FINAL REPORT

2024-25

Impacts and mitigation of proposed limestone mine near Khuiyala, Jaisalmer on Great Indian Bustard, its associated wildlife and habitat

Wildlife Institute of India

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Impacts and mitigation of proposed limestone mine near Khuiyala, Jaisalmer on Great Indian Bustard, its associated wildlife and habitat

User agency: SBU-Limestone Rajasthan State Mines & Minerals Limited, Jodhpur
Study agency: Wildlife Institute of India
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Implementation: Bustard Recovery Program and Conservation Advisory & Policy Cell
Collaborators: DFO (WL), Jaisalmer
Funding Agency: Rajasthan State Mines and Mineral Limited
Study Period: December 2024 – November 2025

Citation: *Dutta S., Kher V., Jangid A.K., Supakar S., Sindha P., Kundu, Y., Aparna, Sen, S., Dagur, T., Gowda, Y., Lawrence, S., Pati, A., Paul, I., Phinehas, D., Sundar, P., Pandey, D., Jadhav, M., Moitra, M., Gupta, S., G.V. Gopi, & Bhardwaj G.S. (2025). Impacts and mitigation of proposed limestone mine near Khuiyala, Jaisalmer on Great Indian Bustard, its associated wildlife and habitat. Wildlife Institute of India. TR-0016-2025.*

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Background

The Rajasthan State Mines & Minerals Limited (RSMML) has proposed three new limestone mines, namely Unroi-I (9.98 km^2), Unroi-II (9.98 km^2), and Khuiyala-I (9.44 km^2), with a cumulative lease area of 29.4 km^2 adjacent to the Khuiyala village of Ramgarh tehsil in Jaisalmer district, Rajasthan. These mines are planned to produce a cumulative limestone of 10.5 million tonnes, and would substitute the existing limestone mines (Sanu-I and Sanu-II) that have supplied raw material to major steel industries such as SAIL and TATA since 1989. The Sanu mines contribute significantly to both the State Government (approx. ₹40 crores annually) and Indian Railways (approx. ₹1200 crores annually), but their limestone reserves are projected to be exhausted within the next three years.

The lease area for the proposed mines falls between 27°9'31.89"N–27°7'20.51"N and 70°31'48.84"E–70°24'8.56"E, in Seismic Zone III (Figure 1). As per the EIA Notification, 2006 (Schedule 1[a]), the project is listed as Category "A" activity since the lease area exceeds 250 ha, requiring appraisal at the central level. The Indian Bureau of Mines (Ajmer) approved the mining plan (Ref. 584(4)(3)(1913)/2022-RCOM-AJM, dated 16.08.2022) for 27 years, and the proposal is currently under review for Environmental Clearance (EC) by the Ministry of Environment, Forest & Climate Change (MoEF&CC).

Although the proposed project lies outside the designated forest land, it falls within the Great Indian Bustard (GIB) Priority Area recognised in the judgment of the Hon'ble Supreme Court (dated 21.03.2024) in the matter of M.K. Ranjitsinh & Ors. vs. Union of India & Ors. (Writ Petition (Civil) No. 838 of 2019). The proposed project (all three blocks) also falls within the revised Priority Area recommended in the report of the expert committee in the GIB matter constituted by the Hon'ble Supreme Court vide its Judgement dated 24.03.2024 in the aforementioned matter. Additionally, apprehensions about mining in the revised Priority Area have been raised in a dissent note by one of the expert committee members.

It is important to note here that the GIB Priority Area is of exceptional ecological sensitivity as it harbours the last remaining stronghold of the Critically Endangered Great Indian Bustard (*Ardeotis nigriceps*), whose global population is estimated at fewer than 140 individuals, most of which persist only in the Priority GIB Area of Jaisalmer. The landscape also supports several other Schedule-I species under the Wildlife (Protection) Act, 1972, and IUCN-listed threatened species, such as the Red-headed Vulture (*Sarcogyps calvus*), White-rumped Vulture (*Gyps bengalensis*), Chinkara (*Gazella bennettii*), Desert Fox (*Vulpes vulpes pusilla*), and Spiny-tailed Lizard (*Saara hardwickii*). Protection of these conservation-dependent species is of national and global importance, mandated under Article 48 and Article 51(g) of the Indian Constitution and various multilateral environmental agreements such as the Convention on Biological Diversity (CBD), the Convention on Migratory Species (CMS) and the UN Sustainable Development Goals.

Recognising this ecological overlap of the lease area with an ecologically sensitive area, the Expert Appraisal Committee (non-coal mining sector) of MoEF&CC, in its meeting (on 12-14 June 2024), directed RSMML to "engage a wildlife institute of national repute to study the short-term and long-term effects of proposed mining within the lease area along with the effects of the proposed transportation route on GIB

nesting [and that] the report should clearly indicate whether mining activity and conservation of GIB within the lease area and vicinity can go hand in hand or not." It further mandated submission of a compliance report in accordance with the Supreme Court's directions on GIB (WP (C) No. 838 of 2019 order dated 21.03.2024).

In response, RSMML requested the Wildlife Institute of India (WII) to undertake a comprehensive ecological study on the short- and long-term effects of the proposed mines. The study aims to assess baseline information on wildlife values, with emphasis on GIB distribution and habitat suitability, and to evaluate the potential impacts of mining, transportation, road traffic, power lines, and associated disturbances. This scientific assessment is expected to provide evidence-based recommendations on the impact of the project, scope of mitigation, habitat restoration, and conservation planning for ensuring the coexistence of industrial development and species persistence in one of India's most fragile desert ecosystems.

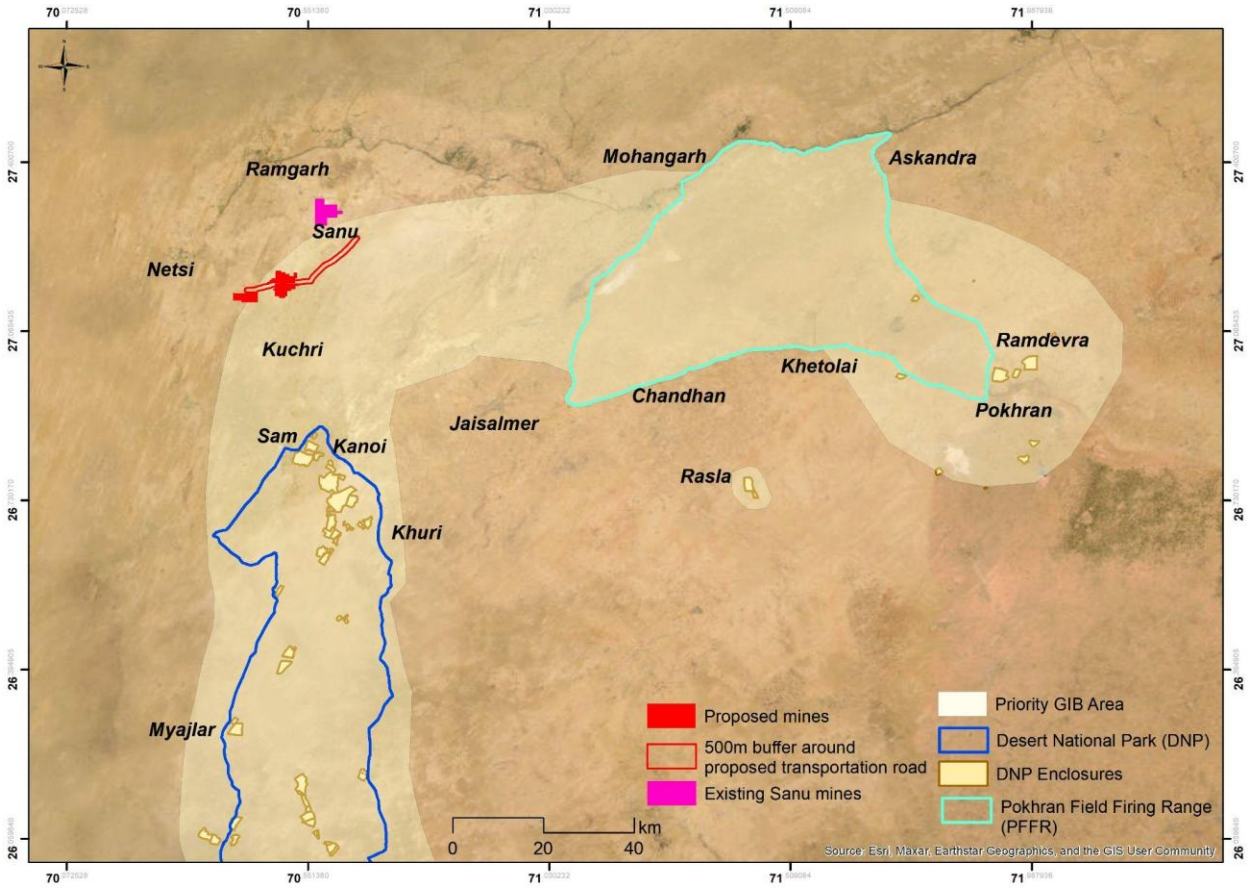

Figure 1: *Location of the proposed and existing limestone mines, proposed transportation route, Priority GIB Area and Desert National Park within the Thar landscape (2025)*

Limestone mining in Jaisalmer

Jaisalmer district of western Rajasthan constitutes one of India's most mineral-rich regions, renowned for its extensive Tertiary limestone deposits. The limestone-bearing formations of the Jaisalmer Basin belong

to the Eocene Khuiyala Limestone Formation, extending about 100 km in length and 5 km in width over a roughly 500 km^2 area. These deposits consist predominantly of high-grade Steel Melting Shop (SMS) limestone and cement-grade limestone, both of which are economically significant for industrial use. The limestone of Jaisalmer occurs as bedded, stratiform, and tabular deposits, typically lying horizontally with minimal structural deformation, which allows for large-scale mechanised extraction. The SMS-grade limestone, characterised by high calcium carbonate (CaO 53–55%) and low SiO_2, MgO and Al_2O_3, occurs in the upper horizons as hard, compact, bouldery limestone, embedded within a clayey matrix and occasionally capped by a thin alluvial layer. The underlying horizon contains chalky, cement-grade limestone, with slightly higher silica content but suitable for use in the cement industry. Intervening layers of bentonitic clay and fuller's earth are also common, which are often utilised for soil stabilisation and reclamation work during mine closure.

Limestone mining in this region has been primarily undertaken by the Rajasthan State Mines and Minerals Limited (RSMML), a government enterprise engaged in the extraction and supply of SMS-grade limestone to major steel industries, including SAIL and TATA Steel Ltd. The current operational mines (Sanu-I and Sanu-II) situated near the village Sanu in Jaisalmer have been active since 1989 and have long served as a principal source of flux-grade limestone in the country. However, as indicated by RSMML, the economically viable reserves in these mines are expected to be exhausted within the next few years, necessitating the development of new mining blocks in the adjoining region.

The proposed mine projects aim to mine steel-grade (SMS-grade) limestone from these three sites, namely Unroi-I, Unroi-II and Khuiyala, in Ramgarh tehsil of Jaisalmer district, Rajasthan. All mining blocks fall within the Khuiyala limestone formation of tertiary age, which extends from Mandha and Tulsiram ki Dhani to Sam via Sanu and Khuiyala (Figure 2). The limestone formation largely overlaps with the distribution of Great Indian Bustard habitat and movement 'Arc' from the northern tip of Desert National Park northwards to Ramgarh and then eastwards towards Mohangarh (Anoop et al., 2017).

The area has been explored by the Department of Mines and Geology and the Geological Survey of India, delineating several blocks for SMS and cement-grade mining. Geomorphologically, the Khuiyala block exhibits gently undulating terrain with isolated rocky outcrops (*magras*) interspersed with plains and agricultural fields, while the Unroi blocks comprise predominantly gravelly plateaus with natural grassland. These habitats retain high ecological value due to limited anthropogenic disturbance and represent potential zones for rewilding captive-bred birds under the Project Great Indian Bustard-national conservation action for Great Indian Bustard and Lesser Florican.

In contrast, the existing Sanu mines illustrate the post-mining transformation of desert landscapes, where mined-out areas now display barren alkaline substrates and dense invasion by *Prosopis juliflora*, inhibiting native grass regeneration. Recognising these restoration challenges, WII has recommended the establishment of a 1 km^2 experimental grassland restoration site within the existing Sanu mines to evaluate soil amendment, native seedbank transfer, and reseeding treatments using species such as *Dactyloctenium* and *Cenchrus*. The outcomes of this experiment will inform future reclamation and post-mining ecological restoration protocols across the proposed mining leases.

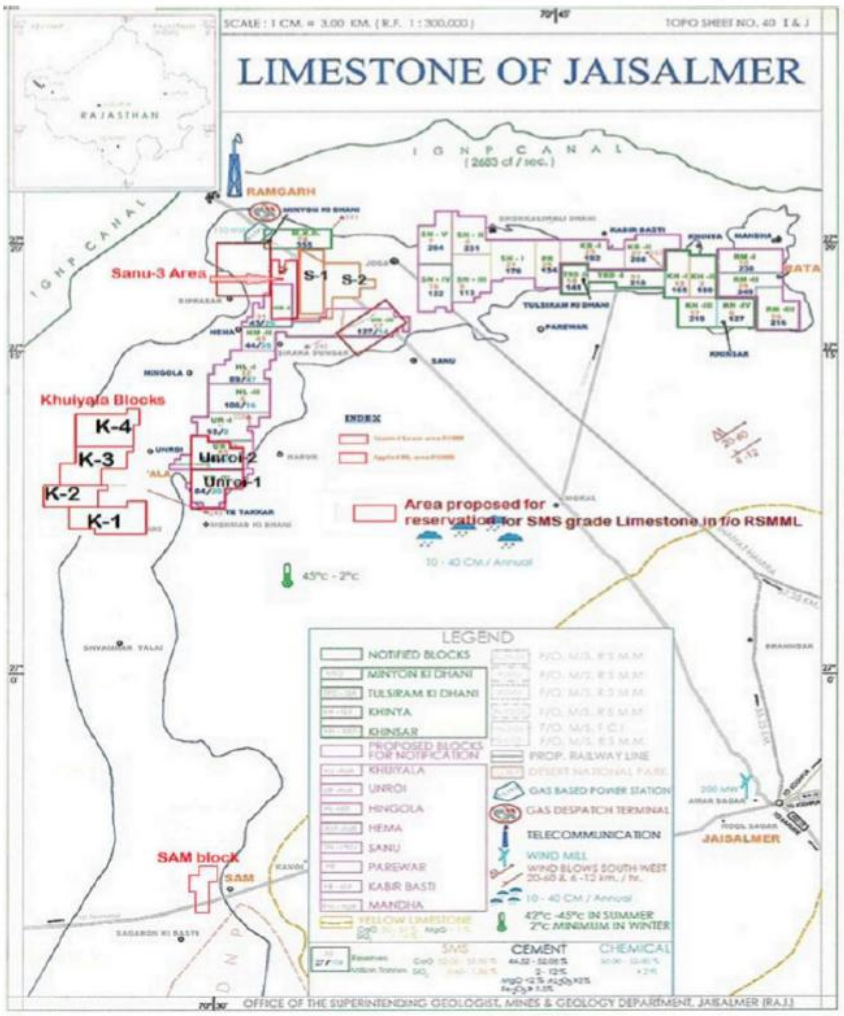

Figure 2: *Location of the proposed project area with reference to the Khuiyala Limestone Formation containing SMS-Grade Limestone in Jaisalmer, Rajasthan*

Details of the proposed mining

According to RSMML, SMS-grade limestone occurs up to 6 m depth from the surface, suitable for open-case single-bench mechanised mining using Heavy Earth Moving Machinery (HEMM) and deep-hole drilling (Figure 3). The run-of-mine (RoM) material will be used for backfilling mined-out pits. The underlying cement-grade limestone may be intermixed with lower-grade material for optimal utilisation. Processed limestone will be transported by tippers to Sanu railway siding (~22km) for rail dispatch. RSMML is already operating similar activities at Sanu-I and Sanu-II mining blocks in the vicinity of the proposed mines in Jaisalmer.

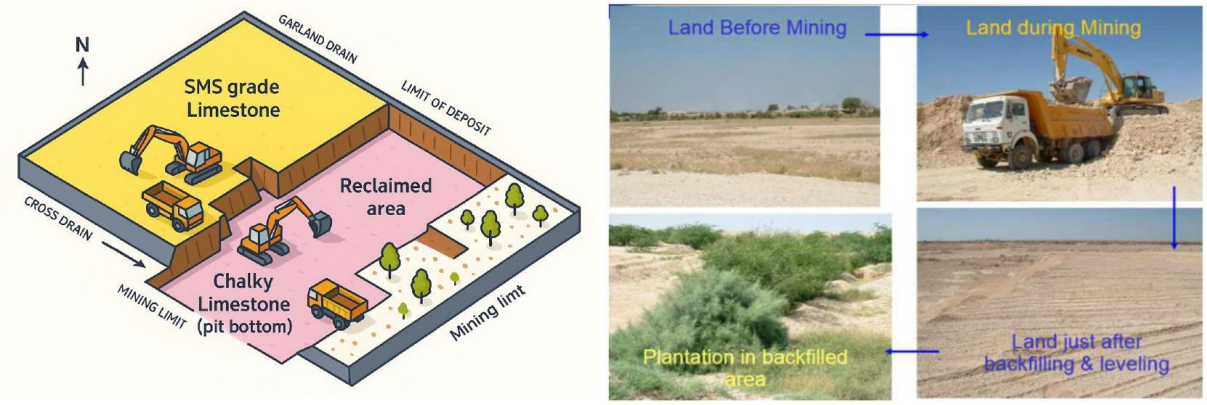

Figure 3: *Schematic diagram of mining reclamation plan provided by the RSMML for proposed limestone mining near Khuiyala in Jaisalmer district, Rajasthan (2025)*

Delineation of Project Impact Zone

The study was conducted in a stratified framework within two zones: a "Direct Impact Zone", also referred to as the "core", and an "Indirect Impact Zone", also referred to as the "buffer". The core included the mining lease areas with a 1 km buffer and the proposed mine transportation routes with a 500 m buffer, whereas the buffer encompassed the surrounding landscape extending up to 10 km beyond the core area boundaries. The core and buffer zones, collectively termed as the Project Impact Zone, were designed to capture the full spectrum of direct and indirect effects of mining activities (Figure 4).

The Khuiyala-I block is located immediately south of Khuiyala village and is bisected by NH-70, which comprises a mosaic of flat grasslands, shrublands, cultivated fields, rocky hillocks (magras), and sand dunes interspersed with traditional water catchments (*nadis*). In contrast, the Unroi-I & II blocks represent relatively undisturbed rocky plateaus drained by ephemeral streams and characterised by expansive natural grasslands with old-growth trees such as *Prosopis cineraria* (Khejri), *Acacia senegal* (Kumat), *Ziziphus* spp. (Ber), *Capparis decidua* (Ker) and *Commiphora wrightii* (Guggal), with minimal human settlements. Previous long-term surveys in Jaisalmer (Dutta et al., 2017; Dutta et al., 2024) have highlighted that this region supports many species of high conservation significance.

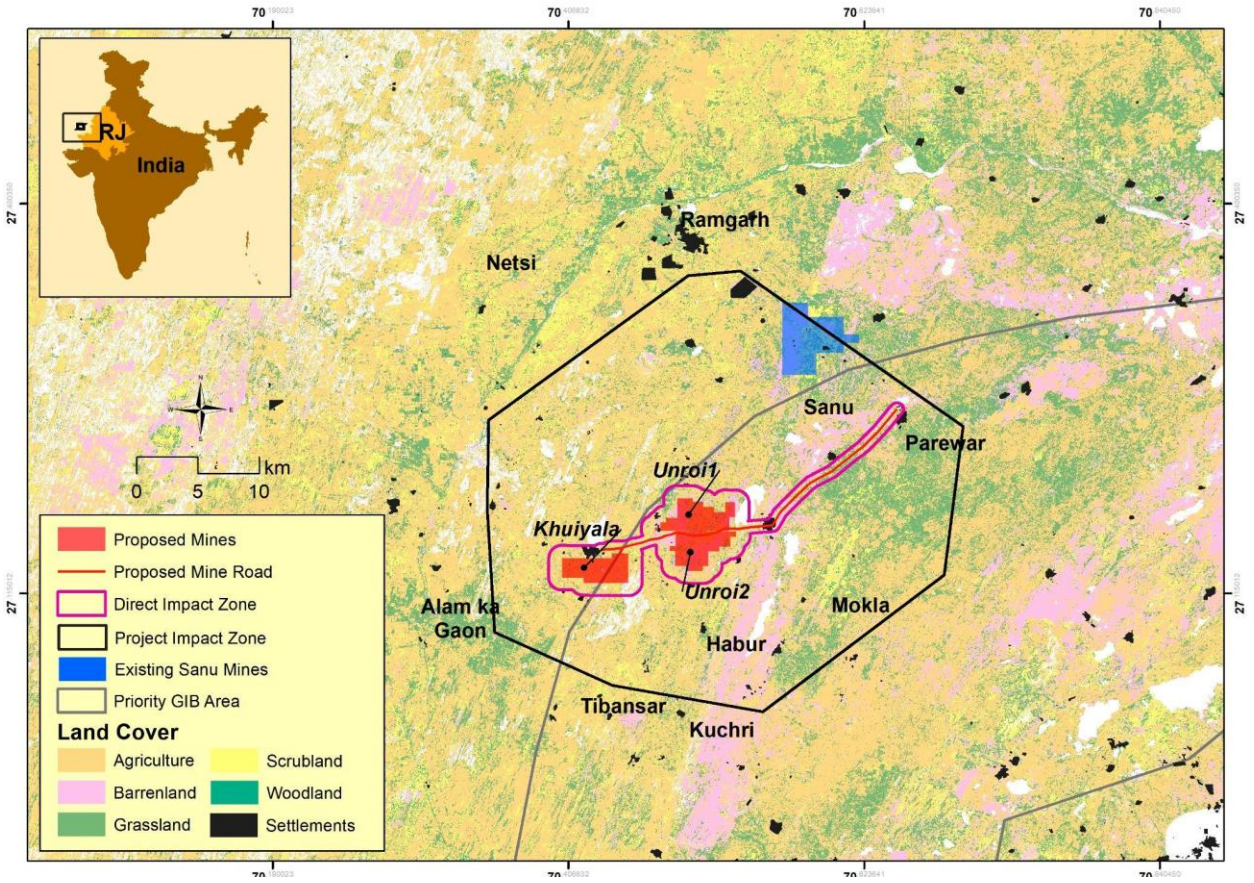

Figure 4: *Map of the study area, indicating the proposed mines (Khuiyala, Unroi-I and Unroi-II), existing mines (Sanu-1 and Sanu-2) with respect to the GIB priority area in Jaisalmer, Rajasthan, along with the direct and project impact zones and proposed connecting road, Jaisalmer, Rajasthan (2025)*

Mitigation Hierarchy

In the context of sustainable development, the purpose of mitigation is to identify strategies and measures that will address conservation concerns likely to be associated with the development proposals. To deliver the potential benefits of environmentally friendly economic development, these strategies and measures must follow a hierarchy of key mitigation principles, as set out below:

1. First, avoid or prevent adverse impacts as far as possible by considering spatial or design alternatives. Where impacts are highly significant or could lead to loss of irreplaceable biodiversity or conservation assets, avoidance is the only real option if development is to be sustainable.
2. Second, minimise or reduce adverse impacts to 'as low as practicable' levels;
3. Third, restore areas damaged by construction/mining; and
4. Fourth, remedy or compensate for adverse residual impacts that are unavoidable and cannot be reduced further.

These mitigation principles were considered while providing recommendations from this study.

Biodiversity Assessment

Study approach

Information on wildlife values concerning the Great Indian Bustard and associated species was compiled from published literature and previous long-term surveys conducted by the Wildlife Institute of India and the Rajasthan Forest Department (Dutta et al., 2017, 2024). These studies revealed that the region supports several species of high conservation importance, including the Critically Endangered Great Indian Bustard, Red-headed Vulture, and White-rumped Vulture, many of which are listed under Schedule-I of the Wildlife (Protection) Act, 1972 (Amendment 2023), or listed as threatened by IUCN Red List assessments. A list of nationally Schedule-I and globally threatened species within the project impact zone is provided below. However, as these datasets were coarse in resolution and were unable to capture fine-scale species' distribution and population patterns, detailed field surveys were conducted to assess wildlife occurrence and habitat associations within the Project Impact Zone.

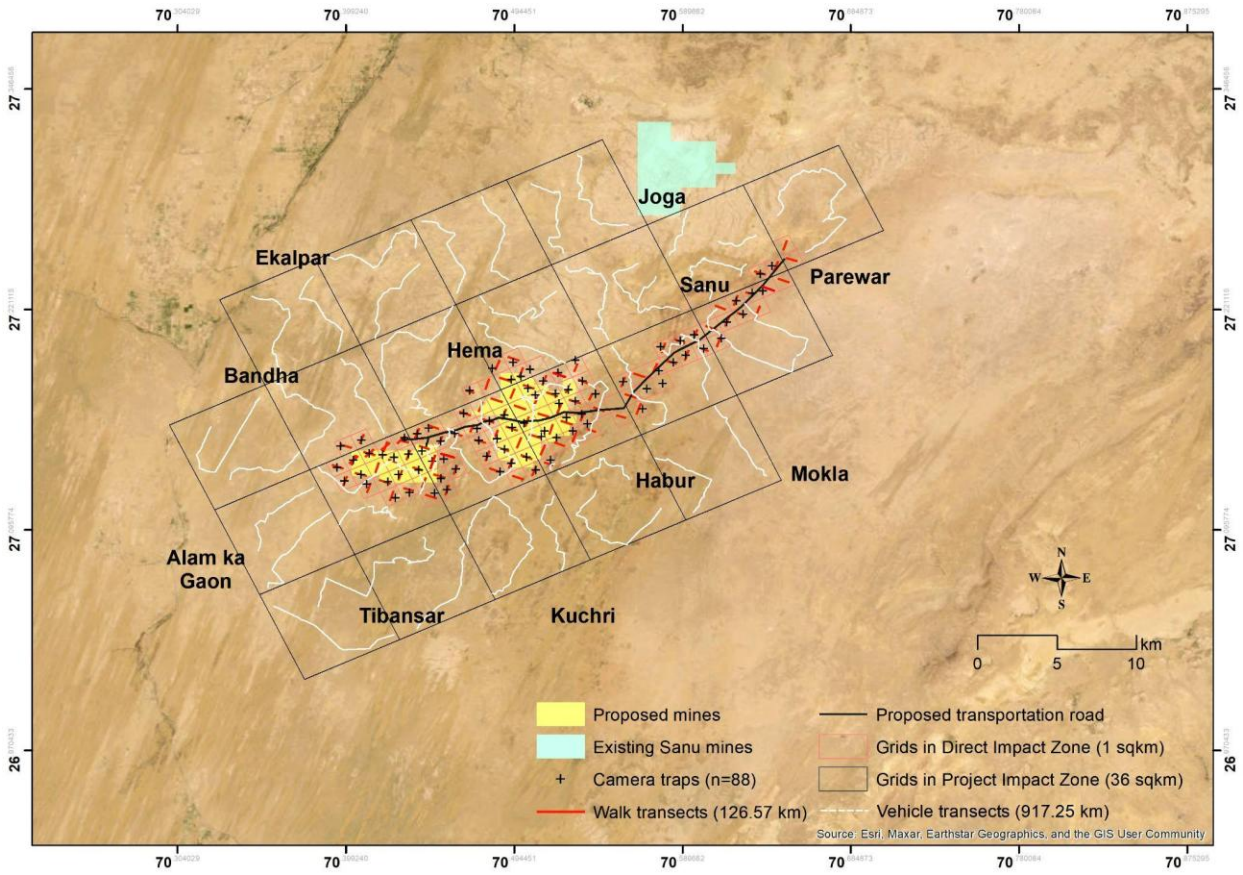

Figure 5: *Map showing field efforts for camera trapping, walk transects and vehicle transects for biodiversity assessment within the direct impact zone and project impact zone in and around proposed mines in Jaisalmer, Rajasthan (2025)*

Although the impact(s) of mining to GIB is the main focus and mandate of this study, since the species' occurrence has reduced drastically and its conservation now revolves around restoring erstwhile habitats and releasing captive-bred birds therein, our study uses information on the occurrence of suitable habitat

for GIB and status of grassland-adapted conservation-dependent species that are ecologically associated with (and surrogates of) GIB, as important markers of biodiversity values to infer the ecological sensitivity and potential impact of mining in the study area.

A multi-season biodiversity assessment was carried out for the project impact zone to assess the species' populations that will be affected by the proposed mine and also to evaluate the ecological sensitivity of the proposed mining leases. Sampling was conducted at two spatial scales. Within the direct impact zone (core), 1 km^2 grids were established covering an area of 108 km^2, while 36 km^2 grids were overlaid to cover the project impact zone (direct impact zone/core and indirect impact zone/buffer). In the direct impact zone, camera-trap distance sampling was used to determine the densities of Chinkara (*Gazella bennettii*), Desert Fox (*Vulpes vulpes pusilla*), Indian Fox (*Vulpes bengalensis*) and Desert Cat (*Felis sylvestris*), while intensive walk-transect distance sampling was carried out to estimate small bird densities (Figure 5). Further, plots to determine the abundance of trees, shrubs and insects within the direct impact zone were laid along the walk transects. In the project impact zone, vehicle-based line transects were conducted to record wide-ranging species such as the Great Indian Bustard, Chinkara, and raptors during winter, summer, and monsoon seasons. Along with the vehicle transects, information on dominant land cover, vegetation structure and composition, and disturbances were also observed (Table 1). Detailed methodology is provided below under the corresponding sections.

Habitat attributes were examined for their relevance to bustard habitat suitability, supporting potential reintroduction and recovery efforts for captive-bred individuals in the future. Conservation weightage was assigned to surveyed grids and mining blocks, based on habitat suitability for GIB, rescaled encounter rates of GIB-associated species, and occurrence of Schedule-I and conservation-dependent species.

Table 1: *Table of studies conducted for assessment of biodiversity in the Direct and Indirect Project Impact Zone of the proposed mining area, 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
	Disturbances	LT & VT	VT
Key fauna	Raptors	VT	VT
	Mammals	CT & VT	VT
Other fauna	Small birds	LT	-
	Insects	LT	-
	Fossorial animals	VT	VT

Study findings

Our multi-season biodiversity assessment recorded occurrences of the following threatened and Schedule-I (conservation-dependent) species in the project impact zone: Chinkara, Desert Fox, Indian Fox, Desert Cat (mammals), Laggar Falcon, Long-legged Buzzard, White-eyed Buzzard, Steppe Eagle, Tawny Eagle, Short-toed Snake Eagle, Montagu's Harrier, Pallied Harrier (raptors), and Stoliczka's Bushchat, and Rufous-fronted Prinia (other birds), Spiny-tailed Lizard, Desert Monitor Lizard, Red Sand Boa (reptiles) based on the current study, and Great Indian Bustard from recent studies.

Habitat

A detailed habitat assessment was carried out within the project impact zone to assess baseline information on landcover, substrate, vegetation structure and composition. In the indirect impact zone, systematic sampling was undertaken along trails traversed by slow-moving vehicles (10-15 kmph) to record key habitat attributes within 36 km^2 cells. At each plot, land-cover types (grassland, scrubland, woodland, barren, active and fallow agriculture; 100 m radius). The relative cover of dominant upperstorey (trees and shrubs) and understorey vegetation (herbs and grasses) was also noted. All the habitat data were noted at every 2 km interval along vehicle transects to cover an even spatial representation across the landscape.

Habitat data with additional parameters were also collected in the direct impact zone. Vegetation structure of understorey vegetation, divided into classes of less than 20 cm, 20-60 cm and 60-100 cm, was quantified within 2 x 2m plots along walk transects. The upperstorey woody vegetation data were recorded to estimate the abundance of each plant in these areas. For this purpose, 700 m walk transects were laid within 1 km^2 grids in the direct impact zone. Each belt transect (100 x 20m for trees and 50 x 20m for shrubs) comprised two segments (between 0^{th}–100^{th} m and 600^{th}–700^{th} m) (Figure 6). All trees and shrubs within these belts were counted.

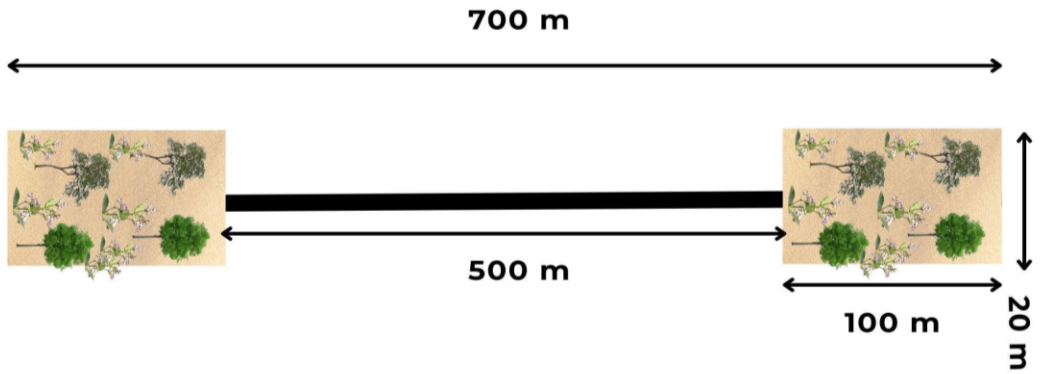

Figure 6: *Depiction of an Intensive habitat survey transect showing sampling plots, Jaisalmer, Rajasthan (2025)*

This survey provided a detailed understanding of land-cover composition and vegetation characteristics across the project landscape. The information on vegetation structure and composition is vital for

assessing habitat quality for GIB and predicting the likely impacts of mining on vegetation communities that influence the persistence of endangered fauna.

Land-cover

Land cover in both direct and indirect impact zones consisted of grassland > seasonal agriculture > scrubland > woodland > barren areas (Figure 7). Notably, grassland occurred in >90 % of sampling points intermixed with other land cover types. Comparison of areas with and without GIB in the larger landscape indicated that GIB occupied areas had >60% grassland occurrence (Figure 8). Therefore, the land cover of the mine impact area matches that of the GIB used areas. Further proportion of grassland cover was greater in Unroi-I and II blocks than Khuiyala block.

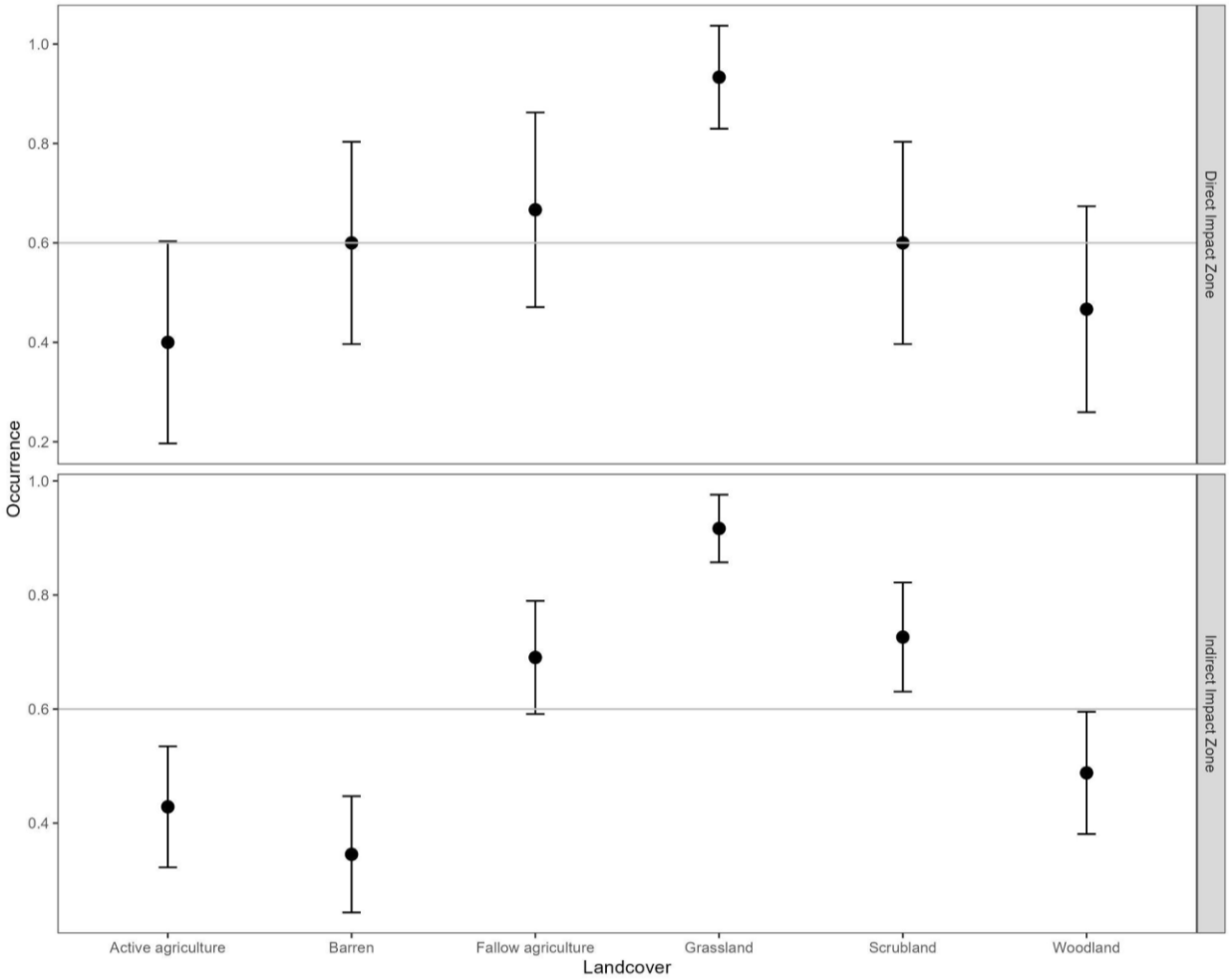

Figure 7: Both the direct and indirect impact zones had high occurrence of grasslands as a land-cover category. *Mean ± SE (Error bars) occurrence (proportions) of landcover types in direct (top) and indirect (bottom) impact zones of the proposed Khuiyala-Unroi mining blocks, sampled at 100m radius points along vehicle transects during summer and monsoon seasons of 2025. Grasslands are the most important habitat for the GIB, and high grassland cover indicates good habitat suitability for the GIB.*

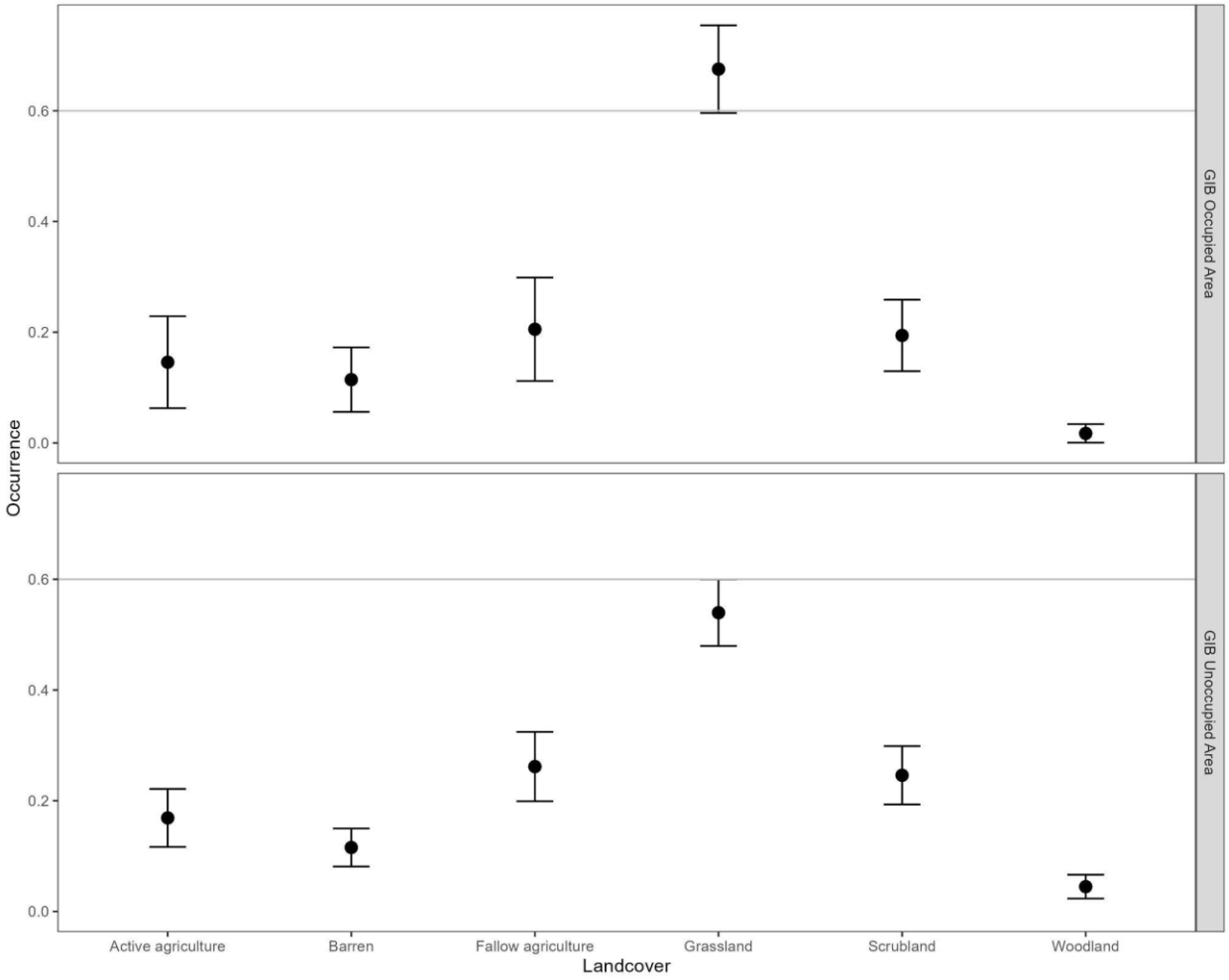

Figure 8: Areas occupied by GIB had higher proportion of grasslands as opposed to areas not occupied by GIB. *Mean ± SE (Error bars) occurrence (proportions) of landcover types in areas with (top) and without (bottom) Great Indian Bustard in and around Desert National Park, sampled at 100m radius points along vehicle transects during summer and monsoon seasons of 2022-24.*

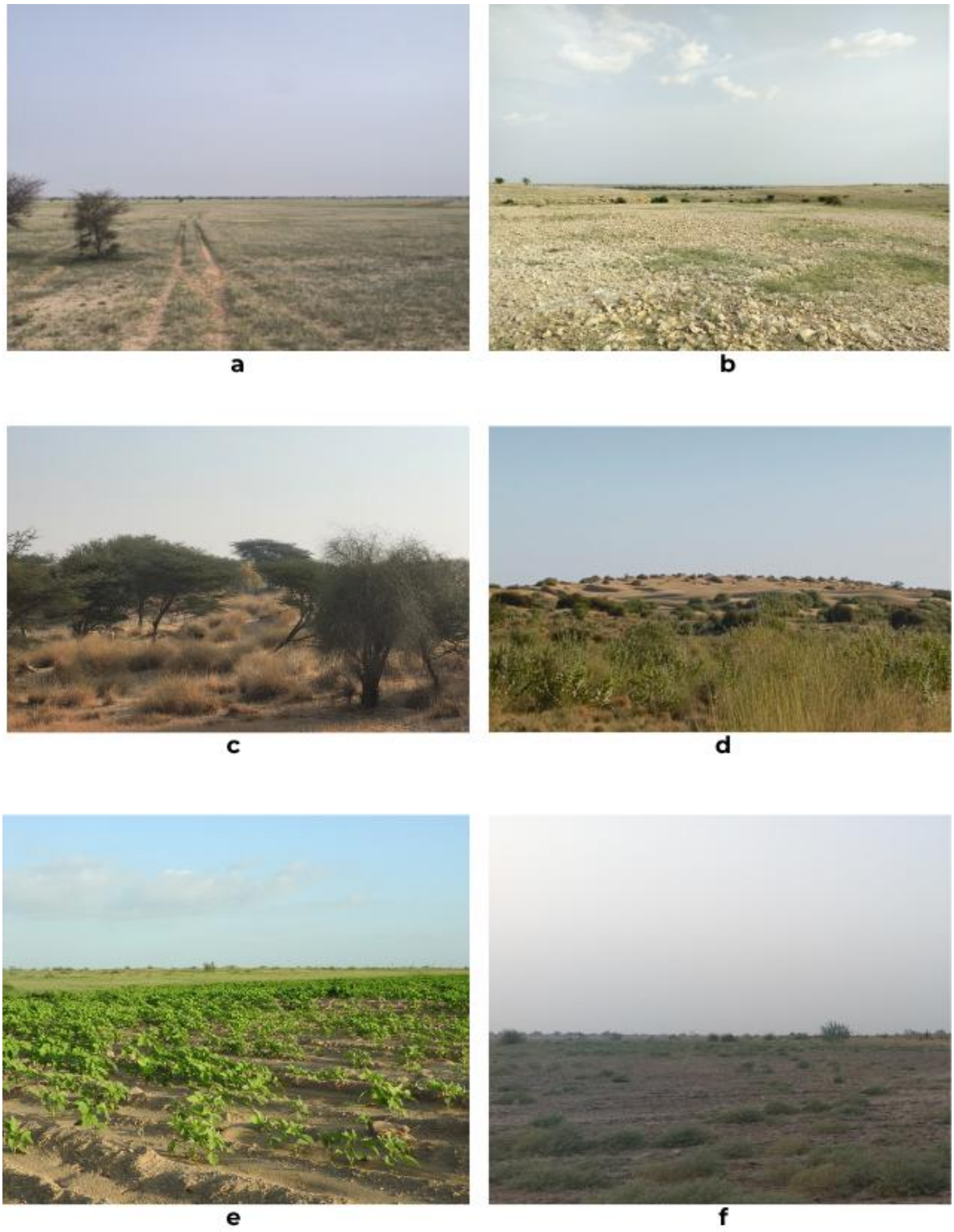

Plate 1: *Different types of land cover (a- Grassland, b- Barren, c- Woodland, d- Scrubland, e- Active agriculture, f- Fallow agriculture) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

Vegetation Composition

The understorey vegetation was dominated by grasses *Dactyloctenium aegyptium* and *D. scindicum* that are salient vegetation speccies of short grassland preferred by GIB during the breeding season, along with *Fagonia cretica*- a salient plant of regenerating fallows of seasonal agriculture which is a highly used land-cover during the non-breeding season (Figure 9). The similarity of the vegetation (particularly the dominance of *Dactyloctenium* spp.) in project impact zone and the areas occupied by GIB in the larger landscape can be understood by comparing Figures 9 & 10. The upperstorey vegetation was dominated by *Capparis decidua* (ker) > *Ziziphus sp* (ber) > *Calotropis sp* (aak) > *Leptadinia pyrotechnica* (kheemp) in both the direct and the indirect impact zones (Figure 11). Notably, the survey also documented the critically endangered plant, Guggal (*Commiphora wightii*), within the direct impact zone. The upperstorey/ tree composition in the GIB occupied areas in the larger landscape also shows the same pattern of plant composition (Figures 11 & 12). Thus, the vegetation composition analysis indicates strong similarity between mined areas and GIB used areas in the larger landscape. Within the three mining blocks, Unroi I and Unroi II were more similar to GIB-occupied areas in terms of ground vegetation, and the same is described in detail in the next section.

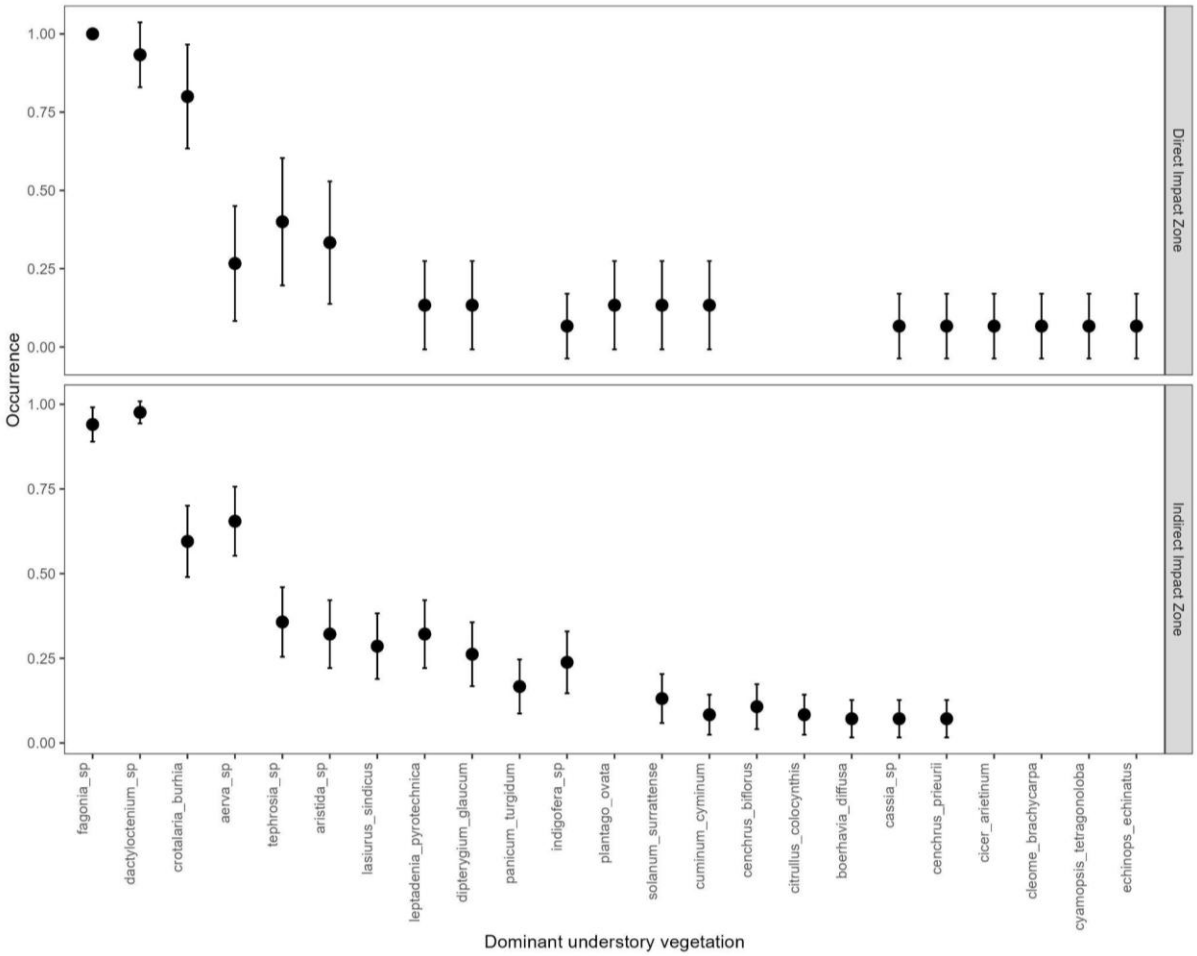

Figure 9: *Mean ± SE (Error bars) occurrence of dominant understorey vegetation (grasses and shrubs) in direct (top) and indirect (bottom) impact zones of the proposed Khuiyala-Unroi mining blocks, sampled at*

20m radius points along vehicle transects during summer and monsoon seasons of 2025. Short Grasslands with Dactyloctenium spp. are preferred by GIB, and this group of grass species had high occurrence within the direct and indirect impact zone.

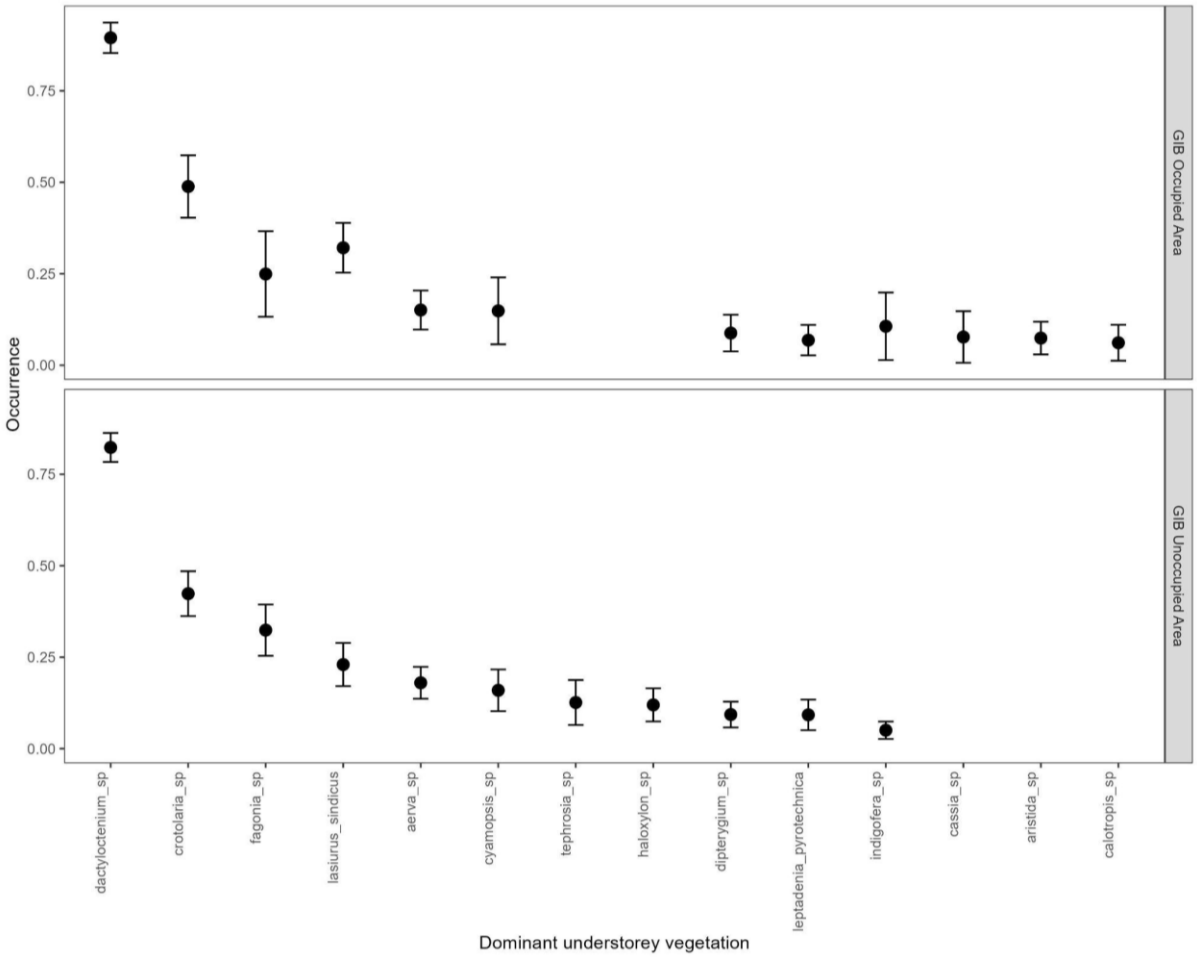

Figure 10: *Mean ± SE (Error bars) occurrence of dominant understorey vegetation (grasses and shrubs) in areas with (top) and without (bottom) Great Indian Bustard in/ around Desert National Park, sampled at 20m radius points along vehicle transects during summer and monsoon seasons of 2022-24. Note the preference of areas with Dactyloctenium spp.*

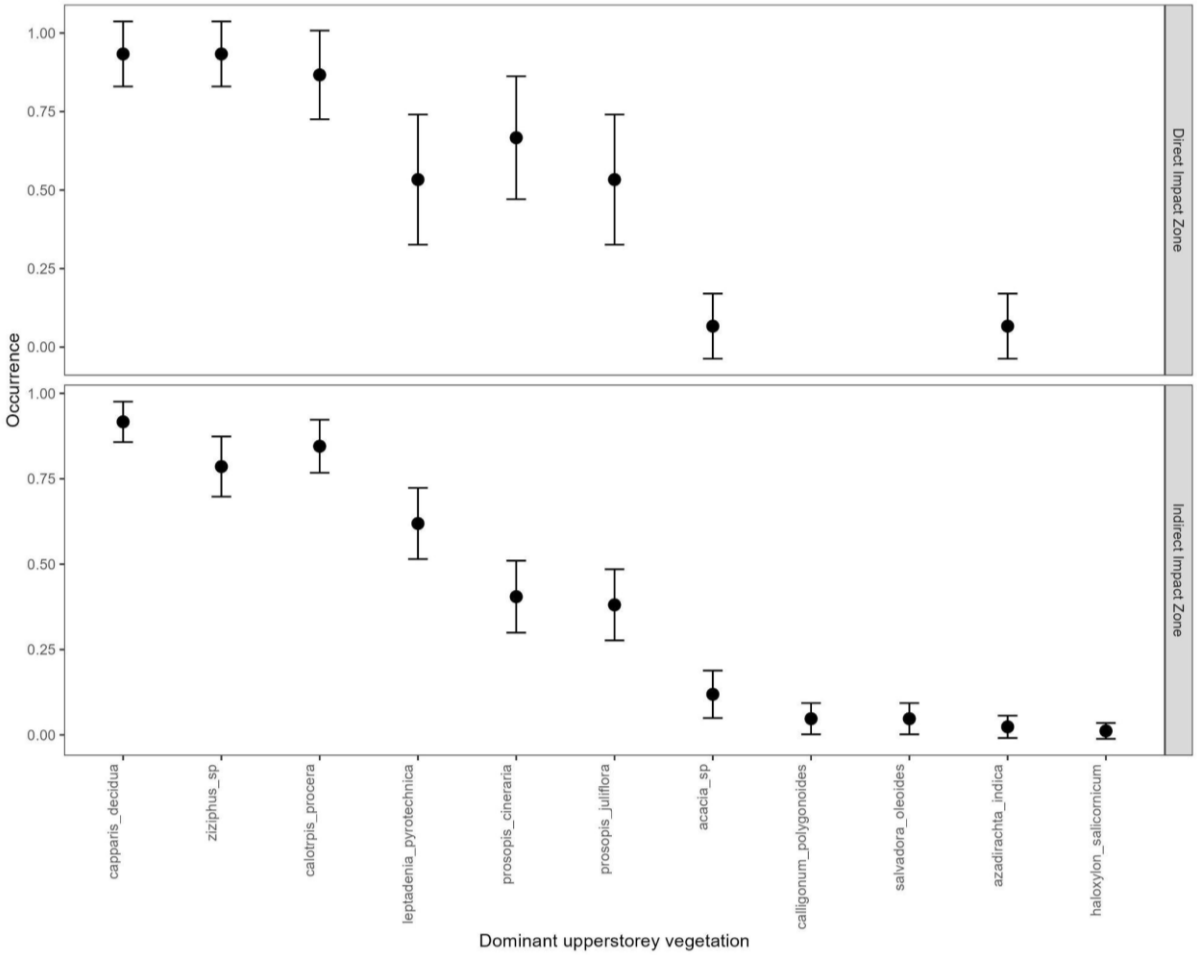

Figure 11: *Mean ± SE (Error bars) occurrence of dominant upperstorey vegetation (trees) in direct (top) and indirect (bottom) impact zones of the proposed Khuiyala-Unroi mining blocks, sampled at 20m radius points along vehicle transects during summer and monsoon seasons of 2025*

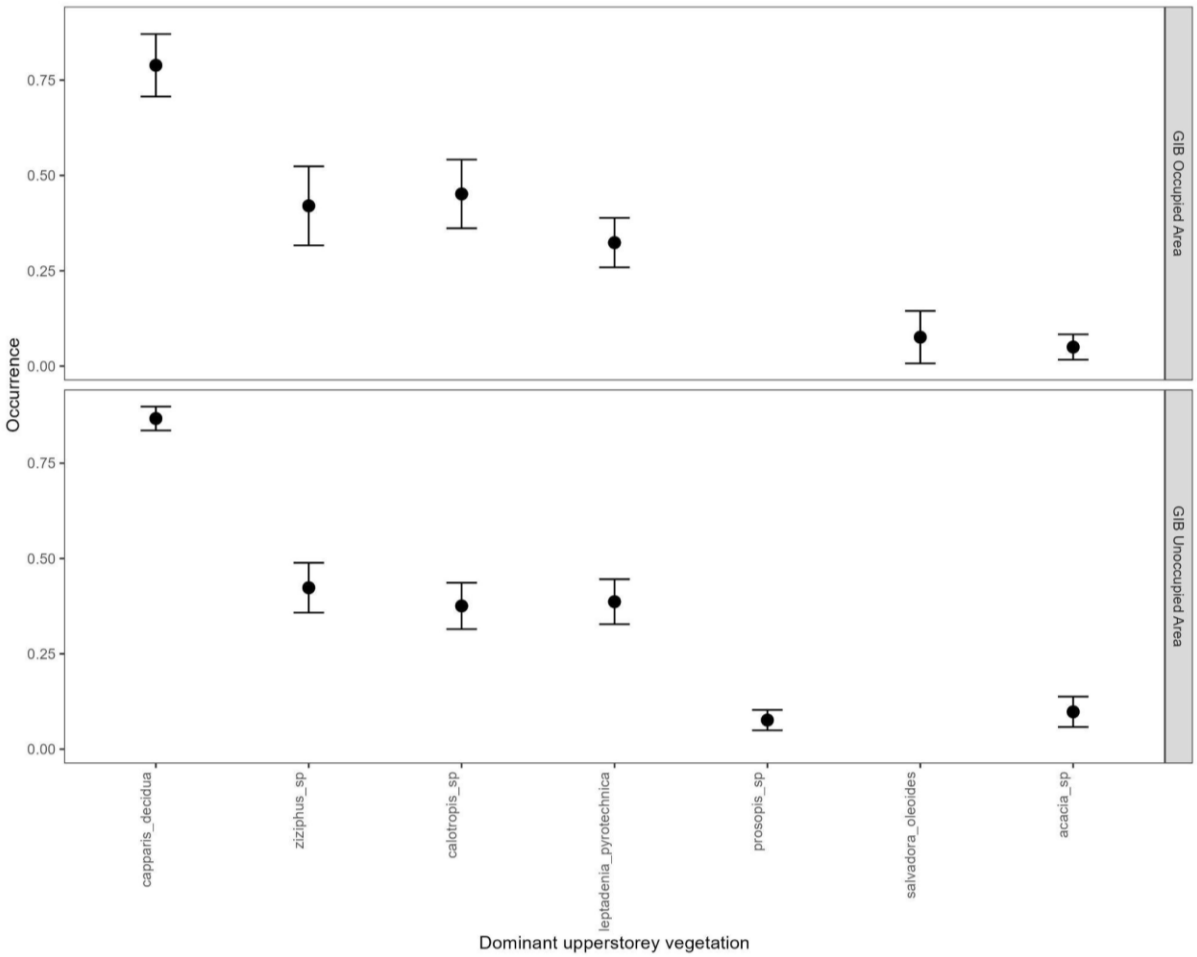

Figure 12: *Mean ± SE (Error bars) occurrence of dominant upperstorey vegetation (trees) in areas with (top) and without (bottom) Great Indian Bustard in/ around Desert National Park, sampled at 20m radius points along vehicle transects during summer and monsoon seasons of 2022-24*

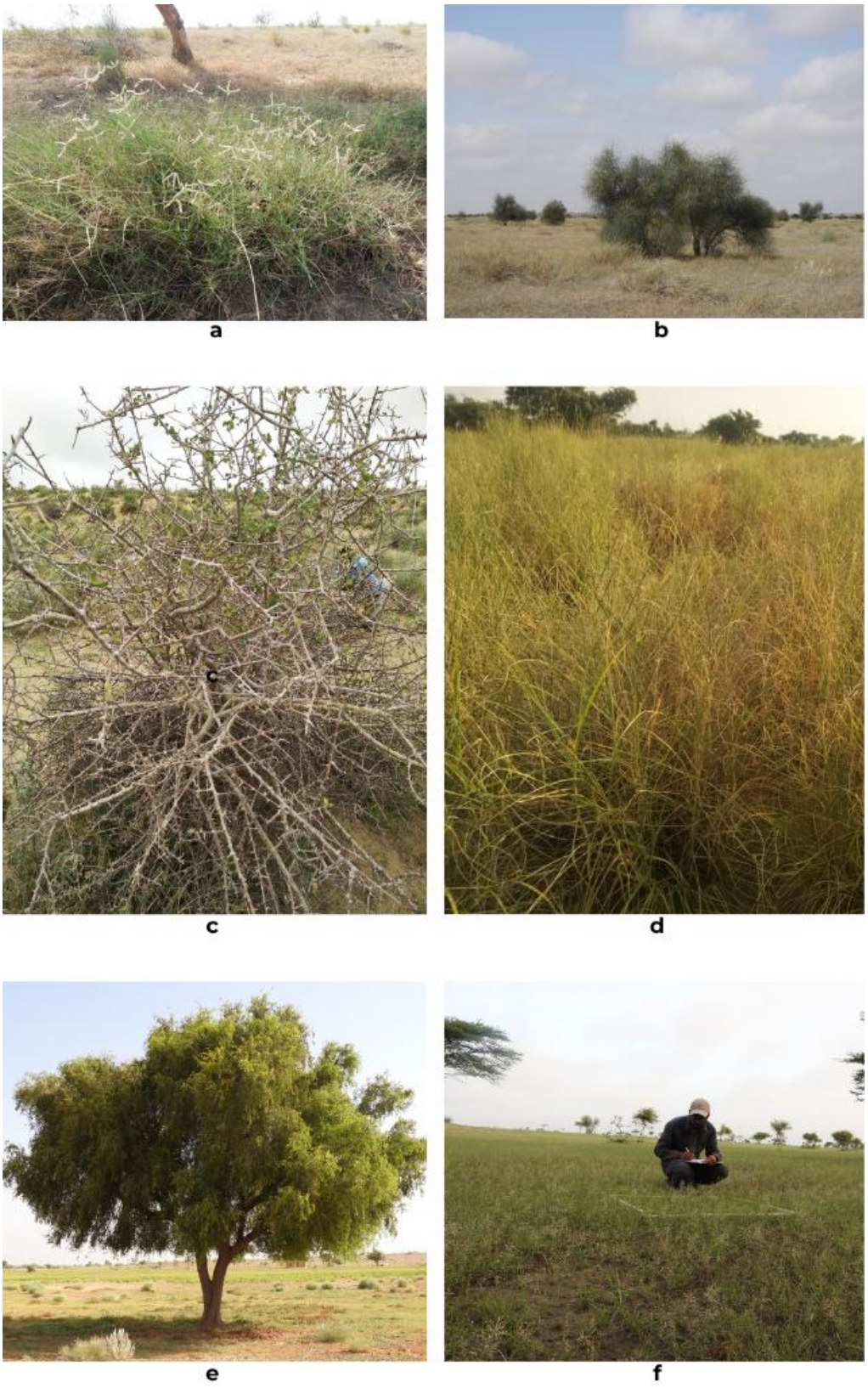

Plate 2: *Important dominant vegetation (a- Ghatiya, b- Ker, c- Guggal, d- Sewan, e- Khejri, f- Vegetation sampling) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

Vegetation Structure

The structure of understory vegetation in the direct impact zone and the transportation road was dominated by vegetation shorter than 20 cm in height, followed by medium height vegetation (20 cm–60 cm height) with little variation between seasons. Comparatively, the GIB occupied areas have significantly higher vegetation of medium height with higher coverage in the monsoon season (Figure 13). The higher coverage of shorter vegetation and minimal seasonal variation in the proposed mining area is due to higher livestock grazing pressure, which is less in GIB occupied areas of the larger landscape.

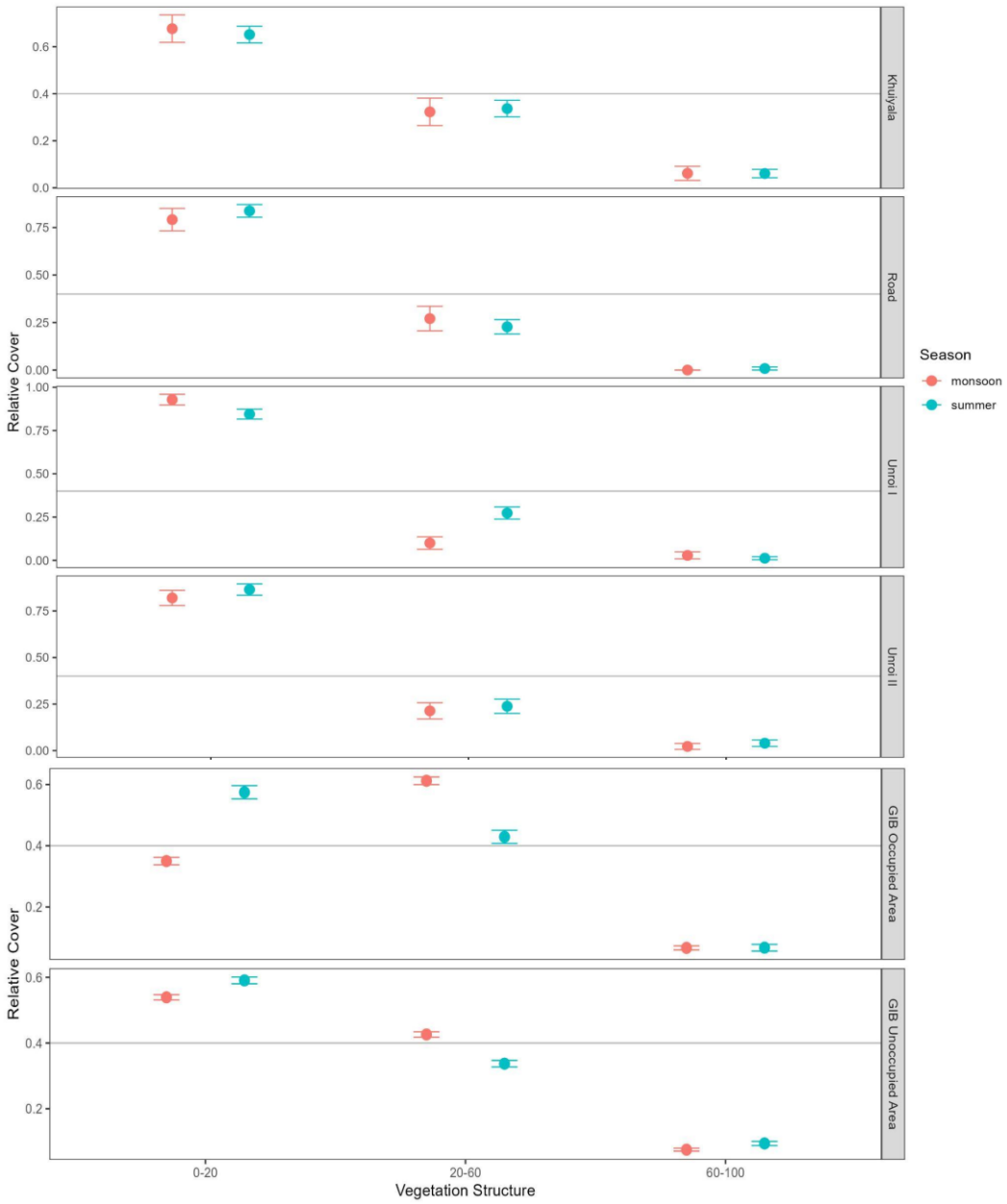

Figure 13: *Mean ± SE (Error bars) relative cover of understorey vegetation in the different blocks of Khuiyala-Unroi proposed mine areas and transportation road (top), sampled within 2m x 2m plots along walk transects during summer and monsoon 2025; and, Great Indian Bustard occupied and unoccupied*

areas (bottom) in and around Desert National Park, sampled in similar framework during summer and monsoon seasons of 2022-24

Disturbance

Quantification of renewable energy infrastructure (wind turbine), high-tension transmission lines and human settlements in the direct and indirect impact zone and the GIB usage area was carried out. The mean length of high-tension power lines within the direct impact zone is negligible and comparable to that in GIB-occupied area. The direct impact zone no wind turbines compared to the GIB-occupied area. The indirect impact zone has comparatively higher disturbance than both the direct impact zone and the GIB-occupied area. These observations indicate that the direct impact zone presently retains low disturbance, similar to GIB-occupied areas, which support its potential for GIB rewilding and post-release adaptation under the ongoing conservation efforts.

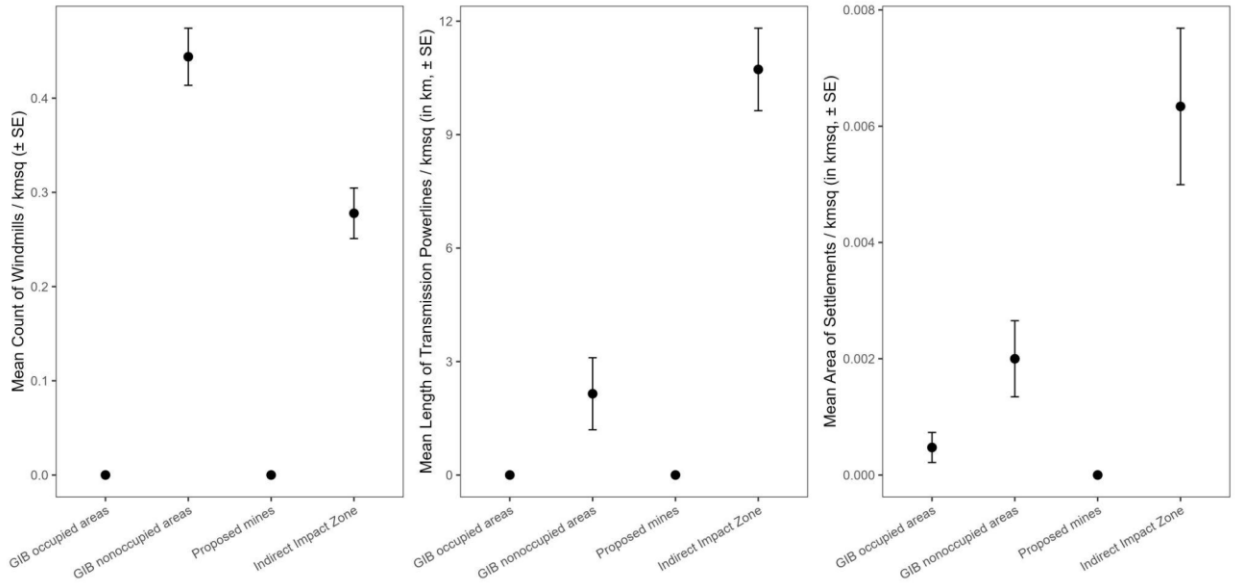

Figure 14: *Mean ± SE (Error bars) count per km^2 of windmills (left), mean ± SE length of high-tension transmission lines per km^2 (centre), and mean ± SE area of human settlement (right) in the project impact zones of the proposed Khuiyala-Unroi mining area compared to areas having the Great Indian Bustard (2025)*

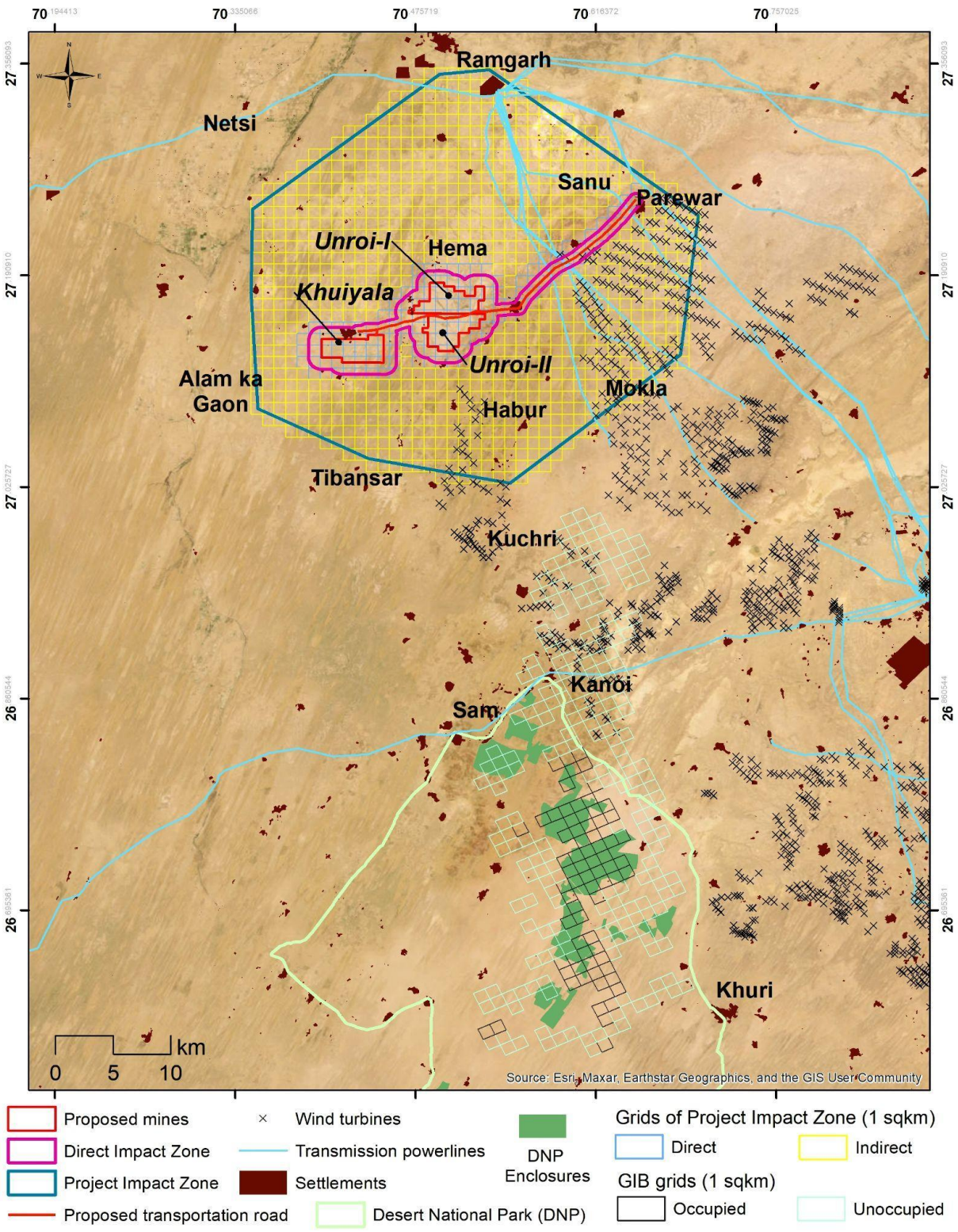

Figure 15: *Map showing the intensity of renewable energy infrastructures (transmission power lines and wind turbines) and human settlements with respect to the project impact zone and GIB use areas in Jaisalmer, Rajasthan*

Plant species densities and numbers

An estimated ~75,000 trees are present in the direct impact area. A list of all genus/species of trees and shrubs, along with their density (per ha) and total counts, is provided in subsequent tables (Tables 2 and 3).

Table 2: *Estimate of Density ± SE (per hectare) and total Abundance of all tree species (woody plants with height more than 2m) found in the direct impact zone in the proposed Khuiyala-Unroi mining blocks and transport road, sampled in a 200 m^2 belt along walk transects during summer and monsoon seasons of 2025*

S. No.	Tree Species	Density ± SE (#/hecare)	Total Abundance
1	*Acacia spp.*	1.69 ± 0.56	5,015
2	*Azadirachta indica*	0.02 ± 0.02	59
3	*Capparis decidua*	8.35 ± 0.92	24,776
4	*Prosopis cineraria*	1.40 ± 0.33	4,154
5	*Salvadora oleoides*	0.35 ± 0.15	1,039
6	*Ziziphus spp.*	13.54 ± 1.96	40,176
		Total	75,220

Table 3: *Estimate of Density ± SE (per hectare) and total Abundance of all shrub species found in the direct impact zone in the proposed Khuiyala-Unroi mining blocks and transport road, sampled in a 100 m^2 belt along walk transects during summer and monsoon seasons of 2025*

S. No.	Shrub Species	Density ± SE (#/hecare)	Total Abundance
1	*Aerva spp.*	3.50 ± 0.81	10,385
2	*Calotropis procera*	52.05 ± 7.30	1,54,445
3	*Cassia spp.*	0.77 ± 0.40	2,2845
4	*Cressa cretica*	3.29 ± 2.49	9,762
5	*Crotalaria spp.*	7.32 ± 1.5	21,720
6	*Dipterygium glaucum*	1.26 ± 0.77	3,739
7	*Echinops echinatus*	1.10 ± 0.78	3,264
8	*Fagonia sp.*	20.37 ± 4.68	60,443
9	*Haloxylon salicornicum*	5.30 ± 3.00	15,726
10	*Leptadenia pyrotechnica*	33.19 ± 4.53	98,483

S. No.	Shrub Species	Density ± SE (#/hecare)	Total Abundance
11	*Solanum surrattense*	0.85 ± 0.37	2,522
12	*Tephrosia spp*	8.9 ± 3.39	26,408

Key Fauna

Great Indian Bustard

The species is found in the project impact zone as per recent surveys and records from the recent past, along with the movement of tagged GIBs in and around the Priority GIB area (Figure 16). GIB represents the flagship of India's arid grassland ecosystems, and its survival largely depends on the protection of large, contiguous tracts of open habitats. The Priority GIB Area, delineated under the Hon'ble Supreme Court's directive (WP(C) 838 of 2019), functions as the focal area for in-*situ* conservation and future rewilding of captive-bred birds to recover the species from the vortex of extinction. Notably, the large grasslands in and around proposed mining blocks are considered potential rewilding spaces for captive-bred birds under the national GIB conservation breeding program. Any alteration of these natural grassland mosaics, through fragmentation, infrastructure development, or increased mining activities, will compromise the success of ongoing and future recovery efforts aimed at establishing self-sustaining populations in the wild.

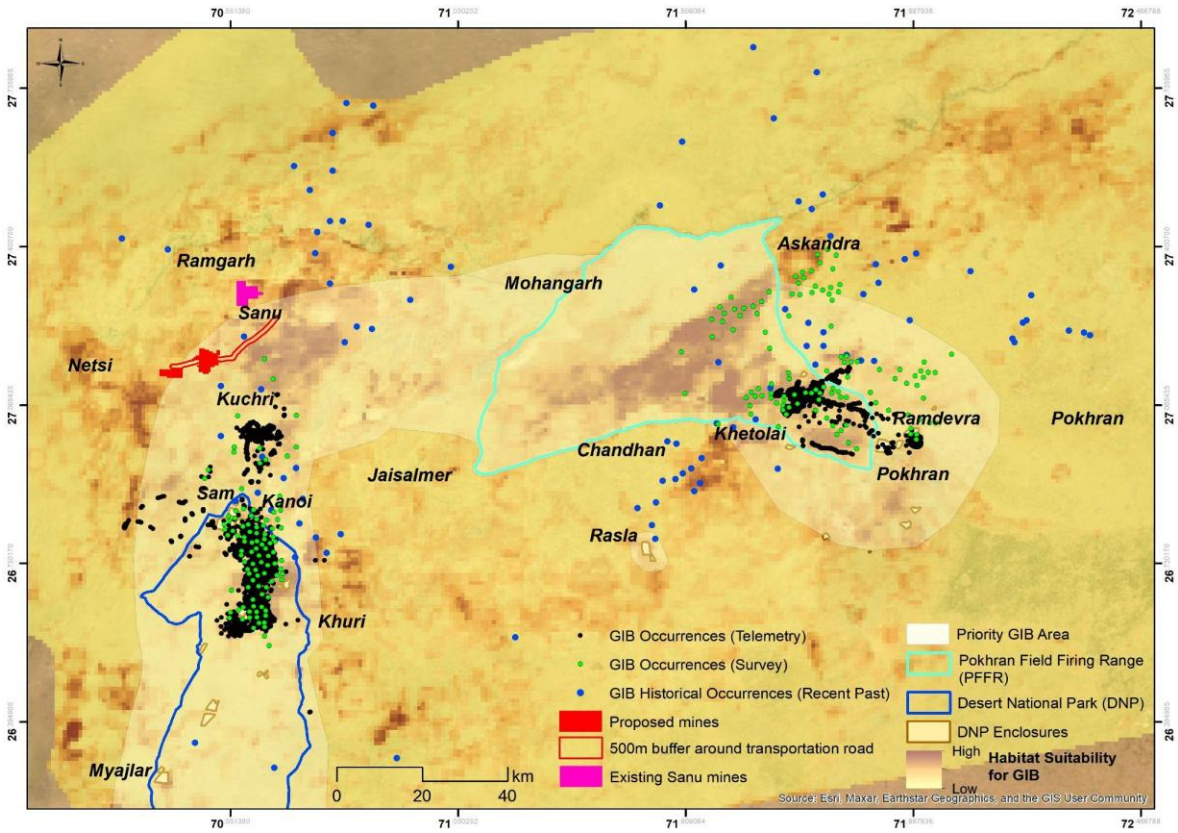

Figure 16: *Location of proposed and existing mines with respect to GIB occurrence within the Thar landscape (2025)*

Raptors

To assess the population status and distribution of wide-ranging raptors within the project impact zone, vehicle-based line transects were conducted. Given that raptors are large-ranging birds, the impact zone for them will be larger than that for other species such as small birds and mammals. Thus, raptor surveys were conducted in 6 x 6 grids covering both the direct and indirect impact zones. This approach is particularly effective for detecting large-bodied and open-habitat species, such as raptors, which are visible from moving vehicles across substantial distances. The survey design followed standardised protocols established for large-scale population assessment of GIB (Dutta et al., 2018, 2024). Systematic vehicular transects were conducted along existing dirt trails by teams of two observers moving at low speeds (10–15 km/hr). Surveys were carried out during peak hours, early morning (0700–1100 hrs in winter and 0600–1030 hrs in summer and monsoon) and late afternoon (1600–1815 hrs in winter and 1700–1930 hrs in summer and monsoon). For each observation, species identity, group size, GPS location, sighting distance, and bearings were recorded. In the case of soaring or flying individuals, detections were included in estimating encounter rates.

Surveys were conducted during three seasonal replicates: winter (February 2025), summer (April 2025), and monsoon (July-August 2025). The total cumulative efforts were 917.25 km (13.90 ± 0.20 km SE/grid; 14.50 ± 0.34 km in winter, 13.63 ± 0.27 km in summer, and 13.56 ± 0.38 km in monsoon). For raptors, where detections were insufficient (<20) for reliable density estimation, encounter rates (individuals/km) were calculated for key species. The density estimates were inferred from the better-performing model based on the least AIC and better goodness of fit (Buckland et al. 2001).

In total, 31 species of raptors were observed, of which 26 species are of conservation importance (Table 4), listed under Schedule I of WPA 1972 (2023 Amendment), or threatened by the IUCN Red List.

Table 4: *Population estimates (density and numbers) of conservation-dependent and threatened species in direct and indirect impact areas around the proposed limestone mines in Jaisalmer, Rajasthan (2025).*

Species and Model Details	Population Parameters	Direct Impact Zone	Indirect Impact Zone
	Area	108 km^2	756 km^2
Egyptian vulture (Endangered, Schedule-I)	Density ± SE (no/km^2)	0.33±0.14	0.37±0.11
	Encounter rate (no/km)	0.47 ± 0.04	0.303 ± 0.027
Short-toed snake eagle (Schedule-I)	Density ± SE (no/km^2)	0.06 ±0.03	0.08 ±0.02
	Encounter rate (no/km)	0.08 ± 0.01	0.109 ± 0.01
Tawny eagle (Vulnerable, Schedule-I)	Density ± SE (no/km^2)	0.04 ±0.02	0.05 ±0.02
	Encounter rate (no/km)	0.042 ± 0.01	0.079 ± 0.001
White-eyed buzzard (Schedule-I)	Density ± SE (no/km^2)	0.09 ±0.04	0.1 ±0.04
	Encounter rate (no/km)	0.04 ± 0.01	0.060 ±0.01

Species and Model Details	Population Parameters	Direct Impact Zone	Indirect Impact Zone
Cinereous Vulture	Encounter rate (no./km)	0.11 ± 0.01	0.023 ± 0.004
Eurasian Griffon	Encounter rate (no./km)	0.09 ± 0.02	0.046 ± 0.01
Eurasian Sparrowhawk	Encounter rate (no./km)	0.09 ± 0.002	0.01 ± 0.002
Greater Spotted Eagle	Encounter rate (no./km)	-	0.012 ± 0.003
Imperial Eagle	Encounter rate (no./km)	0.04 ± 0.004	0.003 ± 0.001
Laggar Falcon	Encounter rate (no./km)	0.01 ± 0.003	0.013 ± 0.004
Long-legged Buzzard	Encounter rate (no./km)	0.07 ± 0.01	0.02 ± 0.003
Montagu's Harrier	Encounter rate (no./km)	0.03 ± 0.004	0.04 ± 0.005
Pallid Harrier	Encounter rate (no./km)	0.07 ±0.01	0.07 ± 0.01
Shikra	Encounter rate (no./km)	0.003 ± 0.001	0.013 ± 0.003
Steppe Eagle	Encounter rate (no./km)	0.22 ± 0.03	0.03 ± 0.01
Common Buzzard	Encounter rate (no./km)	0.01 ± 0.002	-
Himalayan Griffon	Encounter rate (no./km)	0.04 ± 0.01	-
Indian Spotted Eagle	Encounter rate (no./km)	0.01 ± 0.003	-

Across the project impact zone, four Schedule-I raptor species listed under the WPA 1972 (2023 amendment) were systematically assessed using distance sampling. The Egyptian Vulture was the most abundant, with 114 flocks (235 individuals) primarily observed perched on pylons, trees, or the ground. 64 detections yielded encounter rates of 10.57 ± 4.0 and 11.8 ± 2.95 individuals/100 km and densities of 0.330 ± 0.135 and 0.368 ± 0.109 individuals/km² in the core and buffer, respectively, under a half-normal detection function with cosine adjustment. Short-toed Snake Eagle recorded 83 times, showed encounter rates of 3.52 ± 1.39 and 4.68 ± 1.14 individuals/100 km and densities of 0.06 ± 0.03 and 0.08 ± 0.02 individuals/km², also best explained by a half-normal cosine model. The Tawny Eagle had 27 sightings, which yielded encounter rates of 2.35 ± 0.92 and 2.85 ± 1.11 individuals/100 km and densities of 0.04 ± 0.02 and 0.05 ± 0.02 individuals/km², derived from a uniform key function with cosine adjustment. The White-eyed Buzzard had 22 independent detections and showed densities of 0.09 ± 0.04 and 0.1 ± 0.04 individuals/km² in the core and buffer, respectively, using a uniform cosine model.


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a


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Plate 3: *Conservation important raptor species (a- Long-legged Buzzard, b- Laggar Falcon, c- Tawny Eagle, d- Egyptian Vulture, e- Eurasian Griffon Vulture, f- Short-toed Snake Eagle, g- Montagu's Harrier, h- Steppe Eagle) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

Mammals

Population status and spatial distribution of terrestrial mammals were assessed using the same vehicle-based line transect framework employed for raptor surveys. Guided by long-term and large-scale surveys in the landscape, this method has proven effective for detecting wide-ranging and open-habitat species such as the Chinkara, Desert Fox, Indian Fox, and Desert Cat (Dutta et al., 2018, 2024).

To complement vehicle surveys and to account for nocturnal or elusive behaviour of mammals such as the Desert Cat, Desert Fox, and Indian Fox, Camera Trap Distance Sampling was also implemented within 1 km^2 grids in the Direct Impact Zone (Howe et al. 2017; Dutta et al. 2024). A single Browning Dark OPS Full HD camera trap was deployed in each grid (n=101), at the centroid or within 100 m of it. Each camera was mounted safely on a wooden stand and programmed to capture a burst of eight images per trigger. Reflective markers (stones at 2 m and 5 m; sticks at 8 m and 12 m) were installed to aid in assigning detection distances in front of the camera. Cameras remained operational for 32 ± 10.49 days (9–48 days) and were checked weekly for functionality and alignment. 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, hazard-rate, and uniform key functions were compared using cosine, hermite, polynomial, and null adjustment terms to select the most parsimonious model based on AIC. Only species with >50 independent detections were retained for analysis. Sampling effort was defined as the total camera-active time (seconds) multiplied by 0.12, corresponding to the effective proportion of the 42° detection angle. Final species-specific density estimates were derived from the best-fitting models.

In total, 23 species of mammals were recorded during the surveys (Appendix 2), of which 8 species are of conservation concern, listed under Schedule I of the WPA 1972 (2023 amendment), or included in threatened categories of the IUCN Red List.

In vehicle surveys, 267 Chinkara were sighted, yielding encounter rates of 43.47 ± 12.25 individuals/100 km in the core and 11.39 ± 2.33 individuals/100 km in the buffer. The distance data was best explained by the uniform detection function with cosine adjustment. The density of Chinkara was estimated as 0.99 ± 0.29 individuals/km^2 in the core and 0.26 ± 0.06 individuals/km^2 in the buffer region of the direct impact zone, with a total density of 0.62 ± 0.1 individuals/km^2 in the entire landscape.

The CTDS analysis was conducted for three key fauna and ecological associates of GIB- Chinkara, Desert Fox, and Indian Fox. The density estimates were inferred from a half-normal detection function with no adjustment terms. Densities were estimated at 0.96 individuals/km^2 (±0.37 SE) for Desert Fox, 0.33 individuals/km^2 (±0.16 SE) for Indian Fox, and 0.29 individuals/km^2 (±0.14 SE) for Chinkara. These three species are closely associated with GIB (Table 5).

Overall, our field surveys show that about 10-30 Chinkara, 30 Desert Foxes, and 10 Indian Foxes use the direct impact zone of the proposed mine areas.

Table 5: *Density (#/km^2) of threatened terrestrial mammals assessed from camera trap surveys in the proposed Khuiyala-Unroi mining blocks*

Species	Camera Trapping	Vehicle Transect	
	Direct Impact Zone	Direct Impact Zone	Indirect Impact Zone
Chinkara	*0.29 ± 0.14*	*0.99 ± 0.29*	*0.26 ± 0.06*
Desert fox	*0.96 ± 0.37*	-	-
Indian fox	*0.33 ± 0.16*	-	-

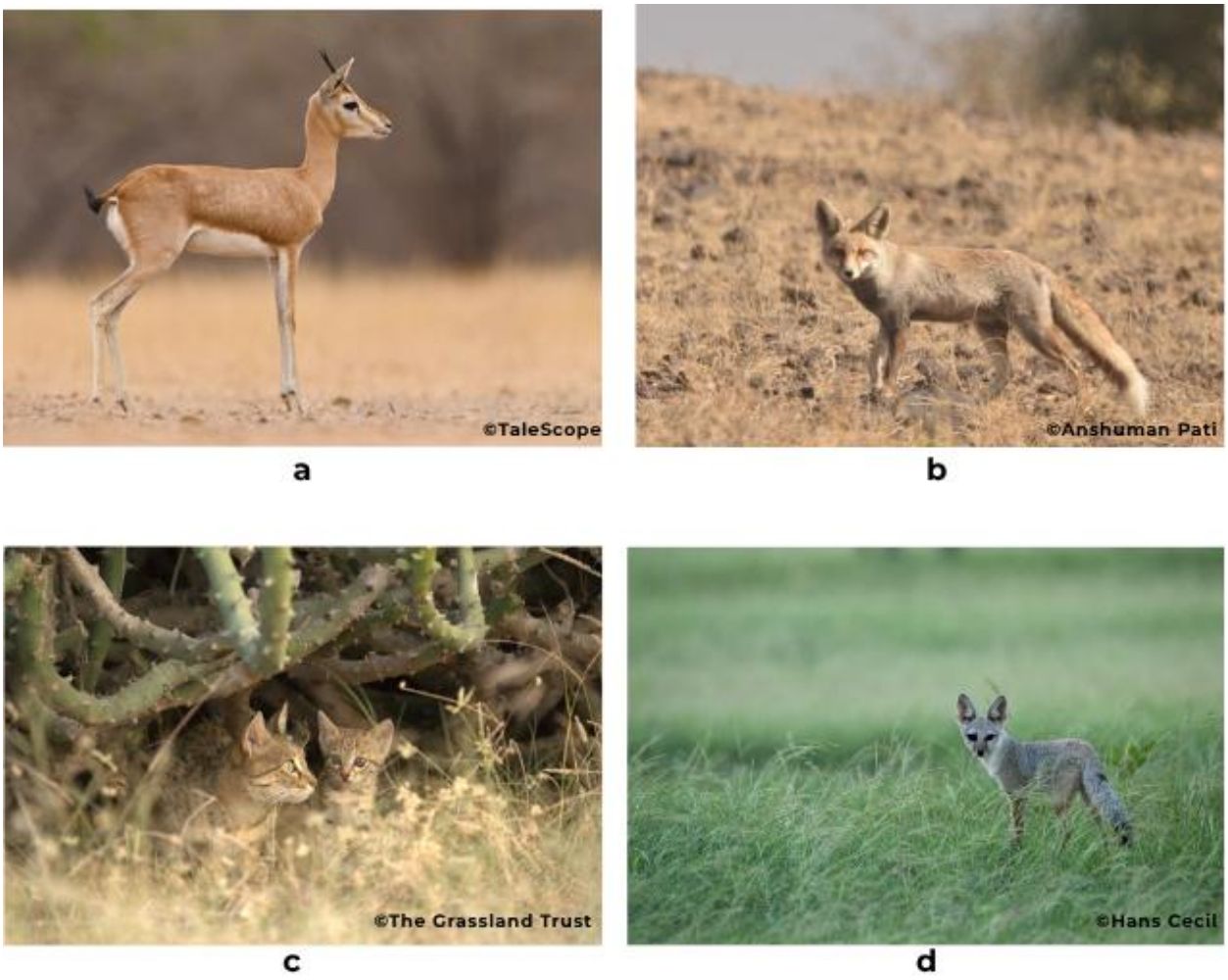


Plate 4: *Conservation Important mammal species (a- Chinkara, b- Desert Fox, c- Desert Cat, d- Indian Fox) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks*

Plate 5: *Field Sampling (a- Camera Trap Installation, b- Vehicle Survey) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks*

Other fauna

Birds

Walk-transect-based distance sampling was employed to estimate the distribution and abundance of small birds in the direct impact zone. Surveys were conducted in two seasons to capture temporal variation in bird communities: winter (February 2025) and monsoon (August 2025). In total, 105 grids were surveyed during the first replicate (total effort 72.2 km; mean transect length 697.51 ± 8.32 SE m per transect), and 80 grids during the second replicate (total effort 54.37 km; mean transect length 684.09 ± 8.17 SE m). Field effort during the monsoon replication was reduced due to waterlogging in grasslands and agricultural fields. Transects were placed systematically within grids to represent habitat heterogeneity across various land use classes, such as grasslands, scrublands, croplands, and rocky outcrops. Each transect was walked by two trained observers at a steady pace during peak bird activity hours in the morning (0700–1100 hrs) and evening (1600–1815 hrs). For every sighting, the species name, group size, and perpendicular distance from the transect line were recorded following standard distance sampling protocols (Buckland et al., 2001).

Population estimation followed the multivariate conventional line-transect distance sampling framework (Buckland et al., 2001). Owing to low species-specific sample sizes, detections were pooled across species using the median detection distance approach. For each species, the median perpendicular detection distance was calculated, and species were subsequently assigned to one of the four distance-detection groups based on quartile thresholds: proximal detection group (<25th percentile), intermediate (25th–50th percentile), distant (50th–75th percentile), and very distant detection group (>75th percentile). Detection functions (half-normal and hazard-rate, with null and hermite adjustments) were fitted to the species' detection data with each detection group as a covariate, and the best-fitting model was selected using the least AIC. Additionally, goodness of fit for models was checked based on the chi-square test. For each group, detection probability and effective strip width were estimated, which were then applied to encounter rates to derive species-specific density estimates (individuals per km^2) from encounter rates.

Final density estimates were summarised by species and further aggregated according to their feeding guilds to determine abundance across seasons.

A total of 96 bird species were recorded during the survey, including species of high conservation concern, such as the Rufous-tailed Prinia and Stoliczka's Bushchat (Annexure 1). Of these, 57 species had fewer than five detections and were excluded from the distance analysis, while the remaining 39 species provided sufficient data for population estimation. Several of these species are listed under Schedule-I of the Wildlife Protection Act (WPA, 2023 amendment).

Among the candidate models tested, hazard-rate detection function without adjustment yielded the best fit with the lowest AIC. Based on 1,501 cluster detections, the overall bird density was estimated to be 476.12 individuals/km^2 (± 52.39 SE; CV = 11%) in the direct impact zone. Model fitness was confirmed by goodness-of-fit tests, indicating a strong fit to the observed data (GOF statistic = 0.12, p = 0.49).

Species-wise density estimates are presented in Figure 17. Among the recorded species, Greater Short-toed Lark, being a large-flock species, showed the highest estimated density of 78.01 individuals/km^2 (±17.48 SE). Several species of high conservation concern evaluated by the SoIB assessment were recorded within the direct impact zone, including Stoliczka's Buschat (IUCN Red List-Vulnerable), Great Grey Shrike (2.33 ± 0.43 ind/km^2), Rufous-tailed Lark (8.52 ± 2.35 ind/km^2), and Desert Wheatear (4.18 ± 1.03 ind/km2) (Figure 17; Annexure 1). Additionally, species categorised under moderate conservation priority in SoIB assessment, such as Crested Lark (5.54 ± 2.53 ind/km^2), Chestnut-bellied Sandgrouse (22.51 ± 6.99 ind/km^2), Lesser Whitethroat (30.02 ± 23.33 ind/km^2), Eastern Orphean Warbler (0.7 ± 0.44 ind/km^2), Desert Lark (2.29 ± 0.77 ind/km^2), Asian Desert Warbler (1.04 ± 0.49 ind/km^2), Black-crowned Sparrowlark (16.53 ± 3.57 ind/km^2) and a few more were also recorded in considerable densities (Figure 17; Annexure 1). Notably, many of the aforementioned species are legally protected under Schedule-II of the WPA 1972 (2023 amendment). 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.

Plate 6: *Conservation Important small bird (Stoliczka's Bushchat) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

Several species of high conservation significance (Threatened according to IUCN or listed in Schedule I of the Wildlife Protection Act (WPA), 1972) were recorded inside the direct impact zone (Appendix 2). These included raptors such as the Egyptian Vulture and Indian Spotted Eagle, along with arid specialists such as Yellow-eyed Pigeon and Stoliczka's (White-browed) Bushchat, both of which have restricted distributions. In addition, several Near Threatened raptors, including the Laggar Falcon, Red-necked Falcon, and Pallid Harrier, were observed predominantly in the monsoon. While not yet globally threatened, these species are undergoing declines associated with agricultural intensification, prey-base depletion, 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 17: *Density (#/km^2) of birds assessed from walk transect surveys in the proposed Khuiyala-Unroi mining blocks.*

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 100m circular plot of each sampling point.

During monsoon, the mean burrow occurrence of the Spiny-tailed Lizard (0.23 ± 0.15 SE) was observed to be higher in the Unroi-II block compared to Khuiyala (0.18 ± 0.11 SE) and Unroi-I (0.08 ± 0.4 SE). However, the occurrences were higher in Khuiyala (0.39 ± 0.19 SE) than Unroi-II (0.23 ± 0.02 SE) and the proposed transportation road (0.21 ± 0.09 SE) in summer. In the case of Desert Gerbil, the mean burrow occurrence was higher in the Khuiyala block (14.54 ± 5.08 SE) in comparison to Unroi-I (1.94 ± 1.1 SE), Unroi-II (4.07 ± 2.07 SE), and the proposed road (3.46 ± 0.99 SE) in the monsoon. During summer, the occurrence was higher in Khuiyala (7.49 ± 1.49SE) than Unroi-I (4.8 ± 1.58 SE), Unroi-II (3.04 ± 1.11SE) and proposed road (1.49 ± 0.52 SE) (Figure 18).

In addition, the presence of burrowing taxa like Spiny-tailed Lizards and Desert Gerbils in core and buffer suggests the presence of suitable microhabitat features and soil conditions that are favourable to fossorial animals. Both these species are very important components of the desert ecosystem that form the major prey base for predators, attracting large congregations of Tawny and Steppe Eagles. Further, the Spiny Tailed Lizard is provided the highest protection status (Schedule-I) under the Wildlife (Protection) Act, 1972.

Plate 7: *Conservation Important Fossorial Animals (a- Spiny-tailed Lizard, b- Desert Gerbil) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

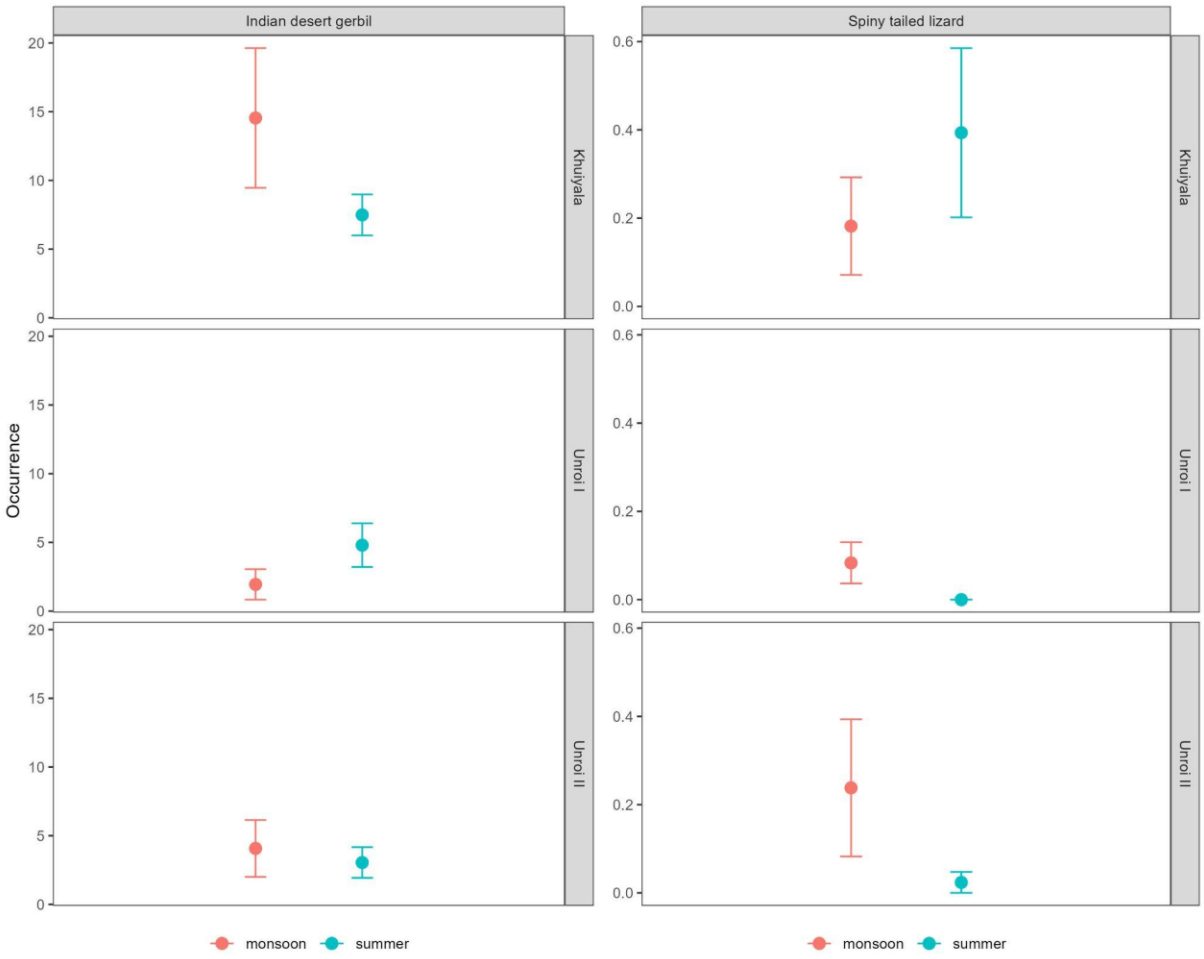


Figure 18: *Mean ± SE (Error bars) occurrence of Indian Desert Gerbil (left) and Spiny Tailed Lizard (right) in different blocks of the proposed Khuiyala-Unroi mining area, sampled within 20 m around points along walk transects during summer and monsoon seasons (2025)*

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. 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 insect assemblage was dominated by the order Orthoptera (grasshoppers and crickets), with densities of 35.1 ± 3.9 SE (per 50 m^2) in the direct impact area during monsoon, and 1.7 ± 0.2 SE (per 50 m^2) in summer. Total insect density in the same area was 35.6 ± 3.9 SE and 2.2 ± 0.2 SE in monsoon and summer, respectively. Orthopteran (and total insect) densities in Unroi mining blocks were greater than those in

Khuiyala block, and were comparable to GIB breeding enclosures of Desert National Park, where Orthopteran density in monsoon was estimated at 36.6 ± 2.8 SE between 2021-25 (Figure 19). These results indicate that the food resource availability is adequate for supporting GIB during monsoon in the mining blocks.

Plate 8: *Insect assessment (a-Field Sampling, B- Grasshopper) in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

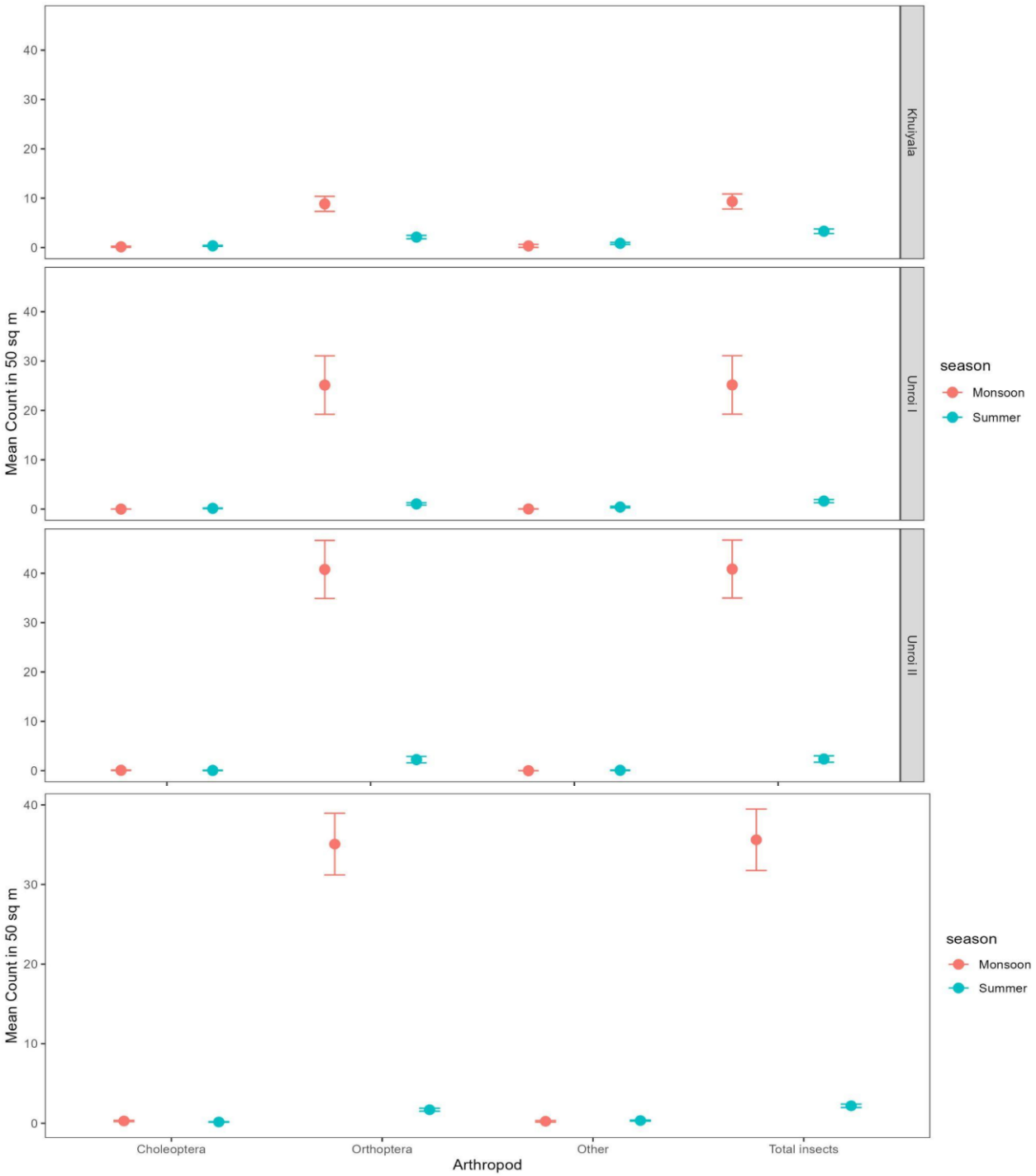


Figure 19: *Mean ± SE (Error bars) counts of arthropods in the direct impact zones depicted blockwise (top) and overall area (bottom) of the proposed Khuiyala-Unroi mining area, sampled at 50 m^2 radius points along walk transects during summer and monsoon seasons of 2025*

Landscape Characterisation

Land Cover Mapping

To map land cover classes and quantify the coverage of each class in the project impact zone, supervised classification was conducted following the framework of Dutta et al. (2023). Seven major land cover categories were identified and geotagged: cropland, barren, human settlement, grassland, scrubland, woodland, and waterbodies (Figure 20). Multispectral datasets from Sentinel-2A were acquired for the period January 2023 to August 2025. Images were processed for standard radiometric and geometric corrections, and cloud-free composites (<5%) were generated. Spectral indices derived from Sentinel bands, including the Normalised Difference Vegetation Index (NDVI) and Normalised Difference Water Index (NDWI), were computed and additively used with 13 bands used for classification.

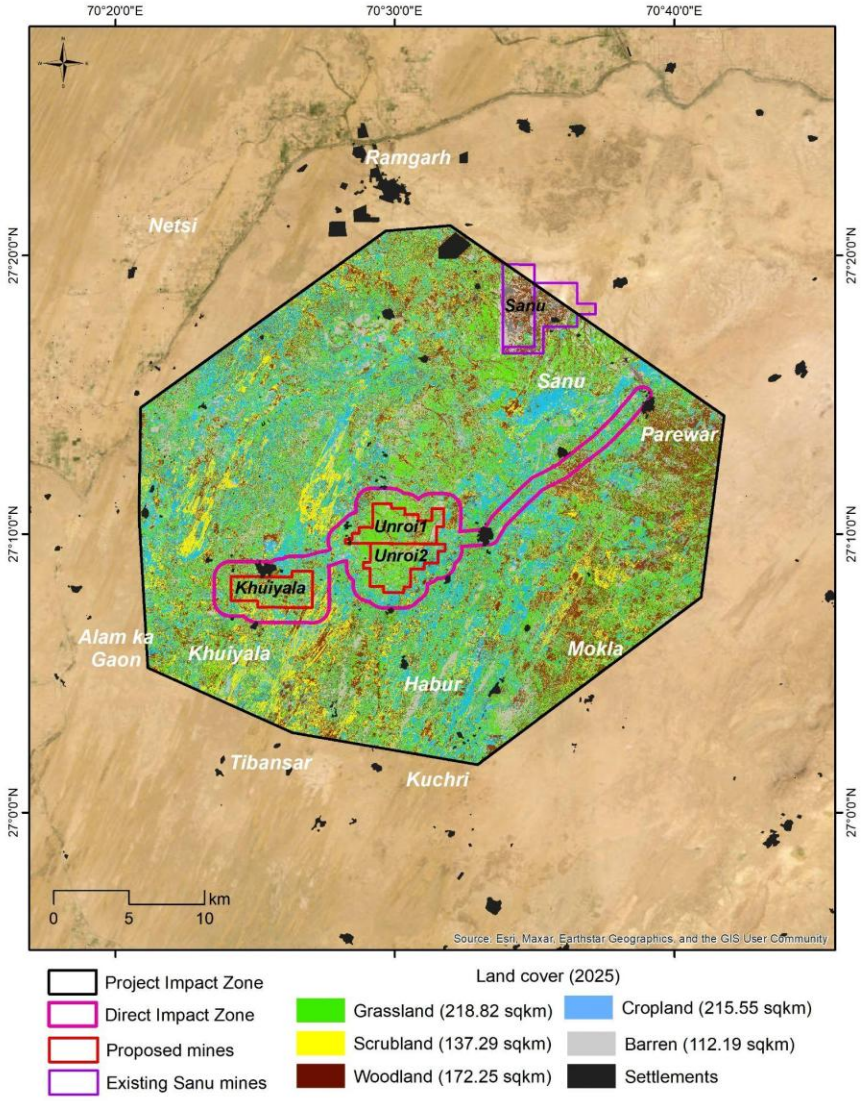


Figure 20: *Land use land cover in the project impact zone around mining blocks of Khuiyala in Jaisalmer, Rajasthan*

For this purpose, ground-truthing data were collected through 670 geo-referenced field points, stratified across land cover types. Of these, 70% (n = 469) were used to train the classification model, and the remaining 25% (n = 201) were reserved for independent validation. Training samples were distributed as follows: woodland (n = 362), scrubland (n = 59), grassland (n = 80), agriculture (n = 64), settlement (n = 30), water (n = 36), and barren (n = 40). A Classification and Regression Tree (CART) algorithm was implemented in Google Earth Engine to predict land cover classes. The performance of the model was evaluated using overall accuracy (based on the confusion matrix) and Kappa coefficient.

Precise information on land cover is critical for assessing the availability of suitable habitats for conservation-significant species, such as the Great Indian Bustard, and for mapping potential impacts of mining activities on vegetation cover and ecosystem integrity. As per this model, the project impact zone is largely dominated by grasslands (area 218.82 km^2), followed by croplands (215.55 km^2), woodland (172.25 km^2), scrubland (137.29 km^2), and barren (112.19 km^2). Unroi blocks are largely dominated by grasslands.

Drainage mapping

The project impact zone is situated within the plains of the GIB landscape in Jaisalmer, where surface hydrology is influenced by ephemeral stream networks driven by monsoonal rainfall. Recent anomalies of high rainfall highlighted the importance of maintaining intact drainage systems to prevent waterlogging and soil erosion in low-lying areas.

Hydrological mapping was carried out using the USGS-SRTM digital elevation model (30m spatial resolution) to delineate flow direction and stream order. At Khuiyala, surface runoff follows a predominantly northwestward flow toward the plains near Netsi, located below the Indira Gandhi Canal. In contrast, runoff from Unroi-I and II drains both northward toward Hema and southeast toward agricultural fields near Habur. Several first- and second-order streams flow north and northwest, with their natural connectivity, potentially interrupted by the Indira Gandhi Canal (Figure 21).

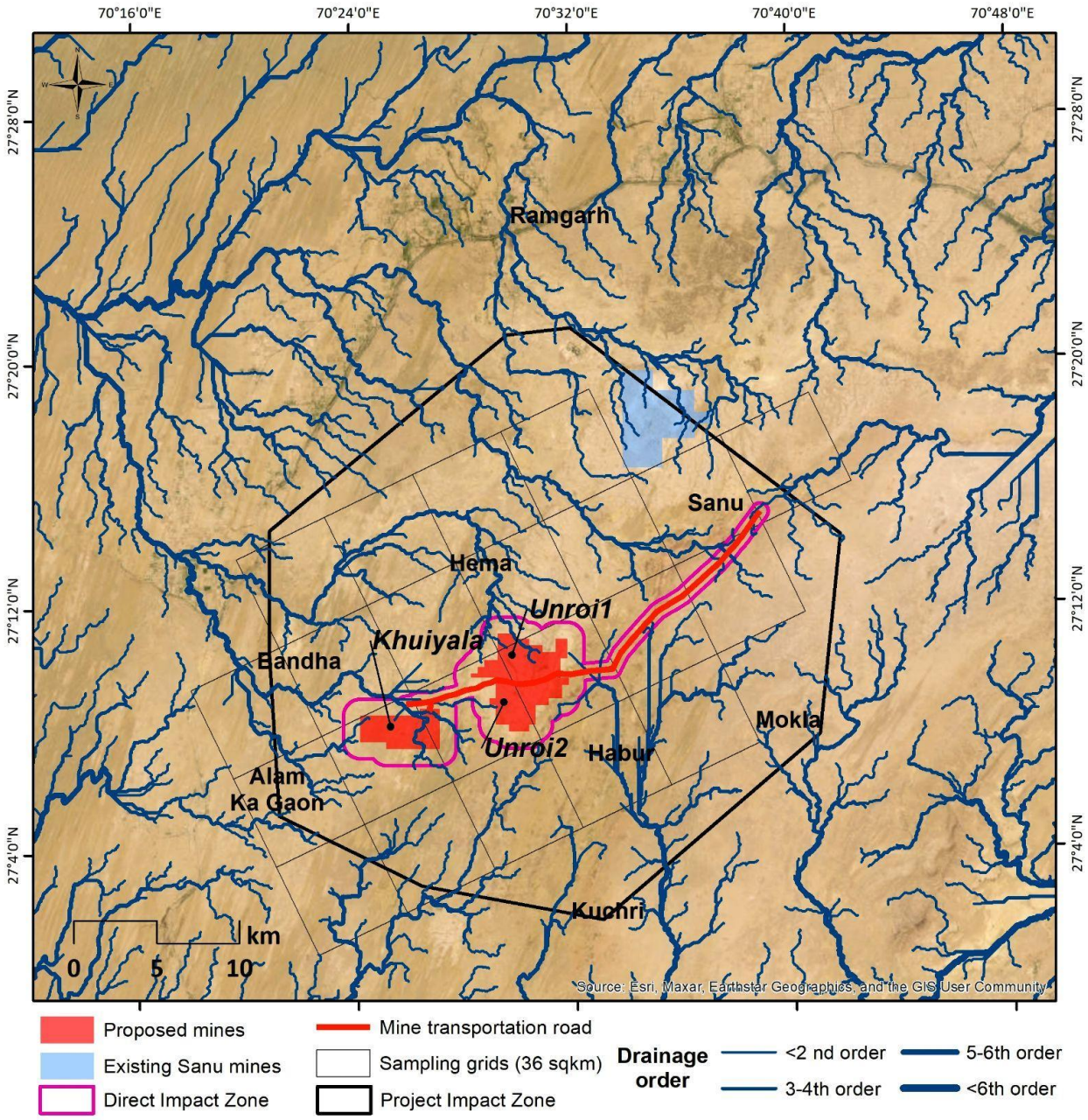


Figure 21: *Drainage network in the proposed mining landscape within the GIB habitats of Jaisalmer, Rajasthan*

These seasonal streams play a critical role in supporting vegetation regeneration, groundwater recharge, and wildlife movement. Disruption of natural drainage patterns by mining activity may alter surface flow, reduce water availability in natural depressions, and increase the risk of runoff into agricultural lands. Given the ecological sensitivity of this semi-arid system, particularly for species such as the GIB, continued ground validation and seasonal hydrological monitoring are essential to evaluate changes in the runoff dynamics and to mitigate potential impacts on the local biodiversity and agro-ecosystems.

Livestock census

A major source of livelihood for inhabitants of the Thar Desert is livestock rearing. The areas proposed for mining contain natural grasslands that serve as critical grazing resources for local pastoral communities. If mining operations are initiated in these regions, the loss of these grazing lands would displace livestock-dependent activities towards adjacent areas, thereby intensifying grazing pressures, particularly in other potential GIB habitats.

To quantify the livestock population depending on these grassland patches, field surveys were conducted across all settlements (villages & *dhanis* with >10 households) located within a 4km radius of the mining blocks. The distance of 4km was considered based on the typical daily grazing range of tagged livestock in previous studies in the Thar landscape. Household interviews were conducted to record the number of sheep-goats and cattle within each 500m x 500m grid cell, and further analysed to generate density gradient maps.

The livestock survey indicated that approximately 5,378 sheep-goats and 716 cattle utilise these areas for grazing (Figure 22). The initiation of mining activities would result in the loss of natural vegetation and the displacement of ~2000 Animal Units of livestock into adjoining grasslands, within the Priority GIB area, that would increase grazing pressure in GIB habitats, leading to reduced vegetation cover and degradation of breeding habitats, impacting the species conservation efforts. Further, the intensity of livestock use was greater in Khuiyala than in Unroi blocks.

Plate 9: *Livestock census in the direct and indirect impact zones of the proposed Khuiyala-Unroi mining blocks.*

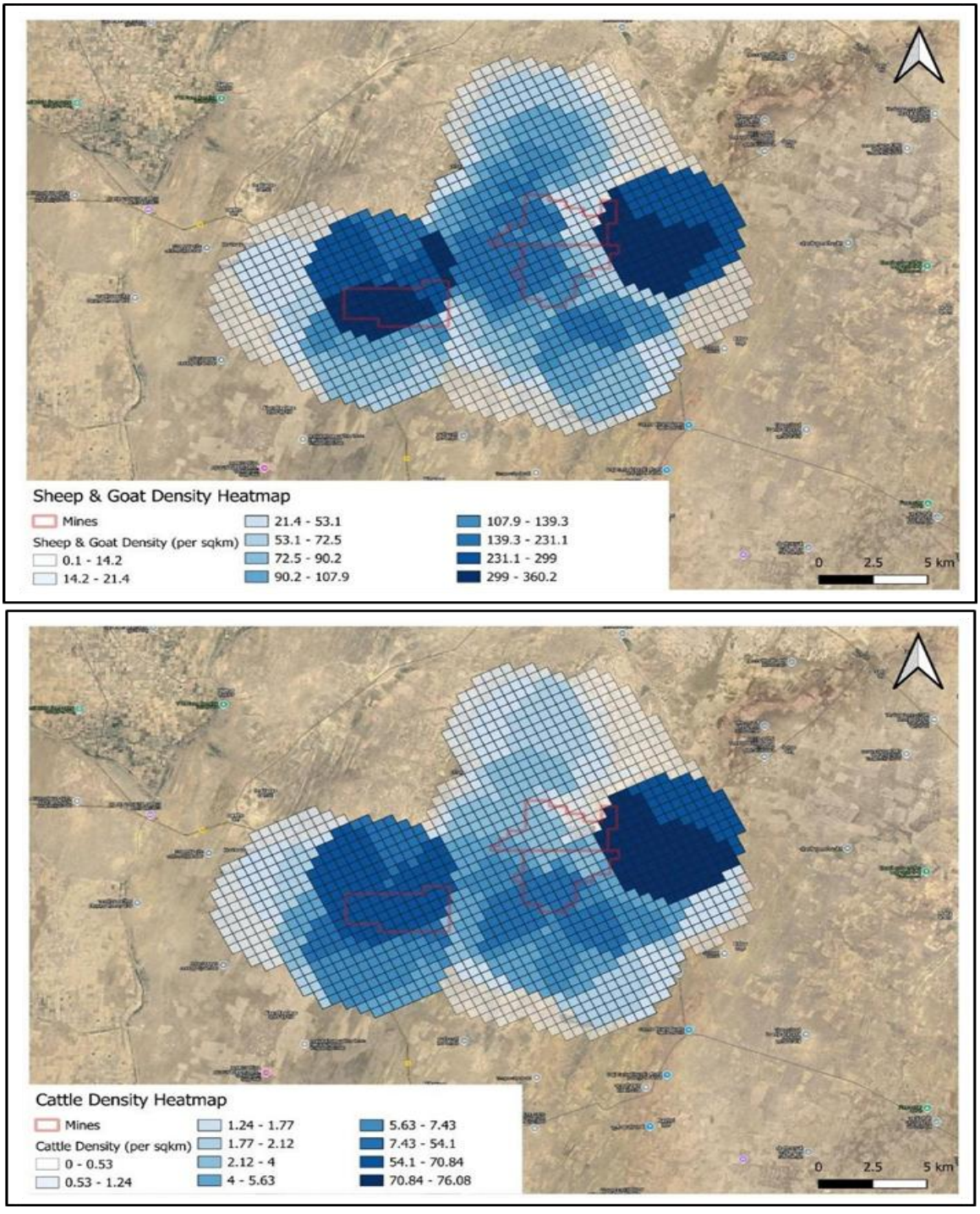


Figure 22: *Heatmap of Density of Sheep & Goat (Top) and Cattle (Bottom) in the Project Impact Zone (2025)*

Impact Assessment

Habitat loss

Land cover analysis showed that the Unroi (I & II) blocks are dominated by intact flat grasslands with native grass and woody species, good (monsoonal) insect density, minimal croplands and infrastructure- rendering them a suitable habitat for Open Natural Ecosystems-adapted wildlife species. The proposed mine sites are not fragmented margins but functioning wildlife habitats. Loss of such habitats is difficult to offset elsewhere in the western Thar landscape, due to the unavailability of such large contiguous flat grasslands with low disturbances that are in spatial connectivity with other good habitats. The proposed mining activity will alter this habitat, making it unsuitable for native species, unless the area is effectively restored to its original habitat post-mining. Mining activity will result in the removal of about 75,000 old-growth native trees across blocks.

Displacement of species of conservation importance

Wildlife population surveys revealed that the proposed mining blocks support many species of conservation importance associated with (and surrogates of) GIB such as the Chinkara, Desert Fox, Indian Fox, Desert Cat, Laggar Falcon, Long-legged Buzzard, White-eyed Buzzard, Steppe Eagle, Tawny Eagle, Short-toed Snake Eagle, Montagu's Harrier, Pallied Harrier, Stoliczka's Bushchat, Spiny-tailed Lizard, Desert Monitor Lizard, and Red Sand Boa. Some of these species were found in high density in mining blocks, comparable to the Protected Area (Desert National Park-DNP). Open-cast mining in these sites will result in habitat loss through the removal of topsoil, vegetation, and prey base (of Insects, Gerbils and Spiny-tailed Lizards), potentially leading to the displacement of resident populations of the above species, and localised extirpation of ground-nesting birds and mammals, many of whom show strong site fidelity and/or limited dispersal. Given the expansion of agriculture and infrastructure in this landscape and the scarcity of wildlife habitats around the proposed mining blocks, many of these displaced individuals may not find alternative sites to colonise, ultimately impacting their local populations.

Impact of mining on Great Indian Bustard and its habitats

The Great Indian Bustard has now disappeared from 90% of its erstwhile range due to past hunting, loss of grasslands, and infrastructural expansion, with most of the current occurrences restricted to the Priority GIB Area in Jaisalmer- a critical habitat for the species. The Indian Government is implementing the Project Great Indian Bustard- a national action plan for the species' conservation- that involves breeding birds in captivity for releasing them in the wild, where safe and suitable habitats exist (or are restored) within the range, to augment the wild populations.

Overlaying the GIB habitat map onto the project impact zone (Figure 23) indicates that Unroi-I and II mining blocks fall squarely within the Priority Great Indian Bustard Area, earmarked for the species' conservation in the Hon'ble Supreme Court's Order in (Writ Petition (Civil) No. 838 of

2019) M. K. Ranjitsinh and Ors vs Union of India and Ors case. Our biodiversity assessment showed that Unroi blocks encompass large contiguous grasslands which are in contiguity with neighbouring grassland patches that are dominated by native grasses with sparse shrub cover, minimal energy infrastructure and high (monsoonal) insect densities. These characteristics are typical of GIB habitats in the larger landscape. Additionally, the rocky substrate and low soil depth of Unroi blocks naturally restrict agricultural expansion. The above factors render the Project Impact Zone as one of the ideal sites for rewilding captive-bred birds under the National Bustard Recovery Program. If mining proceeds, and efforts to restore these habitats to their original state do not succeed, then these areas would no longer be available for such reintroductions, thereby constraining long-term population recovery for this critically endangered species. The impact extends beyond immediate habitat loss, as GIB is highly sensitive to anthropogenic disturbances and will be affected by the percolation of disturbances caused by mining (noise, traffic and human movements) into the larger project impact zone, where the species still occurs. Only if mining blocks are restored back to flat productive grasslands, post-mining, and the effects of temporary disturbances are mitigated, will the species' conservation go hand in hand with this development.

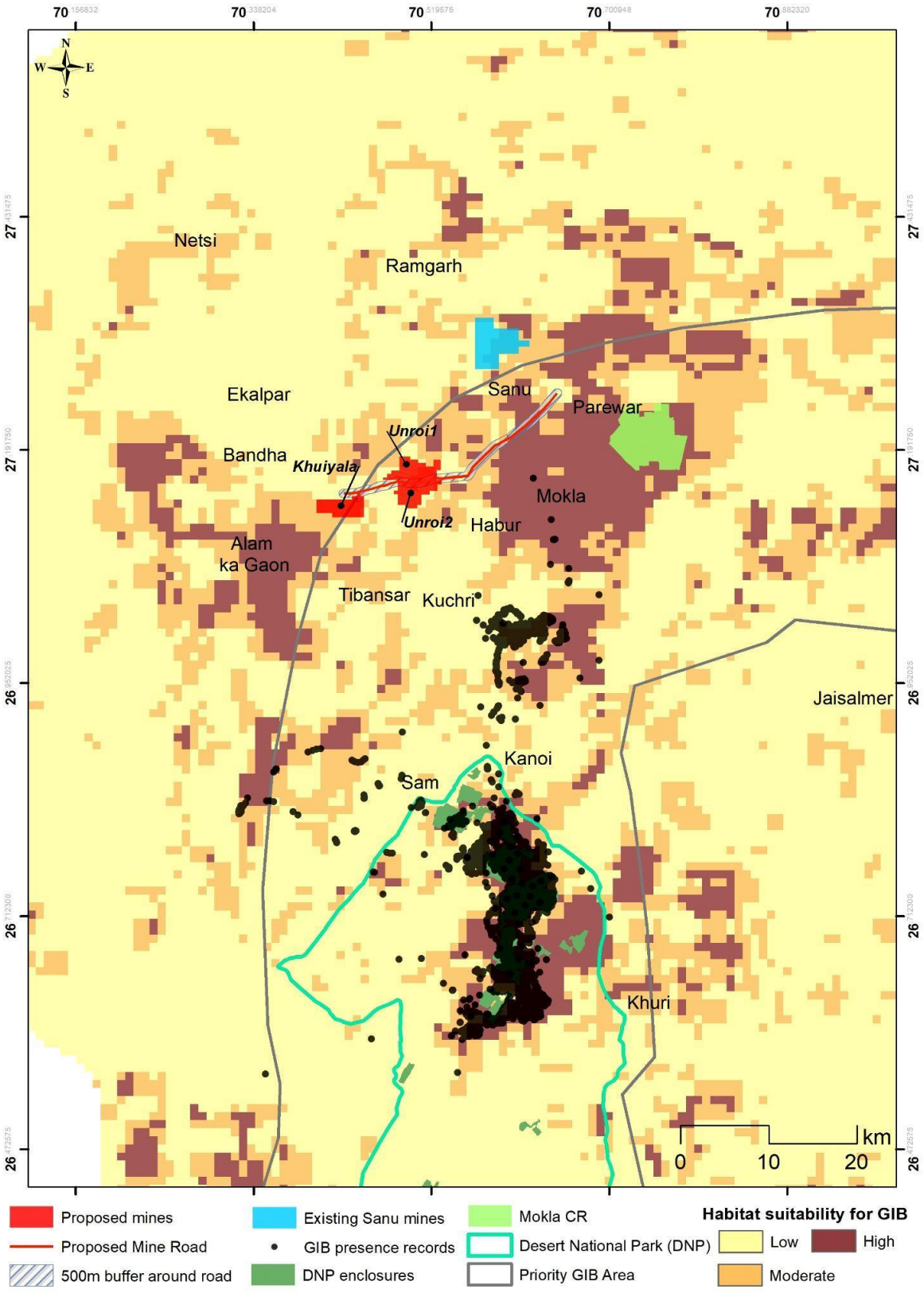


Figure 23. *Location of the proposed mines with respect to the Priority GIB Area and GIB presence in recent surveys and monitoring in Jaisalmer, Rajasthan*

Impact on drainages and water channels

Drainage mapping of the mining impact zone identified several ephemeral channels that feed into localised catchments during the rainy season. These catchments recharge soil moisture, which supports seasonal vegetation growth, and provide foraging opportunities for GIB, wild ungulates, and livestock. Mining and deposition of mining waste would damage these natural channels, potentially altering localised hydrological processes. Our field assessments show that in Unroi blocks, at least two catchments intersect directly with the proposed lease areas, which, if disrupted, would diminish the productivity of adjacent grassland habitats. This disruption will not be limited to the foothills of the plateau where mining is proposed, but will also extend further downstream and will potentially compromise seasonal water availability and agricultural activity in the larger landscape.

Impact of displaced livestock grazing

Our livestock census in villages surrounding mining blocks recorded a substantial population of pastoral communities dependent on grasslands in proposed mining areas for livestock fodder. Displacement of these herds due to mining actions will gradually redirect and increase the livestock grazing pressures in adjoining intact grasslands. This will lead to excessive grazing and reduced vegetation cover in adjoining grasslands, degrading breeding and foraging habitats of GIB, and will intensify competition with Chinkara for food resources. Consequently, the ecological footprint of mines and associated operations would extend into habitats beyond the lease boundary.

Increase in overall disturbance around mines

Mining operations can induce chronic stress to wildlife, including noise from crushing units, continuous vehicular movements, and dust deposition. Spatial encounter rates of conservation-dependent species in the region show that many disturbance-sensitive species, such as Chinkara, Indian Fox, and some vultures, currently utilise habitats within the core zone, where human disturbances are currently low. Increased disturbances are likely to render these sites less suitable, at least in the short term, which extends beyond the direct mine pits into the larger impact zone. Further, dust deposition and noise pollution are likely to alter habitat and vegetation characteristics, indirectly impacting the suitability of the Project impact zone.

Impact of increased traffic on transportation road

The introduction of heavy truck traffic would elevate risks of direct mortality from wildlife-vehicle collisions. If a new haul road is constructed through such wildlife habitats, then collision risks and habitat fragmentation will increase exponentially, as roads would facilitate secondary infrastructural development in adjoining wildlife habitats. Additionally, sustained heavy traffic could potentially displace local populations of sensitive species from disturbed areas.

Impact of power lines associated with mining activities

Power infrastructure associated with mining poses a significant risk to GIB's survival. As documented in studies, GIBs are highly susceptible to collisions with overhead wires due to their poor frontal vision, fast flight and limited manoeuvrability. The addition of power lines associated with mining infrastructure would directly increase fatal collision risk for this critically endangered species, which has an existing global population of <140 individuals. Further, raptors and vultures recorded in our surveys are also vulnerable to both collision and electrocution, and a substantial portion of their detections were associated with perching on power lines and electric poles. Unless new lines in mining blocks (within the Priority GIB Area) are buried underground, the cumulative impact of power line expansion would threaten these already declining populations.

Wildlife Conservation and Mitigation Plan

The Restoration and Wildlife Management Plan for Unroi-I limestone mine, submitted by the user agency in consultation with Overseas Min Tech Consultants, outlines a site-specific framework to minimise mining-caused disturbances and to support ecological recovery in the Thar landscape. The plan mentions mitigating habitat loss, erosion, and biodiversity degradation through restoration of mined areas using native plant species, control of invasive weeds, soil stabilisation, and habitat conservation for small mammals, reptiles and birds. It also mentions conservation by involving local communities in habitat management, awareness building, and sustainable resource use. However, many recommendations in this document cover mitigation and restoration measures traditionally developed for forested landscapes. In contrast, the proposed mining leases lie within the Open Natural Ecosystems (ONE) of the Thar Desert, dominated by natural grasslands and scrublands. Restoration planning must be specific for desert ecology, focusing on grassland restoration, which is vital for conservation-dependent and threatened species. Therefore, the current report provides a rationale and a way ahead for designing restoration and mitigation strategies that are based on arid-grassland dynamics and compatible with biodiversity in Thar's ONEs.

Sensitivity mapping within Project Impact Zone

Our multiseason surveys capturing habitat and wildlife usage across winter, summer and monsoon seasons informed us about the ecological sensitivity of proposed mining blocks and their surrounding indirect impact zones. Among these blocks, Unroi blocks are more critical sites for GIB and grassland conservation (Figure 24). These blocks comprise intact grasslands, comparable to the Desert National Park, in terms of habitat quality, that support viable populations of Chinkara, foxes, and other grassland species of high conservation concern. Importantly, Unroi mines fall entirely within the Priority GIB Area. Their relatively flat terrain, low agricultural use, less energy infrastructure, large contiguous grasslands- connected to other grassland patches in the landscape- high biodiversity values and high (monsoonal) insect density highlight the suitability of these blocks as potential sites for future rewilding of captive-bred GIB under the Project Great Indian Bustard- announced by Hon'ble PM. The Khuiyala block lies partly outside the Priority Area and is relatively less important for GIB, but supports various threatened and protected raptors and other species, thereby retaining notable ecological significance. Notably, densities of Chinkara, foxes and insects in Khuiyala block and transportation road were lower compared to Unroi-I and II blocks, indicating the suitability of the latter for ONE-adapted species associated with GIB. While the Unroi blocks are important for GIB and associated species, the Khuiyala block had higher usage of other conservation-dependent species. Collectively, these observations show a hierarchy of conservation importance for GIB and associated species among the three mining blocks, with Unroi mines being more important areas for GIB conservation than Khuiyala.

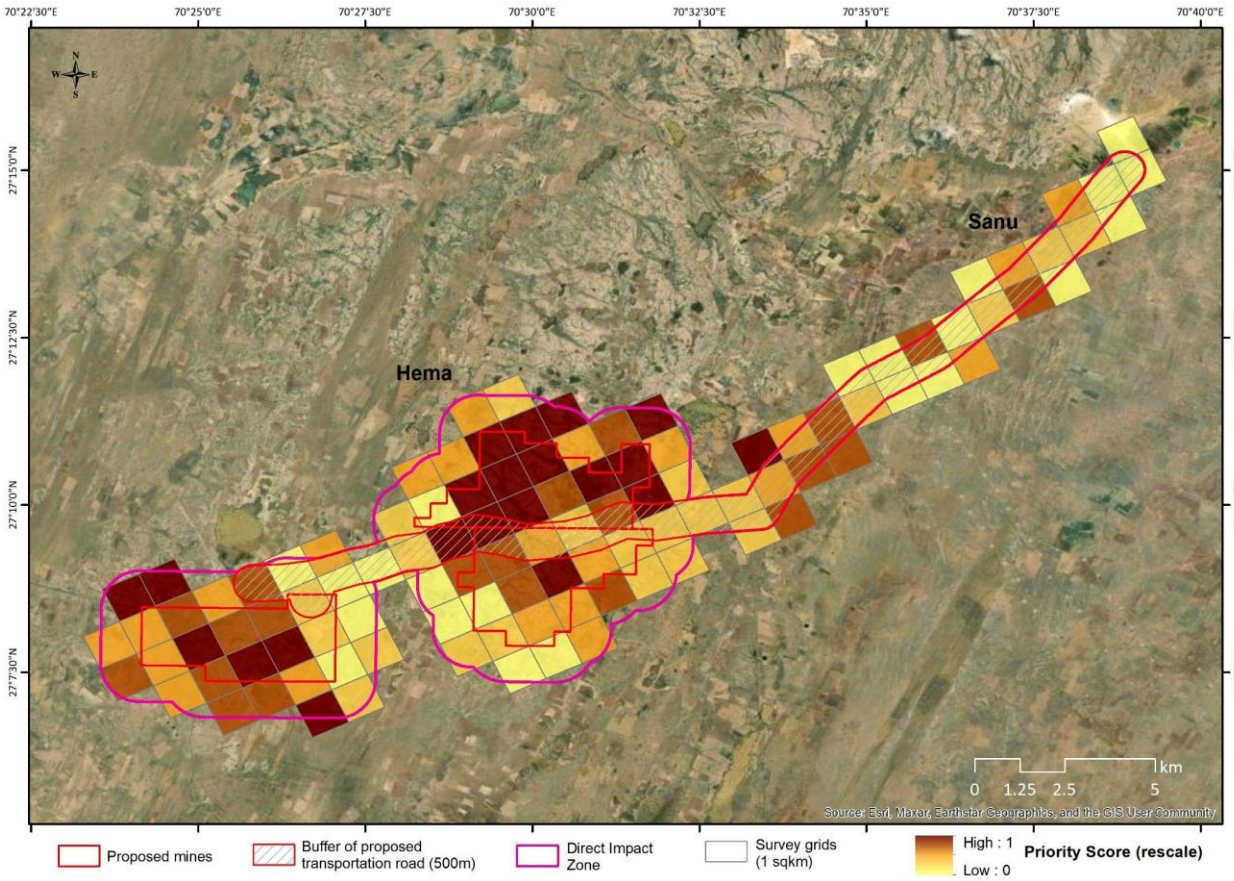


Figure 24: *Prioritisation values given to 1 km^2 cells within the direct impact zones, based on the weighted average of rescaled matrices of grassland habitat (0.4 weight), camera trap-based rescaled density of GIB-associated mammals (0.3 weight), vehicle transect-based rescaled density of GIB-associated raptors (0.2 weight), and walk transect-based rescaled density of GIB-associated small birds (0.1 weight). Encounter rates of conservation-dependent and threatened species based on spatial prioritisation. This highlights the higher biodiversity significance of the Unroi-I and Unroi-II mines compared to the Khuiyala mines.*

Restoration of mined blocks

The mining agency has reported the establishment of a 1.5-hectare experimental restoration plot at Sanu-II Mines near Joga village. As per the report, the site was backfilled, levelled, and planted with approximately one thousand saplings of Sewan grass (*Lasiurus scindicus*) in September 2025, following the recommendation in the interim report of the Wildlife Institute of India. Photographs were provided by the user agency to document grass establishment and watering (see Annexure 7). While this effort demonstrates a step toward grassland restoration, the approach needs scientific and quantitative validation. The scale of the trial is too small (1/10th of what was proposed), does not represent the lease landscape (~30 km^2), and must be expanded to assess restoration efficacy. Monitoring has been limited to watering and visual checks, without rigorous ecological metrics such as vegetation growth across topsoil depths or faunal colonisation. Further, the larger area needs to be maintained with multi-species assemblages essential for habitat structure and ecological processes. In brief, restoration outcomes cannot be meaningfully evaluated at such a small scale within a few months of planting, and recovery of

wildlife habitat must be assessed over three to five years, which should account for vegetation succession and wildlife usage.

As per the operative plan of the user agency, about one square kilometre area will be mined at any time, partly backfilled with run-of-the-mine materials, and the adjacent plot will be mined in the successive year. Should mining operations be permitted in a proposed block by the approving authority, it is recommended that the user agency restore the mined area post extraction, by levelling the ground, refilling soil (with grass seeds) from the prospective compartment / reseeding grass/planting rootslips, protecting the area (by temporary fencing), and carrying out associated restorative management. To monitor habitat recovery, a reputable wildlife agency can be engaged for regular field monitoring and data collection on ecological succession and wildlife usage. These restoration and monitoring exercises must be carried out for at least five years, concurrent with mining in the block. **Large-scale demonstration of the restoration potential of the mined area by the user agency would be a necessary prerequisite for assessing whether mining activity can go hand in hand with GIB conservation in the lease area.**

Further, as explained above, Unroi blocks (Unroi-I and II) have greater importance in conservation of GIB and associated grassland species, compared to the Khuiyala block, which is also partly outside the Priority Area. **Therefore, should limestone mining be allowed by the approving authority in the lease area, it should be restricted to the Khuiyala block initially, and approval of mining for the Unroi blocks can be conditional upon successful demonstration of habitat recovery by the user agency in Khuiyala block, concurrent to mining, and in the experimental plot of Sanu, both vetted by the monitoring agency.**

Conservation measures (plan)

Despite restoration of mined blocks, the proposed mining operations will exert direct and indirect short-term impacts on conservation-dependent species in the region, owing to anthropogenic disturbances and potential displacement of GIB and other sensitive species from the larger Project Impact Zone, and redirection of livestock grazing pressure to adjoining GIB habitats. Should mining be allowed in these blocks by the approving authority, conservation measures to offset the above adverse short-term impacts, by securing other GIB-occupied habitats, need to be supported by the user agency. Therefore, should mining be allowed in Khuiyala block, besides the above proposed concurrent restoration of mined areas to be undertaken by the user agency with self-funding, the following GIB conservation measures in/around Desert National Park can be undertaken by the State Forest Department with technical support of collaborating organisations, and funding support of the user agency, following **MoEF&CC guidelines on instructions for processing of wildlife conservation plan for Projects (including mining) outside 10 km buffer of Protected Areas, for Environmental Clearance under Environmental Protection Act 1986**.

Site-specific wildlife conservation measures in the Priority GIB Area of Rajasthan:

a) **Establishment of grassland enclosures** of at least 50% of the area of mining blocks in breeding habitats of the Great Indian Bustard within the Priority GIB Area (Figure 25). This goal can be achieved inside / outside Desert National Park by acquiring private lands adjacent to existing breeding enclosures or by transferring government lands against Forest Clearances to the Rajasthan Forest Department (Jaisalmer Division), followed by chain-link fencing and protection

of these enclosures. Management of these areas may include reseeding/planting of native grass species (*Dactyloctenium* spp and *Lasiurus scindicus*), removal of excessive woody species, especially *Prosopis juliflora* and *Calotropis procera*, and other silvicultural / restoration operations. If water guzzlers are being provided for animals, the number should be restricted to one per 10 km^2 area, and operated only during summer months, to meet the requirements of arid-adapted species, as opposed to non-native species.

b) **Establishment of community fodder farms** in rangelands outside Desert National Park (e.g., Salkha and Netsi areas) that are suitable habitats for GIB, but are over-utilised for agro-pastoral activities, for dual benefits to local pastoral livelihoods and grassland conservation. This goal can be achieved by leasing of land- at least 50% of the area as mining blocks- from the village *panchayat* by the user agency and handing it over to the State Forest Department for development of fenced grasslands. Since the activity will require support from local communities, the State Forest Department may consider collaborating with an expert organisation for liaisoning (e.g., NGOs expertising on rural development). Management of these areas may include reseeding/planting of native grass species (*Dactyloctenium* spp and *Lasiurus scindicus*), removal of excessive woody species, especially *Prosopis juliflora* and *Calotropis procera*, and other silvicultural / restoration operations. The potential sites for this activity are in Salkha-Kuchhri and/or Netsi areas (see Annexure 6).

c) **Mitigation of threats to GIB** in terms of spay neutering of free-ranging dogs, removal of nest predators from GIB breeding enclosures, eradication of woody invasives (e.g., *Prosopis juliflora*, *Calotropis procera*), and other measures recommended in the Expert Committee appointed by Hon'ble Supreme Court with regard to Writ Petition (Civil) No. 838 of 201, inside Desert National Park and adjoining habitats within the Priority GIB Area. Since the activity will require specialised support, the State Forest Department may consider collaborating with competent technical agencies (e.g., NGOs expertising on Animal Birth Control programs) for this activity.

d) **Capacity building of Rajasthan Forest Department (Jaisalmer Division)**

e) **Monitoring of grassland restoration in mined areas and above conservation activities** by a technical agency, overseen by a committee composed of members of an institute of national repute, the State Forest Department, and other statutory bodies, as the EAC deems fit.

Financial Outlay of Wildlife Conservation Plan (WCP)

According to the Guidelines of the Rajasthan Government, the outlay of the WCP will be the maximum of the two figures arrived from the formula as under:

Formula 1: 1% of project cost

OR

Formula 2: Rs. 0.50 lacs per ha. of core area (project area) + Rs. 5 lacs (lump sum) for the buffer area, for each Schedule-I species.

The project authorities are free to spend more than the amount arrived at from the above criterion on 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 (39 species)*

Taxa	Species	WPA Schedule	IUCN Red List Status
Mammal	Desert Fox	I	Least Concern
Mammal	Chinkara	I	Least Concern
Mammal	Desert Cat	I	Least Concern
Mammal	Indian Fox	I	Least Concern
Mammal	Jungle Cat	I	Least Concern
Mammal	Golden Jackal	I	Least Concern
Raptor	Booted Eagle	I	Least Concern
Raptor	Egyptian Vulture	I	Endangered
Raptor	Eurasian Griffon Vulture	I	Least Concern
Raptor	Eurasian Sparrowhawk	I	Least Concern
Raptor	Indian Spotted Eagle	I	Near Threatened
Raptor	Laggar Falcon	I	Near Threatened
Raptor	Long-legged Buzzard	I	Least Concern
Raptor	Montagu's Harrier	I	Least Concern
Raptor	Pallid Harrier	I	Near Threatened
Raptor	Red-necked Falcon	I	Least Concern
Raptor	Short-toed Snake Eagle	I	Least Concern
Raptor	Steppe Eagle	I	Endangered
Raptor	Western Marsh Harrier	I	Least Concern
Raptor	Common Buzzard	I	Least Concern
Raptor	Himalayan Griffon	I	Near Threatened
Raptor	Tawny Eagle	I	Vulnerable
Raptor	White-eyed Buzzard	I	Least Concern

Taxa	Species	WPA Schedule	IUCN Red List Status
Raptor	Imperial Eagle	I	Vulnerable
Raptor	Cinereous Vulture	I	Near Threatened
Raptor	Greater Spotted Eagle	I	Vulnerable
Raptor	Rock Eagle owl	I	Least Concern
Raptor	Long-eared Owl	I	Least Concern
Raptor	Shikra	I	Least Concern
Other birds	Rufous-fronted Prinia	I	Least Concern
Other birds	Rufous-tailed Lark	II	Near Threatened
Other birds	Stoliczka's Bushchat	II	Vulnerable
Other birds	Yellow-eyed Pigeon	I	Vulnerable
Other birds	Indian Peafowl	I	Least Concern
Other birds	Indian Roller	II	Near Threatened
Reptile	Spiny-tailed Lizard	I	Vulnerable
Reptile	Desert Monitor Lizard	I	Least Concern
Reptile	Red Sand Boa	I	Near Threatened
Plant	Guggal (*Commiphora wrighti*)	I	Critically Endangered

Using Formula 2, the total outlay as per the above guidelines is as follows:
((2967.24 ha x 50,000 rs INR) + (5 lakhs INR)) X 39 species) = 580.56 cr INR for all three mining blocks, 5.31 cr INR for the proposed road and 184.08 cr INR for the Khuiyala mining block alone.

Area: Khuiyala (944 ha), Unroi-I (998 ha), Unroi-II (998 ha), road (27.24 ha)

As per above guidelines, the total amount for the site-specific wildlife conservation and mitigation plan, against all three mining blocks, would be 580.56 cr INR that is to be utilised for securing GIB habitats, restoring grasslands, developing fodder farms, increasing enclosure protection and patrolling in general landscape, mitigating threats to GIB and other species (predator and invasive management), and subsequent monitoring of habitat recovery. Should the Khuiyala block be initially sanctioned for mining by the approving authority, 184.08 cr INR is to be funded by the user agency for site-specific wildlife conservation actions in the initial phase.

Table 7: *Proposed financial outlay for conducting activities under wildlife conservation planning in the direct (core) and indirect impact zones (buffer) in Jaisalmer, Rajasthan*

Project Impact Zone	Mine Block	Area (hectare)	Amount (Rs)
Direct Impact Zone (Core)	Khuiyala	944	184.08 cr
	Unroi-I	998	194.61 cr
	Unroi-II	998	194.61 cr
	Proposed road	27.24	5.31 cr
Indirect Impact Zone (Buffer)			1.95 cr
Total			**580.56 Cr INR**

Table 8: Annual cost estimation for the wildlife conservation plan for grassland restoration and protection

S. No.	Particulars	Cumulative Budget (cr INR)	Budget for Khuiyala block (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)	**290.28 (50%)**	**92.04**
2	**Awareness and Extension involving locals and forest frontline staff** (community meetings and school programmes for conservation awareness)	**58.06 (10%)**	**18.41**
3	**Support to the local forest department for monitoring, rescue and rehabilitation of wildlife** (veterinary care and wild animal health, rescue, tools and equipment)	**58.06 (10%)**	**18.41**
4	**Conservation efforts for wildlife inside protected areas (DNP)** (enclosure fencing- establishment and repair, patrolling and wildlife monitoring)	**58.06 (10%)**	**18.41**

S. No.	Particulars	Cumulative Budget (cr INR)	Budget for Khuiyala block (cr INR)
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)	**58.06 (10%)**	**18.41**
6	**Miscellaneous and unforeseen costs, including eco-development**	**58.06 (10%)**	**18.4**
Total		**580.56 cr INR**	**184.08 cr INR**

Study Recommendations

1. The EAC, MoEFCC has mandated this study to indicate if mining activity and conservation of GIB within the lease area and its vicinity can go hand in hand.
2. Our recommendations follow the general principle of mitigation hierarchy from avoidance to minimisation, restoration to offset.
3. Based on our biodiversity assessment of mining activities, Unroi-II and I lease areas comprise large, contiguous grasslands with low agricultural activity, minimal energy infrastructure, and good insect resources that render these habitats suitable for GIB, having recent past occurrences, and potential for rewilding captive-bred birds under the Project Great Indian Bustard in the future. Further, these lease areas are located inside the Priority GIB Area (near the north-western boundary), where conservation measures for the species are to be implemented as per the Hon'ble Supreme Court Order in the matter of WP(C) 838 of 2019. **Therefore, mining in these blocks will not go hand in hand with GIB conservation, unless habitats can be restored effectively post-mining.**
4. Whereas, Khuiyala is relatively less critical for GIB conservation, partly outside the Priority Area, but important for other conservation-dependent species such as threatened raptors. All mining blocks have reasonably high wildlife values, especially of Schedule-I and conservation-dependent species, and their habitat characteristics match the ecological requirements of species adapted to Open Natural Ecosystems.
5. According to the project plan submitted by the user agency, the SMS limestone mining involves the removal of substrate from the top 4 m of land surface over ~1 km^2 area every year (annual compartments) and shifting to the adjacent area progressively, covering 29.4 km^2 area over the operational period. After the extraction of materials, the mined area will not be used for other purposes as per the Project plan, and 30% of the materials (stones and dust) will be concurrently backfilled and reclaimed. **If these areas can be restored into productive, protected grasslands post-mining, and not mined for further utilisation of mineral resources, such as to produce cement, then the adverse impact on Great Indian Bustard conservation can be reduced, although not completely negated.**
6. In our interim report, it was recommended that the user agency may initiate experimental grassland restoration in one km^2 area within the existing Sanu mine, where soil from a neighbouring grassland (with a natural seedbank of native grass species such as *Dactyloctenium* spp.) can be added, and reseeded with grasses to boost herbaceous regeneration. These experimental results may take up to 2-3 years. The user agency initiated the pilot restoration about a month ago in a 1.5-ha area, and it will require time to yield conclusive evidence.
7. **Therefore, the clearance of mining, if accorded, can be on a conditional basis, initially only for the low-priority Khuyiala block**. Concurrent with the mining plan in an annual compartment of the Khuiyala block, the user agency can attempt to restore the mined areas into grasslands by levelling the ground, filling soil with native grass seeds from the prospective compartment, and providing protection by temporary fencing. If these efforts show that grasslands cannot be restored in mined areas, then the two goals (mining and GIB conservation) are conflicting. Conversely, if these efforts result in habitat restoration post-mining, then it can be considered that mining activities do not compromise GIB conservation in the long-term (after mining operations are over), but in the short-term, the area will be unavailable for GIB usage or release, as the species is highly sensitive to anthropogenic disturbances. **If this mining block is effectively**

restored into grasslands post mining and attracts usage of grassland-adapted wildlife subsequently, then mining sanction in the other blocks, which are ecologically more sensitive (Unroi-II & I), can be considered by the approving authority, otherwise not.

Therefore, mining and GIB conservation within lease area and vicinity will not go hand in hand, unless habitat restoration (post mining) is successfully demonstrated. If environmental clearance for mining is being granted to the user agency, the same should be initially restricted to only Khuiyala block in the first phase (of 5-7 years). Subsequently, the clearance of Unroi I & II mining blocks can be conditional on satisfactory demonstration of habitat restoration in Khuyiala block by the user agency that has to be vetted by a technical monitoring agency, and overseen by an independent committee.

Additionally, if mining clearance is granted, then:

a. The crusher unit should be located outside the Priority Area to minimise disturbances to the critical GIB habitat.
b. The proposed new road to transport materials from mining blocks to the railway station passes through a suitable GIB habitat, and if allowed, can increase disturbances. Since the initial mining activity will be in Khuiyala block, which is connected with Sanu via Ramgarh by the existing state highway, this alternative route can be used for transporting materials.
c. No large, permanent structures or overhead power lines should be installed in the mining blocks.
d. Mining and associated activities should cease in the preceding annual compartment(s) and restoration work following the best model (based on the above exercise) should be initiated by the user agency while mining the succeeding annual compartment.
e. The area, after reclamation, cannot be further utilised for extracting other mineral resources that nullifies restoration efforts and lead to land degradation.
f. To offset the short-term disturbances of mining activity on GIB and associated conservation-dependent species, a comprehensive wildlife conservation and mitigation plan, comprising activities as elaborated above in the Wildlife Conservation Plan, needs to be implemented. The compliance of these measures should be monitored by the technical monitoring agency, further overseen by an independent committee comprising representatives of a reputed institute working on wildlife and representatives of the State Forest Department.

References

1. Anoop, K.R., Bhardwaj, G.S., Shekhawat, R.S. (2017). Management plan for Desert National Park Wildlife Sanctuary: Plan period 2017-2017. Rajasthan Forest Department. Pp 374.
2. 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.
3. Celis, G., Ungar, P., Sokolov, A., Sokolova, N., Böhner, H., Liu, D., ... Ehrich, D. (2024). A versatile, semi-automated image analysis workflow for time-lapse camera trap image classification. Ecological Informatics. Vol 81: 102578.
4. Dutta S., Karkaria T., Uddin M., Jangid A.K., Sharma, H., Joshi, H., Gupta, T., Gupta, S., Bipin, C.M., Bishnoi, V., Sonika, B.L., Supakar, S., Paul, I., Pati, A., Nagar, A., Purohit, N., Lawrence, S., Gujar, M., Moitra, M., Sawant, M., Krishna, M., Sakhlani, P., Kawlni, L., Kolipakam, V., Kher, V. (2024) Bustard Recovery Program: Phase 1 (2016–24), Final Report. Wildlife Institute of India, Dehradun.
5. 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, and Rajasthan Forest Department, Jaipur.
6. Dutta, S., Onial, M., Jangid, A.K., Pandey, D.D., and Bustard Recovery Program (2023). Scientific Animal Passage and Mitigation Plan for 62 km stretch of Myajlar-Jaisalmer Road (NH-11) passing through Desert National Park. Report submitted by Wildlife Institute of India to National Highway Authority of India. Pp 71.
7. Howe, E. J., Buckland, S. T., Després-Einspenner, M. L., Kühl, H. S. (2017). Distance sampling with camera traps. Methods in Ecology and Evolution. Vol 8(11). Pp 1558-1565.
8. IUCN (2025). The IUCN Red List of Threatened Species. Version 2025-2. https://www.iucnredlist.org.
9. M.K. Ranjitsinh & Ors. vs. Union of India & Ors. Writ Petition (Civil) No. 838, 2019.
10. Ministry of Environment and Forests, EIA Notification (2006). S.O. 1533, 14 September 2006 <http://parivesh.nic.in/writereaddata/ENV/EnvironmentalClearance-General/18.pdf>.
11. Overseas Min Tech Consultants. Wildlife Conservation Plan for Unroi - I Limestone Mine Project.
12. Pati, A., Paul, I., Dutta, S. (2025). Drylands Under Pressure: Responses of Insect Density to Land-Use Change in a Tropical Desert. Insects 2025, 16, 1043. https://doi.org/10.3390/insects16101043.
13. The Wildlife Protection Act (1972) Amendment (2023). Government of India (Last Updated 1-4-2023).

Annexures

Annexure 1. *Density (#/km^2) of different birds assessed from walk transect surveys in the proposed Khuiyala-Unroi mining blocks*

Species	Feeding Guild	Density (±SE) / km^2
Ashy Prinia	Insectivore	0.72 ± 0.3
Asian Desert Warbler	Insectivore	1.04 ± 0.49
Black Drongo	Omnivore	1.46 ± 0.46
Black Redstart	Insectivore	0.84 ± 0.36
Black-crowned Sparrow Lark	Granivore	16.53 ± 3.57
Black-winged Stilt	Insectivore	0.71 ± 0.33
Blue-cheeked Bee-eater	Insectivore	1.5 ± 0.65
Chestnut-bellied Sandgrouse	Granivore	22.51 ± 6.99
Common Babbler	Omnivore	44.24 ± 5.22
Crested Lark	Granivore	5.54 ± 2.53
Desert Lark	Omnivore	2.29 ± 0.77
Desert Wheatear	Insectivore	4.18 ± 1.03
Eastern Orphean Warbler	Insectivore	0.7 ± 0.44
Eurasian Collared Dove	Granivore	31.52 ± 4.41
European Roller	Insectivore	0.55 ± 0.21
Graceful Prinia	Insectivore	0.87 ± 0.44
Great Grey Shrike	Vertebrate	2.33 ± 0.43
Greater Hoopoe Lark	Insectivore	0.87 ± 0.39
Greater Short-toed Lark	Insectivore	78.01 ± 17.48
Green Bee-eater	Insectivore	3.32 ± 0.81
Grey Francolin	Granivore	1.69 ± 0.77
House Crow	Vertebrate	2.92 ± 1.31
House Sparrow	Granivore	42.74 ± 9.13

Species	Feeding Guild	Density (±SE) / km^2
Indian Robin	Insectivore	0.87 ± 0.47
Indian Silverbill	Granivore	5.66 ± 2.09
Laughing Dove	Granivore	41.29 ± 35.65
Lesser Whitethroat	Insectivore	30.02 ± 23.33
Plain Prinia	Insectivore	2.41 ± 0.76
Purple Sunbird	Frugivore	9.05 ± 1.62
Red-vented Bulbul	Omnivore	2.62 ± 0.64
Red-wattled Lapwing	Insectivore	2.45 ± 1.04
Rock Pigeon	Granivore	9.56 ± 4.76
Rosy Starling	Insectivore	15.28 ± 6.01
Rufous-fronted Prinia	Insectivore	1.04 ± 0.67
Rufous-tailed Lark	Omnivore	8.52 ± 2.35
Steppe Eagle	Vertebrate	0.58 ± 0.42
Tawny Pipit	Insectivore	11.13 ± 2.44
Variable Wheatear	Insectivore	18.89 ± 11.84
White-eared Bulbul	Omnivore	47.16 ± 4.74

Annexure 2: *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 Data List)*

No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB
Mammals					
1	Chinkara	*Gazella bennettii*	I	Least Concern	-
2	Desert Cat	*Felis lybica ornata*	I	Least Concern	-
3	Desert Fox	*Vulpes vulpes pusilla*	I	Least Concern	-
4	Golden Jackal	*Canis aureus*	I	Least Concern	-
5	Indian Fox	*Vulpes bengalensis*	I	Least Concern	-
6	Jungle Cat	*Felis chaus*	I	Least Concern	-
7	Indian Desert Jird	*Meriones hurrianae*	NA	Least Concern	-
8	Indian Hare	*Lepus nigricollis*	II	Least Concern	-
9	Nilgai	*Boselaphus tragocamelus*	II	Least Concern	-
10	Wild Pig	*Sus scrofa*	II	Least Concern	-
11	Grey Wolf (Old record)	*Canis lupus pallipes*	I	Least Concern	-
12	Five-striped or Northern Palm Squirrel	*Funambulus pennantii*	NA	Least Concern	-
13	Indian Gerbil	*Tatera indica*	NA	Least Concern	-
14	Little Indian Hairy-footed Gerbil	*Gerbillus gleadowi*	NA	Least Concern	-
15	Collared Hedgehog	*Hemiechinus collaris*	NA	Least Concern	-
16	Asian House Shrew	*Suncus murinus*	NA	Least Concern	-
17	Indian Hedgehog	*Paraechinus micropus*	II	Least Concern	-
18	Indian Hare/Black-naped hare	*Lepus nigricollis*	II	Least Concern	-
19	Greater Mouse-tailed Bat	*Rhinopoma microphyllum*	NA	Least Concern	-
20	Indian Flying Fox	*Pteropus medius*	II	Near Threatened	-
21	Lesser Mouse-tailed Bat	*Rhinopoma hardwickii*	NA	Least Concern	-
22	Small Indian Mongoose	*Urva auropunctatus*	I	Least Concern	-
23	Grey Mongoose	*Urva edwardsii*	I	Least Concern	-
Birds					
1	Egyptian Vulture	*Neophron percnopterus*	I	Endangered	High
2	Steppe Eagle	*Aquila nipalensis*	I	Endangered	Low
3	Eastern Imperial Eagle	*Aquila heliaca*	I	Vulnerable	Moderate
4	Greater Spotted Eagle	*Clanga clanga*	I	Vulnerable	Low
5	Indian Spotted Eagle	*Clanga hastata*	I	Near Threatened	Moderate
6	Tawny Eagle	*Aquila rapax*	I	Vulnerable	High
7	Yellow-eyed Pigeon	*Columba eversmanni*	I	Vulnerable	High
8	Cinereous Vulture	*Aegypius monachus*	I	Near Threatened	Moderate
9	Himalayan Griffon	*Gyps himalayensis*	I	Near Threatened	Moderate
10	Laggar Falcon	*Falco jugger*	I	Near Threatened	Moderate
11	Red-necked Falcon	*Falco ruficollis*	I	Least Concern	Moderate

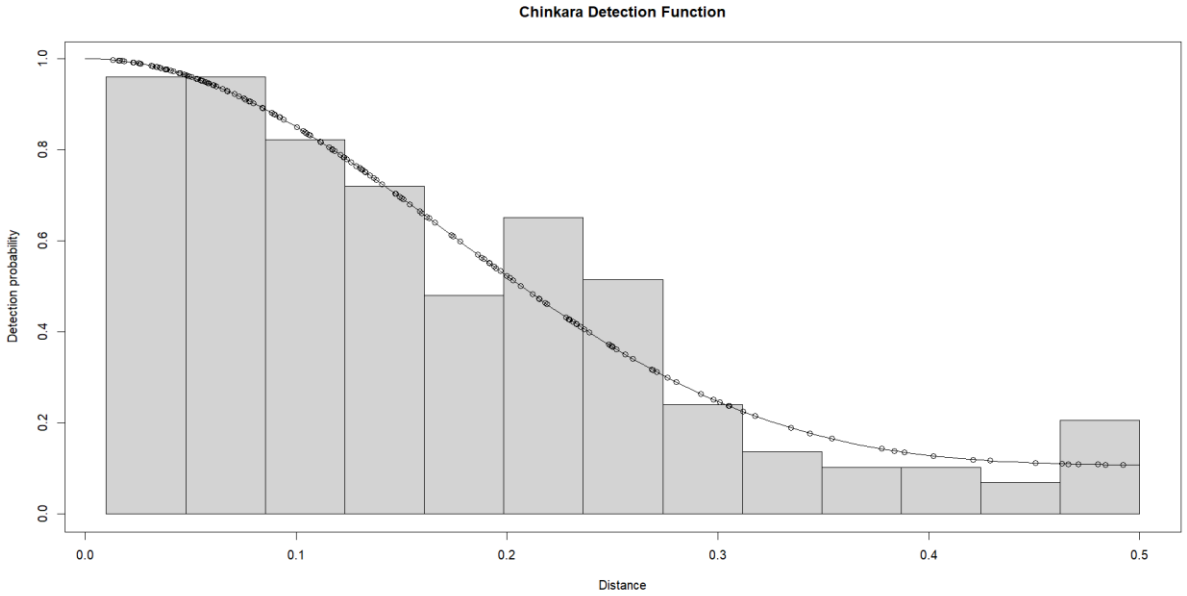
No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB
12	Booted Eagle	*Hieraaetus pennatus*	I	Least Concern	Low
13	Pallid Harrier	*Circus macrourus*	I	Near Threatened	High
14	Common Buzzard	*Buteo buteo*	I	Least Concern	Low
15	Common Crane	*Grus grus*	I	Least Concern	High
16	Eurasian Griffon	*Gyps fulvus*	I	Least Concern	High
17	Eurasian Sparrowhawk	*Accipiter nisus*	I	Least Concern	Low
18	Indian Peafowl	*Pavo cristatus*	I	Least Concern	Low
19	Long-legged Buzzard	*Buteo rufinus*	I	Least Concern	Low
20	Montagu's Harrier	*Circus pygargus*	I	Least Concern	High
21	Rufous-fronted Prinia	*Prinia buchanani*	I	Least Concern	Moderate
22	Shikra	*Accipiter badius*	I	Least Concern	Low
23	Short-toed Snake Eagle	*Circaetus gallicus*	I	Least Concern	High
24	White-eyed Buzzard	*Butastur teesa*	I	Least Concern	High
25	Ashy Prinia	*Prinia socialis*	II	Least Concern	Low
26	Asian Desert Warbler	*Sylvia nana*	II	Least Concern	NA
27	Baya Weaver	*Ploceus philippinus*	II	Least Concern	Low
28	Bimaculated Lark	*Melanocorypha bimaculata*	II	Least Concern	NA
29	Black Drongo	*Dicrurus macrocercus*	II	Least Concern	Low
30	Black Kite	*Milvus migrans*	II	Least Concern	Low
31	Black Redstart	*Phoenicurus ochruros*	II	Least Concern	Moderate
32	Black-Crowned Sparrow Lark	*Eremopterix nigriceps*	II	Least Concern	NA
33	Black-winged Kite	*Elanus caeruleus*	II	Least Concern	Moderate
34	Black-winged Stilt	*Himantopus himantopus*	II	Least Concern	Low
35	Blue-cheeked Bee-Eater	*Merops persicus*	II	Least Concern	Low
36	Brahminy Starling	*Sturnia pagodarum*	II	Least Concern	Low
37	Brown Rock Chat	*Cercomela fusca*	II	Least Concern	Low
38	Chestnut-bellied Sandgrouse	*Pterocles exustus*	II	Least Concern	Low
39	Common Babbler	*Turdoides caudata*	II	Least Concern	Moderate
40	Common Chiffchaff	*Phylloscopus collybita*	II	Least Concern	Low
41	Common Kestrel	*Falco tinnunculus*	II	Least Concern	High
42	Common Sandpiper	*Actitis hypoleucos*	II	Least Concern	Moderate
43	Cream-coloured Courser	*Cursorius cursor*	II	Least Concern	NA
44	Crested Lark	*Galerida cristata*	II	Least Concern	Moderate
45	Desert Lark	*Ammomanes deserti*	II	Least Concern	NA
46	Desert Wheatear	*Oenanthe deserti*	II	Least Concern	High
47	Eastern Orphean Warbler	*Curruca crassirostris*	II	Least Concern	Low
48	Eurasian Collared Dove	*Streptopelia decaocto*	II	Least Concern	Low
49	Eurasian Hoopoe	*Upupa epops*	II	Least Concern	Moderate
50	European Roller	*Coracias garrulus*	II	Least Concern	Moderate
51	Glossy Ibis	*Plegadis falcinellus*	II	Least Concern	Low
52	Graceful Prinia	*Prinia gracilis*	II	Least Concern	NA
53	Great Grey Shrike	*Lanius excubitor*	II	Least Concern	High

No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB
54	Greater Hoopoe Lark	*Alaemon alaudipes*	II	Least Concern	NA
55	Greater Short-toed Lark	*Calandrella brachydactyla*	II	Least Concern	Moderate
56	Green Bee-eater	*Merops orientalis*	II	Least Concern	Low
57	Grey Francolin	*Francolinus pondicerianus*	II	Least Concern	Low
58	House Crow	*Corvus splendens*	NA	Least Concern	Low
59	House Sparrow	*Passer domesticus*	II	Least Concern	Moderate
60	Indian Robin	*Saxicoloides fulicatus*	II	Least Concern	Low
61	Indian Roller	*Coracias benghalensis*	II	Near Threatened	Moderate
62	Indian Silverbill	*Euodice malabarica*	II	Least Concern	Low
63	Indian Thick-knee	*Burhinus indicus*	II	Least Concern	Low
64	Isabelline Shrike	*Lanius isabellinus*	II	Least Concern	High
65	Isabelline Wheatear	*Oenanthe isabellina*	II	Least Concern	High
66	Jungle Babbler	*Turdoides striata*	II	Least Concern	Low
67	Laughing Dove	*Spilopelia senegalensis*	II	Least Concern	Low
68	Lesser Whitethroat	*Sylvia curruca*	II	Least Concern	Low
69	Little Grebe	*Tachybaptus ruficollis*	II	Least Concern	Low
70	Little Ringed Plover	*Charadrius dubius*	II	Least Concern	High
71	Merlin	*Falco columbarius*	II	Least Concern	NA
72	Oriental Skylark	*Alauda gulgula*	II	Least Concern	High
73	Pied Bushchat	*Saxicola caprata*	II	Least Concern	Low
74	Pied Cuckoo	*Clamator jacobinus*	II	Least Concern	Low
75	Plain Leaf Warbler	*Phylloscopus neglectus*	II	Least Concern	NA
76	Plain Prinia	*Prinia inornata*	II	Least Concern	Low
77	Purple Sunbird	*Cinnyris asiaticus*	II	Least Concern	Low
78	Red-naped Ibis	*Pseudibis papillosa*	II	Least Concern	Low
79	Red-breasted Flycatcher	*Ficedula parva*	II	Least Concern	Low
80	Red-tailed Wheatear	*Oenanthe chrysopygia*	II	Least Concern	NA
81	Red-vented Bulbul	*Pycnonotus cafer*	II	Least Concern	Low
82	Red-wattled Lapwing	*Vanellus indicus*	II	Least Concern	Low
83	Rock Pigeon	*Columba livia*	NA	Least Concern	Low
84	Rose-ringed Parakeet	*Psittacula krameri*	II	Least Concern	Low
85	Rosy Starling	*Pastor roseus*	II	Least Concern	Moderate
86	Rufous-tailed Lark	*Ammomanes phoenicura*	II	Near Threatened	High
87	Rufous-tailed Scrub Robin	*Cercotrichas galactotes*	II	Least Concern	NA
88	Siberian Stonechat	*Saxicola maurus*	II	Not Evaluated	Low
89	Tawny Pipit	*Anthus campestris*	II	Least Concern	High
90	Tree Pipit	*Anthus trivialis*	II	Least Concern	Moderate
91	Variable Wheatear	*Oenanthe picata*	II	Least Concern	High
92	White-eared Bulbul	*Pycnonotus leucotis*	II	Least Concern	Low
93	White-throated Kingfisher	*Halcyon smyrnensis*	II	Least Concern	Low
94	Wood Sandpiper	*Tringa glareola*	II	Least Concern	Moderate
95	Zitting Cisticola	*Cisticola juncidis*	II	Least Concern	Low

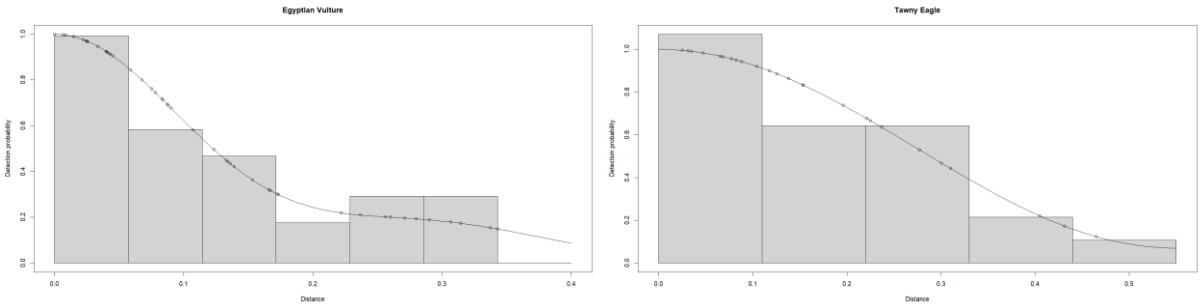
No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB
96	Great Indian Bustard	*Ardeotis nigriceps*	I	Critically Endangered	High
97	Barn Swallow	*Hirundo rustica*	II	Least Concern	NA
98	Bonelli's Eagle	*Aquila fasciata*	I	Least Concern	Low
99	Common Kingfisher	*Alcedo atthis*	II	Least Concern	Low
100	Common Myna	*Acridotheres tristis*	II	Least Concern	Low
101	Common Raven	*Corvus corax*	II	Least Concern	Low
102	Demoiselle Crane	*Grus virgo*	I	Least Concern	High
103	Eurasian Wryneck	*Jynx torquilla*	II	Least Concern	Low
104	Griffon Vulture	*Gyps fulvus*	I	Least Concern	High
105	Indian Courser	*Cursorius coromandelicus*	I	Near Threatened	High
106	Indian Scops Owl	*Otus bakkamoena*	II	Least Concern	NA
107	Large Grey Babbler	*Turdoides malcolmi*	II	Least Concern	Low
108	Little Swift	*Apus affinis*	II	Least Concern	Low
109	Long-billed Pipit	*Anthus similis*	II	Least Concern	Moderate
110	Long-tailed Shrike	*Lanius schach*	II	Least Concern	Low
111	Oriental Magpie Robin	*Copsychus saularis*	II	Least Concern	Low
112	Paddyfield Pipit	*Anthus rufulus*	II	Least Concern	Low
113	Red Collared Dove	*Streptopelia tranquebarica*	II	Least Concern	Low
114	Red-headed Vulture	*Sarcogyps calvus*	I	Critically Endangered	High
115	Red-tailed Shrike	*Lanius phoenicuroides*	II	Least Concern	NA
116	Short-eared Owl	*Asio flammeus*	I	Least Concern	Low
117	Sind Sparrow	*Passer pyrrhonotus*	II	Least Concern	Low
118	Spanish Sparrow	*Passer hispaniolensis*	II	Least Concern	NA
119	Spotted Owlet	*Athene brama*	II	Least Concern	NA
120	Stoliczka's Bushchat	*Saxicola macrorhynchus*	II	Vulnerable	Moderate
121	Trumpeter Finch	*Bucanetes githagineus*	II	Least Concern	NA
122	Water Pipit	*Anthus spinoletta*	II	Least Concern	NA
123	Western Marsh Harrier	*Circus aeruginosus*	I	Least Concern	High
124	White-rumped Vulture	*Gyps bengalensis*	I	Critically Endangered	High
125	White-throated Kingfisher	*Halcyon smyrnensis*	II	Least Concern	Low
126	Yellow-throated Sparrow	*Petronia xanthocollis*	II	Least Concern	Low
Reptiles					
1	Sind Sand Gecko	*Crossobamon orientalis*	NA	Least Concern	
2	Keeled Rock Gecko	*Cyrtopodion scabrum*	NA	Least Concern	
3	Brook's House Gecko	*Hemidactylus brookii*	NA	Least Concern	-
4	Yellow-bellied House Gecko	*Hemidactylus flaviviridis*	NA	Least Concern	-
5	Bark Gecko	*Hemidactylus leschenaultii*	NA	Least Concern	-
6	Persian Microgecko	*Tropiocolotes persicus*	NA	Least Concern	-
7	Indian Garden Lizard	*Calotes versicolor*	NA	Least Concern	-

No.	Species	Scientific Names	WPA Schedule	IUCN Status	SoIB
8	Brilliant Ground Agama	*Trapelus agilis*	NA	Least Concern	-
9	Spiny-tailed Lizard	*Saara hardwickii*	I	Vulnerable	-
10	Earless Dwarf Skink	*Ablepharus pannonicus*	NA	Least Concern	-
11	Yellow-bellied mole skink	*Lygosoma albopunctatum*	NA	Least Concern	-
12	Indian Fringe-toed Lizard	*Acanthodactylus cantoris*	NA	Least Concern	-
13	Small-scaled Lacerta	*Ophisops microlepis*	NA	Least Concern	-
14	Snake-eyed Lacerta	*Ophisops jerdonii*	NA	Least Concern	-
15	Bengal Monitor Lizard	*Varanus bengalensis*	I	Least Concern	-
16	Desert Monitor Lizard	*Varanus griseus*	I	Least Concern	-
17	Brahminy Worm Snake	*Indotyphlops braminus*	NA	Least Concern	-
18	Red Sand Boa	*Eryx johnii*	I	Near Threatened	-
19	Indian Rat Snake	*Ptyas mucosa*	I	Least Concern	-
20	Glossy-bellied Racer	*Platyceps ventromaculatus*	NA	Least Concern	-
21	Black-headed Royal Snake	*Spalerosophis atriceps*	NA	Least Concern	-
22	Red-spotted Royal Snake	*Spalerosophis arenarius*	NA	Least Concern	-
23	Sind Awl-headed Snake	*Lytorhynchus paradoxus*	NA	Least Concern	-
24	Russell's Kukri Snake	*Oligodon taeniolatus*	NA	Least Concern	-
25	Common Kukri Snake	*Oligodon arnensis*	NA	Least Concern	-
26	Common Wolf Snake	*Lycodon aulicus*	NA	Least Concern	-
27	Common Cat Snake	*Boiga trigonata*	NA	Least Concern	-
28	Afro-asian Sand Snake	*Psammophis schokari*	NA	Least Concern	-
29	Leith's Sand Snake	*Psammophis leithii*	NA	Least Concern	-
30	Checkered Keelback	*Fowlea piscator*	I	Least Concern	-
31	Sindh Krait	*Bungarus sindanus*	NA	Least Concern	-
32	Common Krait	*Bungarus caeruleus*	NA	Least Concern	-
33	Spectacled Cobra	*Naja naja*	I	Least Concern	-
34	Sochurek’s Saw-scaled Viper	*Echis carinatus sochureki*	II	Least Concern	-

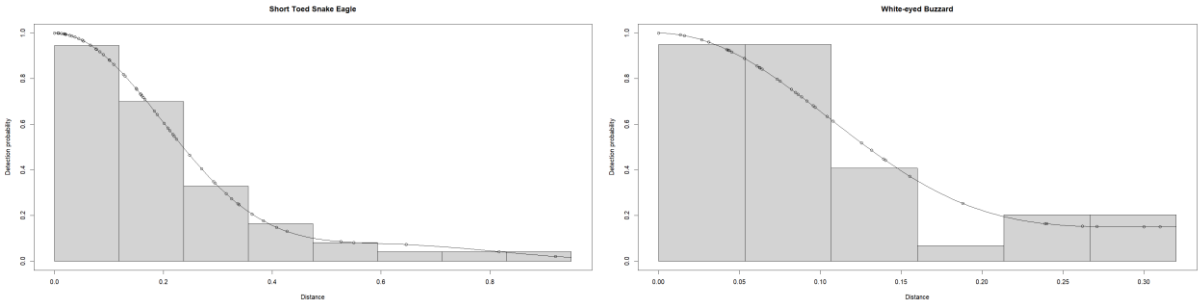
Annexure 3: *Detection probabilities of species observed during the vehicle transect surveys*



Supplementary Figure 1. Fitted detection curve for Chinkara using detections from vehicle transect surveys in the project impact zone, Jaisalmer (2025)

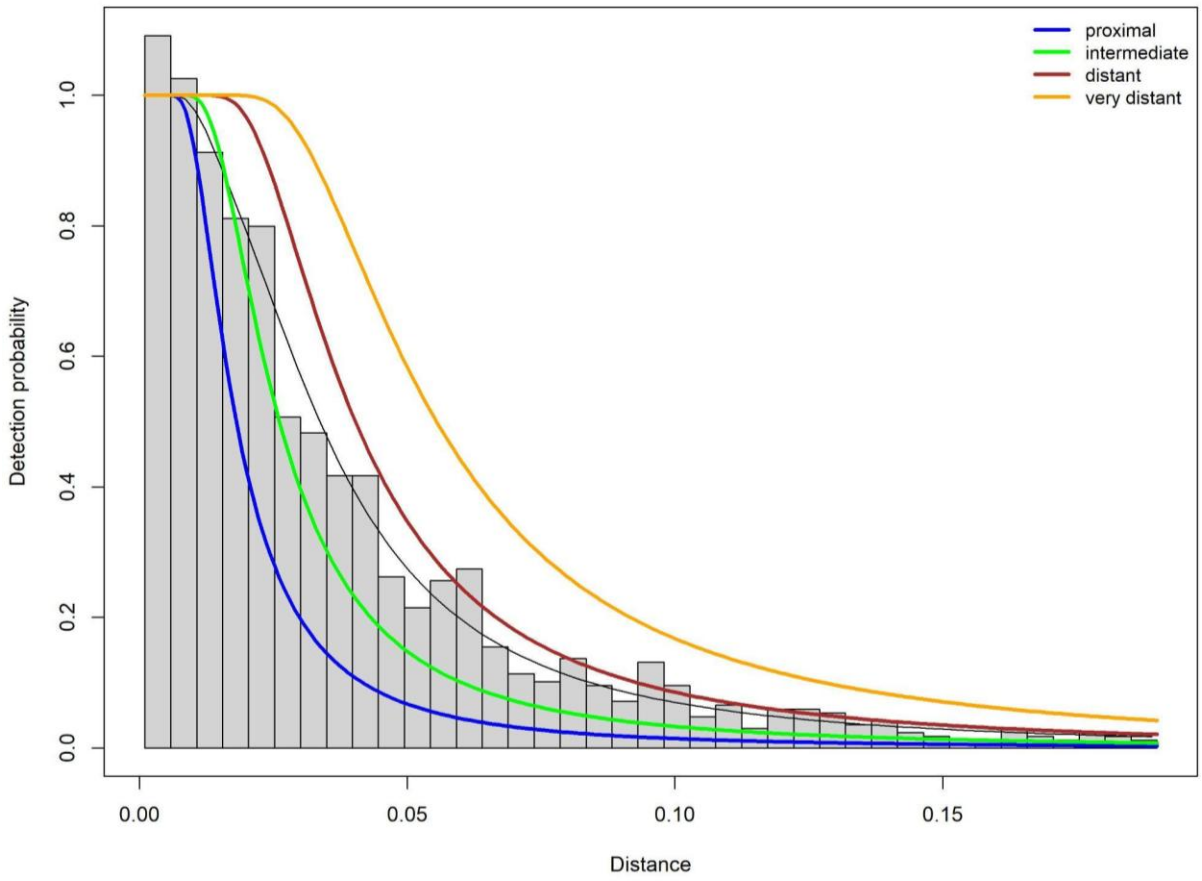


Supplementary Figure 2. Fitted detection curves for Egyptian Vulture (left) and Tawny Eagle (right) using detections from vehicle transect surveys in the project impact zone, Jaisalmer (2025)



Supplementary Figure 3. Fitted detection curves for Short-toed Snake Eagle (left) and White-eyed Buzzard (right) using detections from vehicle transect surveys in the project impact zone, Jaisalmer (2025)

Annexure 4: *Detection probabilities of species of different detection groups (low, moderate, high, and very high)*



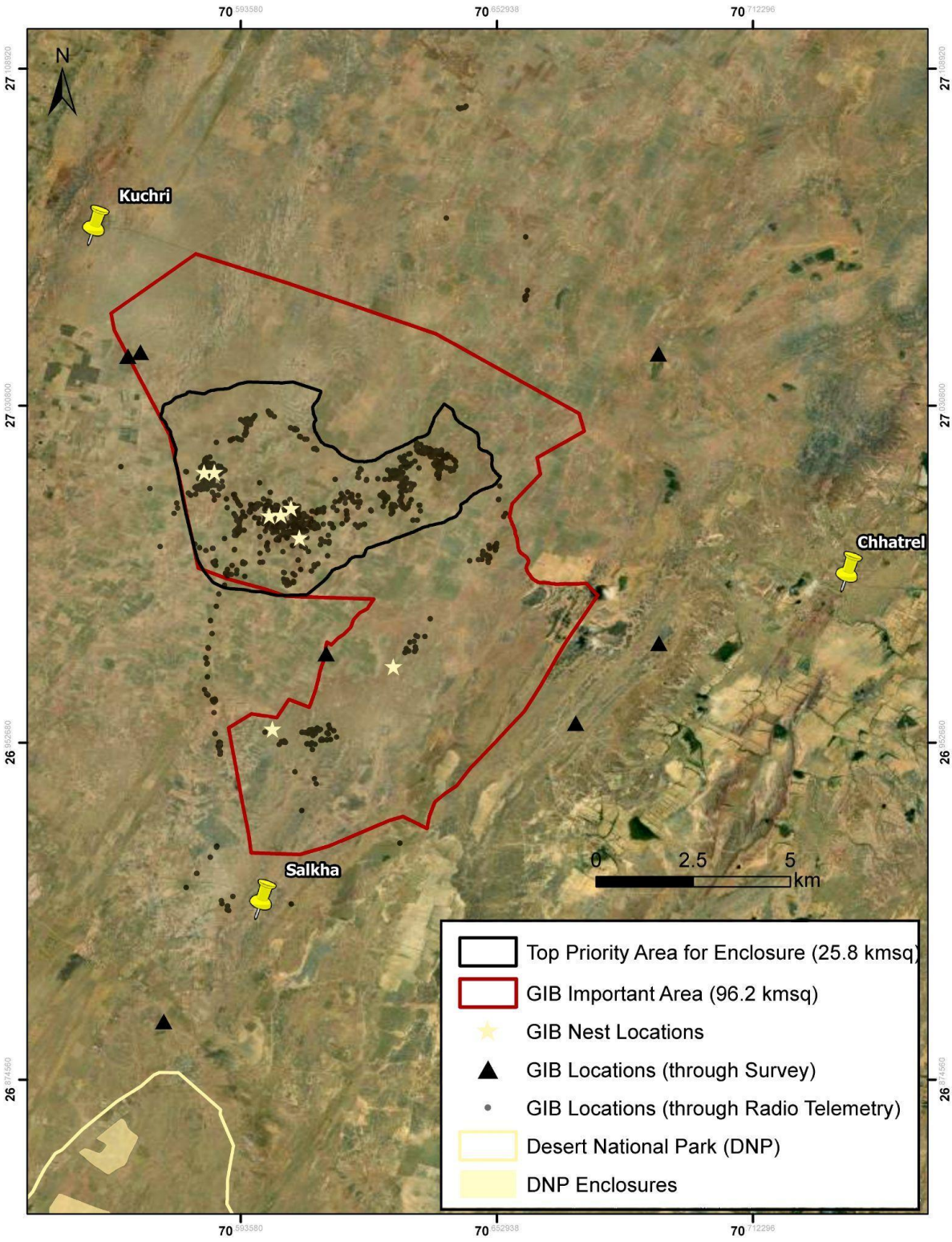
Supplementary Figure 1 Detection probability curves for different detection groups (low, moderate, high, and very high) as a function of the median distance from the transect line.

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

Detection Groups	Detection Probability (p)	Effective strip width (m)
Proximal	0.12	23.16 m
Intermediate	0.18	33.47 m
Distant	0.27	51.01 m
Very distant	0.36	69.11 m

Annexure 5. *Density (#/km^2) of conservation-important terrestrial mammals assessed from camera trap surveys in the direct impact zone of Khuiyala-Unroi mining blocks*

Species	Population Parameters	Khuiyala	Unroi-I	Unroi-II	Transportation Road	Direct Impact Zone
Chinkara *P: 0.83 ± 0.01 Activity proportion: 0.31 ± 0.05 Effective detection radius: 11.21 m*	*Density (#/km^2) (± SE)*	*~0*	*0.68 ± 0.4*	*0.6 ± 0.38*	*~0*	*0.29 ± 0.14*
	Encounter rate (#/km) (± SE)	*~0*	*2.3 ± 0.32*	*2.05 ± 1.2*	*~0*	*0.99 ± 0.4*
Desert Fox *P: 0.25 ± 0.02 Activity proportion: 0.36 ± 0.02 Effective detection radius: 3.44 m*	*Density (#/km^2) (± SE)*	*~0*	*2.87 ± 1.29*	*1.28 ± 0.74*	*~0*	*0.96 ± 0.37*
	Encounter rate (#/km) (± SE)	*~0*	*3.52 ± 1.53*	*1.58 ± 0.89*	*~0*	*1.18 ± 0.43*
Indian Fox *P: 0.23 ± 0.03 Activity proportion: 0.21 ± 0.05 Effective detection radius: 3.12 m*	*Density (#/km^2) (± SE)*	*~0*	*~0*	*1.39 ± 0.62*	*~0*	*0.33 ± 0.16*
	Encounter rate (#/km) (± SE)	*~0*	*~0*	*0.91 ± 0.31*	*~0*	*0.22 ± 0.08*



Annexure 6: *Priority area proposed for establishing grassland enclosure based on habitat usage by GIB near Salkha-Kuchhri, Jaisalmer, Rajasthan*

Annexure 7: *Experimental work for Reclamation and Rehabilitation of mined out land by Local Grass at RSMML's Sanu Mines, Jaisalmer*

Experimental work for Reclamation and Rehabilitation of mined out land by Local Grass at RSMML's Sanu Mines, Jaisalmer

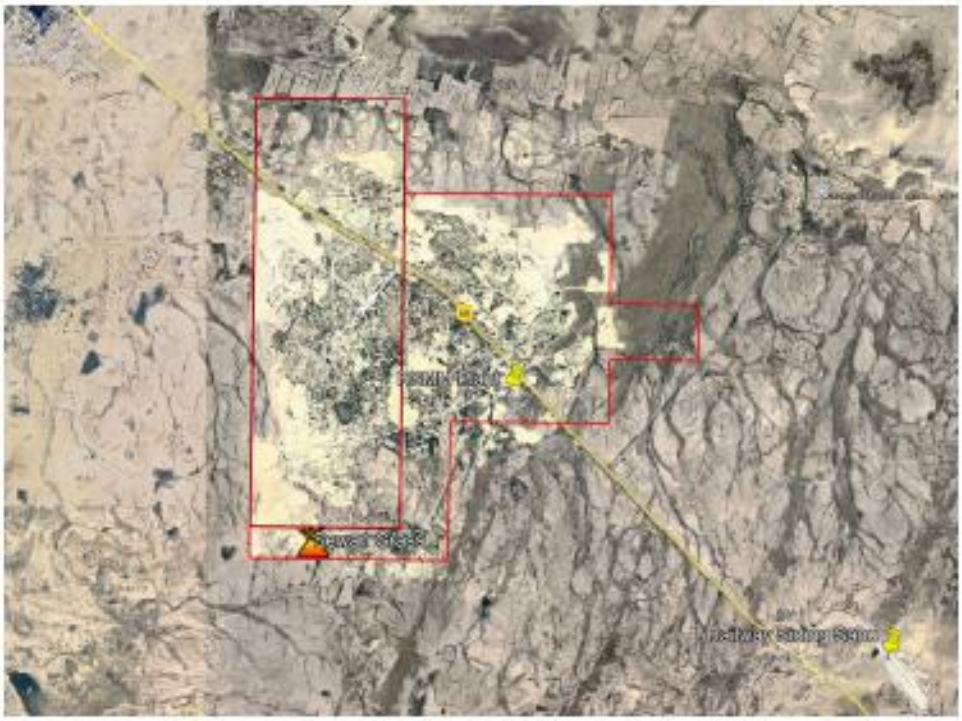
The Sanu-2 Limestone Mines, operational since the 1997, have been supplying SMS-grade limestone to major steel plants across India for over 35 years. In alignment with environmental clearances granted by the MoEF&CC, Government of India, RSMML remains committed to sustainable mining practices and environmental stewardship.

To ensure sustainable development, the company has adopted several green initiatives, including the use of electrification of equipment, renewable energy, water conservation, recycling, waste (OB/backfilled mining) reuse, reforestation and ecosystem restoration. These efforts aim to minimize the environmental footprint of mining operations while promoting long-term land and mineral resource management.

As part of its reclamation and rehabilitation activities, RSMML has undertaken significant plantation efforts. Mined-out areas are first levelled and covered with inter-burden material. Subsequently, plantation is carried out, followed by regular watering and maintenance.

Our new areas clearances are pending with MOEFCC for obtaining prior EC. EAC committee desired to undertake study through Institute of National repute to understand the impact of proposed limestone mined of RSMML's areas on GIB and its habitat. Accordingly, RSMML has engaged WII, Dehradun to do work for RSMML for the purpose. During study, WII desired that the mined-out land needs to be reclaimed and rehabilitate with grass land using local grass, which is most suitable habitat for GIB, as area is falling under Priority Zone of GIB. After due discussion with WII official, a part of mined out land selected in Sanu-II mine area of RSMML to do experimental work trough mine office.

An area of 1.50 hectares Sanu Mines-II mine is identified and after proper levelling of the backfilled area, 1000 saplings of Sewan Grass have been planted to understand ecological restoration and recreation of habitat suitable to GIB on reclaimed land after mining of limestone. The work was commenced in First week of September'25 and regular monitoring was carried out by observing proper watering etc. The site photographs are taken and placed here below for assessment.



Mining Lease areas of RSMML at Sanu

Mined out Levelled area at Sanu-II mines (1st week of Sept'25)

Area development for Grassing at Sanu-II mines (2nd week of Sept'25)

Sawing of Grass land over Mined out Levelled area at Sanu-II mines (Sept'25)

Sawing of Grass land over Mined out Levelled area at Sanu-II mines (Sept'25)

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