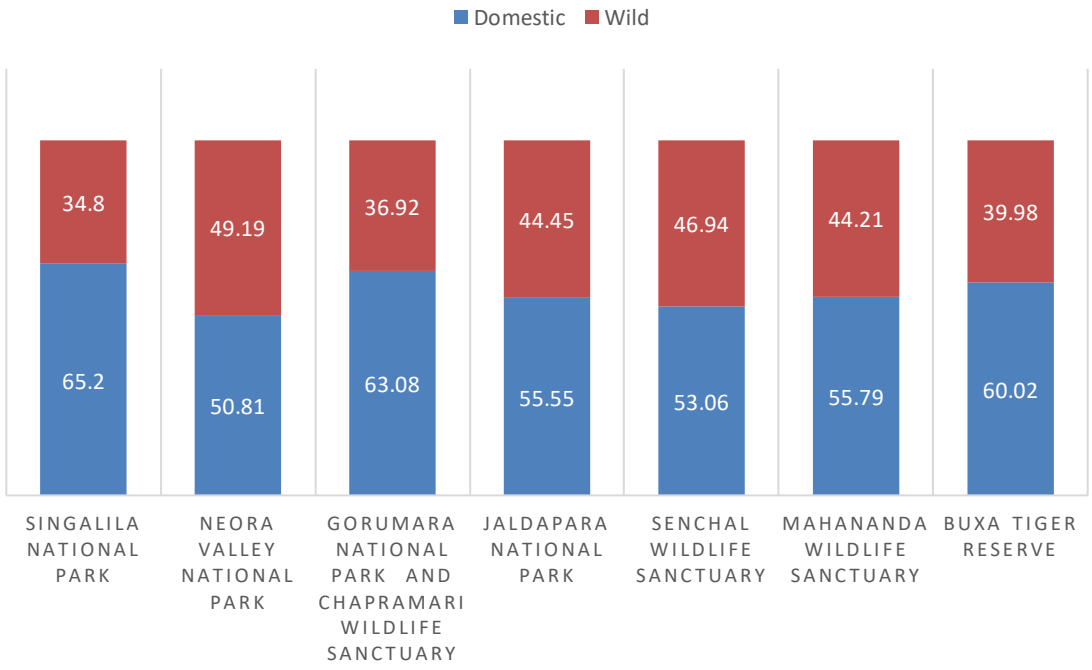

Figure 24. Percentage biomass of domestic versus wild prey in leopard diet across the protected areas.

5. DISCUSSION

Conservation of highly adaptable species like leopard is a challenging task for wildlife managers, particularly, in a complex human dominated landscape like North Bengal. In the past two decades, a considerable increase in numbers of human-leopard conflict instances has been recorded in the region (Kshettry et al. 2017; Naha et al. 2018) raising an alarm among the conservationists. This necessitates active human intervention to identify the drivers of human-leopard conflict, create positive perception and devise scientifically robust management plan which will help in minimizing loss of human life and property and maximize the survival of the species. The present study assessed the status of human-leopard conflict, people's perception towards leopard, its population status, leopard prey abundance and its dietary preferences in the PA network of North Bengal.

5.1. Human-Leopard Conflict

The questionnaire survey data in the present study show high percentage of respondents depend on forest resources such as fuel wood, fodder and vegetables. During field survey it was also observed that people living in the fringe areas of the PAs often go inside the forest for collection of the same which increases the risk of leopard attack on human being. The questionnaire data show no clear trend of increase or decrease of human-leopard conflict across North Bengal landscape over the last five years. Further, no clear pattern of time or place of occurrence of predatory attack by leopard on human or their livestock could be observed during the questionnaire survey. However, Kshettry et al. (2017) had previously reported attacks on human being by leopards mostly occurring in the day time in tea garden areas in the Jalpaiguri district of North Bengal. Naha et al (2018) predicted higher leopard predation risk on humans in the central and the western parts of North Bengal based on their predation risk model. Further, Naha et al (2020) reported higher levels of livestock predation in winter and spring season with maximum cases of livestock predation in the day time in North Bengal.

The human-leopard conflict in North Bengal is often attributed to large scale change in land use pattern, particularly, the expansion of tea gardens in the region (Manoj et al. 2013; Vyas and Sengupta 2014; Naha et al. 2018). However, leopards are historically known to inhabit areas close to human habitation with reports of attacks on human being along with livestock predation (Athreya et al., 2007; Daniel 2009, Naha et al. 2018). Our observation is that, human-leopard conflict incidences, particularly attacks on human are area specific. Although, majority of the leopard attacks are reported from tea garden areas not all the gardens across the landscape have similar pattern of conflict instances. Kshettry et al (2017) found ubiquitous presence of leopard in the Jalpaiguri district of north Bengal and reported high availability of dense ground vegetation and low human presence as positive predictors of leopard habitat-use. They observed that the leopard attacks on human being were not significantly predicted by leopard habitat-use. Naha et al (2020) reported livestock depredation risk in different habitat types in North Bengal. They further predicted that in North Bengal the probability of livestock killing is higher in areas which have dense to moderate vegetation cover and decreases with human presence, increase in distance form forests and water bodies.

Livestock depredation incurs heavy economic loss to owners particularly to those whose livelihood is entirely dependent on them as shown in various studies (Miahra 1997; Madhusudan 2003; Wang and Mcdonald 2006; Tamang and Baral 2008). During questionnaire survey it was observed that despite predatory leopard attacks on livestock no definite measures are taken by the livestock owners to avoid such attacks. Livestock (cow, pig, goat etc) are often left alone to range freely during the day time. During night, although animals are kept under sheds they are often not well protected and leopards can easily break through them. Livestock grazing was also evident from the sign survey data that was conducted inside the PAs increasing the risk of livestock depredation by leopards. The questionnaire survey results show that many of the leopard attacks on livestock potentially go unreported owing to complicated and lengthy procedure, lack of awareness regarding compensation procedure as well as inadequate compensation as observed among respondent.

5.2. People's Perception and Response

Majority of the respondents felt that leopards are important for ecosystem (70.28%) and do not have problem if leopards exist in nearby forests (56.96%). A good percentage of the respondents further believed that leopard population of North Bengal needs to be conserved and were willing to be part of future efforts to conserve the species. This shows that despite attacks on human being or loss of livestock the people's perception towards presence of leopards is positive across the North Bengal Landscape and is encouraging for future conservation efforts.

Leopard population increase, habitat loss, depletion of prey base in wild, preference of easy prey were identified as some of the drivers of present human-leopard conflict in North Bengal by the respondents of the questionnaire survey and were of the view that efforts should be given to improve both leopard habitat and prey base (30.78%) in the wild.

7.37% and 2.24% respondents were in favour of capturing and relocating or repelling conflict causing leopard individuals using disrupting stimulant respectively as an effective mitigation strategy of present human-leopard conflict situation. However, capture and relocation can cause stress when a leopard is captured and released in an unfamiliar territory as seen in other large carnivore species worldwide (Wielebnowski et al. 2002; Dembiec et al. 2004; Wells et al. 2004; Letty et al. 2007; Teixeira et al. 2007). This could also, disrupt the dynamics of the existing leopard population in the release area (Athreya and Belsare 2007; Athreya 2010). Further, relocation of conflict individuals does not necessarily reduce the degree of human-leopard conflict as the vacant territory may be occupied by new leopard individuals (Athreya et al. 2007; Weilenmann et al. 2010).

It is interesting to note that 16.98% of the respondents believed that the current mitigation efforts undertaken by authorities is not satisfactory while 19.81% were of the view that it could improve. 10.26% of the respondent found it satisfactory. However the majority, 52.95% of the respondents chose not to respond to the query. The respondents of the questionnaire survey also believed that there is a need to improve

the compensation process in terms of hassle free reporting, adequate compensation and speedy procedure.

5.3. Population Status and Distribution

The genetic population size and density estimation of leopard across major PAs of North Bengal using noninvasive genetic tools has been performed for the first time in the present study. We found highest density of leopard in the Senchal WLS (32.6 per 100 Km^2) with estimated population size of 12 (95% CI) individual leopards. On the other hand the lowest leopard density was observed in Buxa TR (8.2 per 100 Km^2) with estimated population size of 16 (95% CI, 14-21) individual leopards. Jhala et al (2020) reported 83 (SE limit, 66-100) individual leopards from North Bengal as part of status report of leopard in India. However, their study included only three PAs viz., Gorumara NP, Jaldapara NP and Buxa TR. Our estimate of leopard population from these PAs are 27 (95% CI, 24-31) 23 (95% CI, 21-26), 16 (95% CI, 14-21) respectively. We also recorded a healthy female to male ratio which ranged between 3 to 1 (Senchal WLS) to 1.2 to 1 (Buxa TR) across PAs of the North Begal Landscape. Within the PAs surveyed during the present study highest percentage of leopard signs were recorded in dense forest areas followed by grasslands and open forest areas.

5.4. Prey Abundance and Dietary Preference

In the present study, high percentage of signs of cattle was recorded from almost all the PAs of North Bengal suggesting extensive cattle grazing. Among wild prey animals' highest signs were recorded for barking deer (ranging from 3.07 signs/10 km to 17.06 signs/10 km) and wild boar (ranging from 2.03 signs/10 km to 11.88 signs/10 km).

We identified 15 different prey species in 287 genetically identified leopard scat samples that were collected from PAs of North Bengal. Notably, multiple prey items were sampled from many of the leopard scats. It is also interesting to note that although all the scats were collected from inside the forest there was a high percentage of domestic prey species such as dog, goat and cattle were frequently sampled from the leopard scats. Among wild preys, the barking deer and macaque were most frequently sampled species in the leopard scats. The results indicate the ability of leopards to prey upon a

wide range of species ranging from rodents to large mammals such as Gaur. Our results are similar to previous studies where leopards are reported to prey upon a wide variety of species (Hoppe-Dominik 1984; Bailey 1993; Karanth and Sunquist 2000; Mandol et al. 2012; Zehra et al 2017; Kshettry et al. 2018).

In the present study, it was also observed that domestic prey constituted major proportion of relative biomass consumed by leopard which varied from 50.81% (Neora Valley NP) to 65.2% (Singalila NP) in comparison to wild prey species despite their availability. Amongst the wild prey, macaque and barking deer contributed highest relative biomass consumed by leopards. Previously, Kshettry et al (2018) also reported domestic animals constituting 80% of diet of leopard from Jalpaiguri district of North Bengal. Similar observations were also made by various authors (Athreya et al., 2014; Hussain et al. 2018).

5.5. Conservation and Management Implications

Conservation of leopards in a human dominated complex landscape like North Bengal is challenging as loss of human life and property due to predatory attacks by leopard could create anger towards the species and wildlife in general among local people. Although, positive attitude towards leopard was shown by respondents of questionnaire survey in the present study, retaliatory killing of leopard has been reported from the region. During this study it has been observed that there is enough scope for improvement in the livestock rearing practices in North Bengal. We recommend that local communities should be encouraged not to leave their livestock to range freely and improve the quality of pen which can drastically reduce the intensity of livestock depredation in the region. The compensation procedure in case of loss of human life and property should be made speedy and comprehensive. North Bengal has a high density of domestic animals and there is a need for ascertaining the economic value of livestock based on sex and age and depredation value should be fixed in accordance their economic value. This will help in building confidence of local communities on the human-leopard conflict mitigation measures that are undertaken by the authorities.

We also recommend promoting measures to reduce household dependencies on forest resources (such as firewood, fodder for livestock and food etc.) which were observed to be high, particularly, in the fringes of protected areas during the study.

In the present study, it was also observed that there is general lack of awareness among respondents on leopard biology, pattern of leopard attack, native diversity of wildlife etc. Therefore, we recommend conducting regular awareness programs focusing on these issues targeting people from different age group, sex and profession (e.g., school students, teachers, media personals, farmers, women working in tea gardens, housewives etc.) and to promote sustainable coexistence of human and leopards in the landscape.

For conservation and management of the leopard population of North Bengal we recommend for developing a comprehensive monitoring programme for leopards of North Bengal. Such programme should emphasize on regular monitoring and systematic collection of information of leopard population in both protected and outside protected areas (e.g., leopard population size and abundance, their movement pattern etc.), existing leopard prey base as well as prey preference, human leopard conflict instances, nature of conflict (livestock depredation, injury to human being, loss of life, retaliatory killing of leopard etc.) and other relevant information in case of a human-leopard conflict incidence. Further, a central repository of such information should be created which will enable authorities to understand population trends and assess human-leopard conflict situation across the landscape in long term as well as identify priority areas to undertake necessary management actions. Simultaneously, effort should be given to identify and train personnel of protected areas of North Bengal as well as members of local communities who can actively participate in such monitoring programmes.

One of the key takeaways of the present study was high percentage of signs of cattle being recorded from the PAs of North Bengal suggesting extensive cattle grazing inside PAs. There is an urgent need to implement effective measure to reduce cattle grazing inside the PAs of North Bengal. Further, during surveys presence of human inside PA, particularly, in the fringe areas for collection of firewood and fodder was extensively

recorded. We recommend for identification of permeable areas within the PAs that are used for extraction of forest resources and strengthening of the existing mechanism of protection of forest to reduce the human footprints. Preparation of detailed Land Use Land Cover (LULC) maps of the buffer and the fringe of the protected areas may be undertaken, in order to identify alternative land for grazing for the cattle.

Capture and translocation is one of the preferred interventions to mitigate human-leopard conflict. However, mere presence of leopard in the vicinity of human habitation does not imply conflict and considering the negative impacts of the process we strongly recommend that such intervention should be considered only under extreme conditions as outlined in the Guidelines for Human-Leopard Conflict Management, MOEF, Government of India.

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7. APPENDIX I

Photographs of Different Project Activities

Plate 1: Field team during Questionnaire Survey

Plate 2: Field team during Questionnaire Survey

Plate 3: Field team during Sign Survey

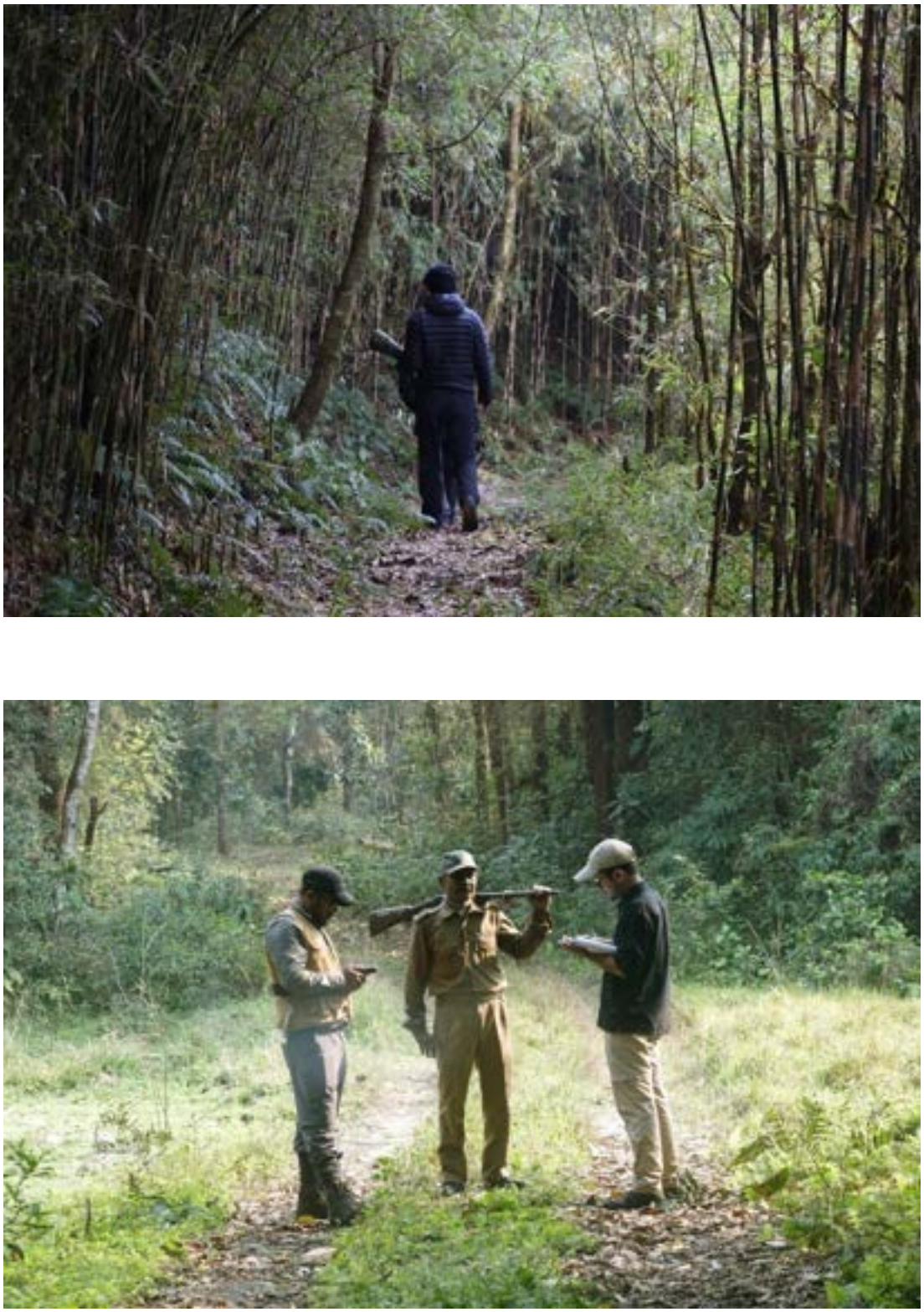


Plate 4: Field team during Sign Survey

Plate 5: Photographs of carnivore scat collected during survey

Plate 6: Snap shot of Wildlife Genetics Laboratory, Aaranyak and Research Scholar working with the carnivore scat samples

8. APPENDIX II

The Human-Leopard Conflict Management Plan for North Bengal

1. SPECIES BIOLOGY

- Among big cats leopard is the most agile species with light bone structure, flexible joints, strong muscle, padded feet and retractile claws (Karanth 2013).
- Height: 50-75 cm (Karanth 2013).
- Weight: In male 45-77 kg; in female 30-45 kg (Karanth 2013).
- Length: Adult male 203-243 cm and adult female 180-208 cm including tail of 76-106 cm (Karanth 2013).
- Adult leopards are solitary in nature (Stein and Hayssen 2013) except for,
    - Females which rear cubs and
    - Mating individuals which remain associated for several days before separating again
- Leopards generally mate throughout the year. The litter sizes vary between one to six with two cubs being common after 88-112 days of period of gestation. However, litter size of 5 or 6 occur vary rarely (Karanth 2013; Stein and Hayssen 2013).
- Leopards may have overlapping home range with neighbours but maintain their individual territories. Females tend to share portion of their territories with their female offspring (Stein and Hayssen 2013).
- Leopards are highly adaptable animal which can live near human inhabitations without being detected.
- Leopards can feed on large variety of prey species. They often prey on livestock and domestic animals.
- It has been observed that the homing instincts of leopard are very strong and it can travel long distances to come back to the site of capture if relocated.

2. POPULATION STATUS AND DIET PREFERENCE OF LEOPARDS OF NORTH BENGAL

- Genetic population estimation shows all the major PAs of North Bengal have a good sustainable population of leopard with healthy female to male sex ratio.
- Despite availability of wild prey, major proportion of the relative biomass consumed by leopard of North Bengal is constituted by domestic prey such as cattle, goat, pig, dog etc. indicating that in North Bengal leopards' prey on domestic animals on a regular basis. This is true for leopards inside as well as at the edge of the protected areas.
- North Bengal has a very high density of livestock. Regular depredation will incur heavy economic loss to the livestock owners. This could also build negative attitude towards leopard among local people.

3. PEOPLE'S PERCEPTION AND ITS RELATION TO CONFLICT

- In general, the attitude of local people towards leopard in North Bengal, as assessed from our study, is positive despite regular predation of livestock and attacks on human being.

  However, loss of human life and property due to predatory attacks by leopard could create anger towards the species among local people. Retaliatory killing of leopard has been recorded in North Bengal from time to time. A negative attitude in local people can create hurdles in achieving the conservation goals for the species.
- There is a general lack of awareness among people on the biology of leopard, pattern of leopard attack and native diversity of wildlife. Understanding the various aspects of species biology could help in avoiding direct/indirect conflict with leopard.

4. MANAGEMENT ACTIONS

Leopard is found across the North Bengal landscape. Historically, leopards are known to inhabit near human habitation in North Bengal and prey on livestock. Therefore, mere presence of leopard in human dominated landscape cannot be considered as human-

leopard conflict and a holistic approach is required to mitigate the current human-leopard conflict situation.

4.1. IDENTIFICATION OF THE CONFLICT PRONE AREA

- Collection of information on human-leopard conflict

  For identification of conflict prone areas, accurate data on sighting of leopard or signs in human dominated landscape (with GPS location and habitat information), nature of conflicts (such as livestock depredation, injury/death of human, number of such incidences) and trends (spatial and temporal variation in conflict intensity) must be collected regularly.

- Such information should be collected division wise in a systematic way (using stand form/datasheet) and deposited in a central digital repository.

- Only based on the conflict data collected from field human-leopard conflict prone areas should be identified.

4.2. MONITORING OF LEOPARD CONFLICT PRONE AREA

- Long term monitoring program should be taken up in human-leopard conflict prone areas on priority basis. Such long term monitoring effort should include,
  - Monitoring of leopard population size and abundance in conflict prone areas.
  - Identification of conflict animals and monitoring of their movement pattern.
  - Monitoring of leopard prey availability and dietary preferences in conflict prone areas.

4.3. CONFIDENCE BUILDING MEASURES WITH LOCAL COMMUNITY

4.3.1. Involvement of Local Community in Conservation Efforts

- Involvement of local communities is important for successful implementation of any conservation and management effort.
- For conservation of leopard in North Bengal a participatory approach should be taken ensuring involvement of local communities and other stakeholders in the process.

- Mitigation measures as well as standard operating procedures (SOPs) should be prepared in consultation with all the stakeholders.
- The concerns of the local communities should be adequately addressed while preparing action plan.
- Involve members of local community in gathering data mentioned in section 4.1.

4.3.2. Conservation Education and Outreach

- Conservation education and outreach efforts should be carried out across the North Bengal Landscape irrespective of whether an area is conflict prone or not.
- Different media and communication platforms should be used for conservation education and outreach.
- Conservation education program should target people from different age group, sex and profession.

  (For example: school students, teachers, media personals, farmers, women working in tea gardens, housewives etc.).
- The education programs should focus on
  - Leopard biology
  - Reasons of leopard attacks on human and livestock
  - Pattern of leopard attacks
  - Measures to mitigate human-leopard conflict
  - Overall diversity of flora and fauna of North Bengal
- Effort should be given on sensitization of the media personals on issues related to wildlife conservation (Ministry of Environment and Forests, 2011).
  - Media reporting plays an important role in creating people's perception towards human wildlife conflict situation.
  - Particularly aggressive reporting may create negative perception among local people as well as public in general towards mitigation efforts.
- Recruit suitable participants of conservation education programs in collection of data mentioned in section 4.1.

4.3.3. Livestock Management

- Local communities should be encouraged to adopt better livestock rearing practices.
- Subsidy should be provided for simple but sturdy and leopard-proof livestock sheds in conflict prone areas.
- Subsidy should be provided in procurement of fodder for livestock.
- Efforts on maintaining livestock health could be taken up by Forest Department in collaboration with Animal Husbandry Department. This will help in confidence boosting of local community.
- Possibility of initiating insurance schemes for livestock also needs to be explored.
- Possibility of use of non-lethal deterrents (such as use of fox light, cost effective motion detection based alarm systems etc.) should be explored on experimental basis in high conflict prone areas.
- Possibility of compensating killed livestock outside PA with fresh livestock by the forest department/ other govt. department.

4.4. EMERGENCY RESCUE

The provisions of emergency rescue of leopard (if deemed necessary by competent authorities) are outlined below (Ministry of Environment and Forests 2011; Athreya and Belsare 2007).

4.4.1. Legal Aspects

- As per provisions of Wild Life (Protection) Act (1972), India attacks on livestock or sighting of leopard do not justify trapping (Athreya and Belsare 2007).
- Permission for trapping should be permitted only by Chief Wild Life Warden (CWLW) if deemed necessary as per provisions of Wild Life (Protection) Act (1972), India.
- Members of local community, media personals should be sensitized on specific conditions under which rescue/trapping/translocation is permissible under relevant provisions of the law.

4.4.2. Management of Crowd

- Management of crowd near leopard rescue operation site should be given priority. Crowd management should to be done by the civil administration so that the wildlife staff and veterinarian can concentrate on containing the animal.
- Uncontrollable crowd often obstruct rescue operation. Chances of attack on human by leopard increases when huge crowd surrounds the animal.
- Prior to rescue operation a perimeter should be defined and completely cordoned off completely with the help of police and civil administration.
- Provide regular updates to local public.
- Provisions for emergency medical support should be made available.

4.4.3. Management of Animal

- Rescue operation should be situation based.
- The priority of any rescue operation should be to provide scope for the animal to return to its natural habitat.
- Range/Division wise emergency response teams should be constituted specifically to deal with any conflict situation related to leopard. Such emergency response team should also be responsible for collection of systematic data on sighting of leopard, leopard signs as well as human-leopard conflict data as mentioned in section 4.1. and updating central database.
- Presence of veterinary doctor should be ensured at the site of rescue prior to start of rescue operation.
- Protocols to be followed in different scenarios are mentioned in section 6 and 7.

4.4.4. Different Situations for Rescue

4.4.4.1. If Animal is in Open Area

In case of a leopard being present in an open area such as barren land, grassland, street, thicket, crop field with standing crop or woodland, with the leopard being either up on a tree or on the ground surrounded by man,

- First, the effort should be made to remove gathering of people from the area and then allow the animal to escape in dark.
- Immobilization of leopard (through drug) or trapping should be avoided unless deemed fit by CWLW.
- For trapping well designed traps should be used to ensure minimal injury to the animal in the process.

4.4.4.2. If the Animal is Confined in Semi-confined Ares

If the leopard is present in semi confined areas (i.e., a well or trench),

- First keep crowd away from the site of rescue.
- In such a situation, it is prescribed that a ladder is let down into the well which will facilitate escape of the animal.
- The rescue team should monitor the situation until the animal escapes.

4.4.4.3. If the Animal is Confined in a Closed Area:

If the leopard is present in a house, garage, under a culvert etc.

- Avoid crowd gathering near rescue site.
- If the area is near forested area the animal should be allowed to return to its natural habitat at night.
- If the rescue site is in an area with high human density and there is a high risk to human life the animal may be chemically immobilized (by order of CWLW under appropriate provisions of Wild Life (Protection) Act (1972), India).

4.4.4.4. If the animal is Trapped in a Foothold Snare/Trap:

- Avoid crowd gathering so as to reduce stress of the animal.
- The animal should be immobilized using drugs (by order of CWLW under appropriate provisions of Wild Life (Protection) Act (1972), India) and then attempt should be made to release it from the snare/trap.

4.4.5. Trapping Device

While using/designing trapping device for leopard following points needs to be taken into consideration (Ministry of Environment and Forests 2011; Athreya and Belsare 2007).

- The trap cage should be in good and functional conditions. The trap cages should be regularly monitored to ensure they work properly.
- It should not have any sharp edges to avoid any injury to the trapped animal from such edges
- The trap cage should be escape proof.
- Trap cage should have gap of 1.5 inches between the cage floor and lower edge of the trap door. This reduces chances of leopard tail getting cut during the rescue process (Athreya and Belsare 2007)
- Trap cage should have minimum of 8 cm distance between the bars of the cage to prevent the canines from breaking if the leopard tries to bite the bars of the cage.
- Well ventilated trap cages should be used during rescue in order to prevent the animal from dying as a result of overheating.
- The trap cage should be at of adequate size with the trap door activation region being at the extreme end, in the opposite direction to the trap door.
- The trap cage should be anchored properly so that it does not fall over during trapping process.
- Each trap cage should be associated to a housing cage of adequate size, at least 2 x 1.5 x 2 metres as per provisions of Wild Life Protection Act (Appendix I in the Recognition of Zoos section)

4.5. POST CAPTURE MANAGEMENT

4.5.1. Immediately After Trapping

- After trapping the trap cage should be covered with suitable material (such as greenhouse material). This will help in reducing stress level of the animal.

- The cage should be cordoned off and no person should be allowed near the cage.
- In case there is a huge crowd gathering and provisions are available, the animal should be transported to nearest rescue centre immediately and provided with proper post capture care.
- The trapped animal should be checked for presence of any microchip to confirm if it was previously captured.
- The provisions for feeding, housing and cleaning of enclosures, transportation of trapped leopard should be made as per recommendations (Ministry of Environment and Forests 2011; Athreya and Belsare 2007).

4.6. RELEASE OR TRANSLOCATION OF CAPTURED LEOPARDS

Following points needs to be considered before release or translocation of captured leopards

- While releasing the trapped/chemically immobilized animal, priority should be given to release the animal in a place near to where it was captured i.e., within its home range.
- Translocation of trapped animal should be avoided as,
    - It could lead to human-leopard conflict in the newly released site.
    - It may break the dynamics of the existing leopard population.
    - It may attempt to head back to its original territories owing to its strong homing instinct.
- If a leopard deliberately attacks human being it is recommended not to release it into the wild post capture (Ministry of Environment and Forests 2011).

4.7. MONITORING OF TRANSLOCATED LEOPARDS

- In case, translocation is considered as the mitigation option under circumstances deemed fit, appropriate monitoring of the animal post release should be done to ensure success of translocation.
- The animals should be marked with microchips and ear tags or colour coded collars before their release.
- Considerations should be made to use radio collars to monitor movement pattern and survival rates of animals post release.
- Wildlife experts must be involved in such radio-tracking programmes.

5. COMPENSATION PROCEDURE AND SUGGESTION FOR IMPROVEMENT

Payment of ex-gratia compensation immediately in case of loss of life, livestock, and property due to attack by leopards will help calm people.

5.1. Present Procedure of Ex-gratia Compensation

As per the government of West Bengal notification (vide G.O. No. 195-For/11M-95/2011(Pt-I) date 30.01.2015) the procedure for claiming ex-gratia compensation due to wildlife depredation and its processing are detailed below:

- **Eligibility for claiming Ex-gratia compensation**

  A person who is affected by the attack of wildlife as specified in the above Government order & whose crop and/or house is damaged by wild animal and if any domestic animal is injured/died due to wild animal attack is eligible for claiming ex-gratia compensation.

- **Whom to apply**

  Apply to the local Beat-Officer in the prescribed format downloading from website. Application Form may also be collected from the nearest Range-Office or Beat-Office.

- **Submission of Application**
  - The person affected by wildlife has to apply in the prescribed Form for claiming of Ex-gratia compensation due to wildlife depredation. The Form can be downloaded from website or collected from nearest Range-Office or Beat-Office.
  - The application has to be filled up giving land details (Mouza, J.L. No., Plot No., Khatian No.& area of crop damage), house details, details of human death & domestic animal death, whichever is applicable, along with Bank details (Name of account holder, Account No, IFSC No., Bank name & Branch name).
  - The filled in application Form should be signed by the applicant & submitted to the nearest Beat-Office.
- **Field Enquiry**
  - On receipt of the application Form, the Beat-Officer will fix a date of enquiry and informed the applicant accordingly well in advance to be present in the spot of enquiry at the specified date & time along with land details, Porcha (R-O- R) and show to the enquiry team in the field.
  - Enquiry will be completed as early as possible, maximum within 30 days from the date of receipt of the application.
  - Inquiry Officer may invite local panchayat member to be present during the enquiry.
  - The Beat-Officer will send his enquiry report with comments to the Karmadhakhaya, Ban-O-Bhumi Sanskar Sthayee Samity of the concerned Panchayet samity for his recommendation.
  - After Karmadhakhaya's recommendation, the application will come to Range-Officer. Range-Officer will sort out the applications Bank branch-wise and Post-Office wise & and make separate bunch and send to DFO for making arrangement for payment.

- **Mode of Payment**
  - Finally, the application will be sent by Range Officer to the DFO for sanction & payment.
  - On receipt of applications, DFO will sanction the payment amount & send the bills to the Treasury for payment to the affected persons in their account.

5.2. Suggestion for Improvement to Present *Ex-gratia* Compensation Procedure

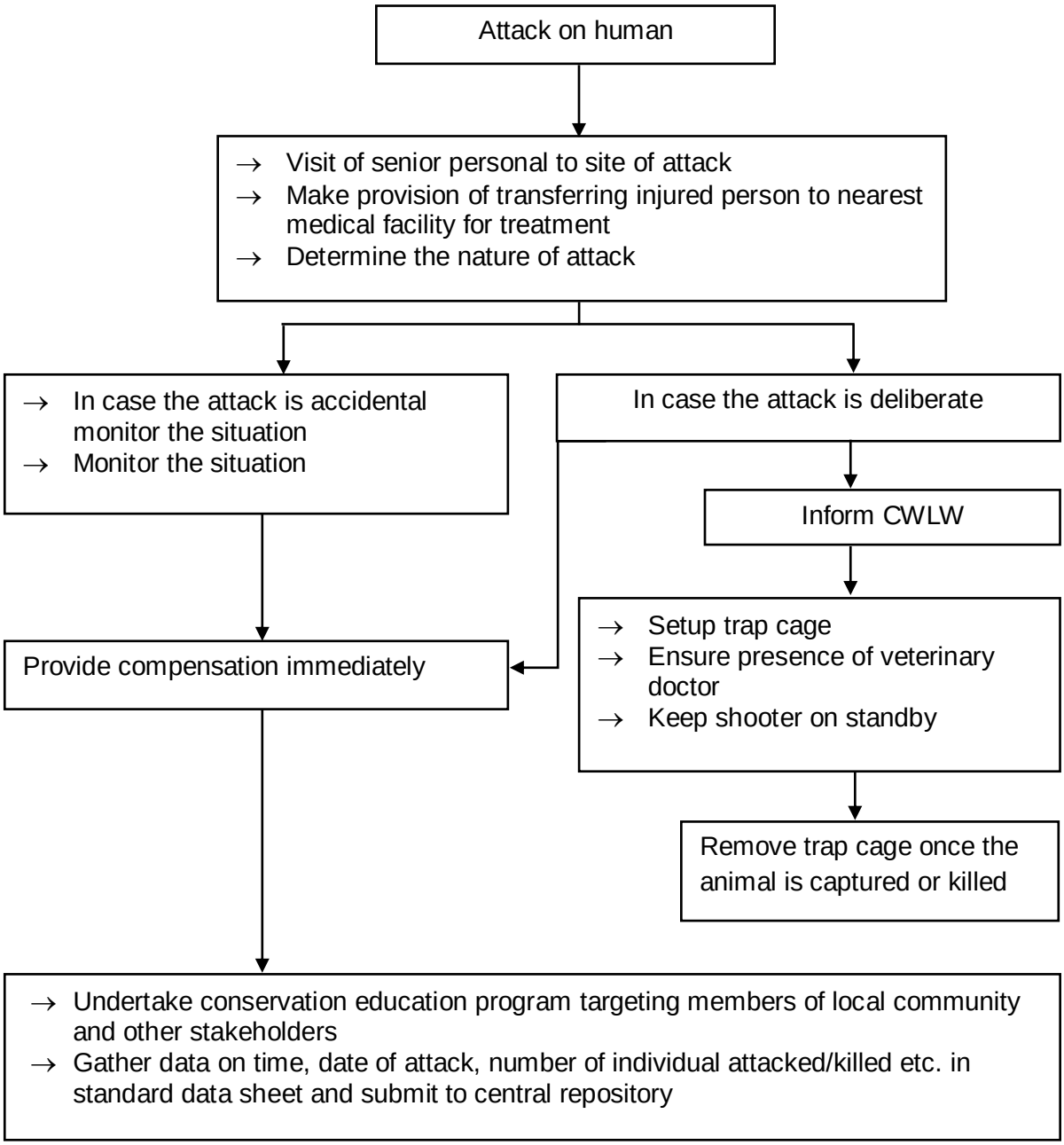
In case of human-leopard conflict situation the payment of *ex-gratia* for injury/loss of life/livestock/property should be comprehensive and released at the earliest.

- *Attack on Human Being*

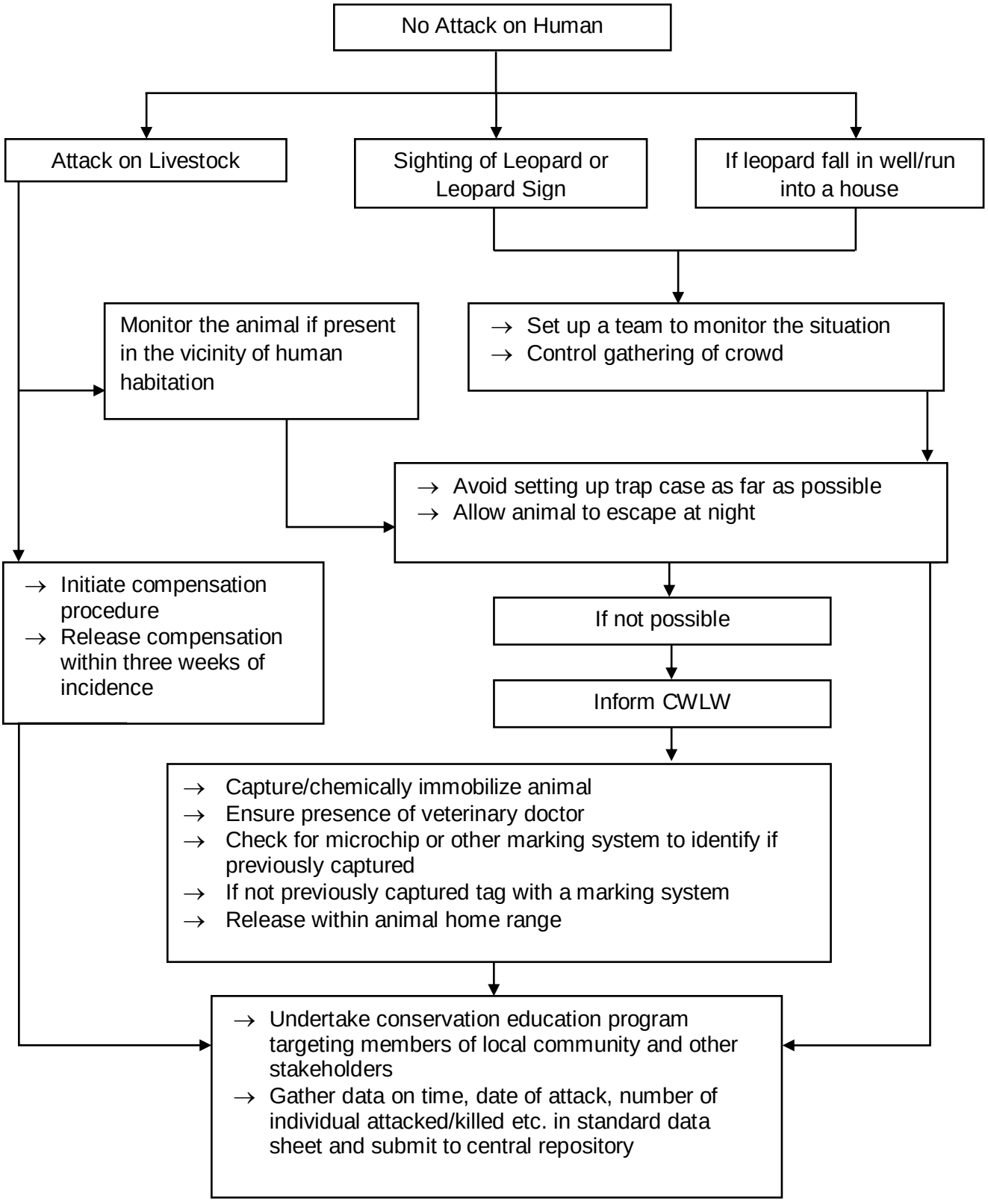
In case of predatory attack on human being provisions should be made to immediately provide all necessary medical attention to the victim and appropriate *ex-gratia* compensation (as per government norms such as in case of injury/degree of injury/loss of life) should be released to the victim/victims family immediately under supervision of a senior forest official.

- *Attack on Livestock*
  - In case of predatory leopard attack on livestock, appropriate *ex-gratia* should be paid to the owner within a period of three weeks of submission of application. Upon receiving complaint concerned beat officer should visit the site immediately along with veterinary officer, members of concerned gram panchayat and make their recommendations within a week. The amount should be dispatched directly to the account of the owner of livestock.
  - The *ex-gratia* compensation amount should be revised on regular basis. The livestock depredation value should be fixed in accordance with their economic value.
  - Considerations should be made to develop a digital portal for *ex-gratia* compensation procedure to reduce paperwork and speedy disposal of applications.
  - Self-financed insurance schemes for livestock should be promoted and facilitated by appropriate government agencies.

6. PROTOCOL TO BE FOLLOWED IN CASE OF LEOPARD ATTACK ON HUMAN



7. PROTOCOL TO BE FOLLOWED IN CASE NO LEOPARD ATTACK ON HUMAN



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Government of West Bengal