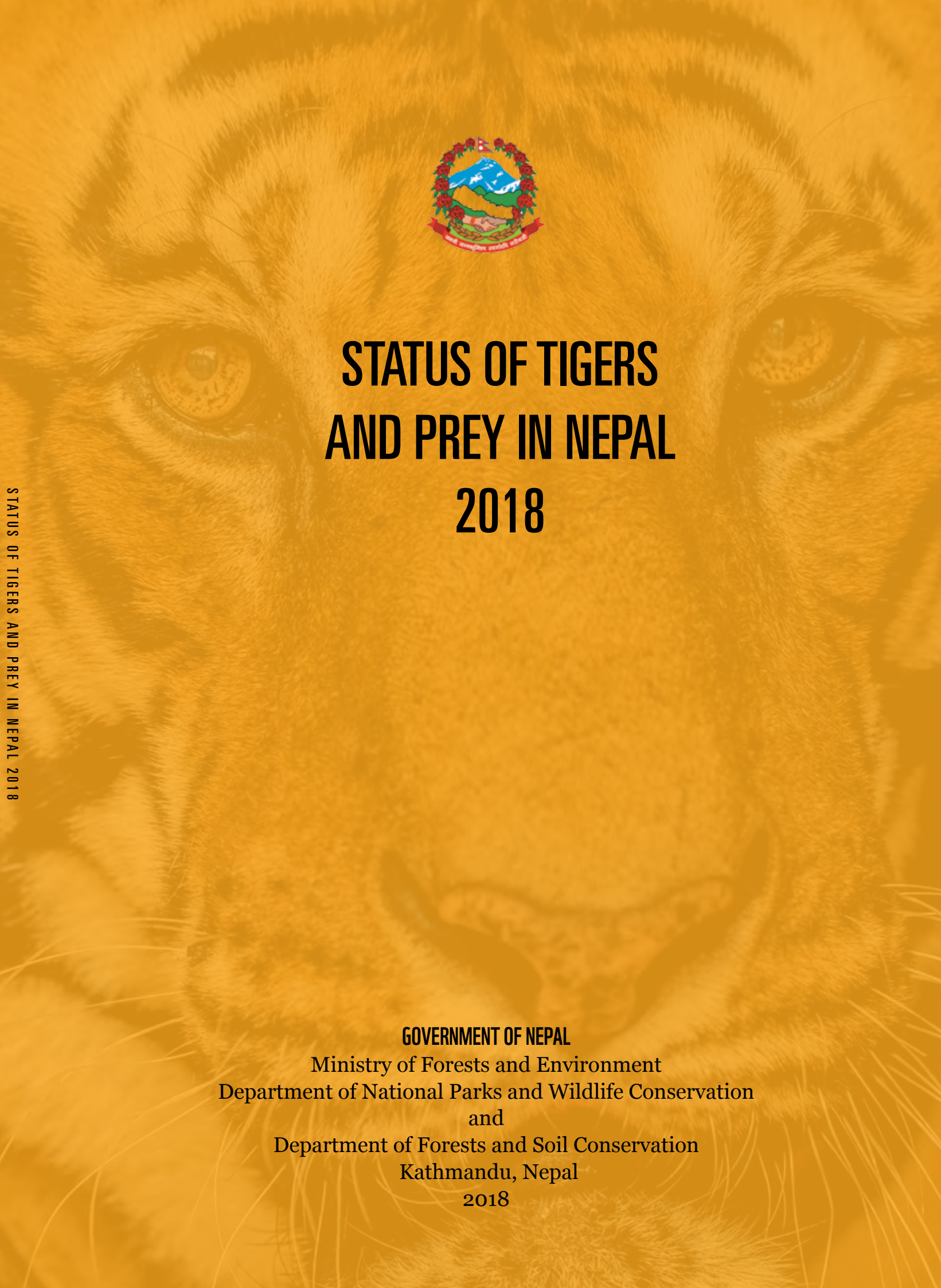

STATUS OF TIGERS AND PREY IN NEPAL 2018

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Ministry of Forests and Environment
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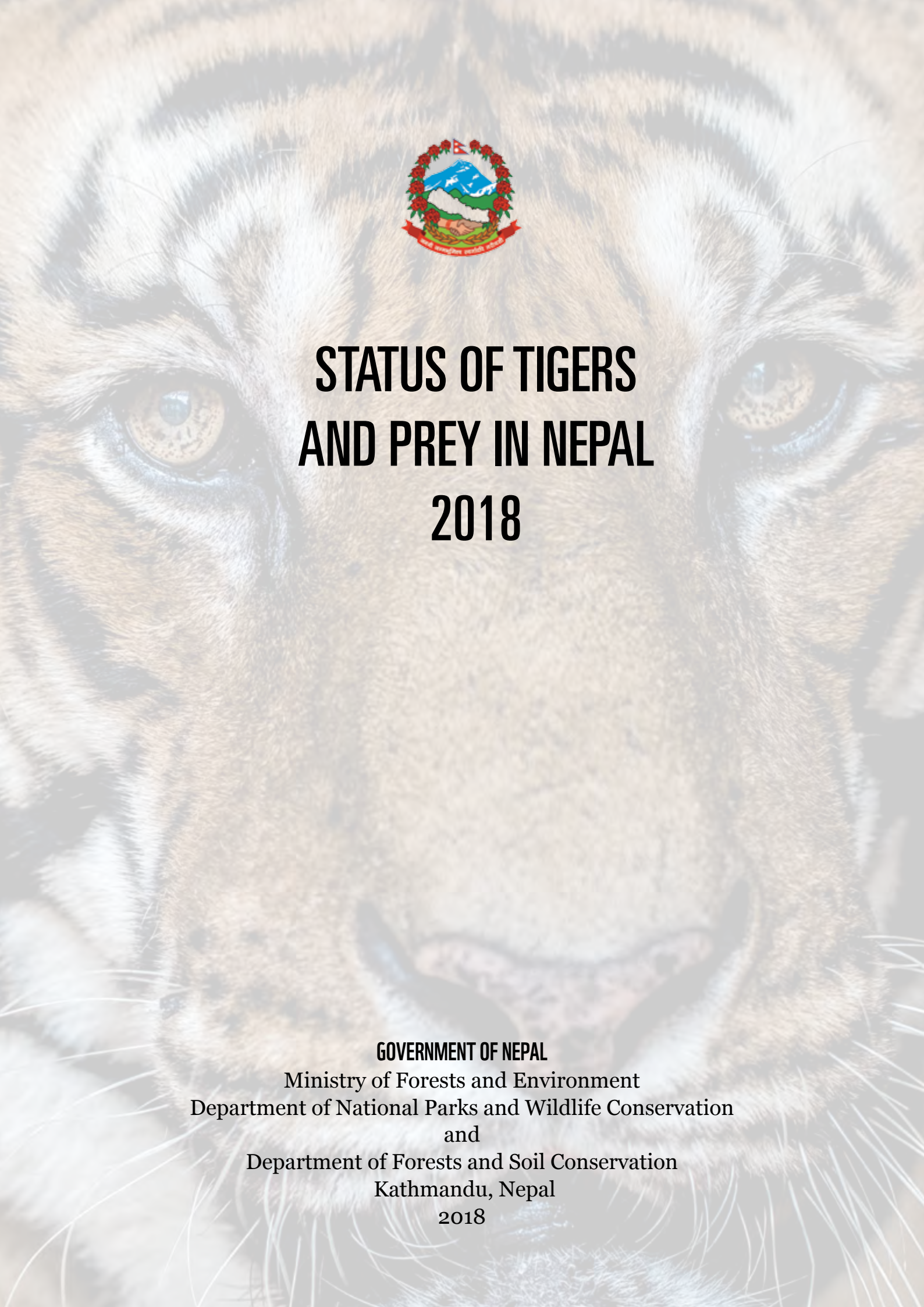
and
Department of Forests and Soil Conservation
Kathmandu, Nepal
2018



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Foreword

Tigers are charismatic creatures that are at the top of the food chain and depend on large and undisturbed habitats for their survival. Historically, these magnificent mammals roamed much of Asia, with their range extending from Turkey in the west to the eastern coast of Russia. However, during the last century, tigers were ruthlessly hunted throughout their range in the form of trophy hunting and retaliatory killing. Increasing human population resulting in agriculture expansion, urbanization and large-scale unplanned development are some of the reasons for degraded, fragmented and often isolated habitats. As a result, the tiger population estimated to be around 5,000-7,000 individuals during 1998 rapidly declined to 3,890 in 2016. Considering the rapid plunge of tiger population in the last decades, it has been listed as "Endangered" in the IUCN's Red List and under Appendix I in Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). As one of the tiger range countries, Nepal has also listed the species under Schedule I in its National Parks and Wildlife Conservation Act, 1973.

The Government of Nepal (GoN) is committed to achieve its international pledge of doubling the tiger population by 2022. GoN identified tiger recovery sites in Terai Arc Landscape (TAL), a priority conservation landscape in Nepal. Major focus areas include addressing key threats such as poaching, habitat loss and human-wildlife conflicts. To manage tiger meta-population in the landscape, investments are also being made to secure core breeding sites and to restore corridors for habitat linkage between the protected areas of Nepal and India. GoN has also been working with the local communities under the framework of participatory forest management. Within the protected area system, buffer zone communities benefit through 30-50% of the park royalty.

The national status of tigers and prey is updated on a four-yearly basis to understand population trends and evaluate effectiveness of conservation interventions in the country. The third national tiger and prey survey carried out during November 2017-April 2018 in all the potential tiger habitats in TAL estimated a total of 235 tigers as compared against 198 tigers in 2013. This is an increase of around 19% since the last survey; the result indicates that Nepal is heading towards doubling the tiger population by 2022.

This report highlights the major findings of the latest national tiger and prey survey and provides recommendations to strengthen conservation in the country. I would like to express my sincere thanks to all the government and partner organizations including the 'National Tiger and Prey Survey 2018' Advisory Committee, Technical Committee, Technical Task Force, Field Implementation Committee and all the frontline staff, citizen scientists and student volunteers for bringing this report alive with several months of field work, data analysis and report preparation. I specially thank the Department of National Parks and Wildlife Conservation (DNPWC) and Department of Forests and Soil Conservation (DFSC) for leading the survey; WWF Nepal, ZSL-Nepal and National Trust for Nature Conservation (NTNC) for financial and technical support with field implementation. Finally, I would like to thank local communities and all the relevant stakeholders who have contributed towards the long-term survival of this magnificent species.

.....

Bishwa Nath Oli, PhD
Secretary

ACKNOWLEDGEMENT

Nepal, among the 13 range states, is committed to doubling tiger by 2022 as per St. Petersburg Declaration, 2010. Tiger is mainly found in the five protected areas and area outside the protected areas along the low land area of Nepal. In line with Nepal Tiger Recovery Program (NTRP) and Tiger Conservation Action Plan (2016-2021), third nationwide tiger and prey survey 2018 has been conducted to update the national database on tiger and their prey in Nepal.

Third Nationwide Tiger and Prey Survey 2018 Nepal has shown 19% increase from 2013 estimate of 198 tigers and results give us pride and encouragement to continue our tireless efforts to save the magnificent animal which is endangered globally. The survey was conducted by the Government of Nepal in collaboration with National Trust for Nature Conservation, Zoological Society of London-Nepal office, and World Wildlife Fund-Nepal office. We would like to thank Dr. Maheshwar Dhakal - Joint Secretary, MoFE; Mr. Govinda Gajurel - Member Secretary, NTNC; Dr. Hem Sagar Baral - Country Representative, ZSL Nepal and Dr. Ghana Shyam Gurung - Country Representative, WWF Nepal for their support and advice in making this national survey a success.

We extend our thanks to the technical committee members: Mr. Gopal Prakash Bhattarai (DNPWC, Chair), Mr. Dhananjaya Lamichhane (MoFE), Ms. Madhuri Karki (Thapa) (DFSC), Mr. Laxman Prasad Poudyal (DNPWC), Dr. Shant Raj Jnawali (WWF Nepal), Mr. Shiv Raj Bhatta (WWF Nepal), Mr. Bhupendra Prasad Yadav (DNPWC), Mr. Rishi Ranabhat (DNPWC), Mr. Sujan Maharjan (DFSC), Dr. Kanchan Thapa (WWF Nepal), Dr. Naresh Subedi (NTNC), Dr. Chiranjibi Prasad Pokheral (NTNC), and Dr. Bhagawan Raj Dahal (ZSL Nepal) for their untiring work throughout the survey.

Our special thanks go to all chief conservation officers and their staff of Parsa, Chitwan, Banke, Bardia, and Shuklaphanta National Parks; District Forest Officers of the (Dadeldhura, Kanchanpur, Kailali, Bardia, Surkhet, Banke, Salyan, Dang, Arghakhanchi, Kapilvastu, Rupendehi, Palpa, Nawalparasi, Chitwan, Parsa, Makwanpur, Bara and Rautahat and their staff of tiger bearing forest districts, staff of NTNC, ZSL Nepal, WWF Nepal and TAL field offices for their participation and support in the field survey implementations. Ms. Sabita Malla, Mr. Samundra Subba, Mr. Saroj Koirala, Mr. Shailendra Giri, Mr. Babu Ram Lamichhane deserves special thanks for their outstanding contribution in designing the survey, field technical support, data analysis, report writing and publication. We would also like to thank Dr. Rajan Amin, Dr. Marcella J. Kelly and Ms. Rebecca May for their thorough review and constructive comments in finalizing this report. Besides, Nepali Army, law enforcement agencies, buffer zone user committees, community forest user groups, CBAPUs, citizen scientist, students and volunteers deserve special thanks for their role and participation in the survey.

The technical and financial support of WWF Nepal, ZSL Nepal, NTNC, USAID-Hariyo Ban Program, Leonardo DiCaprio Foundation, KfW/IUCN, Panthera, WildCats Conservation Alliance for nationwide tiger survey deserves special acknowledgement.

We hope this technical report will be useful to all policy makers, protected areas and divisional forest managers, conservationist, academia, and general readers nationally and internationally. Finally, we reiterate our sincere thanks to every individual and institutions who made the nationwide tiger and prey survey a huge success and timely publication of this technical report.

Ram Prasad Lamsal, PhD
Director General
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EXECUTIVE SUMMARY

Tiger is an apex predator and an umbrella species that ensures well-being of entire ecosystems across its habitat range in Asia. Its population and distribution range had drastically declined in the last century, with the species verging towards extinction. Over the past few decades, however, implementation of strategic conservation interventions has aided in the revival of the tiger.

In 2010, Nepal along with other range countries endorsed the St. Petersburg declaration to double the tiger population by 2022. Since then, Nepal has been conducting four-year periodic assessments to track the progress towards reaching the national target of 250 tigers. The first and the second nationwide assessments carried out in 2009 and 2013 estimated 121 and 198 tigers, respectively.

This report synthesizes the findings of the third nationwide tiger and prey survey, led by the Department of National Parks & Wildlife Conservation (DNPWC) and Department of Forests and Soil Conservation (DFSC) with the support from WWF Nepal, National Trust for Nature Conservation (NTNC), and ZSL-Nepal. Citizen scientists and students of various institutions provided for human resource needs to achieve this landscape-level exercise.

The survey was conducted in all potential tiger habitats in the Terai Arc Landscape (TAL) of Nepal, following nationally approved Tiger and Prey Base Monitoring Protocol, 2017, between November 2017 to April 2018. The major objectives were to estimate: i) habitat occupied by tigers, ii) tiger abundance and density, and iii) prey density. This report also recommends appropriate measures to address challenges in tiger conservation and presents the road map towards achieving TX2 by 2022.

To implement this survey, various working committees were formed at central to field levels. Orientation trainings were provided to field survey teams prior to the field work. Habitat occupancy survey was carried out in 112 (15 km×15 km) grid cells covering 16,261 km² of forested habitats to estimate tiger distribution across TAL-Nepal. Camera-trap survey was carried out in 1,643 (2 km×2 km) grid cells encompassing a) sampling area: 6,572 km², b) effective sampling area (total sampling area plus buffer): 12,356.6 km² (protected areas, buffer zones, corridors, and adjoining forests) to estimate tiger population and density. Overall effective sampling effort was 27,829 trap days. Survey of 1,294 line transects, with a total sampling effort of 2,485 km, provided the prey density estimates. An extensive effort of 53,843 person-days and 1,735 elephant-days was invested to complete the field work for the nationwide survey.

Data analysis was done with established latest software. Occupancy estimate was derived using PRESENCE, tiger abundance and density was analyzed using 'secr' and SPACECAP package in R environment, respectively. DISTANCE software was used to estimate prey density.

Tiger signs were detected in 12 districts (Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Dang, Salyan, Banke, Bardia, Surkhet, Kailali and Kanchanpur) out of 18 districts surveyed across TAL-Nepal. Altogether, 494 unique tiger signs were detected, providing an occupancy estimate of approximately 68% (11,057 km² of the total 16,261 km²) across the landscape. Segregating further, habitat occupied by tigers in PAs was found to be as high as 98% (6,828 km²), as against 60% (5,576 km²) outside Protected Areas.

Tigers were captured in camera traps in 482 grids, or 29% of the total 1,643 grids. Altogether, 4,388 photographs of 209 individual tigers [Parsa National Park (PNP) - 15, Chitwan National Park (CNP) - 85, Banke National Park (BaNP) – 17, Bardia National Park (BNP) - 77 & Shuklaphanta National Park (ShNP) – 15] were obtained. Independent detections (1,136) of identified individuals were analyzed to estimate protected area-wise tiger populations. This revealed an estimate of 18 (16-24) tigers in Parsa National Park and adjoining forests, 93 (89-102) tigers in Chitwan National Park and adjoining forests, 21 (18-30) tigers in Banke National Park and adjoining forests, 87 (82-97) tigers in Bardia National Park and adjoining forests, and 16 (15-21) tigers in Shuklaphanta National Park and adjoining forests. This accounts for the total national estimate of 235 tigers. A naïve comparison indicates an approximate increase in the national tiger population by 19%, within the four-year period. Notable increase was recorded in respective populations of BNP, BaNP and PNP and their adjoining forests; population in ShNP remained stable, while a marginal decline was recorded in CNP.

Tiger density (per 100 km²) in PAs and adjoining forests, was estimated to be 0.92 (SD 0.15), 3.28 (SD 0.19), 0.97 (SD 0.12), 4.74 (SD 0.28) and 0.96 (SD 0.14) in PNP, CNP, BaNP, BNP, and ShNP, respectively. Habitat occupancy and usage outside PAs, documented by the

present survey, is well below the optimal potential; this provides opportunities for increase through management interventions that reduce human disturbances and improve habitat quality outside PAs.

Wild prey species detected during line transect survey included four deer species (spotted deer, sambar, hog deer, barking deer), two antelopes (blue bull and four-horned antelope), wild boar, gaur, and two primate species (rhesus macaque and langur). Prey density (per km^2) in Protected Areas and adjoining forests were 22 (SE 3.8), 70.7 (SE 7.5), 8.1 (SE 1.6), 77.5 (SE 6.6) and 68 (SE 7) in PNP, CNP, BaNP, BNP, and ShNP, respectively. The overall positive trends in habitat occupancy, tiger abundance in Nepal plausibly relates to positive outcomes of improved protection and management measures, better connectivity as well as greater support towards conservation by communities.

Nepal has come a long way in its journey towards doubling tiger numbers by 2022. Yet, strategic interventions over the next four years will be critical to achieve this goal. This report compiles necessary efforts needed at both national and site levels. These include policy initiatives, research priorities, further improvements in protection and management interventions as well as greater engagement with communities. Improving on current trends through these interventions and incorporation of new emerging understanding, with sustained political commitment by the Government and consistent efforts of diverse stakeholders, Nepal may well become the first country to achieve its commitment to global tiger conservation.

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1 ! INTRODUCTION

The tiger (*Panthera tigris*) is an icon for wildlife conservation. Presently, there are estimated to be around 3,900 tigers in the wild (WWF, 2016) and the tiger's range has reduced by 95% since historical times (Dinerstein *et al* 2007). Realizing this, the 13 tiger range countries led by Global Tiger Initiative (GTI) and supported by global community joined hands to reverse the decline of this iconic species (GTRP, 2010). This culminated in a global commitment to double the tiger population by 2022 (TX2) and the adoption of Global Tiger Recovery Program (GTRP) in 2010 (GTRP, 2010).

Tiger conservation in Nepal began with the launch of the tiger ecology project in 1972 in Chitwan (McDougal, 1977; Smith, 1993) followed by the establishment of Chitwan National Park (CNP), the first national park of Nepal. Since then, Nepal Government has established an additional four protected areas (PAs); Parsa National Park (PNP), Banke National Park (BaNP), Bardia National Park (BNP) and Shuklaphanta National Park (ShNP) for the conservation of tigers. Nepal also gradually shifted its conservation focus from protecting isolated core PAs to designing and managing conservation landscapes focusing on providing connectivity between wildlife populations (Wikramanayake *et al.*, 1998). Terai Arc Landscape (TAL) was the first conservation landscape in Nepal that was designed based on tiger dispersal model with the larger goal of mainstreaming species and forest restoration into the rural development agenda. Almost two decades of landscape level conservation coupled with law enforcement efforts has started to pay off with increasing tiger numbers and extent illustrating tiger dispersal is conceivable and breeding habitat can be restored and at the same time enhancing local livelihoods (Chanchani *et al.*, 2014; Thapa *et al.*, 2018).

The Nepal Government conducts country-wide assessment of the status of tiger and prey every four years, following the nationally approved Tiger and Prey Base Monitoring Protocol (DNPWC, 2017). Two nationwide tiger assessments were carried out in 2009 and 2013, respectively. The first assessment estimated 121 tigers in Nepal (*Karki et al.*, 2009), and was crucial in bringing major conservation policy changes in the country. The survey also established the tiger population baseline for the government's commitment to double the tiger population from 121 to 250 tigers by 2022. The second assessment recorded a 63% increase in the country's tiger population from the 2009 baseline, with an estimated population of 198 tigers (Dhakal *et al.*, 2014). It also provided better insight of tigers along the transboundary Terai Arc Landscape with empirical evidence of tiger movement across the borders (Chanchani *et al.*, 2014). The study identified several site-specific management and conservation gaps and recommended appropriate measures to address them.

Accordingly, Nepal has invested intensive efforts over the last four years to strive towards Tx2. Policy documents such as National Biodiversity Strategy and Action Plan (2014-2020), Terai Arc Landscape Strategy and Action Plan (2015-2025), Forest Policy (2015), and President Chure Terai Madhesh Conservation and Management Master Plan (2017) and Tiger Conservation Action Plan (2016-2020) were developed and endorsed which are the major guiding documents for tiger conservation in Nepal.

The third 2018 nationwide tiger and prey status assessment was carried out by the Government of Nepal (GoN) led by Department of National Parks and Wildlife Conservation (DNPWC) and Department of Forests and Soil Conservation (DFSC) in partnership with WWF-Nepal, ZSL-Nepal and the National Trust for Nature Conservation (NTNC). This report presents the findings of the assessment along with appropriate measures to address identified challenges in tiger conservation and a road map for doubling tiger numbers by 2022.


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2 ! OBJECTIVES

THE MAIN OBJECTIVES OF THE NATIONWIDE TIGER AND PREY SURVEY WERE:

1. TO ESTIMATE THE PERCENTAGE OF HABITAT OCCUPIED BY TIGERS AT THE LANDSCAPE LEVEL, WITHIN AND OUTSIDE PROTECTED AREAS;

2. TO ESTIMATE TIGER POPULATION ABUNDANCE AND DENSITY IN PROTECTED AREAS AND ADJOINING FORESTS;

3. TO ESTIMATE PREY DENSITY IN PROTECTED AREAS AND ADJOINING FORESTS.

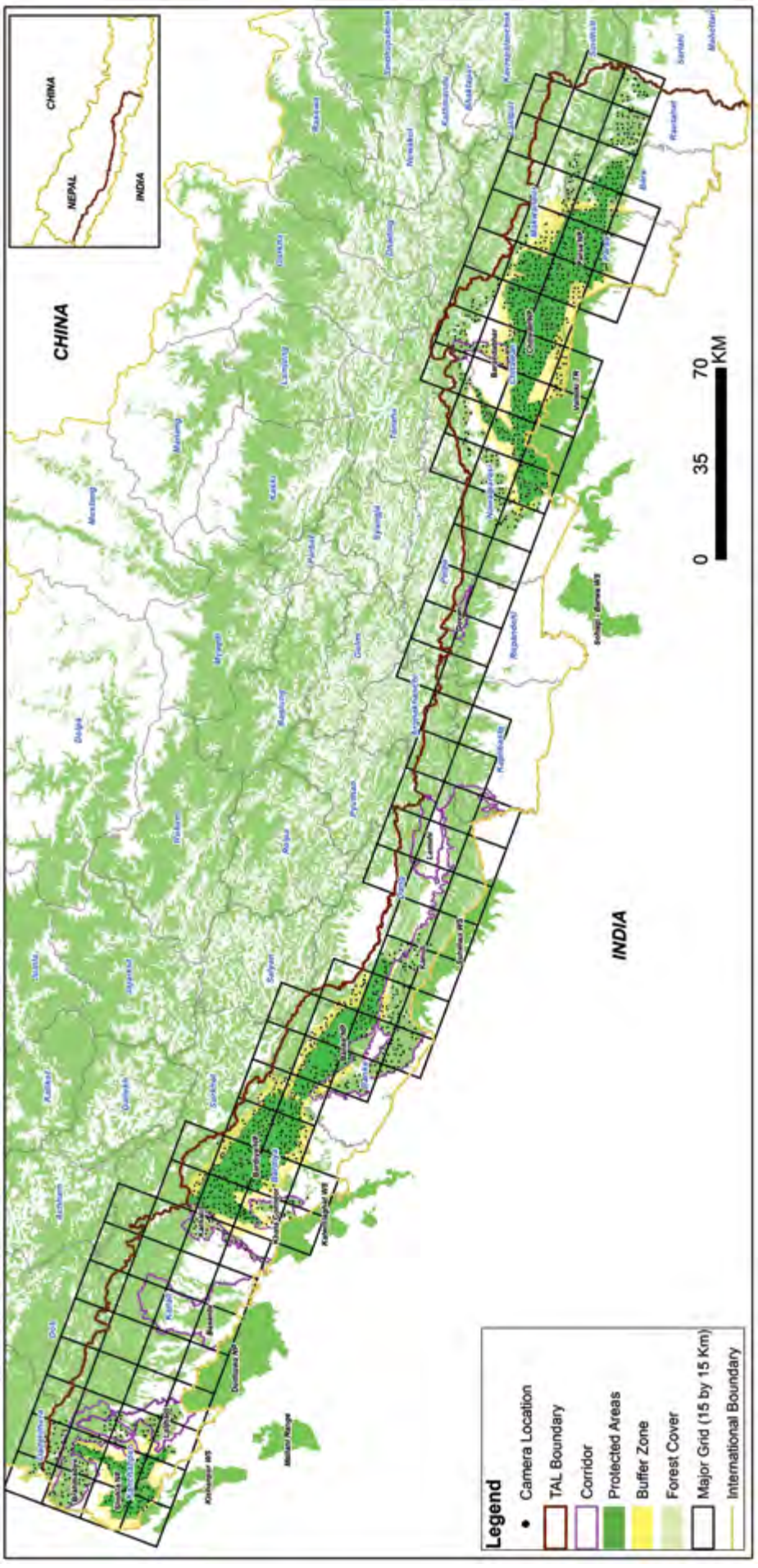

Figure 1.Location of TAL – Nepal showing tiger-bearing PAs and corridors with camera trap locations (black dots) and habitat occupancy grid cells (15 km x15 km).

3 ! STUDY AREA

Tigers in Nepal are distributed across the Terai and Churia habitats within TAL. The National Tiger and Prey Survey - 2018 was conducted across TAL, Nepal (Figure 1). The TAL is a global priority conservation landscape for tigers that extends from the Bagmati river, Nepal in the east to the Yamuna river in Uttarakhand, India in the west, with an area of 51,002 km² (Wikramanayake et al., 1998). TAL-Nepal is spread over 24,710 km², covering 18 districts; Dadeldhura, Kanchanpur, Kailali, Bardia, Salyan, Surkhet, Banke, Dang, Arghakhanchi, Kapilvastu, Rupendehi, Palpa, Nawalparasi, Chitwan, Makwanpur, Bara, Parsa and Rautahat (MoFSC, 2015). PNP, CNP, BaNP, BNP and ShNP are prime tiger habitats in TAL-Nepal; biological corridors (Someshwor, Barandabhar, Kamdi, Khata, Karnali, Basanta, Laljhadi, Brahmadev and Jogbuda) provide habitat connectivity among these PAs of Nepal and with the transboundary PAs in India (Chanchani et al., 2014).

The highly productive alluvial grasslands and riverine forests of TAL are the major habitats of tigers; these also supports 85 species of mammals, 565 species of birds, 47 species of herpeto-fauna and more than 125 species of fish (MoFSC, 2015). Other high profile threatened species include greater one-horned rhinoceros (*Rhinoceros unicornis*), swamp deer (*Rucervus duvaucelii*), Asian elephant (*Elephas maximus*), Gangetic dolphin (*Platanista gangetica*), Bengal florican (*Houbaropsis bengalensis*), Gyps vulture (*Gyps spp*) and gharial (*Gavialis gangeticus*). This landscape is a mosaic of early successional tall grasslands established in the alluvial floodplains to climax stage Sal forests at lower elevations, and broad-leaved forests in the Churia range. Major habitat types include Sal forests, riverine forests, mixed hardwood forests and grasslands (MoFSC, 2015). TAL represents sub-tropical monsoonal climate with three distinct seasons: cool-dry (November-February), hot-dry (March-June) and monsoon (July-October). The average temperature in the cool season drops to 5°C in January and rises to 40°C in the hot dry season (MoFSC, 2015).

The tiger protected areas within Nepal TAL are listed in Table 1.

Table 1. Tiger bearing protected areas in Nepal

Protected Area	IUCN Category	Core Area (km²)	Buffer Zone	Year of Establishment	Elevation (msl)
Parsa NP **	II	627.39	285.3	1984 as WR and upgraded to NP in 2017	435-950
Chitwan NP	II	952.63	729.37	1973	150-815
Banke NP	II	550	343	2010	153-1,247
Bardia NP	II	968	507	1976	150-1,441
Shuklaphanta NP**	II	305	243.5	1976 as WR and upgraded to NP in 2017	174-1,386

(denotes the PAs with revised status of PA or changes in their former size). WR = Wildlife Reserve; NP = National Park.**

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4 ! MATERIALS AND METHODS

The national tiger survey was based on the 'Tiger and Prey Base Monitoring Protocol, 2017' (DNPWC, 2017).

4.1 SURVEY ORGANIZATION

At the national level, an Advisory Committee was setup under the chairmanship of the Director General, DNPWC to provide overall guidance for the survey. Members of this committee included Director General-DFSC, Member Secretary - NTNC, Country Representative WWF-Nepal, and Country Representative - ZSL-Nepal. A Technical Committee chaired by Deputy Director General, DNPWC was formed at the central level with representatives from DNPWC, DFSC, WWF Nepal, ZSL-Nepal and NTNC for overall coordination and supervision of the survey. A Technical Task Force chaired by the Ecologist, DNPWC, and comprising representatives of DNPWC and DFSC, and wildlife biologists from WWF-Nepal, ZSL-Nepal and NTNC, designed the survey, provided technical training and guidance for field work, analyzed data and produced the report.

Field Implementation Committees were formed at PA level in PNP, CNP, BaNP, BNP, and ShNP under the chairmanship of respective Chief Conservation Officers. Members of these committees included respective District Forest Officers, Officers-in-Charge of NTNC field offices, Managers of TAL-PABZ/CBRP, Field Officers from ZSL-Nepal and other relevant stakeholders. The details of the personnel involved is provided in Annex-10.

4.2 FIELD METHODS

4.2.1 FIELD TRAINING

Training of survey field staff on occupancy surveys, camera trap surveys, and line transect surveys were conducted in CNP (for Chitwan-Parsa complex), BNP (for Banke-Bardia Complex), and ShNP (for Shuklaphanta-Laljhadi-Jogbuda Complex). The trained personnel were deployed in groups of 6-8 at strategic locations across the study area. They were assigned to cover the allocated grid cells –to carry out tiger habitat occupancy surveys, to setup and monitor camera traps, and to carry out line transect surveys.

4.2.2 SURVEY TIME FRAME AND HUMAN RESOURCES

The field survey was carried out from December 2017 to April 2018 (Annex-9). It was initiated from PNP following formal inauguration by Dr. Yubak Dhoj GC, Secretary of MoFE. An extensive effort of 53,843 person-days and 1,735 elephant-days was invested to complete the nationwide survey (Annex-9).

4.2.3 TIGER HABITAT OCCUPANCY SURVEYS

Standardized method was followed for tiger occupancy survey (DNPWC, 2012; DNPWC, 2017; Barber-Meyer et al., 2012). The occupancy survey was carried out in 112 grid cells (each measuring 15 km×15 km) that spanned across 16,261 km^2 of potential tiger habitat (forested and grassland) in TAL (Figure 1). Each grid cell was divided into 16 sub-grid cells (3.75 km x 3.75 km). One sub-grid cell was randomly selected to include an element of randomness in spatial distribution of survey routes (Karanth et al., 2008; Barber-Meyer et al., 2012). The number of spatial replicates (i.e. km walked) per grid cell was proportional to the percentage of tiger habitat (Karanth et al., 2008; Barber-Meyer et al., 2012). For grid cells with 100% tiger habitat, 40 km was sampled by traversing random grid in every survey route. Grid cells with less than 10% habitat cover were discarded. Each contiguous 1 km segment was considered a 'spatial replicate' (Hines et al., 2010; Barber-Meyer et al., 2012). Each replicate comprised 10 segments of 100 m each and the data was recorded at every 100 m avoiding spatial auto-correlation by accounting single records for each unique species per segment.

The trained personnel walked along high probability tiger sign areas such as forest trails, fire lines, ridge lines, river beds and streams searching for the signs of tiger (scats, pugmarks, scrapes, kills and urination), prey signs (dung, footprints, sightings and calls) and human disturbances such as wood cutting, lopping, grazing and signs of poaching.

4.2.4 CAMERA TRAP SURVEYS FOR ABUNDANCE ESTIMATION OF TIGERS

A pair of camera traps was systematically placed in 1,643 locations of the total 2,045 grid cells (2 km x 2 km) covering the entire area of tiger-bearing PAs and adjoining forests (6,572 km², Figure 2). The camera trap locations were selected based on extensive field surveys for signs of tiger such as pugmarks, scats, scrape and urination. Camera trapping was carried out in shifting blocks in each survey site (Royle et al., 2009). Cuddeback (C1) and Panthera (V5 and V6) digital cameras were used to obtain high quality images for individual tiger identification. Cameras were programmed to take 3 pictures per trigger with no delay (FAP mode) using white flash. The camera traps were deployed for 15-20 nights in each of the grid cells. with no delay (FAP mode) using white flash.

4.2.5 LINE TRANSECT SURVEYS FOR TIGER PREY DENSITY ESTIMATION

Distance sampling (Buckland et al., 2001) was used for estimating tiger prey densities. Line transects of 1.5-2 km lengths were systematically placed on 2 km x 2 km camera trap grid cells; areas falling in hilly terrains were avoided to adhere to the straight-line assumption of distance sampling (Figure 3). Global Positioning System (GPS) locations of the start and end points of each of the transects were uploaded onto GPS receivers prior to the survey and the straight line was navigated following the bearing using Suunto compass and GPS receiver.

Line transect survey was conducted either on foot or on elephant back. Each transect was traversed by two people between 0630 hours and 0930 hours; each transect was

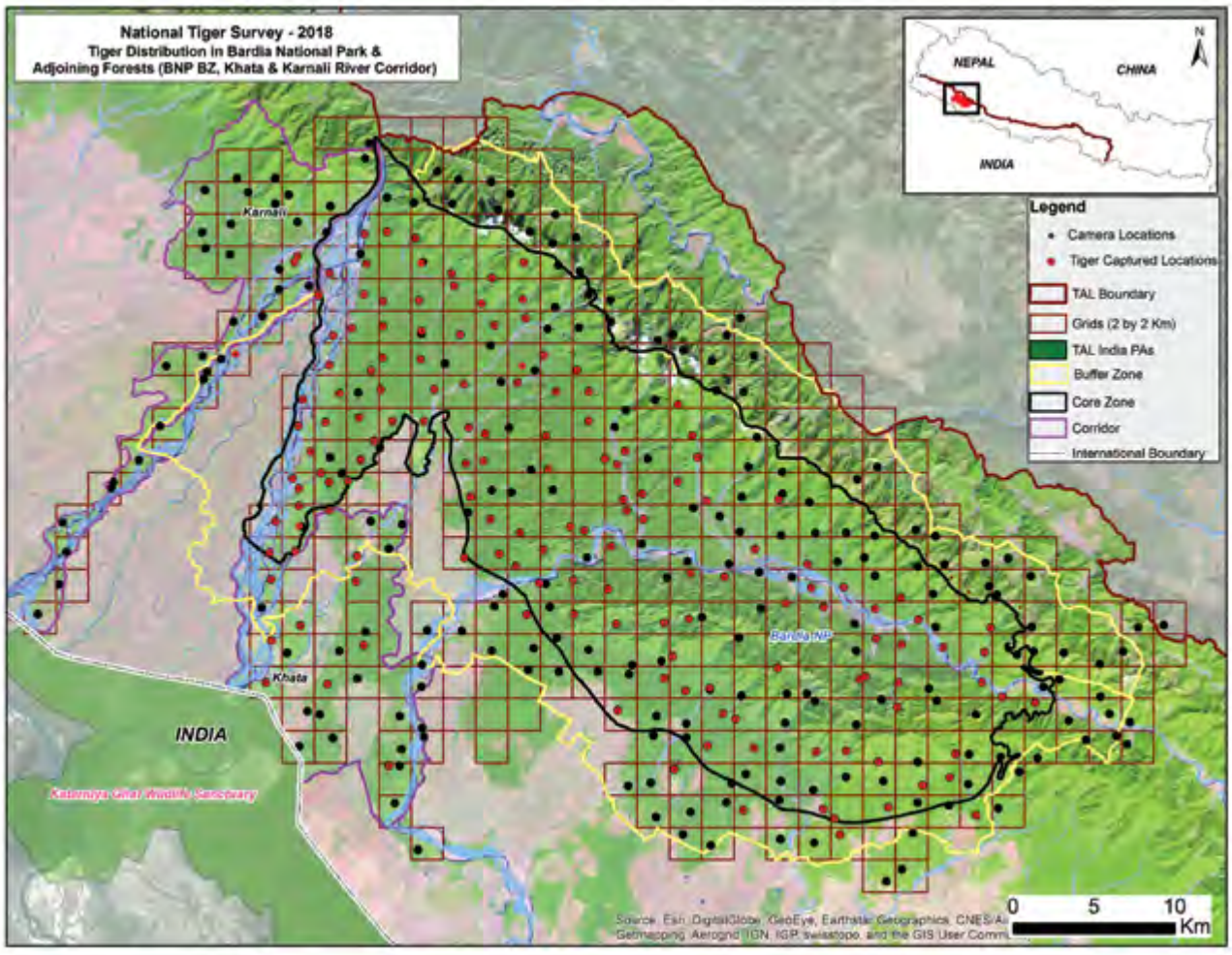

Figure 2. Camera trap layout for Bardia National Park

(similar design was implemented in all other survey sites).

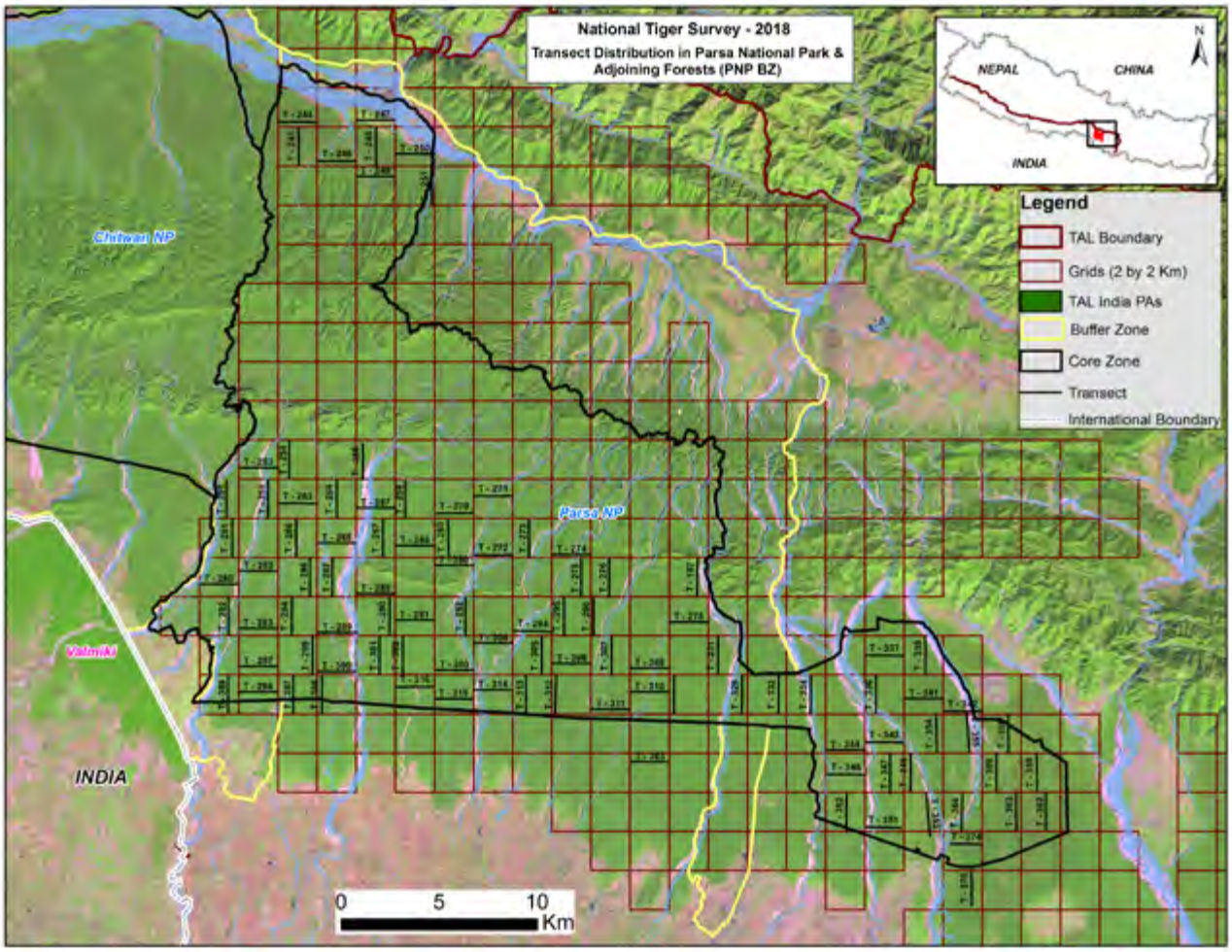

Figure 3. Distribution of line transects in Parsa National Park

(similar design was implemented in all other survey sites).

surveyed twice. Elephants were only used in tall flood plain grasslands. The following data were recorded along the transects - bearing, species sighted, group size, total numbers of adult and young individuals in each group, radial distance to the animal/center of group and the bearing of the group and GPS locations of each sighting. Range finders and Suunto compass were used to measure radial distance and animal bearing.


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5 ! DATA ANALYSIS

5.1 TIGER HABITAT OCCUPANCY MODELLING

Standard occupancy modelling approach (MacKenzie et al., 2002) was used to estimate occupancy (Psi), detection probabilities (p) and including modelling covariate effects on detectability and occupancy. A detection/non-detection history matrix was generated and imported into the program PRESENCE 12.7 (Hines, 2013). Multiple season model (Hines et al., 2014) was used to estimate the trend in occupancy dynamics across the landscape both spatially and temporally. For standard estimates, spatial auto-correlation between sampled replicates was tested using Hines et al., 2010 (for single season) and Hines et al., 2014 (for multiple season) model respectively.

5.2 TIGER POPULATION ABUNDANCE ESTIMATION

Camera trap surveys are now a well-established methodology for density and abundance estimation of elusive carnivores (Karanth et al., 2008; Kelly and Holub 2008). Recent development of spatial capture-recapture methods has led to greater clarity in abundance estimation by integrating spatial or "location" information of animal captures. This involves identification of tigers based on their unique stripe patterns, developing a capture history matrix detailing tiger ID, capture location and sampling occasion over the sampling period (Karanth and Nichols 1998) and analysis of capture history data using maximum likelihood (Efford and Fewster, 2012; Efford, 2018), or Bayesian framework (Royle et al., 2009; Gopalaswamy et al., 2012). The data is also amenable to analysis in a non-spatial framework and can be used for conventional mark-recapture analysis (White & Burnham, 1999).

Individual tigers were visually identified by field technicians and trained biologists at three levels (i.e.- field technicians, field implementation committee and wildlife biologists) by thoroughly examining all the images obtained. Only adult tigers (animals captured independently without mother) were used in the analysis (Karanth et al., 1998). Individual tigers were given a consistent ID based on the national tiger database. The tigers were also segregated by sex where possible. Tiger images from protected areas with shared boundary were also compared and common tigers were identified. Common tigers were assigned to the protected area with maximum spatial coverage to estimate site level tiger population abundance.

Tiger abundance estimates were derived using Maximum likelihood (ML) and Bayesian (B) based spatially-explicit capture-recapture (SECR) (Royle et al., 2009; Efford and Fewster, 2012; Efford, 2018).

Input files i) a spatial capture history matrix, ii) a trap layout matrix and iii) a habitat mask excluding non-habitat areas were prepared and analyzed using 'secr' package (version 3.1.6, Efford, 2018) in the R statistical environment (version 3.5.0, R Development Core Team, 2018).

Range of models with biologically plausible covariates on detection probability (g0) and space range (sigma) were considered. The effects of time factor (t), time trend (T), animal's learned response (b), transient response (B), animal x site learned response (bk), animal x site transient response (Bk), and two-class mixtures (h2) were specified and modelled for both detection and distribution. All models were ranked based on Akaike's Information Criterion (AICc) and model-averaging was done with models having delta AIC<2 to determine population estimates for each site.

Since the PAs surveyed are contiguous (e.g. BaNP share its boundary with BNP, and PNP with CNP), taking population size (Ń) of PAs buffer would overestimate the population. Therefore, SECR models were fitted using the stable buffer size first and then population estimates were exclusively derived for the effectively sampled area or the ellipse that contained all the detectors (camera traps).

5.3 TIGER DENSITY ESTIMATION

SECR models under Bayesian framework using Markov-Chain Monte Carlo (MCMC) methods were used to estimate site-specific tiger densities in SPACECAP (version 1.1.0) (Gopalaswamy et al., 2012) in R 3.4.0 (R Core Team, 2017). Three input files - "animal capture" file detailing trap location, animal ID and sampling occasion, "trap flag" file, and, "habitat mask" were prepared. Trap flag was created and included in the model to specify active days of each camera trap station. This incorporated the block sampling design and explicitly accounted for dysfunctional cameras on account of theft, wildlife damage or malfunction. Habitat mask was created for area that included camera trap array (MCP: Minimum Convex Polygon) surrounded by a buffer of half mean

maximum distance moved (1/2 MMDM) by the tigers as range beyond this were all dominated by human settlements. Pixelated habitat mesh size of 0.3364 km² was used (Karanth et al., 2008). Models with four different combinations - trap response present, trap response absent, half normal and negative exponential detection functions were used to fit the data.

MCMC simulations with over 1,00,000 iterations, burn-in of 15,000-25,000 and thinning rate of 1-5 and data augmentation value of 5 times the number of animals captured was set for running the site-specific analysis. Geweke diagnostic scores (-1.64 to 1.64) was used to check the convergence of chains and data fit (Gopalaswamy et al., 2012). Pixelated map showing the tiger density was produced for each of the sites in ArcGIS (Ver. 10.1).

Two separate density estimates were derived by accounting the area sampled in 2018 and 2013. For comparison with density estimates of 2013, site-specific camera locations of 2018 within the camera trap polygon of 2013 was used and tiger densities were estimated for all the study sites in TAL following the similar approach in SPACECAP.

5.4 TIGER PREY DENSITY ESTIMATION

Line transect data were analyzed using the program DISTANCE version 7.1 to obtain density estimates of prey species (Buckland et al., 2001; Thomas et al., 2010). Due to low detection of prey, multiple years' data (2016-2018) of similar season were used to estimate the prey density (Kumar et al., 2018). These yielded estimates of the density of principal prey species for each site. Observation of all the species was pooled for fitting global detection function. For species with sufficient detections, detection function was fitted at the species level. Chi square goodness of fit test was used to assess the fit of the model, and the best model from the subset of models was selected using lowest AIC value.

6 ! RESULTS

6.1 TIGER HABITAT OCCUPANCY

6.1.1 SAMPLING EFFORT AND TIGER SIGN DETECTION

The team surveyed 112 grid cells in TAL (Figure 4) with a sampling effort of 2,838 km with an area of 16,261 km². A total of 494 unique tiger signs were detected. Of these, 409 (83%) signs were recorded within 45 grid cells located inside the juristic boundary of PAs (Core area and Buffer zone) and 85 (17%) signs were recorded outside PAs in 67 grid cells. The majority of the detections outside PAs (41 tiger signs) were recorded in 25 grid cells located in corridors. Overall, tiger signs were recorded in 12 districts (Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Dang, Salyan, Banke, Bardia, Surkhet, Kailali and Kanchanpur) out of 18 districts surveyed.

6.1.2 TIGER HABITAT OCCUPANCY AND DETECTION PROBABILITY

The naïve tiger occupancy was 0.6 where tiger signs were detected in 68 out of 112 grid cells. The modelled occupancy (proportion of area occupied) in the landscape was 0.68 (SE 0.06) with an estimated detection probability of 0.73 (SE 0.03). Out of the total potential habitat of tigers (16,261 km²) in the landscape, an estimated 11,057.5 km² (SE 663.5 km²) was occupied by tigers as of 2018.

In addition, the modelled occupancy inside the PAs was 0.98 (SE 0.06) covering 6,828 km² and 0.60 (SE 0.11) 5,576 km² outside PAs. The detection probability inside PAs was 0.79 (SE 0.03) and outside PAs 0.37 (SE 0.08) respectively.

6.2 TIGER ABUNDANCE

6.2.1 SAMPLING EFFORT AND TIGER CAPTURES

A pair of cameras were deployed in 1,643 grid cells (2 km x 2 km) across five tiger bearing protected areas and their adjoining forests. Tigers were captured in 482 (29%) grid cells (Table 2). Total effective sampling area (ESA) was estimated at 12,356.64 km².

Camera trapping effort of 27,829 days across all sites resulted in tiger trap rate of 0.04 per trap day (4.2%) with 4,388 tiger images and 1,136 independent tiger detections. Individual tigers were identified using stripe

Table 2. Number of grid cells surveyed and number of grid cells with tiger captures in each site.

Site	Number of surveyed camera trap grid cells	Number of grid cells with tiger captures
PNP and adjoining forests	305	49 (16%)
CNP and adjoining forests	509	199 (39%)
BaNP and adjoining Forests	254	38 (15%)
BNP and adjoining Forests	323	149 (46%)
ShNP and adjoining forests	252	47 (19%)
Total	**1,643**	**482 (29%)**

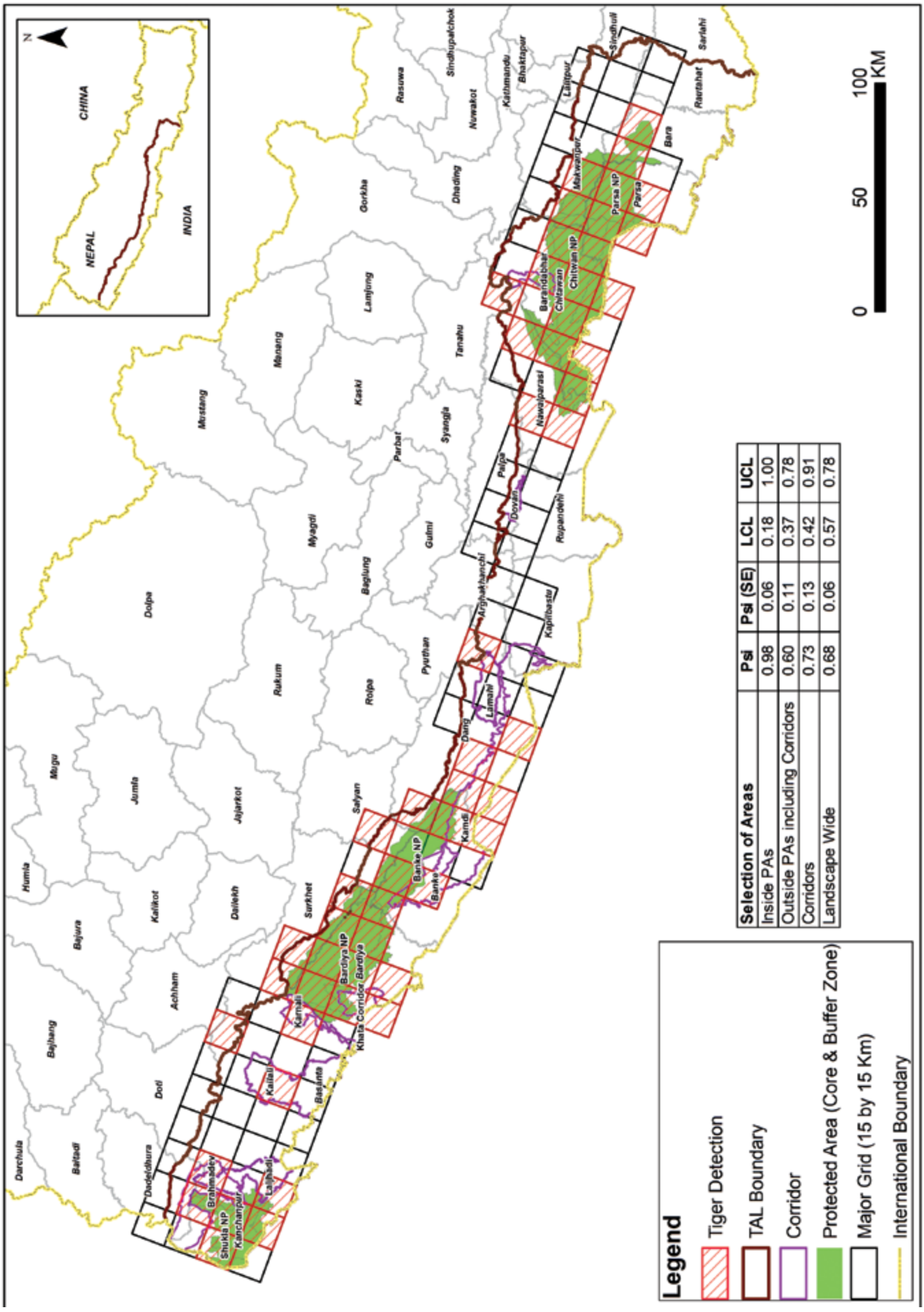

Figure 4. Tiger occupancy in TAL-Nepal, 2018.

patterns of all available "both flank" pictures and either "right or left flank pictures" for each of the study sites. Juveniles and cubs (N=28) captured were not included in the analysis (Table 3).

These resulted into 209 individual tigers (PNP and surrounding forests-15, CNP and surrounding forests-85, BaNP and surrounding forests-17, BNP and surrounding forests-77, ShNP and surrounding forests-15) (Table 3) including 78 males, 118 females and 13 of unknown sex. Site-wise breakdown of tiger numbers is provided in Table 3 with respective sampling efforts.

6.2.2 TIGER POPULATION ABUNDANCE ESTIMATES

The estimated abundance of tigers in PNP and adjoining forests is 18 (16-24), CNP and adjoining forests is 93 (89-102), BaNP and adjoining forests is 21 (18-30), BNP and adjoining forests is 87 (82-97) and ShNP and adjoining forests is 16 (15-21). The SECR-ML based tiger population estimate for each tiger bearing PAs and the adjoining forests is provided in Table 4. Summing up the site-wise estimates, the forests of TAL-Nepal support 235 tigers as of 2018. The details of the model used, and the real parameters are provided in Annex-1.

Table 3: Site wise sampling effort and the minimum tigers (Mt+1) identified

Site	Survey effort (trap days)	Effective sampling area (km^2)	Number of tiger photos	Number of independent detections	Number of individual tigers captured	Adults males	Adult females	Adult unknown sex	Cubs
PNP and adjoining forests	4,810	3,634.50	294	102	15	5	10	-	3
CNP and adjoining forests	8,433	2,281.10	1,744	480	85	30	50	5	12
BaNP and adjoining forests	4,503	2,311.70	565	61	17	6	10	1	0
BNP and adjoining forests	5,479	2,832.80	1,554	404	77	28	42	7	11
ShNP and adjoining forests	4,604	2,154.30	231	89	15	9	6	-	2
Total	**27,829**	**12,356.6**	**4,388**	**1,136**	**209**	**78**	**118**	**13**	**28**

Table 4. Estimated site tiger population estimates in Nepal, 2018.

Site	Mt+1	Model	Detection Function	R N	SE	95% confidence interval
PNP and adjoining forests	15	M (g0~bk sigma~bk)	HR	18	1.9	16 – 24
CNP and adjoining forests	85	M (g0~bk sigma~1, g0~bk sigma~T)	EX	93	3.14	89 – 102
BaNP and adjoining forests	17	M (g0~B sigma~1)	EX	21	2.63	18 – 30
BNP and adjoining forests	77	M (g0~bk sigma~1, g0~bk sigma~T)	EX	87	3.64	82 – 97
ShNP and adjoining forests	15	M (g0~h2 sigma~1 pmix~h2, g0~h2 sigma~T pmix~h2)	EX	16	1.16	15 – 21
TOTAL	**209**			**235**		

RN: Realized Number which refers to the number of tigers detected (N) plus a model-based estimate of tigers in the study area of interest that remain undetected, g0: detection probability, Sigma:space range, T: time trend, B:transient response, bk: animal x site learned response,and h2: two-class mixtures, HR: hazard rate, HN: half normal, EX: Negative exponential

The tiger population estimates generated using other programs have been provided in Annex-2 for better comparison with the earlier surveys.

6.3 TIGER DENSITY ESTIMATES

Data convergence was achieved for results of all the study sites accounting Geweke diagnostic score with other real parameters. The mean posterior density of tigers per 100 km² in PNP and adjoining forests was 0.92 (SD 0.15), CNP and adjoining forests was 3.28 (SD 0.19), BaNP and adjoining forests was 0.97 (SD 0.12), BNP and adjoining forests was 4.74 (SD 0.28) and ShNP and adjoining forests was 0.96 (SD 0.14) respectively.

The density estimates with 95% confidence intervals are provided in Table 5. The summaries of real parameters for each of the sites are provided in Annex-3

The pixelated tiger density map produced by combining site-wise pixel values generated by program SPACECAP is provided in Figure 5.

6.4 PREY DENSITY ESTIMATES

In total 1,294 transects were conducted covering 2,485 km. Tiger prey species recorded during the survey included four deer species (spotted deer, sambar, hog deer, barking deer), two antelope species (blue bull and four-horned antelope), wild boar, gaur, and two primate species (rhesus macaque and langur).

Combined density of prey (all prey per km²) varied between 8.1 and 77.51 animals per km² across the sites. The combined prey density per km² in PNP and adjoining forests is 22.03 (SE 3.8), CNP and adjoining forests is 70.7 (SE 7.49), BaNP and adjoining forests is 8.1 (SE 1.6), BNP and adjoining forests is 77.51 (SE 6.56) and ShNP and adjoining forests is 68.04 (SE 6.95) respectively.

The site-wise sampling effort, number of observations and prey density estimates are provided in Table 6 and species-wise details and species-wise prey density estimates are provided in Annex-7.

Table 5: Tiger density estimates for the tiger-bearing protected areas including buffer zones, adjoining forests and corridors.

Site	Mean	SD	95% CI
PNP and adjoining forests	0.92	0.15	0.64-1.20
CNP and adjoining forests	3.28	0.19	2.92-3.63
BaNP and adjoining forests	0.97	0.12	0.75-1.18
BNP and adjoining forests	4.74	0.28	4.20-5.28
ShNP and adjoining forests	0.96	0.14	0.72-1.21

SD: Standard Deviation.

Table 6.Overall prey density estimates in tiger bearing protected areas and adjoining forests.

Site	Effort (km)	Number of transects	No. of obs.	Density (per km2)	SE	CV (%)	95% CI
PNP and adjoining forests	482	248	194	22.02	3.8	17.48	15.66 - 30.96
CNP and adjoining forests	331.6	175	367	70.7	7.49	10.59	57.49 - 87.05
BaNP and adjoining forests	647	304	99	8.1	1.6	20.25	5.46 - 12.01
BNP and adjoining forests	745	414	776	77.51*	6.56	8.47	65.66 - 91.49
ShNP and adjoining forests	279	153	412	68.04*	6.95	10.22	55.70 - 83.10
Total	**2,484.6**	**1,294**	**1,848**				

** denotes density estimates of all prey excluding swamp deer that was not detected during the line transect survey in both Bardia National Park and Shuklaphanta National Park. SE: Standard Error of Mean, CI: Confidence Interval, CV: Coefficient of Variation (SD/Mean)*

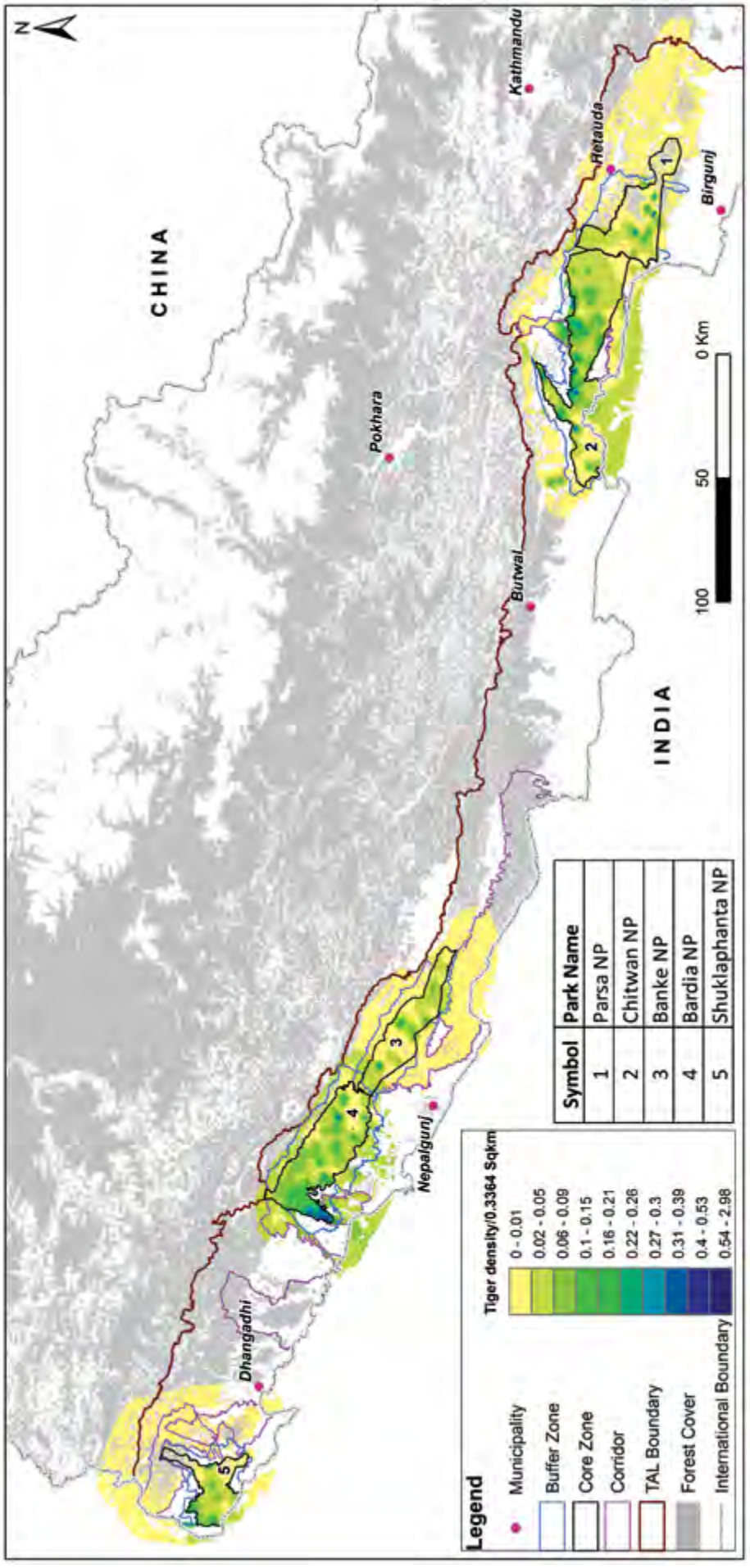

Figure 5. Tiger density within the Terai Arc Landscape, Nepal. The density map is composed of pixels (0.336 km^2) representing potential activity centers of individual tigers.

6.5 HABITAT USE OF TIGERS OUTSIDE PAs

In addition to the core tiger-bearing protected areas, the known tiger distribution range (buffer zones, corridors and adjoining forests) within TAL were sampled using camera traps. Therefore, in the site-specific, spatially explicit capture-recapture estimates of PAs and adjoining forests, the tigers with activity centers outside PAs have been included in the analysis. Altogether, twenty-two tigers were recorded outside PAs. However, only nine tigers were exclusively captured outside PAs (Table 7). Of these, adult female captured in the district forest of Nawalparasi was photographed with three healthy cubs. The rest of the fifteen tigers captured in district forests had their home range extended to core and buffer zones (Table 7). Habitat use of tigers therefore was observed to be minimal outside the juristic boundary of protected areas during the study period (see maps in Annex-8).

In central Terai, a male and female tiger were recorded in the collaborative forests in Parsa, three tigers (1 female, 2 unknown) were observed in Someshwor hill forest (CNP BZ), four tigers (2 male,2 female) were captured from Barandabhar corridor (CNP BZ) and two female tigers were captured in the forests of Nawalparasi close to Binayee and Madhyabindu.

In western Terai, one tiger with a large spatial range extending across BNP and BaNP was also observed in Dang forest near Lauki guard post (Table 7; Annex-8: Figure 8). Altogether, thirteen and three tigers were captured in Khata and Karnali river corridor respectively. Among the thirteen tigers captured in Khata corridor, four were captured exclusively and nine tigers (6 male, 3 female) had their home ranges extended within the habitats in BNP and BNP BZ (Table 7; Annex-8: Figure 9).

In far-west Terai, only one male tiger was recorded from outside ShNP in Laljhadi corridor. This male was recorded from forests that spanned north-eastern part of ShNP and fragmented forest patches in Laljhadi corridor.

Table 7.Number of tigers captured within and outside the juristic boundary of protected areas and exclusively outside protected areas.

S. N	Site	Male	Female	Unknown sex	Total
1	Parsa collaborative forest* and PNP	1	1	-	2
2	Nawalparasi (exclusively)	0	2	-	2
3	Dang forest, BNP and BaNP	1	-	-	1
4	Karnali river corridor (exclusively)	-	-	3	3
5	Khata corridor (exclusively)	-	2	2	4
6	Khata, BNP BZ and BNP	6	3	-	9
7	ShNP core and Laljhadi corridor	1	-	-	1
Total		**9**	**8**	**5**	**22**

**Collaborative forest: A forest jointly managed by national government, local government and local communities*

7 ! DISCUSSION

7.1. TIGER DISTRIBUTION, HABITAT USAGE AND OCCUPANCY

Altogether 494 unique tiger signs were recorded by habitat occupancy survey carried out across TAL. Maximum signs (83%) were recorded within PAs and 17% of tiger signs were detected outside PAs in TAL. Similarly, tigers were captured in 482 out of 1,643 grid cells which is only 29% of the total area surveyed. Combining both tiger signs and tiger captured locations in camera traps, tigers were recorded in 12 districts. However, majority (96%) of the photo-captured tigers (N=200) were mostly confined within protected areas and 9 tigers (4%) were captured in forests outside the protected areas in TAL. Thirteen individual tigers that used core and buffer zones also had their territorial range extended to forests outside PAs. Twenty-four tigers were captured from five biological corridors viz: Laljhadi (1), Khata (13), Karnali (3), Barandabhar (4) and Someshwor hill forest (3). Only few tiger signs were recorded from Kamdi and Basanta corridors.

Modelled tiger occupancy in the landscape is showing an increasing trend. Between 2009-2013, there was a 47% (λ=1.47) increase in occupancy. Similarly, between 2013-2018 there was a 12% (λ=1.12) increase in occupancy across the landscape. The likely reason for the increase in occupancy can be attributed to the increasing tiger population that are expanding, establishing their territories in areas previously unoccupied [colonization probability, γ- 0.45 (SE 0.06)] and ongoing restoration efforts.

In totality, tigers occupied 11,057 km^2 (68%) of the available habitat (16,261 km^2) in the landscape. Within PAs tigers occupied 6,828 km^2 (98%) of the available habitat (6,968 km^2). However, tigers occupied only 5,576 km^2 (60%) of the available habitat 9,293 km^2 outside the PAs. The large tracts of forest exist outside the protected areas in TAL, but majority of these forest patches face high anthropogenic pressure. The ground forest cover is literally non-existent with high cattle grazing, and prey-base is extremely low to support resident tigers. Unlike PAs, these forested habitats have minimal protection, and therefore face risk of becoming a sink for tigers. Thus, the existing limited use of forests by tigers outside PAs can be enhanced through protection and other management interventions similar to PAs. To make habitat outside PAs more conducive for tigers and to facilitate their safe dispersal, measures should be focused towards improving habitat quality, increasing prey population and minimizing human disturbances at the level that comply with tolerance level of tigers. Replicating success of community forestry as seen in Khata corridor could provide a potential solution that benefits both tigers and people.

KEY FINDINGS:

About 68% of the total potential habitat was occupied by tigers across TAL, covering 11,057 km^2.

Camera trap survey identified a minimum of 209 individual tigers.

PA wise tiger population was estimated at PNP-18, CNP-93, BaNP-21, BNP-87 & ShNP-16. This summed up to 235 tigers in Nepal. 88% of the estimated tiger population were photo-captured (Mt+1) in the survey.

Nine tigers were found exclusively in areas outside juristic boundary of PAs with 13 tigers using forested habitats both within and outside PAs.

Tiger density/100 km^2 ranged from lowest 0.9 in BaNP to highest 4.7 in BNP.

Prey density/km^2 ranged from lowest 8.1 in BaNP to highest 77.5 in BNP.

7.2 TIGER ABUNDANCE AND DENSITY

7.2.1 METHODS USED, AND THE EXTENT OF AREAS COVERED

SECR-ML and SECR-B are commonly used techniques in deriving population and density estimates (Gopalaswamy et al. 2012; Royle et al. 2009; Elliot and Gopalaswamy 2016). In the present survey, tiger population estimates were derived using SECR ML while density estimates were derived using SECR-B. In 2013, both population and density estimates were derived using SECR-B without considering the overlaps between the contiguous protected areas in Nepal and India (e.g. CNP, PNP and

Valmiki Tiger Reserve (VTR)). This could have likely overestimated the population abundance in the PAs that shared contiguous habitats. The results of the present survey derived by both SECR-ML and SECR-B have addressed the overlap issues and the estimates derived are similar with 95% CI overlaps (Table 8). In estimating PA wise abundance coefficient of variation (CV %, Table 8) is relatively lower for SECR-ML (av. CV: 7.5%) as compared to SECR-B (av. CV: 11%). Therefore, PA abundance estimate (∑ 235 tigers) have been reported using SECR-ML. Similarly, as program CAPTURE and Mark were used in 2009 and 2013 surveys, the results obtained from these programs have also been reported for readers knowledge. For density estimates, the results from both SECR-ML and SECR-B have been reported (Annex-6).

The 2018 survey extensively covered potential tiger habitat of TAL, Nepal. The sampling effort in this survey was maximized by covering most of the known records of tiger distribution based on findings of annual tiger surveys since 2013 and thus, the extent of the area covered by camera traps increased from 1,039 grid cells in 2013 survey to 1,643 grid cells in 2018 (58%). Tiger captures were recorded in 29% (482) of the 1,643 grids. However, the 604 new grids added in 2018 accounted for only six tigers indicating minimal impact on the overall status change.

7.2.2 TREND IN MINIMUM POPULATION BASED ON INDIVIDUAL TIGER CAPTURES

This study reports a minimum population of 209 individual adult tigers; 78 males, 118 females and 13 unknow sex, from across the study sites (PNP and adjoining forests-15, CNP and adjoining forests-85, BaNP and adjoining forests-17, BNP and adjoining forests-77 and ShNP and adjoining forests-15) compared to 142 individuals (40 males, 102 females)

In PNP, BaNP and BNP where annual/bi-annual tiger monitoring was conducted, minimum population of tigers has increased against 2013 baseline. However, since 2013, Mt+1 has remained stable in ShNP largely because of the male biased sex ratio (2018 survey-1.5:1), that could be other reason impeding the growth in tiger population.

In PNP, the highest number of individual tigers captured was 19 in 2016. This has dropped down to 15 individuals in the 2018 survey. Among the tigers not captured in PNP during the 2018 survey, two were earlier captured in Someshwor hill corridor forest (a transboundary corridor linking CNP, PNP and VTR of India), indicating that these could be transients. It is only through regular/ annual surveys that the fate of individual tigers lost through natural death or dispersal and also recruitment from births or immigration is understood, which can provide a rigorous audit for the successes or failures in tiger conservation programs. Hence annual surveys are recommended to provide insights in tiger population dynamics.

7.2.3. TIGER ABUNDANCE ESTIMATES

Status of tigers in Nepal is estimated at 235 individuals in 2018 which is simply a summation of PAs and their adjoining forests-wise estimation without estimated variance. In 2013, a total of 198 tigers were estimated in Nepal (Dhakal et al., 2014). A naïve comparison indicates an increase of approximately 19% within the four-year period. There has been notable increase in BNP, BaNP and

Table 8. Comparison of Population Estimates using SECR-ML and SECR-B

Site		SECR-ML				SECR-B			
	Mt+1	Population Estimate	SE	95% CI	CV (in %)	Population Estimate	SE	95% CI	CV (in %)
PNP and adjoining forests	15	18	1.9	16-24	10.6	17	2.8	12-22	16.5
CNP and adjoining forests	85	93	3.1	89-102	3.3	82	4.6	73-90	5.6
BaNP and adjoining forests	17	21	2.6	18-30	12.4	19	2.3	16-25	12.1
BNP and adjoining forests	77	87	3.6	82-97	4.1	89	5.2	78-99	5.8
ShNP and adjoining forests	15	16	1.16	15-21	7.3	16	2.3	12-20	14.4
Total		**235**				**223**			

CV: Coefficient of Variation, Mt+1: Minimum individual identified, SE: Standard error of Mean, SECR: Spatially Explicit Capture Recapture, ML: Maximum Likelihood, B: Bayesian

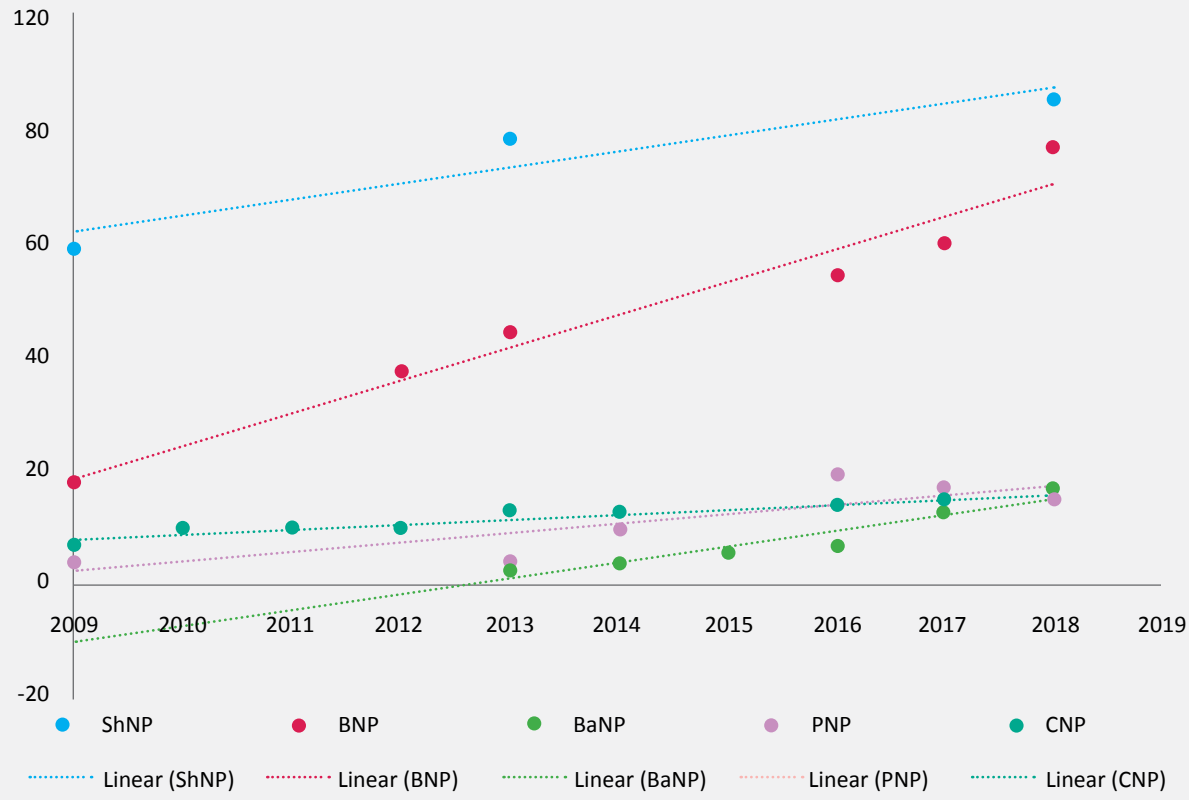

Figure 6. Trend in tiger population (2009-2018) based on Mt+1

PNP (including adjoining forests) whereas the population has remained stable in ShNP and adjoining forests and declined in CNP and adjoining forests. Further, unlike the other protected areas, CNP lacks annual monitoring data to confirm the actual trend in population estimates.

In BaNP and adjoining forests, tiger population has increased by more than five-fold i.e. from 4 (3-7) tigers in 2013 to 21 (18-30) tigers in 2018 (P =0.001). In Bardia, tiger population almost doubled from 50 (45-55) in 2013 to 87 (82-97) in 2018 (P=0.002) Likewise, PNP and adjoining forests, the tiger population significantly increased from 7 (4-7) in 2013 to 18 (16-24) tigers in 2018 (P=0.03). In contrast, the estimated population of CNP has marginally declined from 120 (98-139) in 2013 to 93 (89-102) tigers in 2018 (P = 0.06). The population has remained stable in ShNP and adjoining forest with 17 (13-21) estimated tigers in 2013 to 16 (15-21) tigers in 2018 (P =0.86).

7.2.4. TIGER DENSITY

Tiger density (no. of tigers per 100 km²) ranged from 0.9 in BaNP (lowest) to 4.7 in BNP (highest). Tiger density estimates for 2018 was lower compared to 2013. This was because the additional habitats (~2400 km²) sampled in 2018 supported only a few tigers (n=6). Tigers were mostly confined within the boundaries of protected areas and associated buffer zones. Therefore, to determine the true change in density from 2013 to 2018, density estimates were generated for the effective sampled area of 2013 for better comparison

Detailed outputs from SECR-B analysis for 2013 and 2018 are provided Annex-4. The pixelated tiger density maps for 2013 and 2018 produced by combining site-wise pixel values generated by program SPACECAP are provided in Annex-5.

Site-level tiger densities (individuals per 100 km²) from 2013 to 2018 increased from 0.65 (SD 0.28) to 1.49 (SD 0.23) in PNP (P =0.088), 0.16 (SD 0.05) to 1.38 (SD 0.17) in BaNP (P =0.002) and 3.38 (SD 0.19) to 5.4 (SD 0.29) in BNP (P =0.03). The tiger density estimates for CNP has marginally declined from 3.84 (SD 0.34) to 3.81 (SD 0.25) (P=0.97) whereas it has remained stable in ShNP at 3.4 (SD 0.65) (P=0.92).

7.2.5. FACTORS GOVERNING TIGER POPULATION ABUNDANCE AND DENSITY

The conservation of tigers is dependent on appropriate protection measures, prey densities, habitat connectivity, habitat management of the critical habitats, park-people relationship and human-tiger interaction across TAL,

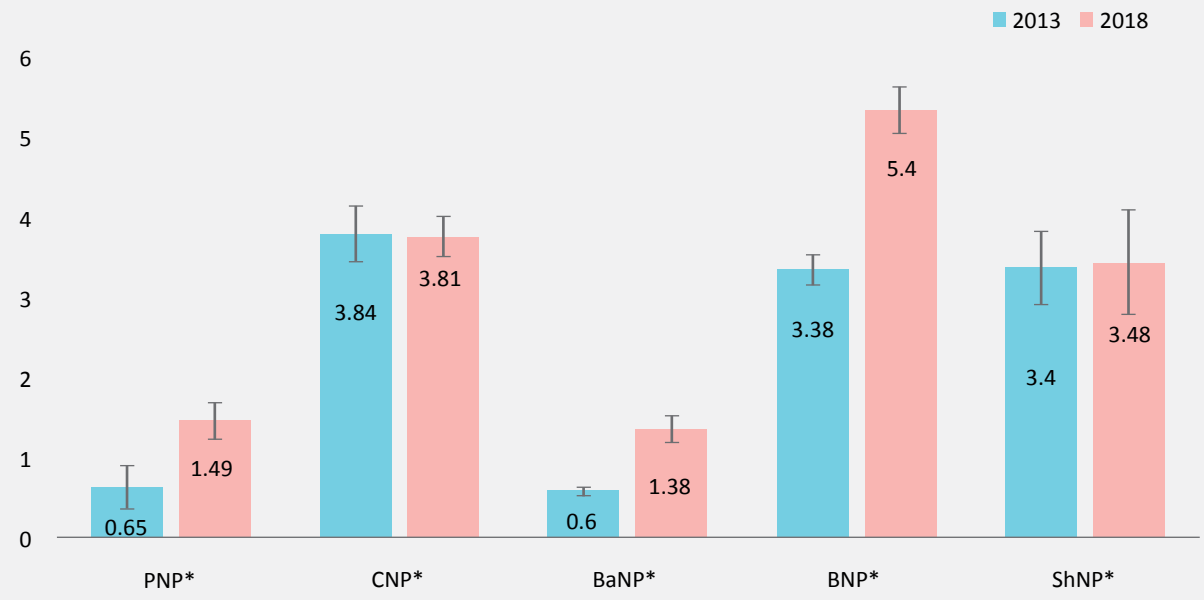

Figure 7. Site-level tiger density estimates with respective standard error bars for 2013 and 2018.

*** denotes respective PAs and adjoining forests.**

Nepal. These are discussed in detailed below.

The significant increase in tiger population abundance in BNP and its adjoining forests can be attributed to enhanced protection measures, increased support from communities in buffer zone and corridors and regular practice of habitat management by park authorities. The park has been equipped with 10 additional protection posts strategically placed at Lamidamar, Kalinara, Ratamate, Lekhparajul, Taranga, Thuloshree, Sotkhola, Banspani, Telpani and Okhariya in the last four years. Patrol coverage throughout the PA and buffer zone has been achieved through the implementation of real-time SMART covering 31 protection/army posts. BNP also benefits from the adjoining Khata corridor that provides direct habitat linkage to Katerniaghat Wildlife Sanctuary (KWS) in India through regular transboundary movement of animals ensuring genetic exchange between the two populations (Chanchani et al.,2014; Thapa et al., 2018).

BNP is also acting as a source site for BaNP; three tigers (2 male, 1 female) born and raised in BNP have overlapped territories with BaNP. Thus, the increase population in BaNP is partially contributed by the dispersal of tigers from adjoining BNP. There has also been improvement in park management and protection over the last four years. Since 2013, total of 15 park posts were constructed along the northern border and in strategic sites in the south. In 2013, real-time SMART was implemented starting with two park posts and extended to fourteen posts to date. Habitat improvement has also been undertaken including restoring and creating water holes (n=17) and managing grasslands (147 hectares). Signs of tiger breeding have been recorded from as early as 2014 and the cubs born in 2014, 2015 and 2016 have survived to adulthood. Therefore, a detailed study to understand the meta-population dynamics of tigers is suggested as future priorities for managing the tigers in Banke-Bardia complex.

In PNP, study by Lamichhane et al. (2017) reported a total of 25 individuals from the annual surveys carried out from 2013 to 2016. Of these, 10 tigers were earlier reported in CNP thus PNP has benefitted through tiger dispersal from the adjoining CNP. The tiger recovery can also be credited to voluntary relocation of villages from the park; these areas now support higher numbers of ungulates and breeding tigers. In 2015, the core area of PNP was extended by 128 km^2 to 627 km^2. Park protection and management have been enhanced through construction of park posts in strategic locations at northern part of the park including Annexed area and increased number of Nepali Army personnel in the park.

Chitwan-Valmiki-Parsa complex holds a significant population of tigers within the eastern part of Terai Arc Landscape. CNP acts as source population replenishing tigers to the adjoining and contiguous protected areas of PNP in the east and VTR in the south. Recent survey has showed a decline in tiger population in CNP and adjoining forests. This could be attributed to 1) dispersal of tigers to neighboring sites (PNP and VTR), 2) increased intraspecific competition, 3) human-wildlife conflicts (two were reported killed in retaliation), 4) poaching (one case), and 5) natural disasters such as the catastrophic flood of 2017.

The loss of eight tigers due to territorial fights between 2014-2018 suggests space could be a limiting factor within CNP. Two tigers were killed in retaliation suggesting further interventions are needed in garnering community support. One recorded case of poaching also captures the prevailing threat of poaching in the park. In addition, massive flood in August 2017 swept away unaccounted numbers of wildlife in CNP. Park authorities rescued a total of 10 rhinos from downstream riverine habitat in India. Furthermore, the flood could have affected significant number of prey species consequently affecting the tiger's space use. However, a detailed study (including carrying capacity) is needed to understand the tiger population in CNP.

Tiger populations in PNP and VTR have increased substantially in recent years. The turnover rate (defined as loss and gain) of tigers in CNP based on camera trap data was found to be almost 70% in the last 4 years with only 19 tigers recorded in 2013. Of the 31 individual tigers captured in PNP between 2013-2018, 10 were earlier captured in Chitwan and the rest 12 documented were not born and raised in PNP suggesting high dispersal from CNP. In VTR, tiger population has increased from 10 individuals in 2008 to 31 individuals in 2016/17 (Source: WWF India).

The major reason for the stagnant population of ShNP is the male biased sex-ratio (1.5:1). The females are known to give births occasionally but the survival of cubs to adulthood has been a major factor. Two cubs died because of possible infanticide in 2017 and one sub-adult tiger was killed by the dominant male in territorial fight (ShNP, 2018). Furthermore, southern section of national park, along Lagga Bagga, offers an opportunity to tigers to disperse into India. Security of dispersing tigers and/or resident tigers along the transboundary protected areas requires special attention.

7.3. PREY DENSITY

Prey density estimates marginally declined across the survey sites as compared to 2013. The prey densities per km^2 decreased from 25.33 to 22.02 (SE 3.8) in PNP (P=0.6), 73.63 to 70.7 (SE 7.49) in CNP (P=0.8), 10.27 to 8.1 (SE 1.6) in BaNP (P=0.6), 92.6 to 77.51 (SE 6.56) in BNP (P=0.3) and 78.62 to 68.04 (SE 3.8) in ShNP (P=0.12) with no significant difference (Dhakal et al., 2014).

The lower density estimates from the present survey could be the results of difference in the study time frame. Field survey for this study was conducted in mid-winter (Jan-Feb) when it was mostly misty until late morning, leading to poor visibility. The 2013 survey was conducted in March-April when the weather was clear and the grass much shorter (Dhakal et al., 2014). On another note, existing method of line transect survey was heavily concentrated in Terai, thus the species like sambar (*Rusa unicolor*), four-horned antelope (*Tetraceros quadricornis*), ghoral (*Naemorhedus goral*) and Himalayan tahr (*Hemitragus jemlahicus*) that are well adapted to undulating Churias were not accounted for.

Other possible reason for decline in prey density could be the catastrophic flood in Chitwan in 2017 and Bardia in 2015. In one event alone, 28 hog deer carcasses were found from a single site, after being washed away by the swelling Narayani and similar cases were reported in Babai valley of Bardia in 2015.

Moreover, swamp deer which occurs in high density in ShNP has not been accounted as they were not sighted in the transect survey. This could have contributed to lower density estimates in ShNP. Recently, prime wetlands (Rani taal, Salgaudi taal and Kalikich taal) have deteriorated in the core area of ShNP primarily due to siltation, while grasslands have been encroached by woody perennials along Chaudhar river. This may also have contributed in the decline of prey base when compared to 2013 study.

Prey density in BaNP and PNP is notably lower than other three tiger bearing PAs (CNP, BNP and ShNP) in Nepal. Larger parts of BaNP and PNP are covered by Churia forests, while the remaining lowland area is dominated by homogenous Sal forests that have lower potential to support high prey density. CNP, BNP and ShNP have extensive riparian forests and tall floodplain grasslands regulated by annual floods where ungulates can reach their highest densities. BaNP and PNP are also extremely dry due to the physical characteristics of Bhabar region and therefore water may be another limiting factor for prey species.

Sightings of prey outside PAs were negligible owing to large scale disturbances. Hence, prey recovery in the surrounding forests of PAs with focus on regulating and reducing disturbances should be emphasized in the management plan.

Based on documented records, the issue of prey poaching across the sites outside PAs cannot be overlooked either, and therefore, it demands a timely investment to elevate protection measures in all such vulnerable sites. Undoubtedly, low prey density will have an impact on tiger populations as tiger densities are mediated mainly by prey abundance (Karanth et al., 2004).

In addition, roads and highways bisect several forests in TAL (tiger bearing PAs and critical corridors) causing fatalities of predators and prey. On average, 26 road kills in BNP and 55 road kills in BaNP occur per year, comprising 70-80% of prey species (chital, wild

boar, sambar, barking deer and langur). The proposed expansion of existing highways to four-lane and the construction of Hulaki road that will pass through hundreds of kilometers along the Terai forests could further worsen this situation by severing connectivity in the fragile corridors. Usage of underpasses by wildlife has been documented in Barandabhar corridor; placement of crossing overs (under or over passes) along vulnerable sections could mitigate some losses.

8 ! MANAGEMENT IMPLICATIONS AND THE ROAD MAP TOWARDS TX2

Nepal has come a long way in its journey of doubling the tiger numbers by 2022. This has been possible through sustained political commitment from the Government of Nepal and consistent efforts made by the conservation stakeholders at all levels. While celebrating this success, it is necessary to note that the present results are an outcome of recovery programs investing significant resources. Therefore, though the TX2 goal may be just a step ahead, efforts must not be reduced. The next four years will remain equally challenging in the present context with insights provided by the 2018 results. Main challenges include managing human-wildlife conflicts in CNP and potentially in BNP due to high tiger densities, addressing skewed sex ratio of tigers in ShNP and low prey base in BaNP, PNP and forested habitats outside PAs. Management recommendations are therefore, made both at national and site levels. These include policy initiatives, key habitat protection and management interventions, tiger and prey protection, creating safe environment for people and wildlife and identifying areas for further research and monitoring. Specific recommended actions are provided below.

8.1. ADDRESSING SECURITY ISSUES

Poaching continues to be a threat to tigers in Nepal. Genetics studies of seized tiger parts in Nepal have traced their origins to ShNP, BNP and CNP. Detailed security assessment may be required on the ground and appropriate protection measures should be in place in the vulnerable sites. ShNP could benefit from additional anti-poaching measures such as construction of guard posts, particularly along the southern parts, to facilitate real time SMART adaptive patrolling.

With improved protection inside PAs, non-protected forests beyond PA boundaries are becoming sinks for tigers. For protection of tigers outside PAs, district forest officials/staff should be capacitated and equipped on anti-poaching measures. Local communities need to be further capacitated through institutionalization of CBAPUs, Coordination with Wildlife Crime Control Bureau (WCCB) cells, particularly in districts surrounding tiger-bearing PAs, is crucial in curbing illegal wildlife trade. Improved coordination, joint patrolling and information sharing between border security force-Seema Suraksha Bal (SSB) in India and, Armed Police Force and Nepali Army in Nepal will additionally help control illegal wildlife trade.

8.2. ADDRESSING LOW PREY DENSITY WITHIN PAs

Within PAs, there are extensive areas where the existing tiger density is relatively low. Management is recommended to emphasize recovery of both tiger and prey population based on site-specific tiger density results presented in pixelated site-wise maps (Refer to Annex-5). Recommended management measures in these areas include scientific management of grasslands to maintain grazing lawns for ungulates, removal of invasive alien plant species (IAPs), ensuring year-round water availability by creating/restoring wetlands and intensifying patrol efforts and monitoring changes of prey recovery over time. Immediate intervention is required to address siltation and invasive plant issues in wetlands situated within core areas. Majority of wetlands in ShNP are drying up, reducing productivity.

8.3. ADDRESSING LIMITED HABITAT USAGE OF TIGERS AND PREY IN FORESTS OUTSIDE PAs (NATIONAL FORESTS, PROTECTION FORESTS AND OTHER IDENTIFIED BIOLOGICAL CORRIDORS)

A combination of efforts will be required to address the limited habitat use by tigers and prey in forests outside PAs (National Forests, Protection Forests and identified biological corridors). Engagement with local communities should be scaled up to reduce their dependence on forests. Legal protection to biological corridors and the remaining forests outside PAs in TAL should be implemented where feasible, to prevent encroachment and fragmentation.

Improving these habitats will help reduce anthropogenic pressures, prevent further fragmentation and thus improve prey densities and provide dispersal grounds for tigers. This will be crucial to help sustain metapopulation of tigers in TAL. Initiating long-term forest monitoring program to track land use land cover changes will help evaluate changes and inform management and policy makers.

8.4 ADDRESSING THE IMPACT OF LINEAR INFRASTRUCTURES

The number and extent of infrastructure is likely to increase within TAL, Nepal, further fragmenting and severing the already fragile forested habitats. Efforts need to continue to ensure the right balance between conservation and development through i) engagement with policy makers to ensure that inviolate zones (critical tiger habitats) are avoided; ii) engagement with developmental agencies to promote smart green infrastructures (SGIs), and integration of effective mitigation measures in the infrastructural planning process; and iii) developing appropriate mitigative measures in existing linear infrastructures (for example- automated barriers to maintain speed limits, digital tracking of passing vehicles, construction of over/ underpasses or guiding fence in vulnerable sites to provide safe passage for wildlife).

8.5 ENHANCING TRANSBOUNDARY CO-OPERATION

Nepal shares approximately 800 km stretches of open border with India, presenting opportunities for the two countries to collaborate closely in conservation. The joint tiger monitoring exercise carried out by the two countries in 2013 identified at least 10 tigers sharing the habitat across borders, highlighting the need to manage tigers as a transboundary metapopulation. However, the porous border between two countries adds challenges to the conservation of these endangered wildlife. Transboundary cooperation needs to be strengthened through intelligence sharing, joint patrols, standardized wildlife monitoring programs and data sharing, restoration and management of the transboundary corridors, addressing the threats posed by infrastructure and knowledge sharing.

8.6 CREATING SAFE ENVIRONMENT FOR PEOPLE AND WILDLIFE

At the national level, tigers contribute only around 2.78% of the total human-wildlife conflict compared to 67.52%, 12.85% and 10.65% caused by elephant, rhino and common leopard respectively (DNPWC, 2018). To manage conflicts, it is pertinent to understand the overall conflict dynamics and consequently create safe environment for both people and wildlife. The survival of these species will depend upon tolerance level of the local communities which is determined by how well the overall conflict is managed, as well as ownership by the communities.

Wildlife Damage Relief Guidelines (2069 BS, third amendment 2075) provisioned for providing the monetary relief to victims of conflicts needs to be implemented. Simplification of the claiming procedures for quick relief and enhancing transparency and efficiency at all levels is recommended.

Focus must be made on understanding conflicts (both social and ecological dimensions), and on monitoring, responding and preventing conflicts, as compensation measures in the long run will become a financial liability to the government. Promoting private insurance schemes (human, livestock, property and the crops) would help reduce the perpetual dependence on the government. Likewise, the government's Rapid Response Team (RRT) in Chitwan and Bardia NPs need to be strengthened and scaled up to additional sites to provide pro-active response to conflict cases. Rehabilitation of individual animals rescued from conflicts should be carefully done and supported by long-term monitoring.

8.7 STRENGTHENING ANNUAL TIGER, PREY AND HABITAT MONITORING PROGRAMS

Data on survivorship, reproduction and social structure in tiger populations is possible only through standardized long-term monitoring programs. Annual monitoring would help keep pulse on core populations. The management is recommended to establish long-term monitoring programs in the respective PAs to keep constant surveillance of the tiger population - increase (through new births or immigration) and losses (due to natural death, poaching or emigration). For Banke-Bardia and Chitwan-Parsa which serve as ecological units, it is recommended to derive complex wise estimates for tiger population for greater ecological insights and to address the issues of area overlap.

Similarly, prey monitoring is recommended during the time of the year when the visibility is optimal in stratified sampling blocks as per the habitat types for robust estimates. This is also recommended in areas that are subject to annual habitat management for monitoring the impact of habitat interventions.

Increasing habitat potential of the existing habitats by increasing forage productivity would have direct relevance to increasing and sustaining growing tiger population. Therefore, research and monitoring programs such as estimating ecological carrying capacity for the preparation of site specific management plans and its implementation to provide scientific guidance for habitat management in PAs and forests outside PAs.

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10 ! ANNEXURE

Annex- 1. Summary of Spatially Explicit Capture Recapture (SECR) models for population estimation at site level. Only the top models are presented.

PROTECTED AREA	MODEL	DETECTFN	PAR	LOGLIK	AIC	△AICc	AICc	AICcWT	g0	sigma
PNP	g0~bk sigma~bk z~1	hazard rate	5	-542.763	1095.526	1102.193	0	0.8517	0.02	3882.7
PNP	g0~bk sigma~1 z~1	hazard rate	4	-546.845	1101.689	1105.689	3.496	0.1483		
CNP	g0~bk sigma~1	Exponential	3	-2565.33	5136.651	5136.947	0	1	0.03	2611
CNP	g0~B sigma~1	Exponential	3	-2647.35	5300.708	5301.004	164.057	0		
BaNP	g0~B sigma~1	Exponential	3	-371.107	748.214	750.06	0	0.7197	0.03	2134.6
BaNP	g0~B sigma~T	Exponential	4	-370.999	749.999	753.332	3.272	0.1402		
BaNP	g0~T sigma~1	Exponential	3	-377.033	760.066	761.912	11.852	0		
BNP	g0~bk sigma~1	Exponential	3	-2021.99	4049.987	4050.316	0	0.5544	0.04	2010.9
BNP	g0~bk sigma~T	Exponential	4	-2021.1	4050.197	4050.753	0.437	0.4456		
BNP	g0~B sigma~1	Exponential	3	-2091.47	4188.934	4189.262	138.946	0		
ShNP	g0~h2 sigma~1 pmix~h2	Exponential	4	-512.691	1033.382	1037.382	0	0.7114	0.03	2369.2
ShNP	g0~h2 sigma~T pmix~h2	Exponential	5	-511.26	1032.52	1039.186	1.804	0.2886		

g0: detection probability, Sigma:space range, T: time trend, B:transient response, bk: animal x site learned response, and h2: two-class mixtures

Annex- 2. Population abundance estimates with standard errors and 95% confidence intervals and detection probability estimates using program Capture and Mark

Protected Area	CAPTURE Program						MARK Program					
	Number	CI (lower)	CI (higher)	SE	P-hat	Selection criteria (value)	Number	SE	CI (lower)	CI (higher)	P-hat	Model
Parsa NP	17	16	25	2.02	0.2	M(h) = 0.99	16	1.8	13	20	0.4	MoRE+Mh2+MBRE
Chitwan NP	92	87	122	7.2	0.2	M(h) = 0.95	89	2.5	84	94	0.3	Mt+MtRE+Mth2
Banke NP	18	18	25	2.4	0.2	M(h) = 1.0	18	1.2	16	20	0.2	Mo+Mb
Bardia NP	81	77	118	5.57	0.14	M(tb) = 1.0	79	2.6	74	84	0.2	MtRE+Mt+Mth2
Shukla NP	15	15	15	3.9	0.27	M(h) = 1.0	16	0.8	15	20	0.4	Mh2
Total	**223**	**213**	**305**				**218**		**202**	**238**		

Annex- 3. Bayesian spatially explicit capture-recapture (SECR) analysis summary outputs from program SPACECAP. Density is presented as per 100 km^2.

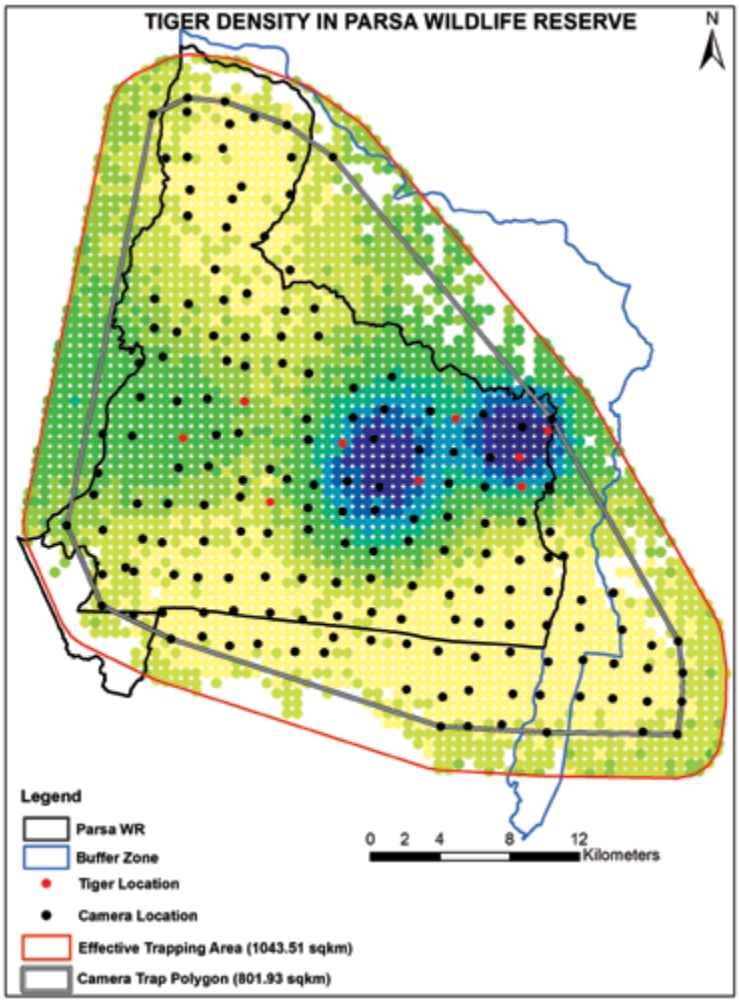
SITES	MODEL	PARAMETER	POSTERIOR_ MEAN	POSTERIORSD	95%_LOWER_HPD LEVEL	95%_UPPER_HPD_ LEVEL	BAYESIAN P VALUE	GEWEKE DIAGNOSTIC SCORE
PNP	Half normal	Sigma	2670.9	161.8	2381.4	2982.9	0.99	-0.2492
		lam0	0.049	0.007	0.034	0.063		0.3931
		Psi	0.269	0.061	0.156	0.391		0.4644
		N	23.707	3.712	16	30		0.3822
		P	0.047	0.007	0.033	0.061		
		D	0.92	0.15	0.64	1.2		
CNP	Half normal	Sigma	3554.5	102	3376.5	3782.6	1	-0.1086
		lam0	0.021	0.001	0.018	0.024		0.2122
		Psi	0.229	0.022	0.185	0.272		0.8617
		N	119.127	6.783	105	131		0.6023
		P	0.033	0.002	0.029	0.036		
		D	3.28	0.19	2.92	3.63		
BaNP	Half normal	Sigma	4612.1	487.9	3706.4	5585.4	0.54	0.9231
		lam0	0.015	0.003	0.009	0.021		-1.1754

		Psi	0.204	0.046	0.121	0.296		1.2175
		N	21.297	2.638	17	26		0.9745
		P	0.014	0.003	0.009	0.021		
		D	0.97	0.12	0.75	1.18		
BNP	Half normal	Sigma	3495.4	122.9	3270.7	3751.9	0.98	1.2984
		lam0	0.024	0.002	0.02	0.027		-0.7936
		Psi	0.211	0.022	0.168	0.255		-0.4294
		N	95.672	5.189	85	105		-0.8301
		P	0.023	0.002	0.02	0.027		
		D	4.74	0.28	4.20	5.28		
ShNP	Half normal	Sigma	3025.8	236.9	2608.1	3519.9	0.79	0.9037
		lam0	0.029	0.005	0.02	0.039		-0.4291
		Psi	0.352	0.08	0.2	0.511		-1.0914
		N	31.37	5.859	20	42		-1.238
		P	0.029	0.005	0.02	0.039		
		D	0.96	0.14	0.72	1.21		

Annex- 4: Site-level tiger density estimates per 100 km² based on the area surveyed in 2013 (for comparison). Sites in bold show significant difference in density between 2013 and 2018.

	National Tiger Survey 2018				National Tiger Survey 2013			
SITES	**Density**	**SD**	**95%_LCL**	**95%_UCL**	**Density**	**SD**	**95%_LCL**	**95%_UCL**
PNP	1.49	0.23	1.01	1.89	0.65	0.28	0.38	1.24
CNP	3.81	0.25	3.35	4.31	3.84	0.34	3.15	4.46
BaNP	1.38	0.17	1.1	1.68	0.16	0.05	0.13	0.3
BNP	5.4	0.29	4.8	5.93	3.38	0.19	3.03	3.7
ShNP	3.48	0.65	2.22	4.66	3.4	0.46	2.67	4.32

Annex- 5. A comparative assessment of change in spatial density between 2013 and 2018 for each protected area.



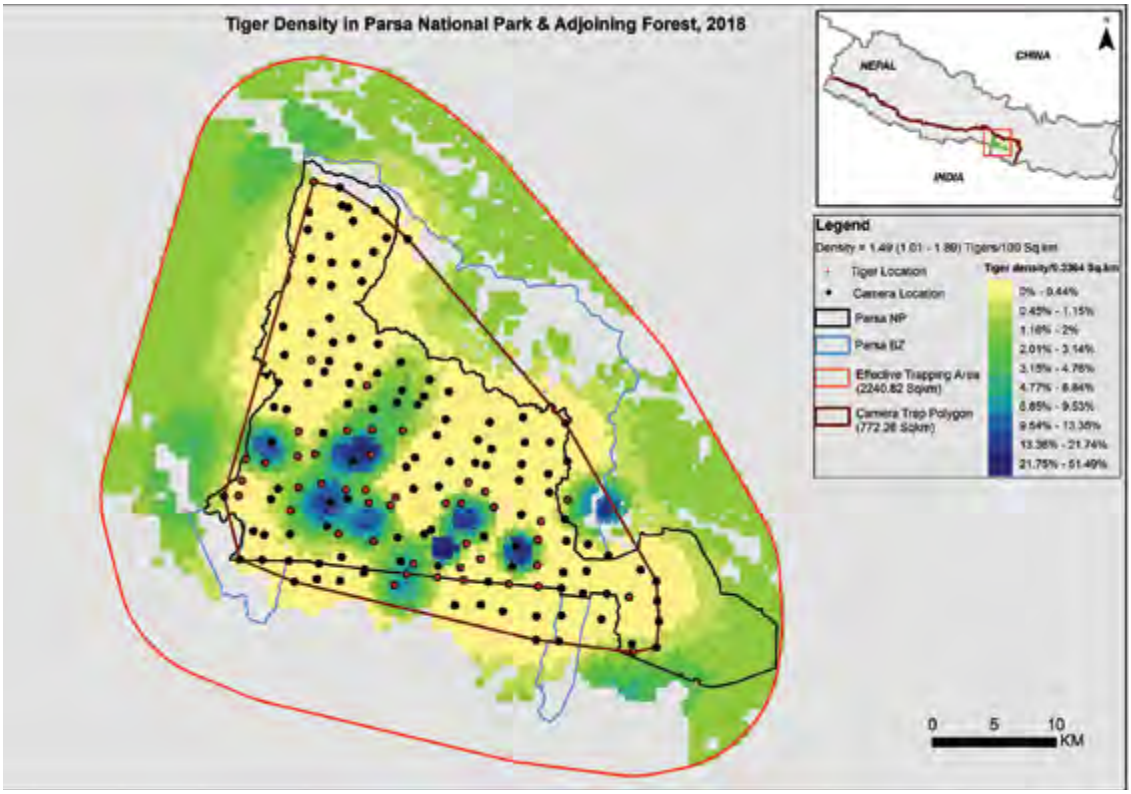


Figure 1. Pixelated tiger density map of Parsa National Park and adjoining forests.

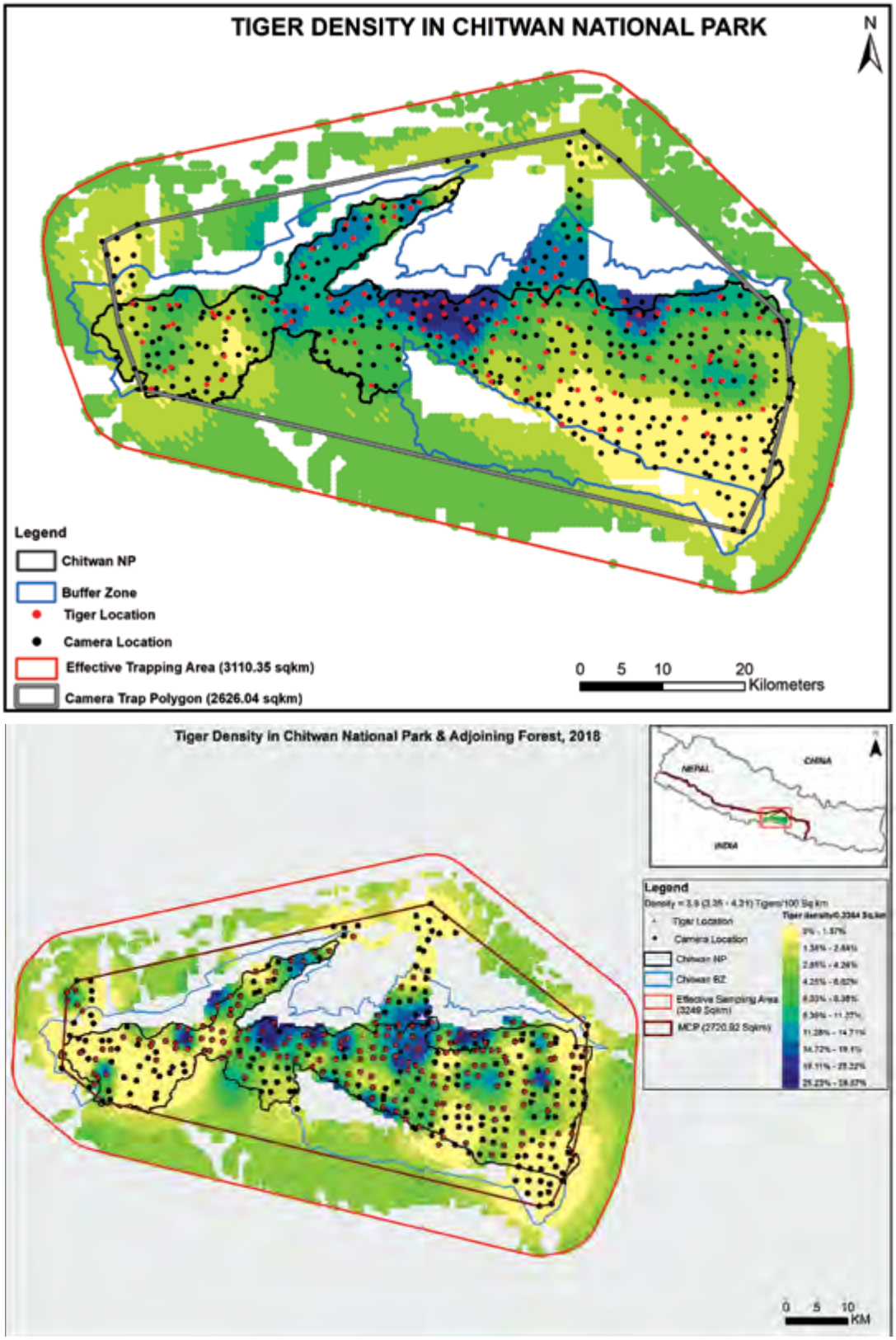


Figure 2. Pixelated tiger density map of Chitwan National Park, adjoining forests and corridors.

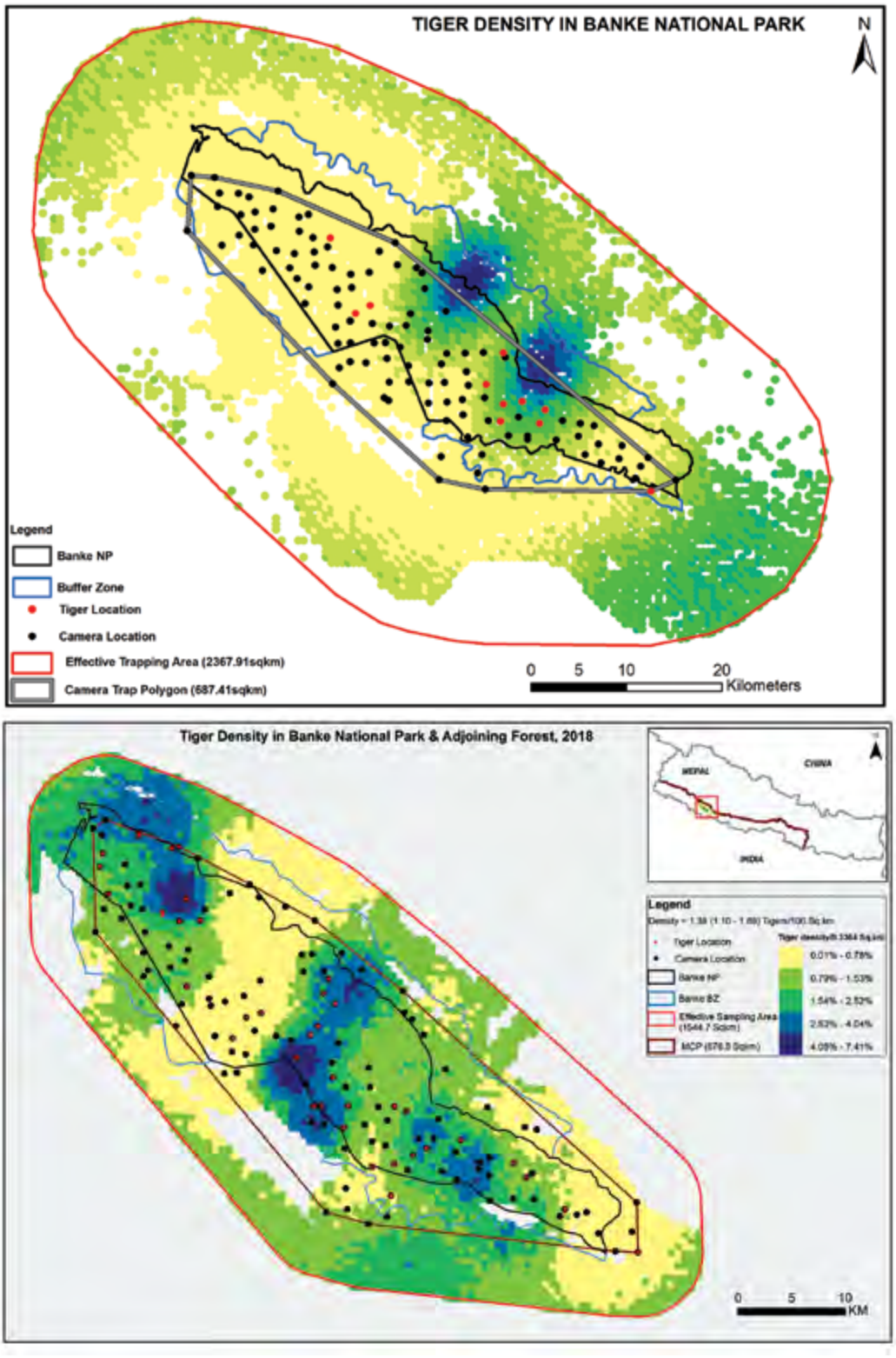


Figure 3. Pixelated tiger density map of Banke National Park, adjoining forests and corridors.

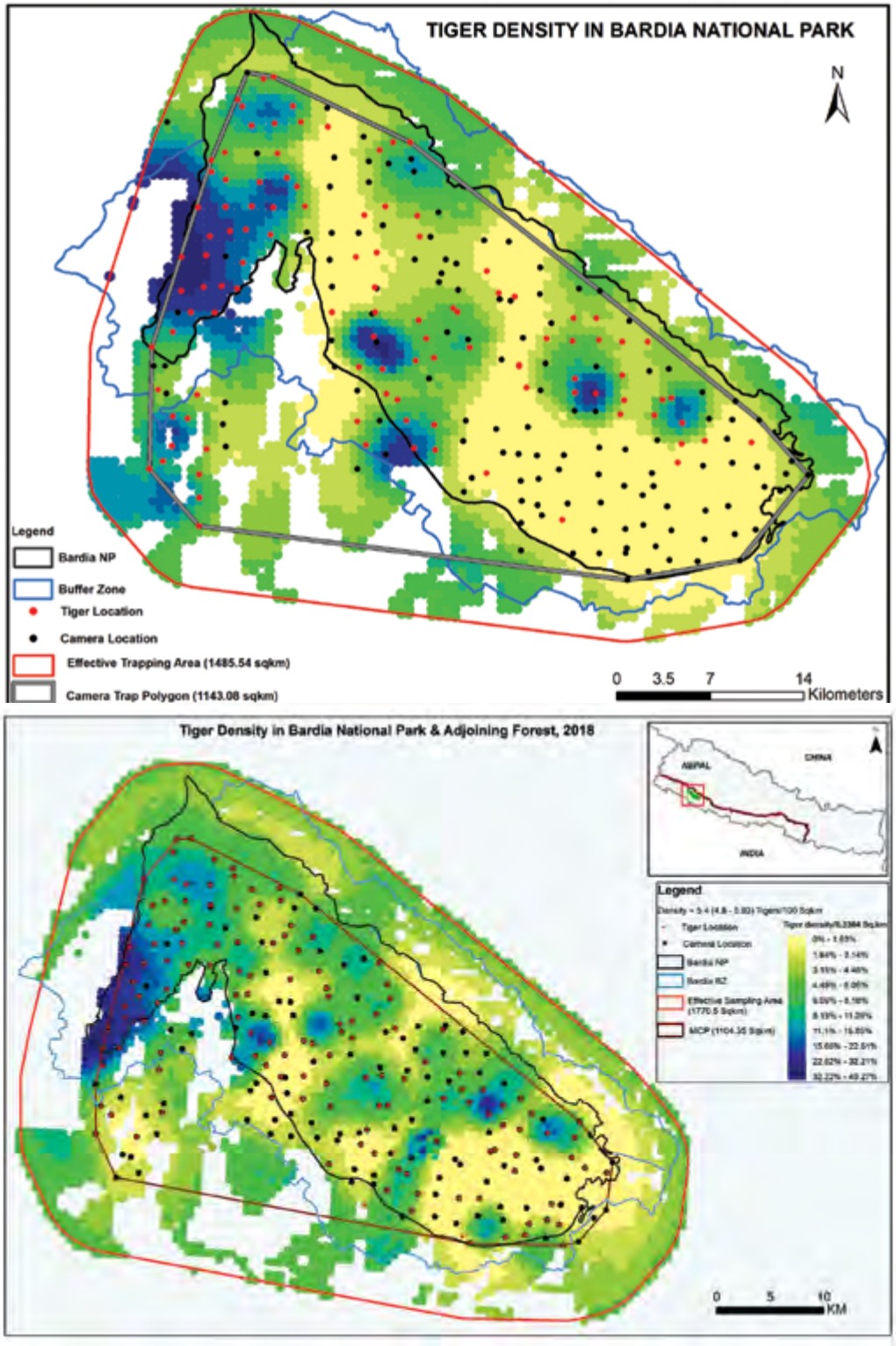


Figure 4. Pixelated tiger density map of Bardia National Park, adjoining forests and corridors.

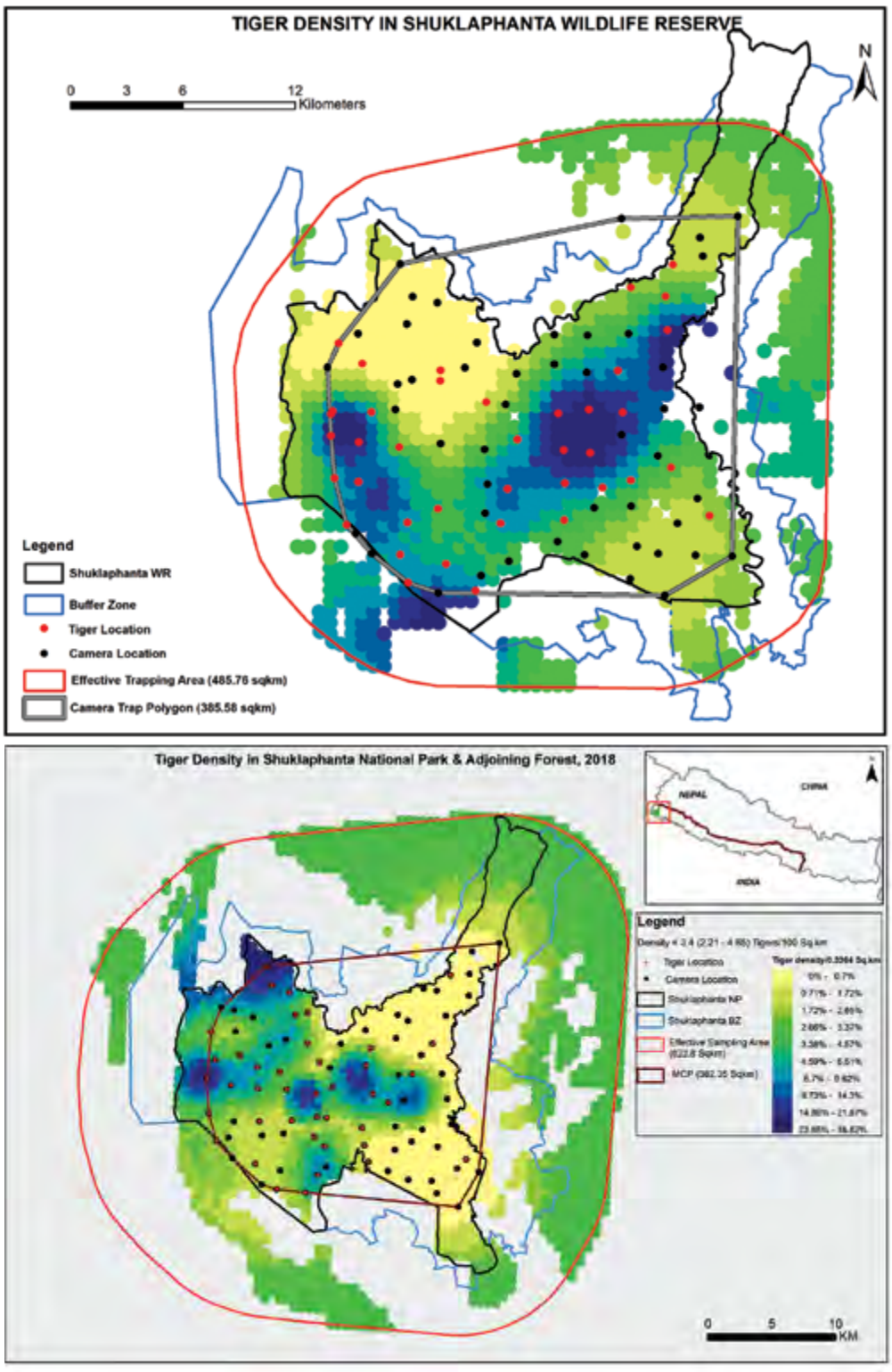


Figure 5. Pixelated tiger density map of Shuklaphanta National Park, adjoining forests and corridors.

Annex- 6: A comparison of tiger density estimates derived by SECR-ML and SECR- Bayesian approaches.

(* denotes "and adjoining forest") for effective sampling area of 2018 survey).

	SECR- Bayesian				SECR- ML			
SITES	**Density**	**SD**	**95%_LCL**	**95%_UCL**	**Density**	**SE**	**95%_LCL**	**95%_UCL**
PNP*	0.9	0.2	0.6	1.2	1.1	0.3	0.7	1.8
CNP*	3.3	0.2	2.9	3.6	4.1	0.5	3.3	5.1
BaNP*	1	0.1	0.8	1.2	1.1	0.3	0.7	1.8
BNP*	4.7	0.3	4.2	5.3	5.6	0.6	4.4	6.9
ShNP*	1	0.1	0.7	1.2	1.4	0.4	0.9	2.3

Annex-7: Prey density estimates and survey effort in each protected area and adjoining forests.

Protected area	Effort (km)	Spatial Replicates	Species	No. of obs.	Density (per km²)	SE	% of CV	95% CI	p	ESW (SE)	GoF- Chi-P
PNP*	482	248	All prey	194	22.02	3.8	17.48	15.66 - 30.96	0.3	28.2 (3.6)	0.76
			Spotted deer	30	8.82	3.6	40.83	4.06 - 19.17	0.3	26.4 (5.1)	0.6
			Sambar	40	2.2	0.6	27.67	1.29 - 3.76	0.3	37.7 (5.2)	0.9
			Wild boar	47	4.89	1.2	24.36	3.05 - 7.86	0.2	18.5 (2.8)	0.7
CNP*	331.6	175	All prey	367	70.7	7.49	10.59	57.49 - 87.05	0.2	20.7 (1.1)	0.3
			Spotted deer	131	43.85	8.2	18.77	30.42 - 63.20	0.2	24.8 (2.4)	0.5
			Sambar	73	9.96	2.04	20.44	6.69 - 14.83	0.2	19.4 (2.4)	0.8
			Barking deer	27	3.84	1.19	31.1	2.09 -7.01	0.2	17.1 (3.7)	0.7
			Hog deer	70	13.4	3.4	25.0	8.19 -22.04	0.2	14.5 (1.9)	0.8
			Wild boar	37	3.8	0.89	23.18	2.45 - 6.04	0.3	20.9 (2.6)	0.5
BaNP*	647	304	All prey	99	8.1	1.6	20.25	5.46 - 12.01	0.4	37.3 (2.8)	0.4
BNP*	745	414	All prey	776	77.51**	6.56	8.47	65.66 - 91.49	0.4	42.2 (2.1)	0.3
			Spotted deer	480	56.44	5.75	10.19	46.24 -68.9	0.3	35.6 (2.2)	0.4
			Sambar	48	1.48	0.32	21.83	0.97 - 2.27	0.3	39.8 (4.2)	0.9
			Wild boar	30	2.04	0.57	28.04	1.18 - 3.52	0.5	32.8 (5.1)	0.8
			Langur	83	15.02	3.2	21.42	9.89 - 22.78	0.4	46.4 (3.8)	0.8
ShNP*	279	153	All prey	412	68.04**	6.95	10.22	55.70 - 83.10	0.2	36.3 (2)	0.4
			Spotted deer	242	48.8	6.6	13.59	37.43 - 63.68	0.3	39.9 (2.9)	0.7
			Hog deer	41	10.14	3.33	32.81	5.39 - 19.06	0.3	15.4 (2.8)	1
			Wild boar	62	9.03	2.15	23.82	5.68 - 14.36	0.4	35 (5.5)	0.9
Total	**2,484.6**	**1,294**									

**Denotes the coverage of adjoining forests in line transect survey. ** denotes density estimates of all prey excluding swamp deer that was not detected during the line transect survey in both Bardia National Park and Shuklaphanta National Park. (p denotes detection probability at defined area, ESW denotes Effective Strip Width of detection, GOF- Chi P- denotes probability of chi square for goodness of fit test*

Annex- 8. Maps illustrating movement of tigers outside protected area boundary (the usage is illustrated by tiger individuals having their MCP lying beyond the boundary)

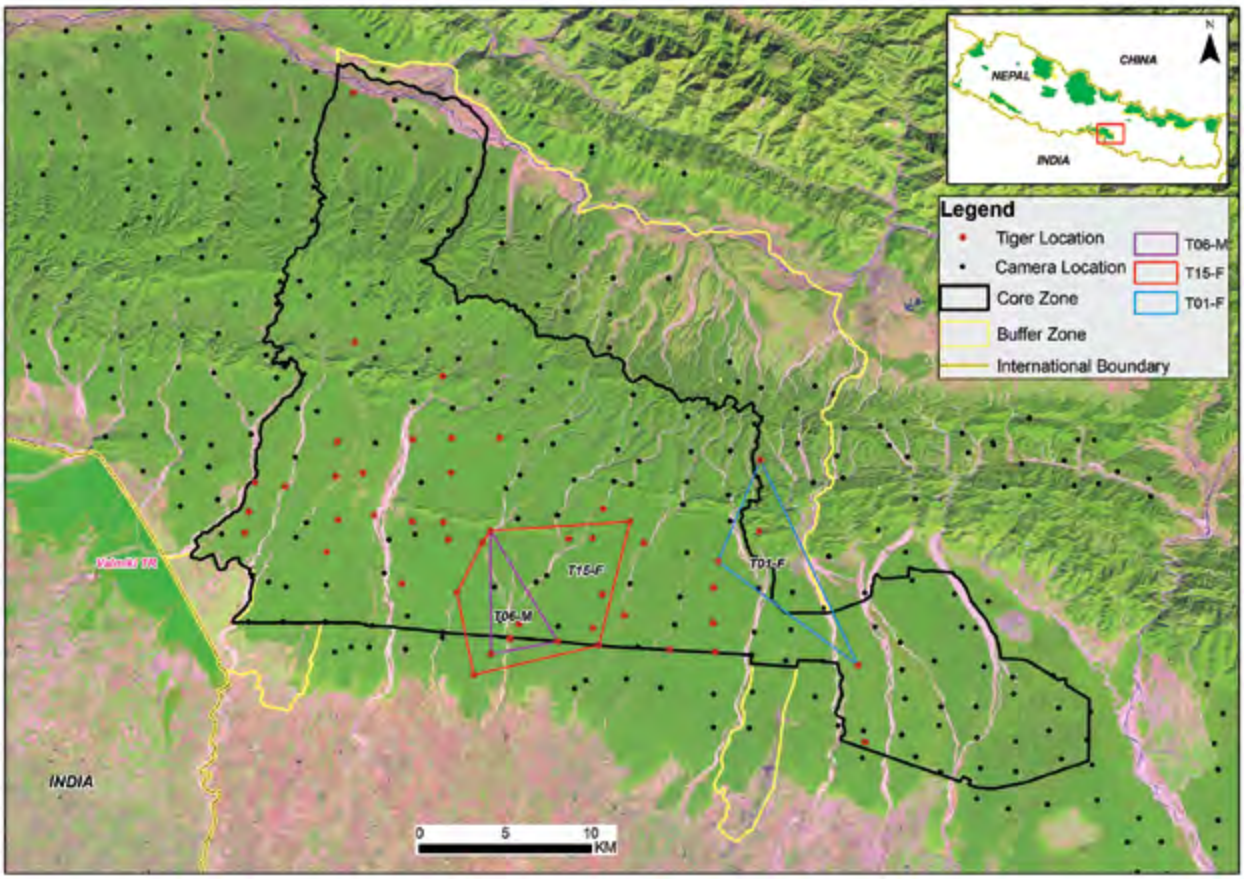


Figure 6.Movement of tigers in adjoining forests of Parsa National Park.

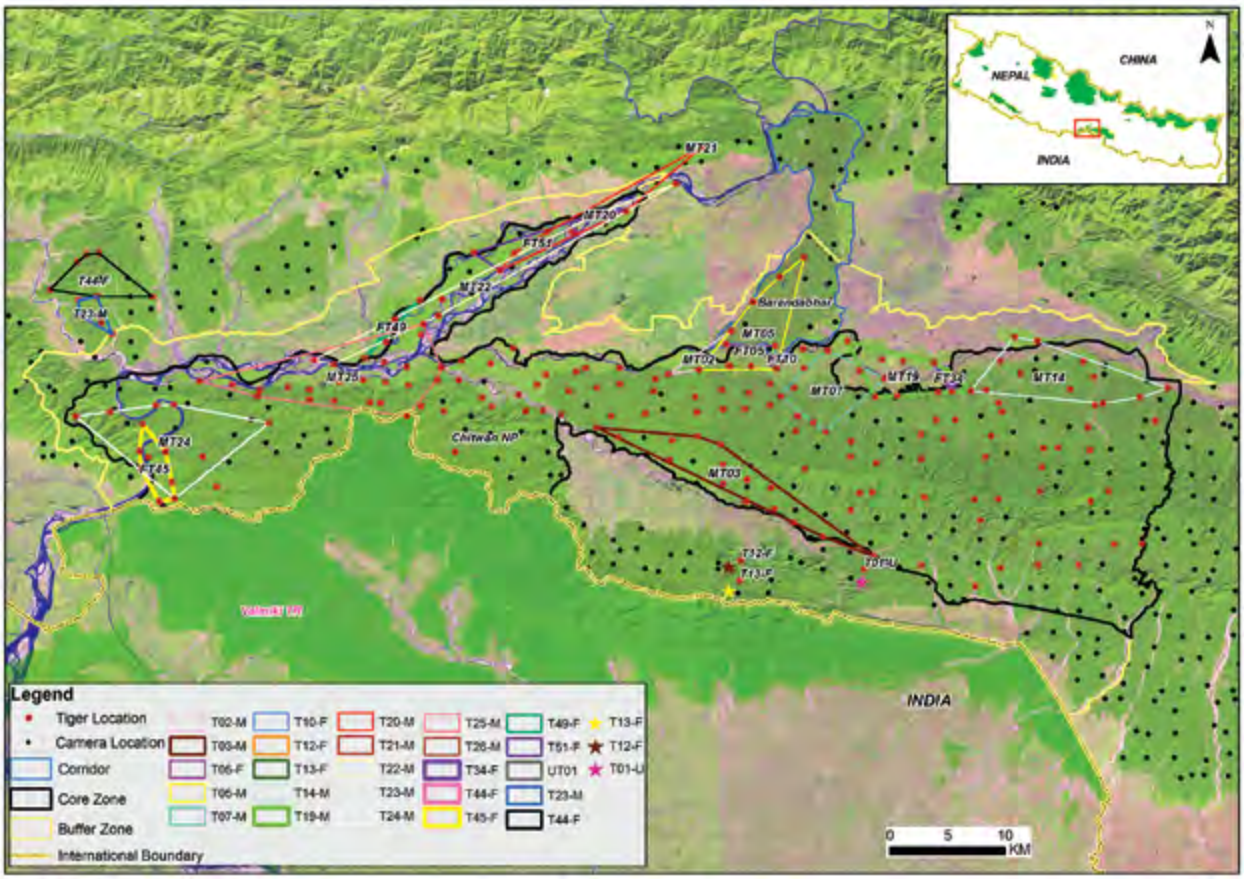


Figure 7. Movement of tigers in adjoining forests of Chitwan National Park.

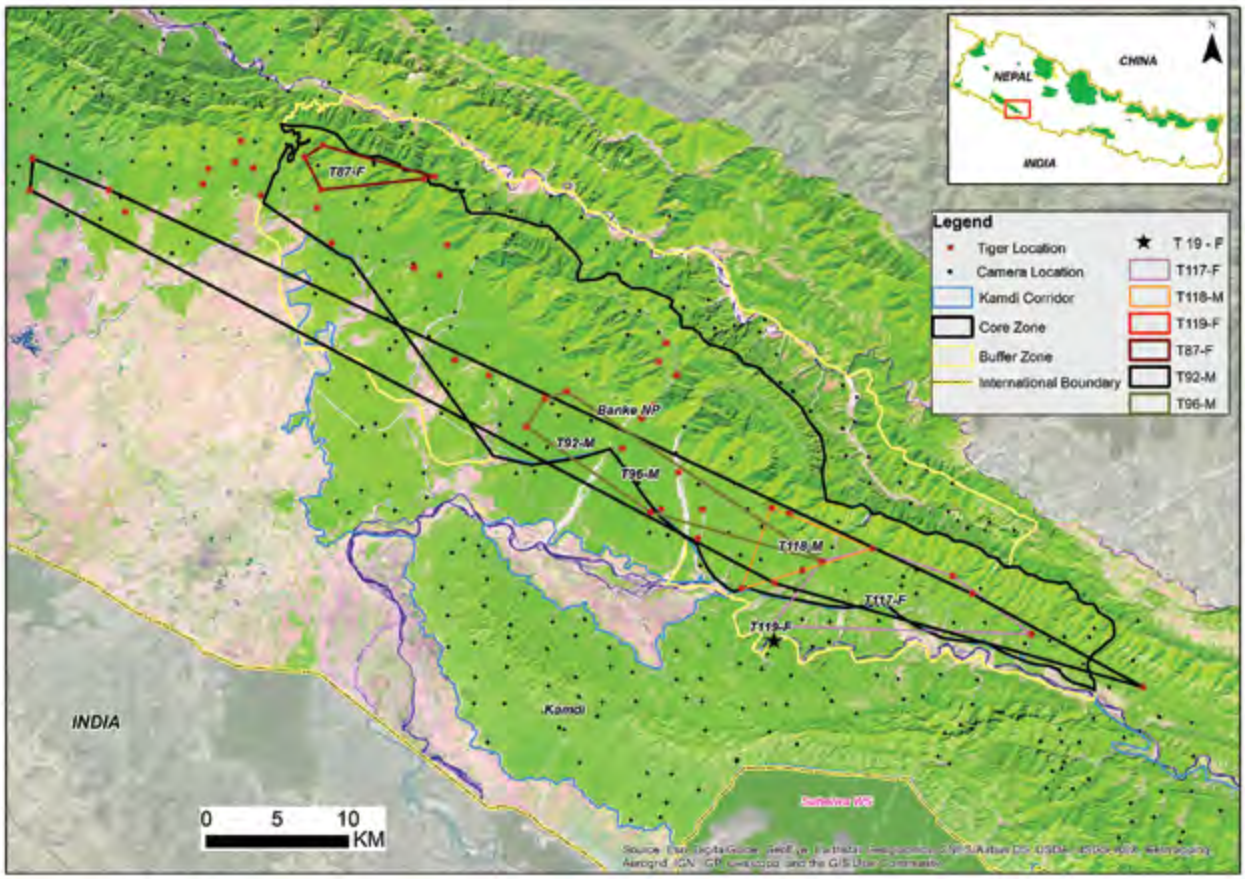


Figure 8. Movement of tigers in adjoining forests of Banke National Park.

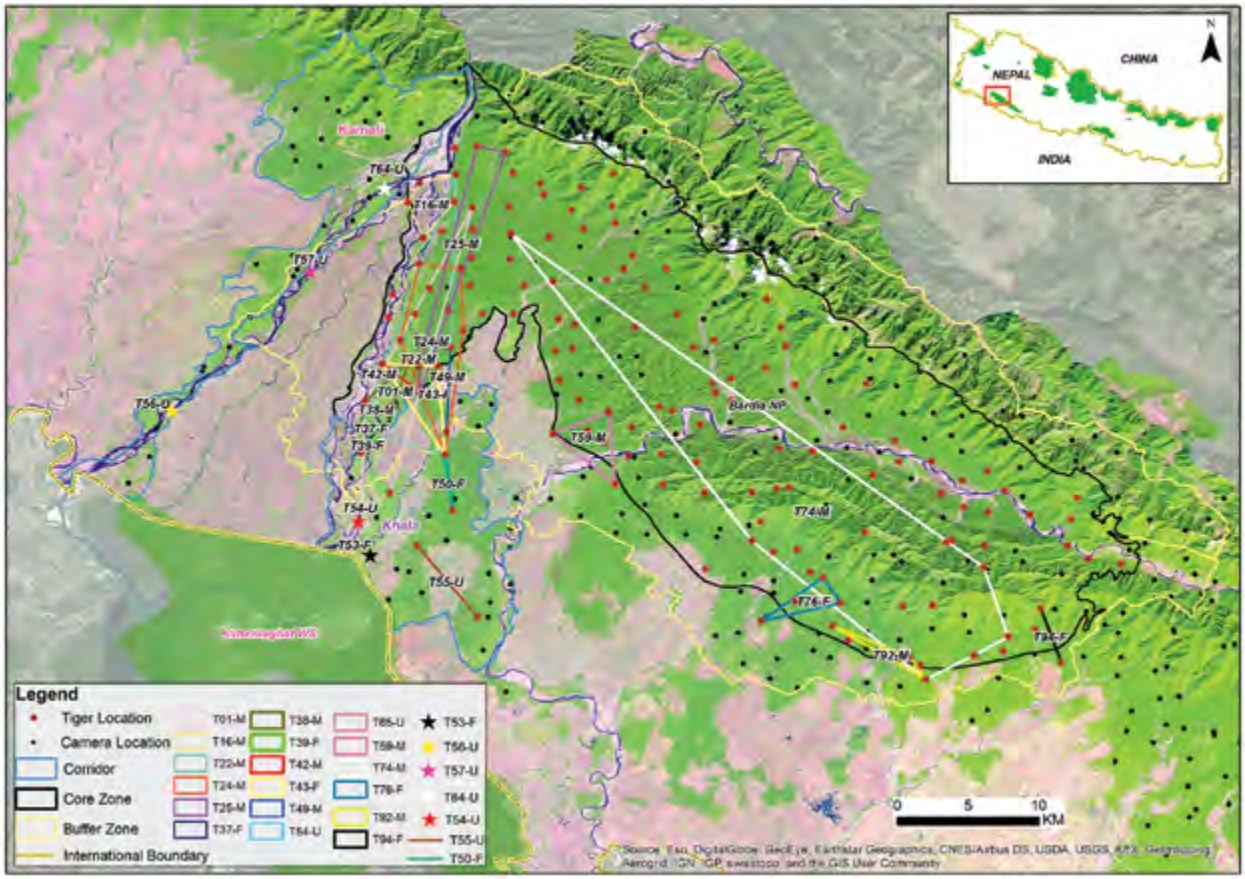


Figure 9. Movement of tigers in adjoining forests of Bardia National Park.

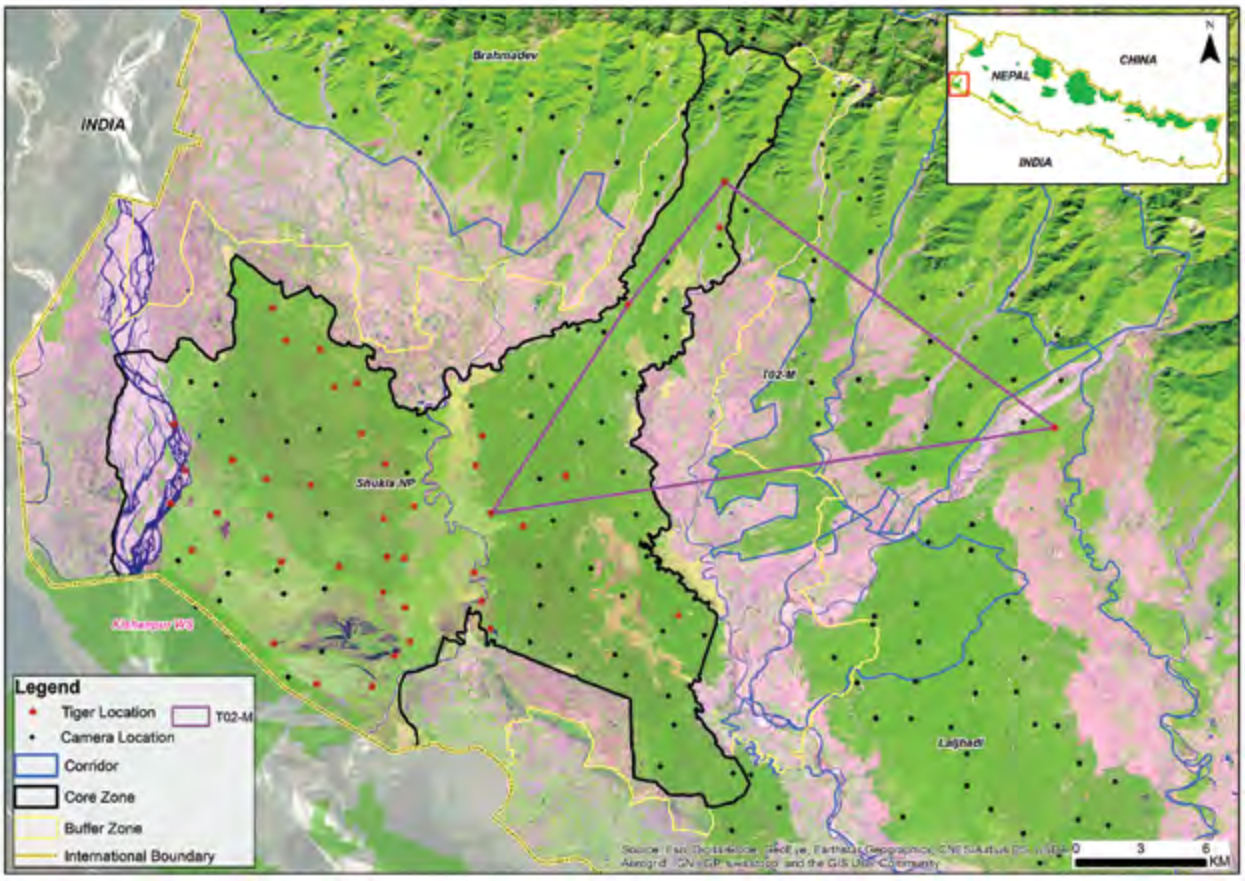


Figure 10. Movement of tigers in adjoining forests of Shuklaphanta National Park.

Annex- 9. National Tiger Survey time frame and human resource involved.

SN	Protected Area	Training organized	Field survey	No of working days	No of personnel involved	Person days	Elephant days
1	Chitwan NP, Parsa NP and adjoining forests	28-29 November, 2017	1 Dec, 2017- 3 Feb 2018	63	411	25,893	1,575
2	Banke NP, Bardia NP and adjoining forests	14-15 December, 2018	17-Dec, 2017-11-March, 2018	81	285	23,085	80
3	Shuklaphanta NP, Laljhadi corridor and Jogbuda forest	3-4 February, 2018	23-March, 2018-3-April, 2018	20	81	1,620	80
4	Habitat Occupancy survey	Same date as to the respective study sites	1-Dec, 2017-3-April, 2018	55	59	3,245	
	Total					**53,843**	**1,735**

Annex- 10. Ground personnel involved in National Tiger Survey.

SN	Name of participant	Protected Area	Institution
1	Ashish Bhandari	Chitwan National Park & Parsa National Park	CNP
2	Amrita Pudasaini	Chitwan National Park & Parsa National Park	CNP
3	Chhatra Khadka	Chitwan National Park & Parsa National Park	CNP
4	Gaurishankar Bhagat	Chitwan National Park & Parsa National Park	CNP
5	Him Lal Subedi	Chitwan National Park & Parsa National Park	CNP
6	Ishwari Mahato	Chitwan National Park & Parsa National Park	CNP
7	Kamal Bhujel	Chitwan National Park & Parsa National Park	CNP
8	Kshitiz Shrestha	Chitwan National Park & Parsa National Park	CNP
9	Lalit Malla	Chitwan National Park & Parsa National Park	CNP
10	Laxmi Bahadur Mahat	Chitwan National Park & Parsa National Park	CNP
11	Mahendra Mahato	Chitwan National Park & Parsa National Park	CNP
12	Narayan Baniya	Chitwan National Park & Parsa National Park	PNP
13	Pahuwari Yadav	Chitwan National Park & Parsa National Park	CNP
14	Prativa Kakshapati	Chitwan National Park & Parsa National Park	CNP
15	Pravin Shrestha	Chitwan National Park & Parsa National Park	CNP
16	Prem Chaulagain	Chitwan National Park & Parsa National Park	CNP
17	Ram Bahadur Suyal	Chitwan National Park & Parsa National Park	CNP
18	Ram Julum Yadav	Chitwan National Park & Parsa National Park	CNP
19	Ramchandra Raila	Chitwan National Park & Parsa National Park	CNP
20	Ramnath Yadav	Chitwan National Park & Parsa National Park	CNP
21	Ranger, GS	Chitwan National Park & Parsa National Park	CNP
22	Sajan Pariyar	Chitwan National Park & Parsa National Park	CNP
23	Sanjeet Timilsina	Chitwan National Park & Parsa National Park	CNP
24	Suman Chaudhary	Chitwan National Park & Parsa National Park	CNP
25	Surendra Subedi	Chitwan National Park & Parsa National Park	CNP
26	Suresh Lama	Chitwan National Park & Parsa National Park	CNP
27	Toplal Shrestha	Chitwan National Park & Parsa National Park	CNP
28	Tularam Mahato	Chitwan National Park & Parsa National Park	CNP
29	Umesh Poudel	Chitwan National Park & Parsa National Park	CNP
30	Yadav Shahi	Chitwan National Park & Parsa National Park	CNP
31	Shanta Budha Magar	Chitwan National Park & Parsa National Park	Database
32	Bishal Kushuwar	Chitwan National Park & Parsa National Park	DFO Rautahat
33	Sahendra Jha	Chitwan National Park & Parsa National Park	DFO Rautahat
34	Ashish Gurung	Chitwan National Park & Parsa National Park	NTNC
35	Amar Singh Thakur	Chitwan National Park & Parsa National Park	NTNC
36	Binod Darai	Chitwan National Park & Parsa National Park	NTNC
37	Birendra Gautam	Chitwan National Park & Parsa National Park	NTNC
38	Dip Chaudhary	Chitwan National Park & Parsa National Park	NTNC
39	Ganesh Rana	Chitwan National Park & Parsa National Park	NTNC
40	Harka Man Lama	Chitwan National Park & Parsa National Park	NTNC
41	Om Prakash Chaudhary	Chitwan National Park & Parsa National Park	NTNC
42	Pramod Raj Regmi	Chitwan National Park & Parsa National Park	NTNC
43	Ramesh Darai	Chitwan National Park & Parsa National Park	NTNC
44	Saneer Lamichhane	Chitwan National Park & Parsa National Park	NTNC

SN	Name of participant	Protected Area	Institution
45	Saneer Lamichhane	Chitwan National Park & Parsa National Park	NTNC
46	Tika Ram Tharu	Chitwan National Park & Parsa National Park	NTNC
47	Tirtha Lama	Chitwan National Park & Parsa National Park	NTNC
48	Birendra Karki	Chitwan National Park & Parsa National Park	PNP
49	Kiran Giri	Chitwan National Park & Parsa National Park	PNP
50	Kumar Dhungana	Chitwan National Park & Parsa National Park	PNP
51	Manoj Kafle	Chitwan National Park & Parsa National Park	PNP
52	Narbadev Prasad Yadav	Chitwan National Park & Parsa National Park	PNP
53	Prakash Pun	Chitwan National Park & Parsa National Park	PNP
54	Alina Ale	Chitwan National Park & Parsa National Park	Student volunteer
55	Amit Chaudhary	Chitwan National Park & Parsa National Park	Student volunteer
56	Ananda Kumar Shrestha	Chitwan National Park & Parsa National Park	Student volunteer
57	Ashik Thapa	Chitwan National Park & Parsa National Park	Student volunteer
58	Ashish Subedi	Chitwan National Park & Parsa National Park	Student volunteer
59	Basanta Lamsal	Chitwan National Park & Parsa National Park	Student volunteer
60	Bibek Baiju	Chitwan National Park & Parsa National Park	Student volunteer
61	Bijaya Kunwar	Chitwan National Park & Parsa National Park	Student volunteer
62	Bikram Singh Dhami	Chitwan National Park & Parsa National Park	Student volunteer
63	Dinesh Bhujel	Chitwan National Park & Parsa National Park	Student volunteer
64	Karan Shahi	Chitwan National Park & Parsa National Park	Student volunteer
65	Kiran Rayamajhi	Chitwan National Park & Parsa National Park	Student volunteer
66	Man Bahadur Bohara	Chitwan National Park & Parsa National Park	Student volunteer
67	Nanda Phadera	Chitwan National Park & Parsa National Park	Student volunteer
68	Prabin Poudel	Chitwan National Park & Parsa National Park	Student volunteer
69	Pramod Sunar	Chitwan National Park & Parsa National Park	Student volunteer
70	Purnima Acharya	Chitwan National Park & Parsa National Park	Student volunteer
71	Ramit Rawat	Chitwan National Park & Parsa National Park	Student volunteer
72	Ruben Raj Giri	Chitwan National Park & Parsa National Park	Student volunteer
73	Rupesh Maharjan	Chitwan National Park & Parsa National Park	Student volunteer
74	Sapana Kaiju	Chitwan National Park & Parsa National Park	Student volunteer
75	Sarjan Gwachha	Chitwan National Park & Parsa National Park	Student volunteer
76	Sushil Dhakal	Chitwan National Park & Parsa National Park	Student volunteer
77	Anish Lama	Chitwan National Park & Parsa National Park	Technician assistant
78	Ashish Bhusal	Chitwan National Park & Parsa National Park	Technician assistant
79	Asre Rana	Chitwan National Park & Parsa National Park	Technician assistant
80	Babu Ram Mahato	Chitwan National Park & Parsa National Park	Technician assistant
81	Bikash Pathak	Chitwan National Park & Parsa National Park	Technician assistant
82	Bir Bahadur Kumal	Chitwan National Park & Parsa National Park	Technician assistant
83	Devendra Gotame	Chitwan National Park & Parsa National Park	Technician assistant
84	Ganesh Lama	Chitwan National Park & Parsa National Park	Technician assistant
85	Gopi Chaudhary	Chitwan National Park & Parsa National Park	Technician assistant
86	Govinda Tharu	Chitwan National Park & Parsa National Park	Technician assistant
87	Hom Bahadur Dala	Chitwan National Park & Parsa National Park	Technician assistant
88	Manoj Kumar Mahato	Chitwan National Park & Parsa National Park	Technician assistant
89	Manoj Rai	Chitwan National Park & Parsa National Park	Technician assistant
90	Mithun Tharu	Chitwan National Park & Parsa National Park	Technician assistant

SN	Name of participant	Protected Area	Institution
91	Naresh Tharu	Chitwan National Park & Parsa National Park	Technician assistant
92	Pawan Kumar Basnet	Chitwan National Park & Parsa National Park	Technician assistant
93	Pradeep Chaudhary	Chitwan National Park & Parsa National Park	Technician assistant
94	Prem Mahato	Chitwan National Park & Parsa National Park	Technician assistant
95	Rajesh Mardaniya	Chitwan National Park & Parsa National Park	Technician assistant
96	Raju Kumal	Chitwan National Park & Parsa National Park	Technician assistant
97	Rohit Giri	Chitwan National Park & Parsa National Park	Technician assistant
98	Sachin Lamichhane	Chitwan National Park & Parsa National Park	Technician assistant
99	Samir Shrestha	Chitwan National Park & Parsa National Park	Technician assistant
100	Sandip Syangtang	Chitwan National Park & Parsa National Park	Technician assistant
101	Sanjaya Acharya	Chitwan National Park & Parsa National Park	Technician assistant
102	Santosh Lama	Chitwan National Park & Parsa National Park	Technician assistant
103	Suman Lama	Chitwan National Park & Parsa National Park	Technician assistant
104	Suraj Tharu	Chitwan National Park & Parsa National Park	Technician assistant
105	Tarapati Mahato	Chitwan National Park & Parsa National Park	Technician assistant
106	Yuvanath Padhya	Chitwan National Park & Parsa National Park	Technician assistant
107	Bibek Chaudhary	Chitwan National Park & Parsa National Park	ZSL
108	Suman Acharya	Chitwan National Park & Parsa National Park	ZSL
109	Deepak Kumar Mahato	Chitwan National Park & Parsa National Park	Technician assistant
110	Santosh Chaudhary	Chitwan National Park & Parsa National Park	Technician assistant
111	Devan Chaudhary	Chitwan National Park & Parsa National Park	Cook
112	Devraj Tharu	Chitwan National Park & Parsa National Park	cook
113	Ganesh Chaudhary	Chitwan National Park & Parsa National Park	Cook
114	Jaliram Mahato	Chitwan National Park & Parsa National Park	Cook
115	Jana Bahadur Kumal	Chitwan National Park & Parsa National Park	Cook
116	Kiran Thakuri	Chitwan National Park & Parsa National Park	Cook
117	Manoj Chaudhary	Chitwan National Park & Parsa National Park	Cook
118	Padam Raj Kunwar	Chitwan National Park & Parsa National Park	Cook
119	Subash Tharu	Chitwan National Park & Parsa National Park	Cook
120	Suresh Chaudhary	Chitwan National Park & Parsa National Park	Cook
121	Yubaraj Kumal	Chitwan National Park & Parsa National Park	Cook
122	Jeevan Tharu	Chitwan National Park & Parsa National Park	Cook
123	Rita Mandal	Chitwan National Park & Parsa National Park	Cook
124	Binti Ram Chaudhary	Bardia National Park & Banke National Park	NTNC-BCP
125	Phiru Lal Chaudhary	Bardia National Park & Banke National Park	NTNC-BCP
126	Ramraj Chaudhary	Bardia National Park & Banke National Park	NTNC-BCP
127	Khusi Ram Chaudhary	Bardia National Park & Banke National Park	NTNC-BCP
128	Hari Lal Chaudhary	Bardia National Park & Banke National Park	NTNC-BCP
129	Kabiraj Jaisi Acharya	Bardia National Park & Banke National Park	Cook
130	Ganesh Tharu	Bardia National Park & Banke National Park	CBAPU Cook
131	Sitaram Chaudhary	Bardia National Park & Banke National Park	CBAPU
132	Suraj Lal Tharu	Bardia National Park & Banke National Park	CBAPU
133	Rajesh Tharu	Bardia National Park & Banke National Park	CBAPU
134	Om Prakash Rajbansi	Bardia National Park & Banke National Park	CBAPU
135	Asaram Tharu	Bardia National Park & Banke National Park	CBAPU
136	Om Prakash Yogi	Bardia National Park & Banke National Park	CBAPU

SN	Name of participant	Protected Area	Institution
137	Pramod Chaudhary	Bardia National Park & Banke National Park	CBAPU
138	Rim Bahadur Magar	Bardia National Park & Banke National Park	CBAPU
139	Anasram Tharu	Bardia National Park & Banke National Park	CBAPU
140	Anu Ram Chaudhary	Bardia National Park & Banke National Park	CBAPU
141	Lalitram Chaudhary	Bardia National Park & Banke National Park	CBAPU
142	Dharmendra Tharu	Bardia National Park & Banke National Park	CBAPU
143	Hari Ram Tharu	Bardia National Park & Banke National Park	CBAPU
144	Dewari Lal Dahit	Bardia National Park & Banke National Park	CBAPU
145	Khom Lal Chaudhary	Bardia National Park & Banke National Park	CBAPU
146	Nirmal Tharu	Bardia National Park & Banke National Park	CBAPU
147	Lokraj Tharu	Bardia National Park & Banke National Park	CBAPU
148	Bishal Bhujel	Bardia National Park & Banke National Park	CBAPU
149	Maniram Chaudhary	Bardia National Park & Banke National Park	Forest Bardia
150	Lok Bahadur Tharu	Bardia National Park & Banke National Park	Forest Bardia
151	Kabiram Tharu	Bardia National Park & Banke National Park	Khata/CBAPU
152	Hiramani Parajuli	Bardia National Park & Banke National Park	Khata/CBAPU
153	Salikram Reule	Bardia National Park & Banke National Park	Nepali Army
154	Ganga Bahadur Buda	Bardia National Park & Banke National Park	Nepali Army
155	Kulraj Bhatta	Bardia National Park & Banke National Park	Nepali Army
156	Tek Bahadur Bhandari	Bardia National Park & Banke National Park	Nepali Army
157	Prakash Adhikari	Bardia National Park & Banke National Park	Nepali Army
158	Dipendra Basnet	Bardia National Park & Banke National Park	Nepali Army
159	Dan Bahadur Bista	Bardia National Park & Banke National Park	Nepali Army
160	Maniram Gayali	Bardia National Park & Banke National Park	Nepali Army
161	Gopal Singh Aeri	Bardia National Park & Banke National Park	Nepali Army
162	Jatiram Gharti Magar	Bardia National Park & Banke National Park	Nepali Army
163	Harka Bahadur Chand	Bardia National Park & Banke National Park	Nepali Army
164	Sandip Rana	Bardia National Park & Banke National Park	Nepali Army
165	Hari Ram Chaudhary	Bardia National Park & Banke National Park	Kailali forest
166	Antaram Chaudhary	Bardia National Park & Banke National Park	Kailali forest
167	Saroj Khadka	Bardia National Park & Banke National Park	BNP
168	Puspadeep Shrestha	Bardia National Park & Banke National Park	BNP
169	Narayan Devkota	Bardia National Park & Banke National Park	BNP
170	Shyam Prakash Tamang	Bardia National Park & Banke National Park	BNP
171	Binod Dahal	Bardia National Park & Banke National Park	BNP
172	Mahesh Shahi	Bardia National Park & Banke National Park	BNP
173	Kaladhar Gautam	Bardia National Park & Banke National Park	BNP
174	Pradip Thapa	Bardia National Park & Banke National Park	BNP
175	Ratiman Raut	Bardia National Park & Banke National Park	BNP
176	Khum Bahadur Mahatara	Bardia National Park & Banke National Park	BNP
177	Bharat Paudel	Bardia National Park & Banke National Park	BNP
178	Indra Prasad Jaisi	Bardia National Park & Banke National Park	BNP
179	Hingua Tharu	Bardia National Park & Banke National Park	BNP
180	Kalu Thapa	Bardia National Park & Banke National Park	BNP
181	Kalu Chand Thakuri	Bardia National Park & Banke National Park	BNP
182	Surya Chaudhary	Bardia National Park & Banke National Park	BNP

SN	Name of participant	Protected Area	Institution
183	Prasad Chaudhary	Bardia National Park & Banke National Park	BNP Hattisar
184	Bishnu Tharu	Bardia National Park & Banke National Park	BNP Hattisar
185	Mim Raj Acharya	Bardia National Park & Banke National Park	BNP Hattisar
186	Ishwar BK	Bardia National Park & Banke National Park	BNP Hattisar
187	Hirasingh Tharu	Bardia National Park & Banke National Park	BNP Hattisar
188	Min Bahadur Magar	Bardia National Park & Banke National Park	BNP Hattisar
189	Rabi Lal Tharu	Bardia National Park & Banke National Park	BNP Hattisar
190	Cheduwa Tharu	Bardia National Park & Banke National Park	BNP
191	Chitra Bahadur Khatri	Bardia National Park & Banke National Park	BNP Hattisar
192	Sukhlal Chaudhary	Bardia National Park & Banke National Park	BNP
193	Bichitra Kumar	Bardia National Park & Banke National Park	BNP
194	Punsaram Tharu	Bardia National Park & Banke National Park	BNP Hattisar
195	Balkisun Tharu	Bardia National Park & Banke National Park	BNP Hattisar
196	Biru Lal Tharu	Bardia National Park & Banke National Park	BNP Hattisar
197	Akshaya Chaudhary	Bardia National Park & Banke National Park	BaNP
198	Rajan Pandit	Bardia National Park & Banke National Park	BaNP
199	Pankharaj Tiruwa	Bardia National Park & Banke National Park	BaNP
200	Hari Kafle	Bardia National Park & Banke National Park	BaNP
201	Bishnu Bahadur Kumal	Bardia National Park & Banke National Park	BaNP
202	Bishal Thapa Magar	Bardia National Park & Banke National Park	BaNP
203	Gopal Singh Basnet	Bardia National Park & Banke National Park	BaNP
204	Purna Bahadur Lama	Bardia National Park & Banke National Park	BaNP
205	Sahadev Tharu	Bardia National Park & Banke National Park	BaNP
206	Karan Buda	Bardia National Park & Banke National Park	BaNP
207	Yuraj Siris Magar	Bardia National Park & Banke National Park	BaNP
208	Topendra Bahadur Thapa	Bardia National Park & Banke National Park	BaNP
209	Chandra Bahadur Buda	Bardia National Park & Banke National Park	Nepali Army
210	Samjhana Chaudhary	Bardia National Park & Banke National Park	Nepali Army
211	Shiva Bahadur Thapa	Bardia National Park & Banke National Park	Nepali Army
212	Dambar Bahadur Raut	Bardia National Park & Banke National Park	Nepali Army
213	Sanjeev Babu Shrestha	Bardia National Park & Banke National Park	Nepali Army
214	Subaraj Bhujel	Bardia National Park & Banke National Park	Nepali Army
215	Ganga Bahadur Oli Chhetri	Bardia National Park & Banke National Park	Nepali Army
216	Jeevan Ale Magar	Bardia National Park & Banke National Park	Nepali Army
217	Yek Mani Basnet	Bardia National Park & Banke National Park	Nepali Army
218	Janak Bahadur Devkota	Bardia National Park & Banke National Park	Nepali Army
219	Suman Kathayat	Bardia National Park & Banke National Park	DFO
220	Umesh Rai	Bardia National Park & Banke National Park	ZSL Kohalpur
221	Amrit Rai	Bardia National Park & Banke National Park	CBAPU Banke
222	Purna Bahadur Magar	Bardia National Park & Banke National Park	CBAPU Banke
223	SantoshKhatri	Bardia National Park & Banke National Park	CBAPU Banke
224	Surendra Chaudhary	Bardia National Park & Banke National Park	CBAPU Banke
225	Sharada Khuna	Bardia National Park & Banke National Park	CBAPU Banke
226	Krishna Chaudhary	Bardia National Park & Banke National Park	CBAPU Banke
227	Sovaram Oli	Bardia National Park & Banke National Park	CBAPU Banke
228	Rama Khanal	Bardia National Park & Banke National Park	CBAPU Banke

SN	Name of participant	Protected Area	Institution
229	Tejkumari Oli	Bardia National Park & Banke National Park	CBAPU Banke
230	Khusiram Tharu	Bardia National Park & Banke National Park	CBAPU Banke
231	Bhimsing Rokaya	Bardia National Park & Banke National Park	CBAPU Banke
232	Prabhat Shah	Bardia National Park & Banke National Park	Student Volunteer
233	Rajkumar Tharu	Bardia National Park & Banke National Park	Student Volunteer
234	Bhim Bahadur Dangi	Bardia National Park & Banke National Park	Student Volunteer
235	Prem Prasad Chaudhary	Bardia National Park & Banke National Park	Student Volunteer
236	Deepa Dangol	Bardia National Park & Banke National Park	BaNP
237	Sabina Dahal	Bardia National Park & Banke National Park	BaNP
238	Melina Karki	Bardia National Park & Banke National Park	CBAPU Bardia
239	Anupama Dahal	Bardia National Park & Banke National Park	CBAPU Bardia
240	Ganesh Shahi	Bardia National Park & Banke National Park	BaNP
241	Bed Bahadur Magar	Bardia National Park & Banke National Park	BaNP
242	Binod Chaudhary	Bardia National Park & Banke National Park	CBAPU Bardia
243	Nabin Acharya	Bardia National Park & Banke National Park	CBAPU Bardia
244	Sanjok Shahi	Bardia National Park & Banke National Park	BNP
245	Prem Chaudhary	Bardia National Park & Banke National Park	BNP
246	Rom Harsa Khadka	Bardia National Park & Banke National Park	BaNP
247	Bintiram Chaudhary	Bardia National Park & Banke National Park	CBAPU Bardia
248	Hem Raj Parajuli	Bardia National Park & Banke National Park	CBAPU
249	Chabilal Buda Magar	Bardia National Park & Banke National Park	DFO
250	Ganesh Kumar Chaudhary	Bardia National Park & Banke National Park	DFO
251	Bhagwati Dhungana	Shuklaphanta National Park	BAFER Nepal
252	Karan Sing Bist	Shuklaphanta National Park	Chure Sanjal
253	Naresh Tharu	Shuklaphanta National Park	Bardia CBAPU
254	Hari Bahadur Thapa	Shuklaphanta National Park	Nepali Army
255	Raju Dura	Shuklaphanta National Park	Nepali Army
256	Prakash Chaudhary	Shuklaphanta National Park	Nepali Army
257	Amar Buda Chhetri	Shuklaphanta National Park	Nepali Army
258	Rabin Shrestha	Shuklaphanta National Park	Nepali Army
259	Birendra Kumal	Shuklaphanta National Park	Nepali Army
260	Padam Pun	Shuklaphanta National Park	Nepali Army
261	Indra Singh Karki	Shuklaphanta National Park	Nepali Army
262	Dhan Bahadur Thapa	Shuklaphanta National Park	Nepali Army
263	Purushottam Pokharel	Shuklaphanta National Park	Birendra Campus, Chitwan
264	Anta Ram Chaudhary	Shuklaphanta National Park	CBAPU
265	Punaram Chaudhary	Shuklaphanta National Park	CFCC Kanchanpur
266	NirmalaDadel	Shuklaphanta National Park	CFCC Kamdi
267	Maya Chaudhari	Shuklaphanta National Park	CFCC Kanchanpur
268	Devendra Gautam	Shuklaphanta National Park	Student
269	Naresh Shah	Shuklaphanta National Park	Student
270	Bhim Bahadur Bist	Shuklaphanta National Park	Chure Network
271	Krishnanandan Mahato	Shuklaphanta National Park	DFO Dadeldhura
272	Deepak Kumar Chaudhari	Shuklaphanta National Park	DFO Dadeldhura
273	Maan Bahadur Khadayat	Shuklaphanta National Park	DFO Kanchanpur

SN	Name of participant	Protected Area	Institution
274	Bibas Kalauni	Shuklaphanta National Park	Dadeldhura
275	Arjun Singh Thapa	Shuklaphanta National Park	DFO Kanchanpur
276	Thaman Badwal	Shuklaphanta National Park	CBAPU Dodhara
277	Ajay Basyal	Shuklaphanta National Park	IOF, Hetauda
278	Santosh Bajgai	Shuklaphanta National Park	IOF, Hetauda
279	Shiv Shah	Shuklaphanta National Park	IOF,Hetauda
280	Manoj Parajuli	Shuklaphanta National Park	IOF,Hetauda
281	Datendra Kumar Gole	Shuklaphanta National Park	IOF,Hetauda
282	Bikram Singh	Shuklaphanta National Park	IOF,Hetauda
283	Ashish Neupane	Shuklaphanta National Park	IOF,Hetauda
284	Chiranjivi Khanal	Shuklaphanta National Park	IOF,Hetauda
285	Kapil K.C	Shuklaphanta National Park	KAFCOL
286	Shubhash Sharma	Shuklaphanta National Park	KAFCOL
287	Arjun Sharma	Shuklaphanta National Park	KAFCOL
288	Parbin Goli	Shuklaphanta National Park	KAFCOL
289	Maan Bahadur Bohara	Shuklaphanta National Park	KAFCOL
290	Bibek Baiju	Shuklaphanta National Park	KAFCOL
291	Maan Bahadur Chaudhari	Shuklaphanta National Park	KAFCOL
292	Bibek Baiju	Shuklaphanta National Park	KAFCOL
293	Tribishal Sunar	Shuklaphanta National Park	KAFCOL
294	Bikash Rana	Shuklaphanta National Park	Mahakali
295	Deep Prashad Chaudhari	Shuklaphanta National Park	NTNC BCC
296	Ramesh Darai	Shuklaphanta National Park	NTNC BCC
297	Binod Darai	Shuklaphanta National Park	NTNC BCC
298	Om Prakash Chaudhari	Shuklaphanta National Park	NTNC BCC
299	Devraj Joshi	Shuklaphanta National Park	NTNC SCP
300	Suman Malla	Shuklaphanta National Park	NTNC SCP
301	Amar Singh Thakur	Shuklaphanta National Park	NTNC SCP
302	Ganesh Rana	Shuklaphanta National Park	NTNC SCP
303	Shreeram Tharu	Shuklaphanta National Park	NTNC SCP
304	Sankarlal Tharu	Shuklaphanta National Park	NTNC SCP
305	Krishna Bahadur Bhaat	Shuklaphanta National Park	Siddhanath Science Campus
306	Manoj Sah	Shuklaphanta National Park	Siddhanath Science Campus
307	Bhagawan Kalauni	Shuklaphanta National Park	Siddhanath Science Campus
308	Gajendra Singh Dangaura	Shuklaphanta National Park	ShNP
309	Manpuran Sunaha	Shuklaphanta National Park	ShNP
310	Taula Rana	Shuklaphanta National Park	ShNP
311	Prem Rana	Shuklaphanta National Park	ShNP
312	Mukesh Rana	Shuklaphanta National Park	ShNP
313	Umesh Sunaha	Shuklaphanta National Park	ShNP
314	Anand Sunaha	Shuklaphanta National Park	ShNP
315	Chotelal Rana	Shuklaphanta National Park	ShNP
316	Thaggu Rana	Shuklaphanta National Park	ShNP

SN	Name of participant	Protected Area	Institution
317	Raj Kumar Sunaha	Shuklaphanta National Park	ShNP
318	Bijaya Sunaha	Shuklaphanta National Park	ShNP
319	Binod Chaudhari	Shuklaphanta National Park	ShNP
320	Gyanendra Bahadur Shah	Shuklaphanta National Park	ShNP
321	Madan Raj Bhatta	Shuklaphanta National Park	ShNP
322	Meen Bahadur Luhar	Shuklaphanta National Park	ShNP
323	Aanand Sunaha	Shuklaphanta National Park	ShNP
324	Ganesh Bahadur Bist	Shuklaphanta National Park	ShNP
325	Bikram Chaudhari	Shuklaphanta National Park	ShNP
326	Sant Bahadur Magar	Shuklaphanta National Park	ShNP
327	Yaam Bahadur Rawat	Shuklaphanta National Park	ShNP
328	Puran Dev Mishra	Shuklaphanta National Park	ShNP
329	Aasare Rana	Shuklaphanta National Park	ShNP
330	Bijay Sunaha	Shuklaphanta National Park	ShNP
331	Bikram Chaudhari	Shuklaphanta National Park	ShNP

Annex- 11: Identified tigers from National Tiger Survey 2018.

TIGERS OF PARSA NATIONAL PARK AND ADJOINING FORESTS

PNP-FT01-RIGHT

PNP-FT01-LEFT

PNP-FT02-RIGHT

PNP-FT02-LEFT

PNP-FT07-RIGHT

PNP-FT07-LEFT

PNP-FT08-RIGHT

PNP-FT08-LEFT

PNP-FT09-RIGHT

PNP-FT09-LEFT

PNP-FT10-RIGHT

PNP-FT10-LEFT

PNP-FT11-RIGHT

PNP-FT11-LEFT

PNP-FT12-RIGHT

PNP-FT12-LEFT

PNP-FT15-RIGHT

PNP-FT15-LEFT

PNP-FT16-RIGHT

PNP-FT16-LEFT

PNP-MT01-RIGHT

PNP-MT01-LEFT

PNP-MT06-RIGHT

PNP-MT06-LEFT

PNP-MT07-RIGHT

PNP-MT07-LEFT

PNP-MT08-RIGHT

PNP-MT08-LEFT

PNP-MT09-RIGHT

PNP-MT09-LEFT

TIGERS OF CHITWAN NATIONAL PARK AND ADJOINING FORESTS

CNP-FT01- RIGHT

CNP-FT01- LEFT

CNP-FT02- RIGHT

CNP-FT02- LEFT

CNP-FT03- RIGHT

CNP-FT03- LEFT

CNP-FT04- RIGHT

CNP-FT04- LEFT

CNP-FT05- RIGHT

CNP-FT05- LEFT

CNP-FT06- RIGHT

CNP-FT06- LEFT

CNP-FT07- RIGHT

CNP-FT07- LEFT

CNP-FT08- RIGHT

CNP-FT08- LEFT

CNP-FT09- RIGHT

CNP-FT09- LEFT

CNP-FT10- RIGHT

CNP-FT10- LEFT

CNP-FT11- RIGHT

CNP-FT11- LEFT

CNP-FT12- RIGHT

CNP-FT12- LEFT

CNP-FT13- RIGHT

CNP-FT13- LEFT

CNP-FT14- RIGHT

CNP-FT14- LEFT

CNP-FT15- RIGHT

CNP-FT15- LEFT

CNP-FT16- RIGHT

CNP-FT16- LEFT

CNP-FT17- RIGHT

CNP-FT17- LEFT

CNP-FT18- RIGHT

CNP-FT18- LEFT

CNP-FT19- RIGHT

CNP-FT19- LEFT

CNP-FT20- RIGHT

CNP-FT20- LEFT

CNP-FT21- RIGHT

CNP-FT21- LEFT

CNP-FT22- RIGHT

CNP-FT22- LEFT

CNP-FT23- RIGHT

CNP-FT23- LEFT

CNP-FT24- RIGHT

CNP-FT24- LEFT

CNP-FT25- RIGHT

CNP-FT25- LEFT

CNP-FT26- RIGHT

CNP-FT26- LEFT

CNP-FT27- RIGHT

CNP-FT27- LEFT

CNP-FT28- RIGHT

CNP-FT28- LEFT

CNP-FT29- RIGHT

CNP-FT29- LEFT

CNP-FT30- RIGHT

CNP-FT30- LEFT

CNP-FT31- RIGHT

CNP-FT31- LEFT

CNP-FT32- RIGHT

CNP-FT32- LEFT

CNP-FT33- RIGHT

CNP-FT33- LEFT

CNP-FT34- RIGHT

CNP-FT34- LEFT

CNP-FT35- RIGHT

CNP-FT35- LEFT

CNP-FT36- RIGHT

CNP-FT36- LEFT

CNP-FT37- RIGHT

CNP-FT37- LEFT

CNP-FT38- RIGHT

CNP-FT38- LEFT

CNP-FT39- RIGHT

CNP-FT39- LEFT

CNP-FT40- RIGHT

CNP-FT40- LEFT

CNP-FT41- LEFT

CNP-FT42- RIGHT

CNP-FT42- LEFT

CNP-FT44- RIGHT

CNP-FT44- LEFT

CNP-FT45- RIGHT

CNP-FT45- LEFT

CNP-FT46- RIGHT

CNP-FT46- LEFT

CNP-FT47- RIGHT

CNP-FT47- LEFT

CNP-FT48- RIGHT

CNP-FT48- LEFT

CNP-FT49- RIGHT

CNP-FT49- LEFT

CNP-FT51- RIGHT

CNP-FT51- LEFT

CNP-FT52- RIGHT

CNP-FT52- LEFT

CNP-MT01- RIGHT

CNP-MT01- LEFT

CNP-MT02- RIGHT

CNP-MT02- LEFT

CNP-MT03- RIGHT

CNP-MT03- LEFT

CNP-MT04- RIGHT

CNP-MT04- LEFT

CNP-MT05- RIGHT

CNP-MT05- LEFT

CNP-MT06- RIGHT

CNP-MT06- LEFT

CNP-MT07- RIGHT

CNP-MT07- LEFT

CNP-MT08- RIGHT

CNP-MT08- LEFT

CNP-MT09- RIGHT

CNP-MT09- LEFT

CNP-MT10- RIGHT

CNP-MT10- LEFT

CNP-MT11- RIGHT

CNP-MT11- LEFT

CNP-MT12- RIGHT

CNP-MT12- LEFT

CNP-MT13- RIGHT

CNP-MT13- LEFT

CNP-MT14- RIGHT

CNP-MT14- LEFT

CNP-MT15- RIGHT

CNP-MT15- LEFT

CNP-MT16- RIGHT

CNP-MT16- LEFT

CNP-MT17- RIGHT

CNP-MT17- LEFT

CNP-MT18- RIGHT

CNP-MT18- LEFT

CNP-MT19- RIGHT

CNP-MT19- LEFT

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CNP-MT20- LEFT

CNP-MT21- RIGHT

CNP-MT21- LEFT

CNP-MT22- RIGHT

CNP-MT22- LEFT

CNP-MT23- RIGHT

CNP-MT23- LEFT

CNP-MT24- RIGHT

CNP-MT24- LEFT

CNP-MT25- RIGHT

CNP-MT25- LEFT

CNP-MT26- RIGHT

CNP-MT26- LEFT

CNP-MT27- RIGHT

CNP-MT27- LEFT

CNP-MT28- RIGHT

CNP-MT28- LEFT

CNP-MT29- RIGHT

CNP-MT29- LEFT

CNP-MT30- RIGHT

CNP-MT30- LEFT

CNP-UT01- RIGHT

CNP-UT01- LEFT

CNP-UT02- LEFT

CNP-UT04- LEFT

CNP-UT05 LEFT

CNP-UT06- RIGHT

CNP-UT06- LEFT

TIGERS OF BANKE NATIONAL PARK AND ADJOINING FORESTS

BaNP-MT86-RIGHT

BaNP-MT86-LEFT

BaNP-FT87-RIGHT

BaNP-FT87-LEFT

BaNP-FT88-RIGHT

BaNP-FT88-LEFT

BaNP-MT92-RIGHT

BaNP-MT92-LEFT

BaNP-FT94-RIGHT

BaNP-FT94-LEFT

BaNP-MT95-RIGHT

BaNP-MT95-LEFT

BaNP-MT96-RIGHT

BaNP-MT96-LEFT

BaNP-FT97-RIGHT

BaNP-FT97-LEFT

BaNP-FT98-RIGHT

BaNP-FT98-LEFT

BaNP-FT99-RIGHT

BaNP-FT99-LEFT

BaNP-FT100-RIGHT

BaNP-FT100-LEFT

BaNP-MT101-RIGHT

BaNP-MT101-LEFT

BaNP-FT115-RIGHT

BaNP-FT115-LEFT

BaNP-FT117-RIGHT

BaNP-FT117-LEFT

BaNP-MT118-RIGHT

BaNP-MT118-LEFT

BaNP-FT119-RIGHT

BaNP-FT119-LEFT

BaNP-UT120-RIGHT

BaNP-UT120-LEFT

TIGERS OF BARDIA NATIONAL PARK AND ADJOINING FORESTS

BNP-MT01-RIGHT

BNP-MT01-LEFT

BNP-MT02-RIGHT

BNP-MT02-LEFT

BNP-FT03-RIGHT

BNP-FT03-LEFT

BNP-MT05-RIGHT

BNP-MT05-LEFT

BNP-FT06-RIGHT

BNP-FT06-LEFT

BNP-FT07-RIGHT

BNP-FT07-LEFT

BNP-FT08-RIGHT

BNP-FT08-LEFT

BNP-MT09-RIGHT

BNP-MT09-LEFT

BNP-FT11-RIGHT

BNP-FT11-LEFT

BNP-FT14-RIGHT

BNP-FT14-LEFT

BNP-FT15-RIGHT

BNP-FT15-LEFT

BNP-MT16-RIGHT

BNP-MT16-LEFT

BNP-FT17-RIGHT

BNP-FT17-LEFT

BNP-FT18-RIGHT

BNP-FT18-LEFT

BNP-FT19-RIGHT

BNP-FT19-LEFT

BNP-MT20-RIGHT

BNP-MT20-LEFT

BNP-FT21-RIGHT

BNP-FT21-LEFT

BNP-MT22-RIGHT

BNP-MT22-LEFT

BNP-FT23-RIGHT

BNP-FT23-LEFT

BNP-MT24-RIGHT

BNP-MT24-LEFT

BNP-MT25-RIGHT

BNP-MT25-LEFT

BNP-FT26-RIGHT

BNP-FT26-LEFT

BNP-FT28-RIGHT

BNP-FT28-LEFT

BNP-MT29-RIGHT

BNP-MT29-LEFT

BNP-FT32-RIGHT

BNP-FT32-LEFT

BNP-FT34-RIGHT

BNP-FT34-LEFT

BNP-FT36-RIGHT

BNP-FT36-LEFT

BNP-FT37-RIGHT

BNP-FT37-LEFT

BNP-MT38-RIGHT

BNP-MT38-LEFT

BNP-FT39-RIGHT

BNP-FT39-LEFT

BNP-FT40-RIGHT

BNP-FT40-LEFT

BNP-MT41-RIGHT

BNP-MT41-LEFT

BNP-MT42-RIGHT

BNP-MT42-LEFT

BNP-FT43-RIGHT

BNP-FT43-LEFT

BNP-MT44-RIGHT

BNP-MT44-LEFT

BNP-FT45-RIGHT

BNP-FT45-LEFT

BNP-MT46-RIGHT

BNP-MT46-LEFT

BNP-MT49-RIGHT

BNP-MT49-LEFT

BNP-FT50-RIGHT

BNP-FT50-LEFT

BNP-FT53-RIGHT

BNP-FT53-LEFT

BNP-UT54-RIGHT

BNP-UT54-LEFT

BNP-UT55-RIGHT

BNP-UT55-LEFT

BNP-UT56-RIGHT

BNP-UT56-LEFT

BNP-UT57-LEFT

BNP-MT58-RIGHT

BNP-MT58-LEFT

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BNP-FT60-RIGHT

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BNP-UT64-RIGHT

BNP-UT64-LEFT

BNP-UT65-RIGHT

BNP-UT65-LEFT

BNP-FT66-RIGHT

BNP-FT66-LEFT

BNP-MT67-LEFT

BNP-FT69-RIGHT

BNP-FT69-LEFT

BNP-FT70-RIGHT

BNP-FT70-LEFT

BNP-MT71-RIGHT

BNP-MT71-LEFT

BNP-FT72-RIGHT

BNP-FT72-LEFT

BNP-FT73-RIGHT

BNP-FT73-LEFT

BNP-MT74-RIGHT

BNP-MT74-LEFT

BNP-FT75-RIGHT

BNP-FT75-LEFT

BNP-FT76-RIGHT

BNP-FT76-LEFT

BNP-MT77-RIGHT

BNP-MT77-LEFT

BNP-FT78-RIGHT

BNP-FT78-LEFT

BNP-MT82-RIGHT

BNP-MT82-LEFT

BNP-FT84-RIGHT

BNP-FT84-LEFT

BNP-MT85-RIGHT

BNP-MT85-LEFT

BNP-FT89-RIGHT

BNP-FT89-LEFT

BNP-FT91-RIGHT

BNP-FT91-LEFT

BNP-FT93-RIGHT

BNP-FT93-LEFT

BNP-FT104-RIGHT

BNP-FT104-LEFT

BNP-MT105-RIGHT

BNP-MT105-LEFT

BNP-MT106-RIGHT

BNP-MT106-LEFT

BNP-FT109-RIGHT

BNP-FT109-LEFT

BNP-FT110-RIGHT

BNP-FT110-LEFT

BNP-UT111-RIGHT

BNP-UT111-LEFT

BNP-MT112-RIGHT

BNP-MT112-LEFT

TIGERS OF SHUKLAPHANTA NATIONAL PARK AND ADJOINING FORESTS

ShNP-FT02-RIGHT

ShNP-FT02-LEFT

ShNP-FT03-RIGHT

ShNP-FT03-LEFT

ShNP-FT04-RIGHT

ShNP-FT04-LEFT

ShNP-FT06-RIGHT

ShNP-FT06-LEFT

ShNP-FT07-RIGHT

ShNP-FT07-LEFT

ShNP-FT08-RIGHT

ShNP-FT08-LEFT

ShNP-MT01-RIGHT

ShNP-MT01-LEFT

ShNP-MT02-RIGHT

ShNP-MT02-LEFT

ShNP-MT03-RIGHT

ShNP-MT03-LEFT

ShNP-MT06-RIGHT

ShNP-MT06-LEFT

ShNP-MT07-RIGHT

ShNP-MT07-LEFT

ShNP-MT08-RIGHT

ShNP-MT08-LEFT

ShNP-MT09-RIGHT

ShNP-MT09-LEFT

ShNP-MT10-RIGHT

ShNP-MT10-LEFT

ShNP-MT11-RIGHT

ShNP-MT11-LEFT

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