



STATUS AND TREND OF GREAT INDIAN BUSTARD, ASSOCIATED WILDLIFE, HABITAT AND THREATS IN THAR

PROJECT GREAT INDIAN BUSTARD

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ANOOP K.R.,
IFS

SUMMARY



The Thar landscape in Jaisalmer district is the last stronghold for the Critically Endangered Great Indian Bustard (GIB) *Ardeotis nigriceps* and supports a unique assemblage of arid-adapted species dependent on Open Natural Ecosystems. This report presents the population status and decadal trend of the GIB, associated wildlife, habitat, and threats, based on landscape-level surveys conducted during October 2024 and April 2025.

Using a standardized vehicle-based distance and occupancy sampling framework consistent with earlier assessments, surveys covered ~14,000 km² across Desert National Park, Pokhran Field Firing Range, and surrounding habitat in Priority GIB Area. A total of 419 transects (4,522 km) with habitat sampling at 2 km intervals, were surveyed systematically in 144 sqkm grid-cells, to ensure adequate and representative spatial and temporal coverage.

The last survey, conducted in 2017-18, estimated a population of 128 ± 19 (SE) GIB and assessed the occupancy and density trends of associated key fauna, habitat and anthropogenic disturbances from 2015 to 2018 (Dutta et al. 2018). The current survey estimated the GIB population (2025) as 130 ± 21 individuals, with an occupancy of about 16% of the surveyed landscape. Trend analysis showed that GIB detections, encounter rate, abundance and occupancy have remained broadly stable since 2017. The species' detections continue to be concentrated in relatively undisturbed, flat grassland-dominated areas without energy infrastructure, particularly in and around enclosures of the northern Desert National Park and Pokhran Range. Native associated species such as chinkara and desert fox also showed stable population trends, while non-native and human-subsidised species, including nilgai, pig, and free-ranging dogs, exhibited increasing occupancy across the landscape.

Habitat assessments revealed that the short grass and sparse shrub cover forming the primary vegetation structure suitable for GIB is widely distributed in the Thar Landscape. The overall land-cover composition has remained relatively stable over the last decade, but there has been a marked increase in anthropogenic features over time. Power lines, agricultural fencing, roads, water sources, and solar plants have expanded substantially, intensifying habitat fragmentation and mortality risks. Although grassland restoration efforts and fenced enclosures have contributed to localized improvements in habitat quality, these gains have been offset by infrastructure expansion at the landscape scale.

Overall, the report highlights that the GIB population remains small and spatially restricted, underscoring the urgent need for strengthened threat mitigation, particularly power-line mitigation, regulation of fencing, control of non-native species, and protection of remaining open grasslands, following the latest Judgement of the Hon'ble Supreme Court regarding GIB conservation. The findings provide critical evidence to guide adaptive management under the National Bustard Recovery Program, emphasizing that long-term persistence of the species depends on landscape-scale habitat security alongside conservation breeding and targeted restoration efforts.



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BACKGROUND

The Thar landscape covering Jaisalmer District of Rajasthan represents the last stronghold of the Critically Endangered Great Indian Bustard (*Ardeotis nigriceps*, GIB) with only ~140 individuals surviving globally (Dutta et al. 2017). This arid Open Natural Ecosystem also supports several conservation priority species, including Chinkara (*Gazella bennettii*), Desert Fox (*Vulpes vulpes pusilla*), Indian Fox (*Vulpes bengalensis*), Desert Cat (*Felis lybica*), Spiny-tailed Lizard (*Saara hardwickii*) and threatened raptors. Increasing anthropogenic pressures in the form of habitat modification and infrastructural expansion are impacting this ecosystem. This necessitates regular ecological assessments to track population trends to guide science-based conservation.

The GIB, the State Bird of Rajasthan, is extremely rare, patchily distributed, cryptic, and wide-ranging that makes monitoring challenging. The species typically inhabits flat to slightly undulating terrain with grasslands and sparse fallows, often avoiding intensive agriculture and infrastructure (Dutta et al. 2024). Over the past few decades, its distribution range has contracted substantially, with the Thar region remaining the last viable landscape for population recovery. In response to conservation requirements, structured landscape-level population and habitat surveys were carried out between 2014 and 2018 by Wildlife Institute of India (WII) and Rajasthan Forest Department (RFD), covering over ~19,000 km² of area using vehicle-based distance sampling and occupancy modelling. These surveys estimated a population of 128 ± 19 (SE) individuals in 2017-18 and identified key threats, including power infrastructure and predator pressures (Dutta et al. 2018). Since 2014, conservation efforts have been ongoing in and around Desert National Park, including habitat restoration through the establishment of fenced grassland reserves and a conservation breeding program. Given these interventions, reassessment of the known population status, distribution and habitat conditions is timely.

Following the protocol standardised in earlier surveys (Dutta et al. 2015), we conducted repeat surveys in October 2024 and April 2025 to capture seasonal variation in population dynamics. The survey covered Desert National Park (DNP), Pokhran Field Firing Range (PFFR), and surrounding habitats in the Priority GIB area (Figure 1). In addition to GIB and associated species, surveys documented fine-scale data on land cover, dominant vegetation, and anthropogenic disturbances. The landscape was stratified into key blocks (Sam, Ramdevra, PFFR, Ramgarh, Rasla, Myajlar, and Mohangarh) in which trained teams conducted vehicle transects within 144km² grids.

This report presents findings from past and recent surveys to provide an updated account of population status, spatial distribution and habitat conditions of the GIB and associated fauna across the Thar landscape. It also evaluates the growing human footprint that fragments habitats and escalate species displacement and mortality risks. These findings aim to inform conservation management under the National Bustard Recovery Program, supporting population recovery through conservation breeding, adaptive habitat management, grassland restoration and threat mitigation.



ABOUT THE LANDSCAPE

The Thar Desert is part of the Desert Biogeographic Zone and is among India's most ecologically distinct and biologically rich arid ecosystems. The region receives mean annual rainfall of 100-400 mm, decreasing from east to west, with high inter-annual variability and recent anomalies marked by increased and stochastic precipitation. Temperatures range from 50°C in summer to 0°C in winter, with high diurnal variation. The landscape features a mosaic of grasslands and croplands over gravel plains, rocky hillocks, sand-soil cover and sand dunes. Vegetation characterised by thorny scrub and open woodland dominated by native species such as *Prosopis cineraria* and *Salvadora oleoides*, along with non-native *Acacia tortilis* and *Prosopis juliflora*. The shrub layer includes *Capparis decidua*, *Zizyphus mauritiana*, *Leptadenia pyrotechnica* and *Calligonum polygonoides*, and the grass layer largely comprises *Lasiurus scindicus* and *Dactyloctenium aegyptium* (Anoop et al. 2017). These plant communities are crucial for supporting insect populations, ground-nesting birds and native herbivores.

Besides the GIB, Thar supports several other high conservation value species, including Chinkara, Desert fox, Indian fox, Desert cat, and Spiny-tailed lizard. Avian fauna includes resident and migratory species, such as MacQueen's Bustard (*Chlamydotis macqueenii*), Cream-coloured Courser (*Cursorius cursor*), Sandgrouses (*Pterocles* spp.), larks, and a diverse raptor assemblage, including Gyps vultures, eagles and falcons. Many migratory species use the landscape as part of the Central Asian flyway.

Human density is high compared to other deserts (~85 people / km²), with livelihoods largely dependent on pastoralism, tourism and agriculture, including irrigated farming along the Indira Gandhi Canal. Desert National Park Wildlife Sanctuary (area 3,162 km²) is a multiple-use area with 73 resident villages. Rapid expansion of linear infrastructures and renewable energy developments is altering habitat quality and landscape connectivity across the region (Anoop et al. 2017). These changes pose serious threats to wildlife species that depend on open, less disturbed landscapes. Despite these pressures, Thar landscape remains one of relatively less-modified Open Natural Ecosystems in the country and retains large, contiguous habitats of high conservation values.



METHODS

A. Sampling design

The GIB habitat within the Thar landscape (~14,000 km² surveyed), largely covering the Priority GIB Area (as per the Hon'ble Supreme Court of India), was surveyed using a systematic vehicle-based transect design following Dutta et al. (2017). The survey area was stratified into seven blocks: (a) Ramdevra (18 grids), (b) Rasla (14 grids), (c) Pokhran Field Firing Range (PFFR; 16 grids), (d) Mohangarh (10 grids), (e) Ramgarh (19 grids), (f) Sam (22 grids), and (g) Myajlar (16 grids). A total of 115 grids (area of 144 km², 12 × 12 km each) were used as the sampling frame to ensure uniform spatial coverage (Figure 1).

Surveys were conducted during October 2024 (16-30 October 2024) and April 2025 (09-15 April 2025). 20 teams simultaneously surveyed these grids to obtain a temporal snapshot of species distribution and population while minimizing non-random animal movements between survey areas. Each team comprised two to three trained observers, including a primary observer for GIB and associated species, a secondary observer for raptors, and a forest guard from the Rajasthan Forest Department. To maximize detectability, surveys were conducted using four-wheel-drive vehicles driven at 10-20 km/hr speed during morning (0630-1030 hrs) and late afternoon hours (1630-1830 hrs), the peak activity period. Teams were equipped with binoculars, rangefinders, compasses and handheld mobile GPS. Surveys within each block were coordinated by experienced field biologists from the Bustard Recovery Program team. Intensive pre-survey workshops were conducted to train observers in the standardized survey protocols, equipment use and species identification. The workshop was followed by hands-on field training sessions to ensure methodological consistency across teams.

All observations were recorded digitally using Epicollect5 (v5.0) for standardised data collection. Transect routes were recorded using the Locus mobile application (v4.26), generating .gpx tracks for each trail. Habitat plots were sampled systematically at 2 km intervals along transects, and animal sightings were recorded with perpendicular distance and group size. Areas with dense human settlement were excluded from the sampling frame as these areas are not suitable for GIB.

B. Data collection

1. Species' information

Data on GIB and key associated species (native: chinkara, desert fox, Indian fox, desert cat; non-native: nilgai, pig, free-ranging dogs; resident and migratory raptors) were collected in 2 km segments along transects. For each detection, the following information was recorded: species, number of individuals (group size), sighting distance (radial/perpendicular), transect bearing, animal bearing, and geographic coordinates (degree decimal format). Distances were measured using rangefinders (Bushnell/Nikon make) and bearings using a compass (Suntoo make). Transects were largely linear, and along curvy-linear segments of the transect, the closest approach distances (perpendicular distances) were recorded following Hiby and Krishna (2001).

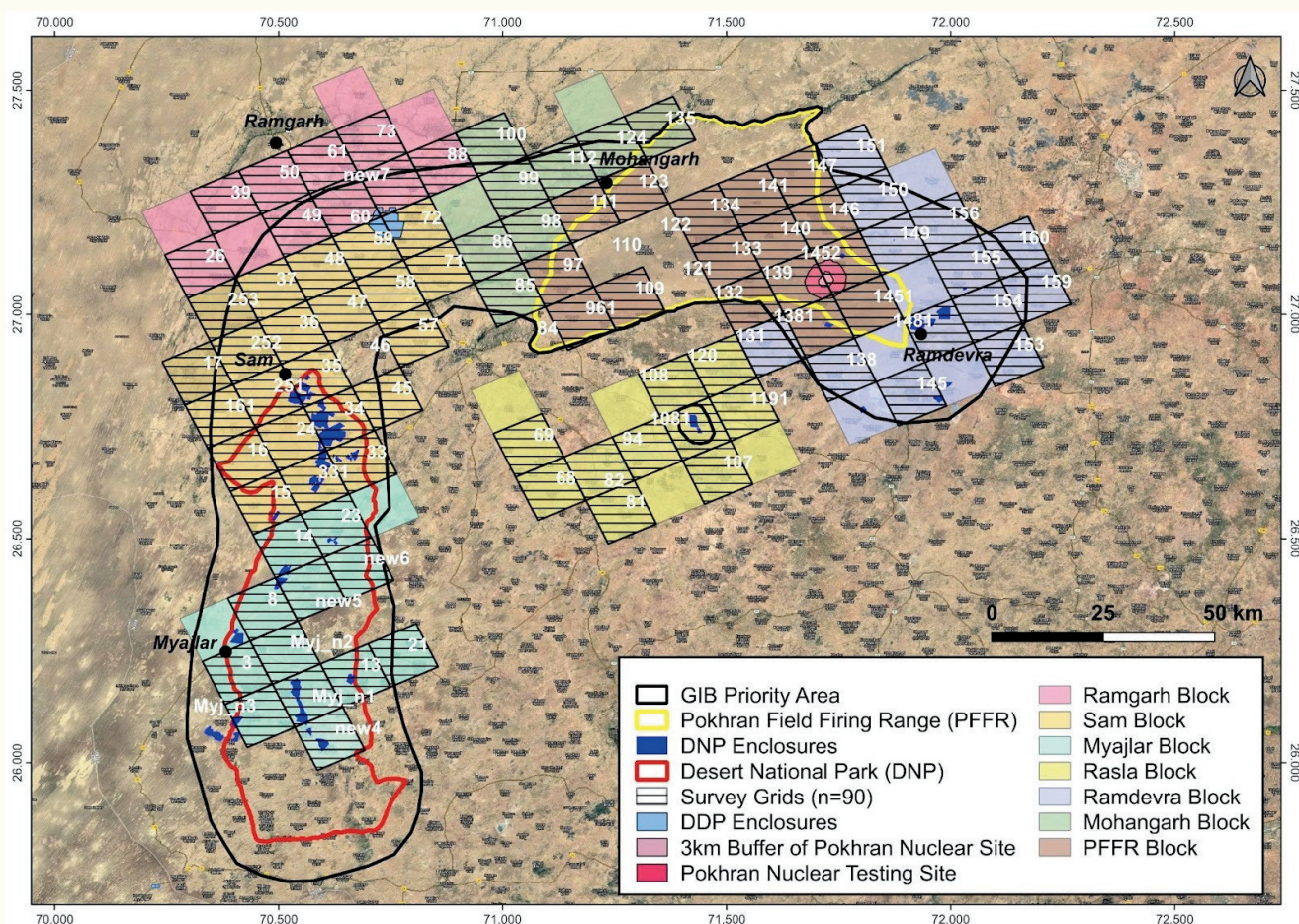


Figure 1. Map showing the survey framework along with the surveyed trails with respect to blocks in Jaisalmer district, Rajasthan, India

2. Habitat variables

Additionally, habitat characteristics were recorded at every 2 km interval along the survey transect, which included:

I. Habitat within a 100 m radius - recorded as type of:

- Terrain (flat / slope / undulating)
- Substrate (soil / sand / gravel & rock)
- Land cover (grassland / shrubland / woodland / active or fallow agriculture / barren)

II. Vegetation structure within a 20 m radius - recorded as percentage cover in broad classes (0, 1–10, 11–20, 21–40, 41–60, 61–80, 81–100 %), of:

- Short grass and herbs (< 30 cm height)
- Tall grass (> 30 cm height)
- Shrubs or woody vegetation (< 2 m height)
- Trees or woody vegetation (> 2 m height)
- Crop

III. Vegetation composition (dominant plant species) in 100 m radius - recorded as percentage cover in broad classes (1–10, 11–20, 21–40, 41–60, 61–80, 81–100 %) of:

- a. Names of two dominant upperstorey species (> 2 m height) and their relative cover
- b. Names of three dominant understorey species (< 2 m height) and their relative cover
- c. Crop name

IV. Disturbances - recorded as presence/absence of:

- a. Active disturbances within a 200 m radius (human, vehicle/machinery)
- b. Passive disturbances within a 500 m radius (settlement, farm hut, metal road, wind turbine, solar power plants, water sources, industry/mine)
- c. Powerlines within a 500 m radius (further classified as marked high tension, unmarked high tension, and low tension lines)
- d. Agricultural fences within a 500 m radius (further classified as electric, barbed wire, chain-link/weld-mesh and other)

V. Burrowing animals within a 20 m radius -recorded as presence/absence:

- a. Occurrence of spiny-tailed lizard and rodent (Indian desert jird / gerbil) burrows

Additionally, information about the habitat quality of the segments from the GIB perspective (>25% area under contiguous grasslands and less infrastructure) and repeatability of the transects were recorded by observers for future surveys (in the April 2025 survey).



C. Data analysis

1. Population status of GIB and associated species

Population density was estimated using line-transect distance sampling, analysed using the *distance* R package (Marshall et al. 2025). During both landscape surveys, all GIB sightings (excluding juveniles, to ensure comparability with previous estimates) and associated species were recorded along vehicle transects. Perpendicular distances of sightings were used to model detectability as a function of distance from the transect line (Buckland et al. 2001).

For GIB, detection functions were fitted to pooled distance data to account for decreasing detectability with distance from the transect. Half-normal, hazard-rate and uniform key functions with cosine and Hermite adjustment terms were compared. A 5% right truncation was applied to remove extreme distance observations and improve model fit.

Model selection was based on the lowest AICc (Burnham and Anderson 2002), and detection probability was obtained from the top-ranked model. Population density was estimated using a component-wise framework. Encounter rates (individuals km⁻¹) were calculated at cell level and aggregated using geometric mean to reduce the influence of extreme values. Uncertainty in encounter rates was estimated assuming a Poisson distribution by fitting an intercept-only generalised linear model with log-transformed survey effort as an offset. Encounter rates were corrected for detection probability to derive density estimates, and uncertainty was quantified using the delta variance method. Density estimates were extrapolated to the sampled area (13,392 km²) to obtain conservative abundance estimates.

For associated species, population densities were estimated following the conventional distance-sampling framework. Species-specific detection functions were fitted using appropriate key functions and adjustment terms, with truncation applied where required to improve model fit. Model selection was based on AICc, and density estimates were based on encounter rates corrected for detection probability using the least AICc model for each species.

To quantify current distribution patterns of GIB and associated species, occurrence data from both surveys were first analysed using single-season occupancy models (MacKenzie et al. 2006). Detection histories were prepared for each grid cell using detection/non-detection data from 2-km trail segments treated as spatial replicates. Occupancy (ψ) and detection probability (p) were estimated and compared against null models using an information-theoretic approach based on AICc (Burnham and Anderson 2002). All analyses were conducted in the *unmarked* R package (Chandler et al. 2025). These models provide a baseline estimate of the proportion of grid cells occupied by GIB and associated species during 2024-25 (Table 1).

2. Population trends of GIB and associated species

To evaluate recent trends in space use, multi-season (/dynamic) occupancy models were fitted for the period 2017 to 2025, as earlier trends have been documented in previous assessments (Dutta et al. 2017). Dynamic occupancy models estimated initial occupancy (ψ), colonization (γ), extinction (ϵ) and detection probability (p), while explicitly accounting for imperfect detection. Detection/non-detection data were structured year-wise, with 2-km trail segments treated as spatial replicates. To ensure comparability of occupancy estimates through time, trend analyses were conducted for only those cells that were surveyed in both 2017 and 2025 ($n=79$). A candidate set of models, allowing either constant or time-varying changes in occupancy dynamics, was evaluated using an information-theoretic approach based on AICc, and year-specific occupancy estimates were derived from the best-supported model (Burnham and Anderson 2002) (Table 1). Additionally, encounter rates (count/km) were compared for GIB and associated species between 2017 and 2025 (Table 1).

3. Habitat status

Habitat characteristics were summarised using habitat and vegetation covariates collected, during both 2024-25 surveys at every 2km along the transects within the 144 km² grids. On average, in each grid cell, 16.1 (2.78 SD) plots were sampled. For categorical covariates, incidence was computed as the proportion of plots wherein a category occurred in each cell. Vegetation structure was recorded as percentage cover classes of vegetation in predefined height bins. The midpoint of each cover class was averaged across plots within a cell. Vegetation composition was quantified as the proportions of plots where the dominant species occurred in a cell. Thereafter, for all covariates, including habitat attributes (terrain, substrate, and landcover), vegetation structure (height-based cover classes), vegetation composition (dominant upperstorey and understorey vegetation), disturbances (active and passive), and burrowing species (spiny-tailed lizard and rodents), landscape-level means were estimated across sampled cells, separately for each survey (Table 2).

In addition to current habitat status, temporal trends in habitat condition were assessed by comparing data from 2017 with 2024 and 2025 surveys (Figure 6). These comparisons were used to evaluate changes in the magnitude and spatial prevalence of anthropogenic threats (eg, powerlines, farm huts, roads, settlements, solar plants, water sources, and wind turbines), land-cover classes (agriculture, grassland, scrubland, and woodland), vegetation structure and composition. Comparative trend plots are presented in Figure 7.



RESULTS

A. Efforts

The 2024 survey involved 193 transects of 2061 km length across 87 cells, while the 2025 survey included 226 transects of 2461 km length across 90 cells. Overall, 419 transects covering 4522 km were completed, and habitat sampling was conducted at 2598 points in 93 grid-cells (surveyed at least once).

Each grid cell was surveyed with an effort of 27 ± 4.93 (SD) km, providing substantial coverage of ~35% of the cell area, assuming a visibility range of up to 1 km (with imperfect detection) for large-bodied animals in open landscapes. In each survey, >80% of the cells within the sampling frame were covered (Dutta et al. 2014). The repetition of surveys ensured improved spatial and temporal representativeness, yielding a reliable estimate of GIB population status and enabling seasonal assessment of species distribution and habitat composition.

B. Population status of GIB and associated species

During the 2024-25 surveys, 35 GIB flocks, 1568 chinkara herds and 79 desert foxes were recorded, along with non-native species including nilgai, pigs, and free-ranging dogs.

The GIB occupancy was estimated to be 0.16 (SE 0.06) i.e., 16 ± 6 % area occupied and abundance was estimated as $130 \pm \text{SE } 21$ individuals. The population status of the GIB has remained stable since 2017 (Table 1; Figure 4 & 5).

Density of native mammalian species, namely Chinkara and Desert fox density (#/sqkm) was estimated at 1.42 (0.13) and 0.08 (0.02), respectively. This has also remained stable since 2017. In contrast, non-native species showed expansion, with increased occupancy of nilgai and pigs (Figure 4). Nilgai abundance remained stable, and dogs showed a slight decline in encounter rates since 2017 in the wildlife areas, partly attributable to exclusion of dogs within or in close proximity to human settlements (Figure 5). GIB detections were largely concentrated in and around northern enclosures of DNP, PFFR and Ramdevra; a pattern also observed for chinkara and desert fox (Figure 3).

Table 1. Population and distribution status of the Great Indian Bustard and associated key and non-native fauna of the Thar landscape during 2024 and 2025.

Parameters	Focal species			Non-native species		
	GIB	Chinkara	Desert fox	Nilgai	Pig	Dog
Observed groups (individuals)	35 (60)	1568 (3179)	79 (85)	171 (426)	34 (118)	222 (335)
Mean group size (SE)	1.65 (0.019)	2.09 (0.06)	1.1 (0.04)	2.74 (0.26)	3.75 (0.07)	1.55 (0.07)
Mean encounter rate (SE)	0.009 (0.001)	0.615 (0.053)	0.018 (0.003)	0.098 (0.016)	0.026 (0.007)	0.086 (0.010)
Best-fit detection model	Uniform cosine	Half normal ~ season	Hazard rate ~ season	Uniform polynomial	Uniform cosine	Hazard rate ~ season
Detection model GOF-CM (p-val)	0.06 (0.81)	0.2 (0.26)	0.11 (0.55)	0.13 (0.44)	0.02 (0.99)	0.04 (0.89)
Group detection probability (SE)	0.55 (0.05)	0.53 (0.013)	0.36 (0.05)	0.68 (0.03)	0.53 (0.04)	0.52 (0.04)
Effective strip width in m (SE)	448 (39)	218 (11)	104 (13)	264 (12)	317 (21)	163 (13)
Density in #/sqkm (SE)	0.01 (0.002)	1.42 (0.13)	0.08 (0.02)	0.18 (0.03)	0.04 (0.01)	0.27 (0.04)
95% CI of density (LCI-UCI)	0.006 - 0.02	1.18 - 1.70	0.06 - 0.13	0.13 - 0.26	0.02 - 0.07	0.20 - 0.35
Abundance (SE)	130 (21)	19017 (1578)	1071 (225)	2411 (410)	NR	3615 (506)
Occupancy (SE)	0.16 (0.06)	0.81 (0.04)	0.59 (0.09)	0.63 (0.09)	0.65 (0.12)	0.63 (0.07)
Species detection probability (SE)	0.08 (0.02)	0.32 (0.01)	0.06 (0.01)	0.09 (0.01)	0.03 (0.01)	0.12 (0.01)
Occupancy trend (2017 to 2025)	Stable	Decreasing	Stable	Increasing	Increasing	Increasing
Population trend (2017 to 2025)	Stable	Stable	Stable	Increasing	Stable	Decreasing

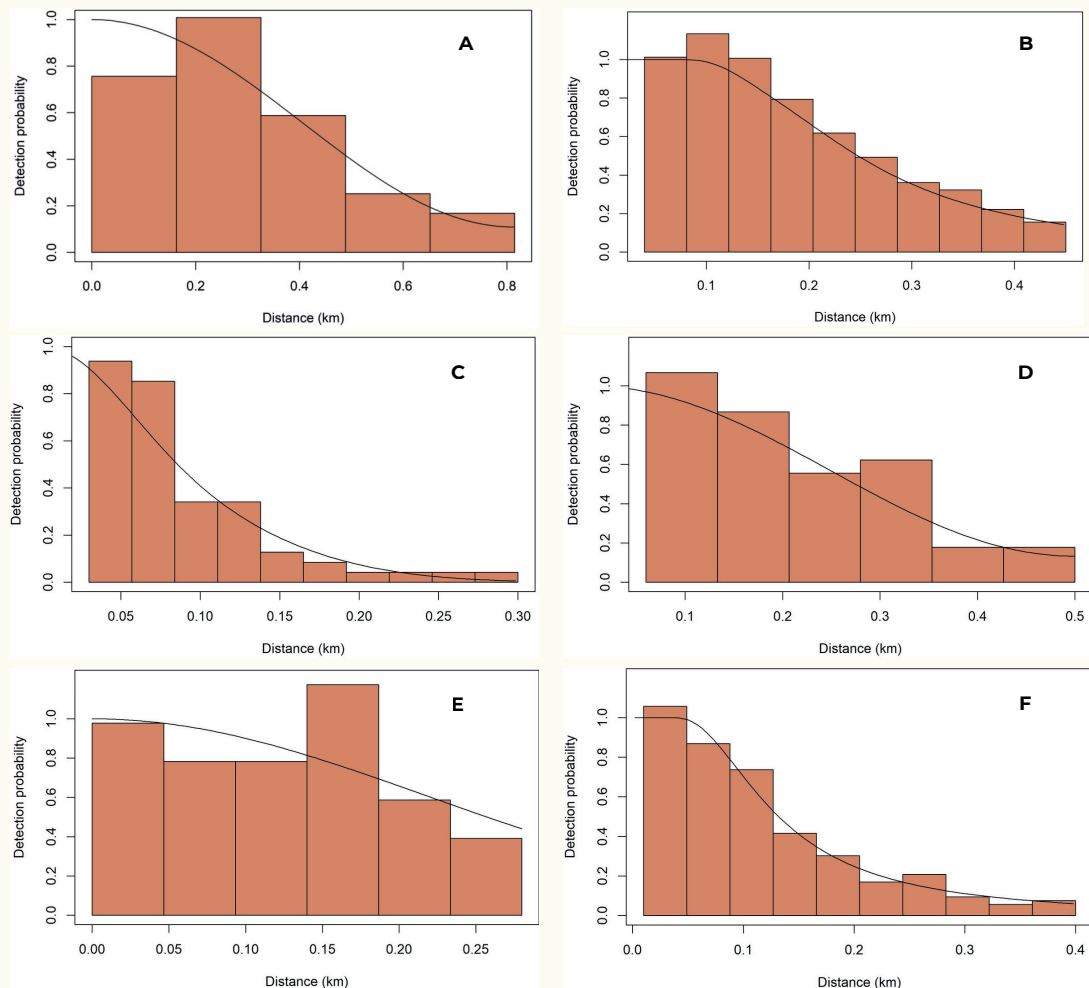
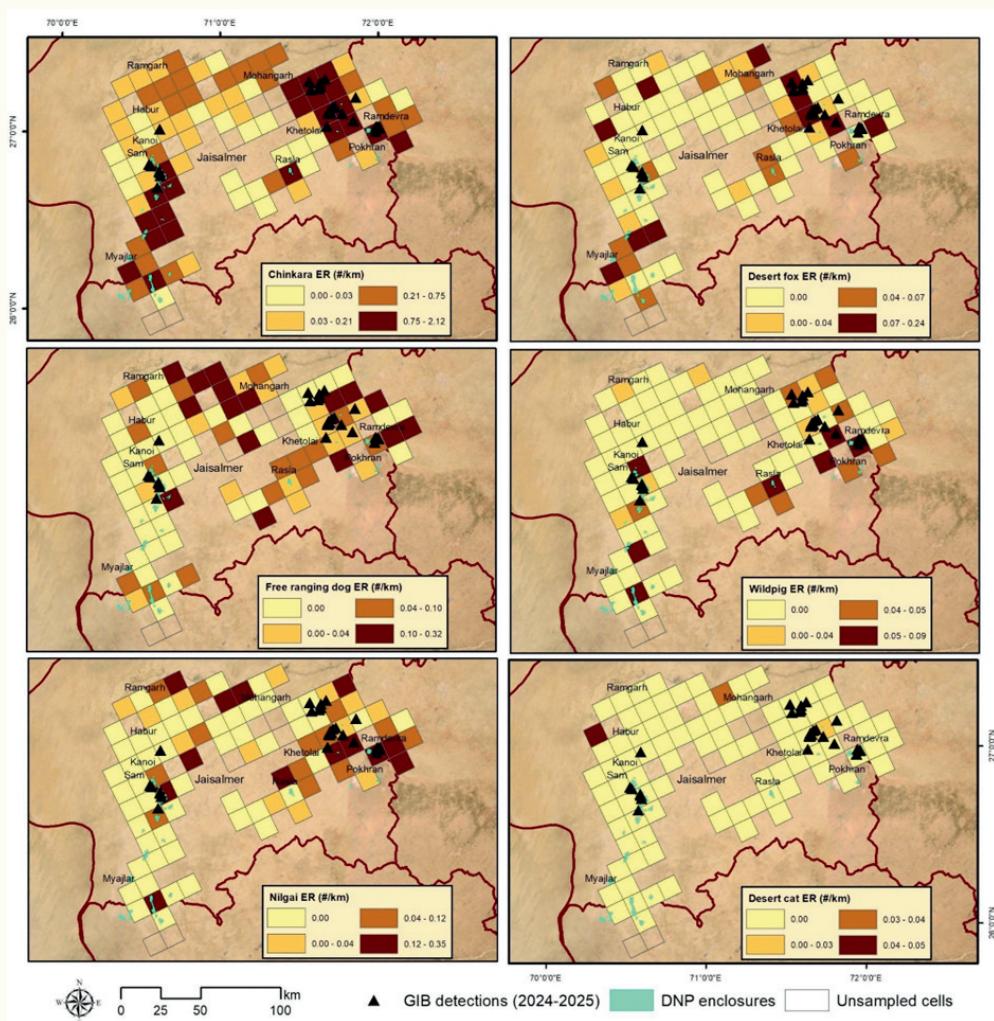


Figure 2. Density detection curves for estimating population as per best fit model (with lowest AIC) for GIB and associated key and non-native fauna in Thar landscape during 2024-25.

- (A) GIB
- (B) Chinkara
- (C) Desert fox
- (D) Nilgai
- (E) Pig
- (F) Free-ranging dog

Figure 3. Spatial distribution of encounter rates for GIB-associated native and non-native species with respect to GIB detections in Thar landscape (2024 and 2025).

- (A) Chinkara
- (B) Desert fox
- (C) Free ranging dogs
- (D) Pig
- (E) Nilgai
- (F) Desert cat



C. Population trends of GIB and associated species

Subsetting the population trend analysis to common grid-cells between 2017 and 2025, a) GIB occupancy and encounter rate remained stable, b) chinkara occupancy declined but encounter rate was stable, c) desert fox occupancy and encounter rate were stable, whereas d) nilgai and pig occupancy increased significantly (Figure 4 & 5). These non-native species, along with free-ranging dogs, displayed persistently high occupancy, indicating presence across the landscape.

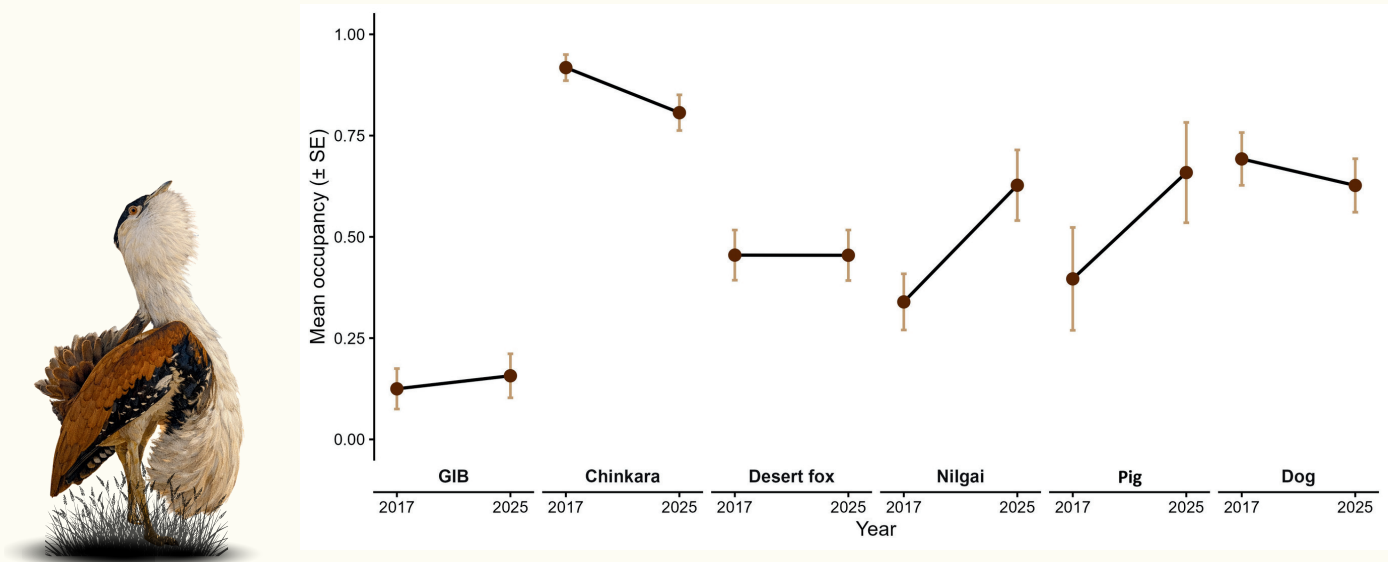


Figure 4. Species' occupancy (mean and SE proportion of sites occupied) trend from 2017 to 2025 in Thar landscape, for native (GIB, chinkara, desert fox) and non-native species (nilgai, pig, dog).

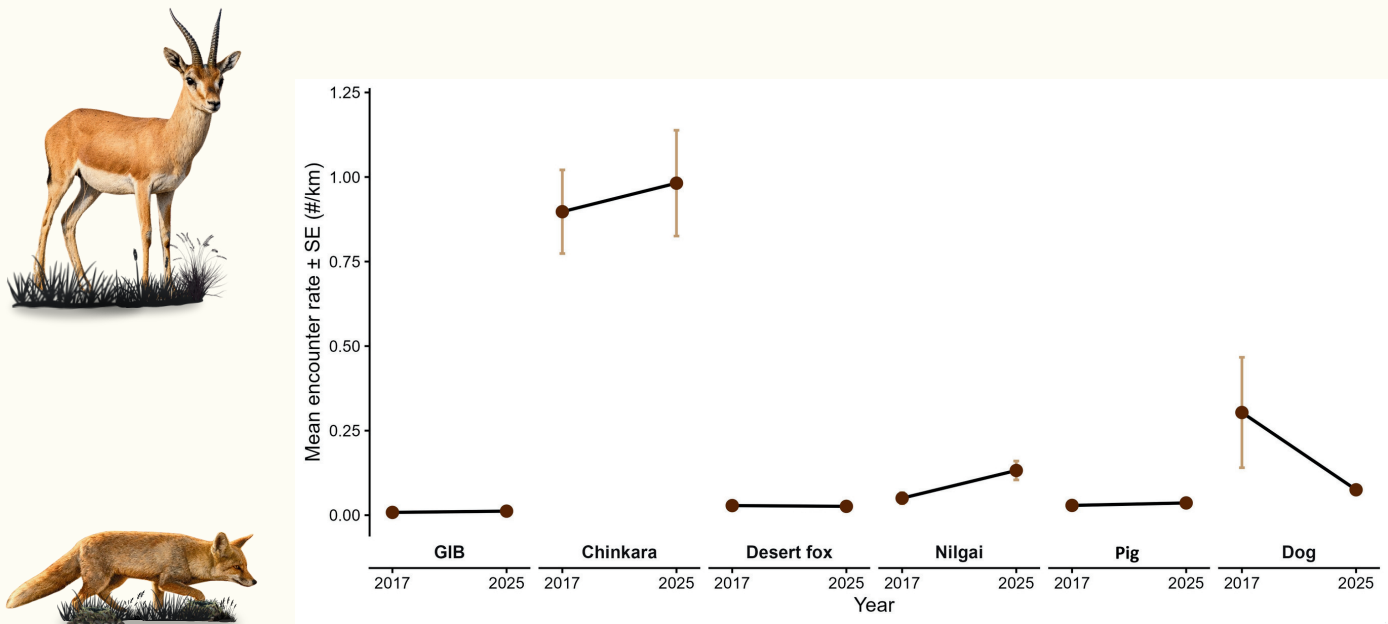


Figure 5. Species' encounter rate trend from 2017 to 2025 in Thar landscape, indicated as mean (SE) count per km, for native (GIB, chinkara, desert fox) and non-native species (nilgai, pig, dog).

D. Habitat status

The surveyed landscape was predominantly flat. Substrate composition was largely dominated by soil, with lower representation of sand and rock or gravel surfaces (Table 2). Land cover was primarily characterised by grassland, followed by scrubland, agriculture, woodland, and barren land (Table 2; Figure 7). Expectedly, active agriculture and crop cover were higher during September 2024 survey compared to April 2025, as cultivation is primarily seasonal and rainfed (Table 2). Vegetation structure was dominated by short grass and herbaceous cover (<30 cm), followed by shrub or low woody vegetation (<2 m) = tall grass or herbaceous cover (>30 cm) > > tree and tall woody vegetation (>2 m) (Table 2; Figure 7).

Among dominant upperstorey vegetation, *Capparis decidua*, *Calotropis procera*, and *Ziziphus* spp. were the most dominant, followed by *Prosopis juliflora* > *Leptadenia pyrotechnica* > *Salvadora oleoides* > *Prosopis cineraria* > *Acacia* spp (Table 2; Figure 6). Dominant understorey vegetation was primarily represented by *Dactyloctenium* spp., followed by *Cassia* spp., *Aerva* spp., *Fagonia* spp., *Aristida* spp., *Indigofera* spp., *Leptadenia* sp., and *Crotalaria* spp. Seasonal variation in understorey composition was evident for some ephemeral species, including *Cassia* spp., *Fagonia* spp., *Crotalaria* spp., and *Indigofera* spp. (Table 2; Figure 6).



Table 2. Descriptive statistics of habitat covariates in 144 km² cells of the Thar landscape (2024 & 2025)

Covariate	Category	Mean occurrence ($\pm$ SE)	
		2024	2025
Active disturbance (200 m radius)	Human	-	0.49 $\pm$ 0.03
	Machinery & Vehicle	-	0.37 $\pm$ 0.02
Passive disturbance (500 m radius)	Farm hut	0.43 $\pm$ 0.02	0.39 $\pm$ 0.02
	Agricultural fence	0.60 $\pm$ 0.03	0.50 $\pm$ 0.03
	Industry / Mine	-	0.01 $\pm$ 0.005
	Power line	0.59 $\pm$ 0.03	0.58 $\pm$ 0.03
	Metal road	0.20 $\pm$ 0.02	0.17 $\pm$ 0.01
	Human settlements	0.15 $\pm$ 0.01	0.16 $\pm$ 0.01
	Solar plants	0.03 $\pm$ 0.01	0.03 $\pm$ 0.01
	Water sources	0.48 $\pm$ 0.03	0.44 $\pm$ 0.02
	Wind turbines	0.09 $\pm$ 0.02	0.10 $\pm$ 0.02
Landcover (100 m radius)	Active agriculture	0.20 $\pm$ 0.01	0.02 $\pm$ 0.01
	Fallow agriculture	0.07 $\pm$ 0.01	0.22 $\pm$ 0.01
	Barren	0.02 $\pm$ 0.01	0.1 $\pm$ 0.01
	Grassland	0.43 $\pm$ 0.02	0.30 $\pm$ 0.02
	Scrubland	0.25 $\pm$ 0.02	0.23 $\pm$ 0.02
	Woodland	0.12 $\pm$ 0.01	0.18 $\pm$ 0.02
Terrain (100 m radius)	Flat	0.79 $\pm$ 0.02	0.76 $\pm$ 0.02
	Slope	0.09 $\pm$ 0.01	0.09 $\pm$ 0.01
	Undulating	0.12 $\pm$ 0.02	0.14 $\pm$ 0.02
Substrate (100 m radius)	Rock / Gravel	0.14 $\pm$ 0.02	0.15 $\pm$ 0.02
	Sand	0.12 $\pm$ 0.01	0.12 $\pm$ 0.01
	Soil	0.11 $\pm$ 0.01	0.12 $\pm$ 0.01
Spiny-tailed lizard (20 m radius)		0.08 $\pm$ 0.01	0.11 $\pm$ 0.01

Covariate	Category	Mean occurrence (± SE)	
		2024	2025
Indian desert gerbil (20 m radius)		0.34 ± 0.03	0.50 ± 0.03
Power line (500 m radius)	Marked high tension	0.08 ± 0.01	0.07 ± 0.01
	Unmarked high tension	0.07 ± 0.01	0.11 ± 0.02
	Low tension	0.52 ± 0.03	0.49 ± 0.03
Agricultural fence (500 m radius)	Barbed wire	0.45 ± 0.03	0.36 ± 0.03
	Chain-link / Weld-mesh	0.25 ± 0.03	0.24 ± 0.02
	Electric	0.20 ± 0.02	0.09 ± 0.02
Vegetation structure (20 m radius)	Short grass / herb (veg < 30 cm) %	27.08 ± 1.05	22.48 ± 1.16
	Tall grass / herb (veg > 30 cm) %	15.52 ± 1.11	9.78 ± 0.83 %
	Shrub / woody (veg < 2 m) %	16.35 ± 1.01	16.29 ± 0.98 %
	Tree / woody (veg > 2 m) %	10.63 ± 0.70	13.31 ± 0.94 %
	Crop %	7.94 ± 0.78	0.75 ± 0.19
Dominant upperstorey vegetation (100 m radius)	<i>Calotropis procera</i>	0.41 ± 0.03	0.42 ± 0.03
	<i>Capparis decidua</i>	0.43 ± 0.03	0.48 ± 0.03
	<i>Prosopis cineraria</i>	0.09 ± 0.01	0.11 ± 0.02
	<i>Acacia sp.</i>	0.01 ± 0.004	0.04 ± 0.01
	<i>Acacia tortilis</i>	0.06 ± 0.01	0.04 ± 0.01
	<i>Leptadenia sp.</i>	0.15 ± 0.02	0.16 ± 0.02
	<i>Prosopis juliflora</i>	0.19 ± 0.02	0.17 ± 0.02
	<i>Salvadora oleoides</i>	0.12 ± 0.02	0.11 ± 0.02
	<i>Ziziphus sp.</i>	0.27 ± 0.03	0.25 ± 0.02
Dominant understorey vegetation (100 m radius)	<i>Dactyloctenium sp.</i>	0.62 ± 0.03	0.61 ± 0.03
	<i>Leptadenia sp.</i>	0.04 ± 0.01	0.27 ± 0.03
	<i>Cassia sp.</i>	0.14 ± 0.02	0.24 ± 0.03

Covariate	Category	Mean occurrence ($\pm$ SE)	
		2024	2025
Dominant understorey vegetation (100 m radius)	<i>Fagonia</i> sp.	0.06 $\pm$ 0.01	0.35 $\pm$ 0.03
	<i>Crotalaria</i> sp.	0.02 $\pm$ 0.01	0.22 $\pm$ 0.02
	<i>Aerva</i> sp.	0.12 $\pm$ 0.02	0.21 $\pm$ 0.02
	<i>Haloxylon</i> sp.	0.04 $\pm$ 0.01	0.10 $\pm$ 0.02
	<i>Aristida</i> sp.	0.24 $\pm$ 0.02	0.10 $\pm$ 0.01
	<i>Lasiurus scindicus</i>	0.02 $\pm$ 0.01	0.08 $\pm$ 0.01
	<i>Indigofera</i> sp.	0.24 $\pm$ 0.02	0.08 $\pm$ 0.01
	<i>Calotropis procera</i>	0.03 $\pm$ 0.01	0.12 $\pm$ 0.02
	<i>Cenchrus</i> sp.	0.12 $\pm$ 0.02	0.06 $\pm$ 0.01
	<i>Tephrosia</i> sp.	0.08 $\pm$ 0.02	0.09 $\pm$ 0.02
	<i>Ziziphus</i> sp.	0.01 $\pm$ 0.003	0.04 $\pm$ 0.01

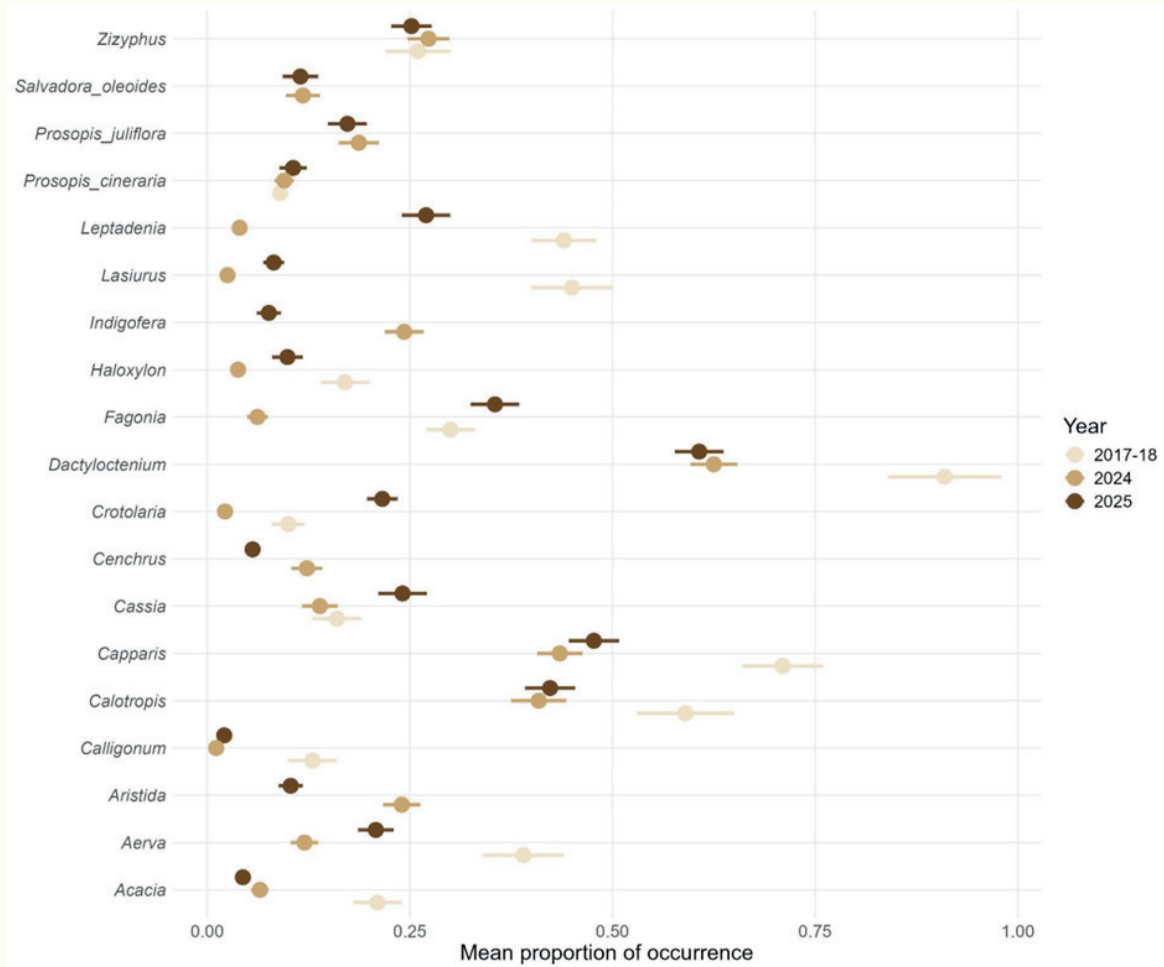


Figure 6. Mean (SE) incidence of dominant vegetation (understorey and upperstorey) in 2017-18 and 2024-2025 surveys (bars not shown for species not found to be dominant during 2017-18)

Anthropogenic features were widespread across the landscape. Among passive disturbances, power lines were the most prevalent, followed by agricultural fencing, water sources, farm huts, roads, and human settlements. Only a fraction of high-tension power lines were fitted with bird flight diverters, indicating limited mitigation measures for low-flying birds across the landscape (Table 2). Active disturbances associated with human presence and vehicle movement were also high, with mean occurrences of around 49% and 37%, respectively (Table 2).

The use of electric fencing was relatively higher during the cropping season (Table 2). However, the continued presence of barbed-wire and chain-link fencing across both surveys suggests permanent installation of such protective structures, even during the non-cropping season. The occurrence of the spiny-tailed lizard was low across the landscape, whereas the Indian desert gerbil showed relatively high presence (Table 2).

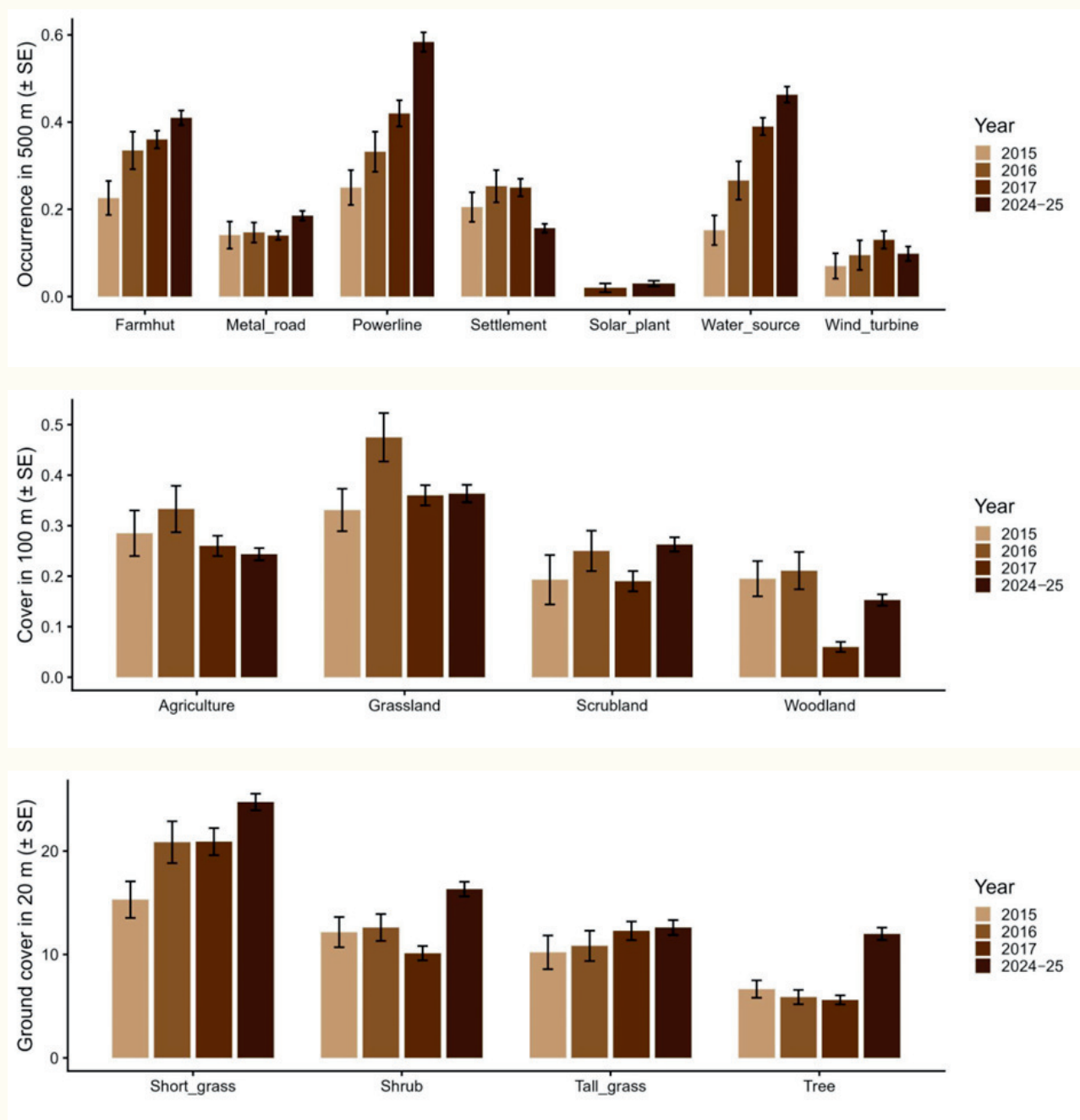


Figure 7. Mean (SE) incidence of human artefacts (top), land-cover (middle) and percentage ground cover of vegetation types across sampling plots in Thar landscape from 2015 to 2024-25

Across the surveyed years (2017-2025), the landscape showed a consistent increase in the occurrence of multiple human artefacts, indicating expansion of human footprint (Figure 7). Power lines showed the most pronounced increase of 38.1%, and solar plants increased by 45%, indicating expansion of renewable energy infrastructure over the study period (Figure 7). This expansion is of particular conservation concern for GIB, given their vulnerability to collision, which has previously been documented around DNP. The identified decrease in human settlements and windmills is potentially an artefact of excluding dense human settlement areas from the latest sampling frame. Compared to 2017, farm huts, metal roads and water sources also increased over time, showing an increase of 9%, 21.4% and 14.1% respectively (Figure 7), indicating expanding agro-pastoral and access-related infrastructure. Increase in water sources indirectly subsidises non-native predators such as pig, nilgai, and free-ranging dogs and facilitates increased livestock presence in grassland areas, impacting native wildlife.

Land-cover composition did not show major changes over the last decade (Figure 7). Agriculture showed a slight decrease, particularly after 2017. Grassland cover showed moderate increase, likely reflecting targeted conservation interventions such as the establishment of grassland enclosures within DNP and Mokla Conservation Reserve, aimed at enhancing habitat suitability for GIB and associated grassland species. Scrubland cover remained broadly stable. Vegetation structure patterns showed land-cover stability, with total vegetation cover increasing slightly over time and with an observed increase in woodland cover post-2017 (Figure 7).

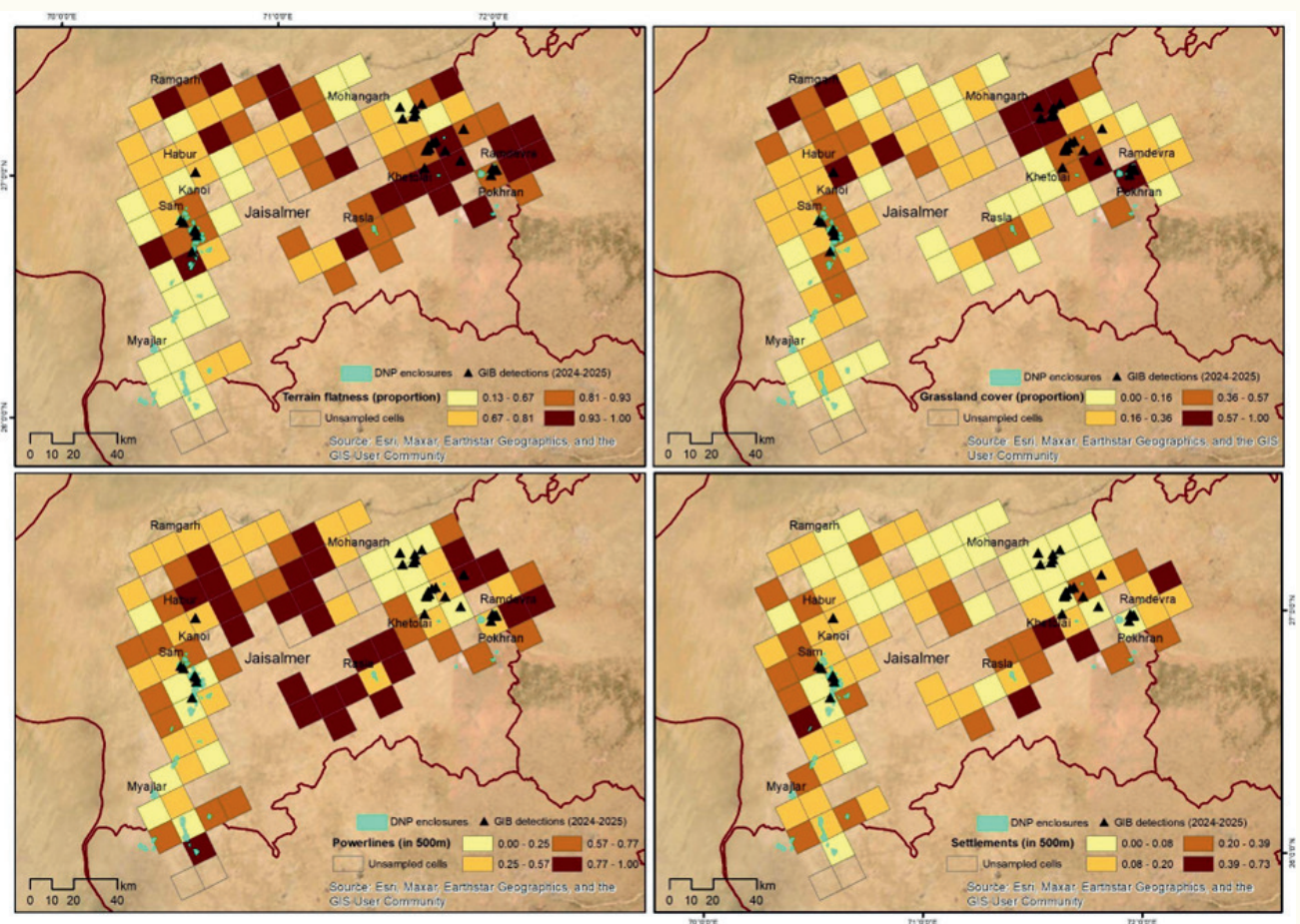


Figure 8. Spatial distribution of key landscape features across Thar landscape (2025): (clockwise) terrain flatness, grassland cover, power lines, and human settlements

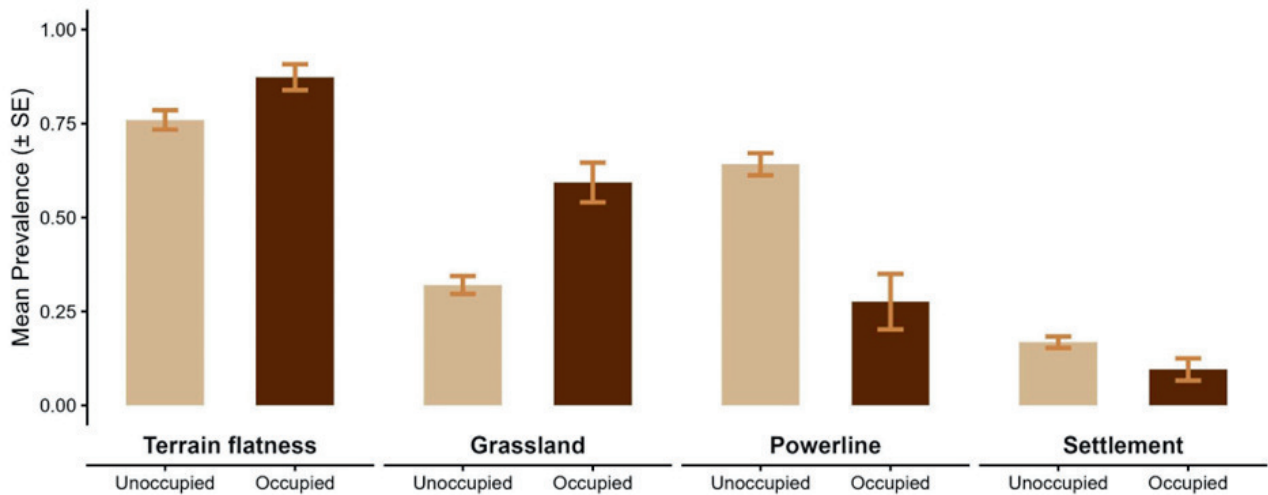


Figure 9. Comparison of habitat features (left to right) - terrain flatness, grassland cover, power lines and settlements between GIB occupied and unoccupied cells in the Thar landscape (2025)

Overall, landscape change in the last decade has been dominated by the expansion of human-associated infrastructure, while land cover and vegetation structure have remained largely stable. Comparison of habitat features in GIB occupied vs unoccupied cells showed that GIB selected areas with flat grasslands, less settlements and less infrastructure (Figures 8 & 9). Thus, the growing human footprint raises concerns for the conservation of GIB, which is sensitive to anthropogenic disturbances.



E. Status of Raptors

The survey recorded a total of 32 species of raptors, clearly demonstrating the importance of this landscape for raptor conservation. The most commonly recorded species were Common Kestrel and Tawny Eagle, followed by Egyptian Vulture (Figure 10). The survey also recorded rare species such as the Saker Falcon, Merlin, Red-headed Vulture, White-rumped Vulture, Indian Vulture, all of which were found in very low numbers (Figure 10). The postmonsoon period (October 2024) recorded high encounter rates of Harriers (*Circus* spp; 0.35 ± 0.02 / km) indicating the importance of Thar landscape as a major wintering and stopover site for harriers (Figure 10). Encounter rates of the raptor species are shown in Figure 10.

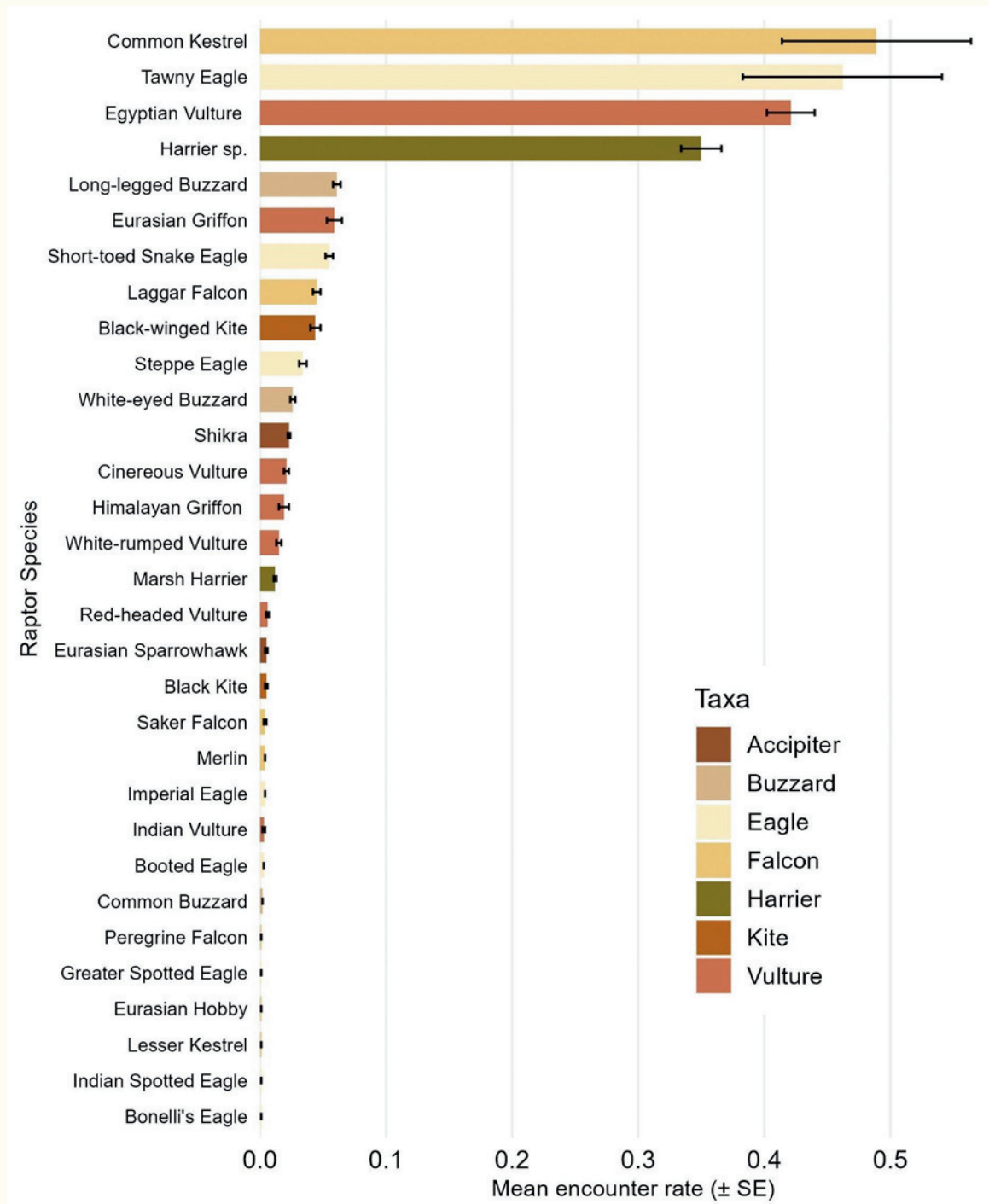


Figure 10. Mean encounter rates of Raptor species in Thar landscape (2024-25)

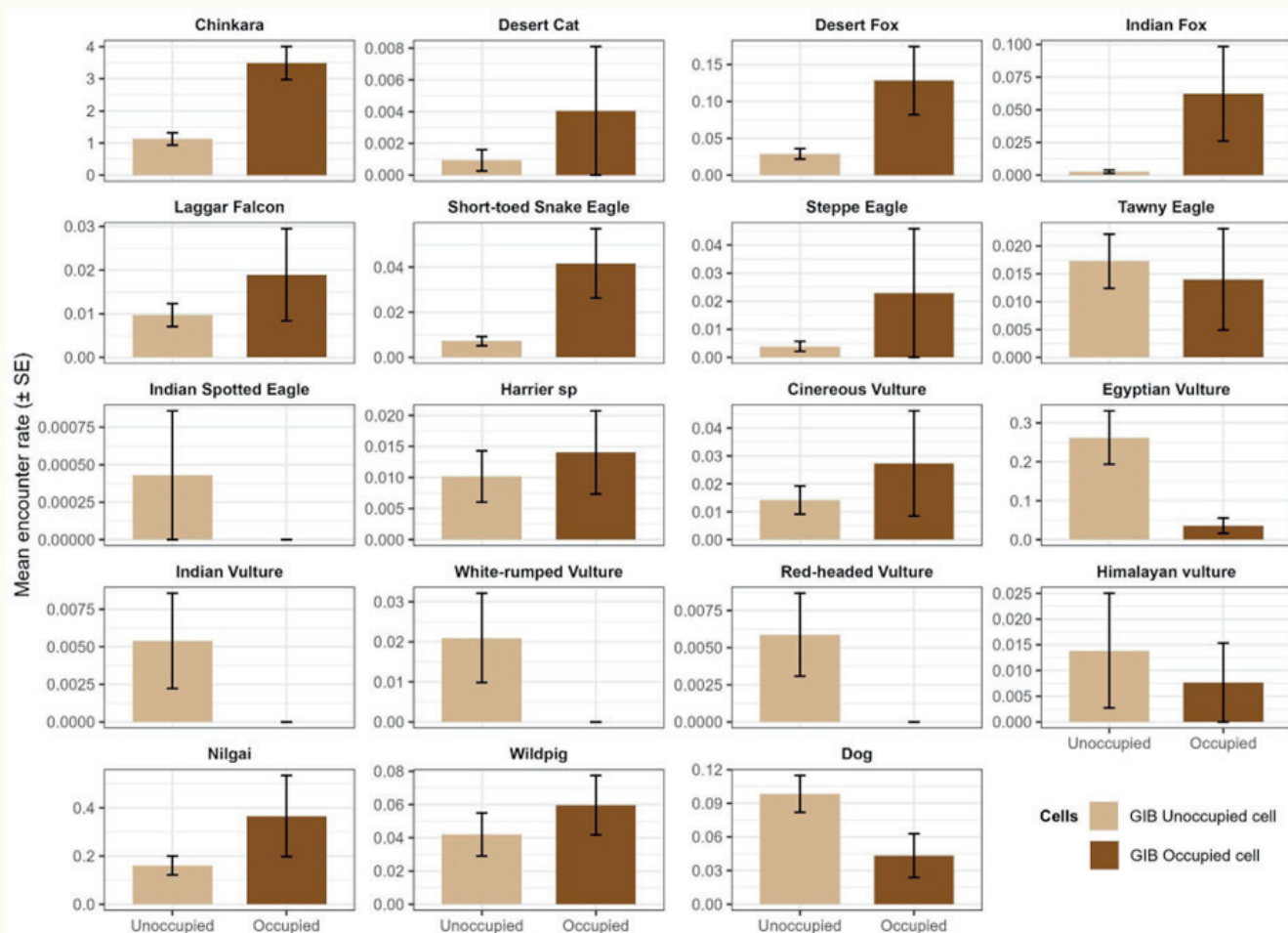


Figure 11. Mean encounter rates of mammals and threatened raptors in GIB occupied and unoccupied cells in Thar landscape during 2024-25



DISCUSSION

The Thar GIB survey is a long-term periodic assessment of the population status of the Great Indian Bustard, associated key fauna, dominant plants, habitat characteristics, and anthropogenic disturbances in the Jaisalmer landscape of the Indian Thar Desert. It is one of the few systematic wildlife monitoring programs running in the country that has generated time-series georeferenced information on the distribution and abundance of key flora and fauna from the largest Open Natural Ecosystem of India. The survey methodology, developed in 2014-15, entailed a balance between scientific rigour and logistic practicability (Dutta et al. 2015). Since a vast landscape has to be covered within a brief duration, and involves large man-power of varying skills - ecologists, frontline staff and volunteers - surveyors are rigorously trained through a field workshop at the start of the annual exercise until their observations are standardized, and the data collection is restricted to minimal essential information on easily identifiable taxa. The exercise was repeated in 2014, 2015, 2016, 2017-2018 and (after a gap due to COVID and fund constraints) 2024-2025, following the standard methodology. All surveys were conducted in March (except 2018 and 2024), to take advantage of longer day length, relatively mild temperature, and higher species' detectability (short dry grass, minimal haze, and pre-nesting season of GIB). Minor modifications in design have been incorporated over time, such as the addition of raptors and the reduction of the sampling frame in the latest exercise.

The latest survey has covered the Revised GIB Priority Area of Rajasthan, excepting ~2,000 sqkm area in the southern end of Desert National Park, ~1,000 sqkm in restricted parts of Pokhran Firing Range, and additional 1,440 sqkm area around Rasla. To account for the difference in sampling frame, species' trends were compared between the common subset of grid-cells across survey years (2017 and 2025). The Thar landscape is one of India's largest contiguous wilderness with historically low human pressures that has retained substantial populations of many specialised arid-adapted wild species - including the Critically Endangered GIB and threatened raptors of the Central Asian Flyway - and is therefore a priority conservation landscape (Dutta et al. 2024). Additionally, it is one of the most promising areas for renewable energy generation, to meet the national targets of climate change mitigation by substituting fossil fuels. Being one of the marginalized and aspiring districts, it is also prioritized for economic development and livelihood upliftment. Thus, the landscape is experiencing expansion and intensification of human footprint over recent years that can impact its unique wildlife in myriad ways. Our monitoring exercise, having completed its tenth year, provides a unique opportunity to understand decadal trends in species' densities, vegetation composition, and anthropogenic disturbances across this globally important landscape.

The conservation flagship of the Thar landscape - GIB - showed a stable population across the last decade, as per our survey findings. Since the species is extremely rare and patchily distributed, reducing the precision of status estimates, we inferred its population trend based on both occupancy and density measures derived from standardized efforts. This period has been marked by substantial conservation efforts as well as human-induced mortality of the species. *In-situ* efforts have included habitat restoration through development of chain-link-fenced grassland enclosures in the species' breeding area, restriction on large power infrastructure post 2021, large-scale dog neutering programs, predator translocations from GIB breeding enclosures, removal of invasive species (*Prosopis juliflora* and pigs), and development of a few community fodder plots, through combined efforts of Rajasthan State Forest Department, Wildlife Institute of India, and conservation NGOs working in this landscape. This period, particularly the latter half, has also seen multiple years of good rainfall, which have boosted insect biomass and consequently GIB productivity.

Simultaneously, a conservation breeding program has commenced, for which 44 wild-laid eggs were collected from the Desert National Park and Pokhran Range, resulting in 33 surviving wild founders along with 35 captive-bred birds that will initiate pilot release of captive-bred chicks from the next year. Whereas, we have recorded deaths of 17 wild adults, of which 59% are from power-line collisions and 41% are from other causes, in this period (2016-25). It is encouraging news that the GIB population in the Thar landscape has not declined despite these human-induced deaths, and offtake of eggs, likely due to the above benevolent *in-situ* efforts, good rainfall in consecutive years, and relaying by females post egg-collection. The species' occupancy is restricted to only 16% of the landscape area at any time, despite a larger area with suitable vegetation being available. The occupied sites are largely concentrated in areas with flat grasslands devoid of human settlements and renewable energy infrastructure, in/around Desert National Park and Pokhran Range. The recent Judgement of Hon'ble Supreme Court has restricted the future expansion of renewable energy plants and transmission lines, along with time-bound mitigation (undergrounding / rerouting) of risky power lines in the Revised Priority Area. These actions will greatly benefit GIB conservation in future, by minimizing mortality and habitat displacement caused by large power infrastructure. Supported by population augmentation through release of captive-bred birds, the population and area occupied by the GIB will hopefully increase in the next decade.

With respect to other wild fauna, chinkara and desert fox populations have remained stable through this decade, although more robust estimates of the latter based on cameratrap surveys are required. Whereas, the populations of non-native fauna (nilgai, pig and dogs) are expanding and are now widespread in the landscape.

There was a high congruence between GIB distribution and encounter rates of some other native fauna, such as chinkara, desert fox, Indian fox, laggar falcon, harriers, and short-toed snake eagle that also highlight the benefits to these species under GIB centric conservation of habitat (Figure 11). Also, higher encounters of invasive pigs in GIB occupied areas necessitate their routine removal for egg/chick protection.

Structural changes in the landscape during this period are largely marked by the progression of anthropogenic disturbances. We note 38%, 45% and 14% annual increase in powerline, solar plants and surface water respectively, based on proportion of survey points with occurrence of each of these features across the survey years. However, land-cover composition, measured as proportional areas under grassland, scrubland and agriculture, have remained the same in the common sampling frame. The vegetation composition trend shows reduction in *Lasiurus scindicus* and *Dactyloctenium* spp, highly palatable and locally preferred fodder grasses, compared to an increase in weedy species such as *Cassia angustifolia*. An increase in total vegetation cover and of woody species such as *Calotropis procera* was noted, probably correlated with an increasing trend of annual rainfall and availability of surface water. Increase in surface water relaxes hydric constraints earlier limiting the spread of non-native mesic-adapted species, such as nilgai, pig and dogs - that is perhaps the reason behind their increasing distribution across the landscape - and poses new challenges for the native conservation-dependent species such as GIB and chinkara, through competition and/or predation (Dutta et al. 2024).

WAY FORWARD

The Thar landscape in Jaisalmer is the primary hope for recovery of the Critically Endangered GIB, currently supporting about 130 individuals. The existing population has the potential to recover if the larger landscape is consolidated, effectively protected, scientifically managed, and threats therein are mitigated, along with augmentation of captive-bred birds into secured habitats. In this regard, the Hon'ble Supreme Court has directed time-bound mitigation (undergrounding / rerouting) of existing high-risk transmission lines within the Revised Priority Area of Rajasthan in the latest Judgement on WP(C) 838/2019, whose expeditious implementation by power agencies will be vital for the species' recovery. With regard to habitat management, key recommendations of the Expert Committee on GIB conservation, approved by Hon'ble Supreme Court, are as follow:

- 1. Critical Conservation Units:** Five critical conservation sites within the Revised Priority Area, each about 200-500 sqkm in area, have been identified on scientific basis for intensive conservation management (Figure 12). These units need to be restored and protected to support a cumulative target population of >300 wild GIB. Improving habitat connectivity between these units by mitigating energy infrastructure is vital for safe dispersal and gene flow.
- 2. Protected Grassland enclosures:** Protected grassland enclosures are essential to improve breeding success of GIB. Consolidation of the existing 75 enclosures in Desert National Park and establishment of new ones, with the target of having three ~10 sqkm enclosures in each Critical Conservation Unit, especially within the Pokhran Field Firing Range, have been recommended (Figure 12). These areas should be chain-link fenced embedded in concrete to effectively exclude predators like foxes and dogs, and restrict livestock grazing.
- 3. Predator Management:** Predator density needs to be controlled within key GIB breeding enclosures through scientific translocation of foxes, cats and mongooses to areas at least 50 km away. Additionally, a long-term spay-neutering programme is recommended for free-ranging dogs. Further, pigs should be removed routinely from enclosures to protect GIB nests.
- 4. Habitat restoration:** To improve habitat suitability, invasive species such as *Prosopis juliflora*, *Cassia angustifolia* and excessive woody encroachment of *Calotropis procera* need to be removed. Future afforestation programmes in GIB areas should be strictly avoided, and native grass species, such as *Lasiurus scindicus* should be promoted, as these open natural habitats are preferred by GIB.
- 5. Water management:** Water provisioning should be ideally limited to one unit per 10 sqkm, to prevent excess numbers of egg / chick predators, and this measure can also be restricted to harsh summers for GIB and associated arid-adapted species, instead of the entire year that might benefit other non-native species.
- 6. Protection:** Regular patrolling around GIB breeding enclosures and other intensive usage areas should be strengthened by increasing staff through contractual recruitment, or Eco Task Force and Agniveers. Modern patrolling tools and new anti-poaching camps equipped with solar power can be considered.

7. Community-based conservation: Community support for GIB and grassland conservation is improving in the landscape over recent years. Mobilizing local communities as "GIB Mitra" through Eco-Development Committees will strengthen support. Initiatives, such as GIB scholarships, skill development and promotion of traditional handicrafts can provide sustainable livelihoods. Development of community fodder farms in Desert National Park and other Critical Conservation Units, with the involvement of local communities, should be considered, where controlled and rotational grazing or grass cutting can be permitted during non-breeding seasons to support local pastoralists with livestock fodder, and divert grazing pressure from conservation enclosures.

With respect to GIB population monitoring, future repetition of the Thar wildlife survey, once every three years, is recommended, as any discernible change in the true population status of GIB - given the uncertainty of estimates vis-a-vis its slow growing, long-living nature, can only be detected over such periods at the desired statistical power.

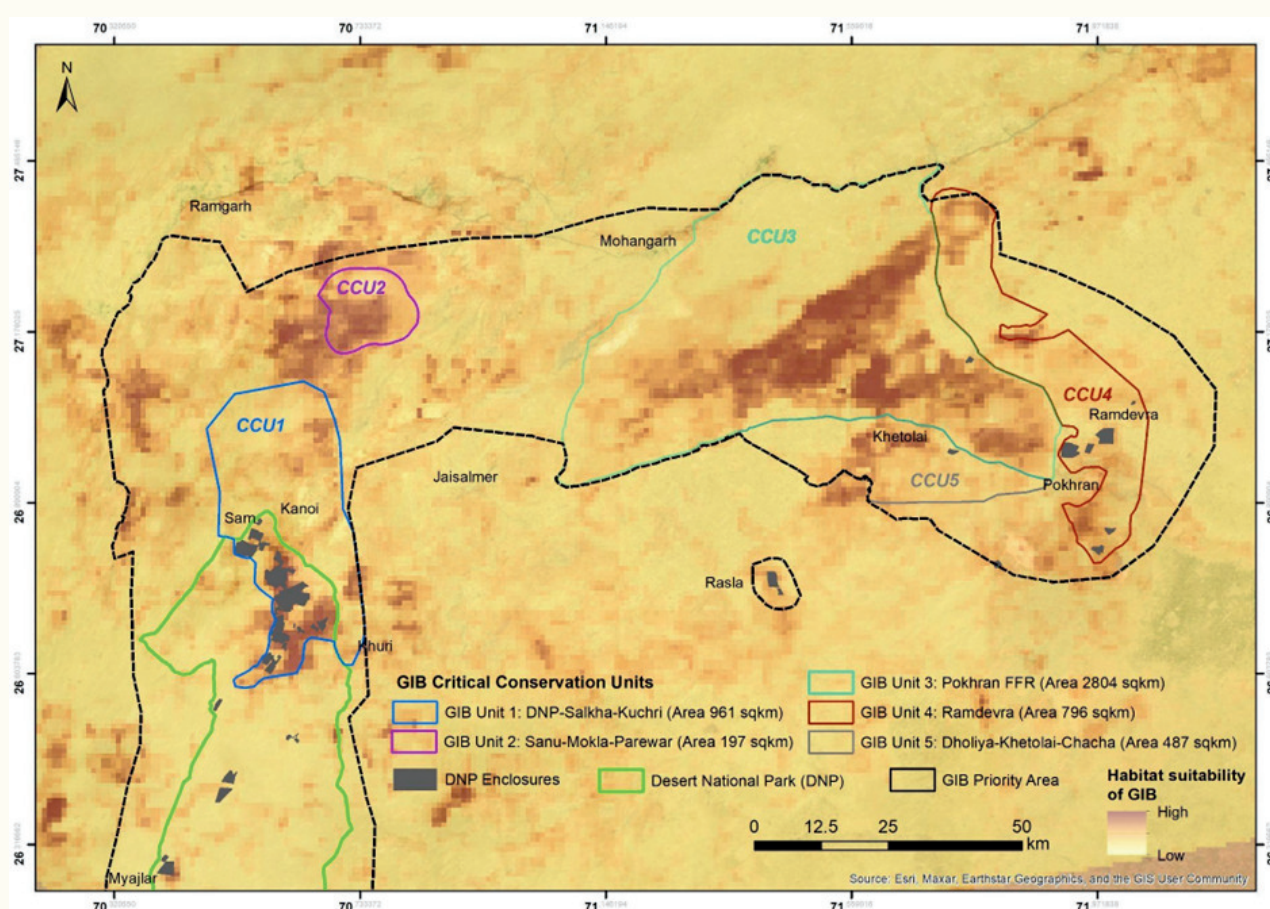


Figure 12. Map depicting the distribution of GIB Critical Conservation Units to support GIB and associated species conservation in Jaisalmer, Rajasthan (as per Expert Committee Report formed by Hon'ble Supreme Court of India)

REFERENCES

- Anoop, K.R., Bhardwaj, G.S., & Shekhawat, R.S. (2017). Management plan for Desert National Park Wildlife Sanctuary: plan period 2017-2027. Rajasthan Forest Department.
- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., & Thomas, L. (2001). Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press. ISBN: 9781383021325.
<https://doi.org/10.1093/oso/9780198506492.001.0001>.
- Burnham, K.P., & Anderson, D.R. (2002). Model selection and multimodel inference: A practical information-theoretic approach. Springer New York.
- Chandler, R., Kellner, K., Fiske, I., Miller, D., Royle, A., Hostetler, J., Huntchinson, R., Smith, A., Pautrel, L., Kery, M., Meredith, M., Fournier, A., Muldoon, A., & Baker, C. (2025). Model for data from unmarked animals: R Package unmarked ver 1.5.1 on CRAN. Published on 26-09-2025.
- Dutta, S., Bhardwaj, G.S., Anoop, K.R., Bhardwaj, D.S., & Jhala, Y.V. (2015). Status of Great Indian Bustard and associated fauna in Thar. Wildlife Institute of India, Dehradun and Rajasthan Forest Department, Jaipur.
- Dutta, S., Bipin, C.M., Anoop, K.R., Uddin, M., Shekhawat, R.S., & Jhala, Y.V. (2017). Status and trend of Great Indian Bustard, associated wildlife and threats in Thar. Wildlife Institute of India, Dehradun.
- Dutta, S., Karkaria, T., Uddin, M., Jangid, A.K., Bipin, C.M., Sharma, H., Joshi, H., Gupta, T., Gupta, S., Bishnoi, V., Sonika, B.L., Supakar, S., Paul, I., Pati, A., Nagar, A., Purohit, N., Lawrence, S., Gujjar, M., Moitra, M., Sawant, M., Krishna, M., Sakhlani, P., Kawni, L., Kolipakam, V., Kher, V., & Jhala, Y.V. (2024). Bustard Recovery Program: Phase I (2016–24). Wildlife Institute of India, Dehradun.
- Dutta, S., Bhardwaj, G.S., Bhardwaj, D.K., & Jhala, Y.V. (2014). Status of Great Indian Bustard and Associated Wildlife in Thar. Wildlife Institute of India Dehradun and Rajasthan Forest Department Jaipur.
- Hiby, L., & Krishna, M.B. (2001). Line transect sampling from a curving path. *Biometrics* 57: 727–731.
- Marshall, L., Miller, D., Clark-Wolf, T.J., Thomas, L., Laake, J., & Rexstad, E. (2025). Distance sampling detection function and abundance estimation. R Package Distance ver 2.0.1.
- McKenzie, D.I., Nichols, J.D., Royle, J.A., Pollock, K.H., Bailey, L.L., & Hines, J.E. (2006). Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier Academic Press, Burlington. ISBN: 0120887665.
- Miller, D. L., Rexstad, E., Thomas, L., Marshall, L., & Laake, J. L. (2019). Distance Sampling in R. *Journal of Statistical Software* 89(1): 1-28. <https://doi.org/10.18637/jss.v089.i01>.

LIST OF OBSERVERS

2024

Researchers: Aparajita Som, Ashish Kumar Jangid, Devendra Dutta Pandey, Gokul Vivek, Himani Singh Khati, Indranil Paul, Mahesh Gurjar, Mohib Uddin, Pavithra Sundar, Pradhyuman Sindha, Priyadarshini, Shimontika Gupta, Sneha Pandey, Sourav Supakar, Sutirtha Dutta, Swapna Lawrence, Swati Sen, Swayam Thakkar, Varun Kher, Vivek Sarkar, Yashwanth Gowda

Field Assistants: Aradin Khan, Bashir Khan, Chanesar Khan, Devender Genwa, Jaam Khan, Manohar Ram, Ramzaan, Saawan Khan, Sabir, Saddam Khan, Toshif

Forest Department Staff: Jitendra Singh, Hukma Ram, Kamlesh Bishnoi, Kaushalya, Manohar Singh, Pemp Singh, Sunil, Suresh

2025

Researchers: Anshuman Pati, Ashish Kumar Jangid, Chandraprakash, David Phinehas, Devendra Dutta Pandey, Indranil Paul, Krishna Singh Jani, Mahesh Gurjar, Mayuri Moitra, Mohib Uddin, Pallavi Upadhyay, Pavithra Sundar, Pradhyuman Sindha, Pradeep Dobhal, Priyank Kapadi, Shimontika Gupta, Sourav Supakar, Sutirtha Dutta, Swapna Lawrence, Swati Sen, Tanisha Dagur, Varun Kher, Yashwanth Gowda, Yudhajit Kundu

Volunteers: Aanshi Suman, Anupriya, Kranti Dev Singh, Kumari Priya, Md. Suhail, Mohabbat Singh, Ramesh V. Shenai, Samanyu Mugulure, Sarabjeet Kaur, Shivam Sharma, Vijay Patel Vinay Sharma, Vinayak Upadhyay

Field Assistants: Chandan, Devender Genwa, Prabhu Singh, Prakash, Saavan Khan, Tousif Khan, Vivek

Forest Department Staff: Ajaypal Singh, Ashok, Danveer, Kamlesh Bishnoi, Devi Singh, Ghammu Devi, Indra, Kalu Ram, Kojraj Jaipal, Lalita Saini, Laxman, Priyanka, Rekharam, Sanjay Kumar, Shankar Singh, Suman, Sunita, Tanaram, Vikram

The **Bustard Recovery Program** aims to revive the Critically Endangered Great Indian Bustard by integrating ex-situ & in-situ conservation.

These actions are being jointly implemented by the Wildlife Institute of India and Rajasthan Forest Dept under the aegis of MoEF&CC, in collaboration with the International Fund for Houbara Conservation, and are funded by the National CAMPA.

Conservation Breeding Centers, running since 2019, will be continued under the Project Great Indian Bustard for reinforcing wild populations of this nationally important species.

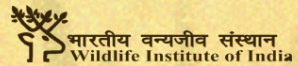
Simultaneously, research, monitoring, outreach and threat mitigation are underway to guide scientific management of GIB habitats in Thar.



सत्यमेव जयते
Government Of India



Government of Rajasthan
FOREST DEPARTMENT



الصندوق الدولي للحفاظ على الحباري
International Fund For Houbara Conservation



