

FINAL REPORT

2024-25



STUDY ON IMPACTS AND MITIGATION OF PROPOSED
MINE AND CEMENT PLANT ON GREAT INDIAN BUSTARD,
ITS ASSOCIATED WILDLIFE, AND HABITAT NEAR
RAMGARH, JAISALMER

Final report

Title: Study on impacts and mitigation of proposed mine and cement plant on Great Indian Bustard, its associated wildlife, and habitat near Ramgarh, Jaisalmer

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Background

Dalmia Bharat Green Vision Ltd. has proposed a new limestone mining project near Ramgarh village, Ramgarh tehsil, Jaisalmer district, Rajasthan, along with an associated cement plant. The proposed mine (2.56 km²) and cement plant (1.40 km²) encompass a combined lease area of 3.96 km² (396 ha), with an anticipated annual production capacity of 5.4 metric tonnes of limestone. The lease area is geographically located between 27°20'37.900"N–27°22'21.923"N and 70°30'34.467"E–70°31'3.603"E and falls under Seismic Zone II (Figure 1). According to the EIA Notification, 2006 (Schedule 1[a]), the project falls under Category “A” because the lease area exceeds 250 hectares, thereby requiring evaluation at the central level. The project has been approved by the Indian Bureau of Mines, Ajmer (ref no.- MCDR-MPCOLST/10/2023-AJM-IBM_RO_AJM on 04.09.2023) for an initial period of 20 years.

The proposed mine site and the associated cement plant area are located outside any designated forest land, however, the project site is in proximity to the ecologically sensitive Priority Great Indian Bustard (GIB) Area, as mentioned by the Hon’ble Supreme Court of India in *M.K. Ranjitsinh & Ors. vs. Union of India & Ors.* [Writ Petition (Civil) No. 838 of 2019]. Furthermore, the proposed site falls within the Potential GIB Area, which serves as an important ecological corridor connecting the Desert National Park with adjoining semi-arid grassland systems in Pokhran Field Firing Range and in the western Thar landscape. Accounting for this, the Expert Appraisal Committee (non-coal mining sector) of MoEF&CC, in its meeting held on June 12- 14, 2024, advised the proposing agency to “engage an institute of national repute to determine the presence of GIB within the lease area or nearby”. The EAC also requested the submission of a conservation and management action plan in accordance with the Hon’ble Supreme Court's order passed in WP(C) No. 838 of 2019.

In compliance with these directives, Dalmia Bharat Green Vision Ltd. approached the Wildlife Institute of India, Dehradun, to conduct ecological assessments aimed at establishing the biodiversity values, assessing the potential direct and indirect impacts of the proposed mining and industrial activities, and developing evidence-based recommendations to guide sustainable coexistence between industrial development and the conservation of threatened grassland species.

The Ramgarh landscape forms part of the larger Thar Open Natural Ecosystem, known for its unique assemblage of grassland-dependent flora and fauna. The area supports several species of high conservation importance, including those listed in Schedule I of the Wildlife Protection Act 1972 (2023 amendment) and/or threatened under the IUCN Red List. These include the *Critically Endangered* Great Indian Bustard (*Ardeotis nigriceps*), several species of vultures, along with the *Vulnerable* Spiny-tailed Lizard (*Saara hardwickii*), as well as Chinkara (*Gazella bennettii*) and Desert Fox (*Vulpes vulpes pusilla*), among others. The Thar Desert represents one of India’s most ecologically fragile yet productive arid landscapes. While mining and industrial development contribute significantly to regional economic growth, they also pose challenges in maintaining ecological integrity and landscape connectivity for wide-ranging and ground-nesting species. The proposed mining area and its vicinity near Ramgarh, with its open grassland matrix interspersed with *Prosopis juliflora* scrub, is located close to traditional bustard

movement corridors, seasonal water catchments (*nadis*), and open grazing grounds that support native biodiversity and pastoral livelihoods.

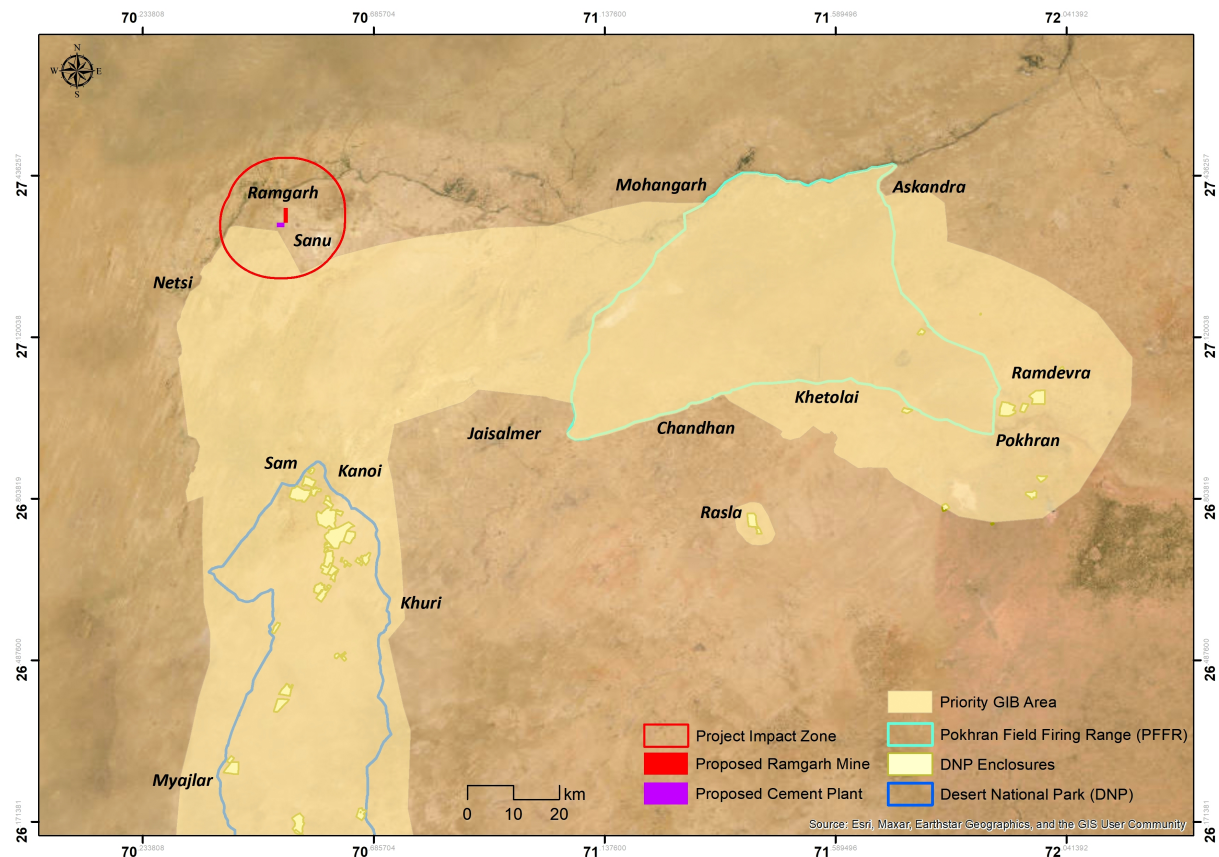


Figure 1: Location of the proposed limestone mine and cement plant in Ramgarh, Priority GIB Area and Desert National Park within the Thar landscape (2025)

Aspects to assess the current ecological value of the area were identified based on reconnaissance visits. They were:

- 1) Occurrence and diversity of faunal species found in the area, with focus on GIB and its associated species of conservation importance (Schedule-I of Wildlife Protection Act of India and/or threatened as per IUCN Red List) that are co-indicators of suitable bustard habitats;
- 2) Habitat composition of the area to determine the floral diversity and assemblages.
- 3) Land use and land cover characteristics (including natural vegetation, waterbodies, agricultural areas, and settlements) to understand the spatial layout and components likely to be impacted by mining activities.

Limestone Mining in the Ramgarh-Jaisalmer Region

The Jaisalmer region of western Rajasthan is geologically renowned for its extensive Eocene-age limestone formations, primarily belonging to the Khuiyala and Sanu Limestone Formations, which host deposits of both Steel Melting Shop (SMS)-grade and cement-grade limestone. The formations extend over ~500 km², with an average width of 5 km, and display bedded, stratiform deposits conducive to large-scale mechanised mining (Figure 2).

Profiling of the Mine Site and the Surrounding Landscape

The proposed mine and cement plant site is situated between Ramgarh village and the Ramgarh Gas Thermal Power Station and is sliced by National Highway 68, which connects Jaisalmer to Ramgarh (Figure 3). The immediate landscape surrounding the lease area is semi-urban, with commercial infrastructure along the road, including a fuel station, shops, and restaurants. On the southern periphery, a BSF camp is also located. The northern edge of the site has village settlements, including Ramgarh town, and the lease area comprises flat, open grasslands interspersed with *Prosopis juliflora* invasions and croplands.

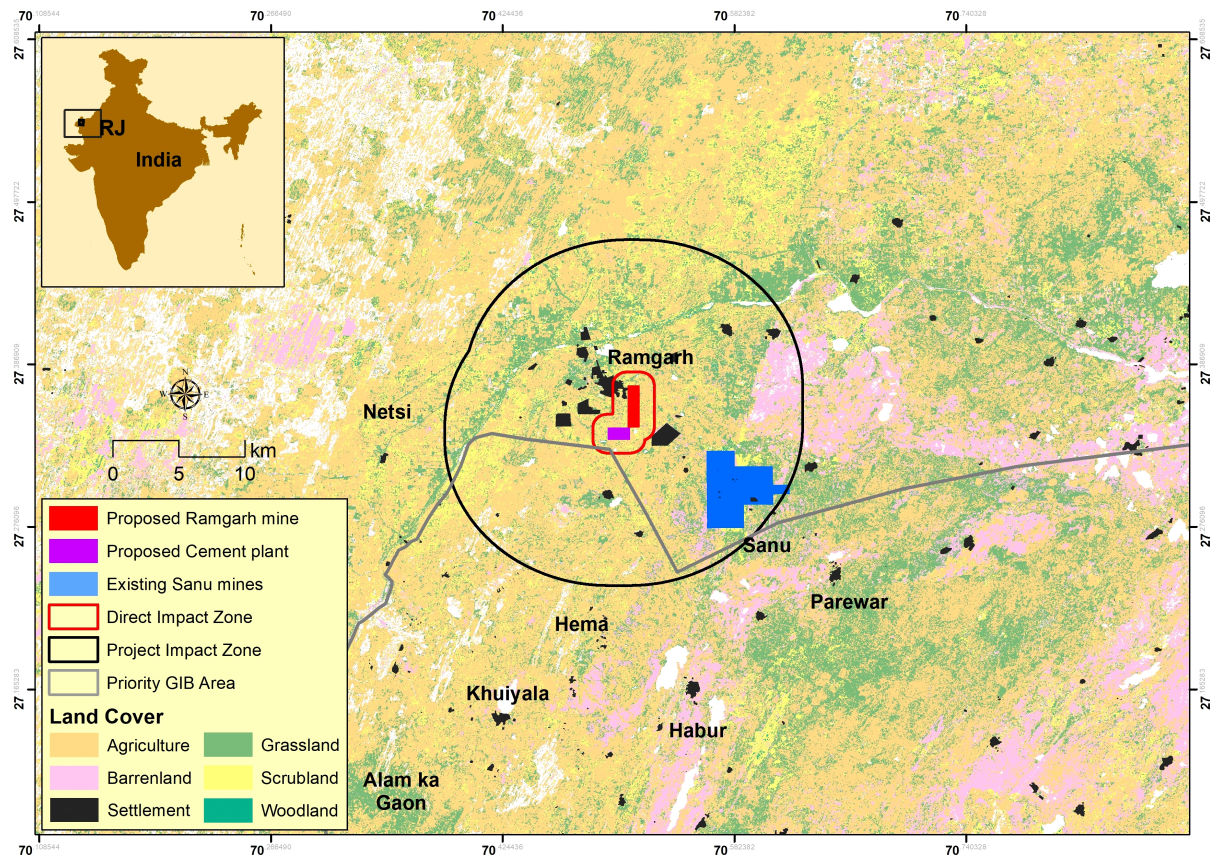


Figure 3: Study area map indicating the proposed Ramgarh mine and the adjacent cement plant in relation to the priority GIB area and recent land cover, including the Direct and Indirect Impact Zones, Jaisalmer, Rajasthan (2025).

Although there are no perennial rivers or major drainage channels within the lease site, traditional water catchments (*nadis*) are present and play a crucial role in sustaining vegetation and livestock during monsoon months. The area supports a mix of land uses, including grassland, scrubland, active/fallow agriculture, and settlement areas. Its proximity to the Priority GIB Area increases its potential ecological relevance for biodiversity assessment and conservation planning.

Mitigation Hierarchy

Mitigation, in the framework of sustainable development, aims at identifying strategies and measures that will address conservation concerns that often arise with development proposals. The

strategies and recommendations made to these development projects must adhere to a hierarchy of key mitigation principles to obtain environmentally friendly economic development.

1. **Avoidance:** In areas where the detrimental impact on the environment and biodiversity is high, avoidance is the only definitive option to achieve sustainability. An alternative location or design can be considered to eliminate such an adverse impact.
2. **Minimisation:** minimise or reduce adverse impacts to 'as low as practicable levels;
3. **Restoration:** restore areas damaged by construction/mining; and
4. **Remediation:** remedy or compensate for adverse residual impacts that are unavoidable and cannot be reduced further.

All recommendations provided in this study adhere to these mitigation principles.

Biodiversity Assessment

Study Approach

Information on the wildlife significance of the GIB and its associated species was derived from published literature and long-term monitoring studies undertaken by the Wildlife Institute of India and the Rajasthan Forest Department (Dutta et al., 2017; 2024). These assessments showed that the larger project impact area supports several species of conservation importance that are listed under Schedule I of the Wildlife (Protection) Act, 1972 (Amendment 2023), or listed as threatened by IUCN Red List assessments (IUCN, 2025). A list of Schedule-I and globally threatened species recorded within the Project Impact Zone is provided in Annexure 1. As the earlier datasets were coarse in spatial resolution and inadequate to represent fine-scale patterns of species distribution and abundance, comprehensive field surveys were subsequently carried out to document wildlife occurrence and habitat associations within the Project Impact Zone.

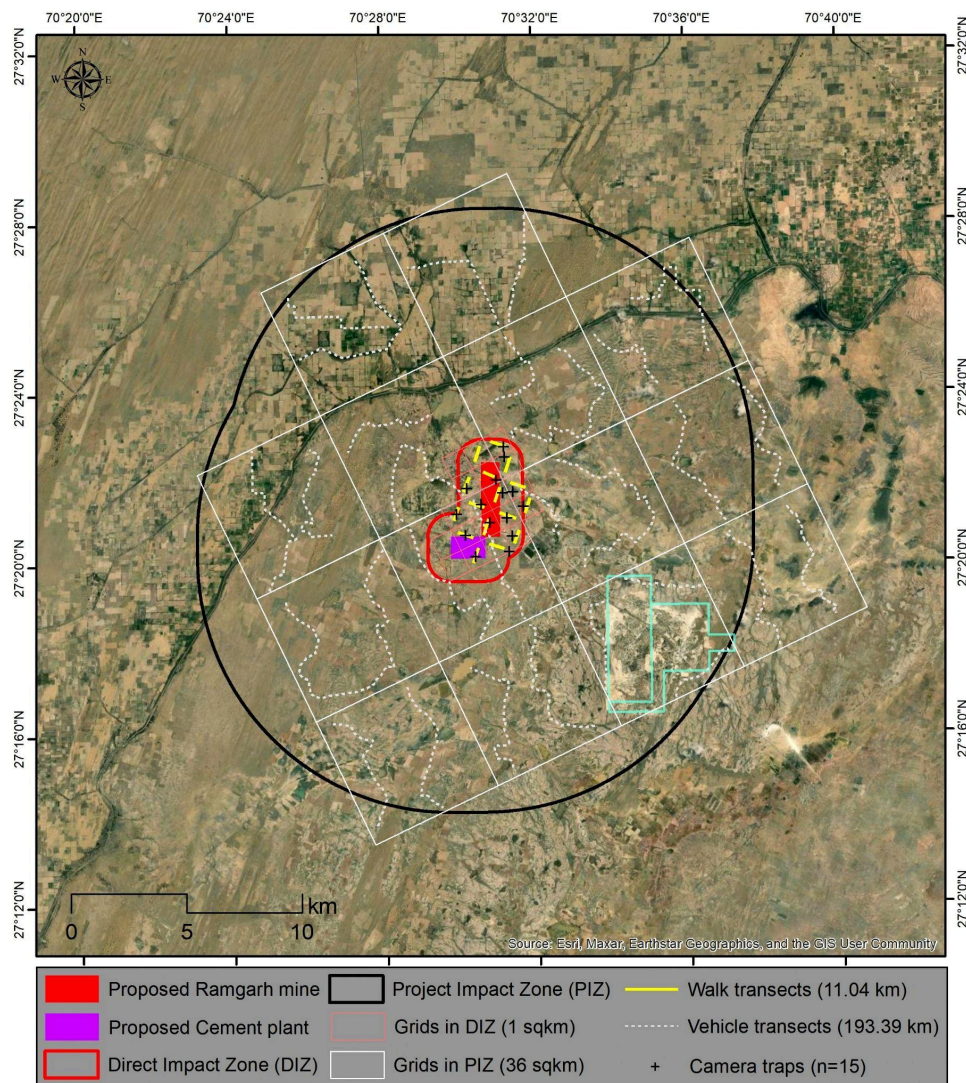


Figure 4: Map showing field efforts for camera trapping (n=15), walk transects (11.04 km) and vehicle transects (193.39 km) for biodiversity assessment within the Direct Impact Zone and Project Impact Zone in and around the proposed Ramgarh mine and associated cement plant in Jaisalmer, Rajasthan (2025)

Although assessing the potential impacts of mining on the GIB is the primary mandate of this study, the species' extreme rarity and the current conservation approach, which focuses on restoring former habitats and reintroducing captive-bred individuals, require a broader analytical perspective. Accordingly, the study emphasises the identification of suitable habitats for GIB and the evaluation of grassland-adapted, conservation-dependent species that are ecologically associated with or serve as surrogates for the GIB. These indicators were used to characterise biodiversity values and infer the ecological sensitivity and potential impacts of mining within the study area.

A multi-season biodiversity assessment was conducted across the Project Impact Zone to evaluate species populations that are likely to be influenced by the proposed mining activities and to assess the ecological sensitivity of the proposed mining leases. Sampling was implemented at two spatial scales. Within the Direct Impact Zone (core area), 1 km² grids were established, encompassing an area of 17 km². In contrast, the larger Project Impact Zone (including both direct and indirect zones) was overlaid with 36 km² grids covering an area of 504 km². In the Direct Impact Zone, camera-trap distance sampling was conducted during April-May, 2025, to estimate the densities of mammals such as Chinkara (*Gazella bennettii*), Desert Fox (*Vulpes vulpes pusilla*), and Indian Fox (*Vulpes bengalensis*), while intensive walk-transect distance sampling was done in February and June-July, 2025, to determine the densities of small birds (Figure 4). Additionally, vegetation and invertebrate sampling plots were established along these line transects to record the abundance of trees, shrubs, insects, and fossorial animals like the Spiny-tailed Lizard (*Saara hardwickii*) and Indian Desert Gerbil (*Meriones hurrianae*). Vehicle-based line transects were conducted in the Project Impact Zone during winter (February), summer (April), and monsoon (June-July) seasons (in 2025), to record wide-ranging species such as GIB, Chinkara, and large birds. Observations on dominant land-cover types, vegetation structure and composition, and disturbance features were also documented concurrently (Table 1). A detailed description of the sampling methodologies is provided in subsequent sections.

Additionally, habitat characteristics were also analysed to assess their suitability for GIB, thereby contributing to ongoing efforts for habitat restoration and potential reintroduction of captive-bred individuals. Our wildlife and conservation planning was informed by the documented presence of Schedule-I species listed under the Wildlife Protection Act, 1972 (as amended in 2023), and species classified as Threatened under the IUCN Red List, highlighting their significant conservation value.

Table 1: Table of studies conducted for assessment of biodiversity in the Direct and Indirect Impact Zone of the proposed mining and plant areas, Jaisalmer, Rajasthan (2025) (LT: line transects, VT: vehicle transects, CT: camera traps)

Assessment	Attributes	Direct Impact Zone	Indirect Impact Zone
Habitat Assessment	Land Cover	LT & VT	VT
	Vegetation Structure	LT & VT	VT
	Vegetation Composition	LT & VT	VT

Key Fauna	Large Birds	VT	VT
	Mammals	CT & VT	VT
Other Fauna	Small Birds	LT	-
	Insects	LT	-
	Fossorial animals	VT	VT

Study Findings

The following Schedule-I and IUCN-listed species were observed during the multiseason assessment conducted within the Project Impact Zone: Chinkara, Desert Fox, Indian Fox (mammals), Long-legged Buzzard, White-eyed Buzzard, Steppe Eagle, Tawny Eagle, Short-toed Snake Eagle, Montagu's Harrier, Pallied Harrier, Egyptian Vulture, Eurasian Griffon (raptors), Indian Peafowl, Rufous-tailed Lark, Common Crane, India roller (other birds), Spiny-tailed Lizard (reptiles), and a few more (Annexure 1).

Habitat

A comprehensive habitat assessment was undertaken within the Project Impact Zone to establish baseline information on land cover, soil substrate, and vegetation composition and structure. In the Project Impact Zone, data were collected systematically along predetermined routes traversed by slow-moving vehicles (10-15 km/hr) to document habitat characteristics within 36 sq km grid cells. At each sampling point (at 200m intervals), representing a 100 m radius, dominant land-cover categories, such as grassland, scrubland, woodland, barren land, and both active and fallow agricultural fields, were identified. The proportional cover of upperstorey vegetation (trees and shrubs) and understorey vegetation (grasses and herbs) was also estimated. Observations were made at 2 km intervals along the transects to ensure uniform spatial coverage across the landscape.

In the Direct Impact Zone, additional habitat parameters were recorded to capture finer details of vegetation structure. Understorey vegetation height was classified into three strata (<20 cm, 20–60 cm, and 60–100 cm) and quantified within 2 × 2 m quadrats laid along walking transects. Data on upperstorey woody species were gathered to estimate plant abundance within these areas. For this purpose, 700 m walk transects were established within each 1 km² sampling grid. Each belt transect (100 × 20 m for trees and 50 × 20 m for shrubs) comprised two sampling sections positioned between 0-100 m and 600-700 m of the walk transect (Figure 5). All trees and shrubs occurring within these belts were enumerated to determine species composition and abundance.

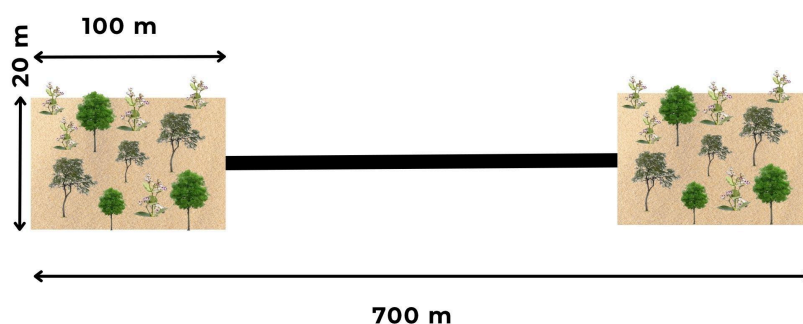


Figure 5: Depiction of intensive habitat survey transect showing sampling plots, Jaisalmer, Rajasthan (2025)

This survey generated a comprehensive understanding of land-cover patterns and vegetation attributes throughout the project landscape. Such information on vegetation structure and composition is essential for evaluating habitat suitability for GIB and for anticipating potential impacts of mining activities on plant communities that underpin the survival of threatened fauna.

Land Cover

The land cover in the Direct Impact Zone consisted of grassland > woodland > scrubland > barren areas (Figure 6). In the Indirect Impact Zone, the land cover consisted of almost equal proportions of woodland and grasslands, followed by seasonal agriculture>scrubland> and barren areas. The Direct Impact Zone did not contain any agriculture.

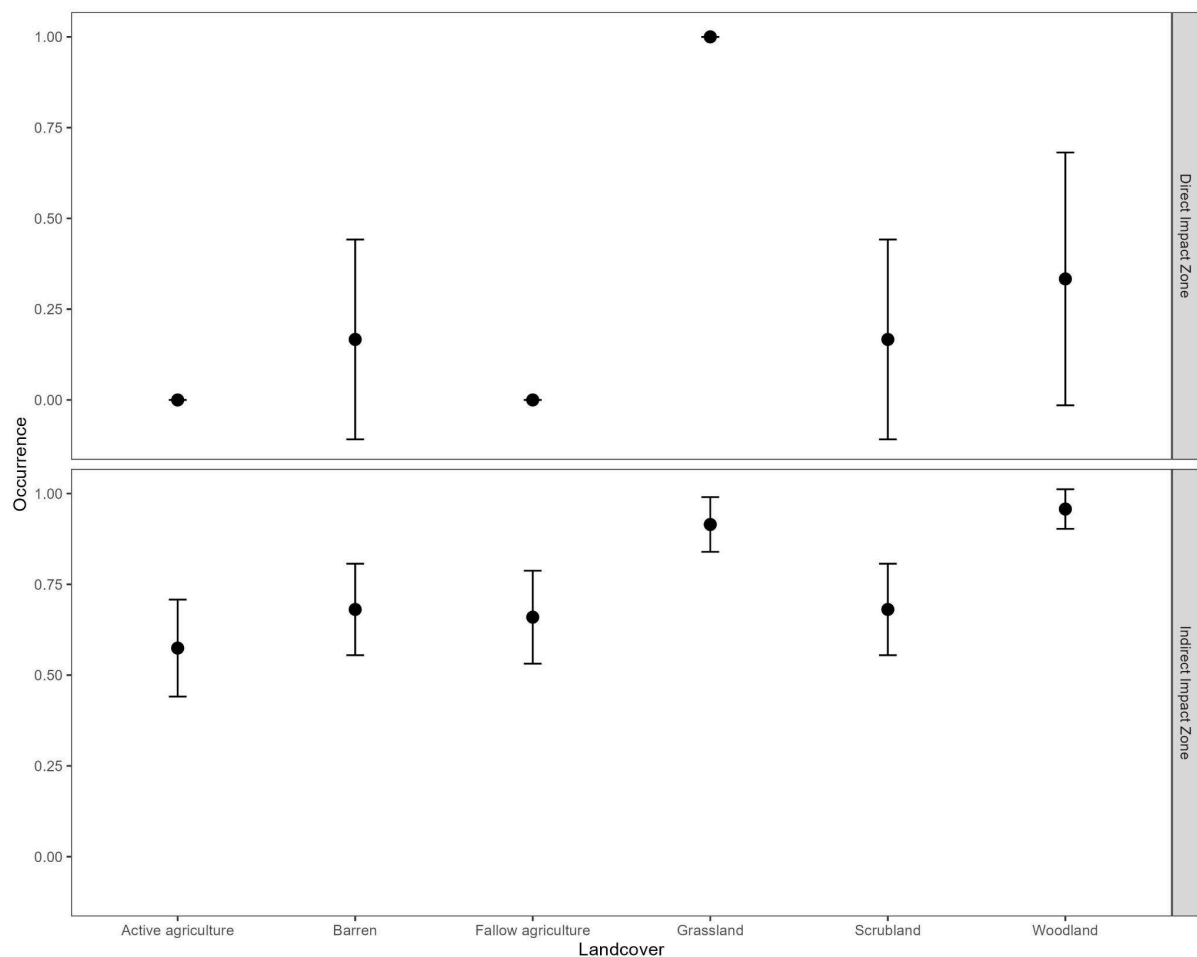


Figure 6: Mean $\pm$ SE (error bars) occurrence (proportion) of landcover types in Direct (top) and Indirect (bottom) Impact Zones of the proposed Ramgarh mining block and associated cement plant, sampled at 100m radius points along vehicle transects during winter, summer and monsoon seasons of 2025.

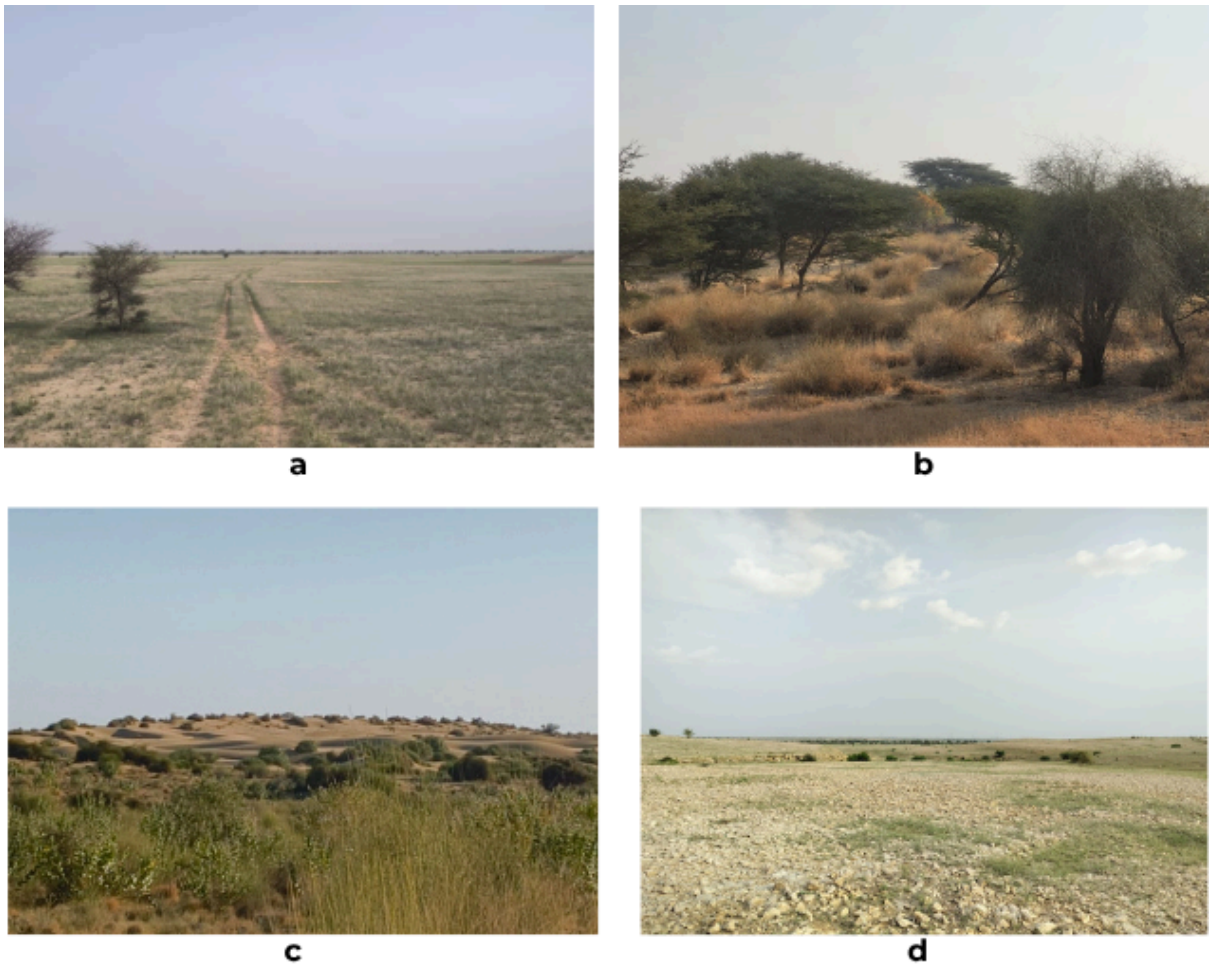


Plate 1: Different types of land cover (a- Grassland, b- Woodland, c- Scrubland, d- Barren) in the Direct and Indirect Impact Zones of the proposed Ramgarh mines, Jaisalmer, Rajasthan (2025).

Vegetation Composition

In the Project Impact Zone, the grass *Dacylotenium spp.* constituted the most dominant component of the understorey vegetation, followed by *Fagonia cretica*. Within the Direct Impact Zone, the shrub *Tephrosia spp.* was recorded as the predominant understorey taxon. In contrast, the Indirect Impact Zone supported a more diverse assemblage of species, including *Aerva spp.* , *Crotalaria burhia*, *Leptadenia pyrotechnica*, etc (Figure 7).

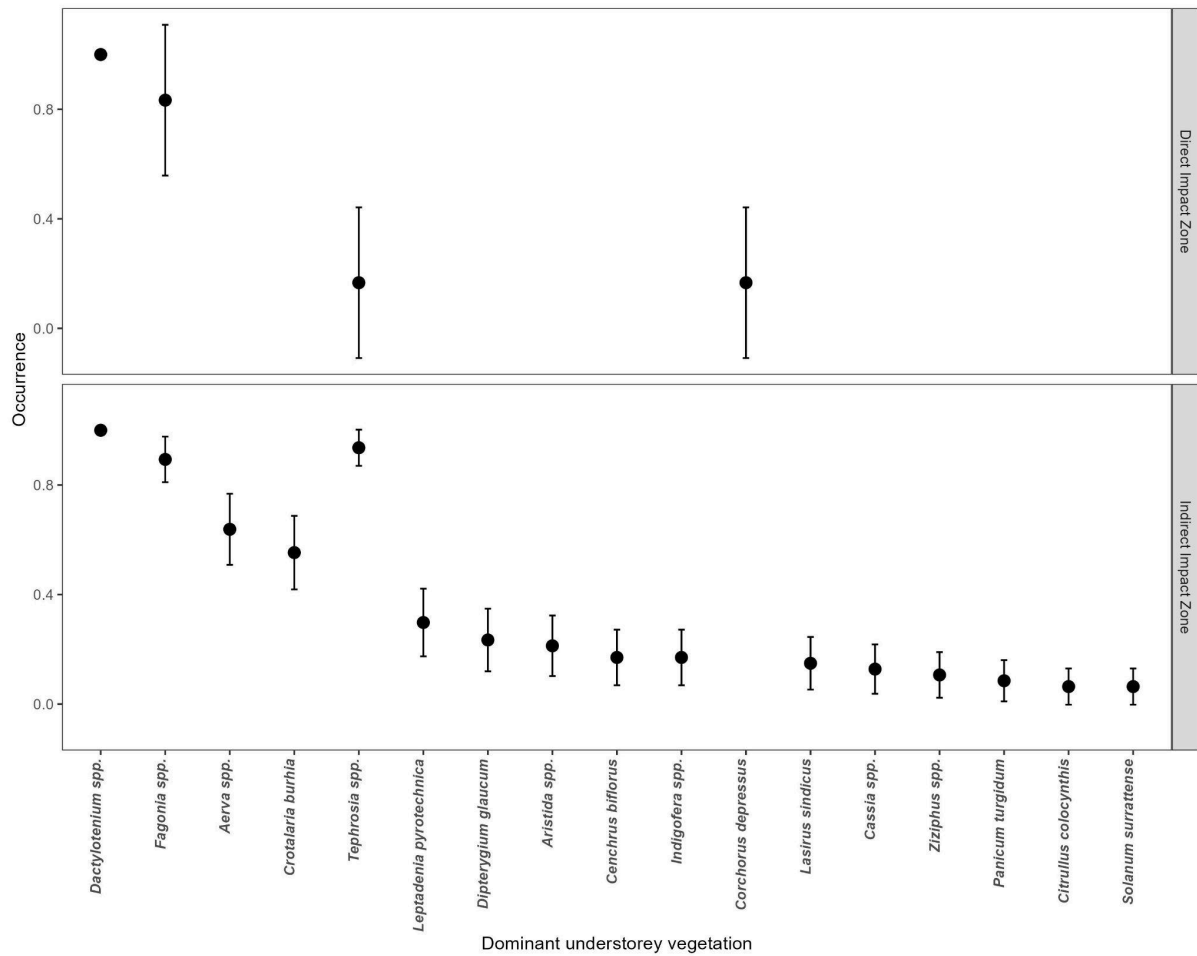


Figure 7: Mean $\pm$ SE (error bars) occurrence of dominant understorey vegetation (grasses and shrubs) in Direct (top) and Indirect (bottom) Impact Zones of the proposed Ramgarh mining block and accompanying cement plant, sampled at 20m radius points along vehicle transects during winter, summer and monsoon seasons of 2025.

The upperstorey vegetation was dominated by the invasive *Prosopis juliflora* in both the Direct and Indirect Impact Zones. The other dominant species included *Capparis decidua* > *Ziziphus spp.* > *Leptadenia pyrotechnica* in the Indirect Impact Zone and *Ziziphus spp.* > *Calotropis spp.* in the Direct Impact Zone (Figure 8). Notably, the culturally and ecologically significant *Prosopis cineraria* (Khejri) was observed exclusively within the Indirect Impact Zone.

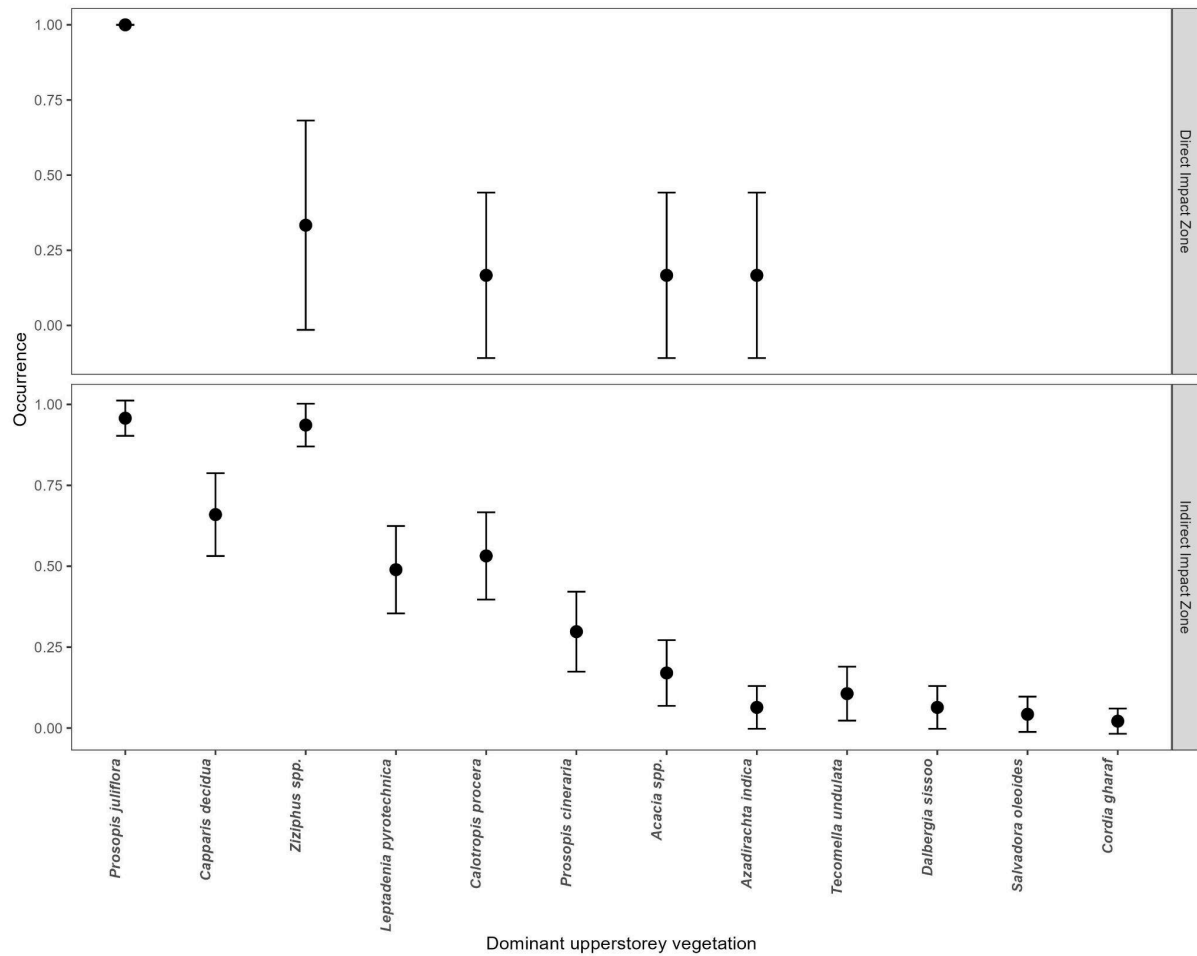


Figure 8: Mean $\pm$ SE (error bars) occurrence of dominant upperstorey vegetation (trees) in Direct (top) and Indirect (bottom) Impact Zones of the proposed Ramgarh mining block and accompanying cement plant, sampled at 100m radius points along vehicle transects during winter, summer and monsoon seasons of 2025



Plate 2: Important dominant vegetation (a- Khejri *Prosopis cineraria*, b- Ker *Capparis decidua*) in the Direct and Indirect Impact Zones of the proposed Ramgarh mine, Jaisalmer, Rajasthan (2025).

Vegetation Structure

The structure of understorey vegetation in the Direct Impact Zone was predominantly short (>20 cm), followed by medium-height vegetation (20 cm - 60 cm) and tall vegetation (60 cm - 100 cm) (Figure 9). Only minor seasonal variation was observed in the overall structural composition.

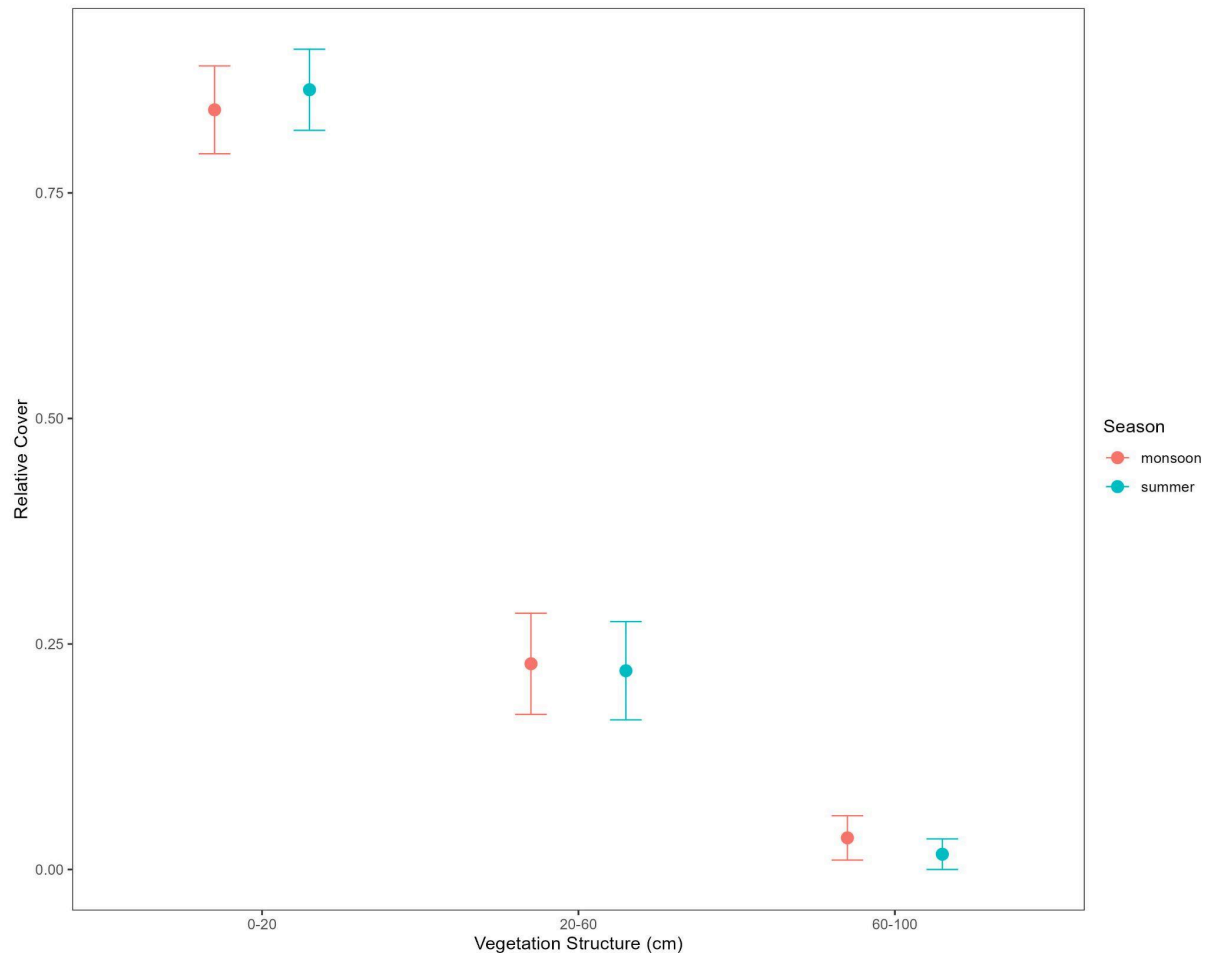


Figure 9: Mean $\pm$ SE (error bars) relative cover of understorey vegetation in the Ramgarh proposed mine area and the associated cement plant, sampled within 2 m x 2 m plots along walk transects during summer and monsoon 2025

Disturbance

Renewable energy infrastructure (wind turbines), high-tension transmission lines, and human settlements were quantified within the Project Impact Zones (both Direct and Indirect Impact Zones) (Figures 10,11). Wind turbines were absent throughout the Project Impact Zone. Both the Direct and Indirect Impact Zones exhibited substantially higher disturbance due to longer high-tension transmission lines and larger settlement areas. These results indicate that the proposed mining block and its surrounding landscape currently experience high anthropogenic disturbances, which are comparatively dissimilar to areas that are occupied by the GIB. Nevertheless, if managed appropriately, the grassland patches within the Indirect Impact Zone still hold potential to support habitat functionality relevant for GIB conservation and landscape-level planning.

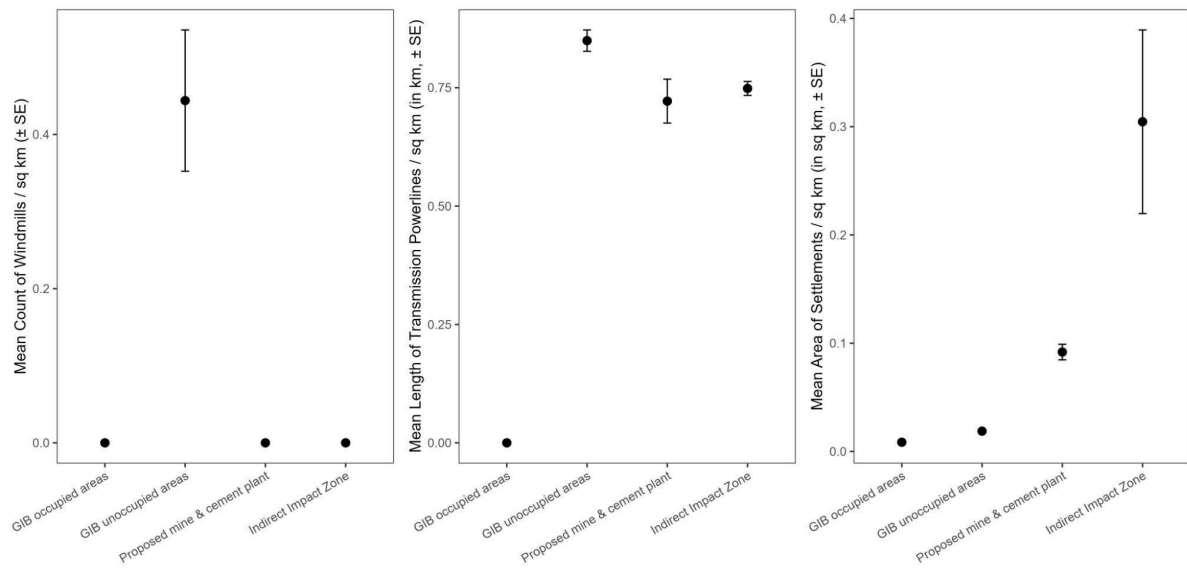


Figure 10: Mean $\pm$ SE (error bars) count per km² of windmills (left), mean $\pm$ SE length of high-tension transmission lines per km² (centre), and mean $\pm$ SE area of human settlement (right) in the Project Impact Zones of the proposed Ramgarh mining area compared to areas having the Great Indian Bustard (2025)

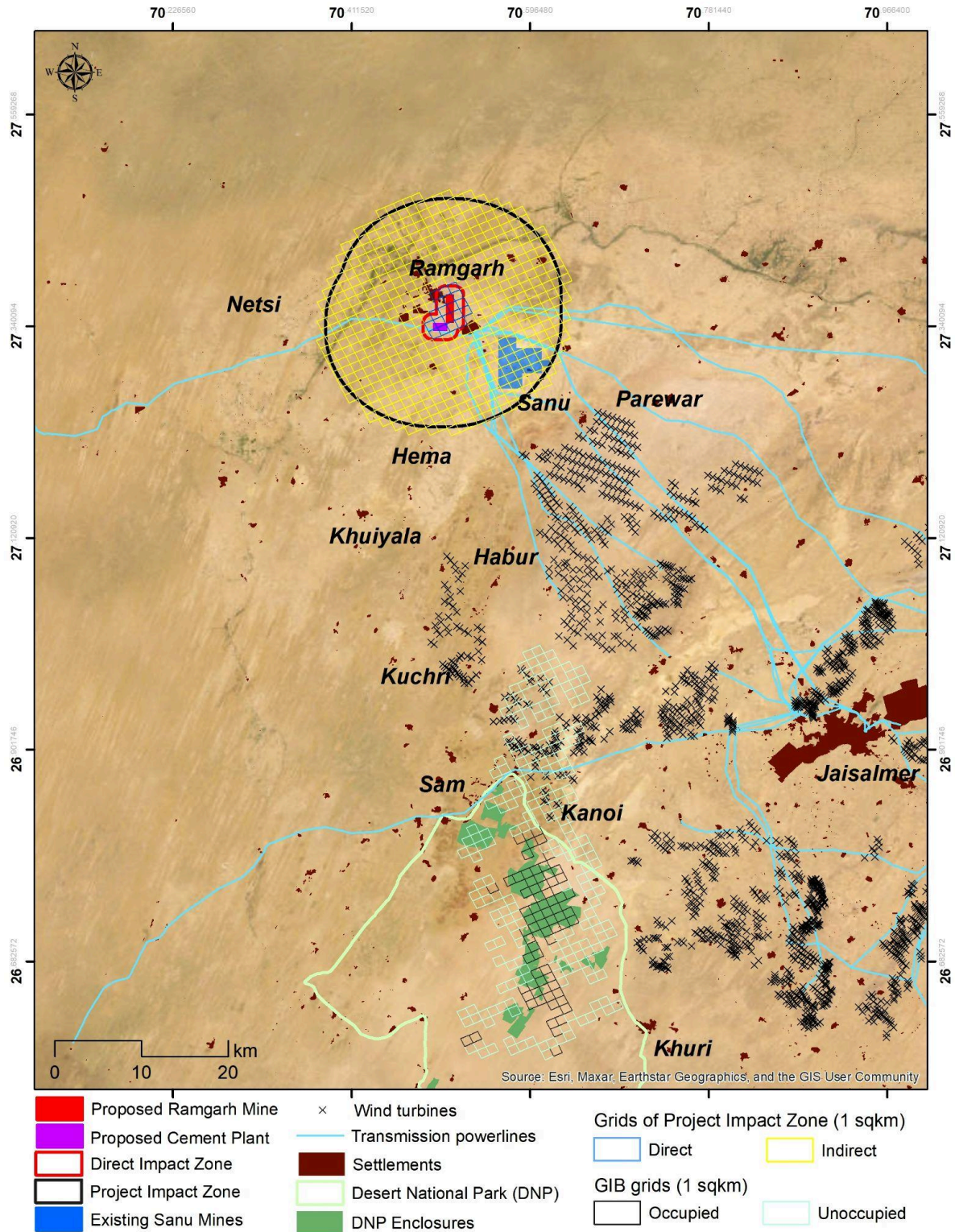


Figure 11: Map showing the intensity of renewable energy infrastructures (transmission power lines and wind turbines) and human settlements with respect to the Project Impact Zone and GIB use areas in Jaisalmer, Rajasthan

Plant Species Densities and Numbers

A total of 1614 trees are estimated to be present in the Direct Impact Zone of the proposed mine and cement plant. A list of all tree and shrub species found in the area, along with their density per hectare and total counts, has been provided in tables below (Tables 2 and 3).

Table 2: Estimate of density $\pm$ SE (count per hectare) and total abundance of tree species (woody plants with height > 2 m) found in the Direct Impact Zone in the proposed mine of Ramgarh and associated cement plant, sampled in a 200m² belt along walk transects during summer and monsoon seasons of 2025

Tree Species	Density $\pm$ SE (count/hectare)	Total Abundance
<i>Capparis decidua</i>	0.93 $\pm$ 0.65	369
<i>Prosopis cineraria</i>	0.12 $\pm$ 0.12	48
<i>Ziziphus spp.</i>	3.02 $\pm$ 1.3	1197
Total		1614

Table 3: Density estimate $\pm$ SE (per hectare) and total abundance of shrub species found in the Direct Impact Zone in the proposed mine of Ramgarh and associated cement plant, sampled in a 100m² belt along walk transects during summer and monsoon seasons of 2025

Shrub Species	Density $\pm$ SE (count/hectare)	Total Abundance
<i>Aerva spp.</i>	0.93 $\pm$ 0.73	369
<i>Calotropis procera</i>	8.26 $\pm$ 2.86	3274
<i>Crotalaria burhia</i>	6.28 $\pm$ 6.28	2489
<i>Echinops echinatus</i>	1.86 $\pm$ 1.86	737
<i>Fagonia spp.</i>	17.44 $\pm$ 8.47	6912
<i>Leptadenia pyrotechnica</i>	3.95 $\pm$ 1.94	1566

Key Fauna

Great Indian Bustard

The critically endangered Great Indian Bustard is a flagship species of the Indian arid grassland ecosystems. The species requires large, contiguous expanses of open habitat for its survival. The Hon'ble Supreme Court, in its directive WP(C) 838 of 2019, delineated the Priority GIB Area, encompassing key grassland habitats essential for the conservation of species. Although GIBs have been documented in the Indirect Impact Zone in the recent past, no individuals have been recorded within the Direct Impact Zone of the proposed mine (Figure 12). Importantly, the extensive grassland around the proposed mining blocks in the Indirect Impact Zone has been recognised as a potential site for GIB rewilding under the national GIB conservation breeding programme. Any alteration of these natural grassland mosaics, whether through fragmentation, infrastructure development, or

increased mining activity, could jeopardise the success of current and future efforts aimed at releasing captive-bred birds and establishing self-sustaining populations in the wild.

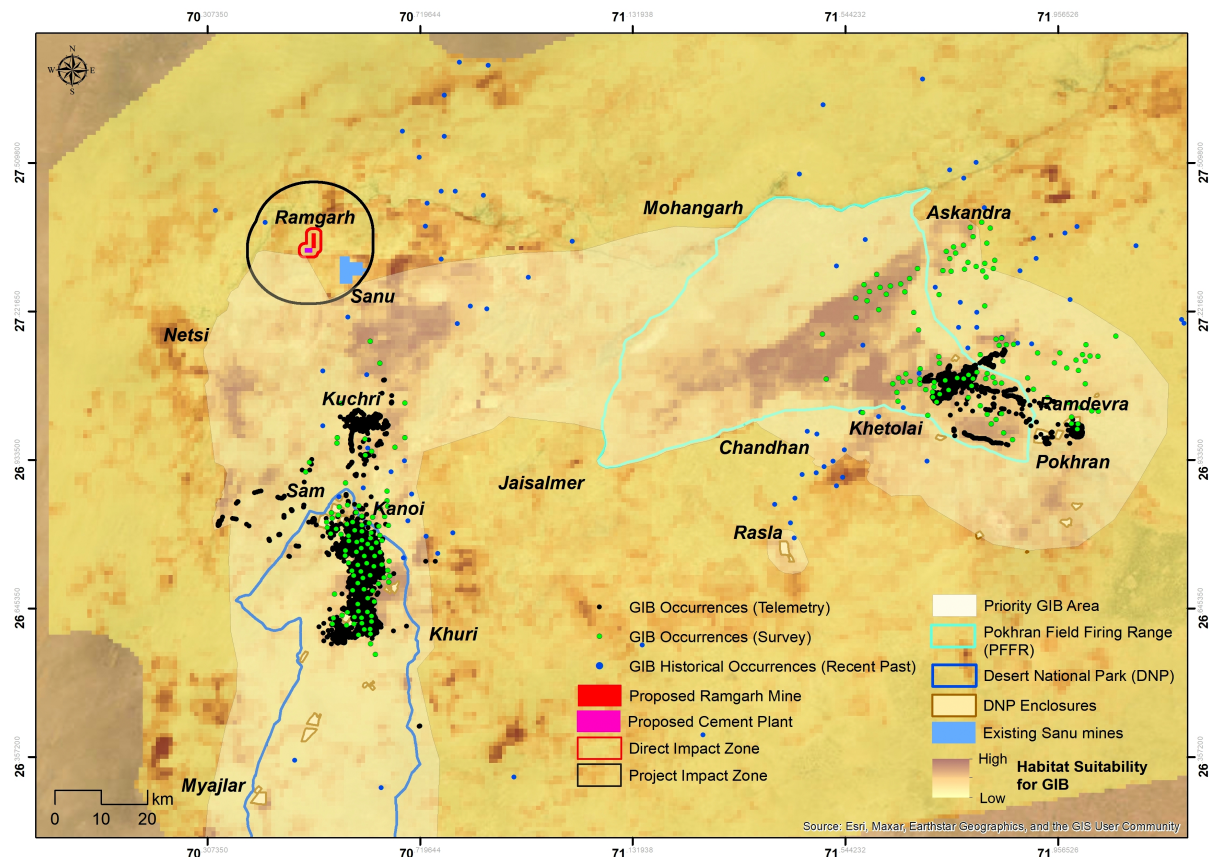


Figure 12: Location of proposed Ramgarh and existing Sanu mines along with the Project Impact Zones with respect to GIB occurrence within the Thar landscape (2025)

Large Birds

The distribution and population status of large-bodied birds within the Project Impact Zone were assessed by conducting vehicle-based transect surveys (Dutta et al., 2017). As these species are typically wide-ranging, their effective impact zone is larger than that of smaller birds and mammals. Therefore, these surveys were conducted in 6 km x 6 km grids covering both the Direct and Indirect Impact Zones. The survey design used was based on the standard protocols established for conducting large-scale population assessment of GIB and associated species (Dutta et al., 2017, 2024). This method has been extremely effective for detecting large-bodied animals and grassland/open habitat species, as individuals are visible from long distances when surveyed from a moving vehicle.

Systematic vehicular transects were conducted along dirt trails in a slow-moving vehicle (10-15 km/hr) by two-observer teams. Surveys were carried out during peak activity hours, varying seasonally: early morning (0700-1100 hrs in the winter and 0600-1030 hrs during summer and monsoon) and late afternoon (1600-1815 hrs during winter and 1700-1930 hrs in summer and monsoon). Species identification, number of individuals, sighting co-ordinates, sighting distance and bearings were recorded for all observations of birds that were stationary (perched on

trees/poles/pylons or on the ground). In case any flying or soaring individuals were detected, their occurrence was included in the estimation of encounter rates.

Three seasonal replicates of the survey were conducted: winter (February 2025), summer (April 2025) and monsoon (July-August 2025). Total survey effort was 551.23 km (mean per grid 13.44 ± 0.32 km SE/grid; winter 13.81 ± 0.34 km/grid, summer 13.39 ± 0.34 km/grid, and monsoon 13.10 ± 0.52 km/grid). If detections of any species were insufficient for reliable density estimation (<20 detections), only encounter rates (individuals/km) were calculated. Density estimates were derived from the best-performing model based on the lowest AIC and better goodness of fit (Annexure 2) (Buckland et al., 2001).

A total of 12 species of large birds were recorded during the survey, all of which are of conservation importance (Table 4), being either listed under Schedule I of the Wildlife Protection Act, 1972 (as amended in 2023), and/or categorised as threatened in the IUCN Red List.

Table 4: Population estimates (density and encounter rate) of conservation-dependent and threatened species in the Project Impact Zones around the proposed Ramgarh mine and cement plant in Ramgarh, Jaisalmer, Rajasthan (2025).

Species	Population Parameters	Project Impact Zone
	Area	504 sq km
Egyptian Vulture	Density $\pm$ SE (ind./sq km)	0.023 ± 0.014
	Encounter Rate (ind./km)	0.095 ± 0.023
Short-toed Snake Eagle	Density $\pm$ SE (ind./sq km)	0.072 ± 0.022
	Encounter Rate (ind./km)	0.253 ± 0.034
Tawny Eagle	Density $\pm$ SE (ind./sq km)	0.037 ± 0.016
	Encounter Rate (ind./km)	0.265 ± 0.032
White-eyed Buzzard	Density $\pm$ SE (ind./sq km)	0.128 ± 0.051
	Encounter Rate (ind./km)	0.185 ± 0.031
Cinereous Vulture	Encounter Rate (ind./km)	0.035 ± 0.009
Common Crane	Encounter Rate (ind./km)	5.28 ± 1.413
Eurasian Griffon	Encounter Rate (ind./km)	0.052 ± 0.016
Steppe Eagle	Encounter Rate (ind./km)	0.006 ± 0.006
Long-legged Buzzard	Encounter Rate (ind./km)	0.009 ± 0.005
Montagu's Harrier	Encounter Rate (ind./km)	0.079 ± 0.019

Pallid Harrier	Encounter Rate (ind./km)	0.114 ± 0.028
Shikra	Encounter Rate (ind./km)	0.026 ± 0.008

Across the Project Impact Zone, four Schedule-I raptors, Egyptian Vulture, Short-toed Snake Eagle, Tawny Eagle, and White-eyed Buzzard, were assessed using distance sampling. All were observed in low numbers but measurable densities (0.023-0.128 individuals/sq km) (Table 4), which indicates sparse yet regular space use by these raptors. Encounter rates for additional species, including Cinereous Vulture, Pallid and Montagu's Harriers, further highlight the impact zone's importance for a diverse assemblage of wide-ranging, conservation-priority birds.



a



b



c



d



e



f

Plate 3: Conservation important raptor species (a- Tawny Eagle, b- Egyptian Vulture, c- Eurasian Griffon Vulture, d- Short-toed Snake Eagle, e- Montagu's Harrier, f- Steppe Eagle) in the Direct and Indirect Impact Zones of the proposed Ramgarh mines.

Mammals

Population status and distribution of terrestrial mammals were assessed employing the same vehicle-based line transect method as employed for the raptor surveys. This method has proven effective for detecting wide-ranging and open habitat species such as the Chinkara (Dutta et al., 2017, 2024). In the current study, robust population estimates were obtained only for Chinkara. For other conservation-important mammals, such as Desert Fox and Indian Fox, the number of observations was insufficient for reliable density estimation due to their predominantly nocturnal and elusive behaviour.

To supplement vehicle-based observations and improve detection of nocturnal or cryptic species, Camera Trap Distance Sampling (CTDS) was implemented within 1 km² grid cells in the Direct Impact Zone (Howe et al., 2017; Dutta et al., 2024). One camera trap was deployed per grid, positioned at or near the centroid and programmed to capture multiple images per trigger. Cameras remained active for approximately one month and were checked weekly. Captured images were processed using the Megadetector 5A algorithm (Celis et al., 2024) to classify detections into animal, human, vehicle, or blank categories. Animal captures were further sorted by species, and metadata, including detection distance and number of individuals, were annotated using ExifPro. Independent detection events were standardised at 5-second intervals between consecutive triggers to minimise temporal autocorrelation. For density estimation, half-normal and hazard-rate functions were compared to select the most parsimonious model based on AIC, and species-specific density estimates were derived (Table 5). The high SE is likely due to the limited number of detections, especially for Desert fox and Indian fox.

Table 5: Density (individuals/sq km) of Schedule-I terrestrial mammals assessed from vehicle transect and camera trap surveys in the Direct and Indirect Impact Zone of proposed Ramgarh mine, Ramgarh, Jaisalmer, Rajasthan (2025)

Species	Vehicle Transects (Project Impact Zone)	Camera Trapping (Direct Impact Zone)
Chinkara	0.692 ± 0.144	7.83 ± 4.43
Desert Fox	-	0.71 ± 0.6
Indian Fox		0.45 ± 0.55



a



b

Plate 4: Conservation-important mammal species (a- Chinkara, b- Desert Fox) in the Direct and Indirect Impact Zones of the proposed Ramgarh mines, Jaisalmer, Rajasthan (2025).



a



b

Plate 5: Field sampling activities in the Project Impact Zone of proposed Ramgarh mine, Jaisalmer, Rajasthan (a- Installation of camera traps for mammal monitoring, b- Vehicle-based surveys for detecting large birds and mammals) (2025).

Other Fauna

Birds

To estimate the distribution and abundance of small birds within the Direct Impact Zone, walk-transects were conducted following the line transect distance sampling method (Buckland et al., 2001). Two seasonal replicates were undertaken to document seasonal changes in bird assemblages during winter (February 2025) and monsoon (August 2025). In the winter season, 16 grids were covered with a cumulative sampling effort of 11.85 km (mean transect length 740.81 ± 14.70 SE m), whereas 10 grids were surveyed in the monsoon, covering 6.39 km (mean transect length 639.2 ± 37.25 SE m). The reduced effort was due to waterlogging in grassland and cropland. Transects were laid systematically within grids to represent habitat heterogeneity across major land-use types, including grasslands, scrublands, croplands, and rocky outcrops. Each transect was traversed by two trained observers moving at a consistent pace during peak activity periods in the morning (0700-1100 hrs) and evening (1600-1815 hrs). For each detection, observers recorded the species

identity, group size, and perpendicular distance from the transect line following the standard distance sampling protocol (Buckland et al., 2001).

Population parameters were derived using a multivariate conventional line-transect analysis (Buckland et al., 2001). To address low detection frequencies, observations were combined across species using the median detection distance approach. Median perpendicular distances were calculated for each species and classified into four detection categories, namely, proximal (<25th percentile), intermediate (25-50th percentile), distant (50-75th percentile), and very distant (>75th percentile). Detection functions (half-normal and hazard-rate, with null and Hermite polynomial adjustments) were fitted with each detection group as a covariate, and model selection was based on the lowest AIC and chi-square tests for goodness of fit. For each group, detection probability and effective strip width were estimated (Annexure 5), which were then applied to encounter rates (Annexure 3) to derive species-specific density estimates (individuals/sq km) from encounter rates. Final density estimates were summarised by species and further aggregated according to their feeding guilds to determine abundance across seasons.

Across both surveys, a total of 34 bird species were recorded, including conservation-priority species such as the Rufous-tailed Lark (*Cercotrichas galactotes*) and Indian Roller (*Coracias benghalensis*) (Annexure 1). Of these, 21 species had fewer than 5 detections, which were excluded from the distance analysis, while 13 species yielded reliable density estimates (Annexure 4).

Among the tested candidate models, the hazard-rate detection function without adjustment yielded the best fit with the lowest AIC. Based on 84 cluster detections, the overall bird density was estimated to be 310.64 individuals/km² ($\pm$ 75.03 SE, CV 0.24) in the Direct Impact Zone. Model fitness was confirmed by goodness-of-fit tests, indicating a strong fit to the observed data (GOF statistic = 0.08, p = 0.71).

Species-wise density estimates are presented in Figure 13. Among the recorded species, the Greater Short-toed Lark, being a large-flock species, showed the highest estimated density of 104 individuals/sq km ($\pm$ 56.66 SE). Several species of high conservation concern evaluated by the SolB assessment were recorded within the Direct Impact Zone, including Desert Wheatear (2 ± 0.86 ind/sq km), Tawny Pipit (14 ± 7.78 ind/sq km), and Variable Wheatear (5 ± 1.94 ind/sq km) (Figure 13; Annexure 4). Additionally, species categorised under moderate conservation priority in SolB assessment, such as Common Babbler (4 ± 2.72 ind/sq km), Crested Lark, Eurasian Hoopoe, European Roller, House Sparrow, and Long-billed Pipit were also recorded in considerable densities (Figure 13; Annexure 4). Notably, many of the species mentioned above are legally protected under Schedule II of the WPA 1972 (as per amendment 2023). The considerable populations of such open-habitat specialists highlight the ecological importance of the landscape. However, these species are highly vulnerable to habitat alteration, energy infrastructure, and other anthropogenic pressures.

Several species of high conservation significance (Threatened according to IUCN or Schedule I in the Wildlife Protection Act, 1972) were recorded inside the Direct Impact Zone (Annexure 1). These included raptors such as the Short-toed Snake Eagle, White-eyed Buzzard, Long-legged Buzzard, Shikra, and Montagu's Harrier. While not yet globally threatened, these species are undergoing declines associated with agricultural intensification, prey-base depletion, plant invasion, and collision

risks. Collectively, the occurrence of these globally threatened migrants and range-restricted residents highlights the high conservation value of the desert ecosystem and emphasises the importance of this area for wildlife conservation.

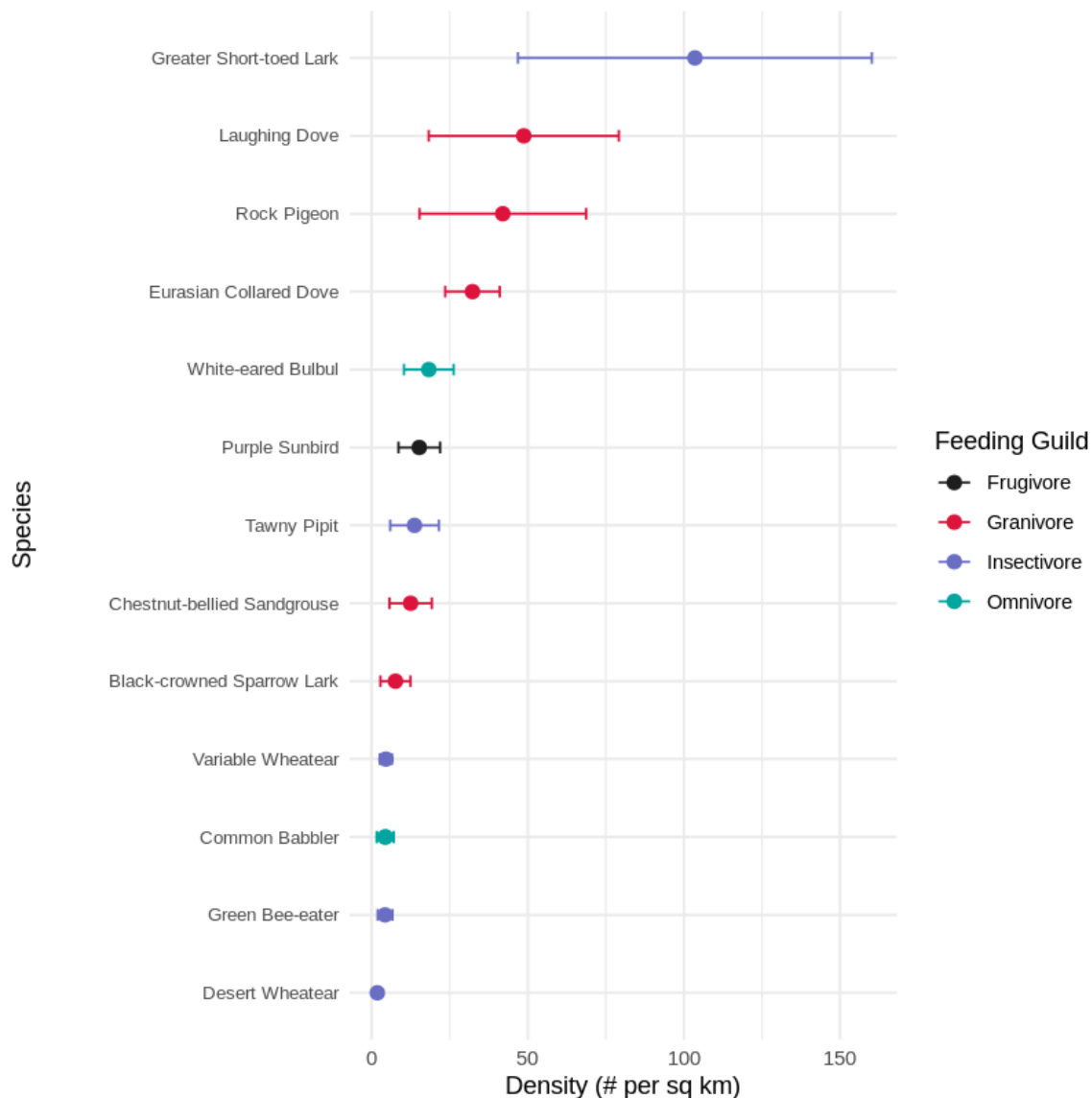


Figure 13: Density (individuals/sq km) of small birds recorded from walk-transect surveys conducted within 1 sq km grids in the Direct Impact Zone of the proposed Ramgarh mine and associated cement plant during winter and monsoon of 2025.

Fossorial Animals

Presence or absence data of burrowing fauna, including Spiny-tailed Lizard (*Saara hardwickii*) and Desert Gerbil (*Meriones hurrianae*), were systematically recorded during the time of intensive data collections. For this, within the selected sampling grids, a 700 m transect was laid, in the same transect, three points were generated at distances of 0m, 350m, and 700m, and the burrowing fauna were recorded within a 20m circular plot of each sampling point (Figure 14).

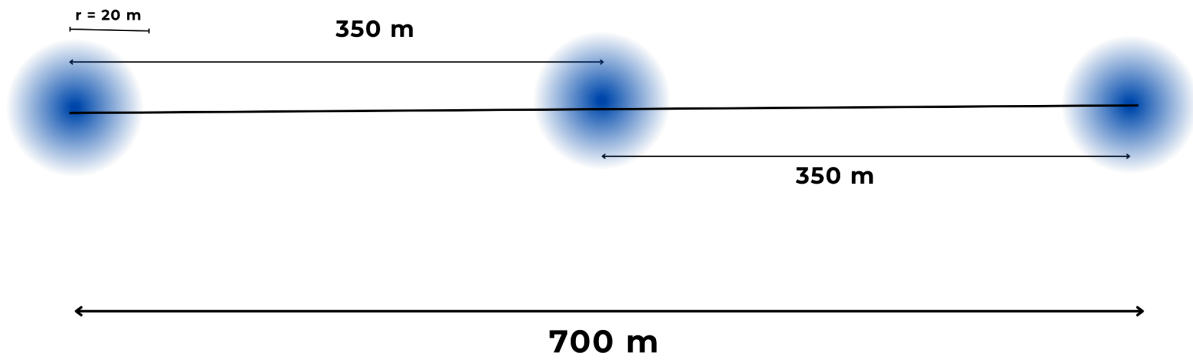


Figure 14: Depiction of fossorial animal survey showing sampling plots, Jaisalmer, Rajasthan (2025)

The mean burrow occurrence of Spiny-tailed Lizard was significantly higher in the monsoon (2.24 ± 0.56) than in the summer (0.26 ± 0.16). A similar trend was also observed in the Desert Gerbil, but the seasonal difference was relatively smaller (1.45 ± 0.85 in monsoon and 1.19 ± 0.83 in summer) (Figure 15).



Plate 6: Conservation-Important Fossorial Animals (a- Spiny-tailed Lizard, b- Desert Gerbil) in the Direct and Indirect Impact Zones of the proposed Ramgarh mines.

The presence of burrowing species such as Spiny-tailed Lizards and Desert Gerbils within the area indicates suitable habitats and soil conditions that support fossorial fauna. These species are key components of arid ecosystems and form an important prey base for raptors like Tawny and Steppe Eagles. Notably, the Spiny-tailed Lizard is accorded the highest protection status (Schedule I) under the Wildlife (Protection) Act, 1972 (as per amendment 2023).

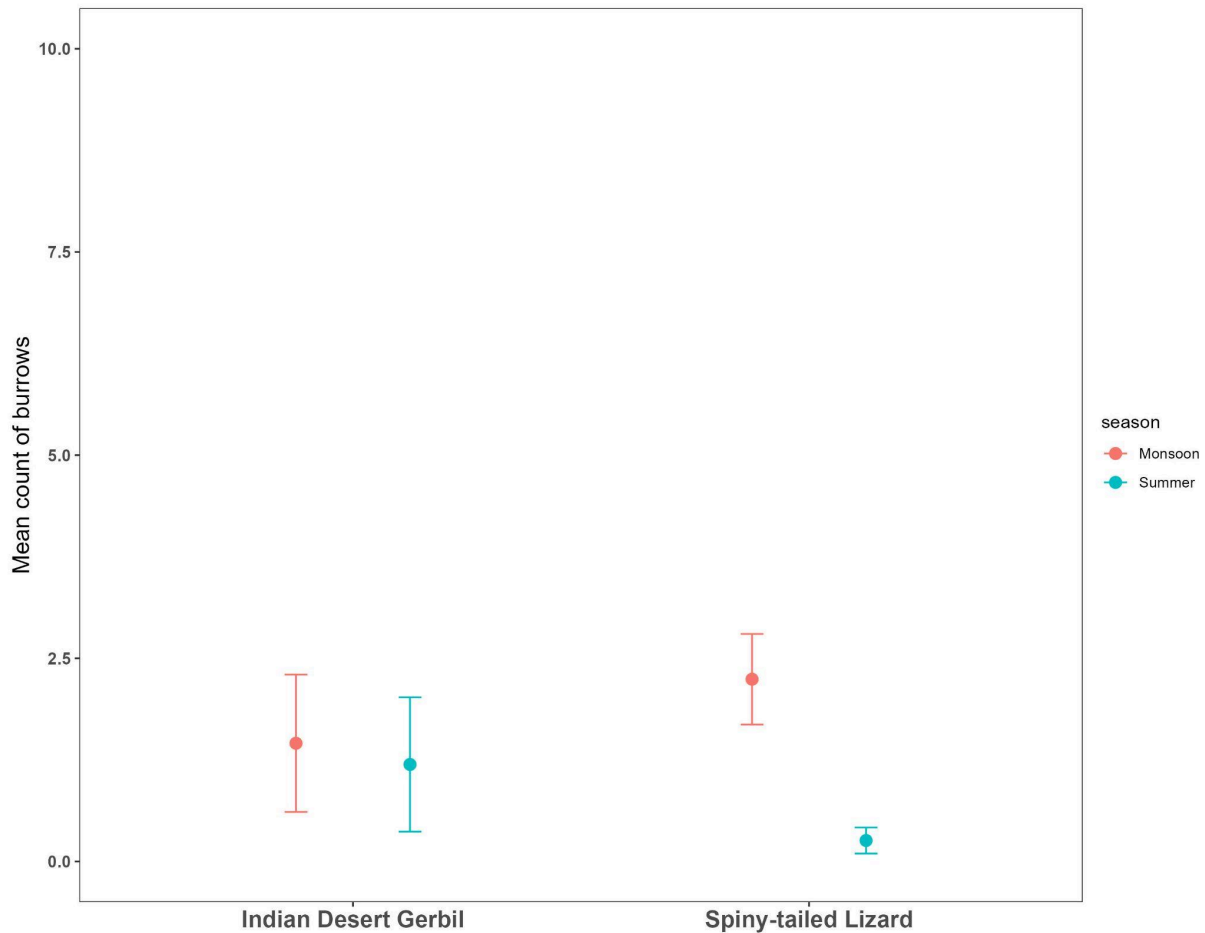


Figure 15: Mean $\pm$ SE (error bars) occurrence of Indian Desert Gerbil and Spiny-tailed Lizard in the Direct Impact Zone of the proposed mine and associated cement plant in Ramgarh, sampled within 20 m around points along walk transects during summer and monsoon seasons (2025)

Insects

Insect assemblages were assessed in the Direct Impact Zone to evaluate their populations and food resources for GIB and other insectivorous species. For this purpose, 700 m transects were laid within selected sampling grids, with three sampling points at 0 m, 350 m, and 700 m along the transect. At each sampling point, a belt of 25 x 2 m was laid in a random direction (Figure 16). Each belt was walked slowly in a time-constrained manner, and insects were recorded using the visual detection method (Pati et al., 2025). All insects observed within the transect were identified to the order level and subsequently categorised into three major groups: Orthoptera, Coleoptera, and Others (including Hemiptera, Hymenoptera, Lepidoptera, Odonata, Neuroptera, and others).

The most dominant insect order found was Orthoptera (grasshoppers and crickets) with 78.73 ± 12.54 insects (per 50 sq m) during monsoon and 1.84 ± 0.58 insects (per 50 sq m) in summer. The total insect density was 79.73 ± 12.54 insects (per 50 sq m) in monsoon and 1.84 ± 0.58 individuals (per 50 sq m) in summer. Other insects, including coleopterans, were recorded in much lower numbers by comparison. There was a stark difference in the insect assemblage densities across seasons, very high in the monsoon and almost absent in the summer (Figure 17).

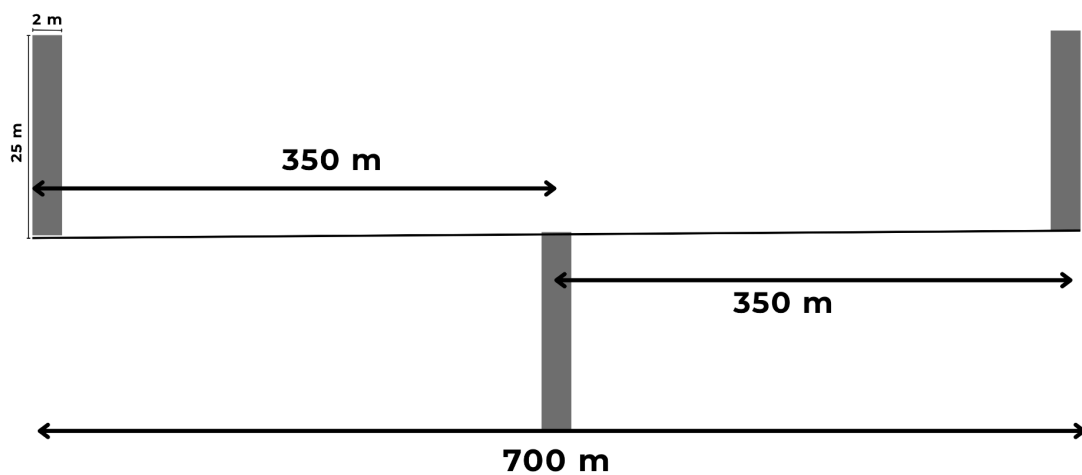


Figure 16: Depiction of arthropod survey method during intensive habitat survey showing sampling plots of size 25 m x 2 m at 350 m intervals, sampled in the Direct Impact Zone of the proposed Ramgarh mine and associated cement plant in Ramgarh, Jaisalmer, Rajasthan (2025)



a



b

Plate 7: Insect assessments conducted in the Direct Impact Zone of the proposed Ramgarh mine and cement plant (a- field sampling of insects in grassland habitats, b- representative grasshopper species recorded during surveys) (2025).

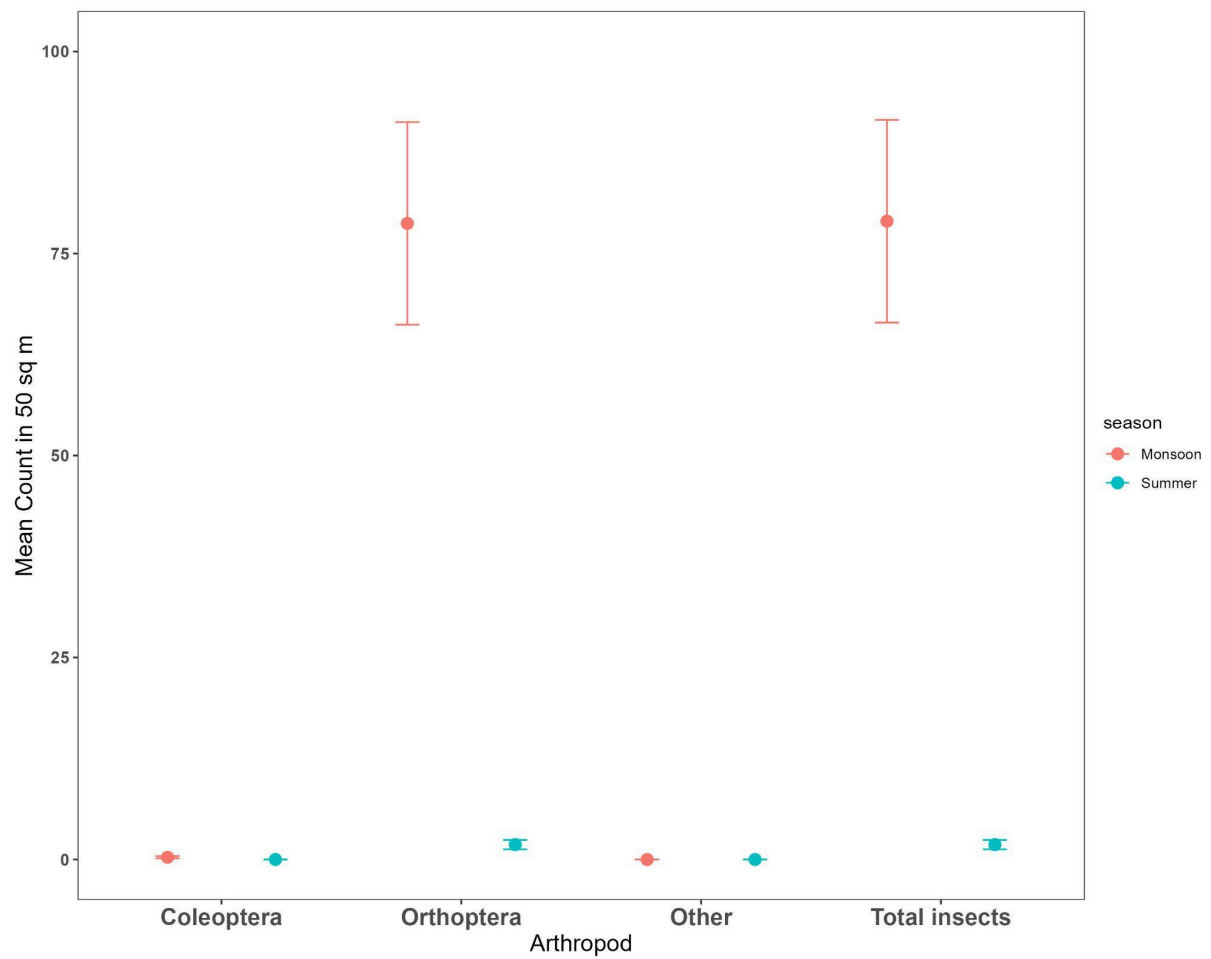


Figure 17: Mean $\pm$ SE (error bars) numbers of arthropods in the Direct Impact Zone of the proposed Ramgarh mine and associated cement plant, sampled at 50 sq m belt along walk transects during summer and monsoon seasons (2025).

Landscape Characterisation

Land Cover Mapping

Land-cover mapping within the Project Impact Zone was conducted using a supervised classification framework following Dutta et al. (2023). Multispectral Sentinel-2A imagery (January 2023-August 2025) was processed after applying radiometric and geometric corrections and generating cloud-free composites (<5% cloud cover).

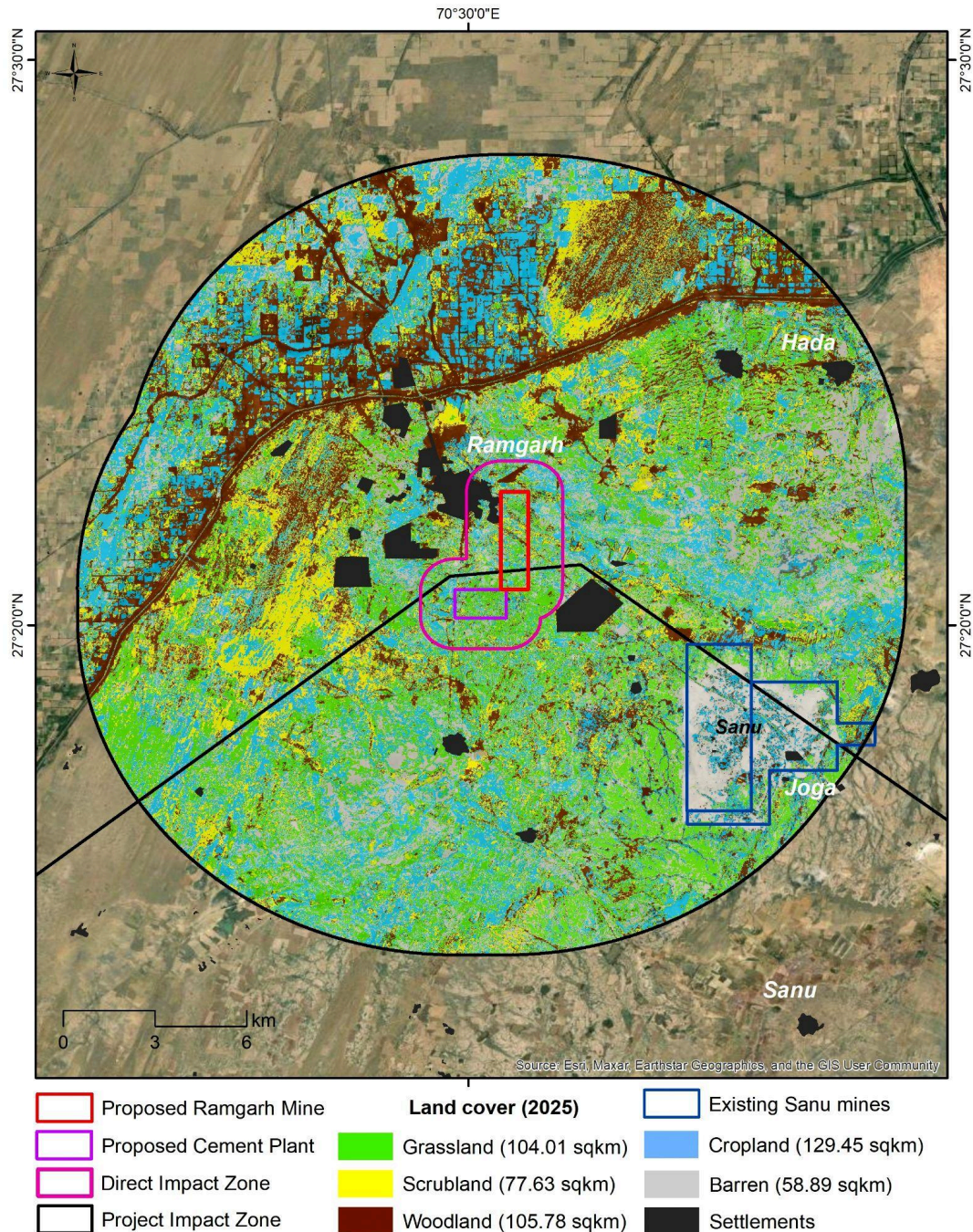


Figure 18: Land use land cover in the Project Impact Zone around the proposed Ramgarh mine and associated cement plant in Ramgarh, Jaisalmer, Rajasthan (2025)

Seven major land-cover classes, namely, grassland, scrubland, woodland, waterbodies, cropland, barren land, and settlements, were identified (Figure 18). A total of 670 geo-referenced ground-truth points were collected across these classes, of which 469 (70%) were used to train a CART classifier in Google Earth Engine and 201 (30%) were used for independent validation. Model accuracy was evaluated using confusion-matrix-based overall accuracy and the Kappa coefficient. Accurate land-cover information is essential for assessing habitat availability for species of conservation significance and for understanding potential ecological impacts of mining. The classification showed that the Project Impact Zone comprises a heterogeneous mosaic dominated by cropland (129.45 sq km), woodland (105.78 sq km) and grassland (104.01 sq km), followed by scrubland (77.63 sq km), barren land (58.89 sq km), settlements (29.83 sq km) and waterbodies (1.89 sq km).

Drainage Mapping

In an arid landscape, such as the Project Impact Zone, the surface hydrology is influenced by a network of several rainfall-driven ephemeral streams. These streams are critical in supporting vegetation regeneration, groundwater recharging and influencing wildlife movement. Activities such as mining and cement plants could disrupt the natural drainage pattern by altering surface flow, reducing water availability in natural depressions, and increasing the risk of waterlogging and runoff into agricultural fields. The ecological importance of these streams necessitates proper groundwater validation and hydrological mapping.

Hydrological mapping of the Project Impact Zone was carried out to delineate stream direction and stream order using the USGS SRTM digital elevation model at 30 m resolution. Apart from one major higher-order stream, there are no major streams that flow within the Direct Impact Zone (Figure 19). That particular stream has already been hindered by the presence of the Indira Gandhi canal. Thus, mining activity would not have a major impact on the surface hydrology of the Direct Impact Zone. The Indirect Impact Zone, however, contains several higher-order streams along with the Indira Gandhi Canal (Figure 19). Proper steps should be taken to ensure that any mining activity happening should not be an impediment to these streams, especially in the ecologically sensitive south-western region of Netsi.

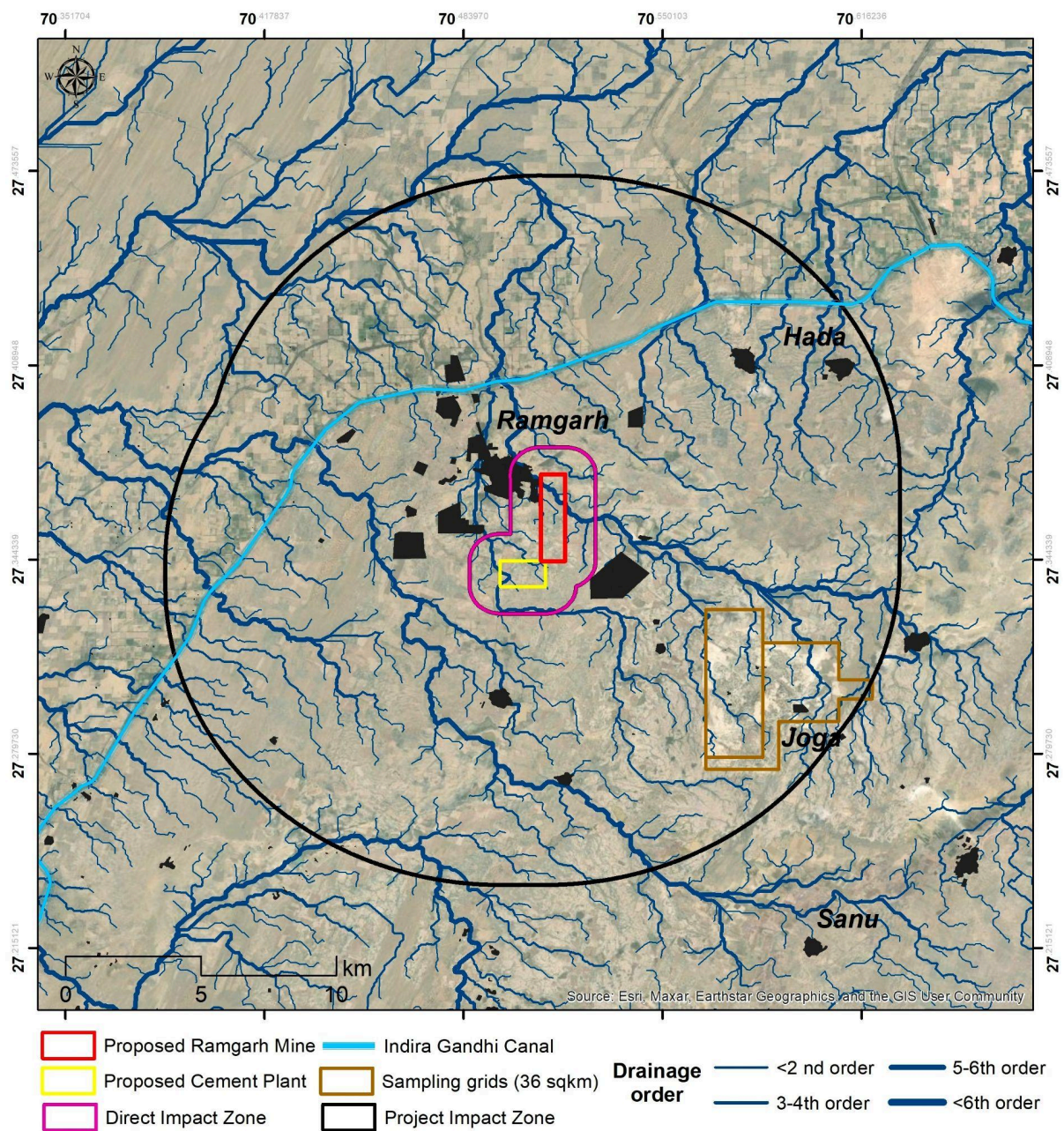


Figure 19: Drainage network in the proposed mining landscape within the GIB habitats of Jaisalmer, Rajasthan

Impact Assessment

The proposed mine and cement plant (area 3.96 sq km) near Ramgarh town lies within a human-dominated landscape with existing human activities and infrastructure. Consequently, as also demonstrated by the field studies, the Direct Impact Zone is less suitable for GIB and associated wildlife. However, the Indirect Impact Zone includes contiguous grasslands that support species of conservation importance such as Chinkara, Desert Fox, Indian Fox, Spiny-tailed Lizard, Desert Gerbil, as well as several raptors, vultures, and other open-habitat birds. In the Direct Impact Zone lie completely outside the Priority GIB Area, no GIBs were recorded during surveys. Given the existing anthropogenic pressures and the absence of critical GIB habitat, this Project and GIB conservation can proceed in parallel. However, some grassland patches within the Indirect Impact Zone are used by GIB-associated species (Figure 20). Therefore, a focused wildlife conservation and mitigation plan is proposed to minimise cumulative impacts. These cumulative impacts are detailed below.

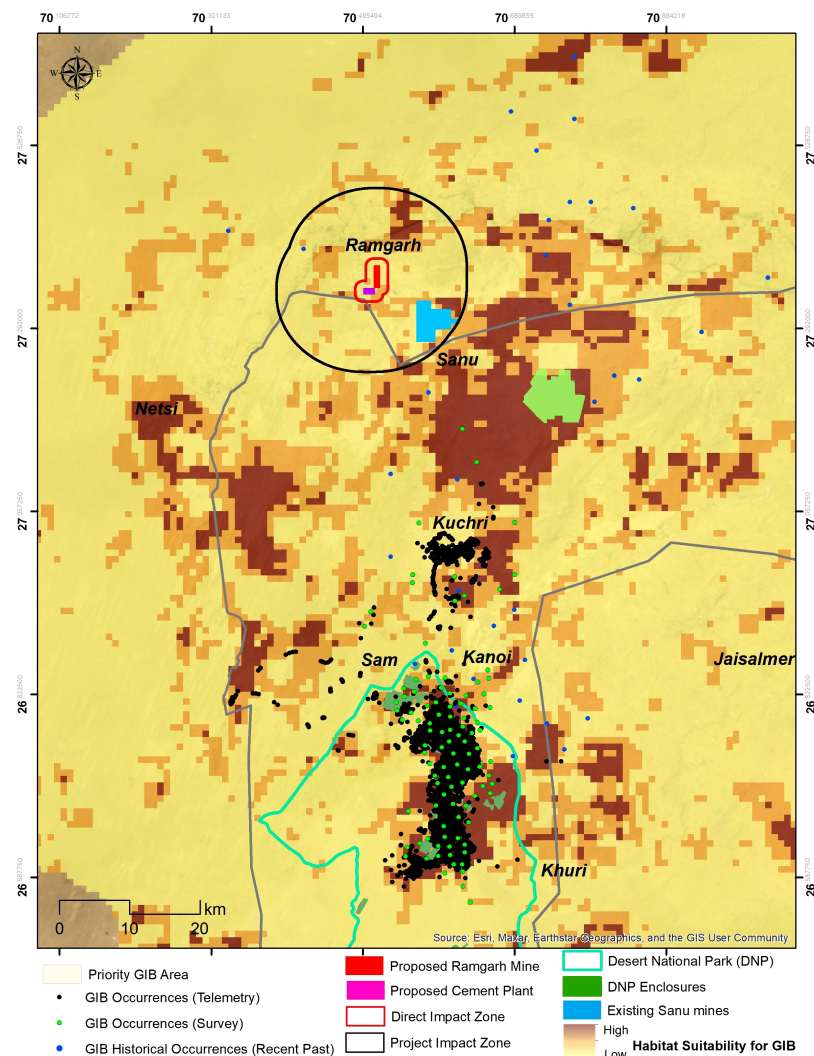


Figure 20: Location of the proposed Ramgarh mine and associated cement plant with respect to the Priority GIB Area and GIB presence in recent surveys and monitoring in the recent past in Jaisalmer, Rajasthan.

Mining activities may alter seasonal drainages and runoff pathways, potentially affecting water accumulation during monsoons and thereby reducing grassland productivity. Disturbance from machinery, dust, and increased traffic may further decrease habitat suitability for sensitive mammals and raptors, potentially displacing them from existing habitats. Increased vehicle movement along the highway and mine-related roads may also increase the risk of animal-vehicle collisions. Additionally, if new transmission lines are installed above ground, collision and electrocution risks for raptors and for future GIB reintroductions could increase, particularly in the Indirect Impact Zone. Currently, the Direct Impact Zone already has an extensive network of powerlines and associated disturbances. Overall, **although the proposed mine and cement plant sites do not hold critical GIB habitat, mitigation measures on habitat restoration will be essential to maintain the ecological functions of the larger Ramgarh landscape.**

Wildlife Conservation and Mitigation Plan

The wildlife conservation and mitigation plan for the proposed Ramgarh mine and cement plant must prioritise the ecological needs of the Open Natural Ecosystems of the Thar Desert, which differ substantially from forest-based restoration approaches. The landscape comprises open grasslands interspersed with croplands and woodlands, supporting conservation-dependent species, such as Chinkara, Desert Fox, Indian Fox, Spiny-tailed Lizard, Desert Gerbil, and several species of raptors, such as Egyptian Vulture, Tawny Eagle, Short-toed Snake Eagle, Montagu's and Pallid Harriers. Restoration measures in the Indirect Impact Zone must therefore focus on native grass establishment, invasive species management and soil treatment.

Multi-season surveys indicate clear differences between the Direct and Indirect Impact Zones. The Direct Impact Zone is located in the close vicinity of Ramgarh town and the Gas Thermal Power Station and is intersected by NH-68, which supports low wildlife usage and absence of recent GIB records, owing to human-caused disturbances. In contrast, parts of the Indirect Impact Zone, especially the southwestern grasslands toward Netsi, contain larger, relatively undisturbed grassland patches with higher conservation value. These areas support 21 Schedule-I species and maintain continuity with the larger DNP grasslands. Netsi grasslands in particular support many declining species such as Black-bellied sandgrouse, Cream coloured courser, Greater Hoopoe Lark, Red necked falcon, and water fowls. Although not as intact as the Unroi blocks, these southwestern grasslands still hold potential for restoration and conservation and should be prioritised for protection.

If mining is permitted, restoration must commence immediately after extraction in the lease area, and once restored, the mined area must not be reopened for further mining, as doing so would compromise soil stability and grassland restoration. Restoration should include ground levelling, soil replacement where feasible, reseeding with native grasses, planting of root slips, and area protection. A scientific agency should monitor grassland restoration efforts and output, soil stabilisation, and faunal recovery to ensure ecological restoration.

Given the high ecological value of southwestern grasslands near Netsi, compensatory investments to support invasive species management and grassland restoration efforts in the Indirect Impact Zone and areas adjoining DNP are needed. This approach will help maintain habitat connectivity, secure key grassland patches, and contribute to long-term conservation outcomes.

Conservation Measures (Plan)

The proposed mining operations in Ramgarh are likely to create short-term direct and indirect impacts on conservation-dependent species due to increased human activity, vehicular movement, habitat alteration, and displacement pressures within the Project Impact Zone. These disturbances may affect wildlife movement and habitat usage in grasslands near Netsi and southern areas in the Indirect Impact Zone that are connected with the larger DNP landscape.

To offset these impacts and support grassland conservation in the landscape, the following measures are recommended if mining is permitted. These actions should be funded by the user agency and implemented by the Rajasthan Forest Department with technical support from competent institutions.

1. **Grassland enclosures:** Protection and management of ecologically sensitive grasslands in the Indirect Impact Zone, especially the southern grassland areas such as Netsi, which retain structural continuity with the protected grasslands in DNP. Management may include habitat protection and restoration of degraded patches using native grass species.
2. **Community fodder farm:** Establishment of a community fodder farm in the rangeland outside DNP. Developing fenced or managed native-grass plots in collaboration with local *panchayats* can manage grazing pressure on key GIB habitats and simultaneously support pastoral livelihoods. Interventions may include reseeding with native grasses (*Dactyloctenium spp.* and *Lasiurus scindicus*), removal of woody invasives such as *Prosopis juliflora* and *Calotropis procera*, and frequent maintenance and protection. Since the activity will require support from local communities, the State Forest Department may consider collaborating with an expert organisation for liaisoning (eg., local NGOs).
3. **Threat mitigation to GIB:** Key threats to GIB and associated grassland species should be mitigated through sterilisation of free-ranging dogs, removal of nest predators in sensitive areas, and targeted removal of invasive woody species such as *Prosopis juliflora*. These actions should follow the recommendations of the Expert Committee constituted by the Hon'ble Supreme Court (W.P. 838/2019) and be implemented in DNP and adjoining priority habitats. The Forest Department may collaborate with specialised technical agencies for effective execution.
4. **Monitoring of grassland restoration:** A technical agency should be engaged to conduct independent monitoring of grassland restoration efforts and implementation of proposed measures in mined areas and grassland restoration sites in the Indirect Impact Zone. A committee comprising representatives from a nationally recognised institution, the State Forest Department, and other statutory bodies should monitor, as stipulated by the EAC.

Financial Outlay of Wildlife Conservation Plan (WCP)

As per the Government of Rajasthan guidelines, the outlay of the WCP will be the maximum of the two figures arrived from the formula as under:

Formula 1: 1% of the total project cost

OR

Formula 2: ₹ 0.50 lakh per hectare of core area (project area) + ₹ 5 lakh (lump sum) for the buffer area, for each Schedule-I species present.

The list of Schedule-I species is given in Table 6.

Project proponents may allocate funds exceeding the amount derived from the above criteria, if required, for the implementation of the WCP.

Table 6: List of conservation-dependent species (mammal, raptor, other birds and reptiles, including Schedule-I and IUCN Red-listed species) observed in Project Impact Zone (21 species)

Taxa	Species	WPA Schedule	IUCN Red List Status
Mammals	Chinkara	I	Least Concern
	Desert Fox	I	Least Concern
	Indian Fox	I	Least Concern
	Grey Mongoose	I	Least Concern
Raptors	Cinereous Vulture	I	Near Threatened
	Egyptian Vulture	I	Endangered
	Eurasian Griffon	I	Least Concern
	Long-legged Buzzard	I	Least Concern
	Montagu's Harrier	I	Least Concern
	Pallid Harrier	I	Near Threatened
	Shikra	I	Least Concern
	Short-toed Snake Eagle	I	Least Concern
	Steppe Eagle	I	Endangered
	Tawny Eagle	I	Vulnerable
	White-eyed Buzzard	I	Least Concern
Other Birds	Common Crane	I	Least Concern
	Indian Peafowl	I	Least Concern
	Indian Roller	II	Near Threatened
	Rufous-tailed Lark	II	Near Threatened
Reptiles	Desert Monitor Lizard	I	Least Concern
	Spiny-tailed Lizard	I	Vulnerable

Using Formula 2, the total outlay as per the above guidelines is as follows:

Interpretation 1: $((256 \text{ ha} + 140 \text{ ha}) \times 50,000 \text{ INR}) + (5 \text{ lakhs INR}) \times 21 \text{ species} = 42.63 \text{ cr INR}$ for the core and buffer of the Ramgarh mining block and cement plant
(where 41.58 cr corresponds to the core and 1.05 cr to the buffer area)

Interpretation 2: $(396 \text{ ha} \times 50,000 \text{ INR}) + (5 \text{ Lakh} \times (19 \text{ Schedule I} + 2 \text{ IUCN NT})) = 3.03 \text{ Crore INR}$

Table 7: Annual cost estimation for the wildlife conservation plan for grassland restoration and protection

S. No.	Particulars	Cumulative Budget (cr INR)
1	Habitat Improvement & mitigation measures - Establishment of grassland enclosures (site selection, fencing, native grass seeding and root-slip plantation, weed control, maintenance, protection and periodic monitoring) - Establishment of community fodder farms (land preparation, soil enrichment, planting of high-yield native fodder species, rotational harvest planning) - Threat mitigation for GIB (predator management, dog population management, protection of nesting enclosures in and around DNP) - Ecological restoration (Site survey and planning; grass seeding and plantation using seeds or root-slips; nursery and seedling development; soil improvement and health monitoring; weeding, hoeing, pit and plot maintenance; protective measures, such as fencing, trenching, site protection; repair and maintenance of restoration infrastructure; procurement of tools and materials; hiring of labour and watch personnels; evaluation, contingency, and administrative management)	21.33 (50%)
2	Awareness and Extension involving locals and forest frontline staff (community meetings and school programmes for conservation awareness)	4.26 (10%)
3	Support to the local forest department for monitoring, rescue and rehabilitation of wildlife (veterinary care and wild animal health, rescue, tools and equipment)	4.26 (10%)
4	Conservation efforts for wildlife inside protected areas (DNP) (enclosure fencing- establishment and repair, patrolling and wildlife monitoring)	4.26 (10%)
5	Administrative cost and monitoring evaluation by representatives of RFD, WII and the external conservation agency (Monitoring of restoration and protection activities, documentation and travel of representative teams)	4.26 (10%)
6	Miscellaneous and unforeseen costs, including eco-development	4.26 (10%)
Total		42.63 cr INR

It is recommended that the agency finalizes the wildlife conservation and financial outlay plan based on the above guidelines in consultation with the Chief Wildlife Warden, Rajasthan.

Study Recommendations

1. The EAC, MoEF&CC mandated this study to determine whether limestone mining in Ramgarh can proceed alongside the long-term conservation of conservation important species, particularly GIB and associated species. The recommendations suggested are based on the mitigation hierarchy: avoid, minimise, restore, and offset.
2. Our biodiversity assessments indicate that the Direct Impact Zone is heavily influenced by human activity and lacks recent GIB records, whereas the southwestern part of the Indirect Impact Zone near Netsi has relatively intact grasslands, which support Schedule-I and conservation important species, and maintains ecological continuity with the larger DNP landscape. These areas hold moderate potential for future GIB use if restored and maintained. **Ramgarh mine and its direct Impact Zone lie outside the priority GIB area. It is close to existing human settlements and infrastructure and does not constitute critical GIB habitat. Therefore, mining operations and GIB conservation can coexist in this area. However, the Indirect Impact Zone falls within the GIB priority area and includes habitats used by species associated with GIB, a focused conservation and mitigation plan has been proposed.**
3. Mining will require the removal of surface substrate and native vegetation, short-term displacement of wildlife and increasing livestock pressure on adjoining grasslands. If mining is permitted, restoration of mined areas should be done immediately after excavation, by doing soil replacement, leveling, reseeding with native grasses, protection through temporary fencing, and independent ecological monitoring to assess vegetation recovery and wildlife usage over upcoming 3-5 years.
4. To offset short-term disturbances caused by mining, compensatory conservation measures must be implemented in the Indirect Impact Zone, particularly around Netsi and nearby village rangelands as they fall within the Priority GIB Area. These should include protection and enhancement of existing grasslands, restoration of degraded patches, removal of woody invasives, community fodder farm development, and mitigation of threats to wildlife (eg, free-ranging dog management and nest predators of GIB).
5. The transportation of materials shall be carried out using the existing road infrastructure to minimise disturbance to suitable habitats in the surrounding areas. While new roads may be constructed within the lease area as per operational requirements, it must be ensured that any proposed road alignment does not pass through or near any small grassland patches.
6. Post-restoration, mining areas must not be reopened for further extraction, as repeated disturbance would negate restoration gains, interrupt land integrity, and create continuous, long-term impacts on wildlife and habitat quality.
7. A comprehensive wildlife conservation and mitigation plan covering habitat protection, threat mitigation, community engagement, and restoration monitoring must be implemented concurrently with mining and restoration activities. Compliance should be monitored by an independent technical agency and overseen by a committee comprising representatives from a nationally recognised scientific institution, the State Forest Department, and other statutory bodies, as required by the EAC.

Ramgarh mine, including the cement plant and its direct Impact Zone, is outside the GIB priority area, in proximity to human settlements and infrastructure and is not a critical habitat for GIB. Hence, GIB conservation and mining in this area can go hand in hand. However, since the Indirect Impact Zone, specially the southern region encompassing the Netsi grasslands includes

habitats of importance for species associated with the GIB conservation, an action plan has been proposed.

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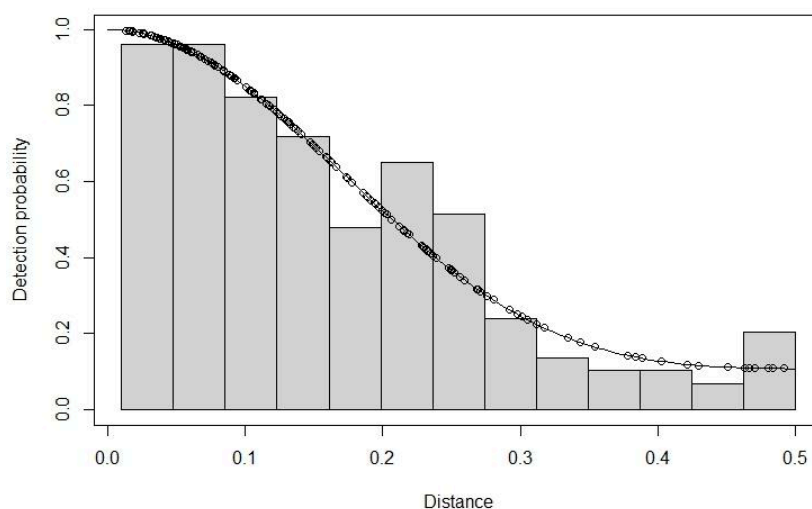
Annexures

Annexure 1: List of species of animals (birds, mammals, and reptiles) which were sighted during the study period, including species of conservation importance (Schedule in WPA or included in the IUCN Red List)

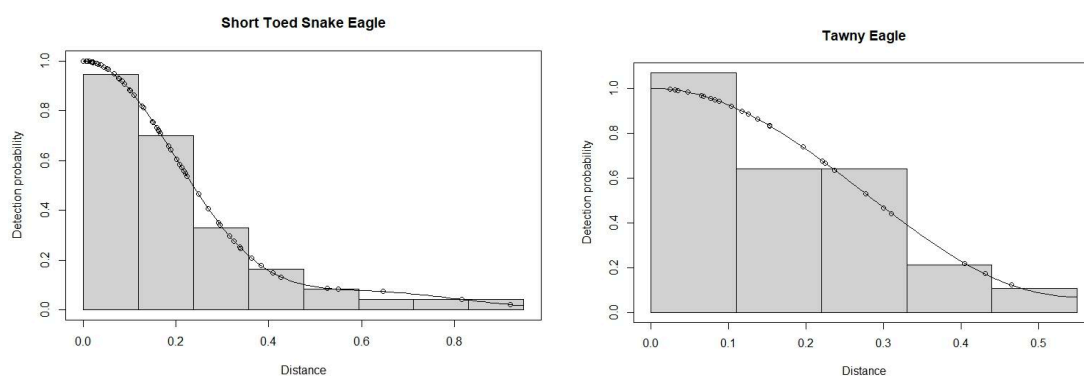
S. No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB Status
Birds (Raptors)					
1	Cinereous Vulture	<i>Aegypius monachus</i>	I	Near Threatened	Moderate
2	Egyptian Vulture	<i>Neophron percnopterus</i>	I	Endangered	High
3	Eurasian Griffon	<i>Gyps fulvus</i>	I	Least Concern	High
4	Long-legged Buzzard	<i>Buteo rufinus</i>	I	Least Concern	Low
5	Montagu's Harrier	<i>Circus pygargus</i>	I	Least Concern	High
6	Pallid Harrier	<i>Circus macrourus</i>	I	Near Threatened	High
7	Shikra	<i>Accipiter badius</i>	I	Least Concern	Low
8	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	I	Least Concern	High
9	Steppe Eagle	<i>Aquila nipalensis</i>	I	Endangered	Low
10	Tawny Eagle	<i>Aquila rapax</i>	I	Vulnerable	High
11	White-eyed Buzzard	<i>Butastur teesa</i>	I	Least Concern	High
Other Birds					
1	Asian Desert Warbler	<i>Sylvia nana</i>	II	Least Concern	NA
2	Bimaculated Lark	<i>Melanocorypha bimaculata</i>	II	Least Concern	NA
3	Black Drongo	<i>Dicrurus macrocercus</i>	II	Least Concern	Low
4	Black-Crowned Sparrow Lark	<i>Eremopterix nigriceps</i>	II	Least Concern	NA
5	Blue-cheeked Bee-Eater	<i>Merops persicus</i>	II	Least Concern	Low
6	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	II	Least Concern	Low
7	Common Babbler	<i>Turdoides caudata</i>	II	Least Concern	Moderate
8	Common Crane	<i>Grus Grus</i>	I	Least Concern	High
9	Crested Lark	<i>Galerida cristata</i>	II	Least Concern	Moderate
10	Desert Wheatear	<i>Oenanthe deserti</i>	II	Least Concern	High
11	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	II	Least Concern	Low
12	Eurasian Hoopoe	<i>Upupa epops</i>	II	Least Concern	Moderate
13	European Roller	<i>Coracias garrulus</i>	II	Least Concern	Moderate
14	Great Grey Shrike	<i>Lanius excubitor</i>	II	Least Concern	High
15	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>	II	Least Concern	Moderate
16	Green Bee-eater	<i>Merops orientalis</i>	II	Least Concern	Low
17	Grey Francolin	<i>Francolinus pondicerianus</i>	II	Least Concern	Low
18	House Crow	<i>Corvus splendens</i>	NA	Least Concern	Low
19	House Sparrow	<i>Passer domesticus</i>	II	Least Concern	Moderate

20	Indian Peafowl	<i>Pavo cristatus</i>	I	Least Concern	Low
21	Indian Roller	<i>Coracias benghalensis</i>	II	Near Threatened	Moderate
22	Laughing Dove	<i>Spilopelia senegalensis</i>	II	Least Concern	Low
23	Lesser Whitethroat	<i>Sylvia curruca</i>	II	Least Concern	Low
24	Long-billed Pipit	<i>Anthus similis</i>	II	Least Concern	Moderate
25	Plain Prinia	<i>Prinia inornata</i>	II	Least Concern	Low
26	Purple Sunbird	<i>Cinnyris asiaticus</i>	II	Least Concern	Low
27	Red-naped Ibis	<i>Pseudibis papillosa</i>	II	Least Concern	Low
28	Red-vented Bulbul	<i>Pycnonotus cafer</i>	II	Least Concern	Low
29	Red-wattled Lapwing	<i>Vanellus indicus</i>	II	Least Concern	Low
30	Rock Pigeon	<i>Columba livia</i>	NA	Least Concern	Low
31	Rufous-tailed Lark	<i>Ammomanes phoenicura</i>	II	Near Threatened	High
32	Rufous-tailed Scrub Robin	<i>Cercotrichas galactotes</i>	II	Least Concern	NA
33	Siberian Stonechat	<i>Saxicola maurus</i>	II	Not Evaluated	Low
34	Tawny Pipit	<i>Anthus campestris</i>	II	Least Concern	High
35	Variable Wheatear	<i>Oenanthe picata</i>	II	Least Concern	High
36	White-eared Bulbul	<i>Pycnonotus leucotis</i>	II	Least Concern	Low
Mammals					
1	Chinkara	<i>Gazella bennettii</i>	I	Least Concern	-
2	Desert Fox	<i>Vulpes vulpes pusilla</i>	I	Least Concern	-
3	Indian Fox	<i>Vulpes bengalensis</i>	I	Least Concern	-
4	Indian Desert Gerbil	<i>Meriones hurrianae</i>	NA	Least Concern	-
5	Indian Hare	<i>Lepus nigricollis</i>	II	Least Concern	-
6	Nilgai	<i>Boselaphus tragocamelus</i>	II	Least Concern	-
7	Wild Pig	<i>Sus scrofa</i>	II	Least Concern	-
8	Five-striped or Northern Palm Squirrel	<i>Funambulus pennantii</i>	NA	Least Concern	-
9	Indian Hedgehog	<i>Paraechinus micropus</i>	II	Least Concern	-
10	Indian Hare/Black-naped hare	<i>Lepus nigricollis</i>	II	Least Concern	-
11	Grey Mongoose	<i>Urva edwardsii</i>	I	Least Concern	-
Reptiles					
1	Yellow-bellied House Gecko	<i>Hemidactylus flaviviridis</i>	NA	Least Concern	-
2	Indian Garden Lizard	<i>Calotes versicolor</i>	NA	Least Concern	-
3	Brilliant Ground Agama	<i>Trapelus agilis</i>	NA	Least Concern	-
4	Spiny-tailed Lizard	<i>Saara hardwickii</i>	I	Vulnerable	-
5	Desert Monitor Lizard	<i>Varanus griseus</i>	I	Least Concern	-

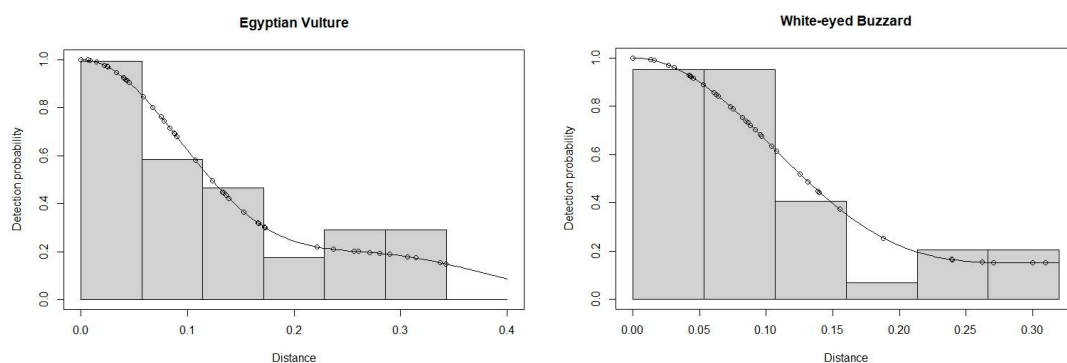
Annexure 2: Detection probabilities of species observed during the vehicle transect surveys



Supplementary Figure 1. Fitted detection curves for Chinkara using detections from vehicle transect surveys in the Project Impact Zone, Jaisalmer (2025)



Supplementary Figure 2. Fitted detection curves for Short-toed Snake Eagle (left) and Tawny Eagle (right) using detections from vehicle transect surveys in the Project Impact Zone, Jaisalmer (2025)



Supplementary Figure 3. Fitted detection curves for Egyptian Vulture (left) and White-eyed Buzzard (right) using detections from vehicle transect surveys in the Project Impact Zone, Jaisalmer (2025)

Annexure 3: Encounter Rates (individual/km) of different birds assessed from walk transect surveys in the proposed Ramgarh mines

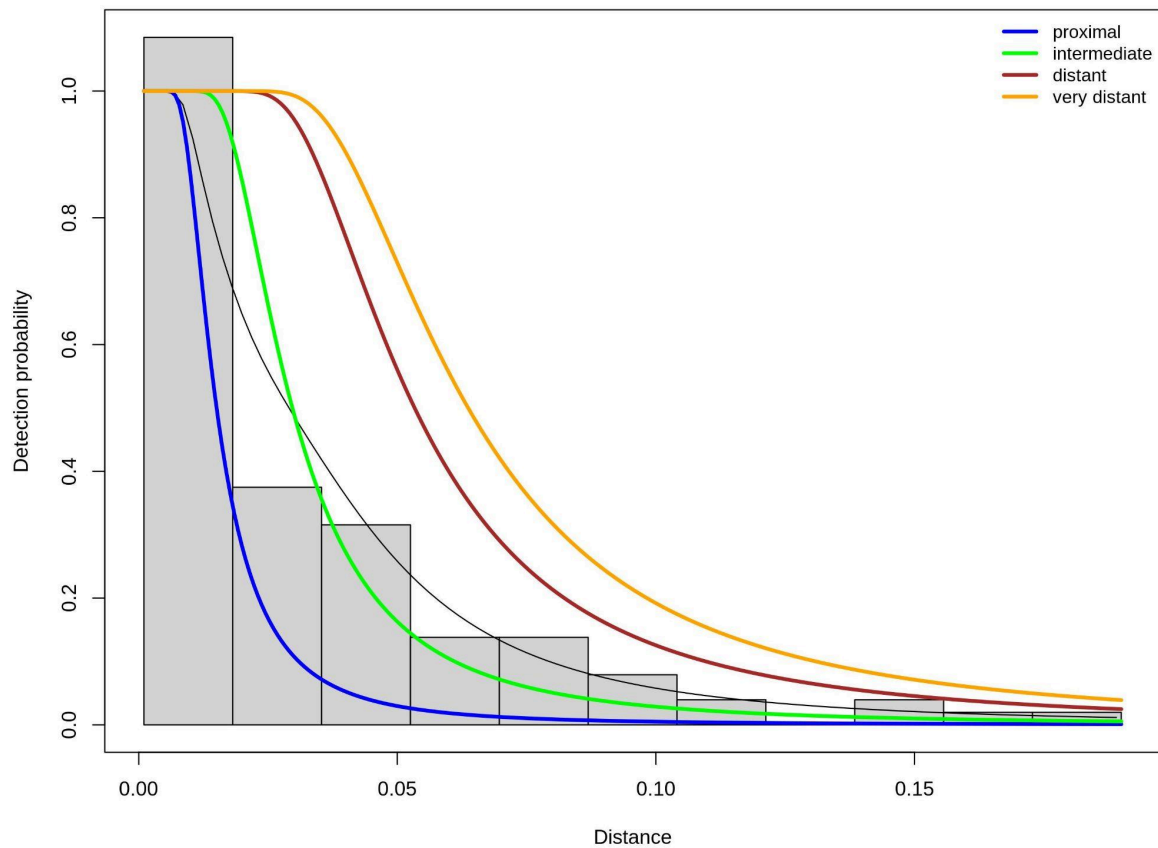
Species	Feeding Guild	Encounter Rate ($\pm$ SE)
Asian Desert Warbler	Insectivore	0.055 $\pm$ 0.055
Bimaculated Lark	Omnivore	0.055 $\pm$ 0.055
Black Drongo	Omnivore	0.110 $\pm$ 0.075
Black-crowned Sparrow Lark	Granivore	0.164 $\pm$ 0.090
Blue-cheeked Bee-eater	Insectivore	0.055 $\pm$ 0.055
Chestnut-bellied Sandgrouse	Granivore	0.384 $\pm$ 0.146
Common Babbler	Omnivore	0.274 $\pm$ 0.136
Desert Wheatear	Insectivore	0.274 $\pm$ 0.110
Eurasian Collared Dove	Granivore	2.192 $\pm$ 0.416
Eurasian Hoopoe	Insectivore	0.110 $\pm$ 0.076
European Roller	Insectivore	0.055 $\pm$ 0.055
Great Grey Shrike	Vertebrate	0.055 $\pm$ 0.055
Greater Short-toed Lark	Insectivore	0.274 $\pm$ 0.110
Green Bee-eater	Insectivore	0.329 $\pm$ 0.144
Grey Francolin	Granivore	0.110 $\pm$ 0.110
House Crow	Vertebrate	0.055 $\pm$ 0.055
House Sparrow	Granivore	0.110 $\pm$ 0.076
Indian Roller	Omnivore	0.164 $\pm$ 0.092
Laughing Dove	Granivore	0.493 $\pm$ 0.205
Lesser Whitethroat	Insectivore	0.219 $\pm$ 0.101
Long-billed Pipit	Insectivore	0.055 $\pm$ 0.055
Plain Prinia	Insectivore	0.055 $\pm$ 0.055
Purple Sunbird	Frugivore	0.438 $\pm$ 0.151
Red-naped Ibis	Omnivore	0.055 $\pm$ 0.056
Red-vented Bulbul	Omnivore	0.055 $\pm$ 0.055

Red-wattled Lapwing	Insectivore	0.164 ± 0.091
Rock Pigeon	Granivore	0.384 ± 0.169
Rufous-tailed Lark	Omnivore	0.219 ± 0.104
Rufous-tailed Scrub Robin	Insectivore	0.055 ± 0.055
Siberian Stonechat	Insectivore	0.055 ± 0.055
Tawny Pipit	Insectivore	0.274 ± 0.110
Variable Wheatear	Insectivore	0.329 ± 0.118
White-eared Bulbul	Omnivore	0.438 ± 0.151

Annexure 4: Density (individual/km²) of different birds assessed from walk transect surveys in the proposed Ramgarh mines

S.No.	Species	Feeding Guild	Density(±SE)
1	Black-crowned Sparrow Lark	Granivore	8 ±4.80
2	Chestnut-bellied Sandgrouse	Granivore	12 ±6.79
3	Common Babbler	Omnivore	4 ±2.72
4	Desert Wheatear	Insectivore	2 ±0.86
5	Eurasian Collared Dove	Granivore	32 ±8.72
6	Greater Short-toed Lark	Insectivore	104 ±56.66
7	Green Bee-eater	Insectivore	4 ±2.36
8	Laughing Dove	Granivore	49 ±30.43
9	Purple Sunbird	Frugivore	15 ±6.66
10	Rock Pigeon	Granivore	42 ±26.69
11	Tawny Pipit	Insectivore	14 ±7.78
12	Variable Wheatear	Insectivore	5 ±1.94
13	White-eared Bulbul	Omnivore	18 ±7.95

Annexure 5: Detection probabilities of species of different detection groups (low, moderate, high, and very high)



Supplementary Figure 1. Detection probability curves for different detection groups (low, moderate, high, and very high) as a function of the median distance from the transect line.

Supplementary Table 1. Detection probability (p) and effective strip width (metres) for different detection groups as derived from distance sampling analysis

Detection Group	Detection Probability (p)	Effective Strip Width (m)
Proximal	0.09	17.96
Intermediate	0.19	36.00
Distant	0.33	63.65
Very Distant	0.39	75.04



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