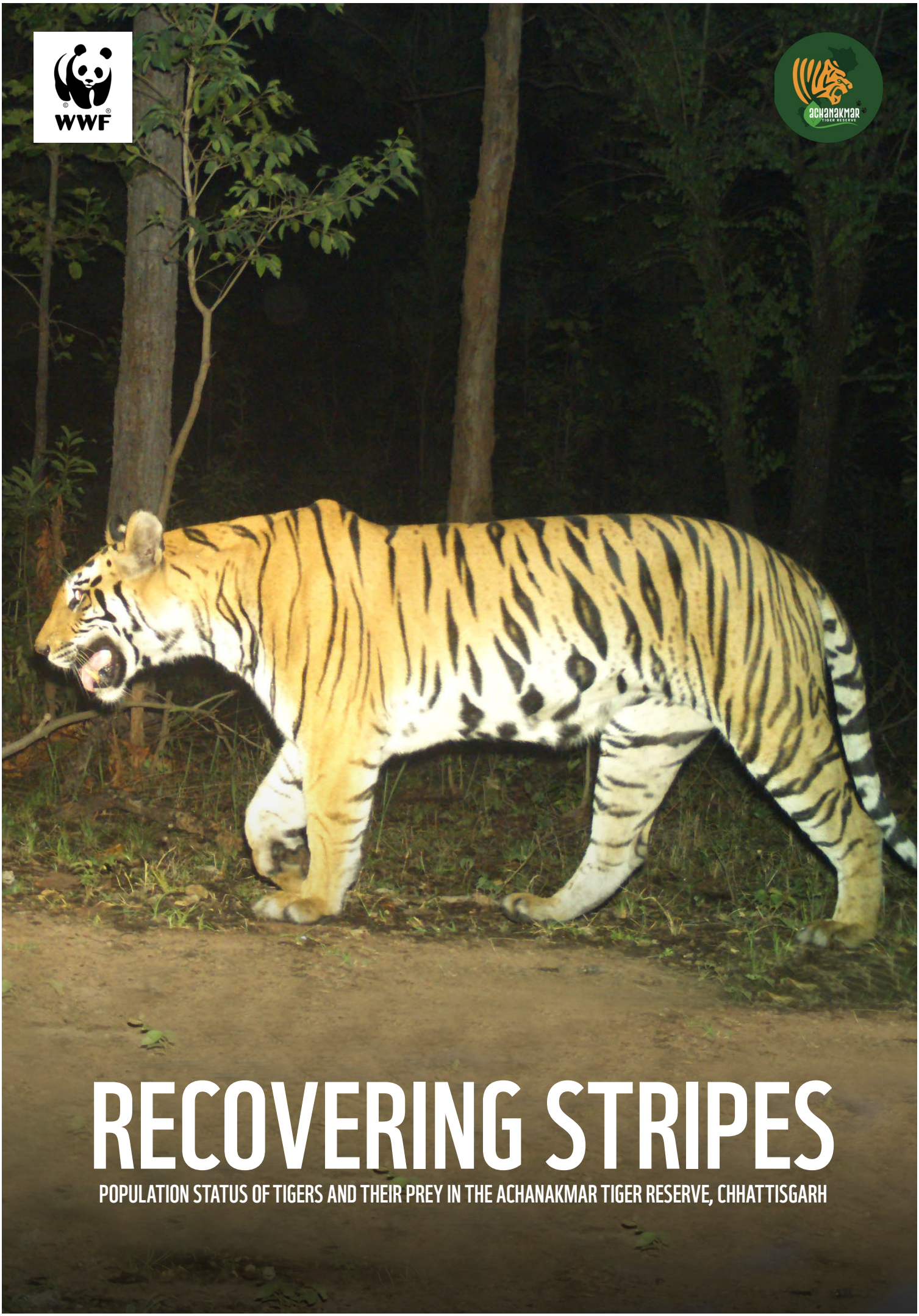

RECOVERING STRIPES

POPULATION STATUS OF TIGERS AND THEIR PREY IN THE ACHANAKMAR TIGER RESERVE, CHHATTISGARH

Report by:
World Wide Fund for Nature-India (WWF-India)

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FOREWORD

Tiger conservation has garnered global attention due to the highly endangered status of this iconic species. Despite sustained efforts, tigers continue to face significant threats, including poaching, habitat loss, fragmentation of movement corridors, and human-tiger conflict. Addressing these challenges requires a multi-faceted approach, incorporating scientific monitoring, robust protection measures, and effective enforcement strategies.

Achanakmar Tiger Reserve (ATR), located in Chhattisgarh, spans 914.02 km^2 and forms a critical part of the Kanha-Achanakmar corridor. This landscape supports rich biodiversity and plays a vital role in tiger conservation by facilitating genetic exchange between tiger populations. Through dedicated conservation initiatives, ATR has observed encouraging trends in tiger recovery.

The Department of Forest and Climate Change, Government of Chhattisgarh, has been actively engaged in wildlife conservation at ATR, with WWF-India providing crucial technical support. This Tiger and Prey Status Report presents a comprehensive assessment of the current status of tiger populations and prey availability in ATR. Based on rigorous scientific methodologies, the findings offer valuable insights into population trends, habitat connectivity, and emerging conservation challenges. These assessments are instrumental in shaping effective strategies for the long-term protection and management of wildlife in the reserve.

I extend my sincere appreciation to the officials and staff of Achanakmar Tiger Reserve, along with their partners at WWF-India and all stakeholders, for their unwavering commitment to tiger conservation in Chhattisgarh. Their collective efforts continue to strengthen the future of this keystone species and its habitat.

3/3/2025

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Principal Chief Conservator of Forests (Wildlife)
& Chief Wildlife Warden, Chhattisgarh

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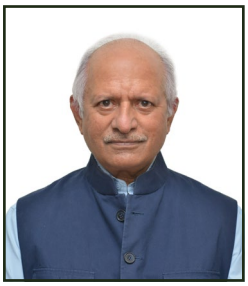
FOREWORD



The Achanakmar Tiger Reserve (ATR), cradled in the Maikal Hills of the Satpura range, is a vital link in India's tiger conservation landscape. It connects Kanha and Bandhavgarh Tiger Reserves, thus facilitating the movement of tigers and other wildlife across Central India. With its diverse habitats and functional corridors, ATR plays a key role in sustaining biodiversity and supporting a growing tiger population.

Beyond its ecological significance, ATR symbolises resilience. Once home to just a minuscule number of tigers, the reserve is now witnessing a slow yet promising recovery. This progress, however, hinges on a deeper understanding of prey availability, habitat connectivity, and long-term conservation strategies. Continuous monitoring and habitat management remain crucial in securing the future of these apex predators.

The report, ***RECOVERING STRIPES- Population of tigers and prey in Achanakmar Tiger Reserve***, offers critical insights into tiger population trends, prey densities, and movement patterns in ATR. It helps assess the reserve's carrying capacity and the effectiveness of ongoing conservation efforts-at a time when habitat fragmentation and human-wildlife interactions are reshaping India's forests.

The report is more than just an assessment—it is a call to action, Strengthening protection measures, improving habitat conditions, and fostering collaboration will ensure that ATR remains a thriving landscape for both the tigers and their prey.

WWF-India, in collaboration with the Chhattisgarh Forest Department, remains committed to strengthening conservation in ATR through research, habitat management, and community-driven initiatives.

Ravi Singh

SG and CEO, WWF-India

ACKNOWLEDGEMENT

This report is prepared as part of the Memorandum of Understanding (MoU) signed between the Forest Department of Chhattisgarh and WWF-India, which establishes a long-term collaboration aimed at tiger recovery in Achanakmar Tiger Reserve. We express our sincere gratitude to Mr M. K. Pandey, Field Director of Achanakmar Tiger Reserve, and Mr U. R. Ganesh, Deputy Director of Achanakmar Tiger Reserve, for their invaluable support throughout the project and for sharing the necessary data that formed the foundation of this study.

We also commend the frontline staff of Achanakmar Tiger Reserve for their tireless efforts during the field surveys. Their hard work and commitment were instrumental in the successful execution of this project. Additionally, we extend our heartfelt thanks to our field assistants—Mr Mahaveer, Mr Rakesh Kumre, Mr Ravindra Mahale, and Mr Vinod Yadav—for their unwavering dedication and contributions during the fieldwork, which were vital to the study's successful completion.

SUMMARY

Achanakmar Tiger Reserve (ATR) in Chhattisgarh, India, is a key recovery site for tiger conservation. The population status and trend of tigers and prey in ATR were assessed using camera trap data from the year 2017 to 2024 and line transect data from 2019 & 2024. There is evidence for progressive recovery of the 'tiger population over this period, with 10 resident tigers being photo-captured in 2024, relative to 5 in 2017. The ratio of male: female tigers (4:1 in 2017), is now 3:7 in 2024.

Wild ungulate densities also appear to be showing an upward trend, from 27.4 ± 3.52 individuals/ km² to 35.41 ± 4.93 individuals/km² between 2019 and 2024. Ungulate densities were highest in the Achanakmar and Chhaparwa ranges, which coincide with areas that have been constantly used by multiple tigers over the study period. Conversely, other ranges like Lamni and Surahi were associated with lower prey densities and tiger presence, suggesting potential for future recovery efforts. The report emphasises the crucial role of the Kanha–Achanakmar and Bandhavgarh–Achanakmar corridors, and sustained management efforts in enabling tiger population recovery in ATR. Despite signs of recovery, strategic management, protection, and community engagement initiatives will be critical to ensure the long term persistence of tigers in ATR.

01

INTRODUCTION

Achanakmar Tiger Reserve (ATR) is one of three tiger reserves in the Indian state of Chhattisgarh and a key part of the state's tiger conservation story. It is located in the Mungeli district, covering an area of 914 km², with a core zone of 626.19 km² and a buffer zone of 287.82 km² (Mandal *et al.*, 2017). Situated in the Maikal Hills of Chhattisgarh, ATR is an important component of the Central Indian Tiger Landscape. The Reserve was initially notified as a wildlife sanctuary in 1975 and was subsequently declared a tiger reserve in 2009 under the Project Tiger initiative. It forms the core zone of the larger Achanakmar-Amarkantak Biosphere Reserve, which spans across Chhattisgarh and Madhya Pradesh (Mandal *et al.*, 2017). The terrain of ATR is varied, ranging in elevation from approximately 500 to 1100 meters above sea level, and is characterised by undulating hills and dense forest cover.

The forest type is predominantly tropical moist deciduous, with a canopy structure largely dominated by sal (*Shorea robusta*) and teak (*Tectona grandis*), along with its associates such as: tendu (*Diospyros melanoxylon*), achar (*Buchanania cochinchinensis*), mahua (*Madhuca longifolia*), haldu (*Haldina cordifolia*), sejha (*Lagerstroemia parviflora*), palash (*Butea monosperma*) etc. The floral diversity supports a rich assemblage of faunal species which includes large carnivores such as tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*), meso-carnivores; striped hyena, golden jackal, small carnivores; rusty-spotted cat (*Prionailurus rubiginosus*), jungle cat (*Felis chaus*), Bengal fox (*Vulpes bengalensis*) and herbivores such as gaur (*Bos gaurus*), sambar (*Rusa unicolor*), chital (*Axis axis*), barking deer (*Cervus muntjac*) and wild pig (*Sus scrofa*). The Reserve also supports a good diversity of avifauna.

ATR experiences a tropical monsoon pattern, with high temperatures during summer, substantial rainfall during the monsoon season, and cooler conditions in winter. There are 19 villages within the Tiger Reserve's boundary. The major indigenous communities living in and around the Reserve are Baiga, Gond, and Kanwar, that are traditionally forest dependent. These communities engage in subsistence agriculture and collect minor forest produce, and fuelwood, which often leads to significant interaction with the forest ecosystem.

The Maniyari River constitutes the principal hydrological feature of Achanakmar Tiger Reserve (ATR). Originating from the Lamni Range within the Reserve, the river flows in a southeasterly direction, traversing the forested landscape before merging with the Seonath River near the southern boundary of Bilaspur district. Although largely seasonal, the Maniyari River system is sustained by forest springs, which provide perennial water availability and play a critical role in maintaining ecological balance throughout the year, especially during the dry season. The river supports a network of riparian habitats and is fed by multiple tributaries and associated water bodies, including Amanala, Mati Nala, Ranjki Nala and Sihawal-sagar. These interconnected water systems contribute significantly to the moisture regime of ATR, and serve as essential water sources for the Reserve's rich biodiversity.

ATR plays a crucial role in the tiger corridor network of Central India, connecting the Kanha Tiger Reserve (KTR) in the south west and Bandhavgarh Tiger Reserve (BTR) in the north

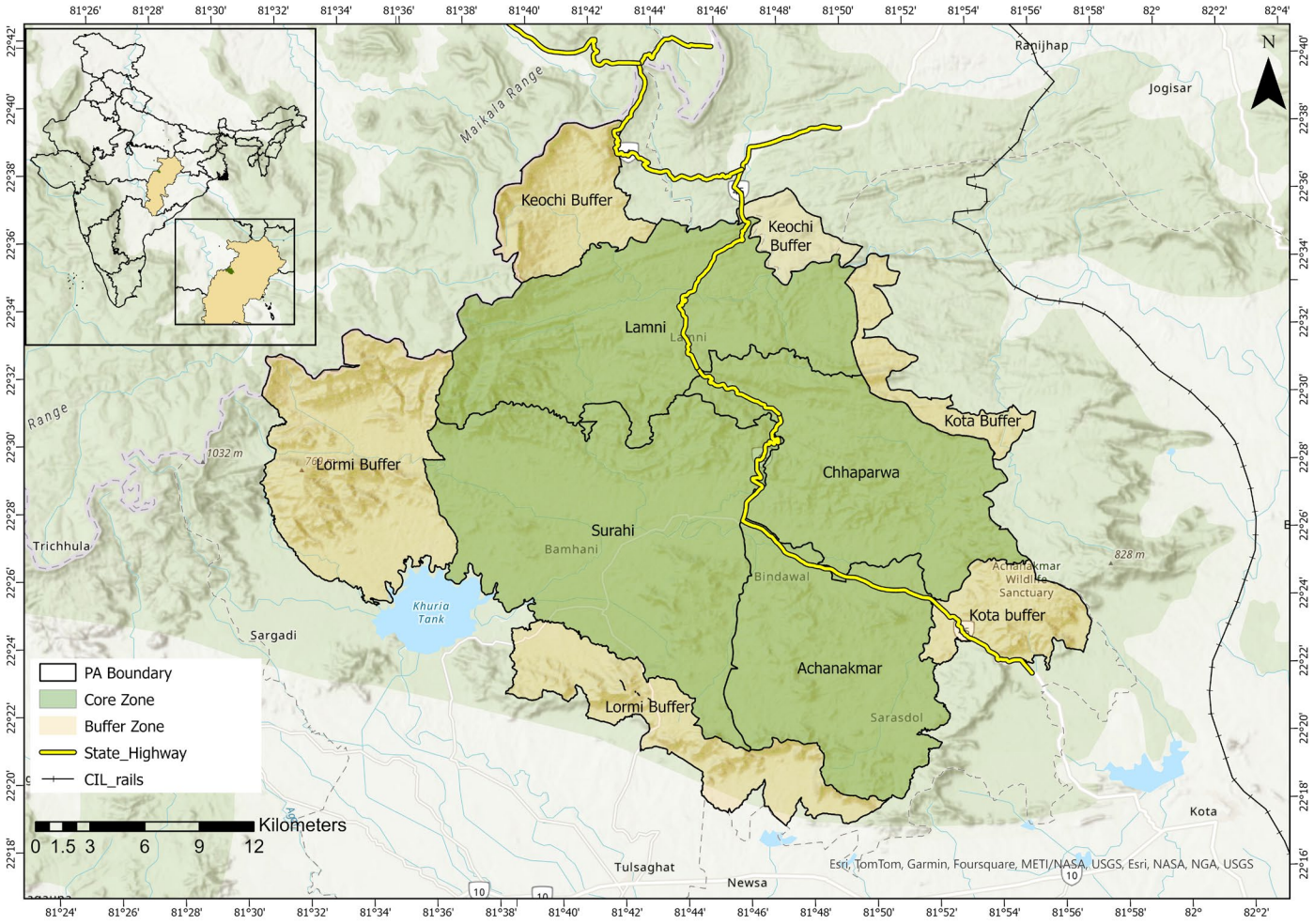


Figure 1: Achanakmar Tiger Reserve with core and buffer zone.

west through corridors (Yumnam *et al.* 2014, Dutta *et al.* 2016). These corridors (Figure 5) are crucial for the movement of tigers and other long ranging mammals, helping maintain genetic diversity and sustainable populations. There have been many reports of tiger dispersal from KTR and BTR into ATR in recent years. However, despite structural and functional connectivity and vast areas of suitable habitat in ATR, the Reserve historically supported a low resident tiger population. For example, the 2010, 2014, and 2018 All India Tiger Estimation (AITE) surveys recorded one, three, and five tigers respectively within the Reserve (Jhala *et al.*, 2015; Jhala *et al.*, 2019).

The presence of tigers in the Achanakmar landscape has been historically acknowledged through British era hunting records and early forest working plans, which noted regular sightings across the dense sal and mixed forests of the Maikal Hills (FSI, 2002; Choudhury, 1970). Before the establishment of formal protection mechanisms, tiger populations in the region were under pressure from hunting, timber extraction, and habitat degradation. During the 1970s and 1980s, Achanakmar was srecognised as a potential tiger habitat, though it remained outside the purview of Project Tiger until 2009. Fragmentation and anthropogenic pressures increased in the 1990s, but indirect evidence, such as pugmark surveys, suggested a low but persistent tiger population (Panwar, 1993; WII, 2005). In the early 2000's, ecological assessments identified Achanakmar as a critical component of the Central Indian Tiger Landscape due to its role in maintaining connectivity with Kanha and other reserves (Jhala *et al.*, 2008). Following the recommendation of the National Tiger Conservation Authority (NTCA), Achanakmar was declared a Tiger Reserve in 2009, formalising conservation efforts. Over the past three years, there have been tangible signs of tiger recovery, likely due to protection and management actions. Since December 2023, 10 tigers have been recorded consistently in the camera traps, and at least three tigresses in the Reserve have raised a litter of 2-3 cubs.

This report aims to understand the population status and trends of tigers in ATR. It further estimates wild ungulate density in ATR and explores the functional connectivity. Based on these results, the report provides management recommendations.

02

METHODOLOGY

a) Camera trapping:

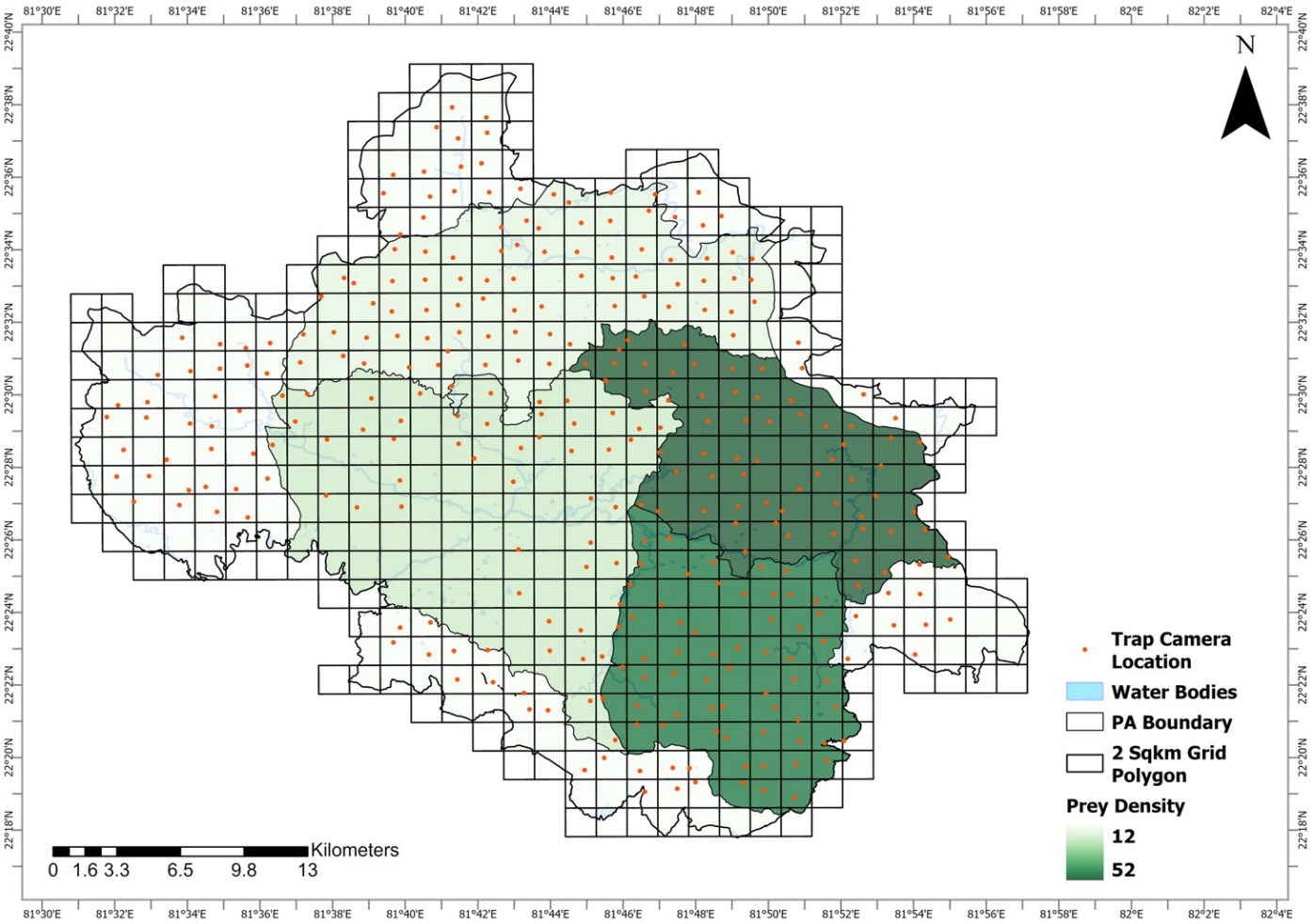
The camera trapping exercise was conducted as a part of the All India Tiger Estimation (Phase IV monitoring) in 2023 and 2024. A standard grid size of 2 km X 2 km was overlaid on the ATR map (Figure 2a). The sampling was done in two blocks with a sampling period of 25 days. Paired camera traps were deployed in each grid at a strategic location to maximise the probability of tiger captures. The survey design, camera trap locations and the sampling duration were the same across the two sampling years. A total of 322 grids were covered in each sampling year, with a minimum convex polygon area of 644 km^2. Individual tigers were identified based on striped patterns. Tigers, approximately two years of age and older (post dispersal) were identified based on their distinct stripe patterns.

b) Line transect sampling:

The total number of transects walked in 2019 was 104, and in 2024 was 106. The total effort in 2019 was 570 km, while in 2024 it was 636 km. While in core zone, a total of 76 and 77 line transects with two to three temporal replicates were sampled in 2019 and 2024 (Figure 2b), respectively, while a total of 28 and 29 line transects were sampled in the buffer zone, in 2019 and 2024 respectively, with the placement of one transect line per forest beat. Thus, the sampling effort across sampling years was comparable: 438 km and 462 km in the core zone in 2019 and 2024, respectively, while the survey effort was 132 km and 174 km in the buffer zone in 2019 and 2024, respectively. The transects were surveyed during peak activity hours by WWF-India volunteers in 2019 and by

forest department staff in 2024. On sighting an ungulate, species identification (ID), cluster size, radial distance, angle, GPS coordinates, forest types and terrain types were recorded. Wild ungulates detected on line transects included gaur (*Bos gaurus*), sambar (*Rusa unicolor*), barking deer (*Cervus mantjac*), chital (*Axis axis*) and wild pig (*Sus scrofa*). Group sizes varied between one individual to 35 individuals in 2019 and one individual to 29 individuals in 2024. Sambar was the least sighted species in both the sampling years. Interestingly, barking deer were sighted nearly three times more frequently in 2019 (n = 61) than in 2024 (n = 22). Due to the low number of detections in both 2019 and 2024, it was not possible to estimate sambar densities. Similarly, there were too few barking deer detections in 2024 to estimate its density.

The line transect data were analysed using conventional distance sampling (CDS) in the programme Distance 8.0 to estimate animal densities (Thomas *et al*. 2010). Three key detection functions, half normal, hazard rate and uniform were fitted to the data along with three adjustment terms: cosine, simple polynomial and hermite polynomial. All combinations of these detection functions and adjustment terms were run. The data was truncated for the farthest observations (120 and 90 meters in the 2019 and 2024 datasets) based on the visual inspection model histograms. Data were also checked for heaping, responsive movement, over-dispersion and other observer biases and corrected using appropriate data filters. The best fit model was selected based on AIC and goodness-of-fit test.



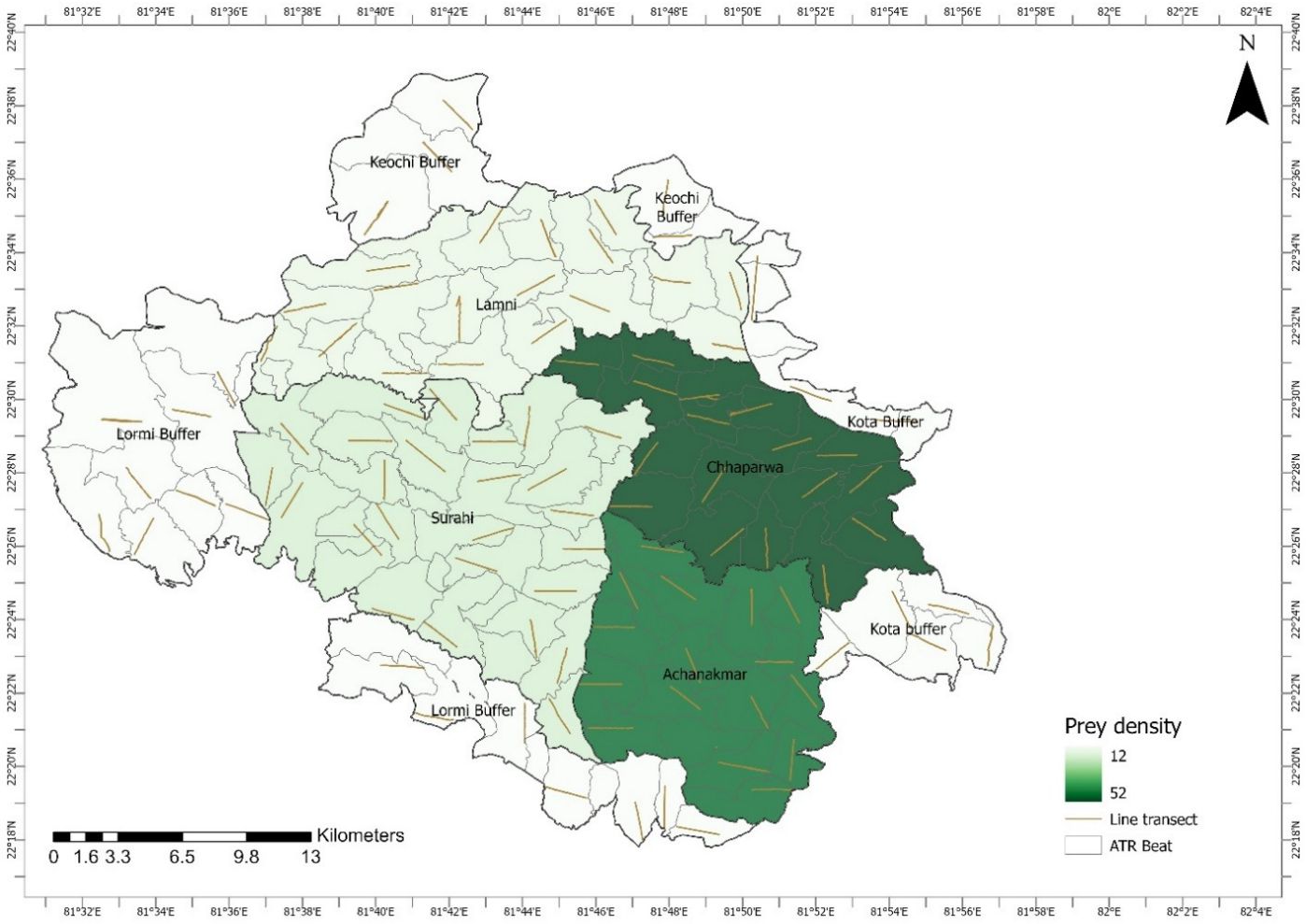


Figure 1: Distribution of a) camera trap points in the study area, and b) line transects in 2024 with estimated wild ungulate density (individuals/ km²) in each range. Darker shades show areas with higher density. The density includes five ungulate species: gaur, sambar, barking deer, chital and wild pig.

03

RESULTS

3.1 Population status and movement ranges of tigers: An overview from the past and present

Camera trap surveys show that recorded tiger numbers in ATR have fluctuated between one and 10 individuals since 2010 (Jhala *et al.* 2011) (Figure 3). Only three individuals were recorded as residents in the Tiger Reserve for more than five years during the 9-year period. Most other individuals have been photo-captured for one to two years. Of the 10 individuals recorded in 2024, two are known to have dispersed from BTR and two from KTR (Figure 5). The habitat connectivity of ATR with Protected Areas in Madhya Pradesh and other tiger occupied forests has been crucial to the repopulation of tigers in the Reserve. Yet, in the last decade, only three individuals have established territories and been resident in the Reserve for multiple years. There have been positive signs of tiger recovery over the past two years in particular: for example, the sex ratio is healthy (six adult females: two adult males), whereas in previous years, there were more males in the Reserve than females. As of 2024, two females currently resident in the Reserve are raising litters of two cubs each.

3.1.1 Population status and trend:

In 2017, there were five tigers in ATR, one female and four males. In 2018, there were three females and two males. Two male tigers (T3, T6) recorded in 2017 were not recorded in 2018, and two female tigers (T2, T8) immigrated into ATR. The population size dropped to four individuals in 2020, with one female (T1) from previous years undetected. In 2021, one of these males (T7) and two females (T2 & T8) were photo-captured for the third year consecutively, and T2 bred in ATR. The male-to-female sex ratio in 2021 fluctuated within the year from 3:3 to 2:3,

with one male (T10) returning to KTR and the death of a female (T11) due to an injury.

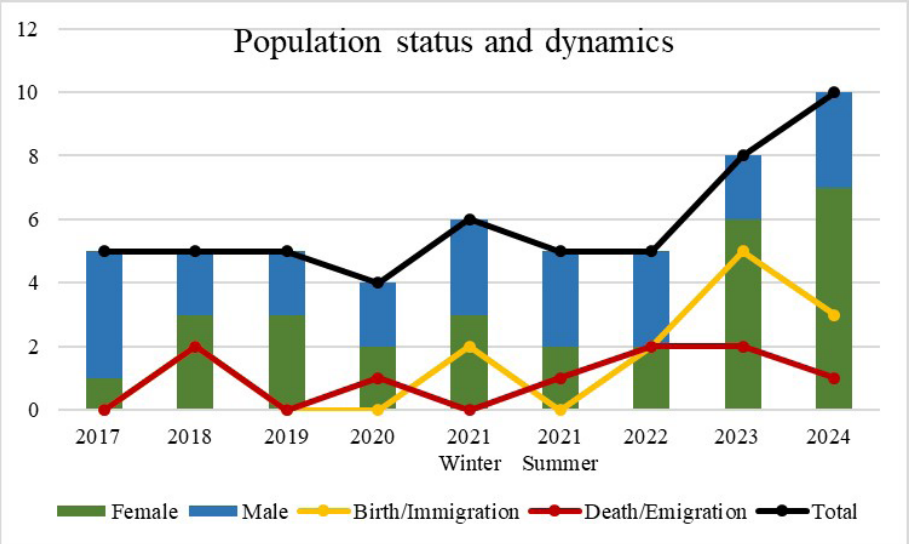
In 2023, there was a marked increase in the population size with the immigration of four individuals (females T13, T14, T17 & male T15), which exceeded the absences from the population (two individuals, male T7 & T12) who either emigrated out or died. The male tiger T7, which was photo-captured in the Reserve since 2017, was not captured in camera traps in 2023 & 2024, and has also not been detected in connected tiger reserves. However, the four females that were recorded in 2023 were photo recaptured in 2024. One new male tiger (male T20) was also detected in the Reserve. The tiger population in ATR now consists of 10 individuals (Figure 2). This number also includes the two sub-adult individuals of the first litter successfully raised by T8.

The Reserve now holds seven females and three male tigers, with regular dispersal into the population from the nearby tiger reserves. This attests to the functionality of the corridors and underscores the critical importance of corridors in enabling population recovery in sites like ATR. If tigers in the Reserve continue to reproduce, and if survival rates (especially of females) are sufficiently high, the population is expected to grow. Harihar *et al.* (2018) set the target tiger population density at 3.86 ± 0.3 individuals per 100 km² for ATR, corresponding to approximately 19 individuals.

3.1.2 Tiger space use:

Spatial data on capture records for individual tigers from camera traps 2023 – 2024 allows us to develop a density hotspot. The camera trap distribution indicates that tigers are using about 50% of the area, highlighting the restricted spatial distribution within the Reserve (Figure 4). The Chhaparwa and Achanakmar ranges have the highest prey density (Table 1). These two ranges have also recorded the presence of all 10 tigers in the Reserve with eight tigers ranging almost entirely in these ranges. Wild ungulate densities are lower in the other ranges of ATR. The prey density is low (18.48 ± 6.81 & 22.66 ± 5.42 individuals of ungulates/ km²) in the Lamni and Surahi ranges and very low (12.31 ± 3.03 individuals of ungulates/ km2) in the buffer zone. As of 2024,, two tigers (T2 & T17) are moving in the buffer zone (Keonchi & Kota buffer) where wild prey density is about 12 individuals/km² .

Figure 3: Population status of tigers in ATR.



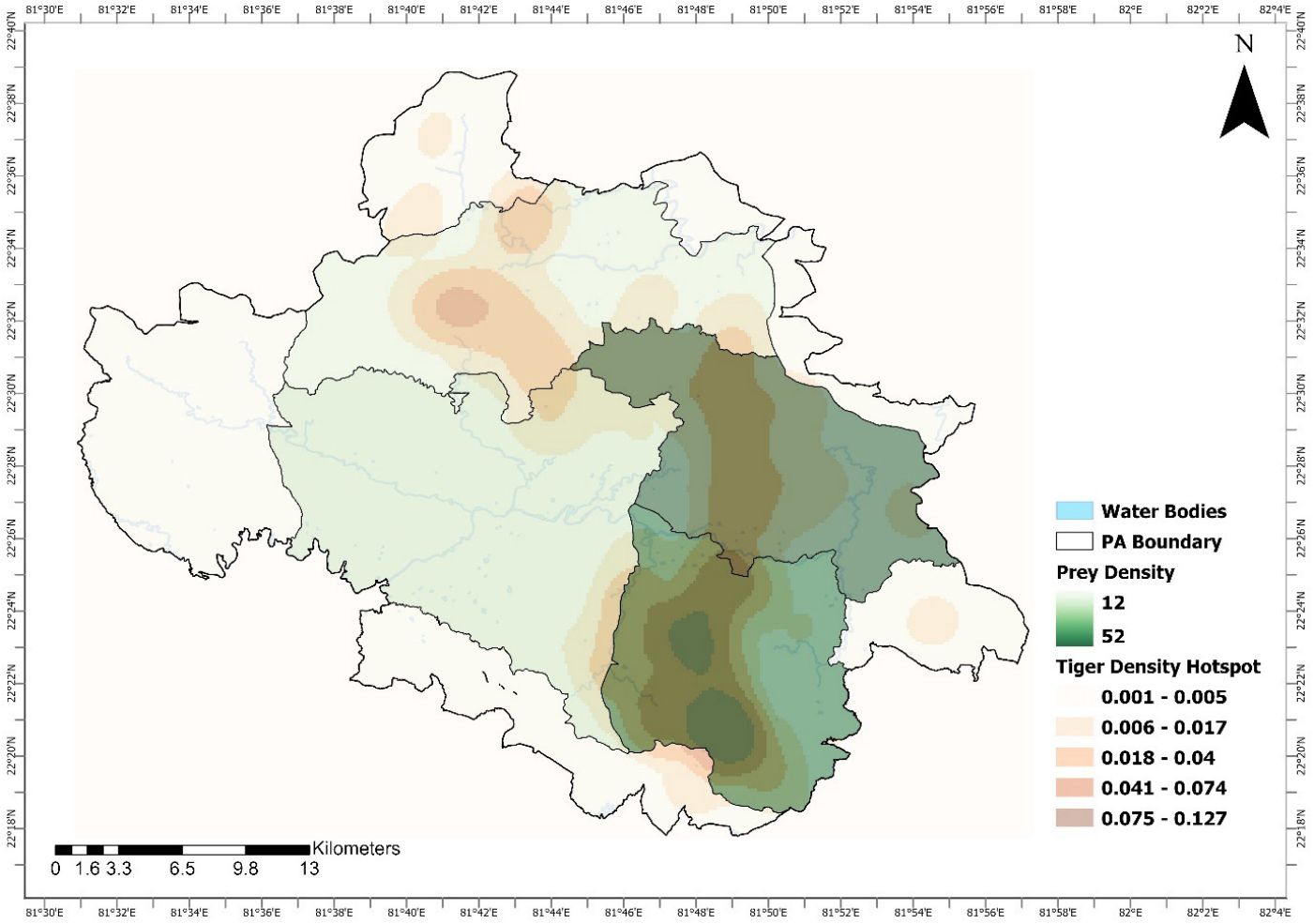


Figure 4: Tiger space use in Achanakmar Tiger Reserve (2023–2024). The background map (shades of green) illustrates spatial variation in prey (wild ungulate) densities at the range level. Kernel densities representing the intensity of tiger use of an area are overlaid (shades of beige) and are based on camera trap capture records.

3.2 Population status of wild ungulates:

In the core zone, there were 260 wild ungulate detections in 2019 and 198 detections in 2024. In the buffer zone, there were 41 detections in 2019 and 42 detections in 2024. Chital was the most detected species (n=122 in 2019 and 79 in 2024), while sambar had the fewest detections (n=12 in 2019 and 11 in 2024). Chital and gaur had the largest recorded group sizes (29 for gaur & 25 for chital individuals in a group). Larger group sizes of wild ungulates were detected in Chhaparwa and Surahi ranges compared to the Lamni range and buffer zone.

3.2.1 ATR Core:

Wild ungulate densities in ATR core (cumulative for five species) varied from 27.4 ± 3.52 individuals/km² in 2019 to 35.41 ± 4.93 individuals/km² in 2024. The Chhaparwa range holds the highest density of wild ungulates in both sampling years, followed by the Achanakmar range; however, the density varies significantly across sampling years (Table 1). In 2019, the wild ungulate population estimates in Chhaparwa range were 39.66 ± 7.59 individuals/km², whereas the 2024 estimate was 52.66 + 12. 0 individuals/km². A similar pattern was

observed for Achanakmar and Surahi ranges (Table 1). While this was not the case with the Lamni range of core, where estimated ungulate densities were similar across the two survey years, 20.23 ± 6.45 individuals/km² in 2019 and 18.48 ± 6.81 individuals/km² in 2024.

3.2.2 ATR Buffer:

The wild ungulate density in ATR buffer varied from 11.71 ± 3.81 individuals/km² in 2019 to 13.58 ± 3.23 individuals/km² in 2024. The number of detections in the buffer zone was insufficient to support rangewise analysis. Despite a lower sampling effort in 2019, the number of observations was higher, resulting in an increased encounter rate. While cluster density and cluster size were comparable between the two sampling years, the coefficient of variation (CV) remained high in both cases. This high CV is likely attributed to a relatively low number of detections and variable detection probabilities across the five ungulate species surveyed and habitat heterogeneity.

3.2.3 Species wise density in ATR:

Chital was the most abundant ungulate species in ATR in both 2019 (11.43 ± 2.08 individuals/km²) and 2024 (12.78 ± 2.29 individuals/km²), followed by gaur (5.54 ± 1.23 in 2019 and 8.59 ± 2.25 in 2024) (Table 2). Although density estimates for chital, gaur, and wild pig were higher in 2024 compared to 2019, encounter rates were notably higher in 2019. In contrast, detections of barking deer declined substantially, with insufficient detections in 2024 to allow density estimation, while in 2019, the estimated density was 1.09 ± 0.18 individuals/km² (Table 2). Consequently, assessing the current status of the barking deer population in ATR is challenging.

Table 1: Prey density estimates of core and buffer zone of ATR in 2019 & 2024. Here, the text in red shows a high Coefficient of variance (CV). The larger the CV, the lower the precision of the estimates.

Area	Range	Year	Density ± SE (Individuals/ km²)	CV	Cluster density	Estimated cluster size	ESW (meter)	Detection probability	Model definition	Encounter rate	No. of line transects	Effort (km)
ATR Core	All ranges	2019 (n=260)	27.4 ± 3.52	12.88	5.54 ± 0.60	4.94 ± 0.34	53.52	0.66	Hazard rate cosine	0.59	76	438
		2024 (n=198)	35.41 ± 4.93	13.93	5.62 ± 0.67	6.29 ± 0.44	38.11	0.42	Half normal with cosine	0.42	77	462
	Achanakmar	2019 (n=63)	30.66 ± 6.45	21.05	4.54 ± 0.76	6.74 ± 0.85	69.29	0.57	Hazard rate cosine	0.63	17	100
		2024 (n=51)	48.28 ± 12.8	26.66	4.91 ± 1.18	9.82 ± 1.13	54.04	0.6	Hazard rate with cosine	0.53	16	96
	Chhaparwa	2019 (n=107)	39.66 ± 7.59	19.15	10.30 ± 1.71	3.85 ± 0.36	49.93	0.45	Hazard rate cosine	1.02	18	104
		2024 (n=77)	52.66 + 12. 0	22.8	10.18 ± 2.04	5.16 ± 0.55	37.04	0.41	Hazard rate with cosine	0.75	17	102
	Lamini	2019 (n=40)	20.23 ± 6.45	31.93	5.13 ± 1.17	3.93 ± 0.87	44.25	0.44	Half normal cosine	0.45	16	88
		2024 (n=21)	18.48 ± 6.81	36.8	3.13 ± 0.93	5.90 ± 1.27	29.41	0.61	Half normal with cosine	0.18	19	114
	Surahi	2019 (n=61)	16.97 ± 3.82	22.54	3.66 ± 0.65	4.62 ± 0.63	56.97	0.58	Half normal cosine	0.41	25	146
		2024 (n=49)	22.66 ± 5.42	23.94	4.95 ± 0.89	4.57 ± 0.71	32.94	0.47	Half normal simple polynomial	0.32	25	150
ATR buffer	Keonchi, Lormi & Kota	2019 (n=41)	11.71 ± 3.81	32.53	3.24 ± 0.93	3.60 ± 0.54	47.86	0.53	Half normal cosine	0.31	28	132
		2024 (n=42)	13.58 ± 3.23	23.85	3.75 ± 0.73	3.61 ± 0.49	32.16	0.38	Half normal with cosine	0.24	29	174

Table 2: Density estimates for five ungulate species: gaur, sambar, chital, barking deer and wild pig in 2019 & 2024. Here, the text in red shows a high Coefficient of variance (CV).

Species	Year	Density +/- SE	CV	Cluster density	Estimated cluster size	ESW	Detection probability	Model definition	Encounter rate
Gaur	2019 (n=65)	5.54 ± 1.23	22.2	0.95 ± 0.18	5.8 ± 0.57	59.62	0.54	Hazard rate cosine	0.11
	2024 (n=60)	7.70 ± 1.85	24.08	1.12 ± 0.26	6.86 ± 0.93	42.01	0.47	Hazard rate cosine	0.09
Sambar	2019 (n=12)	The model did not yield reliable estimates results due to low detection.							
	2024 (n=11)								
Chital	2019 (n=122)	11.43 ± 2.08	18.19	1.88 ± 0.31	6.07 ± 0.44	56.83	0.47	Hazard rate cosine	0.21
	2024 (n=79)	12.78 ± 2.29	17.93	1.54 ± 0.24	8.27 ± 0.68	40.2	0.68	Half normal cosine	0.12
Barking deer	2019 (n=61)	1.09 ± 0.18	17.13	1.02 ± 0.17	1.06 ± 0.02	51.97	0.57	Hazard rate simple polynomial	0.1
	2024 (n=22)	The model did not yield reliable estimates results due to low detection.							
Wild pig	2019 (n=52)	4.11 ± 1.24	27.6	1.13 ± 0.71	3.62 ± 0.71	40.1	0.37	Half normal cosine	0.09
	2024 (n=59)	7.41 ± 1.91	25.89	1.68 ± 0.37	4.40 ± 0.57	27.57	0.31	Half normal cosine	0.09

04

FUNCTIONAL CONNECTIVITY WITH ACHANAKMAR TIGER RESERVE

The Bandhavgarh-Achanakmar-Kanha corridors have been used by dispersing tigers several times. Two female tigers, T8 and T11, dispersed from BTR in 2018 and 2021, respectively. A transient male T10 dispersed from KTR reached ATR and soon returned to the KTR. A long distance dispersal has also been recorded in ATR, as T14, originally from Pench Tiger Reserve (PTR), later dispersed to the ATR probably using the Kanha–Pench corridor and then the Kanha–Achanakmar corridor. Among the dispersed tigers, T8 successfully bred and has a litter size of two: one male and one female in the Reserve. The litter of T8 are now sub-adults and roaming inside the ATR.

A few tigers were captured only in one season, indicating transient movement through the Reserve. A few more dispersal records have been made from the nearby high tiger density areas (T13, T17); however, their previous locations could not be tracked. Such individuals are likely to be from other regions where regular camera trapping is absent. The evidence confirms the functional connectivity of the ATR with KTR and BTR.

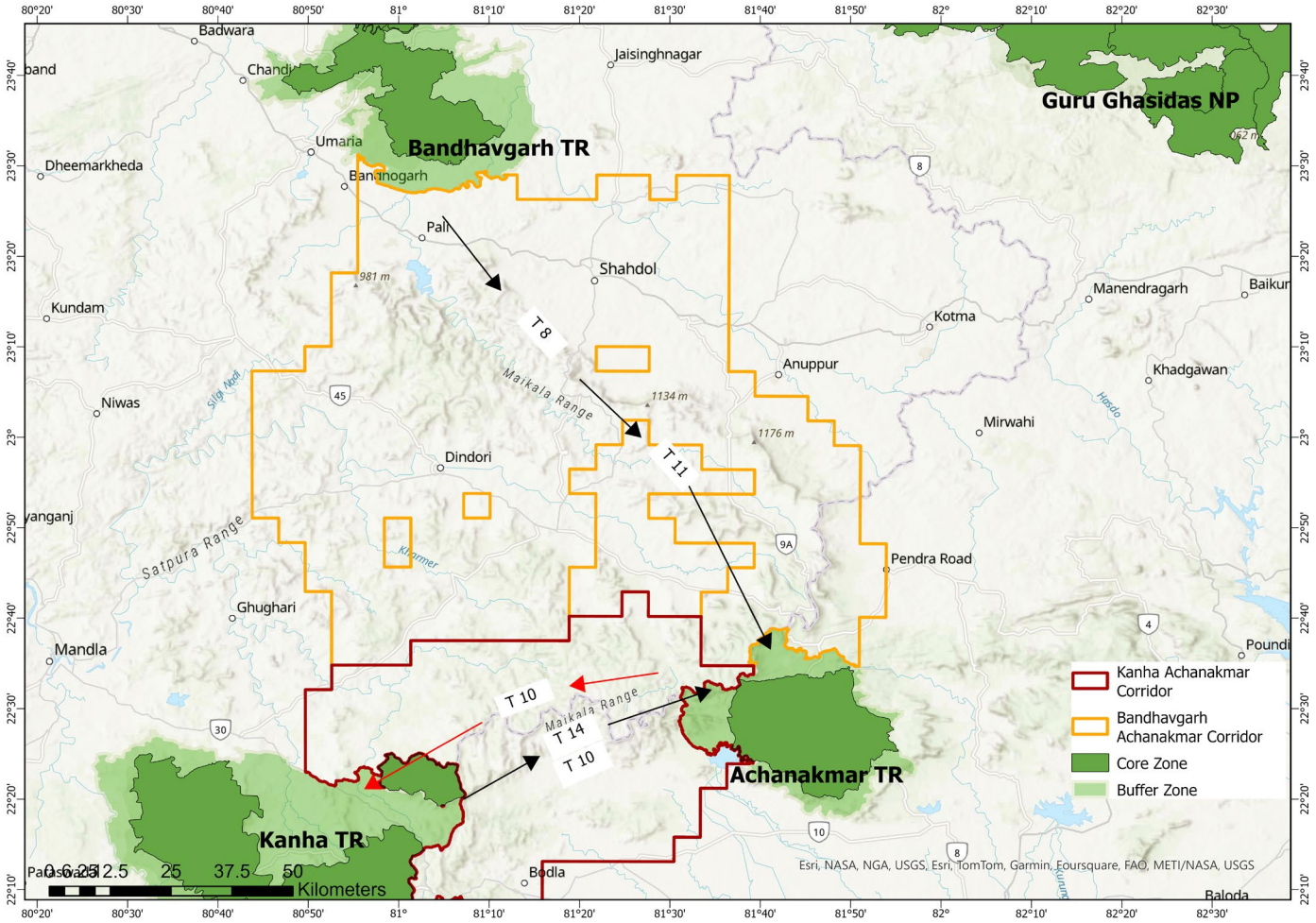


Figure 5: The Bandhavgarh-Achanakmar-Kanha complex. The map shows the structural connectivity of the Achanakmar TR with the Kanha TR and Bandhavgarh TR. The red arrow illustrates recent tiger emigration events, and the black arrow illustrates recent immigration events in the landscape.

05

DISCUSSION

The tiger population in ATR has increased to 10 individuals, rising from only a few incidental records reported previously (Jhala *et al.*, 2010; Harihar *et al.* 2018). This recovery is attributed to the immigration of tigers from other PAs and tiger habitats through wildlife corridors, enhanced protection and management efforts, increased prey density, and consistent monitoring. Despite this progress, a recent study by Jhala *et al.* (2025) highlights how small tiger populations in areas like ATR remain vulnerable to local extinction because of mortality driven by anthropogenic causes or stochastic factors. The long term viability of the tiger population in ATR will depend on sustained and adaptive management practices, effective protection measures, and active community participation in conservation. Harsh *et al.* (2016) reported persistent tiger presence near Protected Areas in the Kanha–Achanakmar corridor and documented frequent signs of large carnivores and prey species throughout the corridor. With continued conservation investment within the Reserve and in surrounding habitats and corridors, it holds the potential to become the key tiger source population within Chhattisgarh.

The tiger and prey population has shown spatial heterogeneity in ATR; high densities in Achanakmar & Chhaparwa ranges, while other ranges appear to be under-utilised. This might be attributed to habitat and resource heterogeneity. These localised patterns emphasise the potential of under-sutilised ranges within ATR for future recovery. These findings also strengthen the critical role of prey density as a key driver of tiger presence and population growth.

Given the habitat heterogeneity and spatial variation in density, estimating the spatial density and factors underlying spatial variation in wild ungulate densities becomes crucial. Generating such insights is contingent on high-quality line transect data, which can be achieved by rigorous staff training and participation of experienced volunteers in surveys.

Inferring trends in wild ungulate densities

Results from the present study indicate that wild ungulate densities have increased in ATR. The density seems to be increasing in the core zone over last five years and continue to remain stable in Lamni range of core and buffer zone. Gaur and wild pig densities have contributed to the rise in prey density, while chital density appears to be stable. The increase in overall prey density is a key factor in tiger recovery (Harihar *et al*. 2018). Despite the apparent increase in density over the past five years for these group living species, the density of groups is identical in the two years. The difference in the density of individuals is caused by the increase in the estimated group size in 2024 compared to 2019. Therefore, it is sensible to scrutinise the difference in estimated group sizes. Given that increase in density should logically affect multiple parameters, it is unlikely that only group size would respond independently. Although larger clusters have a higher probability of detection, figure 6a & b show the relationship between cluster size and distance in 2019 and 2024. The regression line in the graph shows no significant relationship – larger clusters have the same detection probability as small clusters in both datasets in ATR. This inconsistency suggests the possibility of observer bias in estimating group sizes during field surveys. While further exploration of the data, we found over representation of the larger

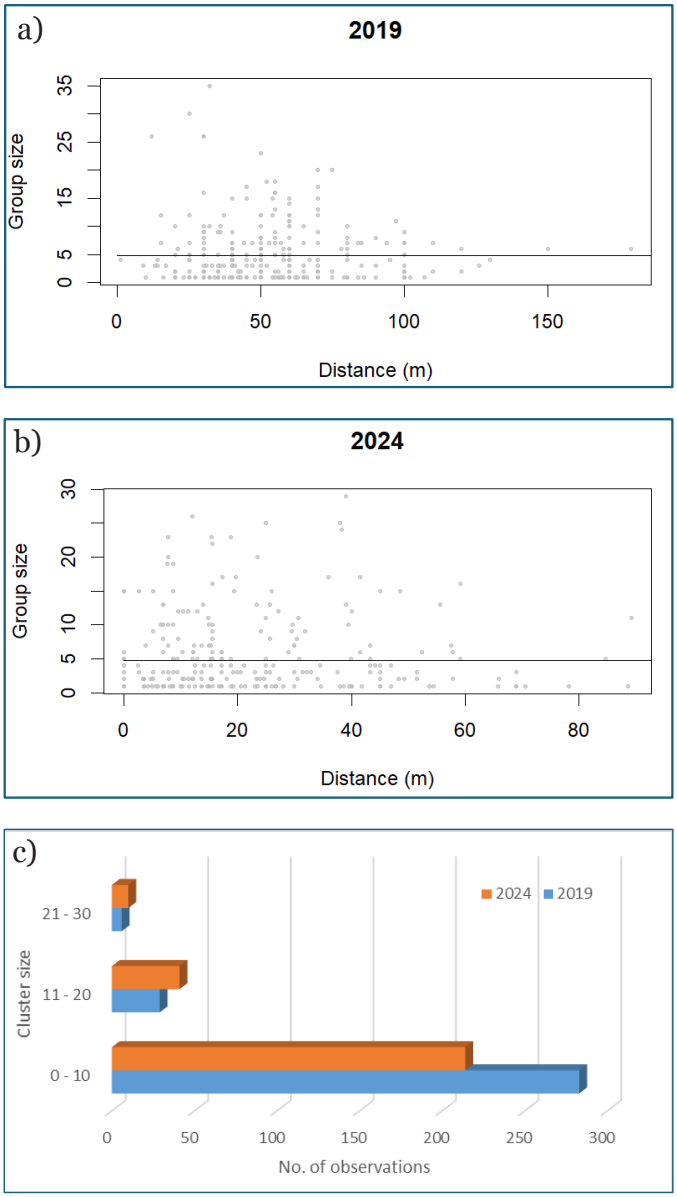


Figure 6: shows the relationship between cluster size and distance from the line a) 2019 & b) 2024. c) shows the number of observations within three ranges of cluster size in 2019 & 2024.

clusters (10 - 20) in the data and small clusters (0 – 10) were significantly underrepresented (Figure 6c) in 2024. Possibly, these two sources of bias may have approximately cancelled out each other and did not affect the density estimates, but this is difficult to ascertain. On account of such biases, inferences about changes in wild ungulate densities must be made with care. Alldredge *et al*. (2007) noted a 15% bias reduction in the estimates following observer training.

Apart from the observer bias, small sample size significantly affects the robustness of the estimates' – for example, only 21 detections were recorded in the Lamni range during the 2024 survey. Such small sample sizes are associated with higher CVs, reducing confidence in parameter estimates. Additional data from future surveys may provide more reliable insights about population trajectories.

06

RECOMMENDATIONS

6.1 Wildlife monitoring & protection:

- For the first time in about 15 years, Achanakmar Tiger Reserve has a tiger population comprising multiple breeding age tigers with a healthy sex ratio and the presence of multiple litters. Conditions appear to be ripe for the population to grow steadily. The upward trend will likely be sustained if individuals in the population have high survival rates, and new individuals continue to disperse into the Reserve from surrounding areas. With active protection and management, population recovery will continue to show a positive trend without translocating tigers into the population (capture in other sites and release). Based on the results of future population monitoring, this recommendation on population augmentation should be re-evaluated.
- We recommend radio-collaring of tigers as per existing protocol in the ATR, focusing on breeding females and dispersal age individuals, to monitor and secure these individuals and gain insights about the foraging ecology and habitat use, about environmental factors and anthropogenic stressors. The radio-collared tigers should be monitored daily (multiple telemetry locations can be collated and mapped each day). This will help enhance the monitoring and protection of the population, including by aiding in strategic planning, patrolling and deploying frontline staff. This will also help understand the behaviour, habitat use, territorial shifts and range expansion of tigers in ATR. This can feed into future management strategies.

- Ensuring suitable habitat for prey base recovery in Surahi, Lamni range of core and buffer zone will directly support the growing tiger population. Additionally, the current density estimates of prey species are associated with high levels of uncertainty, which reduces their utility for management and can cloud any inferences drawn related to trends from subsequent monitoring. Therefore, the frontline staff need to be trained better for wildlife surveys. Engaging trained researcher volunteers during the phase IV monitoring exercise is highly recommended to obtain more reliable estimates, which is essential to inform habitat management interventions and conservation planning for wildlife population recovery.

- Identifying high and low wildlife utilisation areas is critical for targeted conservation interventions. Spatial data from camera-trap and radio-collaring should be analysed to determine areas with low tiger presence. This will help managers to prioritise management efforts to enhance habitat quality and connectivity.

- There are currently 22 patrolling camps inside ATR. Given the remote and often rugged terrain, each camp should be equipped with reliable communication systems, such as two way radios. This will help maintain continuous coordination with other camps and central command, ensuring a quick response for tiger monitoring. Recommendations from the Security Audit exercise should be implemented, and gaps identified in the MEETR exercise should be filled, requiring additional resources from central and state governments.

- A specialised tiger monitoring and protection team should be established within ATR, with targeted training in advanced protection and monitoring protocols. This team will be adept at addressing conservation challenges, managing threats to the tiger population, and providing protection. The team will oversee key entry points that serve as dispersal routes for tigers from surrounding areas into ATR. Monitoring these dispersal routes will support the effective management of individuals and help maintain a balanced and stable population structure within the Reserve, ensuring long term population health and stability.

- Non-invasive methods to assess the physiological stress level in tigers can be studied. This assessment can provide valuable insights into the impact of environmental factors and anthropogenic stressors.

6.2 Community engagement and conservation & protection of corridors

- As the tiger population increases, human-tiger conflict will likely be exacerbated. For example, T2 now resides in the buffer area where prey density is relatively low, and this tiger may depend on livestock. Ensuring cattle kill monitoring and timely compensation for cattle depredation will deter retaliation from the affected livestock owners.

- Engaging local communities in tiger conservation efforts through their involvement in conservation and management can substantially benefit conservation, including the safe dispersal of tigers. Multiple avenues exist, including engagement in ecotourism, value chain, and market development for local products like millet, vegetables, Non Timber Forest Produce (NTFP), and fire management.

- Given that most of the current population of ATR comprises tigers that have dispersed through corridors, corridor conservation should form an essential pillar of the tiger recovery strategy. Corridor management should be integrated into ATR's Tiger Conservation Plan (TCP) and the working plans of key territorial divisions such as Mungeli.

- The above recommendation will be effective only if the the connectivity between ATR and other nearby tiger habitats (KTR and BTR) remains functional for posterity. Regular monitoring of this connectivity and appropriate measures to mitigate any development that would impede the functionality will have to be taken up, such as from planned linear infrastructure development and land use change for mineral extraction or other types of industrial development. Proactive engagement and planning with line departments like National Highways Authority of India (NHAI), Public Works Department (PWD), Chhattisgarh State Power Distribution Company Limited (CPDCL), Police, and Chhattisgarh Mineral Development Corporation (CMDC) should be undertaken to ensure that mitigation measures are integrated into the design of upcoming regional infrastructure projects.

- The tiger reserve and corridors comprise large areas recognised as Community Forest Resources Rights (CFRR) under the FRA, 2006. The Forest Department, NGOs, and community institutes in key villages must collaborate to promote conservation through co-management of these areas.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