

HABITAT IMPROVEMENT
AND CONSERVATION
BREEDING OF

GREAT INDIAN BUSTARD

:AN INTEGRATED APPROACH

PROGRESS REPORT III
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Executive Summary

The Great Indian Bustard (*Ardeotis nigriceps*) is critically endangered with 100-150 individuals left, largely in Jaisalmer (Rajasthan) and very small populations in Kutch (Gujarat), Sholapur (Maharashtra), Ballari (Karnataka) and Kurnool (Andhra Pradesh). The species has suffered 90% reductions in number and range, over the last five decades, due to prevalent habitat loss and human induced mortalities compounded with its slow life history traits. The Ministry of Environment, Forest & Climate Change (MoEF&CC) formulated the National Bustard Recovery Plans in 2013 based on scientific consultation, and initiated the Project “Habitat Improvement and Conservation Breeding of Great Indian Bustard” in 2016 with the Wildlife Institute of India (WII) as the nodal agency along with State Forest Departments and partner NGOs as collaborators. This project aims at recovering the species from extinction through holistic approach of conservation breeding, applied research, outreach and pilot habitat management. This report presents the project activities undertaken between 2018-19.

1. The Tripartite Memorandum of Agreement (MoA) for the Great Indian Bustard (GIB) and Lesser Florican conservation breeding and research program was signed between MoEF&CC, Rajasthan Government and WII to operationalize conservation breeding of the GIB under the guidance of a Steering Committee, with facilitation of Rajasthan Government and funding of MoEF&CC. Based on the preliminary surveys carried out by the Project team, two sites – Sorsan, Baran District and Ramdevra, Jaisalmer District were finalized for establishing the Conservation Breeding Center in consultation with the concerned agencies and construction is under progress in Ramdevra. The project team was trained in husbandry practices and veterinary care at the International Fund for Houbara Conservation (IFHC), Abu Dhabi. To utilize the GIB breeding season in 2019 -20, a fully functional pilot project the first GIB Conservation Breeding Center has been established at Sam, Jaisalmer that currently houses ten hand-reared GIB chicks from wild collected and artificially hatched eggs in close collaboration with Rajasthan Forest Department and technical support of International Fund for Houbara Conservation / Reneco.

2. Under the applied research component, three GIB females were radio tagged in Desert National Park, Jaisalmer for understanding bird movements, identifying critical habitats for conservation planning, prioritizing power lines for mitigation, and searching nesting sites for conservation breeding program. Birds have been transmitting data for months from Jaisalmer and Kachchh and providing hitherto unknown basic information on GIB space use and ranging patterns. The average travel distances were similar between the two tagged birds in Thar and almost double than that of Kachchh. Bird home ranges ranged between 76 km² in Kachchh to 124 km² in Jaisalmer. The core usages for birds ranged between 13–29 km² in Jaisalmer and 15 km² in Kachchh. Movements were located mostly within protected enclosures that corroborate the recommendation of National Bustard Recovery Plans that enclosures of 10 -20 km² can accommodate the birds’ ecological needs to a great extent, if they are managed scientifically. This action supplemented with power line mitigation in the areas surrounding enclosures is necessary to restore potential habitats across the species’ range, wherever feasible. The National Lesser Florican survey was jointly conducted by the project team with partner agencies in July - September 2018 that yielded an estimate of 426 (174–805 95% CI) male territories (conservatively 220 ± 38) across the range; highlighting the critical status of this species for urgent conservation efforts. Investigation on patterns of bird community structure in relation to land-use driven habitat changes in the arid grasslands of Thar suggested that although primary

grassland habitat is essential to save the full spectrum of the regional species pool, low-impact land-uses can act as important secondary habitats for conservation of bird species. Assessment of factors that shape vegetation in the arid zone of India in Thar, Jaisalmer showed a 62% loss in the vegetation types to agriculture and settlements highlighting the need to delineate conservation areas based on requirements of faunal species of interest and its habitat requirements before a complete wipe-out of vegetation structure types occur. Molecular analysis of GIB biological samples revealed that genetic differentiation between GIB subpopulations was low to moderate and level of gene flow between Rajasthan and Gujarat subpopulations was high. From bird carcass surveys under power lines in Kachchh, we estimated carcass encounter rates of 0.27 (0.14 SE) and 0.25 (0.06 SE) per km per month for high- and low- tension power-lines and mortalities of ~22,000 birds (all species) annually in ~1100 km² GIB habitat emphasizing the need for immediate power line mitigation measures. Preliminary investigation of soil and GIB food samples revealed presence of organophosphate pesticides in GIB habitat in a round Rollapadu Wildlife Sanctuary, Andhra Pradesh.

3. As part of social engagement, our team surveyed villages in Jaisalmer district to assess livelihood concerns and conservation attitude of the local population. We intend to involve the locals as stakeholders in GIB conservation to create goodwill, and these social surveys will help in developing outreach programs. Additionally, customized nature education programmes in 22 schools, skill development workshop for responsible nature tourism to local youth and forest department staff, awareness program to sensitize locals and tourists on grassland and GIB conservation at Desert festival, Jaisalmer were conducted. Publicity materials such as posters, t-shirts, caps, books, bags, brochures for power agencies and other stakeholders were prepared and widely disseminated. The team met with representatives of various private and government power agencies as well as senior government officials, media and legal fraternity to sensitize them on the critical issue of power line mitigation for GIB conservation. We also conducted training workshops on population, habitat and threat surveys involving Forest Department staff and volunteers in bustard range states.

4. Under pilot habitat management, 801 dogs from 23 villages in/around DNP were sterilized in collaboration with Humane Society International (HSI)- India and Rajasthan Forest Department. Analysis of data collected from population surveys of dogs and other nest predators in/around DNP is under progress. Preliminary analysis showed that the proportion of unsterilized dogs is still very high in villages. Pigs and desert foxes were the most abundant nest predators in/around DNP. Preparations are underway to relocate nest predators from GIB breeding enclosures in DNP. Meetings with the local community to manage a portion of their land in GIB-friendly manner, and interactions with power agencies and bird diverter suppliers for marking critical power lines were held. More bird diverters for power lines have been procured for installation with the help of power agencies in Thar.

Chapter 1

Introduction

The Great Indian Bustard *Ardeotis nigriceps* (hereafter GIB) is one of the rarest birds in the world. With ~ 150 individuals left, almost exclusively in India, the species is classified as Critically Endangered (IUCN 2018) and Schedule I (the highest protection status) of the Wildlife (Protection) Act, 1972. Their populations have steadily declined by 75% in last 30 years and are facing imminent extinction risk unless serious management interventions are applied (Dutta et al. 2011). Historically distributed across the hot arid and semi-arid grasslands of Indian plains, plateau and desert, GIB are currently restricted in only five isolated regions. According to our latest population assessment (Dutta et al. 2018), the largest population of 128 (19SE) birds occur in Thar landscape of Rajasthan (Desert National Park in Jaisalmer alongside Jodhpur- area 9252 km²). The other populations are almost ecologically extinct with < 10 birds each, occurring in Gujarat (Lala-Naliya Sanctuary and its neighbourhood in Kachchh), Maharashtra (GIB Sanctuary in Solapur, alongside Chandrapur and Nagpur), Andhra Pradesh (Rollapadu Wildlife Sanctuary and its neighbourhood in Kurnool) and Karnataka (Ballari) (Dutta et al. 2011).

The species has declined due to compounding effects of direct and indirect human exploitation on their slow life-history traits. They were subjected to exhaustive hunting and egg collection in the past that reduced their population to ~ 1260 birds in 1969 (Dharmakumarsinhji 1971). However, their contemporary decline is largely due to prevailing habitat loss as dry grasslands have been marginalized as ‘unproductive wastelands’ and progressively converted to other land uses since colonial times. Recent developments in irrigation and farming technologies have intensified agriculture in bustard habitats and changed cropping practices from seasonal to year-round, intensive crops. This change has led to food scarcity for bustards, pesticide contamination, and habitat loss. Development activities like infrastructural growth (electricity, road and irrigation networks), industries, power projects, and wind turbines have caused severe habitat degradation and disturbance to birds. Being low and heavy flyers, they face a very high risk of fatal collisions with power lines, which are difficult to detect from afar. Populations of free-ranging dogs and pigs have increased in bustard habitats, and along with native predators (fox, mongooses, and cats), have increased predation pressure on nests and chicks and reduced recruitment. Past efforts of banning human activities to create bustard Sanctuaries over large human-use landscapes, without appropriate settlement of land rights, have generated resentment among local people, leading to lack of conservation support. These factors have in turn caused local extinctions from some Sanctuaries.

Local people and managers are not sufficiently aware of the conservation benefits of grasslands and the scientific ways to manage them. Whereas, traditional ways to manage these habitats are eroding due to rapid socio-ecological changes driven by state policies (Dutta et al. 2013). Although most remaining breeding habitats are protected to some level, vast movements of bustards expose them to the threats mentioned above in the non-breeding habitats, defeating the purpose of protecting small breeding reserves. Since these large bustard landscapes cannot be freed from human uses, a mixed approach of Protected Area based conservation of breeding habitats and coexistence with compatible human land uses by mitigating survival threats in adjoining landscapes best suits the situation.

Effective conservation of bustard habitats would require information on species' ranging patterns, relative magnitudes and distribution of threats, and ways to reconcile species'

ecological needs and livelihood concerns that are poorly known. Furthermore, management authorities in many areas exhibit poor enforcement ability due to inadequate staff and infrastructure, lack of motivation, and inaccessibility. Concerned about the extinction crisis of GIB, Indian conservation circles have proposed strategic recovery plans for the species as a flagship of dry grasslands. The National Guidelines for Bustard Recovery Plans (Dutta et al. 2013) developed by MoEF&CC strongly recommend filling research gaps, mitigating threats, improving habitat, improving enforcement capacity, and engaging communities in conservation. However, the implementation of *in situ* conservation measures requires some gestation time, but, the population size of GIB (with no birds in captivity) is too small to sustain such delays. Thus, an *exsitu* population needs to be secured for supplementing wild populations and reintroducing birds into restored habitats in favourable times.

This project funded by National Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Advisory Council (NCAC) aims at integrating all these components into a holistic conservation plan for the priority bustard landscapes of Rajasthan, Gujarat, and Maharashtra. The proposed activities are being undertaken since 2016 in collaboration with State Governments, local NGOs, and research organizations so as to pool knowledge/expertise and ensure timely and effective implementation. Since both the endangered bustards of dry grasslands – GIB and Lesser Florican *Sypheotides indicus* – share some habitats, these activities will supplement and complement each other's needs. By doing so, habitats that support a plethora of other endangered wildlife, such as the spiny-tailed lizard *Saara hardwickii*, chinkara *Gazella bennettii*, foxes *Vulpes* spp, wolf *Canis lupus* pallipes, caracal *Caracal caracal* and blackbuck *Antelope cervicapra* will be restored.

1.1. Project objectives

The broad goals and objectives of this project are as follows:

1.1.1. Conservation Breeding

Developing and running Conservation Breeding Centre to secure *ex situ* populations of GIB and Lesser Florican as insurance against extinction and subsequent reintroduction/supplementation into restored habitats.

1.1.2. Applied research

Undertaking targeted research for:

- a) Prioritizing conservation areas,
- b) Characterizing threats,
- c) Monitoring populations and habitats to assess the effectiveness of management actions,
- d) Assessing local communities' livelihood concerns and willingness to adopt bustard-friendly land uses
- e) Comprehensive understanding of population genetics to inform conservation management

1.1.3. Capacity building and awareness

- a) Improving protection enforcement through training of Forest Department staff and implementation of technology aided patrolling,
- b) sensitizing decision-makers, managers and local communities on bustard conservation,
- c) raising public awareness and support for bustard conservation through awareness materials,
- d) Incentivizing local land users to adopt bustard-friendly land uses

1.1.4. Pilot implementations for surgical habitat management

Demonstrating best practices for habitat improvement through pilot/experimental surgical interventions that will be subsequently replicated by State Forest Departments.

CONSERVATION BREEDING



Bustard Recovery Program /Annual Report III /2018-2020

Chapter 2. Project Activities

2.1. Conservation breeding

2.1.1. Background

One of the primary goals of the Bustard Recovery Program is to establish and operationalize the conservation breeding facility for the Critically Endangered GIB. To this end, the Project team has carried out sustained ground work and advocacy including several meetings with the Rajasthan Government and MoEF&CC during 2016–18. Since July 2018 and particularly after April 2019, substantial progress has been made on this front, and the first GIB Conservation Breeding Centre has been established at Sam, Jaisalmer that houses ten hand-reared GIB chicks by March 2020 from wild collected and artificially hatched eggs. The activities that have resulted in this have been carried out by WII in close collaboration with Rajasthan Forest Department, and technical assistance from International Fund for Houbara Conservation (IFHC)/ Reneco (globally renowned bustard husbandry agency). Here, the milestones, approach and preliminary results of the GIB conservation breeding program are reported.

2.1.2. Tripartite Memorandum of Agreement and Steering Committee

The Tripartite Memorandum of Agreement (MoA) for the GIB and Lesser Florican conservation breeding and research program was drafted in 2017 in consultation with the MoEF&CC and the Rajasthan Government. This document details the measures required to rescue the Critically Endangered GIB and Endangered Lesser Florican, and delineates the respective roles/responsibilities of concerned Parties involved in this task. The MoA was signed on 20th June 2018 at MoEF&CC-New Delhi (Image 1), and mandates the scientific team of WII to implement conservation breeding of the GIB in the State of Rajasthan, with facilitation of Rajasthan Government and funding of MoEF&CC. Simultaneously, WII is in the process of signing a MoU with the IFHC and their technical partner Reneco for technical collaboration and knowledge sharing to implement this specialized activity. The MoU has been drafted in March 2019 and is awaiting approval from the Government of India



Image1 Signing of the Tripartite Memorandum of Agreement for Great Indian Bustard and Lesser Florican Conservation © Sutirtha Dutta

A Steering Committee was formed consisting of Additional Director General (ADG) of Forest (Wildlife) MoEF&CC as the Chair, the Deputy Inspector General (DIG) of Forest (Wildlife) MoEF&CC as the Member Secretary, and other members as per the MoA, inclusive of a representative of IFHC/Reneco as an international bustard conservation breeding expert.

The terms of reference of the steering committee include: overseeing the entire programme, determining future objectives of the project, developing a detailed project proposal and approving it, reviewing the progress of project implementation from time to time, issuing suitable directions/advice to project management, facilitating funding for the project, suggesting suitable sites for habitat restoration, approving suitable research proposals under the project, and any other decision as required.

The first meeting of the committee was held at MoEF&CC, New Delhi on 19th July 2018. This meeting formally decided the commencement dates and potential sites of the conservation breeding activity, the institutional support to be offered to WII from Rajasthan Government and MoEF&CC, the rough design of the Conservation Breeding Centres, the visit of WII scientists to receive training at the National Avian Research Centre (NARC) in Abu Dhabi, the need of tagging GIB and Lesser Florican, the need of mitigating power lines in bustard habitat and removal of nest predators from GIB enclosures at DNP.



Image 2 & 3. Steering Committee meeting held at Jaisalmer during August 2019 © Pawan Negi

The second meeting of the Steering Committee was held on 21st July 2019 at Jaisalmer, Rajasthan (Image 2 & 3). The committee was updated on the progress of the Project. The committee decided that Karnataka should be included in the GIB recovery program and the State Government should prepare an *in-situ* conservation programme for GIB in consultation with WII and along with Gujarat explore possibility of conservation breeding program; WII would put up a proposal with appropriate justification for the extra expenditure to CAMPA since the establishment of existing emergency temporary facility was not in the initial project plan; collection of additional GIB eggs; attachment of Rajasthan Forest Department employees to Conservation Breeding Centre; MoEF&CC would consider taking up the matter regarding proposal for power line mitigation submitted by WII with Ministry of New and Renewable Energy (MNRE), Government of India and Rajasthan Vidyut Prasaran Nigam Limited (RVPNL) and Rajasthan Government; 'in-principle' approved the *in-situ* conservation plan prepared by Rajasthan Forest Department and suggested to consider the involvement/support of the NGOs for *in-situ* conservation project, MoEF&CC would seek support of Indian Army in the conservation and breeding programme of GIB at Ministerial level.

2.1.3. Site finalization and construction of the Conservation Breeding Centre

Based on the preliminary surveys carried out by the Project team, two sites – Sorsan and Ramdevra were shortlisted as potential sites for establishing the Conservation Breeding Centre in consultation with the concerned agencies. Finally, the ADG (Wildlife) MoEF&CC, CWLW Rajasthan, Chief Engineer Civil Construction Unit, Member Secretary CZA, and GIB Conservation Project Scientists selected these sites for establishing two conservation breeding facilities during a visit from 6th- 9th August 2018. Since the land in Ramdevra is *Oran* (sacred grove) land, the Forest Department sought a resolution from the concerned Gram Panchayat which passed a no objection motion in the meeting held on 26th January 2019. WII was permitted to use Ramdevra site for construction of the Satellite Breeding facility as of 05th February 2019 (Figure 1).

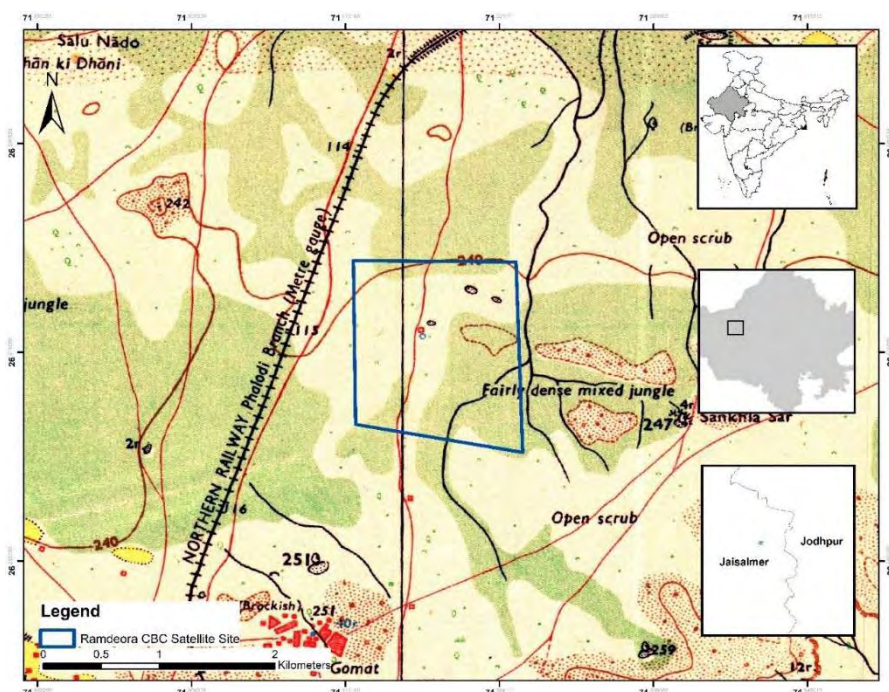


Figure 1. Topographic map of Satellite Conservation Breeding Centre site at Ramdevra in Jaisalmer District, Rajasthan

The land selected in Ramdevra spans 1.93 km² area (Figure 1), and construction of the Satellite Centre has commenced in May 2019. The construction of incubation, hatchery, first age chick rearing, office building and water storage facilities have been fully completed in October 2019 and predator proof fence is being constructed by the Forest Department around the allocated land. The fence is being installed by digging a two feet deep trench and six feet pillars with mesh embedded in the ground.

In Sorsan, Baran 6.76 km² of forest land and 0.1 km² of non-forest land have been allocated (Figure 2). A team of experts including Mr. Bharat Singh, MLA from Sangod, Rajasthan, CWLW Rajasthan and GIB Project Scientists from WII inspected and finalized the site during February 2019 (Image 4). However, construction work has not commenced here, as this will be a long-term Centre and it is vital to develop it following robust architectural designs and site layout plan, based on the learnings from the current small-scale project.

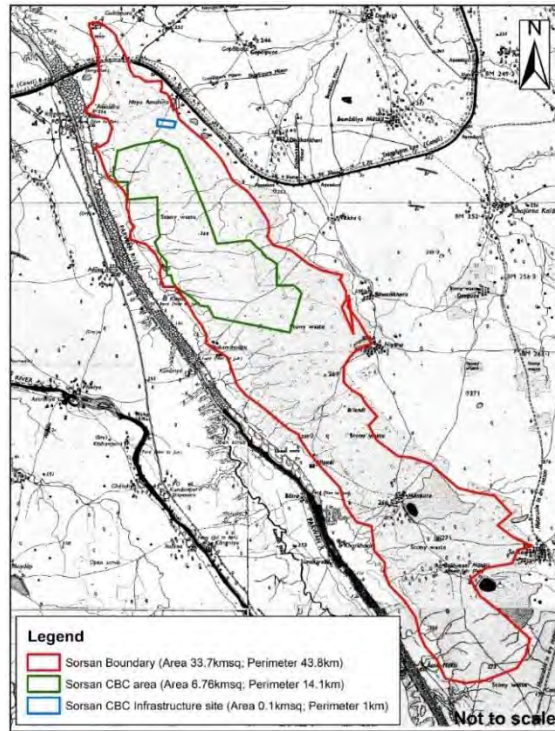


Figure 2. Topographic map of Conservation Breeding Centre site at Sorsan in Baran District, Rajasthan



Image4. Team of experts finalizing the area of Conservation breeding Centre site during February 2019 at Sorsan in Baran District, Rajasthan © Bipin C.M.

Since the Satellite Conservation Breeding facility at Ramdevra had to be built de novo and would not be completed before the GIB breeding season in 2019, it was decided during a meeting between the Project Scientists, Rajasthan Forest Department officers and IFHC/Reneco houbara breeding experts, that a temporary breeding facility be developed from an existing building to utilize the breeding season of 2019. The Forest Department guardhouse (*chowki*) at Sam, Jaisalmer was selected as the pilot Conservation Breeding Centre site, since it had two buildings, area for constructing cages/tunnels, electricity and easy accessibility for logistic support. A team from IFHC, Abu Dhabi along with Forest Department officials and WII

scientists visited the facility in the last week of April 2019. It was decided to modify the existing structures to make it acceptable for incubation, hatching and chick rearing. Two existing buildings and two huts were allocated by the Rajasthan Forest Department for modification. The renovation was immediately started and the Centre was operational by mid July 2019 (Image 5).

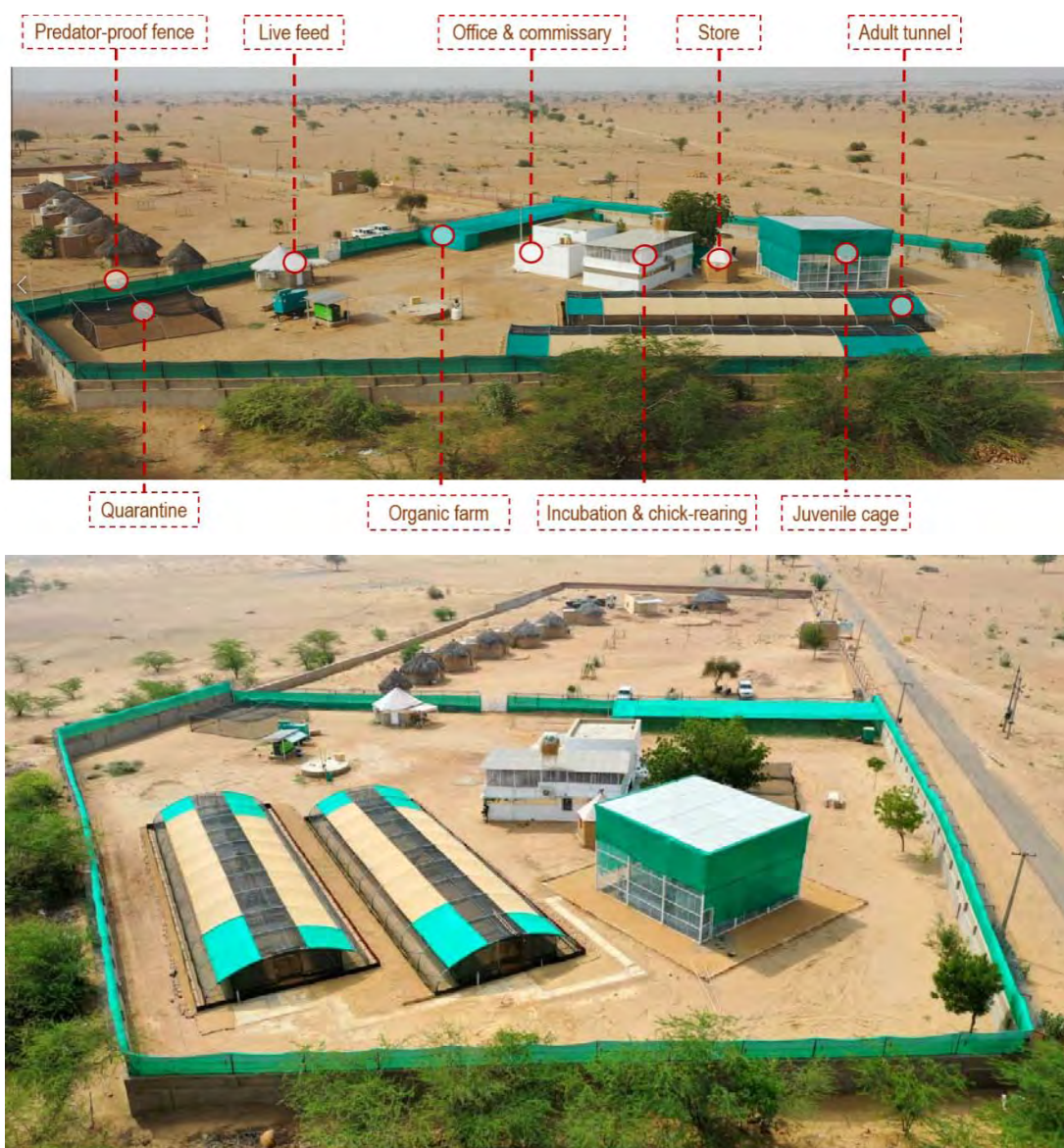


Image 5. Aerial photograph of the newly constructed Great Indian Bustard Conservation Breeding Centre at Sam in Jaisalmer District, Rajasthan (August 2019) © WII

2.1.4. Building modifications for pilot Conservation Breeding Centre in Sam, Jaisalmer

The verandah in both the buildings were converted to changing rooms by constructing a wall and adding a wash area. All the windows were sealed and shelves were covered to insulate the rooms. All metal doors were replaced by PVC doors with rubber seal for dust and contamination (rust) proofing. Washing areas were added to both the buildings and water supply was installed. Toilets in both facilities were sealed and the soak pit was moved out of the facility at a distance of ~100m from the existing position to avoid back flow of sewage. All walls and floors were

painted with white epoxy to allow easy detection of dirt/contaminants. Rooms were fitted with Air Conditioners (AC) to help maintain suitable temperature and humidity.

1. The first building has changing/wash area, incubation room, hatchery room, first age chick rearing room along with indoor bird holding pen of $2.5\text{ m} \times 1.5\text{ m}$ dimension, a Reverse Osmosis tank that supplies purified water to the entire facility, and a washing area for chick rearing accessories. The second building has Office, kitchen, store and washing area for aprons used in the facility (Image 6).



Image6. Incubation building on the right and Office building on the left at the Great Indian Bustard Conservation Breeding Centre at Sam, Jaisalmer © WII

2. The mud hut, an erstwhile building for tourists in the premises was modified into two separate live food production units by creating an inner wall dividing the facility into two rooms with false ceilings for insulation (Image 7).
3. The outer fence wall was modified by increasing the height and adding a recurved mesh for predator proofing around the 270m perimeter (Image 8). For rodent proofing angled metal plate was added to the incubation building, live food unit, and the fence.
4. For constructing the cage and tunnels, the area was dug up and a brick wall laid to prevent rodents from digging in and covered with big stones to allow drainage. Tunnels donated by IFHC were installed herein to house sub-adult birds ($\geq$ four months). A metal cage of $10\text{ m} \times 10\text{ m}$ dimension was constructed to house juveniles ($\geq$ one month) for second age in front of incubation building. The cage was later modified by adding a cement sheet roof to provide protection from rain and heat. The cage contains five portable individual cages of $3\text{ m} \times 2\text{ m}$ dimension made with PVC pipes and soft fishing net that housed 1-3 birds of 1- 4 months each.



Image7. Tourist hut converted into two live feed units with a wash area outside at the Conservation Breeding Centre, Sam- Jaisalmer © WII



Image8. Predator proof fencing around the Great Indian Bustard Conservation Breeding Centre at Sam, Jaisalmer

5. Three furnished portable containers were procured for security outpost and common wash area at the facility entrance, rest room for technical staff and a room to house invertebrate live feed such as crickets.
6. A crop-field was also developed where alfalfa and mustard crops were planted for feeding the chicks fresh organic greens.
7. Two Diesel Generator (DG) Sets were installed as a necessary backup for electricity interruptions, and the electricity connection was upgraded from one-phase to three-phase to support increased power requirement.
8. Two adult bird holding cages or 'tunnels' 30 m x 9 m in dimension, made of metal frames and protection mesh with partitions and canvas shades were erected with materials supplied by IFHC/Reneco, to house sub-adult birds (4 months onward).

These constructions were jointly carried out by the Rajasthan Forest Department and WII Project team, through local contractor(s), village Eco-Development Committee and with the generous assistance of IFHC/Reneco scientific and logistic representatives during May – July 2019.

2.1.5. Collaboration and training at IFHC, Abu Dhabi

The IFHC is dedicated to its aim of bustard conservation and is one of the world's largest species conservation projects, overseeing an international network of specialised houbara bustard breeding centres to support and increase wild populations of the bird in its natural habitats across the species' range. IFHC is an agency of international repute, known for its technological intervention and success at breeding houbara bustard. Experts from IFHC helped finalize the sites at Sorsan and Ramdevra as well as help plan the pilot GIB Conservation Breeding Centre at Sam.

Scientists from IFHC first visited India in the month of October 2018. Dr. Loic Lesobre and Mr. Thibault Dieuleveut visited the sites at Sorsan, Ramdevra, and the DNP in Rajasthan. They have years of expertise in ecology, genetics, and breeding of houbara bustards. They shared their knowledge with the Project team and assisted in finessing our approach to conservation breeding. They also met and briefed the CWLW Rajasthan about their mission and collaboration with WII. A second delegation of IFHC/Reneco scientists working at NARC, Abu Dhabi visited Ramdevra, DNP and also met with the CWLW during April 2019. They assisted the Project team in selecting Sam Forest Department *chowki* for the pilot Conservation Breeding Centre and provided technical inputs and documents for construction of the various facilities required to operationalize conservation breeding activity.

The Project team from WII comprising of Dr. Sutirtha Dutta, Dr. Tushna Karkaria, Mr. Arjun Awasthi and Dr. Shravan Singh Rathore,, travelled to Abu Dhabi in the month of May 2019 to learn incubation, chick rearing, adult breeding, nutrition, veterinary, and live food production practices from the scientists at NARC (Image 9). The team learned scientific management of all aspects of breeding for implementing these approaches at the Conservation Breeding Centres as well as training local Indian staff on these specific techniques.

The IFHC/Reneco have sent a series of experts to India to assist in construction of the Conservation Breeding Centre, egg collection, tagging, incubation and husbandry of GIB since June 2019 (Image 10). The transfer of technology, expertise and know-how of bustard husbandry from IFHC to WII has played an important role in developing the capacity and skillset of the Project team and continued development of conservation breeding protocol that are required for the establishment of a successful conservation breeding program for GIB and Lesser Florican in India.



Image9. Training of Project team in bird husbandry/handling at the National Avian Research Centre, Abu Dhabi © Sutirtha Dutta



Image10. Visiting experts from International Fund for Houbara Conservation/Reneco to assist in Great Indian Bustard conservation breeding program at Sam, Jaisalmer © WII

2.1.6. Great Indian Bustard nest search in Thar, Jaisalmer

For the purpose of collecting GIB eggs for the newly constructed Conservation Breeding Centre at Sam, nest search was commenced during mid-May 2019. Monitoring teams consisting of two members each, observe GIB lek sites and previous years' nest sites using field scopes and binoculars from vantages (Image 11a & 11b). Nest search teams remotely scanned these areas during morning (0500- 1100 hrs.) and evening (1600-2000 hrs.) daily from May to November 2019 in DNP, July-August 2019 in Ramdevra and Pokhran Field Firing Range with permission from the Indian Army. Scientists from IFHC, Abu Dhabi - Mr. Thibault Dieuleveut and Mr. Eric Le Nuz assisted the team initially during GIB nest search and egg collection (Image 12).



Image 11a & 11b.Great Indian Bustard nest search teams scanning the area from vantage locations in Desert National Park © WII

With the onset of breeding season, observations on GIB male displays and female visitations to the lek sites were recorded for mating events (Image 11c). GIB females were remotely tracked post mating to narrow down on areas that could be potential nesting sites. These areas were closely scanned by observers with minimal movement from vantage points for solitary GIB females exhibiting nesting behavior (Image 11d).



Image 11c & 11d. Great Indian Bustard female; (c) ready for mating with the displaying male, (d) Nesting in Desert National Park © WII

Nesting GIB females exhibited behavior such as localized radiating movement from a specific spot mostly within 300m distance, foraging intensively only during early mornings and late evenings, laying down at a specific open spot during daytime, after dusk and before dawn, aggressive interactions with conspecifics (attacks in some cases) and ungulates, and running in a crouching position to the nearest thicket when human presence is detected. This behavioral repertoire observed from distances > 600m were used as cues to determine nesting GIB females and detecting their nests efficiently and without intrusion.

Nests were detected between mid-June and early November. Majority of the GIB nests were located in areas with a mixture of barren and grassland patches (Image 12). The nesting sites ranged from a completely barren gravel patch (*magara*) to a completely grass covered area. The nests were situated in flat terrain and was a scrape on soil substrate with a slight depression. During the breeding season, a total of 15 GIB nests were located in DNP out of which 10 were collected for artificial incubation and hatching at the Conservation Breeding Centre (Table 1)



Image 12. Clockwise from left- Great Indian Bustard nests located during 2019 in Desert National Park-Jaisalmer, International Fund for Houbara Conservation Scientists Mr. Eric Le Nuz and Mr. Thibault Dieuleveut © WII

Table 1 Details of Great Indian Bustard nests located in Desert National Park, Jaisalmer

S. No	Nest confirmation date	Enclosure/Area	Land cover	Fate of the nest
1	14- June-2019	RKVY/Near Digha Magara	Grassland	Collected
2	16- June-2019	ACD/ Near Jhopa	Barren,Grassland	Collected
3	17-June-2019	ACD/ Near Northeast corner	Barren,Grassland	Collected
4	18-June-2019	ACD/ Near B Chowki	Grassland	Collected
5	20-June-2019	ACD/Bhagu Magara, Nanga Dadhiya	Grassland	Collected
6	23-June-2019	ACD/ Near Nadi	Barren,Grassland	Collected
7	25-June-2019	PPC Chowani	Barren,Grassland	Unknown
8	01-July-2019	RKVY/Near Digha Magara	Barren,Grassland	Predated
9	02-July-2019	ACD/Near Nanga Dadhiya	Grassland	Predated
10	02-July-2019	RKVY/Near RKVY Guzzler	Grassland	Unknown
11	03-July-2019	ACD/Near Euphorbia clump	Barren,Grassland	Collected
12	11-July-2019	ACD/Near Jhopa	Barren	Collected
13	18-July-2019	ACD/Near Bhagu Magara	Barren,Grassland	Collected
14	18-July-2019	ACD/Jhopa and Bhagu Magara	Barren,Grassland	Hatched
15	08-November-2019	PPC Chowani	Grassland	Collected
16	14-January-2020	RKVY choki	Grassland	Collected
17	05-March-2020	ACD/Bhagu Magara	Grassland	Collected
18	23-March-2020	ACD/Near Nanga Dadhiya	Barren,Grassland	Predated

19	24-March-2020	ACD/In A enclosure	Grassland	Predated
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2.1.7. Husbandry at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer

2.1.7.1. Incubation and hatching of Great Indian Bustard eggs

The incubation room is Air Conditioned with voltage stabilizer, dehumidifier and multiple plug points connected to an Uninterrupted Power Supply (UPS) unit. All the incubators were set on Inox (stainless steel) tables. The incubation room temperature was maintained at 24°C and humidity controlled by an automatic dehumidifier. Five Brinsea (two oval and two octagon) incubators were set at fixed temperature and humidity. Uninterrupted power supply was maintained by connecting the incubators to UPS and automatic DG Set. Environmental loggers were installed and rigorous tests were conducted to check if incubators maintained the desired temperature and humidity levels throughout the day and corrective actions were taken to offset any undesired fluctuation.

Twelve GIB eggs from the DNP were collected from June 2019 to March 2020. Among these, ten eggs have been artificially hatched with success. One egg was infertile and the other suffered late embryonic death. The artificial incubation period varied from 1-19 days. The eggs brought in for artificial incubation were cleaned, measured using a Vernier caliper, weighed on electronic scale and candled, after which they were put in an incubator. The temperature, weights and movement/vocalization/pulse of the egg was recorded daily. When the egg was about to hatch, it was shifted to the hatchery. Protocols followed by IFHC were modified based on learning from incubating GIB eggs.

The hatchery room also contained a similar set up of AC with voltage stabilizer and multiple plug points connected to UPS unit. Two hatcher (octagons without rotation) and a Brooder were set at fixed temperature and humidity on the Inox tables. The room temperature was maintained at 25°C. The eggs were shifted to the hatcher when the external pip was first visible. The egg took 8 - 18 hours from the external pip to hatch. Once the chick had hatched from the egg, it was removed from the hatcher briefly and a betadine solution was gently applied on its navel for disinfection. The egg shell was weighed and the chick was returned to the hatcher for it to dry and rest. Subsequently, the chick was weighed and shifted to the brooder once it was active and dry. The chick remained in the brooder for almost 24 hrs. Feeding of the chick commenced once the yolk sac had been reabsorbed to prevent delay in this process and ensuing infections. One day after hatching, the chick was shifted to the first age chick rearing room adjacent to the hatchery.

Details of GIB egg collected in terms of their incubation and morphometric parameters are provided in Table 2. Glimpses of infrastructure and husbandry practices at the Conservation Breeding Centre are provided in Images 13-21.

Table2 Details of Great Indian Bustard eggs collected from Desert National Park from June 2019 to March 2020

Nest No	Egg No	Date Collected	Date hatched	No. of days in artificial incubation	Egg Length (mm)	Egg Breadth (mm)	Egg weight at collection (g)	Chick weight at hatch (g)
G19DS01	EP19DW0001	20-Jun-19	21-Jun-19	1	78.82	54.94	112.33	86.90
G19DS02	EP19DW0002	20-Jun-19	08-Jul-19	18	81.33	56.63	139.12	97.80
G19DS03	EP19DW0003	20-Jun-19	09-Jul-19	19	79.61	56.39	139.37	97.00
G19DR01	EP19DW0004	21-Jun-19	05-Jul-19	14	79.35	56.19	132.18	88.61
G19DS04	EP19DW0005	21-Jun-19	07-Jul-19	16	73.67	51.30	106.67	70.63
G19DS05	EP19DW0006	24-Jun-19	Late Embryonic death	11	77.46	55.36	120.11	-
G19DS06	EP19DW0007	09-Jul-19	23-Jul-19	14	78.59	56.49	131.66	96.02
G19DS07	EP19DW0008	16-Jul-19	30-Jul-19	14	72.92	54.69	114.29	82.60
G19DS08	EP19DW0009	02-Aug-19	07-Aug-19	5	81.75	58.37	142.17	-
G19DP01	EP19DW0010	09-Nov-19	10-Nov-19	2	78.42	58.47	130.26	98.59
G20DR01	EP20DW0011	15-Jan-20	Infertile	15	82.5	59.20	111.98	-
G20DS09	EP20DW0012	06-Mar-20	23-Mar-20	18	81.93	53.21	125.33	87.24



Image13. Incubation room at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image 14. Hatchery room at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image15. Two GIB eggs collected from Desert National Park and brought to the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image16. Measurement of egg with a Vernier caliper at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image17. Weighing of an egg at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image18. External pip of an egg at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image19. Freshly hatched chick from an artificially incubated egg at the GIB Conservation Breeding Centre in Sam, Jaisalmer © WII



Image 20. Weighing of freshly hatched chick at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII



Image 21. Freshly hatched chick placed inside the brooder for drying at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII

2.1.7.2. First age chick rearing

The first age chick rearing room is an environmentally controlled room for raising chicks till they are 1-20 days old. The temperature of the room is maintained by an AC between 25-28°C and a dehumidifier to maintain relative humidity around 50%. A glass window allowed natural sunlight. The room has two long Inox tables along with a sink to wash and store utensils used for feeding the chicks.

The chicks brought in were weighed and put in adjustable boxes on top of a rubber mat on the Inox tables (Image 21A top). Each box has a heat lamp which maintains the temperature between 35-39°C underneath the lamp. The chicks born 1-2 days apart were kept together while the others were housed individually. The body weights were recorded twice, once in the morning before first feeding and after the last meal of the day. The chicks were fed Mazuri omnivore diet, dry balanced pellet, mealworms, crickets, super-worms, geckos, boiled country chicken eggs, alfalfa leaves, watermelon and other local fiber/vegetables. They had free access to clean water throughout the day. The daily diet was fed according to the age and individual preference periodically from 0600- 2000 hrs.

To imprint birds on humans, to aid in subsequent handling and assisted reproduction, chicks were massaged before each meal and tended throughout the day (Image 21A bottom). For exercise, the chicks were taken daily to the cage in the backyard for 1-2 hrs. till five days of age and after five days till transfer, the chicks were taken to the exercise pen made of net in the courtyard. The chicks would follow the keepers around and jump or flap their wings during exercise/playtime (Image 22).

The measurements of chicks were taken regularly with Vernier caliper. The head length, bill length, wing length, tarsus length and height were recorded.



Image 21A. Chick rearing box with heatlamps and rubber mat flooring (top)© WII, where birds are housed and hand fed / imprinted during the initial month (bottom) at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © Dr. Y.V.Jhala



Image 22. Great Indian Bustard Conservation team at the breeding facility at Sam

2.1.7.2.1. Notes on the first age rearing of Great Indian Bustard chicks in Conservation Breeding Centre at Sam, Jaisalmer

Based on growth rate data of the best growers (70 percentile) and above-average growers (50 percentile) among the first eight artificially hatched birds, the following limit of acceptable/target growth in the first age was obtained with the following markers: doubling of mass from day 2 (or the 1st day in first age room) to day 6, quadrupling of the same on day 12 and body mass of around 600g at the end of the first age rearing (day 20).

It is normal to attain near zero growth up to the third day in first age rearing, due to delay in yolk-sac absorption and other reasons, and the chicks should not be pushed towards greater consumption during this stage, but, thereafter, daily food intake should be increased to reach the following consumption target (expressed in wet weight), based on data from above-average feeders among the eight artificially hatched chicks.

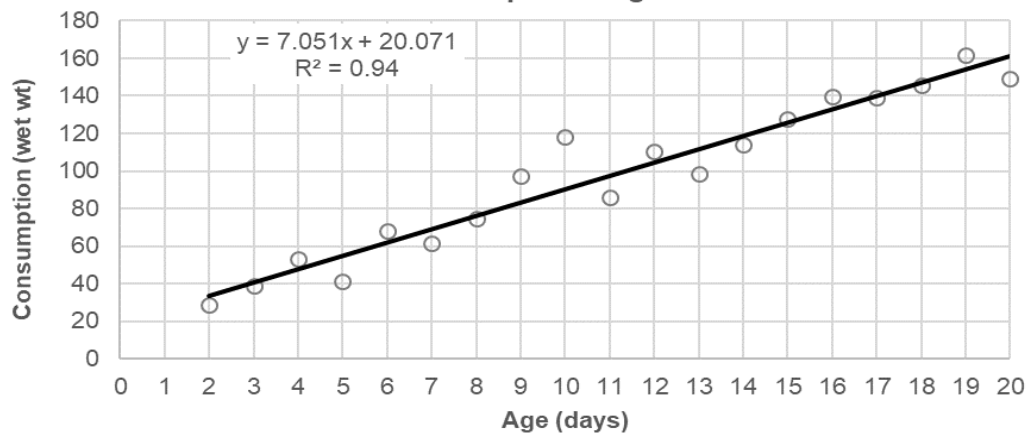


Figure 3. Relationship between age and consumption expressed as wet weight in grams of eight artificially hatched Great Indian Bustard chicks

There are other physical (plumage change, height etc.), behavioral (hopping flights, resting time etc.) and nutritional (angel winging, pellet/fiber consumption thresholds) markers of first age development that are important for documentation.

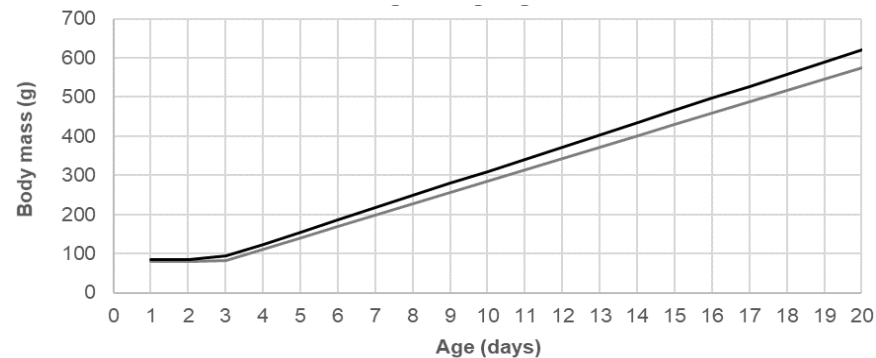


Figure 4. Body mass of average (grey line) and above average (top 25% birds in black line) captive female Great Indian Bustard chicks against age (days), showing the preferred growth rate

2.1.7.3. Second age Great Indian Bustard chick rearing

The chicks were shifted to the outdoor cage around 21 days and are kept till they are autonomous. The birds were fed similar diet of Mazuri Omnivore pellets, dry balanced pellets, mealworms, crickets, locusts, super-worms, boiled poultry/country chicken eggs, alfalfa leaves, mustard leaves, watermelon, pomegranate and other local vegetables and fruits. However, the intensity of hand feeding was diminished and the birds were gradually trained to be autonomous in the consumption at this stage. The consumption was recorded for each day. The birds were weighed twice a day, before the first meal and after the last meal. The height of birds was recorded by taking photographs near a scale for comparison. The feathers were trimmed at regular intervals to prevent them from flying. The chicks were taken to the exercise cage for a few days and then later to the in-house crop field for 1-2 hours daily (Image 24). The chicks were transported by hand after putting a hood on them to minimize stress (Image 23).



Image 23. Transportation of birds by hand after applying a hood to keep them calm at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer. © WII



Image 24. Chicks foraging in the crop field at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer. © WII



Image25. Two birds housed together in the second age outdoor cage at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer. © WII

2.1.8. Veterinary Care at Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer

2.1.8.1. Incubation and hatchery

Two GIB eggs which did not hatch were removed from incubation. Post mortem examination was performed and a late stage embryo was found in the correct position but with no internal pip and an unabsorbed yolk sac in one and the other indicated an infertile egg. The cause of death could not be determined in the fertile egg; however, the embryo was differentiated but underdeveloped.

2.1.8.2. First Age

All the GIB chicks developed a condition called Angel wing in which the wings turn outwards when the growth is faster than normal. Angel wing indicates that the food supplied is high in protein, which is required in the initial stage for growth. This condition was corrected by applying a bandage to the affected wings and all the chicks recovered within a week. There were two cases of curled toes which were corrected by providing exercise on sandy substrate and by using rubber mats as flooring for the first age chicks. There were a few cases of dehydration which were corrected by administering a mix of fluids (Dextrose Normal Saline+ Normal Saline+ Ringer's Lactate Solution) orally by syringe.

2.1.8.3. Second Age

All the GIB chicks were vaccinated for Ranikhet disease after the age of 30 days with Newcastle Inactivated (LaSota strain) by Ventri and against Fowl pox (Live) by Ventri after 90 days. Both these vaccines were administered Intramuscularly. Blood was collected from the first nine chicks twice to check the normal blood parameters, genetic sampling and sexing. There was a case of lameness in both legs in a chick which was treated by giving oral Nonsteroidal anti-inflammatory drug (NSAID) and reducing handling and exercise. There was a case of leg wound which was treated by applying Betadine and a bandage to prevent from pecking. There was one case of wing fracture that was corrected by applying an Intramedullary pin and a supportive bandage. The bird has subsequently recovered from this injury and is currently normal.

2.1.9. Live feed unit at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer

Invertebrates such as mealworms, house and black crickets are produced in-house in two rooms to supply live food that are grown under hygienic and organic conditions to the birds. Mealworms – larva of the beetle *Tenebrio molitor*- are reared in plastic racks within an Air Conditioned room with temperature around 25⁰ C and RH around 40%, and provided with food including wheat-bran and lettuce/apples. Beetles are kept in separate plastic crates to lay eggs in a 2 cm thick layer of wheat bran/flour mixture for a few days. The same batch of beetles lay eggs about 10 times and the whole process of becoming larva usable as GIB feed takes 8 – 9 weeks. Whilst, crickets are reared in plastic racks in a room with AC and auto-regulated heater at room temperature of 30 -35⁰C and RH of 60 -80%, and provided with foods such as bran and lettuce/apples, water in feeders and regular spraying of water to maintain high humidity. House and black crickets are kept separately. Adult crickets require soil to lay eggs and for this, organic potting of soil after drying in the microwave and treatment with disinfectant is used. Soil bowls are kept in adult cricket boxes for 5-7 days and a box of adult crickets can provide 2-3 soil bowls

full of eggs. From egg to becoming an adult for breeding/feeding purpose, it takes 7-8 weeks. The microenvironment these (temperature and RH) of these rooms are logged and monitored daily to maintain optimal ambient conditions for desired production of live food. During the initial days of the Project, invertebrate food was also being procured from suppliers across the country.

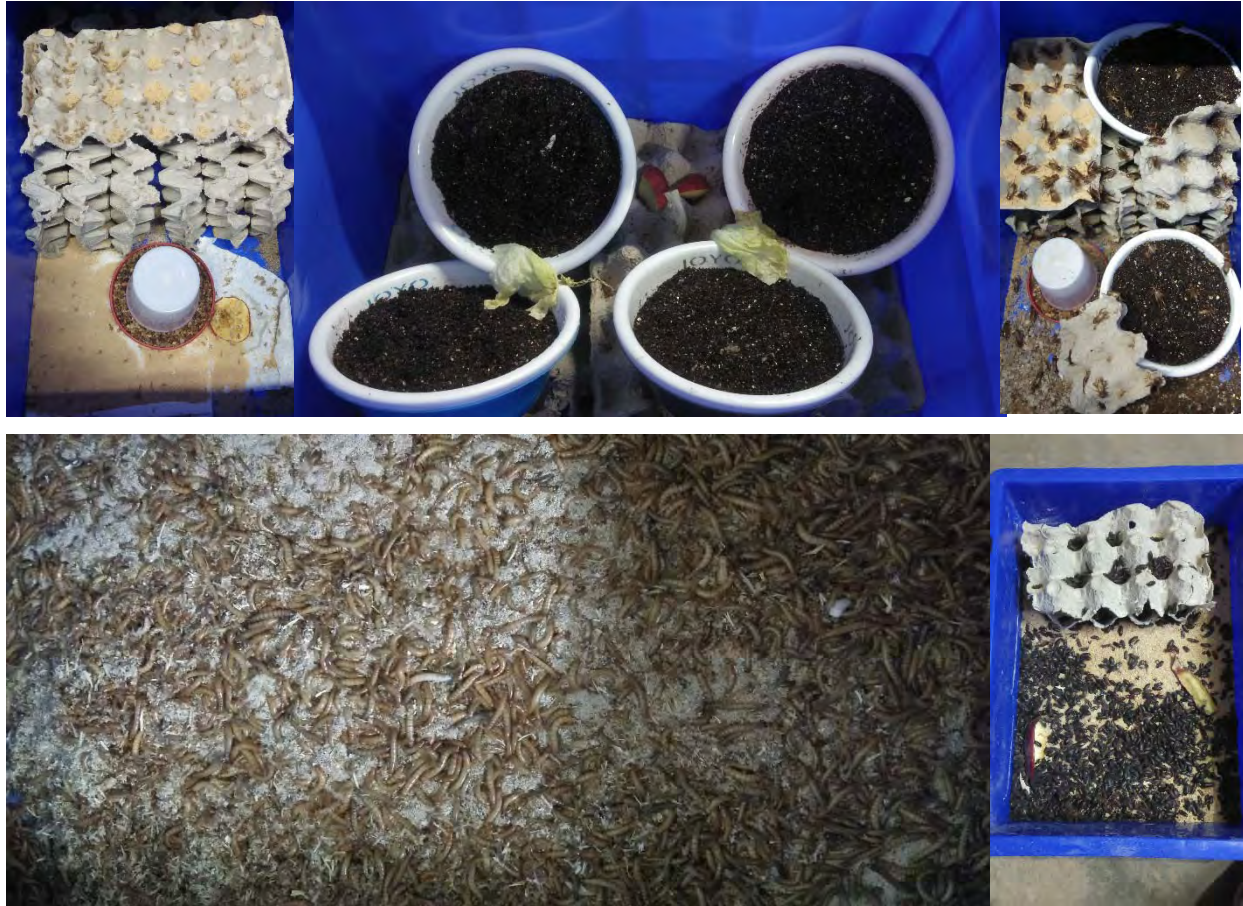




Image 26. Live feed unit; Top- House cricket larvae, soil bowls for larvae, adult black crickets, Middle- Meal worm beetle larvae, Adults and Bottom- Storage crates; in the Great Indian Bustard Conservation Breeding Centre at Sam, Jaisalmer © WII

2.1.10. Sanitation and logistics at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer

The entire Conservation Breeding Centre has high sanitation standards involving daily cleaning of every room/cage up to twice a day, appropriate cleaning of utensils and accessories used in proximity to birds, and a protocol for cleaning and changing into in-house clothes for every technical and support staff working in the Centre. Access to the Centre by visitors is restricted to avoid contamination and stress to birds. The entire Centre is equipped with CCTV surveillance for remote monitoring of birds, human and external activities. The current staff strength of the Centre includes ten technical team members and six logistic team members.



Image 27. Logistic staff at the Great Indian Bustard Conservation Breeding Centre at Sam, Jaisalmer © WII

2.1.11. Way ahead

Nine birds have been shifted to the sub-adult tunnels while the tenth one is in the Juvenile cage at the Conservation Breeding Centre at Sam, where they will stay till the next breeding season. Meanwhile, the Ramdevra Conservation Breeding Site construction will be completed through CPWD and soft modifications/touch-up by local contractor(s), before the next season so that this Centre becomes operational from next year.

APPLIED RESEARCH



Bustard Recovery Program /Annual Report III/2018-2020

2.2. Applied research

2.2.1. Satellite telemetry

2.2.1.1. Space use and ranging patterns of Great Indian Bustard using satellite telemetry

2.2.1.1.1 Tagging of Great Indian Bustard in Desert National Park, Jaisalmer

Permission to tag four GIB was obtained in February 2019 and we commenced the exercise immediately. A pilot tagging exercise was conducted during 22nd to 26th February 2019 with the technical consultation of Dr. Juan Carlos Alonso, International bustard expert from the National Museum of Natural Sciences-Spanish Council for Scientific Research, but were unable to tag any bird. The second tagging attempted was carried out from 20th March – 1st May 2019. Research team from WII, comprising of Project co-investigator Dr. Sutirtha Dutta, Project staff Dr. Tushna Karkaria (Veterinarian), Mr. Bipin C. M., Mr. Arjun Awasthi, Mr. Mohib Uddin, Mr. Devendradutt Pandey, Ms. Tanya Gupta, project interns/assistants, and bird trapper Mr. Aslam undertook this exercise. Pre-tagging fieldwork was conducted from 20th to 30th March 2019 for understanding bird movements and predictable usages. Capture and tagging was carried out in DNP during 31st March 2019 to 01st May 2019 in consultation with the Rajasthan Forest Department (Jaisalmer Wildlife Division) with the support of Dr. Shravan Rathore, Senior Veterinary Officer - Jodhpur, Mr. Kapil Chandrawal- Division Forest Officer (DFO), Mr. Vijay Borana- Assistant Conservator of Forest, Mr. Sriram Saini (Range Officer, Sam) and Mr. Danveer (Forest Guard, Sudasari). Commanding Officer of Pokhran Field Firing Range was informed and sensitized regarding the exercise and possible movement of tagged birds in the Firing Range.



Image 28. Great Indian Bustard tagging team in Desert National Park, Jaisalmer © WII

Two GIB females were captured using noose traps and fitted with solar powered E-obs GSM/GPRS backpack PTTs using elastic harness material that weighed < 1% of their body weights. These tags were equipped with acceleration and GPS sensors that were programmed to collect movement data at every 3 min and transmit them daily at 07:30 IST. Birds were tagged on 31st March 2019 and 11th April 2019 and monitored intermittently on ground till two weeks. Birds have been transmitting data for months now (range: 73 days for GIB-Thar-5946 – 936 days for GIB-Kachchh-01) and there is no apparent anomaly in their behavior. Movement data is disseminated to the concerned Forest Department officers on an automated daily basis. Hitherto

unknown basic information on GIB space use and ranging patterns based on telemetry is reported here. In future, tag information will be used to assess critical habitats (for conservation planning), frequent movement paths, flight heights (for power line mitigation), and in searching nesting sites (for conservation breeding). The accelerometer data of the tags will be used to remotely understand the bird's behavior using calibration experiments.



Image 29. Glimpses of Great Indian Bustard tagging exercise in Jaisalmer and Kutch © WII

2.2.1.1.2. Home range of tagged Great Indian Bustards

The GPS fixes acquired from tagged GIB were plotted on GIS domain to assess their home range and movement patterns with respect to protected enclosures created by Rajasthan Forest Department and power lines which are the primary current threat to these birds. Bird home range was estimated from 1-hour interval fixes (for independence and uniformity between tags with varying data resolutions) using 95% Minimum Convex Polygon technique, and their core usage areas were estimated using 50% Kernel utilization distribution technique.

Key findings were that bird home ranges ranged between 76 km² (three years' long-term usage of GIB-Kachchh-01) – 124 km² (three months' short-term usage of GIB-Thar-5946). The 50% usage areas of birds were relatively small, ranging between 13–29 km². The core usages for birds in Jaisalmer are short-term spanning a few months and their annual core usage may be larger. However, for the tagged bird in Kachchh, which yielded data for over three years, the core usage was only about 15 km². Moreover, majority of bird locations were within protected enclosures (44% for GIB-Thar-5946 and 88% for GIB-Thar-5949). The tagged bird GIB-Thar-5949 crossed a transmission line twice in 169 radio-tracking days, while GIB-Thar-5946 did not cross any transmission line, while GIB-Kachchh-01 crossed multiple power lines several times.

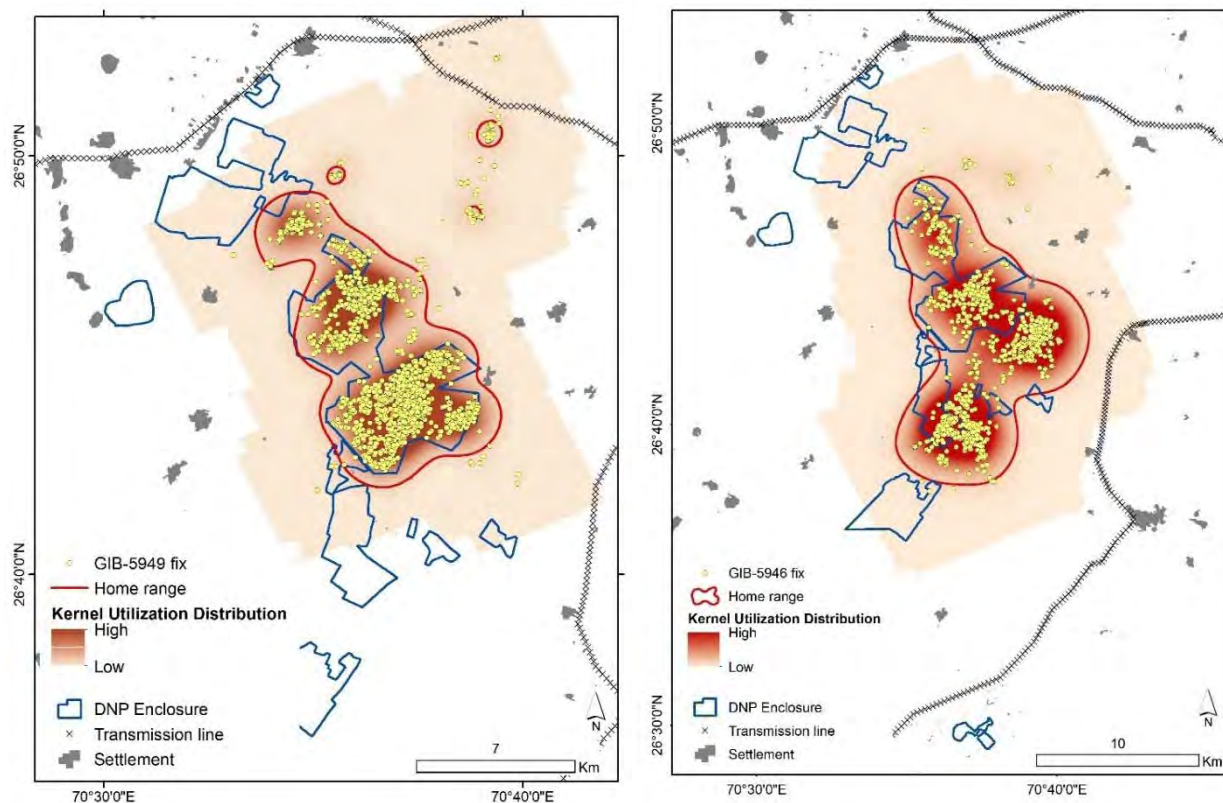


Figure 5. Space use (GPS fixes and home range estimated as Kernel 95% contour) of two tagged GIB females in Thar during March – October 2019

These results corroborate the recommendation of Dutta et al. (2013)'s National Bustard Recovery Guidelines that enclosures of 10-20 km² area that are scientifically managed (predator proofing and habitat management) can accommodate the birds' ecological needs to a great extent. This action supplemented with power line mitigation in the areas surrounding enclosures is necessary to restore potential habitats across the species' range, wherever feasible.

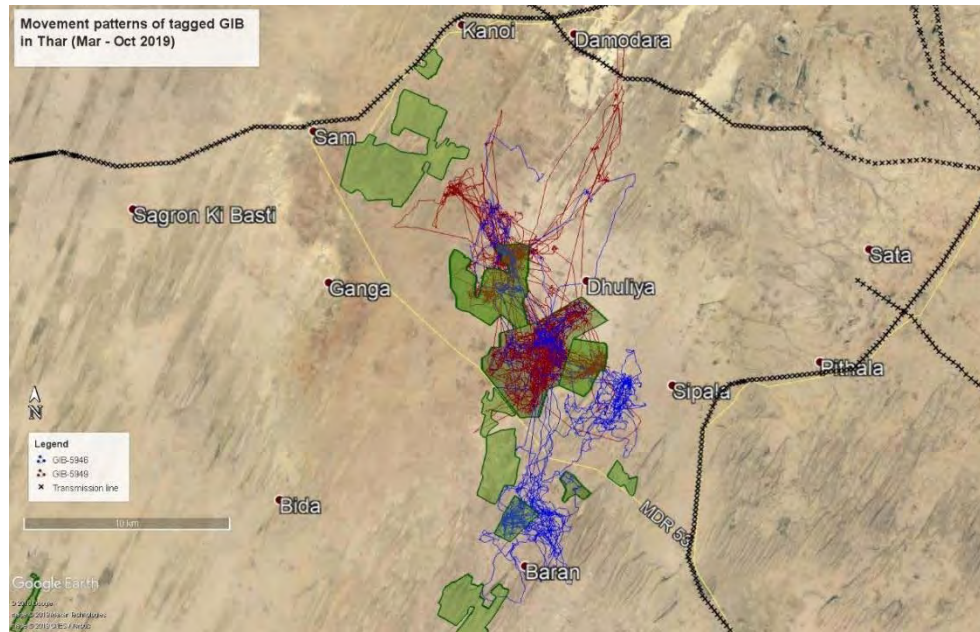


Figure 6. Movement paths of two tagged Great Indian Bustard females during March – October 2019 overlaid with high tension power line in Thar

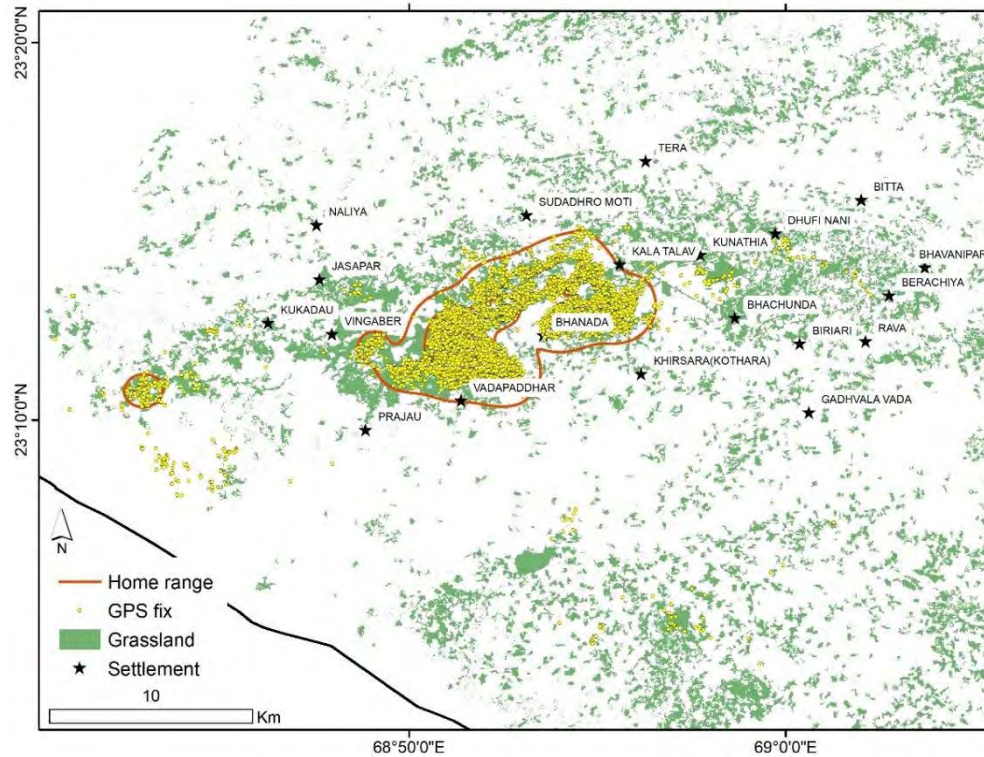


Figure 7. Space use (GPS fixes) of tagged Great Indian Bustard female in Kachchh from May 2017 to October 2019

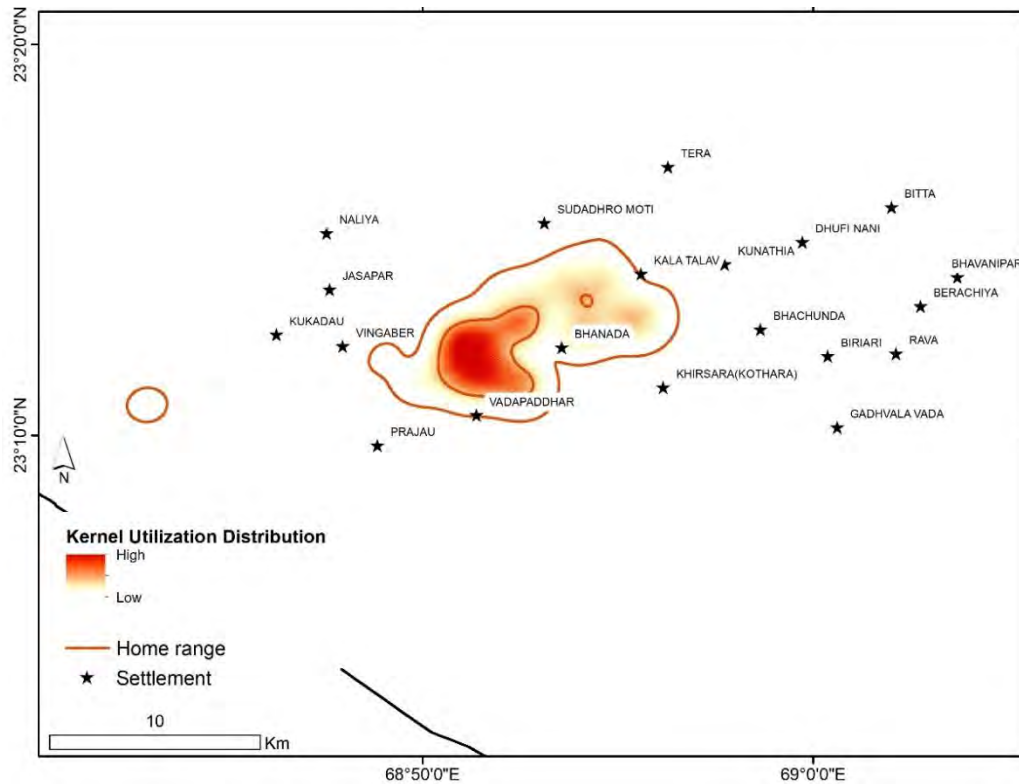


Figure 8. Space use (Home range estimated as Kernel 95% contour) of tagged Great Indian Bustard female in Kachchh from May 2017 to October 2019

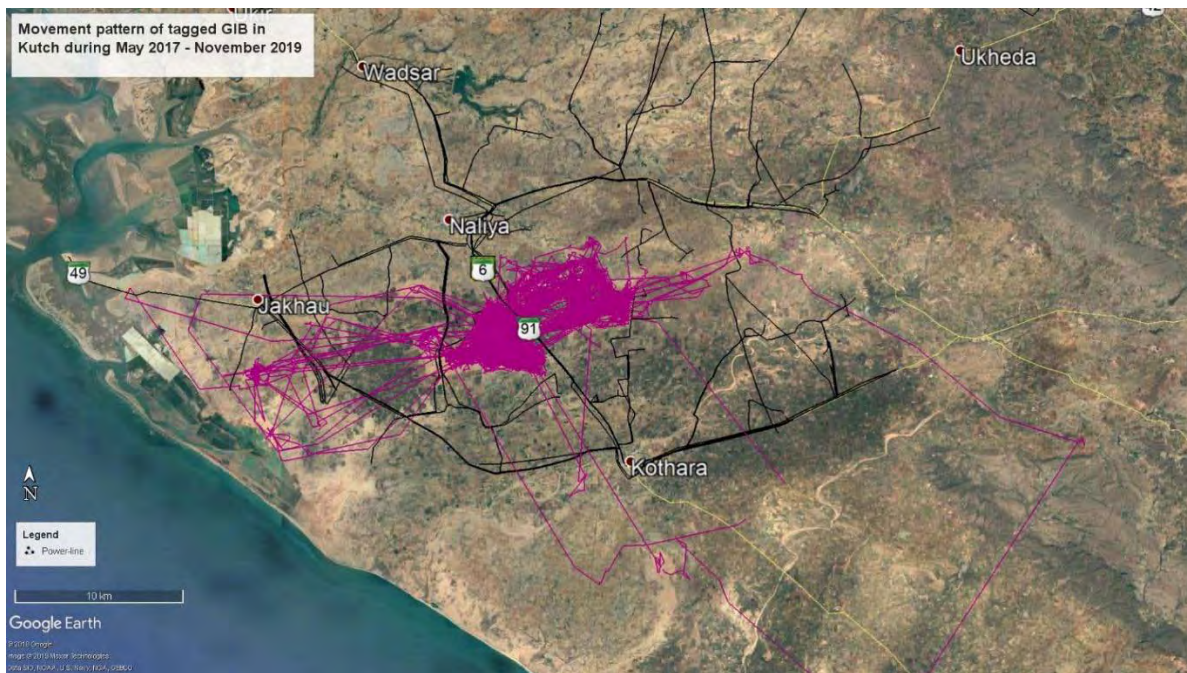


Figure 9. Movement path of tagged Great Indian Bustard from May 2017 to October 2019 overlaid on power line network (partially mapped) to prioritize power line mitigation in Kachchh.

Table 3. Descriptive statistics of Great Indian Bustard ranging based on biotelemetry in Jaisalmer and Kachchh during 2017-19

Parameter	GIB-Thar-5949	GIB-Thar-5946	GIB-Kch-01
Home range (km ²)- MCP 95%	89	124	76
Core usage (km ²)- Kernel 50%	13.3	28.9	14.8
Daily travel distance (km)	11.2 ± 4.65 SD (range 1.7–22.7)	11.9 ± 4.7 SD (range 2.6–26.1)	6.2 ± 4.1 SD (range 0–47)
Ground speed (ms ⁻¹)	0.64 ± 0.39 SE	0.62 ± 0.29 SE	-
Conservative bias-corrected speed (ms ⁻¹)	0.29 ± 0.30 SE	0.25 ± 0.26 SE	-
Radio-tracking days	169	73	936
Count of fixes	152483	88816	55633

2.2.1.1.3. Speed of tagged Great Indian Bustards

The E-obs GSM/GPRS tags deployed on GIB in Thar collect information on the bird ground speed using Doppler effect. However, these tags acquire more fixes when birds are active, thereby positively biasing the ground speed estimates. A conservative correction was applied by supplementing the missed fixes with no movement, whenever applicable, and reported both directly estimated and bias-corrected (conservative) ground speed estimates. Ground speed is a reliable surrogate of bird activity per movement, and reflected the crepuscular pattern of GIB activity with peak movements during 0600-0800 hrs. and 1800-1900 hrs. in summer (Figure 10)

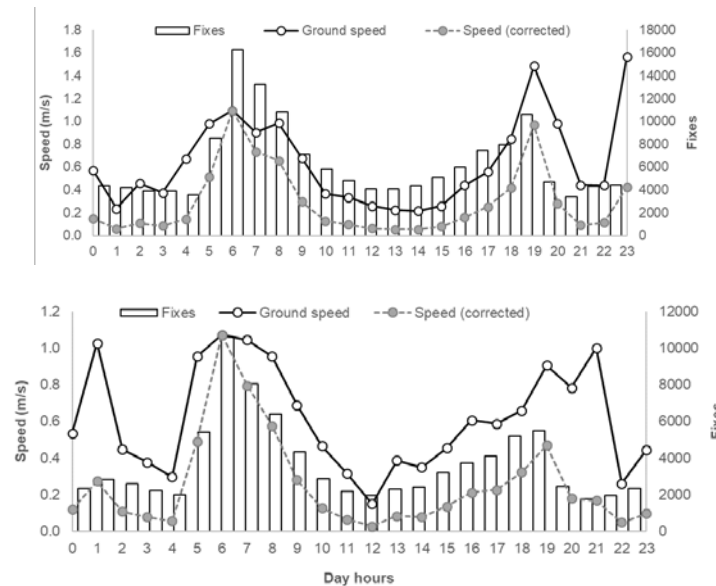


Figure 10. Ground speed: (i) estimated by tag using Doppler effect (black solid line), (ii) conservatively corrected for increased fix acquisition during peak movement hours (grey dotted line), and (iii) count of fixes (open bars) of tagged Great Indian Bustard (GIB-Thar-5949: top and GIB-Thar-5946: bottom) against hour of the day from March to November 2019

Based on ground-speed from fixes separated by 1-hour intervals (for independence and uniformity across tags), a very small proportion of movements (0.68% for GIB-Thar-5949 and 0.32% for GIB-Thar-5946) indicated potential flights ($>2 \text{ ms}^{-1}$ or $>7 \text{ kmh}^{-1}$ ground speeds). Even this is likely to be positively biased as more resting events will be missed, given that the tag acquires more fixes when birds are active/moving (Figure 11). Thus, $<1\%$ of the bird's daily budget comprises of flying, yet that leads to a significant risk of fatal collisions with power lines, as evident from the bird carcass detections during power line surveys in Jaisalmer during 2017–18 (presented in Annual Progress Report 2017-18).

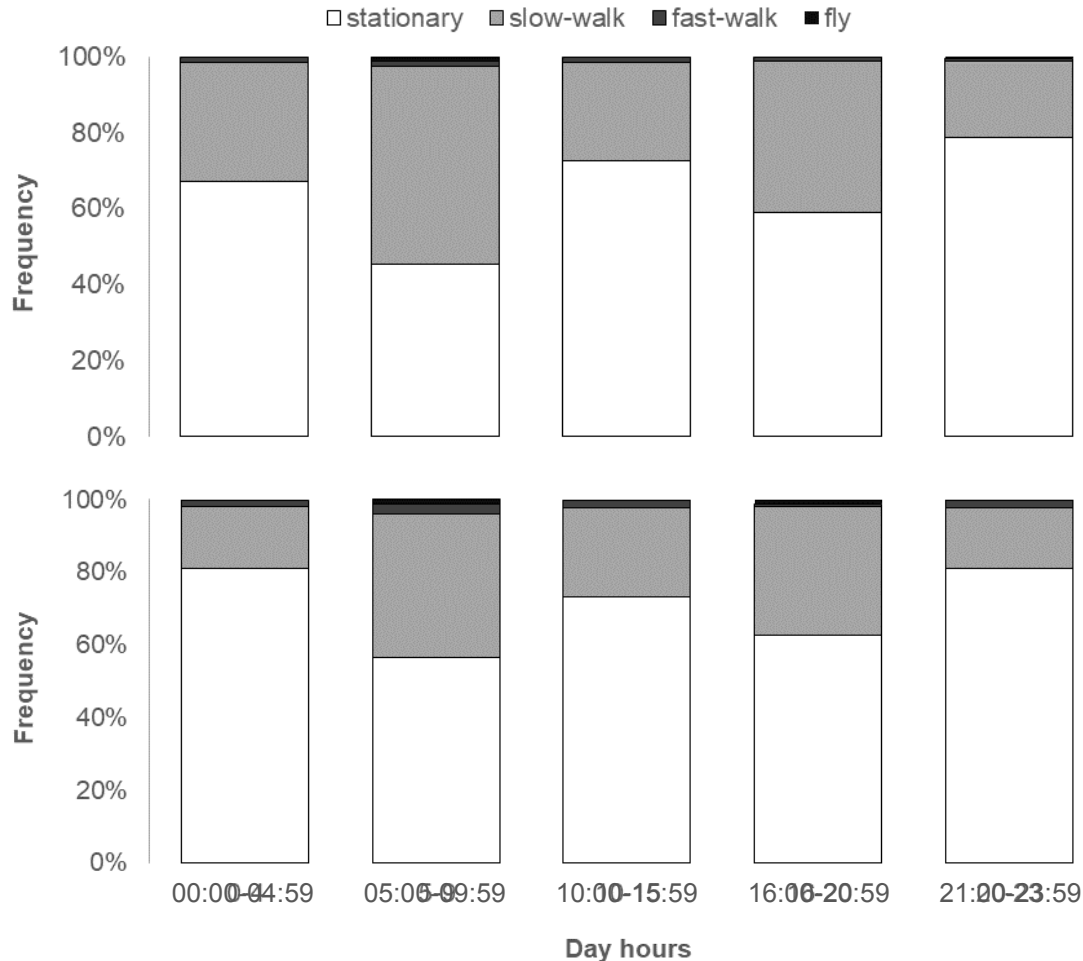


Figure 11. Frequency of independent events (separated by 1-hour for uniformity) classified into four movement classes: stationary (ground speed $<0.3 \text{ ms}^{-1}$), slow-walk ($0.3\text{--}1.0 \text{ ms}^{-1}$), fast-walk ($1.0\text{--}2.0 \text{ ms}^{-1}$) and flight ($>2 \text{ ms}^{-1}$) across hour of the day for tagged Great Indian Bustards (GIB-Thar-5949 at top and GIB-Thar-5946 at bottom) in Jaisalmer during March–November 2019

2.2.1.1.4. Travel distance of tagged Great Indian Bustards

Distance traveled by the birds, estimated from successive GPS fixes summed over days, indicated that the travel distances were highly variable between days ($11.2 \pm 4.65\text{SD}$ for GIB-Thar-5949, $11.9 \pm 4.7\text{SD}$ for GIB-Thar-5946 and $6.2 \pm 4.1\text{SD}$ for GIB-Kachchh-01). The average travel distances were similar between the two tagged birds in Thar and almost double

than that of Kachchh; that may reflect habitat/resource differences as Kachchh is a more productive landscape than Thar, or can be an artifact of relatively sparse fix acquisition for the bird in Kachchh, which can underestimate distance measures and needs to be examined. The daily lower and upper limits of bird movement were about 25 and 5 km respectively for tagged birds in Thar that transmitted very high resolution and accurate location data at every 90 secs on average (figure 11A).

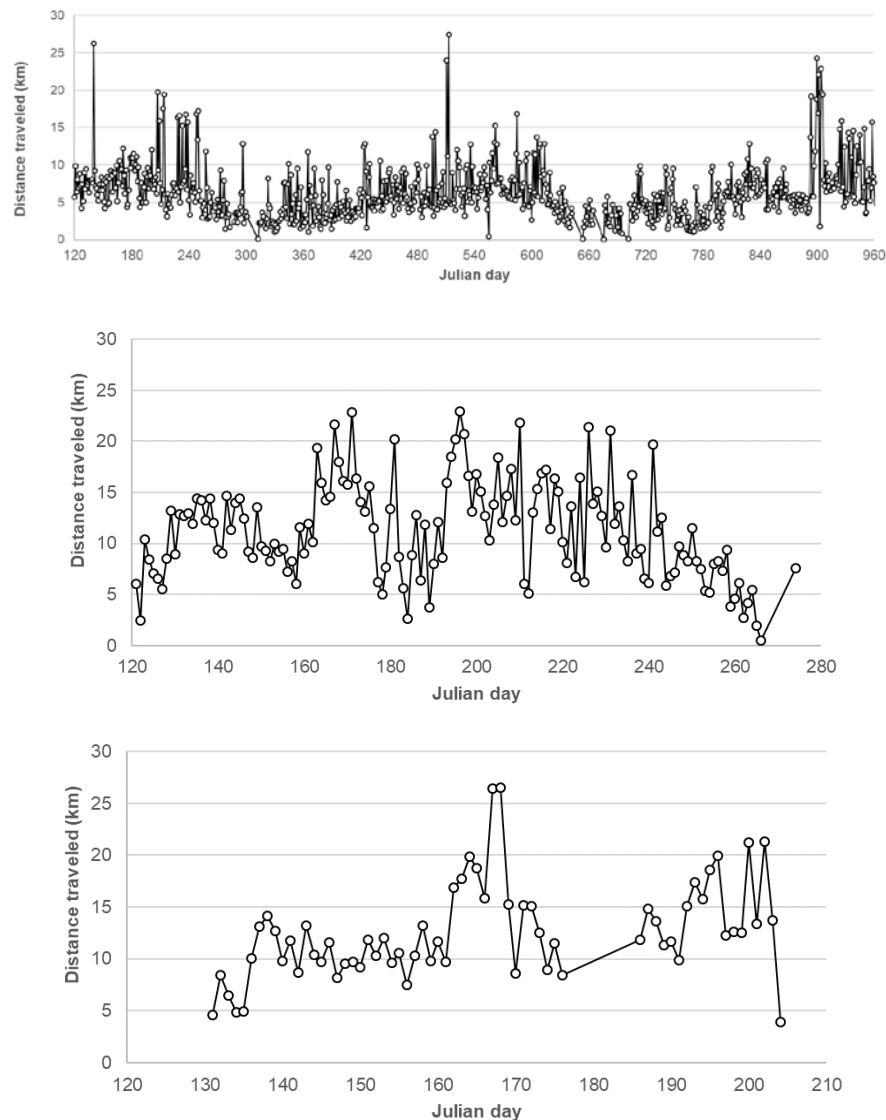


Figure 11A. Distance traveled by tagged Great Indian Bustard (top to bottom: GIB-Kachchh-01, GIB-Thar-5949 and GIB-Thar-5946) in Kachchh and Jaisalmer against Julian days starting from 30th April 2017 in Kachchh and 31st March 2019 in Jaisalmer to November 2019

2.2.1.1.5. Tag diagnostics

The tag performance was remotely monitored in terms of the battery voltage and activity sensor information to diagnose issues related to tag malfunction and/or mortality (Figure 12). A ny mortality incident was not diagnosed with these three tags, but the GIB-Thar-5946 tag is

potentially malfunctioning or is in no GSM network zone. The GIB-Thar-5949 also underwent battery drainage but had recently revived and transmitting data.

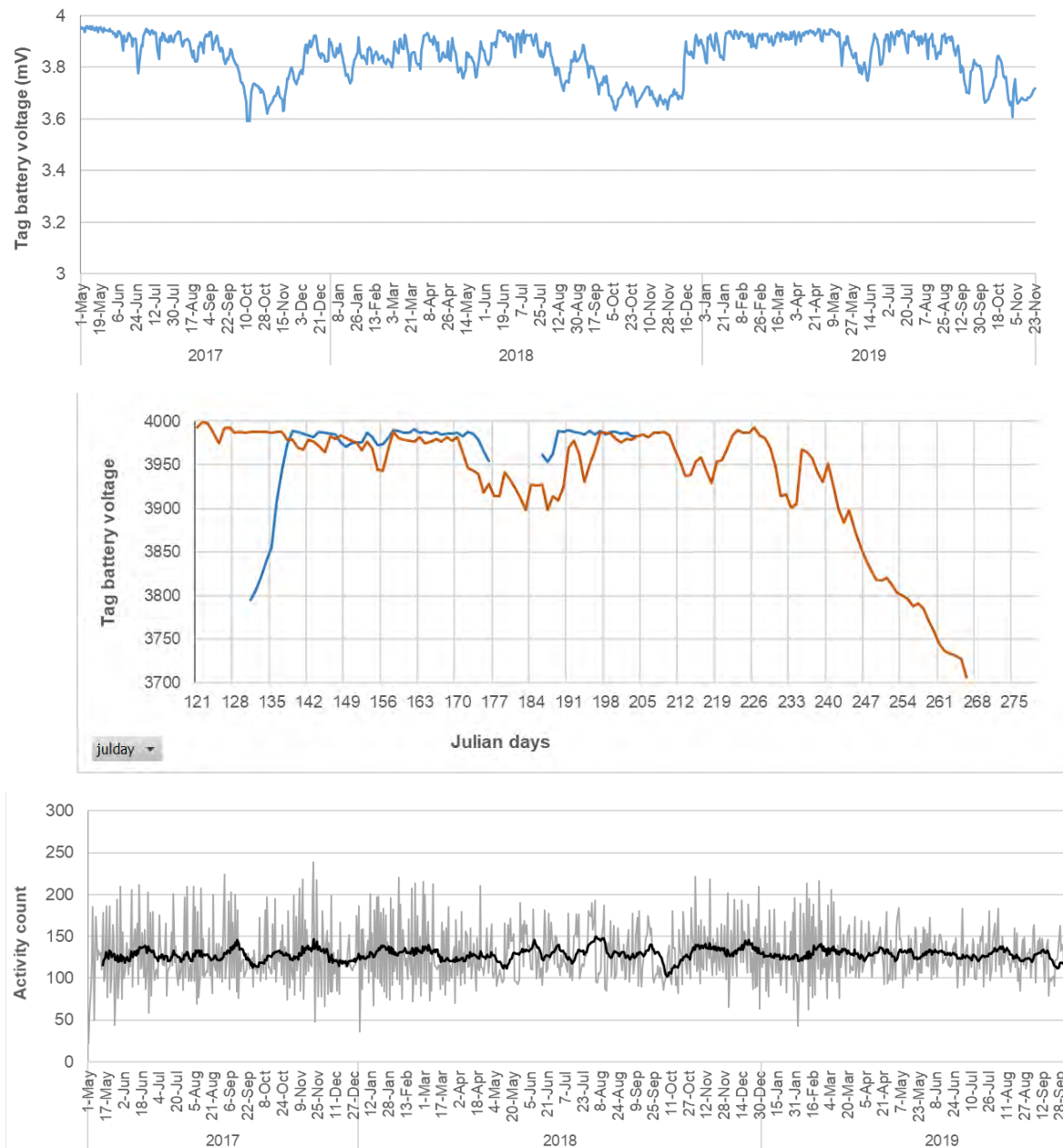


Figure 12. Tag performance diagnostics: battery voltage (top: GIB-Kachchh-01, middle: GIB-Thar-5946 in blue, GIB-Thar-5949 in red) and activity count based on activity sensor (bottom) of tagged Great Indian Bustard in Jaisalmer and Kachchh from March 2017 to November 2019

2.2.1.2. Satellite tagging and preliminary findings of Lesser Florican movement

Lesser Florican is an endangered bird that inhabits agro-grassland habitats. There is a lacuna of information regarding the species' biology and ecology, especially during the non-breeding seasons due to the elusive nature of the species. Proper information regarding food habits, nesting and chick-rearing site preferences, habitat preferences during non-breeding season and response to anthropogenic disturbances is required to formulate robust conservation plans. The approach of satellite telemetry along with simultaneous ground tracking and ecological monitoring being carried out would provide this crucial information.

2.2.1.2.1. Tagging of Lesser Florican in Ajmer, Rajasthan

Prior to the tagging exercise, Lesser Florican presence and its movement was monitored starting from August, 2019 in the known breeding grounds in Shokaliya-Kekri region of Ajmer. This tracking was conducted to identify feasible locations where traps could be laid. The trapping and tagging were attempted from 13th-18th September, 2019 in the agricultural fields of Bhatiyani and Kalyanpura villages of Ajmer. At daybreak, noose traps lines were laid in areas of the cropfield where the bird was likely to cross. These lines were then continuously monitored from different vantage points. A quick response team was on standby in the vicinity in case a bird got captured or to release any non-target captures. The team comprised of Dr. Sutirtha Dutta, Project staff Dr. Tushna Karkaria (Veterinarian), Mr. Mohib Uddin, Mr. Sourav Supakar and were assisted by Dr. Shravan Rathore, Senior Veterinary Officer - Jodhpur, Ms. Sudip Kaur DFO, Mr. Lokesh Sharma ACF, Mr. Rajendra Singh Rathore (Forest Guard) of Ajmer Division, Rajasthan Forest Department.

One Lesser Florican male, later named Sufi, weighing 463 g was captured in the trap on 15th September, 2019 at 07:59 AM in Kalyanpura (GPS co-ordinates- 26.12058 N/ 74.77043 E). It was fitted with a Milsar S-9 GSM tag and released. The light weight tag with a solar powered battery pack, weighed <4% of the bird's body weight and transmits locations via a cellular network. The tag was programmed to record the GPS co-ordinates at an interval of 60 minutes and to transmit the recorded locations every eight hours effectively giving 24 location points per day.

2.2.1.2.2. Monitoring of tagged Lesser Florican

The tag fitted on the Lesser Florican has been providing information about its movement patterns and used locations. To assess the type of habitat that the bird is selecting, ground tracking of the bird is being carried out since tagging. The location-points of 24 hours were divided into five intervals based on the time of day (00:00hrs - 05:00hrs, 05:00hrs -10:00hrs, 10:00hrs -15:00hrs, 15:00hrs - 20:00hrs, 20:00hrs - 00:00hrs). One point was selected at random for each class, giving a total of five data-points per day. Each of the locations were visited when feasible (when the bird wasn't in the vicinity so as not to disturb the bird) and habitat characteristics such as landscape type, terrain, vegetation composition in 50m and 100m radius along with arthropod number and disturbances were recorded. To assess the threat perception of the bird, a checkered board of dimension 100cm × 50 cm with 50 squares of 10cm dimension was used. An observer would crouch at the known location of the bird and another person would display the board at a

distance of 20m, 50m, 100m and 200m at all four cardinal directions respectively. The number of boxes visible from each distance for each direction were recorded.

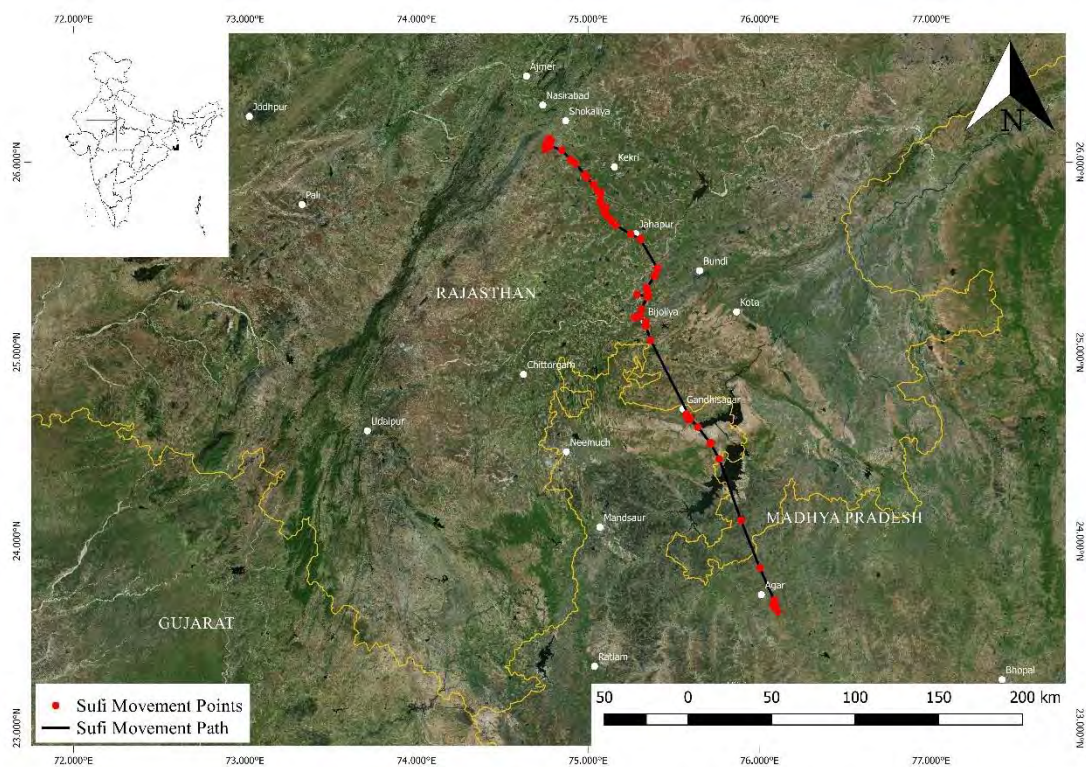


Figure 13. Movement of tagged Lesser Florican male (named Sufi) from 15th September, 2019 - 23rd February, 2020

2.2.1.2.3. Movement and current status of the tagged Lesser Florican

Post tagging, the bird had stayed within a 500-600m vicinity of the area where it had been captured and released (Kalyanpura, Ajmer). It used to move to different crop fields in the area based on harvesting pattern of the crops and consequent human activities in the fields. But the locality remained unchanged for nearly a month after tagging. By 09th-10th October most of the shorter crops (Moong, Til and smaller Jowar) had been harvested and the lands tilled for next session of crops. From then on, the bird started to move to a different location. From 09th- 20th October, it moved within 2-3 kms between the villages of Kalyanpura, Ratanpura, Udaigarh Khara and Bhinai in Ajmer staying at one place for a few days and then moving to the next, still within a range of 2-6 km from its initial tagged location.

The longer journeys (10-20 km in a day) started immediately after this when the bird moved south-eastward stopping for a few days at one location but moving constantly. At Jahajpur and Marari, Bhilwara it changed its direction to South-west and started moving towards Bijoliya, Bhilwara on 4th November, 2019. It stayed in and around the vicinity of Bijoliya till 18th November where after it moved inside Gandhi Sagar Wildlife Sanctuary, Mandasaur (Madhya Pradesh). It stayed inside the Sanctuary for twelve days and moved towards Agar, Madhya Pradesh on 1st December. As of 12th December, 2019, it has stayed in the agricultural fields of

Palda village 10km South-east of Agar. During this period, the maximum distance in a day the Lesser Florican has moved is 101 km (Table 4). From the day the bird has been tagged, it covered a distance of 446 km (305 km aerial distance from tagging location to last location) in 88 days (15th September – 12th December, 2019) encompassing two states.



Figure 14. Tagging of Lesser Florican during September 2019 in Nasirabad, Ajmer District, Rajasthan© WII

Table 4. Distance moved by the tagged Lesser Florican

S no.	Phase	Duration	Daily distance moved (km)		Total distance moved (km)
			Mean (SE)	Range	
1	Breeding (last stage)	16 September-09 October 2019	0.93 (0.16)	0.36 – 4.09	21.32
2	Pre-migration	10 - 20 October 2019	1.78 (0.4)	0.3 - 4.91	21.36
3	Migration	21 October – 12 December 2019	7.61 (2.31)	0.45 - 101.69	403. 27

2.2.2. Population and habitat surveys

2.2.2.1. Lesser Florican range surveys for population and habitat status assessment in 2018

The ecology and population status of endangered Lesser Florican are poorly known that impedes conservation efforts. To fill this gap, a national status survey was designed by the Project in 2017-18 and was jointly implemented with NGO partners and State Forest Departments across the species' breeding range. A follow-up survey was carried out in the year 2018 jointly by WII, BNHS, The Corbett Foundation (TCF) and Hyderabad Tiger Conservation Society (HyTiCoS) in collaboration with the state Forest Departments of Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh following similar methodology as 2017-18. This report presents the latest findings on Lesser Florican distribution, abundance, habitat status, threats and their implications for conservation.

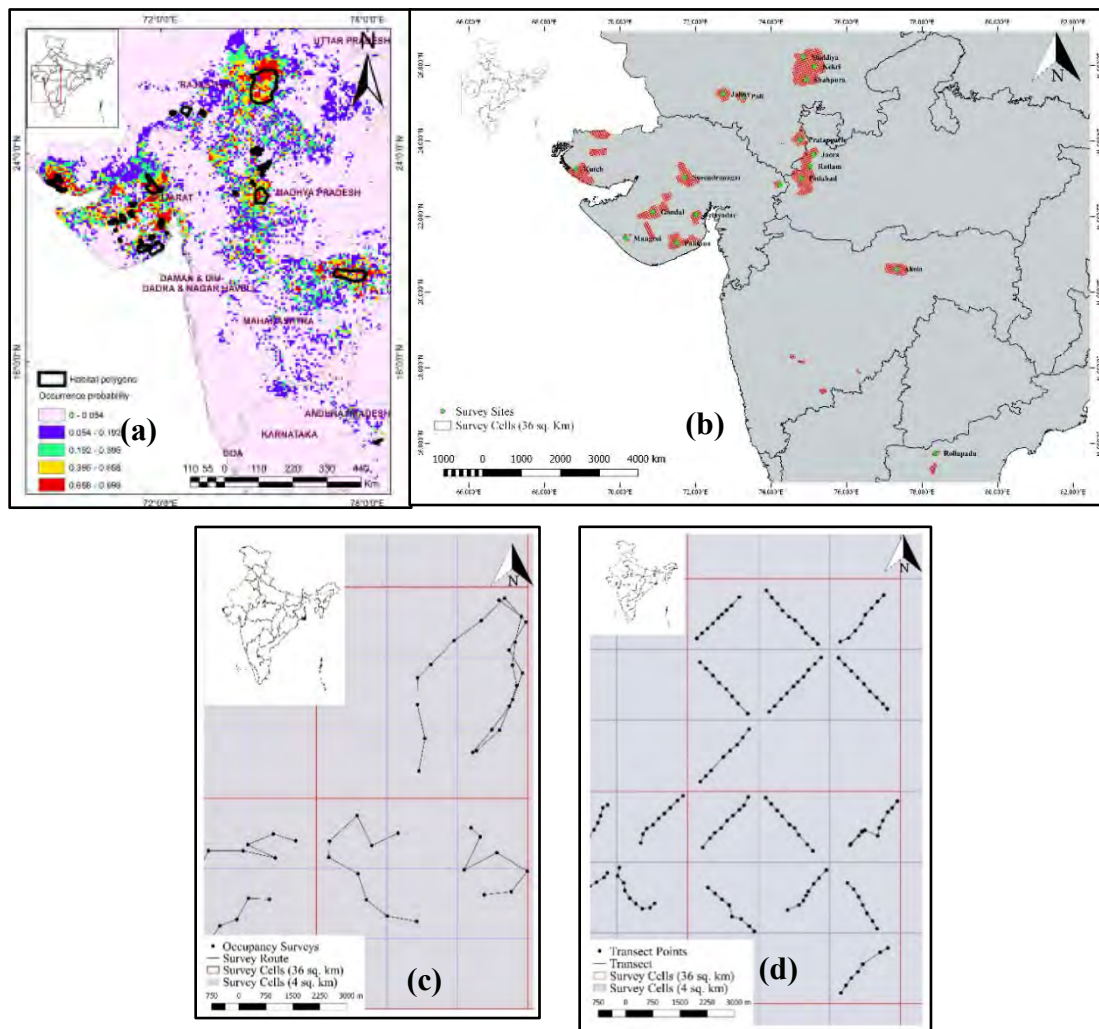


Figure 15. Habitat suitability map showing occurrence probability of Lesser Florican across its breeding range based on Maxent modeling along with digitized habitat polygons (b) Breeding range classified into survey regions, landscape and sites, Graphical representation of (c) point-count based occupancy and (d) line transect based distance sampling for status assessment of Lesser Florican across the breeding range in 2018

Lesser Floricans' breeding range was delineated using informed digitization with the aid of MaxEnt distribution model, and inputs from local experts. The species' status was assessed based on displaying males, using spatially representative sampling and analytical design that accounted for imperfect detection. The assessment used a hurdle modeling approach, where we (i) first estimated the species' occupancy in 36 km² cells using vehicle observation points (stop-overs), (ii) then estimated the species' abundance at detected sites (subset of occupied sites) using line transect distance sampling, (iii) measured habitat characteristics (land cover, vegetation structure and anthropogenic pressures) systematically along occupancy and distance surveys, (iv) explored and developed statistical relationships between habitat covariates and occupancy/abundance, and (v) mapped the species' distribution, local densities and threats, to generate conservation priority map. Inferences were drawn at the scale of breeding range and eco-geographically defined regions and landscapes (Ajmer: Shokaliya-Kekri; Rest of Rajasthan: Shahpura, Jalore, Pratapgarh; Gujarat: Kutch, Saurashtra; Madhya Pradesh: Ratlam; Deccan: Akola-Washim in Maharashtra and Kurnool in Andhra Pradesh) (Figure 15).

The status survey was conducted during the breeding season (July– September, 2018) with a team of 141 observers, who were trained on the standard data collection protocol through state-level workshops at Bhavnagar, Ujjain, Ajmer and Akola (Table 7). Lesser Florican occupancy was assessed at 545 sites (36 km²) spread across ~31,000 km² range, using 8333 stop-overs, and density was assessed in 43 sites (where the species was detected) using 632 km transect-walks that yielded 134 sightings (116 males, 18 females).

Lesser Florican occupied 9.6 (2.3SE) % sampled sites (5.5% naïve occupancy) or 2972 km² area, at ecological density of 0.20 (0.07SE) territorial males per km² (Table 5). The population size was estimated to be 426 (174–805 95% CI) territorial males with a conservative estimate of 220 (38 SE) birds in the covered region (Table 5). These results indicate that their population has declined by ~80% in last 3–4 generations (since 2000). Regional assessments indicated that the population was largely restricted to: Velavadar (Bhavnagar, Gujarat) and Shokaliya-Bhinai (Ajmer, Rajasthan).

Table 5. Regional occupancy and ecological density (numbers km⁻²) of Lesser Florican males across the species breeding range during July–September 2018.

Region	Description of sites	Occupancy (95% CI)	Density km ⁻² (95% CI)
Ajmer	Shokaliya, Bhinai & Malpura	0.35 (0.19-0.55)	0.23 (0.14-0.39)
Deccan	Akola-Washim in Maharashtra & Rollapadu in Kurnool, Andhra Pradesh	0.03 (0-0.18)	0 (0-0)
Gujarat	Kutch, Surendranagar, Bhavnagar, Rest of Saurashtra & Dahod	0.04 (0.02-0.11)	0.72 (0.31-1.7)
Madhya Pradesh	Ratlam (Saliana), Sardarpur & Petlawad	0.08 (0.03-0.18)	0.06 (0.02-0.24)
Rest of Rajasthan	Shahpura, Jalore, Pali & Pratapgarh	0.04 (0.01-0.16)	0 (0-0)
Global		0.1 (0.05-0.15)	0.2 (0.1-0.39)

Birds were dispersed over a large agricultural expanse at low density in Ajmer -occupancy 35 (9 SE) % and ecological density $0.23 (0.06 \text{ SE}) \text{ km}^{-2}$ and clustered at high density in Gujarat -occupancy 4 (2 SE) % and ecological density $0.72 (0.32 \text{ SE}) \text{ km}^{-2}$, mostly within a small grassland reserve and surrounding area in Bhavnagar ($\sim 100 \text{ km}^2$). This inverse density-occupancy relationship perhaps resulted from a flexible social/spatial organization, implying that a contiguous grassland would achieve the same conservation outcome as a much larger agricultural area would. Habitat characteristics inclusive of land-uses, vegetation structure, crop composition, insect abundance and anthropogenic disturbances, as well as associated species' status across Lesser Florican landscapes as baseline information are reported here for monitoring changes over time (Table 6A and 6B).

The methodology used here for estimating Lesser Florican population assumes that expected abundance at sites where species was present but not detected was similar to that where species was detected. If this assumption is violated, which is likely when the species is missed in sites with fewer than average individuals, then the estimated global population size will be positively biased. To avoid this issue, we emphasize the 'minimum population size' of 220 individuals as a conservative estimate of the population.

Highlighting that Lesser Florican population might have dwindled by $\sim 80\%$ over last 3–4 generations, immediate scaling up of efforts for the species' conservation is required. The priority sites for conservation actions are Shokaliya and Saurashtra landscapes followed by Kutch and Kekri landscapes, followed by Ratlam, Shahpura and Akola landscapes. The key recommendations for priority sites are to:

- a) provide protection to sites by creating conservation areas and implementing strict patrolling by Forest Department and local communities;
- b) regulating intensive land-uses such as infrastructural, industrial and salt panned developments, and mitigate existing infrastructure such as power lines;
- c) implementing scientific grasslands management by consolidating relatively large contiguous grasslands, restricting livestock grazing for monsoon months (June–September), restoring habitats by removing exotic shrub/tree plantations;
- d) incentivizing Florican-friendly agricultural practices by promoting scattered organic farming and stall-feeding of livestock in monsoon months against compensations;
- e) consolidating networks of local people or 'Florican friends' who can report and prevent detrimental activities;
- f) reducing nest/chick predation by free-ranging dogs by undertaking a holistic dog population control program in neighbouring villages;
- g) generating scientific information on Lesser Florican ecology particularly during the non-breeding season to aid conservation management using satellite telemetry and associated surveys;
- h) advocacy and outreach programs to generate support among multiple stakeholders for Lesser Florican conservation.
- i) given the potential decline of the species, gaps in knowledge regarding their key threats, and inherent difficulties in implementing urgent conservation actions in their vast unprotected habitats, a conservation breeding program should be implemented urgently to secure an *ex situ* population as an insurance and for possible reintroduction in future. Given the current numbers, there is still a window of opportunity for recovery of the Lesser Florican.

Table 6 A. Regional habitat characteristics (land-use, vegetation structure, crop composition, disturbances), associated species, and sampling details across Lesser Florican breeding range during July – September 2019 with standard error in brackets

	Attributes	Unit	Akola	Jalore	Kekri	Kutch	Pratapgarh	Ratlam	Rolla-padu	Saurashtra	Shah-pura	Sho-kaliya	Global
Land-uses	Grassland		0.205 (0.027)	0.172 (0.024)	0.185 (0.024)	0.16 (0.02)	0.21 (0.047)	0.241 (0.017)	0.139 (0.042)	0.19 (0.013)	0.233 (0.019)	0.2 (0.016)	0.2 (0.007)
	Agricultural		0.696 (0.029)	0.43 (0.035)	0.663 (0.028)	0.237 (0.024)	0.74 (0.041)	0.709 (0.019)	0.799 (0.049)	0.55 (0.015)	0.542 (0.025)	0.569 (0.024)	0.585 (0.01)
	Scrubland	Proportion cover	0.066 (0.013)	0.166 (0.023)	0.025 (0.005)	0.239 (0.029)	0.026 (0.011)	0.014 (0.003)	0.046 (0.022)	0.151 (0.009)	0.137 (0.018)	0.124 (0.022)	0.105 (0.006)
	Woodland		0.02 (0.005)	0.205 (0.023)	0.121 (0.013)	0.248 (0.028)	0.024 (0.009)	0.03 (0.005)	0.007 (0.007)	0.08 (0.009)	0.075 (0.014)	0.098 (0.013)	0.084 (0.005)
	Barren		0.014 (0.005)	0.028 (0.009)	0.007 (0.004)	0.115 (0.024)	0 (0)	0.006 (0.001)	0.009 (0.007)	0.029 (0.005)	0.013 (0.004)	0.009 (0.002)	0.025 (0.003)
Vegetation structure	Ground vegetation height	metre	0.206 (0.015)	0.319 (0.034)	0.231 (0.013)	0.607 (0.03)	0.29 (0.033)	0.172 (0.009)	0.141 (0.032)	0.223 (0.01)	0.247 (0.019)	0.25 (0.012)	0.255 (0.007)
	Ground vegetation cover	Proportion	0.316 (0.02)	0.448 (0.028)	0.335 (0.025)	0.533 (0.026)	0.331 (0.042)	0.282 (0.014)	0.159 (0.042)	0.379 (0.013)	0.366 (0.02)	0.385 (0.018)	0.357 (0.007)
	Crop height	metre	0.32 (0.017)	0.178 (0.021)	0.473 (0.028)	0.158 (0.026)	0.471 (0.051)	0.406 (0.013)	0.241 (0.035)	0.249 (0.009)	0.549 (0.023)	0.45 (0.022)	0.339 (0.008)
	Crop cover	Proportion	0.488 (0.025)	0.182 (0.022)	0.485 (0.028)	0.207 (0.028)	0.596 (0.056)	0.517 (0.015)	0.241 (0.046)	0.474 (0.014)	0.415 (0.022)	0.535 (0.023)	0.441 (0.009)
Cropping	Sorghum		0.016 (0.006)	0.11 (0.022)	0.583 (0.035)	0.008 (0.003)	0.004 (0.004)	0.004 (0.002)	0 (0)	0.345 (0.02)	0.389 (0.034)	0.655 (0.03)	0.226 (0.012)
	Cotton		0.094 (0.017)	0.04 (0.022)	0.075 (0.014)	0.152 (0.033)	0.012 (0.009)	0.029 (0.005)	0.183 (0.05)	0.591 (0.022)	0.072 (0.013)	0.038 (0.009)	0.203 (0.012)
	Sesame		0 (0)	0.14 (0.031)	0.162 (0.021)	0.026 (0.011)	0.064 (0.027)	0 (0)	0 (0)	0.019 (0.006)	0.252 (0.024)	0.078 (0.017)	0.053 (0.005)
	Soya bean		0.619 (0.045)	0 (0)	0 (0)	0 (0)	0.611 (0.089)	0.589 (0.028)	0 (0)	0 (0)	0.008 (0.006)	0 (0)	0.195 (0.014)
	Maize	Frequency occurrence	0.041 (0.013)	0.016 (0.01)	0.102 (0.023)	0 (0)	0.658 (0.063)	0.478 (0.027)	0.122 (0.039)	0.044 (0.007)	0.27 (0.027)	0.037 (0.01)	0.166 (0.01)
	Green gram		0.066 (0.017)	0.088 (0.021)	0.442 (0.043)	0.006 (0.006)	0.016 (0.007)	0.002 (0.001)	0.002 (0.002)	0.01 (0.003)	0.045 (0.016)	0.466 (0.031)	0.091 (0.008)
	Groundnut		0.002 (0.002)	0.011 (0.007)	0 (0)	0.044 (0.014)	0.015 (0.015)	0.007 (0.002)	0 (0)	0.215 (0.021)	0.001 (0.001)	0.011 (0.004)	0.062 (0.007)
	Pearl millet		0.061 (0.02)	0.045 (0.015)	0 (0)	0.013 (0.005)	0.046 (0.019)	0.004 (0.002)	0.313 (0.059)	0.016 (0.004)	0.018 (0.006)	0.003 (0.002)	0.032 (0.005)
	Other crops		0.024 (0.011)	0.119 (0.023)	0.097 (0.022)	0 (0)	0.022 (0.012)	0.006 (0.003)	0 (0)	0.011 (0.003)	0.033 (0.01)	0.143 (0.025)	0.035 (0.004)

Table 6B. Regional habitat characteristics (land-use, vegetation structure, crop composition, disturbances), associated species, and sampling details across Lesser Florican breeding range during July – September 2019 with standard error in brackets

	Attributes	Unit	Akola	Jalore	Kekri	Kutch	Pratapgarh	Ratlam	Rolla-padu	Saurashtra	Shah-pura	Sho-kaliya	Global
Food	Arthropod	# per metre	0.618 (0.042)	0.802 (0.086)	0.979 (0.073)	0.437 (0.044)	0.774 (0.149)	0.587 (0.025)	0.183 (0.027)	0.292 (0.017)	1.113 (0.065)	0.811 (0.061)	0.586 (0.018)
	Dog		0.287 (0.025)	0.203 (0.041)	0.135 (0.018)	0.155 (0.025)	0.286 (0.064)	0.255 (0.017)	0.086 (0.029)	0.205 (0.013)	0.115 (0.015)	0.169 (0.022)	0.199 (0.007)
	Human	Frequency occurrence	0.808 (0.022)	0.636 (0.05)	0.783 (0.029)	0.399 (0.035)	0.909 (0.024)	0.892 (0.011)	0.608 (0.064)	0.803 (0.015)	0.789 (0.02)	0.765 (0.025)	0.763 (0.01)
	Livestock		0.439 (0.034)	0.313 (0.038)	0.347 (0.033)	0.237 (0.027)	0.629 (0.062)	0.57 (0.021)	0.179 (0.053)	0.343 (0.018)	0.438 (0.031)	0.334 (0.026)	0.393 (0.01)
	Pesticide		0.054 (0.011)	0.006 (0.004)	0.037 (0.01)	0.003 (0.002)	0.017 (0.011)	0.03 (0.01)	0.13 (0.043)	0.061 (0.008)	0.004 (0.002)	0.01 (0.004)	0.037 (0.004)
Disturbances	Machines		0.12 (0.024)	0.169 (0.034)	0.135 (0.026)	0.019 (0.006)	0.085 (0.039)	0.055 (0.012)	0.296 (0.053)	0.138 (0.012)	0.021 (0.007)	0.099 (0.017)	0.102 (0.006)
	Settlements		0.372 (0.036)	0.191 (0.038)	0.176 (0.02)	0.195 (0.035)	0.415 (0.058)	0.443 (0.021)	0.105 (0.03)	0.276 (0.021)	0.186 (0.019)	0.17 (0.025)	0.279 (0.01)
	Power line/turbines	Frequency occurrence	0.824 (0.021)	0.542 (0.052)	0.524 (0.042)	0.454 (0.043)	0.833 (0.062)	0.765 (0.022)	0.488 (0.064)	0.72 (0.023)	0.438 (0.033)	0.5 (0.035)	0.642 (0.012)
	Road		0.435 (0.043)	0.172 (0.029)	0.279 (0.037)	0.14 (0.021)	0.415 (0.062)	0.472 (0.025)	0.433 (0.062)	0.296 (0.017)	0.252 (0.029)	0.274 (0.031)	0.327 (0.011)
	Industries		0.02 (0.007)	0.026 (0.015)	0.021 (0.007)	0.001 (0.001)	0 (0)	0.004 (0.001)	0.027 (0.025)	0.016 (0.005)	0.004 (0.002)	0.01 (0.005)	0.012 (0.002)
	Mines		0.033 (0.01)	0.022 (0.017)	0.027 (0.008)	0 (0)	0 (0)	0.021 (0.005)	0.022 (0.015)	0.012 (0.003)	0.007 (0.003)	0.02 (0.005)	0.016 (0.002)
	Blackbuck		0.072 (0.019)	0 (0)	0 (0)	0.002 (0.002)	0.007 (0.007)	0 (0)	0.064 (0.024)	0.006 (0.004)	0 (0)	0 (0)	0.012 (0.003)
Associated species	Fox		0.003 (0.002)	0 (0)	0.002 (0.002)	0.002 (0.002)	0 (0)	0.001 (0.001)	0.015 (0.01)	0 (0)	0 (0)	0 (0)	0.002 (0.001)
	GIB	Frequency occurrence	0 (0)	0 (0)	0 (0)	0.001 (0.001)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
	Chinkara		0.009 (0.006)	0.019 (0.008)	0 (0)	0.008 (0.004)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.003 (0.001)
	Nilgai		0.022 (0.008)	0.029 (0.012)	0.038 (0.012)	0.01 (0.004)	0.004 (0.004)	0.013 (0.004)	0.002 (0.002)	0.023 (0.004)	0.008 (0.004)	0.03 (0.007)	0.019 (0.002)
	Wolf		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Florican past status	Florican detection in past	Proportion respondents	0.444 (0.069)	0 (0)	1 (0)	0.105 (0.042)	0.167 (0.072)	0.296 (0.039)	0.25 (0.089)	0.107 (0.02)	1 (0)	0.287 (0.05)	0.21 (0.015)
Sampling efforts	Sites		59	24	36	56	16	115	27	147	49	57	586
	Visits		789	351	505	875	222	1825	172	2191	713	794	8437

Image 30. National Lesser Florican status survey training workshop at Bhavnagar © Tanya Gupta



© Devesh Gadhvi



Image 31. National Lesser Florican status survey training workshop at Akola © Tanya Gupta

Table 7. Details of training workshops, survey period and partner agencies/individuals involved in collaborative Lesser Florican national-level survey

Region	Training workshop		Partner agencies/ individuals	Survey period
	Date	Venue		
Ajmer & Rest of Rajasthan	04- 05 Aug 2018	Department of Environment, MDS University, Ajmer & Shokaliya Conservation Reserve, Nasirabad, Rajasthan	Dr. Praveen Mathur Head, Environment Science Dept. M.D.S. University, Ajmer	04 Aug- 10 Sept 2018
Deccan	04 Aug 2018	Amphitheatre, Vankuti, Akola, Maharashtra	1) Bombay Natural History Society (BNHS), 2) Hyderabad Tiger Conservation Society (HyTiCoS)	05-11 Aug & 13- 20 Sept 2018
Gujarat	30 Jul- 02 Aug 2018	M.K. Bhavnagar University& Velavadar Blackbuck Sanctuary Bhavnagar, Gujarat	1) The Corbett Foundation (TCF) 2) Dr. Indra Gadhavi Head, Marine Science, Dept. 3) Dr. P. P. Dodia: Associate Professor, Zoology Department, Sir. P. P. Institute of Science - M.K. Bhavnagar University	03 Aug 2018- 10 Sept 2018
Madhya Pradesh	Aug 2018	Office of the Chief Conservator of Forests, Ujjain & Sailana Wildlife Sanctuary, Ratlam, Madhya Pradesh	1) BNHS 2) TCF	12- 28 Aug 2018

2.2.2.2. Patterns of bird community structure in relation to land-use driven habitat changes in the arid grasslands of Thar Desert

The Indian Thar Desert has seen a massive loss of grassland habitat in the last few decades owing to the large-scale change in land-use from nomadic pastoralism to agriculture, leading to expansion of cultivated land, further compounded by a simultaneous rise in livestock population. Furthermore, irrigation schemes (notably the Indira Gandhi Canal) have led to intensification of agriculture in many areas. To understand the impact of land-use change on native biodiversity is thus very important for conservation of this fragile ecosystem. The effects of land-use change on community structure of birds was examined by comparing fundamental properties of biological communities like species richness, abundance and composition in the arid grassland of Thar Desert, Jaisalmer district to understand if and how these properties change with land-use driven habitat change. Additionally, potential habitat correlates of these properties were identified, so as to shed some light on the processes that might be driving community assembly in response to land-use change.

The survey was conducted in 7000 km² into 50 blocks of 144 km² each, of which 14 blocks amounting to an area of 2206 km² were further selected as the extensive study area. The selected extensive study area was further divided into 1 km² cells, the scale at which further sampling was carried out. The area was classified using boundaries of the Protected Area and irrigated lands were obtained from government records, remotely sensed land cover data and visual inspection of satellite imagery. The resultant classified imagery was further validated by inspection of satellite imagery and four dominant land-use categories were delineated as,

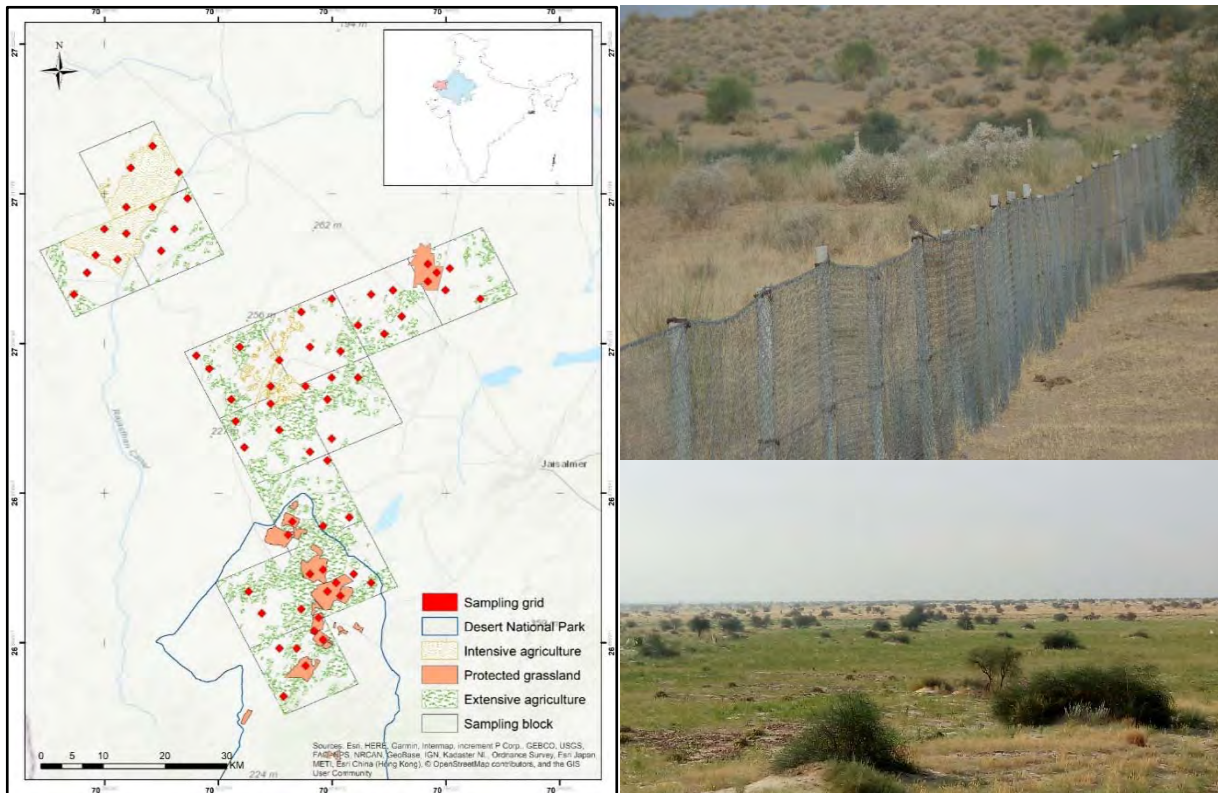


Figure 16. Map of surveyed area with dominant land-use types, **Image 32.** Protected grassland and agriculture, in Jaisalmer district of Western Rajasthan © Bipin C.M.

(i) Protected grasslands - Enclosures constructed and maintained by the DNP and Desert Development Program of the Forest Department to prevent livestock grazing. (ii) Non-irrigated croplands/Rain fed croplands- Agriculture I and II left fallow after cropping and allowed to regenerate through the dry months. Grazing is allowed during the fallow period, (iii) Rangelands or grazing lands primarily used for livestock (goat, sheep, cattle and camel) grazing, firewood and timber for household needs with no recent history of farming and not subjected to any management intervention concerning the habitat, and (iv) irrigated croplands- agriculture land irrigated either by canal water or tube-wells. Most of this land was under cultivation during winter, and the dominant crops were Bengal gram (*Cicer arietinum*), jeera (*Cuminum cyminum*) and mustard (*Brassica sp.*).

Seventy line transects of 1km length were placed across the sampling area to conduct bird abundance and vegetation surveys. A total of 5 (± 1) transects were laid randomly in each of the 14-144 km² blocks. Birds were sampled on these transects thrice using GPS, laser range finder and binoculars in two seasons – winter (December -February), when migratory birds were present and summer (March-May) when many resident species started breeding. Habitat sampling for trees and shrubs was conducted once for all transects whereas the understory was surveyed in each season. Five rectangular belt transects of 1 hectare (200m $\times$ 50m) were laid perpendicular to all transect lines, starting at 100m and then at an interval of every 200 m. Attributes of trees; defined as GBH > 30 cm, height > 2m (species, GBH, height, crown diameter and canopy start height), shrubs and forbs (count, species, maximum diameter and height) in nested 200m $\times$ 10m plot, grasses (genus, % cover, height) in four nested 1m² plots; substrate, surface water availability and anthropogenic activities were recorded.

Analysis was conducted on a dataset with all the recorded species and then with a dataset having only the native species- species recorded in the protected grasslands and mentioned in literature as originally present before advent of Indira Gandhi canal (Rahmani & Soni 1997).

Vegetation composition and structure of sites was visualised using Non-metric multidimensional scaling (NMDS). Additionally, other vegetation composition parameters like vegetation diversity or woody plant diversity were calculated to relate vegetation composition to bird community parameters. Compositional diversity was calculated by the Shannon-weinner index of diversity used on the vegetation dataset. Structural variables- foliar volume of woody plant, woody plant stem density as a surrogate for productivity and age of the habitat, average GBH, herbaceous volume, grass volume to surrogate biomass, crop volume, average height for each plant-form were calculated per hectare for every site.

Local bird species richness across different land-use types were compared using Analysis of Variance (ANOVA) and paired Wilcoxon sign-ranked test was conducted. A species accumulation curve was used to check whether species richness had reached asymptote at a landscape scale. To visualise the differences in community composition of sites with individual land use types, ordination of the data was performed using NMDS. Bray-Curtis index of similarity was used to estimate the ecological distance between the communities of two sites. The differences were then statistically tested using non-parametric multivariate analysis of variance (npMANOVA) or permutation multivariate analysis of variance (perMANOVA) with each community as the response variable and land-use type as the explanatory variable. To understand the relation of species richness and composition with underlying habitat factors, generalised linear models were used on richness data with preselected habitat factors as predictor covariates. The predictor covariates tested were foliar biomass of woody plants, forb biomass, overall vegetation diversity and grass biomass.

A total of 19 woody plant, 18 forb, 10 grass and seven crops species were recorded in the study area during vegetation sampling. Most transects were very homogenous with very few species of plants occurring within them. The mean species richness (per km²) of all plant forms together was largely similar across all land-uses (Figure 17). A peculiar difference between land-use types was in terms of forb species occurring more in rain fed croplands, and intensive agriculture was devoid of grass but had higher number of tree species. Mean foliar biomass of woody plants was much higher in intensive agriculture as compared to other land-uses whereas forb biomass was highest in rangelands but were not significantly different.

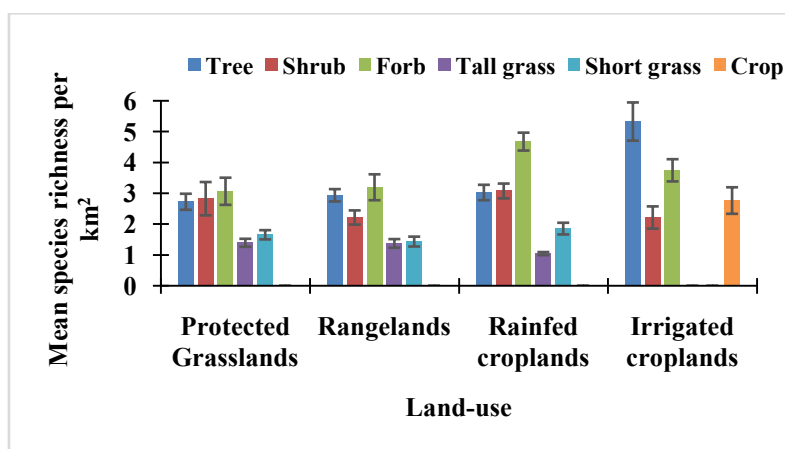


Figure17. Mean species richness per km² of each plant form according to the land-use type. Error bars are standard errors.

Vegetation structure showed a similar pattern across land-uses. Intensive agriculture had distinct vegetation structure compared to other land-uses during winter. Protected grasslands and rangelands had very similar local community composition of plants whereas composition in non-intensive agriculture was significantly different. The magnitude of compositional difference between intensive

agriculture and other land-uses was much higher during winter and reduced notably during the summer (Figure 18).

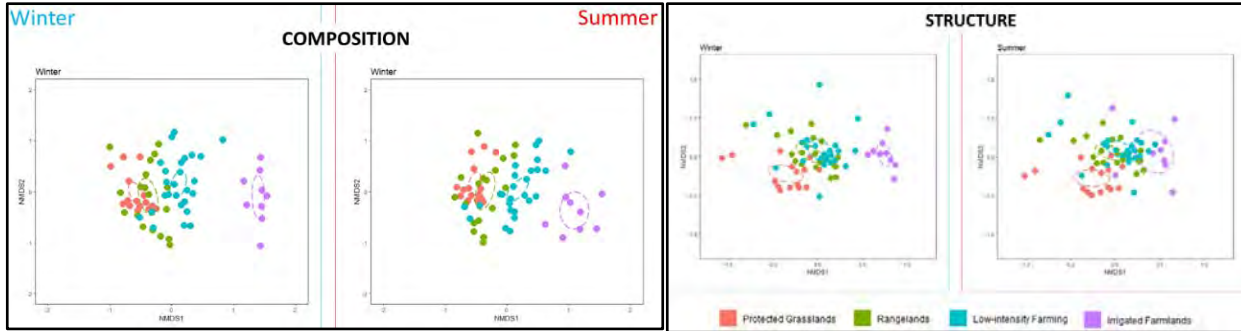
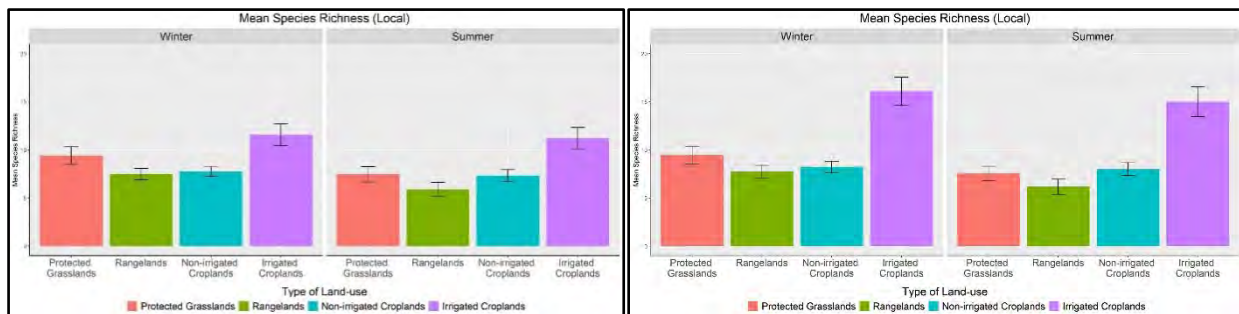


Figure 18. Non-metric multidimensional scaling ordination showing differences in composition and structure of vegetation in different land-use types during winter and summer.

A total of 72 bird species (3555 individuals) - 51 species (1521 individuals) in winter and 52 species (1834 individuals) in summer, with 33 species common in both seasons were recorded. Results indicate that local-scale species richness, abundance and composition did not differ significantly between protected grasslands, rangelands and rain-fed croplands, during either of the seasons. However, intensive irrigated croplands had a notably different community structure with higher species richness and abundance, during both winter and summer (Figure 19).

The change in community structure of irrigated croplands was influenced by the change in native species along with ingressions of newly colonised species. Most of the newly colonised species were restricted to areas with intensive agriculture where their survival was potentially facilitated by the new microhabitats created by irrigation and associated changes. Visual examination of species accumulation curves suggested that sampling could not capture the entire set of species for all land-use types. After controlling for newly colonised species, protected grasslands had the highest species richness in all seasons, indicating loss of certain native species in other land-use types. Average bird abundance was higher in intensive agriculture as compared to other land-uses during both seasons. Rangelands and non-irrigated croplands had notably low average abundance during both the seasons.



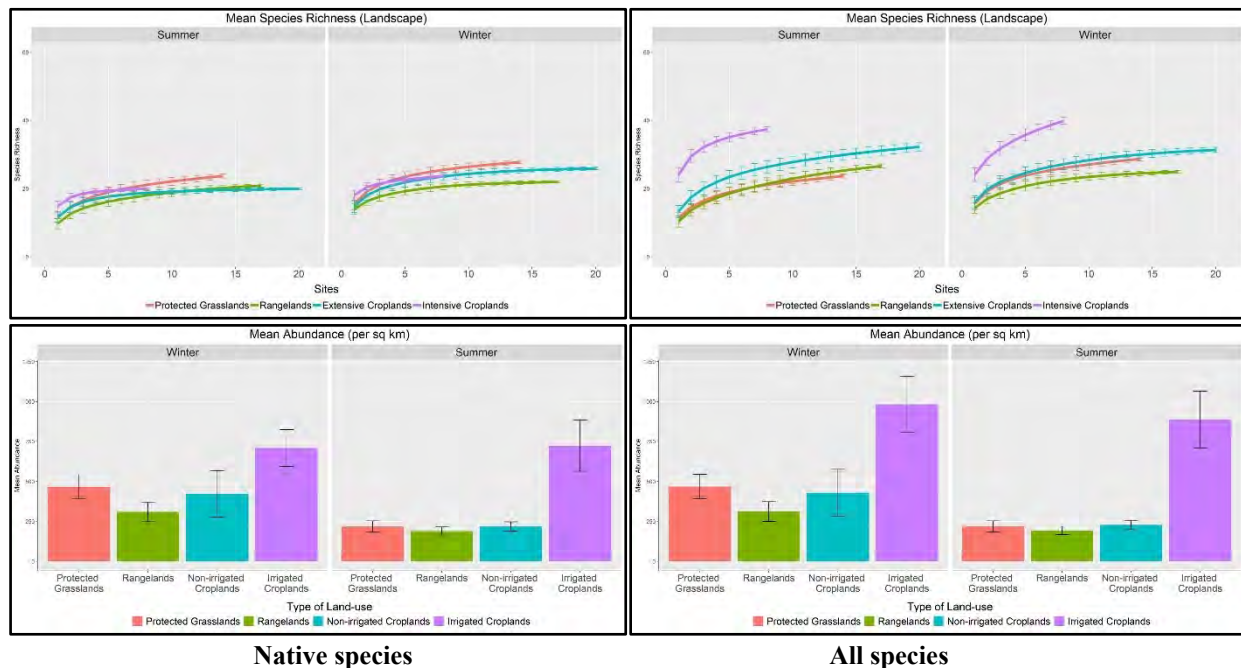


Figure 19. Mean species richness (top), species accumulation curve (middle) and mean species abundance (bottom) of all species and native species across land-use types during winter, and summer seasons. The error bars represent the standard error

At the landscape scale, bird community composition changed progressively with intensification of land use. Protected grasslands had two unique species across the year that were not found in any other land-use, while low-intensity agriculture and rangelands respectively had two and one unique species. However, this could be an artefact of detection and more sampling could've revealed these unique species in other land-uses. On the other hand, fourteen species were unique to intensive agriculture, which is substantial even after considering the species that could have been missed due to imperfect detection in other land-uses. Two threatened species – GIB (Critically Endangered) and MacQueen's Bustard *Chlamydotis macqueeni* (Vulnerable) – were recorded during the study and both were found only in protected grasslands. The magnitude of difference between irrigated croplands and other land-uses reduced when non-native species were excluded. This shows that newly ingressed species are also influencing the overall community structure to a significant extent in irrigated croplands but not in other land-use types.

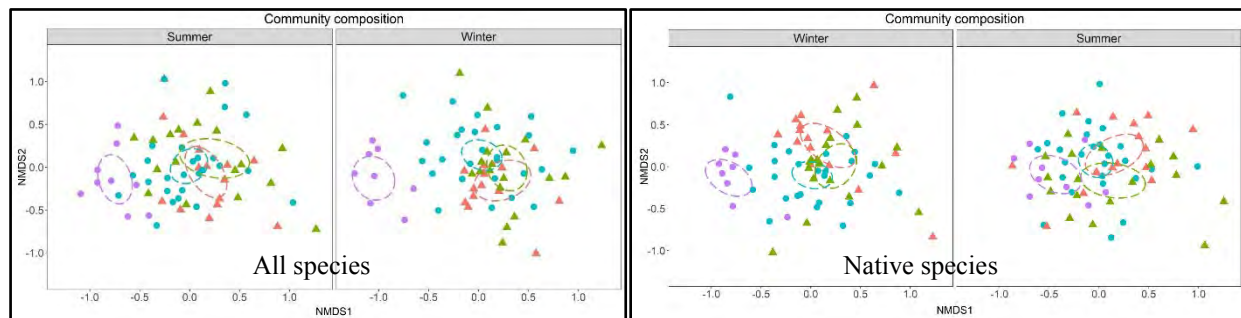


Figure 20. Non-metric multidimensional scaling ordination showing bird community composition of all bird species (left) and native bird species (right) in different land-use types during winter and summer seasons.

In both the seasons, species richness was positively associated with the foliar volume of woody vegetation and negatively associated with forb volume (which in turn was negatively correlated with grass volume). During winter, species richness was positively related to crop volume and during summer, with compositional diversity of vegetation. Community composition like richness was influenced significantly by woody plant foliar biomass in both the seasons. Crop volume also had a significant influence on bird communities during both winter and summer, whereas grass volume was significantly influential only in winters.

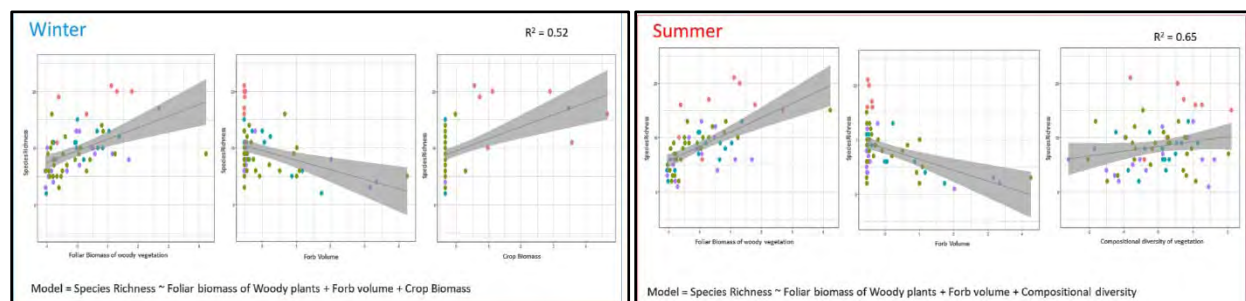


Figure 21: Habitat correlates of species richness during winter (left) and summer (right) based on the best fitting model.

Intensive agriculture increased the overall species of birds in the region by sustaining newly colonised bird species; while the number of native species in this pool was only marginally lower than protected grasslands and comparable to all the other land-uses in both the seasons. Considering both the seasons together, protected grasslands had the highest naïve and estimated number of native species while the naïve and estimated number of native species in other three land-uses – rangelands, rainfed croplands and irrigated croplands – was only marginally lower. This signifies that most species found in the region can use the entire gradient of land-use types at their current levels of intensification.

Results suggest that although primary grassland habitat is essential to save the full spectrum of the regional species pool, low-impact land-uses can act as important secondary habitats for conservation of bird species. The local level patterns suggest that livestock grazing and extensive agriculture do not have drastic negative impacts on bird community structure and are together able to sustain most of the species even at a regional scale. Evidence from this study supports the approach of conserving grasslands as large-landscapes strategically managed as low impact agro-pastoral mosaics with small protected areas embedded in them. Low-impact use of land coupled with habitat management like removal of forbs, controlling logging by provision of alternate firewood supply and reseedling of grass in forbs affected area can help conserve general bird diversity without hampering livelihood needs. Another alternative could be setting up sustainable community farms where agro pastoralism can be strategically managed to achieve biodiversity conservation while also sustaining human livelihoods.



Image 33. Great Indian Bustard foraging in grazing land sandwiched between protected grassland and agriculture land near Desert National Park, Jaisalmer © Mohib Uddin

2.2.2.3. Factors that shape vegetation in the arid zone of India in Thar, Jaisalmer

In the backdrop of expanding agriculture and high prevalence of livestock grazing across the GIB habitat in Jaisalmer, we investigated whether there is vegetation structure shift from a grassland to savanna and the possible causes if any and their intermediate transitions in the Thar Desert, North-Western Rajasthan. Vegetation was sampled in 67 grids of 1-km² area spread across a 10,235 km² study area capturing heterogeneity in precipitation (Figure 22).

In each of the grid, four 1-hectare plots of 50 × 200 m each were laid. In each 1-ha plot, attributes of trees (species, girth, height, crown diameter), shrubs (species, diameter, height) in five 5m² plots and grasses (species, height, percentage cover) in five 1m² plots were recorded. The 20 soil cores collected from each grid (5 samples × 4 ha) were composited into one by mixing soil cores equally either by weight or volume to represent the grid. To calculate potential livestock density as proxy for potential grazing pressure, we performed a two-step process; (i) to determine the maximum daily ranging distance of livestock, 28 animals (cattle-7, goats-10 and sheep-11) were tagged with Holux RCV 3000 GPS logger for 1-2 days each and used the distance obtained to estimate the area (ii) to assess the number of livestock that have potential access to the sampling grid, all the mapped locations were surveyed to determine the number of each livestock types stocked in the settlement. To evaluate livestock foraging preference, focal sampling on individuals (n=22) picked at random both in space and time were carried out. The sampling involved counting the number of bites of every plant species taken by the livestock in one minute with the assumption that area available for foraging for an individual in a given time is restricted by its average moving speed computed from collared livestock.

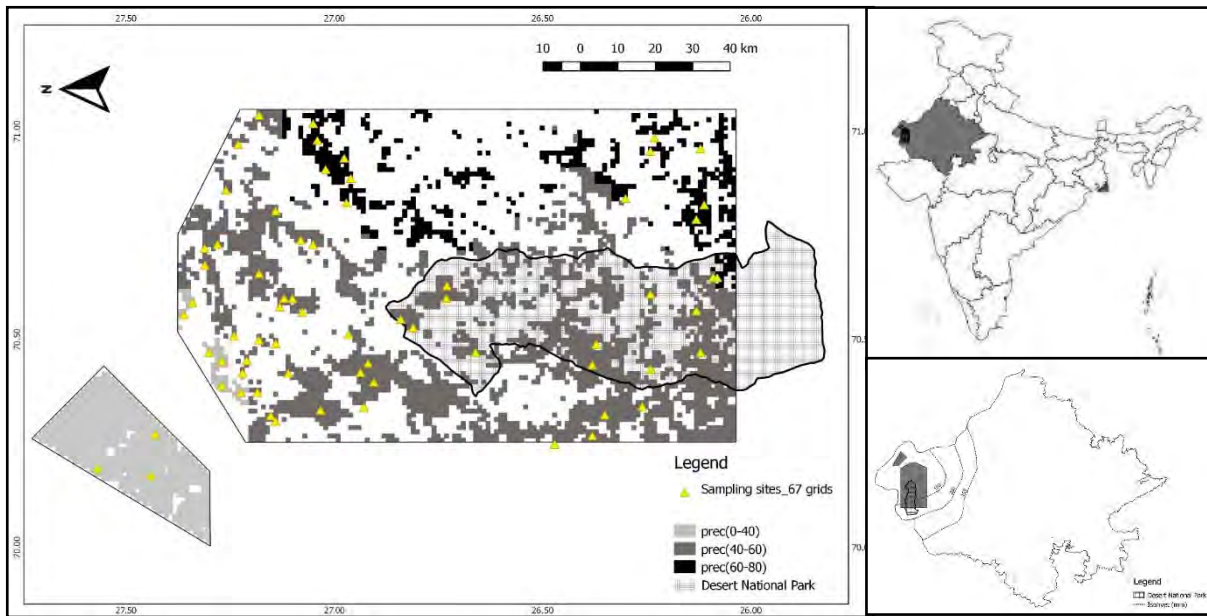


Figure 22. Map showing the plots sampled for vegetation characteristics in and around Desert National Park, Jaisalmer. The isohyet lines show 150 mm, 200 mm and 250 mm precipitation

To assess vegetation composition, we calculated total tree basal area, tree and shrub abundances, and species wise tree, shrub and grass volume and cover in our sampled ha plots for 4-ha per grid. Based on percentage of wood cover, the 67 grids were classified into seven types of vegetation structure into mixed grassland- 5, soft grassland- 22, woody grassland- 2, transition- 6, shrub savanna- 6, tree savanna- 5 and tree shrub savanna- 10. Soil samples collected from sampled grids were analysed for soil texture, water holding capacity, total organic carbon, rodde and loose bulk densities. A total of 11 covariates, viz., precipitation, soil water holding capacity, %sand, %silt and %clay in soil, rodde bulk density, loose bulk density, soil total organic carbon, cattle, goat and sheep densities were identified for further analysis. Ordinary least square and generalized linear models were used to test relationships between our explanatory covariates, namely environmental variables and livestock densities, and (i) species richness, (ii) vegetation structure and (iii) percent cover of different life-forms.

A total of 61 species were recorded during the sampling. The rank-abundance curves (Figure 23) show that the *Dactyloctenium aegyptium* is the dominant graminoid across precipitation classes. However, the sub-dominant grasses vary across the three precipitation classes. While *Lasiurus sindicus* - *Panicum turgidum* occur in the low precipitation class, *Cenchrus biflorus* - *L.sindicus* - *Aristida* sp. occur in the medium precipitation class and *Aristida* sp. - *Cenchrus* sp. occur in the high. With respect to shrubs, relative cover of *Haloxylon salicornium* declines as precipitation increases. Precipitation was the most important variable that explained species richness that linearly increased with increase in precipitation ($R^2=0.39$, $p= 1.029 \times 10^{-6}$). However, the increase in richness was not uniform across all vegetation life forms. Species accumulation was shallow in grasses and shrubs, however, steeper in trees and herbs (Figure 24).

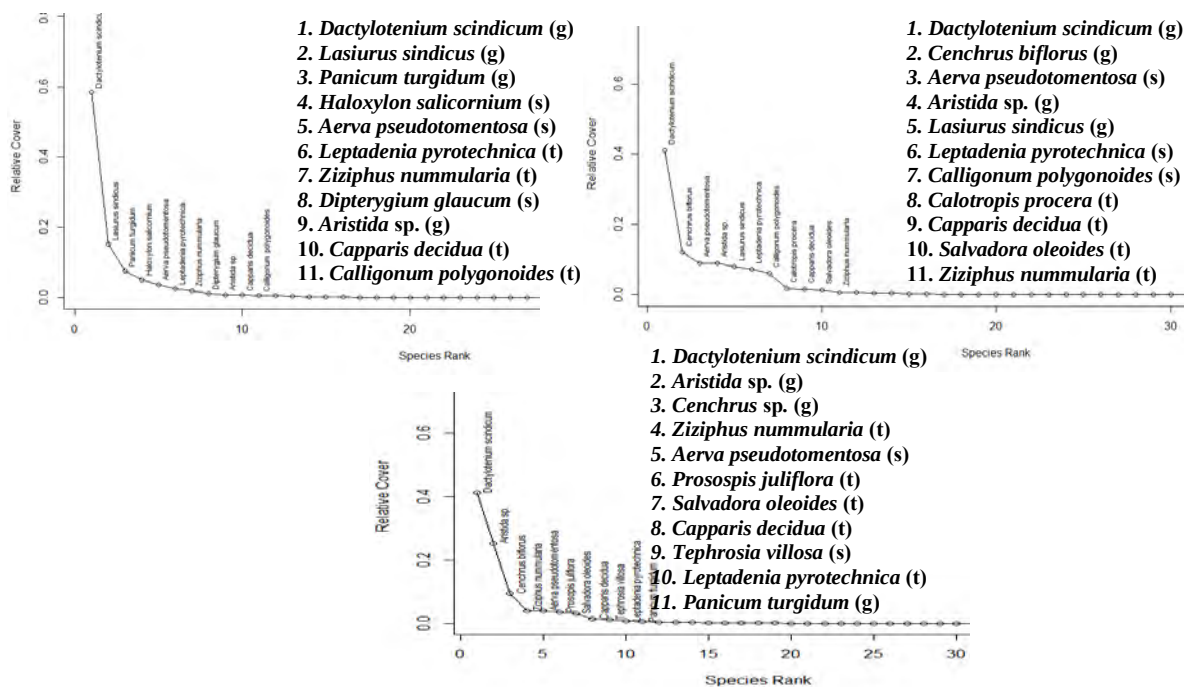


Figure 23. Rank-abundance curve across precipitation classes with the habit for the species indicated in parenthesis: g - grass, t – tree, s – shrub. (Top left) corresponds to low precipitation gradient (0-40 mm), (Top right) with medium (40-60 mm) and (bottom) with high (60-80 mm)

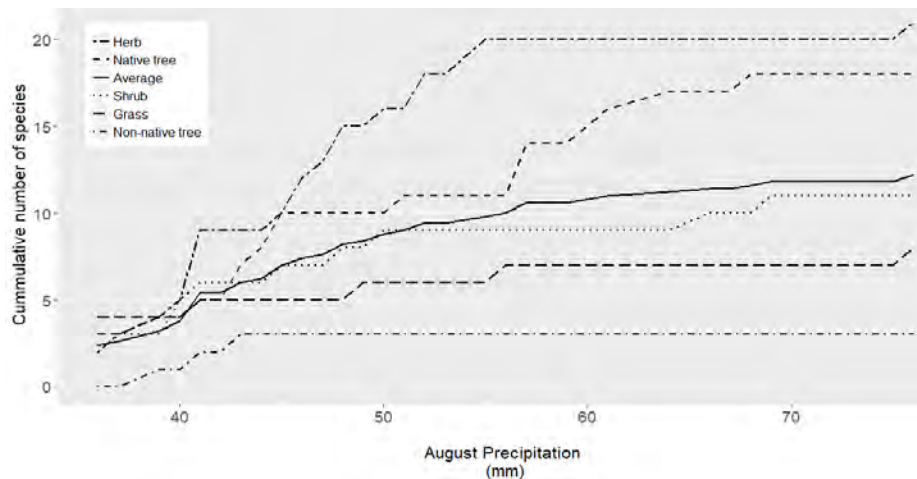
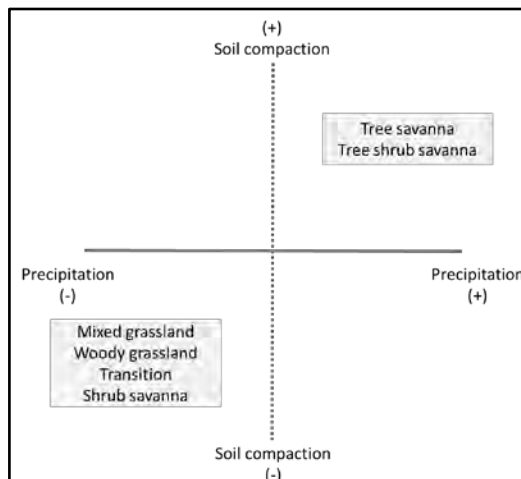


Figure 24. Species accumulation curve of all vegetation life forms along precipitation gradient. Results showed that possibility of tree savanna or a tree shrub savanna increases with an increase in precipitation and soil compaction (Figure 25)

Table 8: Top three models with the lowest AIC tested for determinants of vegetation structure

Model	df	AIC	• AIC	Pseudo R ²
Vegetation structure ~ August precipitation	12	190.4852	0	0.127
Vegetation structure ~ August precipitation+ Soil compactness	18	191.0714	0.5862	0.187
Vegetation structure ~ Cattle density	12	196.0751	5.5899	0.098

**Figure 25:** Visual representation of the factors that determine vegetation structure shifts (+) indicates increase in the determining factor and (-) indicates a decrease

Trends in vegetation structure from univariate regression against all explanatory variables showed that abundances of woody species and tree cover increase linearly with precipitation ($p=0.02e-02$ and $p=0.002$, r respectively) (Table 9 gives the p -values for all the univariate regression carried out testing relationship between the vegetation variable in the rows and explanatory variable in the columns; Table 10 gives the coefficients for the significant relationships). Shrub cover is found to have a negative relationship with both soil compaction ($p=2.86e^{-07}$) and small livestock grazing intensities ($p=0.008$). Grass cover was found to be not determined by livestock grazing intensity or environmental factors. However, grass cover shows a negative relationship with shrub cover ($p=2.86e^{-05}$) with no significant relationship with tree cover ($p=0.25$).

Table 9. Response of the vegetation to environmental factors and grazing

Vegetation type	Precipitation	Soil				Density	
		Water holding capacity	% sand	Total organic carbon	Soil compactness	Cattle	Small livestock
Tree-shrub abundances	0.0002*	0.583	0.653	0.169	0.641	0.366	0.209
Tree cover	0.002*	0.365	0.922	0.294	0.519	0.136	0.229
Shrub cover	0.3	0.083	0.805	0.522	$2.86e^{-07}$ *	0.605	0.008*
Grass cover	0.682	0.511	0.787	0.934	0.616	0.351	0.491

* indicates significant values

There was a clear scale dependence on how the determinants act i.e., precipitation defines the larger community at tributes such as species richness ($R=0.39$, $p=1.029e^{-06}$); soil compaction under the precipitation umbrella defines the vegetation structure (and hence shift from grassland to savanna etc.) and grazing pressure (especially from the smaller livestock) defines the proportion of the life forms within each vegetation structure.

Table 10. Relationship between life forms and their significant explanatory variables

Vegetation type	Intercept	Variable	Estimate	Std. Error	z value	Pr ($>|z|$)	Pseudo R^2
Tree-shrub abundance	3.1158	Precipitation	0.0458	0.0123	3.710	0.0002	0.169
Tree cover	3.8330		0.0523	0.0170	3.077	0.002	0.089
Shrub cover	6.5748	Small livestock density	-0.0014	0.0005	-2.646	0.008	0.026
	9.1882	Soil comp	-0.2332	0.0454	-5.132	$2.86e^{-07}$	0.172
Grass cover	8.6727	Shrub cover	-0.0005	0.0001	-4.185	$2.86e^{-05}$	0.157

The role of environmental determinants in determining vegetation shifts assures that the transitions are going to be gradual and precludes the frequent finding of grasslands shifting to a shrubland or forest due to livestock grazing. This could be attributed to our findings of livestock having no forage preference to any particular species ($\chi^2=25.76$, $df=18$, $p=0.1003$) or life forms ($\chi^2= 5.1939$, $df= 2$, $p= 0.0745$) or possibly due to the low variation in livestock grazing in this landscape. It was also found that change in the environmental determinants, however, can lead to two or three possible structure types.

The determinants of vegetation community composition are scale dependent. Precipitation plays the dominant role in determining community attributes. composition similarity decreases with precipitation and increases with soil compaction. Vegetation structure transitions can be determined with precipitation and soil compaction. But, there are two or more stable states that are possible to result under similar environmental conditions. Vegetation structures being determined by environmental variables would, hence, be gradual.

Based on the results, the presence of four vegetation structures in the landscape were predicted, viz. mixed grassland, soft grassland, tree savanna and tree shrub savanna with the DNP covering one of the vegetation types (Figure 26). Superimposing the human-dominated land-use types, namely agriculture and settlement, the map shows a 62% loss in the vegetation types to agriculture and settlements (empty cells in Figure 26) The loss of vegetation structure poses a larger threat to these grasslands than the expected vegetation structure transitions. Enclosures in DNP protects only one vegetation structure type and covers less than 1%. We emphasize the urgent need to delineate conservation areas based on requirements of faunal species of interest and its habitat requirements before a complete wipe-out of vegetation structure types occur.

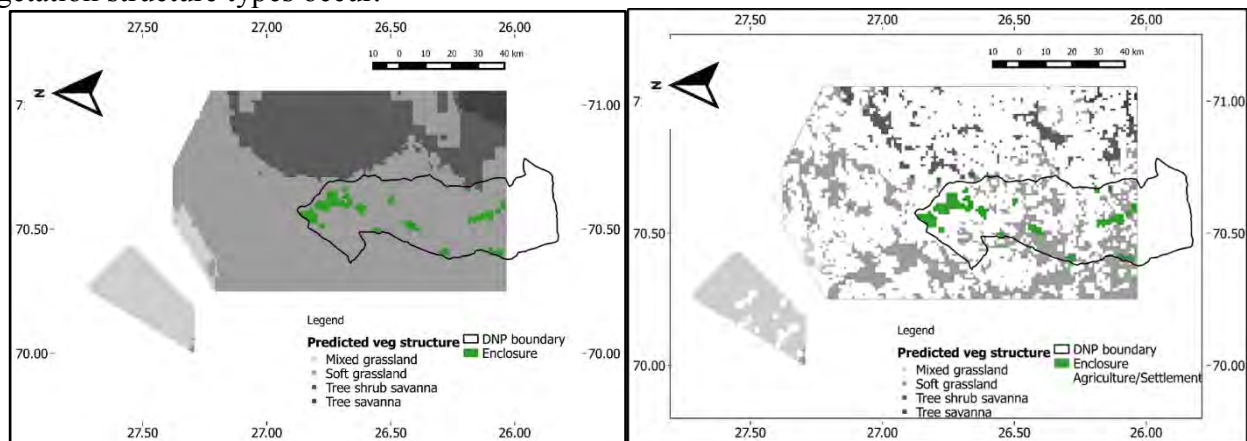


Figure 26. Predicted vegetation structure (left) and land-use types masking the vegetation structure types (right) in the study area highlighted with the regions protected by the Desert National Park



Image 34. Grasslands in Desert National Park, Jaisalmer © Bipin C.M.

2.2.2.4. Assessment of Great Indian Bustard habitat from tagged birds in Kachchh, Gujarat

Based on the information obtained from the GPS transmitter (Platform Transmitter Terminal) deployed on GIB in Kachchh, habitat parameters were recorded in Naliya grasslands and surrounding GIB habitat during November- December 2018. GIB roosting sites and cluster of foraging locations from September- November 2018 were extracted for each day and used for sampling. The habitat characteristics of foraging and roosting locations were quantified.

Circular plots of 30m and 50m radii were sampled to measure vegetation cover and anthropogenic activities were quantified within 500m radius. To assess the visibility in the roosting location, a checker board of 1m² dimension marked with squares of 25cm was placed at random points within 15m of the roosting location. The number of squares visible to the observer at 20m distance while crouching in four different directions were counted from opposite sides. At the foraging location, five 20m × 2m belt transects were sampled to measure the availability of insects, small reptiles, fruits and other available GIB food. Additionally, habitat and forage availability of random locations outside the area used by the two tagged GIBs were quantified for comparison. A total of 47 roosting locations, 83 foraging locations and 59 random locations as control sites were sampled (Figure 27).



Figure 27. Map of locations sampled to assess the Great Indian Bustard habitat in Kachchh, Gujarat

During the sampling period, maximum of seven GIB females were sighted near the Air Force station. GIB males were not seen during the survey period in Naliya grasslands and surrounding areas. Rapid surveys in search of GIB male were carried out in other areas where GIB sightings were reported in the last 10 years, but was not sighted. Due to drought conditions prevailing in Kachchh region since last two years, GIB activity was mostly localized in and around Naliya Air Force Station during the survey. Permission was obtained from the Air force authority to enter the Air Force Station premises as well as the surrounding areas to collect data.

GIB roosting sites were predominantly a mixture of barren patches and grassland with some amount of scrub vegetation. Fallow areas were also used for roosting in a few occasions. The visibility obtained from checkerboard target at the roosting sites was 92%, suggesting that mostly barren patches with short grass and sparse vegetation is used for roosting. In the foraging sites, grassland was the most dominant land-cover, followed by barren and scrub patches. Agriculture areas were not used for either foraging or roosting (Figure 28).

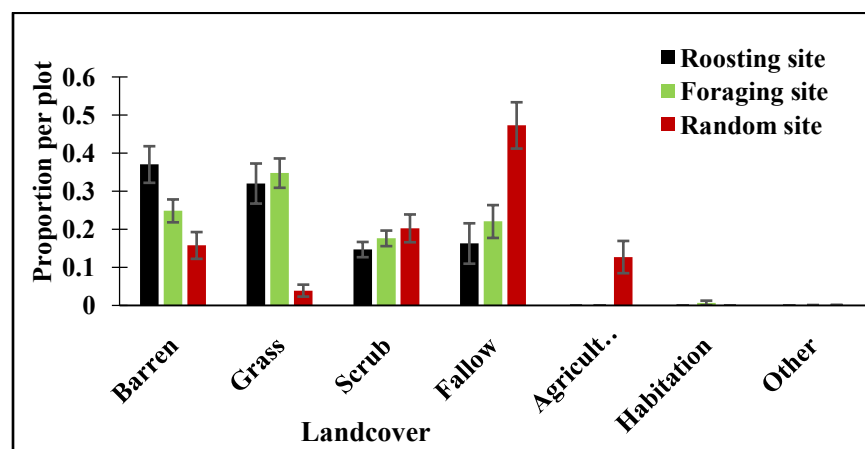


Figure 28. Comparison of proportion of different land-cover in Great Indian Bustard roosting, foraging sites and random locations during November-December 2018 in Kachchh, Gujarat (Error bars are standard errors)

Food availability was significantly higher in foraging sites compared to random locations in the landscape. Availability of plant food material was higher compared to animal food matter. *Ziziphus nummularia* fruits were the most abundant food available followed by grasshoppers and *Capparis decidua* fruits during winter (Figure 29). Termites were found only in one location and in high numbers.

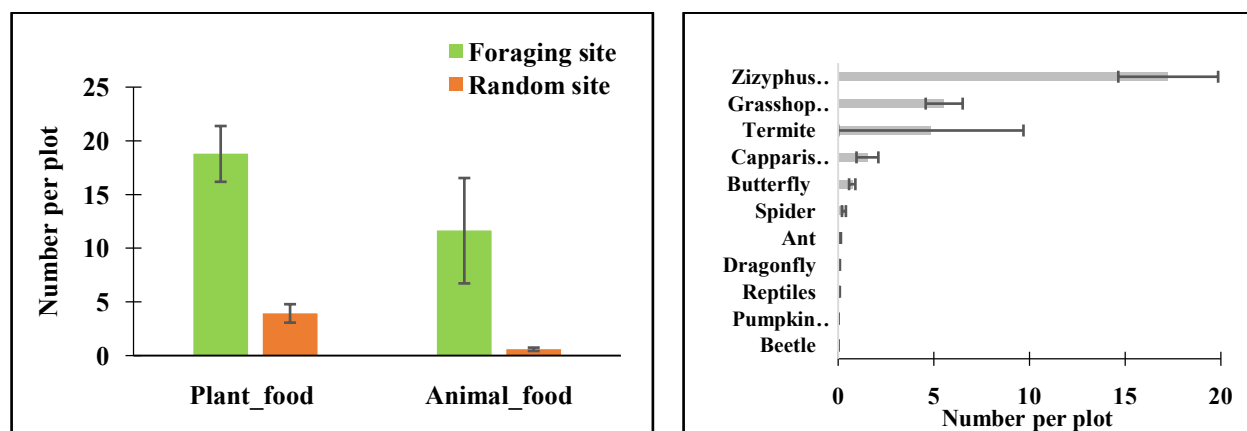


Figure 29. Comparison of Great Indian Bustard food available during November-December 2018 in Kachchh, Gujarat (Error bars are standard errors)

Though most of the agricultural lands were ploughed, they were not cultivated due to lack of rainfall and hence these areas were mostly devoid of any ground vegetation. The only area with substantial grass cover available was in and around the Air force Station and GIB movement was recorded only from this area. Since livestock grazing is prohibited inside the Station and moderately controlled in the vicinity, availability of natural vegetation cover and consequently insect availability was significantly higher compared to the random sites. The GIB habitat in Kachchh is undergoing drastic changes due to agriculture expansion, increase in wind turbines, power lines, and continued invasion of *Prosopis juliflora*.





Image 35. Great Indian Bustard habitat in Kachchh District is undergoing rapid changes due to agriculture expansion; increase in wind mills, power lines and *Prosopis juliflora* © Bipin C.M.

2.2.2.5. Reconnaissance survey of Great Indian Bustard habitat in Ballari District, Karnataka

A reconnaissance survey was conducted across GIB habitat in Ballari District, Karnataka during March 2019 as suggested by DIG of Forests (Wildlife). Based on the information obtained from previous GIB sightings, areas in Siruguppa and Ballari Taluks were surveyed by WII representative Mr. Bipin C.M. with the help of Karnataka Forest Department officials and staff, Ballari Division. The area is predominantly agriculture and the main crops cultivated are paddy, cotton, chickpea, chilly, and pearl millet. River Tungabhadra flows in this region and the terrain is mostly flat. The climate is semi-arid with temperature ranging from a minimum of 26°C in winter to a maximum of 42°C in summer with average annual rainfall of 645mm.

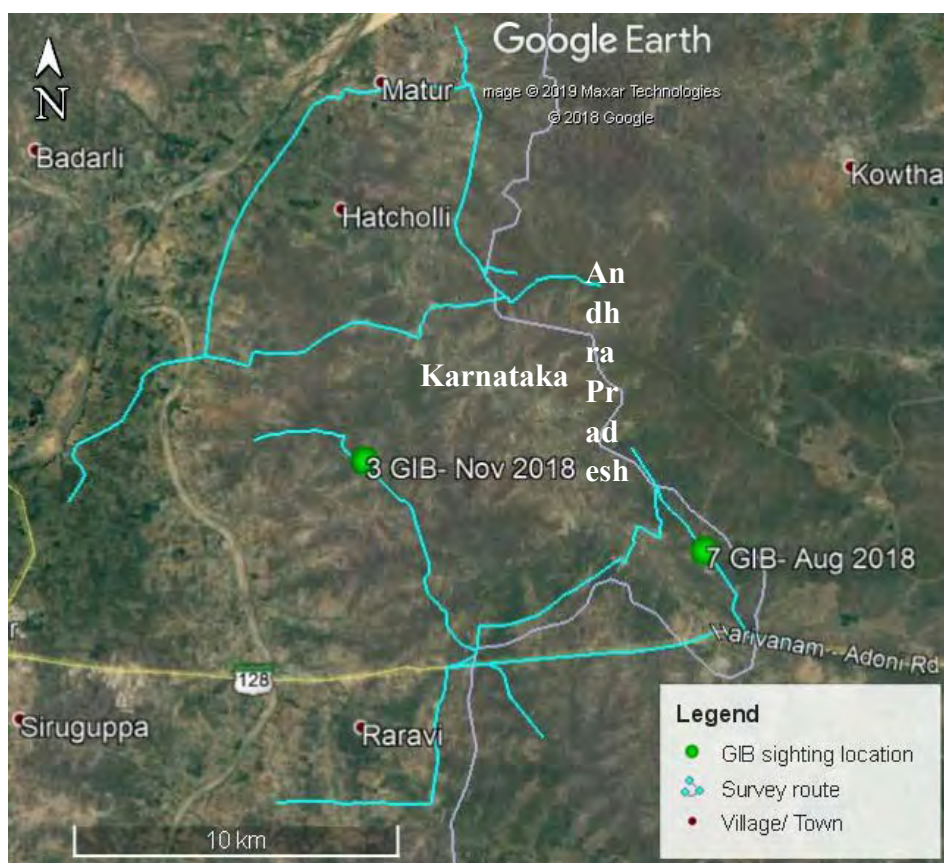


Figure 30. Map of the survey routes in Siruguppa Taluk, Ballari District with locations of Great Indian Bustard sightings in 2018

A total of 133.6 km were surveyed on foot and vehicle in Siruguppa taluk (Figure 30) accompanied by the field staff of Siruguppa Range - Mr. Pampapathy (Deputy Ranger), Mr. Ramalingam (Forest Guard), and Mr. Thippaiah (Forest Watcher). This area is situated near the border of Karnataka and Andhra Pradesh. Additionally, an area around Chellagurki village in Ballari Taluk, where GIB was sighted in 2012 was also visited. GIB were not sighted during this reconnaissance survey. Blackbuck were encountered regularly across the area and a total of 51 animals were seen during the period.



Image36. Agriculture fields in Bommalapura village, Ballari where three Great Indian Bustards were sighted by Karnataka Forest Department staff during November 2018 © Bipin C.M.

According to forest department staff, three GIB were sighted during November 2018 in the agriculture fields of Bommalapura village (Image 36) and seven GIB were reported by people in Raavihaal village (Image 37) during August 2018 in Siruguppa taluk. According to Dr. Ramesh Kumar- DFO of Ballari Division, the Forest Department has acquired ~ 300 acres in the area where GIB are regularly sighted in Siruguppa Taluk for conservation of GIB from a steel company as part of compensatory afforestation. Prof. Abdul Samad Kottur, a local conservationist and bird expert who first reported GIB sighting from this area during 2006 mentioned that based on his observations for more than 10 years, there are 12 GIB in the landscape which includes areas in Gadag, Raichur, Koppal, Chitradurga, and Ballari districts in Karnataka (Image 38). Prof. Kottur was of the opinion that GIB habitats have to be provided protection from hunting and nest predators with the help of dedicated staff and volunteers from the vicinity, but he cautioned that managing it as a Wildlife Sanctuary would antagonize local people towards GIB conservation as seen in many other GIB Sanctuaries.



Image37. Agriculture fields in Raavihaal village, Ballari where seven Great Indian Bustards were reported by local people during August 2018 © Bipin C.M.



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2.2.3. Assessment of threats

2.2.3.1. Assessing impacts of power lines on birds in a multiple-use grassland landscape of Abdasa, Gujarat

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Kachchh District, Gujarat to help in identifying priority areas where maximum bird mortalities occur for mitigation. Based on the information obtained from ongoing digitization of high tension and low tension power lines carried out by WII, a survey was conducted across an area of 1123 km² during March-May 2019. A total of 71 belt transects of 2km each were sampled at randomly generated high tension (23), low tension (23) and control (25- having no power lines) points to compare power line induced bird mortality against natural mortality. Experiments were performed for correcting carcass decomposition and non-detection biases to estimate the actual number of mortalities. Habitat covariates (land-cover, terrain, substrate and distance from water-body) and power line characteristics (number of wires and height of the electric pole) were recorded to assess their influence on bird mortality. To quantify the crossing rate (no. of individuals crossing the power line per hour) for different species, bird movement and activities near power lines were recorded using binoculars.

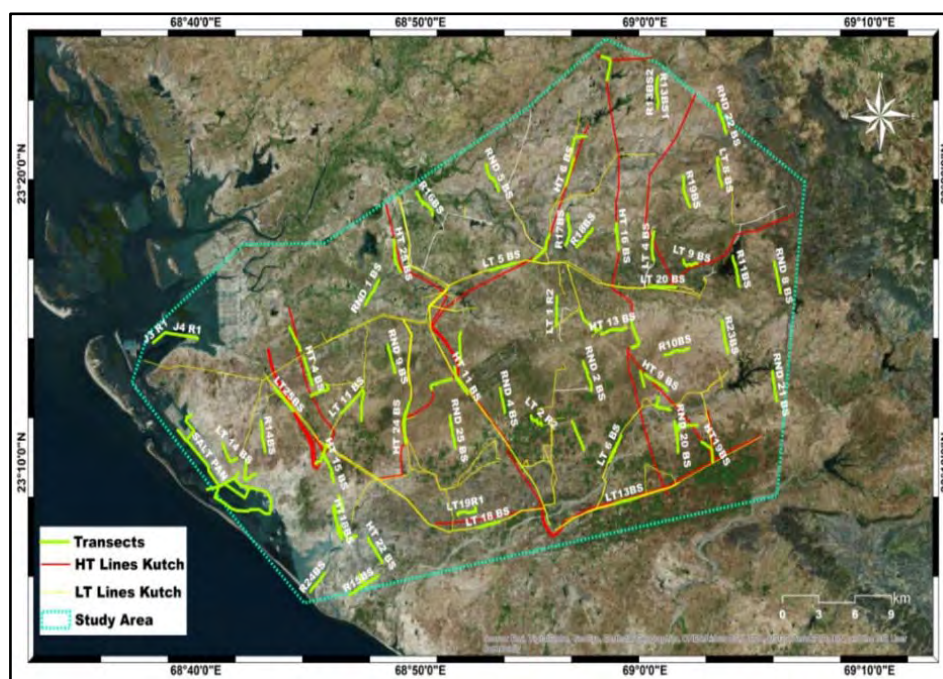


Figure 31. Map showing power line and random transects sampled during bird carcass survey in Kachchh landscape, Gujarat



Image 39. Bird carcass found under power lines during the survey in Kachchh © Aishwarya Joshi

A total of 169 carcasses were found by surveying 310 km on foot, of which the highest number of mortalities belonged to the *Phoenicopteridae* (flamingo) family. Base power line surveys without carcass removal showed that carcass encounter rate was higher in power line transects with 0.78 (0.18SE) carcass per km in high tension power lines and 0.50 (0.12SE) carcass per km, in low tension power lines compared to random transects with 0.25 (0.08SE) carcass per km, indicating relatively greater power line induced mortality than natural mortality (Figure 32). Bird mortalities found in the salt-pan region were analyzed separately because of large differences in its habitat characteristics and avian diversity.

Carcass encounter rate for salt-pan area was found out to be five times greater (mean= 5.25 carcasses per km, SE= 2.54, n=4) than the encounter rate in rest of the surveyed area. Of the 59 mortalities found in the salt-pan area, 28 were identified as that of Greater Flamingo *Phoenicopterus roseus*, which is a matter of serious concern as Kachchh is one of the few important breeding site of flamingoes in India and also the State Bird of Gujarat.

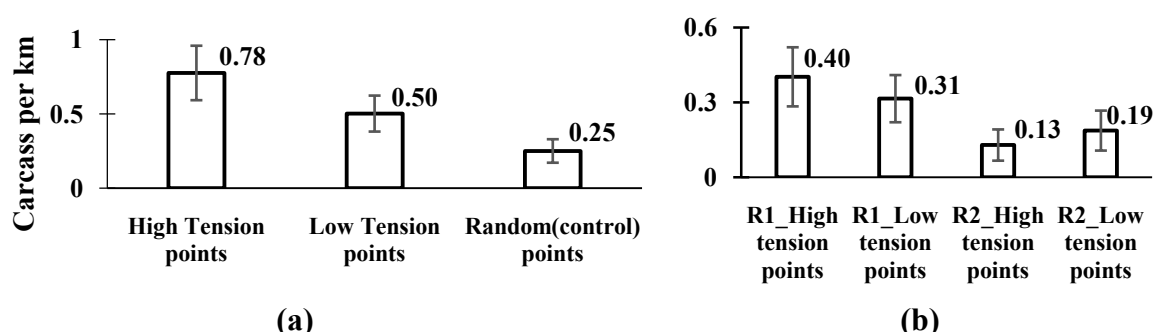


Figure 32. Encounter rate of bird carcasses under power line and random transects during (a) base, (b) first and second replication surveys in Kachchh (Error bars are standard errors)

Surveys conducted after clearing carcasses 30 days earlier, yielded carcass encounter rates of 0.27 (0.14SE) and 0.25 (0.06SE) carcass per km for high tension and low tension power lines respectively. Mean persistence and detection (if available) probabilities were calculated as 0.36 and 0.29 respectively for an average bird carcass over 30 exposure days. Using these statistics, the corrected bird mortality rate was estimated as 2.34 (0.66SE) carcasses per km per month. Extrapolating this value to a conservative figure of power line coverage in the sampled area (1123 km²), it was estimated that 1,818 birds die per month or ~ 22,000 mortalities annually because of power lines (Table 11).

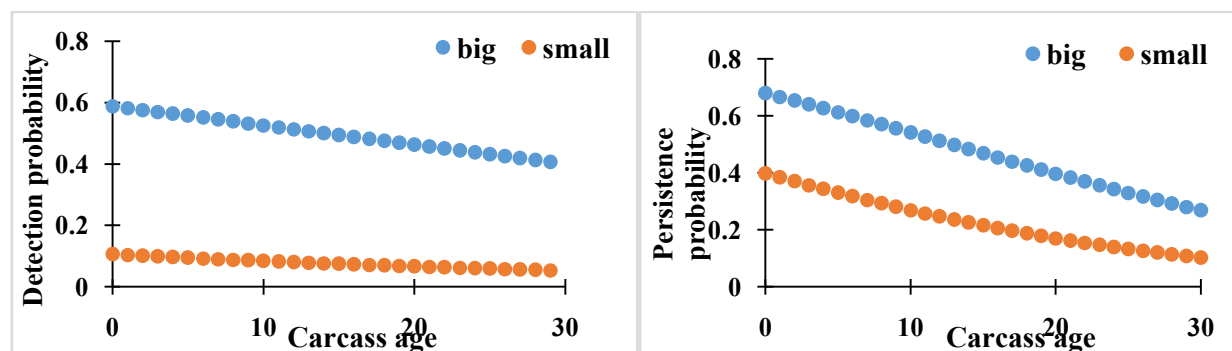


Figure 33. Probability of carcass detection and persistence of small (<100 g) and big (>100 g) birds estimated from carcass detection experiment in Kachchh landscape during April 2019.

Table 11. Estimated bird mortality in Kachchh landscape during March–May 2019. Carcass encounter rate was corrected for detection probability and persistence probability to estimate true bird mortality.

Parameter	Unit / Details	Estimate
Carcass encounter rate	Bird carcasses per km per month	0.25
Detection probability (d)	(mean of <100 g & >100 g bird weights over 30 days)	0.29
Persistence probability (p)	(mean of <100 g & >100 g bird weights over 30 days)	0.36
Correction factor	$d \times p$	0.11
Corrected bird mortality	Carcass encounter rate $\div$ Correction factor	2.34
Total length of power line in the surveyed area (digitized)	Conservative estimate (in km) based on WII's incomplete digitization exercise (2017)	777
Total bird mortalities	Corrected bird mortality per month in 1123 km ² area	1,818
	Annual bird mortality in 1123 km² area	~22,000

However, the value is on the lower side as the digitization of power lines in the surveyed area is not yet complete, but according to visual observations the actual length of power lines is at least thrice the length of digitized power lines. So, the number of mortalities would be thrice of what was estimated and even then it is a conservative estimate as we do not have corrected carcass encounter rate based on bird weight class.

The detection probability for small birds (<100g) was 0.08 and for large birds (>100g) was 0.50, meaning that the observers were able to detect only 8% of the small birds and 50% of the large birds. The reason behind such poor detectability can be credited to massive invasion of *Prosopis juliflora* in the area due to which the area becomes inaccessible with low visibility.

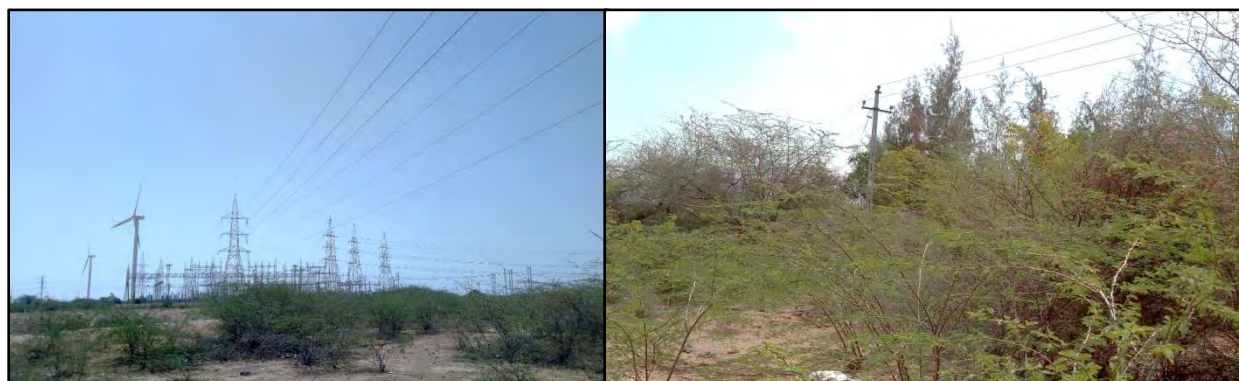


Figure 34. Increasing power line and *Prosopis juliflora* invasion in Kachchh © Aishwarya Joshi

Habitat covariates and power line characteristics were found to be weakly correlated with carcass encounter rate and could be that bird distribution and numbers were independent of the measured habitat characteristics.

Large variations were found in bird crossing rates (no. of individuals crossing the power lines per hr) across different families. Highest crossing rate was found in Columbidae (pigeons and doves) family (8.27 crossings per hr). Small birds (<100g) had higher crossing rate of 6.27 (2.3SE) crossings per hour than birds weighing >100g with 4.23 (2.11SE) crossings per hour. Crossing rate of birds was greater at low tension power lines with 1.60 (0.58SE) crossings per hour than high tension power lines with 0.45 (0.58SE) crossings per hour.

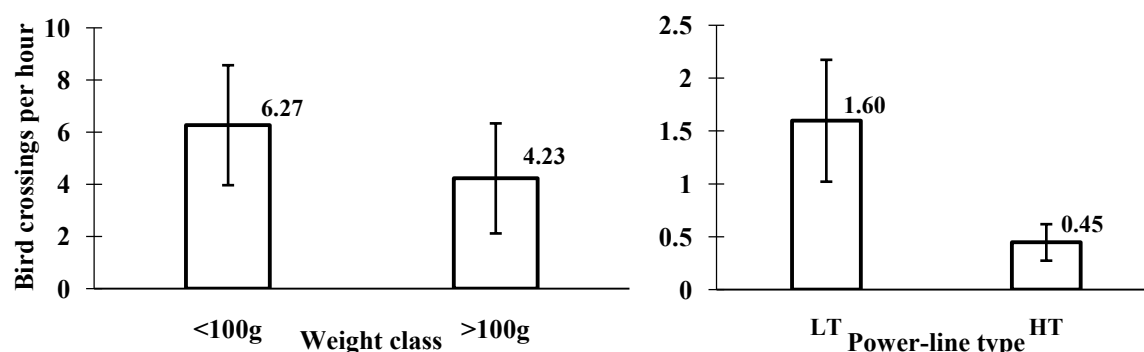


Figure 35. Bird crossing rate- (a) for small(<100g) and big (>100g) birds and (b) at low tension (LT) and high tension (HT) power lines in Kachchh landscape (Error bars are standard errors)

Crossing rate at low tension power lines was twice compared with high tension power lines, indicating that high tension power lines probably acted as barrier to bird movement. Despite lower crossing rate at high tension power lines, their carcass encounter rate was similar to that of low tension power lines. These results indicated that more birds die per crossing at high tension power lines, making them particularly lethal for birds. We found that high tension power lines acted as a barrier to bird movements and resulted in threefold greater mortalities per bird crossing compared to low tension power lines and particularly for large bodied birds. The problem becomes graver when the species is already under stress or has a limited geographic distribution. The area holds high conservation significance owing to the presence of the endangered species such as GIB and Lesser Floricane, but is treated as wastelands and managed to maximize revenue generation.

Some of the mitigation measures that can be implemented in the surveyed area include retrofitting of existing electric poles and the new ones that are yet to come up be placed underground in high risk areas or installed with bird diverters at least that make the power lines more visible to birds. There should be diversion of power line routes passing through high risk area like wetlands, salt-pans, habitat of an endangered or critically endangered species and in and around Protected Areas. There is an urgent need to underground the existing power line network and avoid construction of any new power line network in and around the salt-pan area. Additionally, a before-after-control-impact (BACI) study to find out the effectiveness of various mitigation measures such as wire marking devices, bird diverters, reflectors etc is required. Thus, we need more studies on impact of power lines on bird population at regional levels and covering larger spatial and temporal extents to make the case stronger.



Figure 36. Mitigation measures such as undergrounding high tension power lines implemented in Khadir bet, Gujarat can be replicated in high risk areas © Y.V. Jhala

Identification of high risk priority areas in view of bird conservation must be taken up and construction of power line networks in and around these high risk priority areas should be avoided. In cases where development is inevitable or unavoidable, appropriate mitigation measures should be used to avoid the deleterious impact that power line structures have on avifauna. The cheapest and most effective way to protect avian populations from dwindling is strategic route planning of power lines.

2.2.3.2. Assessment of Great Indian Bustard habitat for pesticide presence in and around Rollapadu Wildlife Sanctuary, Andhra Pradesh

On the request of Andhra Pradesh Forest Department, project staff Mohib Uddin visited Rollapadu Wildlife Sanctuary (RWS), Nagarjunesagar Srisailem Tiger Reserve, Atmakur Division, Kurnool, Andhra Pradesh for 10 days starting from 5th June to 16th June 2018.

RWS is most well-known for the GIB in Southern India. It lies 18 km southeast of Nandikotkur, Kurnool district, Andhra Pradesh. The grassland in Rollapadu covering an area of 6.14 km² was declared as a Sanctuary in 1988 to protect the dwindling populations of the Critically Endangered GIB. The terrain is gently undulating with streams flowing in the depressions during the monsoon. The vegetation of Rollapadu area is classified as tropical thorn forest type (Champion & Seth, 1968). Manakadan & Rahmani, (1988) described the vegetation of the Sanctuary as grassland with some shrubs and trees. The cropping season starts in June and ends by February. Agriculture crop includes jowar, groundnut, cotton and sesame (Manakadan et al., 2014)



Image 40. Grassland in Rollapadu Wildlife Sanctuary © Mohib Uddin

As the human population has grown around RWS after the construction of the Telugu Ganga canal, the development and formation of newly cultivated land has caused overwhelming changes in the area. These changes include intensive agricultural practices, livestock grazing and pesticide use.



Image 41. Bailpadu, Pade barka and Peda padde plots in Rollapadu Wildlife Sanctuary © Mohib Uddin



Image 42. Andhra Pradesh Forest Department staff and WII representative during field work in Rollapadu Wildlife Sanctuary © Mohib Uddin

Purpose of the visit was to collect GIB eggshell and food material samples from the Sanctuary. The most recent eggshell was collected by the Forest Department on 26th May, 2018 from Kotha plot area of the sanctuary. During the visit two GIB females were seen in Kotha plot grassland patch and six Lesser Florican males and one female were sighted in Tower plot of the sanctuary. Three eggshell samples were collected, one of them was from 2018 and two samples were from old eggshells collected by Forest Department. The genetic analysis of egg shells is in process.



Image 43. Nesting site of Great Indian Bustard in Kotha plot, Rollapadu Wildlife Sanctuary © Mohib Uddin

To assess the pesticide residual in bustard food, samples were collected from various plots inside and outside areas of the Sanctuary. A total of 10 sample bags were collected containing insects, berries and soil samples from Thaggu barka, Pade barka, Kotha plot, Tower plot, Temple Plot, No. III plot, Peda padde, Bailpadu areas of the Sanctuary (Figure 37). Soil, insect and berries were collected and stored

in an ice-box (under 4°C). For extraction, the samples were transported to the research laboratory at Wildlife Institute of India, Dehradun, India. The sample was extracted by the latest QuEChERS (AOAC Official 2007.01) method with some modification and analysed for Organophosphate pesticides. All the samples were collected using the systematic protocol.

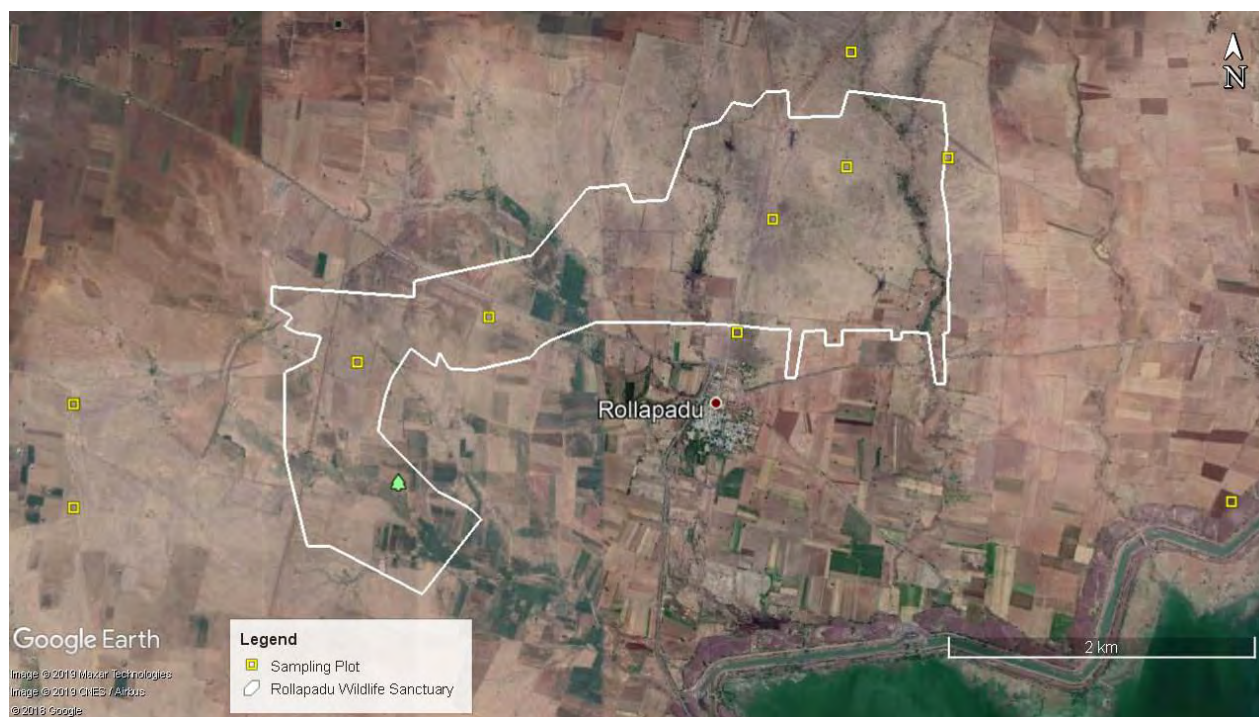


Figure 37. Map of the sampled locations for pesticide presence in and around Rollapadu Wildlife Sanctuary, Andhra Pradesh

Intensive use of agrochemicals mainly pesticides in natural environments have become a major concern. The analysis reported here detected presence of organophosphate pesticides in soil and insects present in RWS and which serves as food for avian species mainly GIB and Lesser Florican. A total of 10 soil and insect samples each were analysed for pesticide concentration. The samples were tested for eight pesticides namely D dichlorovos, Mocap, Disulfoton, Methyl parathion, Ronnel, Chlorpyrifos, Tokuthion and Guthion and six of them were detected in soil as well as insect tissues (Table 12).

Pesticides like Dichlorovos, Mocap, Disulfoton and Chlorpyrifos have been considered to be highly toxic to birds and Methyl parathion and Guthion are considered to be moderately toxic to birds. Avian risk assessment of pesticides depends for the most part on two laboratory derived measures of lethality. First, the median lethal dose (LD50), a statistically derived single oral dose of a compound that will cause 50% mortality of the test population, and second, the median lethal concentration (LC50), which similarly derives the concentration of a substance in the diet that is expected to lead to 50% mortality of the test population. The LD50 concentration of Dichlorovos is 12 mg per kg and Mocap is 4.21 - 61 mg per kg (NIOSH RTECS Online File #82/8110). The acute dietary LC50 for Disulfoton in mallard ducks is 692 mg per kg, and 544 mg per kg in quail.

The United States of America Environment Protection Agency has stated that use of Disulfoton on certain crops may pose a risk to some aquatic and terrestrial endangered species (Walker et al., 1992). A number of studies indicate that birds are highly tolerant of the effects of Methyl parathion (NRC Drinking Water and Health 1977). The oral LD50 for Chlorpyrifos in pheasants is 8.41 mg per kg, 112 mg per kg in mallard ducks and 21.0 mg per kg in house sparrows (Hartely and Kidd, 1983; TOXNET,

1975-1986; US EPA, 1989). The LD50 for a granular product (15G) in bobwhite quail is 108 mg per kg (US EPA, 1989). Guthion is moderately to toxic to birds but acute symptoms of this pesticide poisoning in birds include regurgitation, wing drop, wing spasms, diarrhoea, lack of movement, etc. (USDA-Agricultural Research Service, 1987). The oral LD50 for guthion in young mallards is 136 mg per kg, 74.9 mg per kg in young pheasant, 84.2 mg per kg in young chukar partridges (Sax, 1984) and 32.2 mg per kg in bobwhite quail (USDA-Soil Conservation Service, 1990). Though the concentration of these pesticides was within the permissible limit of LD50 concentration, the continuous exposure of such contaminated food to birds could pose an additional threat.

Table 12 . Organophosphate pesticide concentration (ng per g) in soil and insect samples collected from Rollapadu Wildlife Sanctuary

Pesticide	Dichlorvos		Mocap		Disulfoton		Methyl parathion		Ronnell		Chlorpyrifos	
	S	I	S	I	S	I	S	I	S	I	S	I
Plot 1	-	12.51	-	-	-	-	-	-	-	-	2.76	11.84
Plot 2	-	-	-	-	-	-	-	-	12.65	-	2.26	-
Plot 3	-	-	-	-	-	-	-	-	-	-	-	-
Plot 4	-	-	-	-	-	-	-	-	-	-	-	-
Plot 5	-	26.85	-	-	-	-	19.72	18.47	-	-	-	-
Plot 6	18.89	-	15.77	-	12.14	-	-	-	-	-	-	-
Plot 7	-	-	-	-	-	-	-	-	-	-	-	-
Plot 8	98.69	78.95	-	-	-	-	11.25	-	-	-	-	-
Plot 9	-	-	-	-	-	-	-	-	-	-	26.01	26.32
Plot 10	-	-	-	-	-	-	-	-	-	-	-	-
<i>S- Soil sample, I- Insect sample, - Not detected/ Below detection limit</i>												

2.2.3.3. Pesticide analysis of insect, vegetation and soil samples from Lesser Florican habitat in four States

In recent times, humans have released thousands of synthetic chemicals and pollutants into the environment, creating conditions that wildlife species have never experienced before. Due to this, wildlife populations have suffered severe losses or even faced extinction. Rachel Carson's *Silent Spring* (1962) identified the urban use of pesticides as the cause of a noticeable decline of birds in the eastern United States and also the cause of mass songbird mortalities. Recently, a study directed by a Canadian toxicologist identified insecticides as the best predictor of grassland-bird declines in the U.S., followed by loss of cropped pasture (Mineau and Whiteside 2013). The scientific study assessed and modelled five potential causes of grassland-bird declines: change in cropped pasture; farming intensity or the proportion of agricultural land that is actively cropped; **herbicide use**; **overall insecticide use**; and change in permanent pasture and rangeland. In the authors' words, "In conclusion, it would be foolhardy for anyone to argue that habitat loss is of no importance to bird declines. However, we should be careful to consider pest control and specifically the use of highly toxic insecticides as a potential contributor to those declines. Unfortunately, information on pesticide use is often difficult to obtain or considered to be confidential, hampering any serious analysis of its true impact"

The situation is similar in India regarding information of pesticide use on grassland birds. Lesser Floricans are known to live in habitats that are a matrix of grasslands and agricultural lands with crops like cotton, millet, sorghum, maize, soya bean, sugarcane, mustard, rice, groundnut, lentils and wheat. The species can breed even in small grass patches isolated in cultivated areas. Sankaran (1997)

reported that in areas where grasslands are grazed, or croplands are irrigated during drought, the species tends to be found more frequently in cropland. These crop-based habitats are not only used for breeding and escape cover but also for feeding, and source of food are bound to get affected with the application of pesticides. This may lead to the death of adult birds feeding on the pesticide infected insects and grains. It may also affect hatching success adversely as a result of biomagnification.

2.2.3.3.1. Routes of Exposure

Birds can be exposed to pesticides in many ways as they lead their daily lives, foraging for food in crop fields and grasslands. Some of the primary exposure pathways are (a) direct pesticides intake - pesticides are sometimes sold in granular form which is applied together with the seeds or prey on a granular coated earthworm. Pesticides treated seeds can also be ingested, (b) eating contaminated food - birds may also get exposed to pesticides by eating recently sprayed insect or plants and (c) exposure through the skin and respiration - inhalation and skin exposure occurs when birds are present during or shortly after pesticide application.

To assess the direct and indirect impact of pesticides on Lesser Florican and its habitat, survey was conducted across breeding range of the species. Insect, soil and vegetation samples were collected from sampling grids located in the States of Rajasthan, Gujarat, Madhya Pradesh and Andhra Pradesh, covering an area of ~20000 km² (Figure 38). Different classes of pesticides use were reported (Table 13), especially in the agricultural areas of Rajasthan and Gujarat (Image 44).

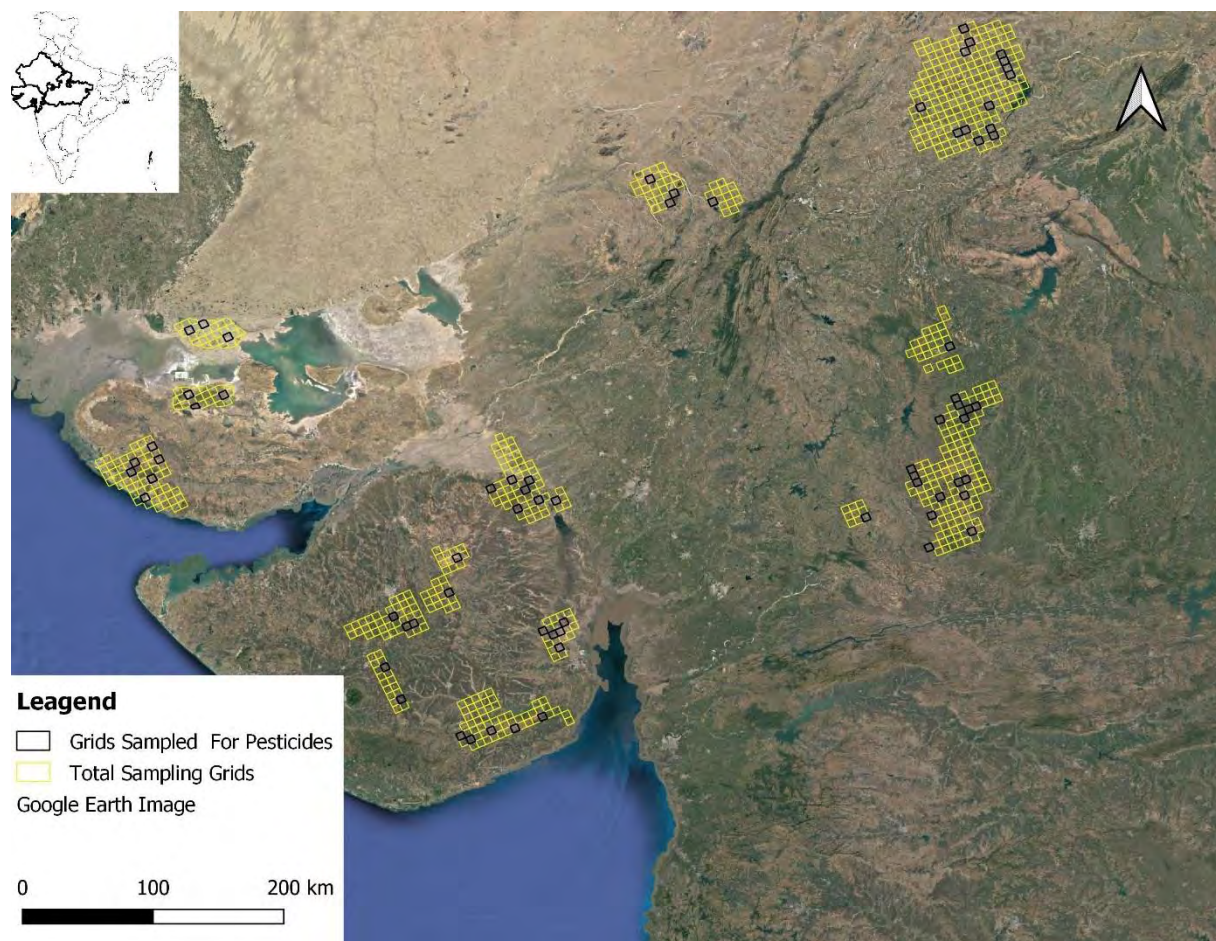


Figure 38. Map of areas sampled (in black) for pesticide use in Lesser Florican habitat (yellow) in Rajasthan, Gujarat and Madhya Pradesh



Image 44. Pesticide application on cotton crop in Lesser Florican habitat © Rizwan Ali Khan.



Image 45. Different classes of pesticide containers found during the survey (A) Organophosphate pesticides, (B) Pyrethroid, (C) Neonicotinoids & (D) Triazine © WII

2.2.3.3.2. Sample preparation and analysis

The insect, soil and vegetation samples were extracted by the QuEChERS AOAC Official 2007.01 method. The prepared samples were stored in -20°C after extraction. The extracted samples are being analysed for pesticides concentration through Gas Chromatography-Electron Capture Detector/ Nitrogen Phosphorus Detector (GC-ECD/NPD) which is under process, and a separate report will be submitted after the completion of the work.

Table 13. Composition and mode of action of different class of pesticides container found during the survey

Pesticide	Compounds	Mode of action
Organophosphate Pesticides	Monocrotophos, Chlorpyrifos, Acephate & Profenofos	Disrupts functioning of nervous system in an organism, causes paralysis or death
Pyrethroid	• - Cyhalothrin, Fenvalerate & Cypermethrin	
Imidazolinone	Imazethapyr	Inhibits Acetohydroxy acid synthase enzyme accountable for synthesis of the amino acids valine, leucine, and isoleucine
Triazine	Atrazine	Kills the weed by inhibiting photosynthesis
Neonicotinoids	Imidacloprid	Causes blockage of nicotinerbic neuronal pathway resulting in insect's paralysis and eventual death

2.2.3.4. Locust outbreak rapid assessment survey to prevent pesticide spraying in Great Indian Bustard habitat in Thar, Jaisalmer

Thar Desert harbors the major population of Critically Endangered GIB with less than 150 individuals in number. The DNP, Pokhran Field Firing Range (PFFR) and adjoining areas are the only remaining home for the last surviving breeding population of GIB that make this area a high conservation priority zone. Locust outbreak was first reported from this area during May 2019 followed by announcements of warnings and control measures by District administration.

Locust swarm is one of the threats to agriculture in African and Asian countries. It is known to find the presence of locust after summer rains and in areas where they previously were (Bahadur, 1942). Western Thar landscape experienced locust outbreak after a rainfall between 12th and 15th May 2019. Natural interventions such as thunderstorms or the passage of depressions in summer, is of special significance in the development of outbreak centers in Desert areas (Bhatia, 1939). Some of the locust outbreak centers were located within the areas intensively used by GIB and reports of large scale pesticide spraying were appearing in the media. Teams from Wildlife Institute of India carried out a rapid assessment of locust infestation in GIB landscape near Pokhran/ Ramdevra from 28th May to 3rd June 2019 to identify the outbreak centres and whether they overlapped with areas intensively used by GIB to suggest mitigation measures against pesticide exposure.

Data on locust population was collected based on Food and Agriculture Organization (FAO) guidelines (Cressman, 2001). Survey area was divided into multiple 36 km² grids. Five plots in each grid was sampled to estimate locust density. At each plot, foot transect of 100 meters (length) and 3 meters (effective detection width; Area 300 m² per site) was walked and direct count method was used to enumerate locust numbers (adults and hoppers). Other associated habitat variables viz., land cover (grassland/ agriculture/ barren), vegetation density (dense/ medium/ low), presence of soil moisture, last date of rainfall and presence of animal carcasses were also recorded.

A total of 29 grids encompassing an area of 1044 km² were surveyed. Locust presence was recorded in a total of 21 survey grids. Average density of locust in the surveyed area was estimated as 2940.46

individuals per km². Highest density was found in grid 66 (Figure 40) with 22000 locusts per km² followed by grids 67 and 78. Animal carcasses were not detected during the survey.



Figure 39. Locust outbreak in Thar (a) Locust congregation on *khimp- Leptadenia pyrotechnica* shrub © Bipin C.M., (b) Dead locusts collected from Malathion spray site © Devendradutt Pandey

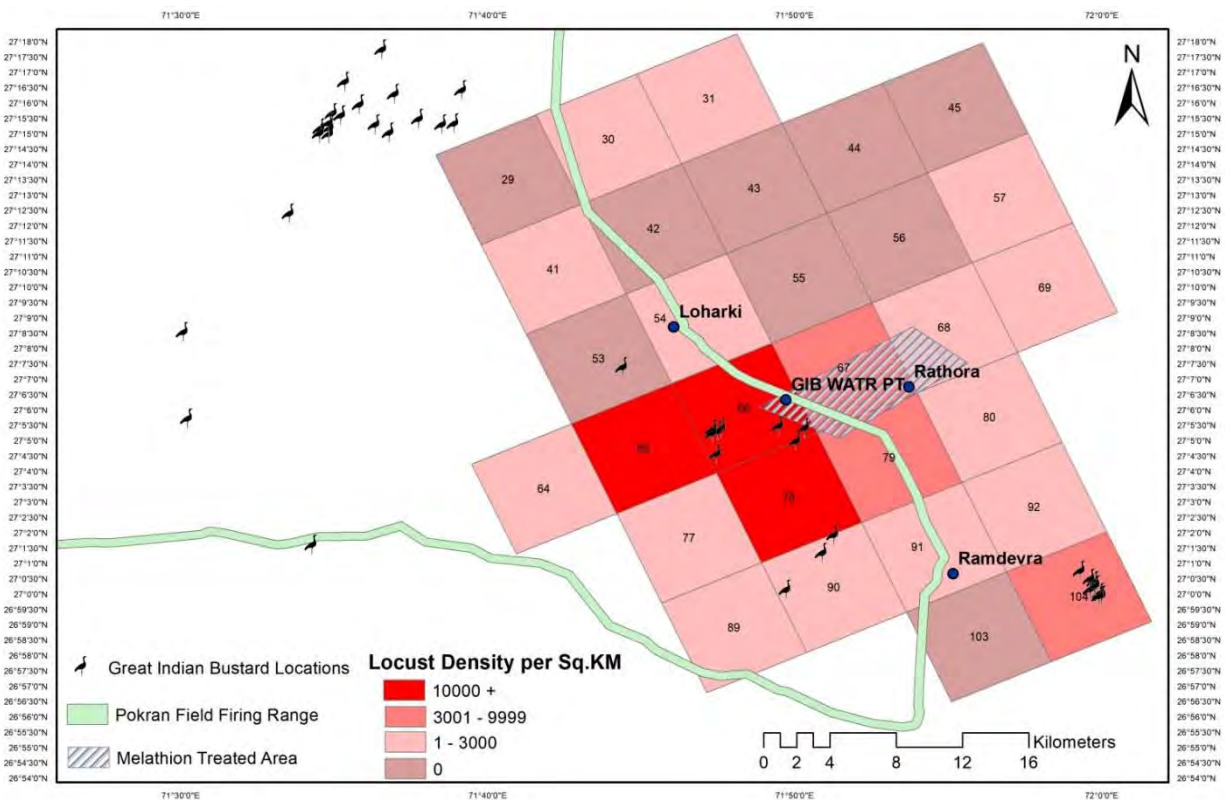


Figure 40. Map of the surveyed area for estimating locust abundance using grid based sampling in Thar, Jaisalmer

To control locust outbreak, a few areas near Loharki village, Jaisalmer (inside PFFR) had already been sprayed using Malathion 96%-a contraceptive insecticide, by the District administration. Some of the previous studies suggest that the chemical can be detrimental to the birds. Malathion does have various effects on birds such as reduced nesting behavior, disorientation and loss of motor coordination, leading to reduced ability to cope with the daily stresses of survival under natural conditions. There

have been observations of abnormal feathering and beak deformities in birds exposed to Malathion (Newhart 2006). The sprayed area is a frequently used water drinking and foraging site of GIB which increases the chances of exposure of GIBs to Malathion which could cause some serious hazard. It is recommended to monitor the entire landscape, where locust outbreaks have occurred, insecticide has been sprayed, and should be guarded to prevent GIB visiting that particular area. Desert Locust Situation update by FAO notified that there is possibility of migration of more locust swarms in Thar Desert after mid-June till year end.

2.2.4. Conservation genetics

2.2.4.1. Genetic structure analysis of Great Indian Bustard populations to aid conservation management

Species populations which are highly fragmented and small are highly vulnerable to extinction events caused due to environmental and demographic stochasticity. Such species are more likely to have limited fitness and fixation of deleterious mutations further increasing loss of genetic variability through genetic drift (Reed and Frankham 2003). Therefore, gaining insights into the genetic status including population differentiation, levels of dispersals and factors promoting them, are essential for the success of any conservation programmes including *in-situ* and *ex-situ* measures, because it allows in defining management units and design of conservation strategies for preserving sub-specific distinctiveness (Hedrick 2001). Such an understanding is vital for critically endangered species whose survival depends on the scientifically informed conservation management. (Frankham 2002)

The only genetic study on GIB (Ishtiaq et. al. 2011) identified low genetic variation at mitochondrial (mt) DNA with no phylogeographic structure and emphasized the importance of using nuclear DNA microsatellite markers to determine the population genetic structure at different spatial scales and sex-specific dispersal patterns in GIB. Therefore, nuclear microsatellites were used to evaluate the genetic status of GIB to identify conservation units, if any, to suggest long term conservation strategy for the species. We conducted a comprehensive population genetic study of GIB from the present distribution ranges primarily using non-invasive techniques and develop genetic data sets consisting of mt DNA and microsatellite markers. The data was analyzed to identify extant levels of genetic diversity, investigate population differentiation and gene flow across different subpopulations of GIB.

2.2.4.1.1. Materials and methods

2.2.4.1.1.1. Sample collection

Non-invasive samples (faeces, feathers and tissue samples from dead birds) were collected between the years 2016-till date from Gujarat (GUJ), Rajasthan (RAJ), Maharashtra (MAH), Madhya Pradesh (MP) & Andhra Pradesh (AP). All the samples were stored either in a sterile zip lock bag filled with silica or preserved in 90% ethanol and later shifted to laboratory for storage at -20°C until DNA extraction.

2.2.4.1.1.2. DNA extractions and species identification

Total genomic DNA was isolated from faecal samples using Guanidine isothiocyanate-silica extraction protocol (Boom et al. 1990), tissue samples and moulted feathers using DNeasy blood and tissue kit (Qiagen), and egg membranes using Bush et al. (2005) methodology. DNA extractions were carried out in a dedicated room free of PCR products, in batches of eleven samples. Negative controls were included for every batch of extraction to monitor potential contamination.

Species identities of faecal pellets, egg membranes and feather samples were established by amplifying and sequencing a considerable proportion of either 399 bps fragment of the cytochrome b gene (LCyt-

B4 and LCyt-B6; Broderick et al. 2003) or a 323 bps fragment of control region II (L438 and H772; Wenink et al. 1993) and gene bank comparison.

2.2.4.1.1.3. Microsatellite marker amplification and genotyping

Eleven polymorphic fluorescently labelled microsatellite loci, namely BUSA2, BUSA10, BUSA22, BUSA112, BUSD110, BUSA18, BUSA205, BUSA210, BUSD117, BUSD12, BUSA204, BUSD118, BUSA29, BUSD119 (Chbel et al. 2002) were amplified. Polymerase chain reaction (PCR) amplification was performed in a 10 μ l reaction mixture, each containing 5 μ l of 1x multiplex PCR Master mix buffer (QIAGEN Multiplex PCR kit, Germany), 1x of bovine serum albumin, 4 μ m of each primer pair, and 2-10 ng of extracted DNA. Thermal profile of the amplification was as follows: initial denaturation at 95°C for 15 minutes, followed by 40-45 cycles of denaturation at 94°C for 45 seconds, annealing at 50°C for 45 seconds and extension at 72°C for 60 seconds with a final extension at 72°C for 30 minutes. Annealing temperature for each microsatellite was first standardised and modified according to optimal amplification. PCR products were electrophoresed using ABI 3130 Genetic Analyser (Applied Biosystems) with Genescan 500 (-250) LIZ with internal lane size standard and alleles were scored manually using Genemapper software (version 3.7, Applied Biosystems).

2.2.4.1.1.4. Data analysis

Program CONVERT (Glaubitz 2004) was used to prepare create input files for all further analyses. Program CERVUS ver. 3.0 (Kalinowski et. al. 2007) was used to identify unique multilocus genotypes using Identity analysis option. $P_{(ID)}$ (probability that two different individuals will share common multilocus genotype at a given number of loci) and $P_{(ID-sibs)}$ (probability that siblings will share common genotype) was also tested to ensure that loci used could reliably help in discriminating two related individuals and siblings using GENALEX ver. 6.5 (Peakall and Smouse 2006).

2.2.4.1.1.4.1. Genetic variation and genetic difference

Microsatellite genetic variation was characterized for each inferred clusters (GUJ, RAJ, MAH, MP & AP) and combining all areas using summary statistics. We estimated number of alleles (N_a), mean number of alleles (MNA), expected (H_e) and observed (H_o) heterozygosity for all the microsatellites using FSTAT ver.2.9.3.2 (Goudet 1995). Allelic richness (AR) was also estimated using FSTAT ver.2.9.3.2 (Goudet 1995) for each study site by incorporating a rarefaction method which corrects for variation in sample sizes. Information on polymorphic information criteria (PIC) was calculated using CERVUS ver.3.0 (Kalinowski et. al. 2007). Significant deviations from Hardy-Weinberg equilibrium at each locus using exact tests (Guo and Thomson 1992) and linkage disequilibrium among all pairs of microsatellite loci were estimated using GENEPOP ver.1.2 (Raymond and Rousset 1995). Bonferroni corrections ($P < 0.05$) were applied for multiple comparisons. A RLEQUIN ver.3.5 (Excoffier and Lischer 2010) was used to calculate Wright's F statistics and to test the statistical significance between the sampling locations using Weir and Cockerham estimator (Weir and Cockerham 1984) with 10,000 permutations.

2.2.4.1.1.4.2. Population genetic structure

In the non-spatially explicit Bayesian clustering algorithm, STRUCTURE ver. 2.3.4 (Pritchard et. al. 2003) was used, wherein a Bayesian based Markov Chain Monte Carlo (MCMC) approach is used to identify number of populations (K). STRUCTURE was executed with a burn in period of 50,000 MCMC runs after which data harvesting was done 500,000 iterations with both location information

(LOCPRIOR=1) and without (LOCPRIOR=0) included a s from prior knowledge. Value of K was allowed to vary between 1 and 10 with 20 independent simulations run for each K value. Web based program STRUCTURE HARVESTER (Earl and vonHoldt 2012) was used to determine optimal value of K (number of assumed genetic clusters) by calculating mean likelihood of data (Pritchard et al 2000) and the rate of change in the log probability between successive K values (Delta K) (Evanno et al. 2005).

In the multivariate analysis, Discriminant analysis of principal components (DAPC), a non-model based method was used, which identifies genetic clusters by transforming the genotypic data into principal components and then uses k-means clustering in defining individual groups, with best supported cluster identified by Bayesian Information Criteria (BIC). Similarly, Principal Coordinate analysis (PCoA) was carried out using GENALEX ver.6.5 (Peakall and Smouse 2006).

2.2.4.1.2. Results

Out of total 228 non-invasive samples, amplifiable DNA was extracted from only 112 samples, of which 96 samples were identified as GIB samples based on Cyt B and CR II regions. From the 96 GIB samples, 83 yielded microsatellite data for more than nine loci out of the panel of 11 microsatellites. These were considered for Identity analysis in CERVUS and gave 73 individuals (faeces=5, feathers=51, egg shell=9, and tissue=8) with 18 recaptures. From all the 11 microsatellite markers, eight markers were polymorphic. Microsatellites, BUSA22, BUSD110 and BUSD119 were monomorphic and were not considered for further analysis. The panel of eight microsatellite markers used for individual identification had cumulative probability of identity P_{ID} value of 2.6×10^{-3} and probability of identity of siblings $P_{ID-sibs}$ value of 4.0×10^{-2} indicating sufficient power to discriminate individuals and siblings (Figure 41).

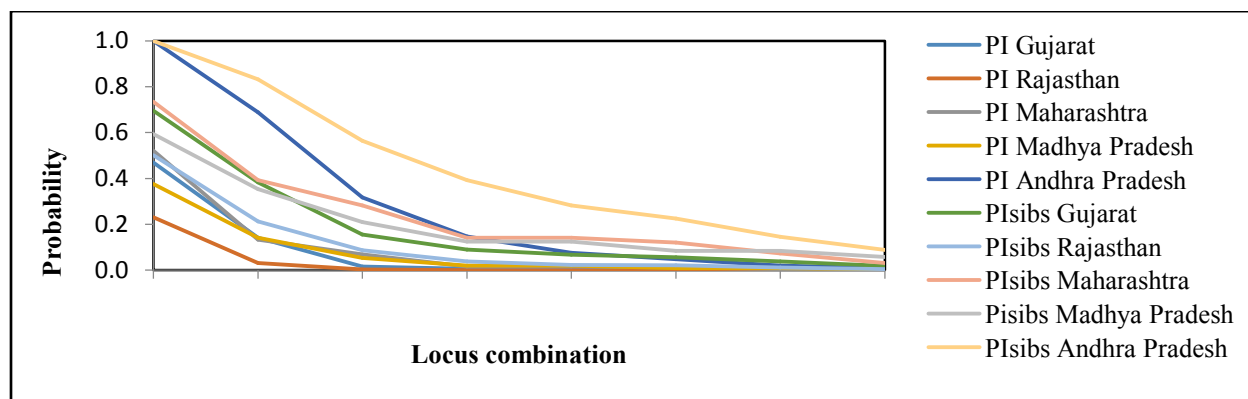


Figure 41. Population-wise Probability of- Identity (P_{ID}) and Identity of Siblings ($P_{ID-sibs}$)

Number of alleles for all loci across all populations ranged from 3-5. Basic genetic diversity estimates including the mean number of alleles (MNA), allelic richness (AR), expected (He) and observed heterozygosity (Ho) values are 2.7, 1.5, 0.31 and 0.52 respectively. Polymorphic information criterion (PIC) values for all the microsatellite markers ranged from 16 to 73 % (BUSA210 and BUSA112) (Figure 42).

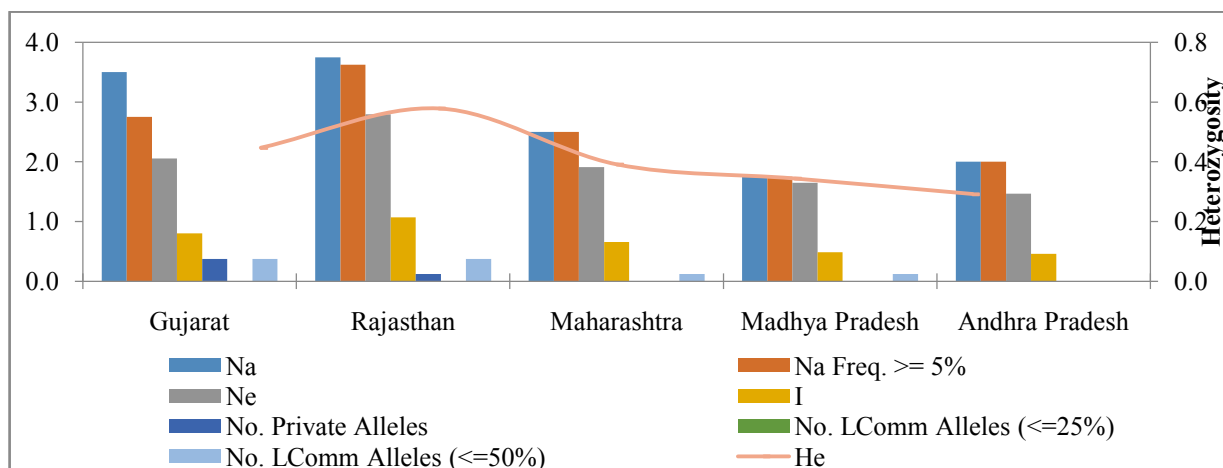


Figure 42. Population-wise allelic patterns and genetic diversity estimates

2.2.4.1.2.1. Genetic diversity and genetic difference

Deviations from Hardy-Weinberg Equilibrium (HWE) were observed in two loci (BUSA205, BUSA210) in Gujarat, one loci (BUSA2) in Rajasthan, five loci (BUSA2, BUSA112, BUSA205, BUSA210, BUSD117) in Maharashtra and almost all loci in Madhya Pradesh and Andhra Pradesh populations. But when tested combining all the sampling sites, it was found only one loci (BUSA210) deviated from HWE. Significant linkage disequilibrium (LD) was detected between fifteen pairs of loci out of twenty-eight pairs of loci combinations after Bonferroni correction ($P < 0.05$), but when tested within individual populations, LD was detected between twelve pairs of loci in Rajasthan, six pairs in Gujarat, four in Maharashtra, two pairs in Andhra Pradesh and none in Madhya Pradesh.

Genetic differentiation between GIB subpopulations was low to moderate. The level of genetic differentiation suggested low levels of gene flow between Maharashtra and Andhra Pradesh (F_{ST} : $0.42 \pm 0.0038SE$) followed by Gujarat and Andhra Pradesh (F_{ST} : $0.30 \pm 0.0SE$) and Madhya Pradesh and Andhra Pradesh (F_{ST} : $0.278 \pm 0.08SE$) subpopulations. High levels of gene flow was observed between Rajasthan and Gujarat (F_{ST} : $0.06 \pm 0.001SE$) populations (Table 14).

Table 14. Estimates of genetic differentiation between Great Indian Bustard populations (* indicates non-significant values p-value, $p > 0.05$)

Population	F_{ST}
Gujarat Vs Rajasthan	0.06929 ± 0.00149
Gujarat Vs Maharashtra	0.12157 ± 0.00604
Gujarat Vs Madhya Pradesh	*0.07143 ± 0.30591
Gujarat Vs Andhra Pradesh	0.30042 ± 0
Rajasthan Vs Maharashtra	*0.05514 ± 0.17672
Rajasthan Vs Madhya Pradesh	*0.00464 ± 0.77339
Rajasthan Vs Andhra Pradesh	0.21879 ± 0.0004
Maharashtra Vs Madhya Pradesh	*0.06011 ± 0.48203
Maharashtra Vs Andhra Pradesh	0.42077 ± 0.00386
Madhya Pradesh Vs Andhra Pradesh	*0.27831 ± 0.08979

2.2.4.1.2.2. Population genetic structure

The Bayesian clustering analysis in STRUCTURE suggested the most probable number of genetic clusters to be four ($K=4$), using no prior location model (LOCPRIOR=0). On the other hand, using prior location information model (LOCPRIOR=1), STRUCTURE analysis suggested $K=3$ as the most probable number of genetic clusters. Clustering pattern was more clear with the LOCPRIOR model when compared to the without LOCPRIOR model. It might not always be possible to know the true value of K , therefore the smallest value of K which captures the maximum structure in the data should be aimed (Faubet et al. 2007). Moreover, both the models using GIB samples suggested different number of clusters with variation in clustering patterns, therefore we showed assignment probabilities for K values from 2-5 (Figure 43) using both models. Without LOCPRIOR model at $K=4$, it was found that the most of the individuals in populations shared ancestry ($q < 0.8$) with very few individuals assigned to separate clusters. However, using the LOCPRIOR model at $K=3$, we observed most of the individuals assigned to separate clusters with few individuals sharing ancestry ($q < 0.8$).

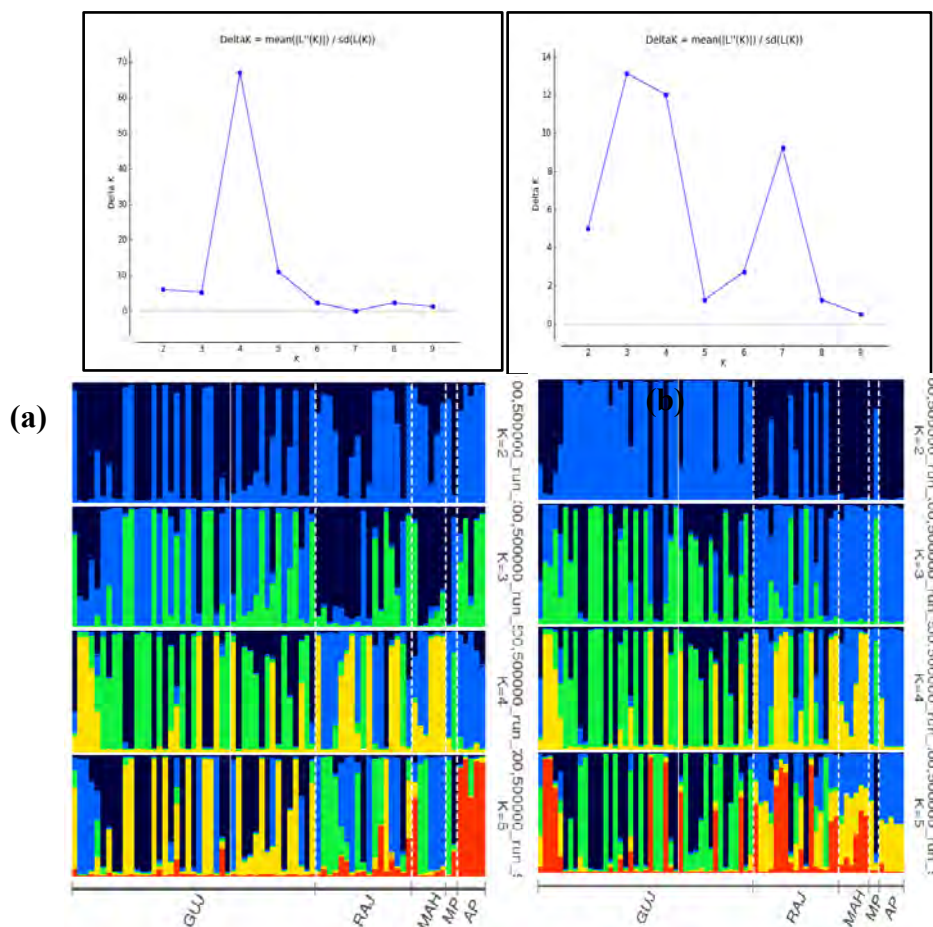
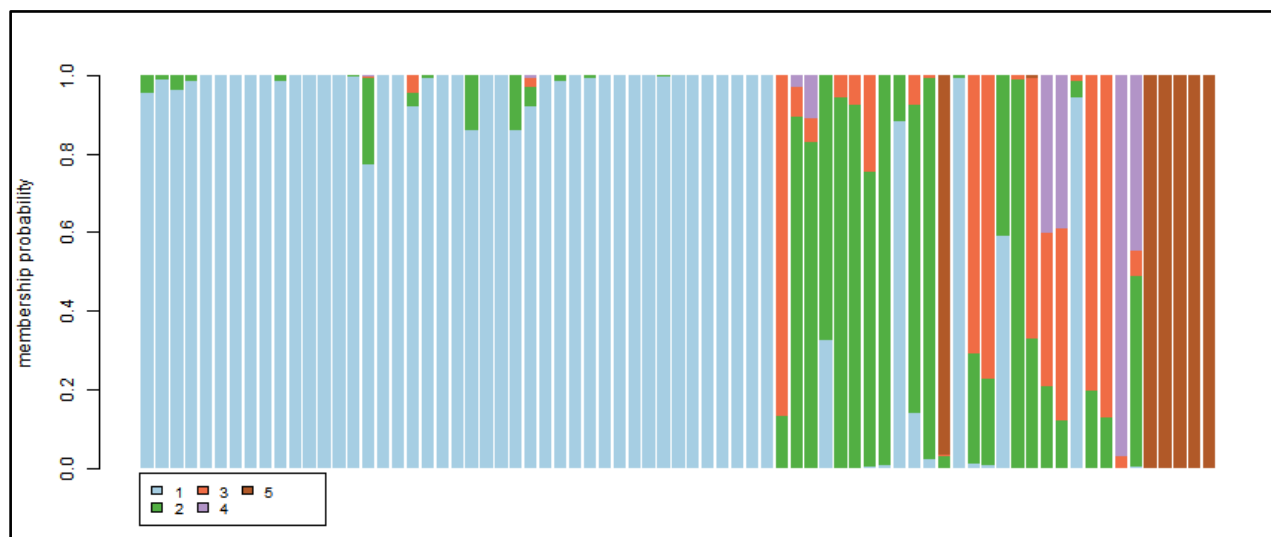


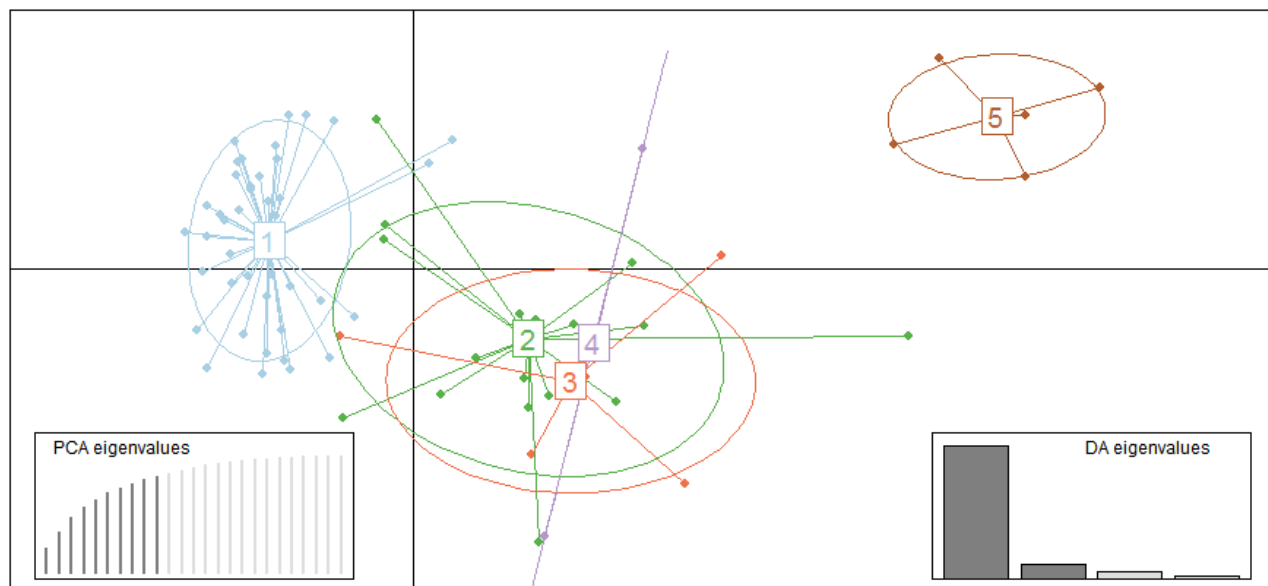
Figure 43. Bayesian clustering analysis result using STRUCTURE- (a) Delta K plot for without LOCPRIOR model (b) Summary bar plot of Structure run from $K=2-5$ using without LOCPRIOR model, (c) Delta K plot for with LOCPRIOR model, (d) Summary bar plot of Structure run from $K=2-5$ using with LOCPRIOR model (Each individual is represented by a vertical bar and indicates probability of membership in each individual)

In multivariate analysis, DAPC also supports the results of Bayesian clustering method, STRUCTURE: LOCPRIOR model in identifying the number of genetic clusters as $K=3$. Clear clustering of populations is seen in DAPC when compared to other Bayesian clustering methods where

GUJ and AP were identified as separate clusters without any sharing ancestry, while the individuals of remaining populations were assigned to separate cluster with sharing ancestry between the individuals (Figure 44). Principal coordinate analysis results with percentage of variation explained in each axis is shown in Figure 45.



(a)



(b)

Figure 44. Discriminant analysis of principal components (DAPC) results- (a) Compoplot & (b) Scatterplot of populations 1, 2, 3, 4 and 5 represent Gujarat, Rajasthan, Maharashtra, Madhya Pradesh and Andhra Pradesh respectively.

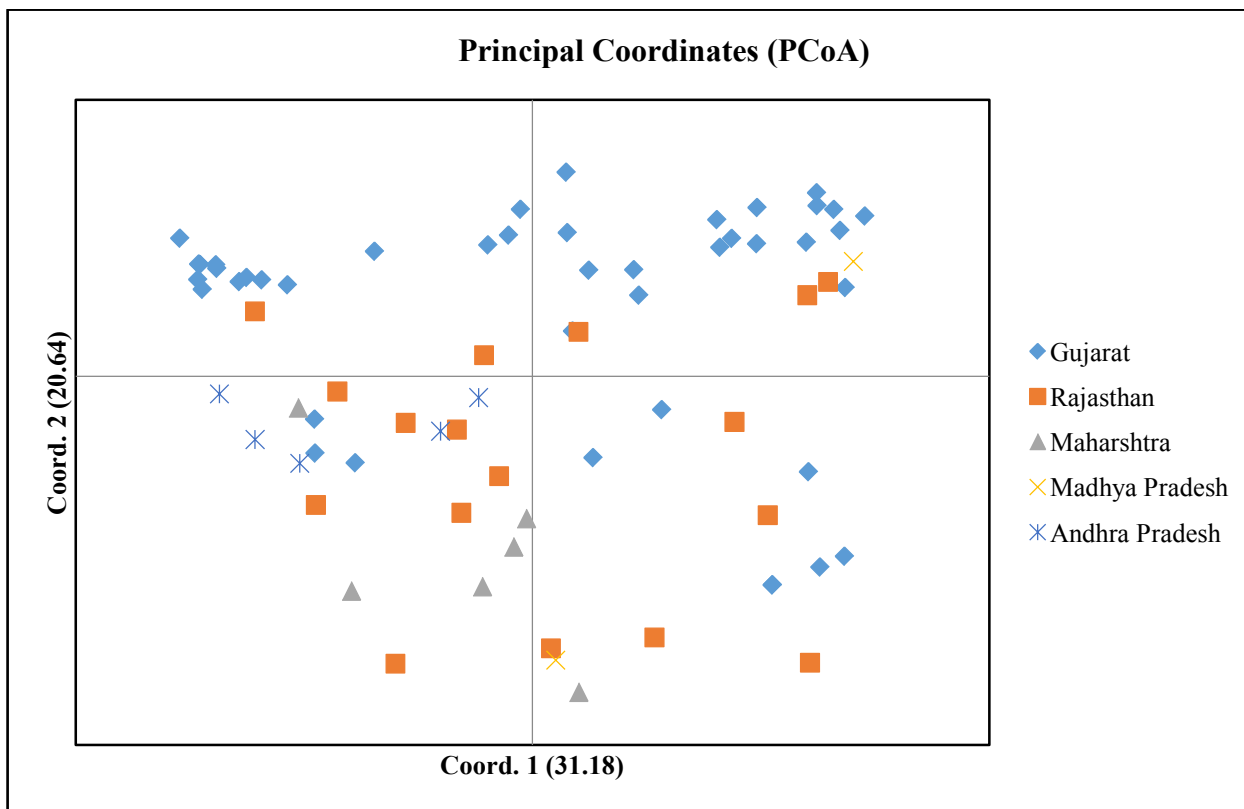


Figure 45.Principal coordinates analysis plot (PCoA) with percentage of variation explained by each axis computed by GenAlEx v 6.5

2.2.4.2. Identification of Great Indian Bustard from tissue, feather and intestine samples collected from a bird carcass using molecular tools

To identify the species of a dead bird whose feather, intestine and tissue samples sent by DFO-Jaisalmer to WII, forensic examination was conducted using molecular tools. DNA was extracted from three samples and amplified using PCR and sequences were generated. Sequences determined for the samples based on 16S, CytB and CR fragments of mitochondrial DNA matched with GIB in comparison with other species examined.

CAPACITY-BUILDING AND OUTREACH



Bustard Recovery Program /Annual Report III /2018-2020

2.3. Capacity building and outreach

2.3.1. Awareness programs, workshops and meetings

2.3.1.1. Conservation education in schools

Wildlife conservation is reliant on the future generation. Students who are connected to the natural world can positively shape the future of wild species and their habitats. Imparting nature conservation education through fun and interactive sessions is always an amazing experience for students. The purpose of this activity is to make the nature education joyful, entertaining and interactive through various games, field visits and interactive sessions. Students also get an opportunity to learn about and identify the biodiversity in their backyard and its role in the ecosystem. Currently various interactive sessions have been conducted in the schools in Thar, enabling the kids to have a better understanding about the importance and significance of Desert ecosystem. During these sessions, kids were awarded with notebooks and bookmarks illustrating the flora and fauna of DNP. We conducted customized nature education programmes and sensitized over 2279 students in 22 schools across 18 villages from January – April 2019 (Phase 1) in Jaisalmer District.

Our intention is to conduct workshops that have elements such as movie screenings, drawing competitions and games, all wildlife themed and leading into discussion with children about the GIB. These activities are would be conducted from the month of December 2019 onwards (Phase 2).



Image 46. Interactive sessions on the Great Indian Bustard and grassland conservation conducted in schools, Jaisalmer © WII

2.3.1.2. Skill development workshop on the scope and effects of wildlife tourism in Jaisalmer

The team conducted a two-day skill development training workshop for the Rajasthan State Forest Department frontline staff, nature guides and wildlife enthusiasts of the area on 27th- 28th January 2019 in Jaisalmer (Image 47). During the workshop, Subject Expert Dr. A sad R ahmani introduced the

participants to the scope and effects of wildlife tourism, along with field observations and conservation ethics, followed by a hands-on instrumentation and field training by project team. The workshop provided useful job skills to the local youth to work as nature guides. The economy in the Thar Desert functions primarily on tourism during the months between October and January. This activity was an icebreaker to bridge the gap between local communities and the team by assisting youth to get trained in relevant skills and to achieve gainful employment. The event received a huge turnout from the local community, and at the end of this workshop the participants were presented with mementos themed on GIB to promote the significance of GIB and grassland conservation in the area.



Image 47. Skill development workshop conducted for Rajasthan Forest Department frontline staff, nature guides and enthusiasts in Jaisalmer © WII

2.3.1.3. Sensitization workshop on Great Indian Bustard Conservation, New Delhi

A workshop was organized at WWF-India headquarters, New Delhi on 21st February, 2019 with partner agencies to sensitize power agencies and the media on GIB conservation. The workshop was attended by ~ 100 participants including officials from MoEF&CC and State Forest Department, representatives from power agencies, conservation organizations, legal fraternity and media. The immediate need to mitigate power-lines caused bustard collisions and deaths, and the necessity of

conservation breeding were highlighted. The objective of this workshop was to create awareness about the plight of the bustard, develop a branding strategy to communicate to the public and all stakeholders in one language about the bustard, and to communicate to power agencies (government and private) the integral role they serve in saving this iconic species of the Indian grasslands.



Image 48. Sensitization workshop on Great Indian Bustard Conservation at New Delhi ©Tanya Gupta

2.3.1.4. Awareness campaign at Desert festival, Jaisalmer

The team setup an exhibition stall in the Annual Desert Festival, Jaisalmer that was held from 17th- 19th February, 2019 and 7th -10th February 2020 which provided us to reach over 10,000 people which included both locals and tourists to raise awareness about the Critically Endangered GIB and its grassland habitats.

We also presented a 3D model of Desert habitat and GIB. Furthermore, there were descriptions and photographs about other Desert fauna such as laggar falcon *Falco jugger* and red spotted royal snake *Spalerosophis arenarius*. To promote awareness and attract the people, placards with conservation messages written in Hindi and English were distributed.



Image 49. GIB conservation exhibition stall during Annual Desert Festival 2019 -2020, Jaisalmer
©Tanya Gupta

2.3.1.5. Training of State Forest Department staff and volunteers in implementing population and habitat surveys for Lesser Florican

Lesser Florican population assessment is feasible within a small window of 45–75 days as displaying males can be spotted only during July-September and across five states including Rajasthan, Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh. Joint surveys through collaborative efforts of Wildlife Institute of India (WII), Bombay Natural History Society (BNHS) and The Corbett Foundation (TCF), Hyderabad Tiger Conservation Society (HyTiCoS) along with range State Forest departments and local NGOs/institutions were conducted during July-September 2018. To train surveyors on the standardized population assessment approach and data collection protocol, training workshops were organized, in four States in collaboration with partner agencies along with range state forest departments and local NGOs/institutions:

1. Gujarat – Department of Marine Science, Department of Zoology, Sir P.P. Institute of Science, Maharaja Krishnakumarsinhji Bhavnagar University and Blackbuck National Park, Velavadar in Bhavnagar on 30th July- 2nd August 2018
2. Madhya Pradesh – Office of the Chief Conservator of Forests, Ujjain and Sailana Wildlife Sanctuary in Ratlam in August 2018
3. Rajasthan – Department of Environment Science, Maharishi Dayanand Saraswati University, Ajmer and Shokaliya Conservation Reserve, Nasirabad on 04th-05th August 2018
4. Maharashtra – Vankuti, Divisional Forest Office, Akola on 04th August 2018

During the course of the survey, 51 State Forest Department staff and 70 volunteers were trained in survey methods, instruments such as GPS, laser range finder, Suunto compass and navigation using Google maps, population sampling protocol for occupancy sampling and line transect based distance sampling, habitat survey along with data collection and recording techniques.



Image 50. Training workshop of National Lesser Florican status survey during August 2019 at Bhavnagar, Gujarat and Akola, Maharashtra © Tanya Gupta

2.3.1.6. Activities related to legal issues regarding conservation of GIB and Lesser Florican

On matters concerning the court cases filed for conservation of GIB, the following activities were carried out-

1. Hon'ble High Court of Rajasthan, Jodhpur

Regarding the *Suo moto* case D.B. Civil Writ Petition (PIL) No.825/2019 filed at Hon'ble High Court of Rajasthan, Jodhpur for the conservation of GIB, a response was prepared about the details of the work on habitat improvement and conservation breeding of the GIB carried about by WII including recommendations for GIB conservation. Subsequently, a meeting was held with Additional Solicitor General, Mr. Sanjit Purohit and an affidavit was filed at the Court on behalf of WII.

2. Principal bench of Hon'ble National Green Tribunal (NGT)

For the Original Application No. 385/2019 filed by Centre for Wildlife and Environment Litigation before the principal bench of National Green Tribunal against adverse impact caused by power and wind projects on GIB, a factual report on the status of GIB and threats to their population, progress of the WII project and key recommendations based on our findings was prepared and submitted on behalf of MoEF&CC. Meetings were held on 16th October and 11th November 2019 at MoEF&CC to draft a time bound action plan to conserve GIB based on our recommendations as directed by NGT under the chairmanship of Director General of Forest & Special Secretary. The meetings were attended by officials from the Ministry, representatives from power agencies and WII representatives.

3. Hon'ble Supreme Court of India

Regarding the Writ Petition (Civil) No. 838 of India with I.A. No.95438/2019-Clarification/ Direction) filed by Dr. M.K. Ranjitsinh in the Hon'ble Supreme Court of India for the conservation of GIB and Lesser Florican, a report on the status of the GIB conservation breeding program and emergency response plan was drafted and submitted for further action. To represent WII and MoEF&CC at the Hon'ble Supreme Court, Advocate Mr. Devendra Singh was appointed with approval from MoEF&CC.

2.3.1.7. Sensitization on GIB conservation ex-situ and in-situ aspects of delegates during their visit at conservation breeding center, Sam during June 2019-March 2020

Sensitisation on bustard conservation breeding during delegate visits at the conservation breeding center for Chief Justice of India, Forest Minister Rajasthan, District Magistrate and Superintendent of Police Jaisalmer, Indian Army officers, IFS trainees, media agency and exposure of Jaisalmer frontline FD staff to conservation breeding

2.3.1.8. Thirteenth Conference of Parties of Convention on Migratory Species of wild animals (CMS CoP13)

UN Wildlife Conference dedicated to migratory species in India that was held from 15th–22nd February, 2020 at Gandhinagar, Gujarat, India with the adoption of a number of significant resolutions and decisions to address the conservation needs and threats facing migratory species around the globe. The CoP13 was officially inaugurated by the Prime Minister of India on 17th February, 2020. Senior government officials, environment advocates, activists, researchers and biodiversity leaders from as many as 130 countries participated in this conference. During the opening ceremony on Monday, the Government of India also issued a special stamp edition featuring the Great

Indian Bustard - the mascot of COP13. Ten new species were added to CMS Appendices at COP13. Seven species were added to Appendix I, which provides the strictest protection: the Great Indian Bustard, Bengal Florican, Little Bustard, Asian Elephant, Jaguar, Antipodean Albatross and the Oceanic White-tip Shark.

WII has conducted three side events on 20th February, 2020. First event was with partnership with MoEF&CC Species Conservation Initiatives in India with Reference to Asian Elephants, Great Indian Bustards, Gangetic River Dolphins and Tigers. This side event was Co-chaired by Shri Soumitra Dasgupta, IGF(WL), MoEFCC, GoI.

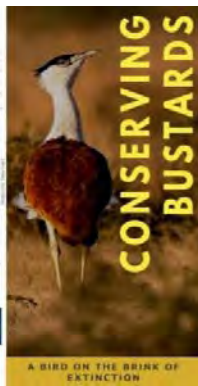
Second side event on behalf of MoEF&CC with partnership of TCF and WCS on 'The Final Flight: Conserving Eurasia's Iconic Bustard Species' This side event was Co-chaired by Dr. Borja Heredia, Dr. Mimi Kessler (IUCN Bustard Specialist Group) Dr. Anand Rahmani, Shri M.K. Vasu, IFS(Retd.), PCCF & HoFE Assam, Shri Devesh Gadhave with Dr. Y.V. Jhala, Dean, WII.

& Last side event was in with partnership of BirdLife International - BNHS on 'Using Sensitivity Mapping to Avoid Conflict between Birds and Renewable Energy Infrastructure in India and Asia'



2.3.2. Awareness materials and publications

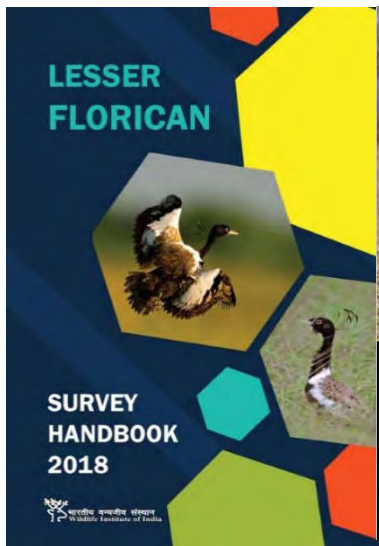
Sensitization Brochures



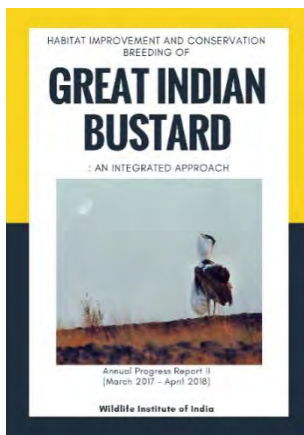
Survey handbook

Poster

Notebook



Reports



Bookmarks



T shirts



Carry bags



2.3.3. Social Engagement

A significant component of the ongoing project is to engage the local inhabitants residing in and around prime GIB habitat, to form a buy-in and create goodwill among locals for long-term success of species conservation efforts to save the GIB. The people inhabiting in and around DNP were primarily focused for this undertaking since DNP harbors a significant portion of the largest viable GIB population. The project team initiated socio-economic surveys with representatives from the villages within DNP. Semi-structured (open and close ended) questionnaires were designed to interview the village representatives. This survey aided to inform us about attitudes of people towards GIB and its habitat. Additionally, the survey helped to assess the motivations, needs, and sensitivity towards GIB. Two lists of villages were prepared for the socio-economic surveys based on priority GIB conservation areas identified from our population and habitat surveys. Questionnaire surveys were conducted in first priority villages (30) during 2017-18 and preliminary findings are reported here. The data collection has been carried on to the third year of the project (year 2019-20).

2.3.3.1. Socio-economic survey

For the first priority villages ($N_{\text{village}}=20$, $N_{\text{dhani}}=10$), heads per households of each village were acquired from the latest census report (Census of India, 2011). Exploratory survey in 20 villages, i.e. Bida, Dhoba, Kumbhar Kotha. Chauhani, Phaledi, Lolai, Doojasar, Khabha, Tejasi, Jajeeya, Salkha, Kanoi, Jamra, Sipla, Neemba, Koriya, Dhuliya, Barana, Kuchhri and Gangawas conducted. With the equi-proportional sample size, ~5% of total households in a village, each head per household ($N=158$) were selected for the socio-economic assessment in 30 villages. These surveys will help to yield information on the livelihood of locals, scope of alternative livelihoods, perceptions on conservation of GIB, and ways to minimize the antagonism among local people towards bustard habitat conservation. It will also help us in designing the outreach programs to sensitize local people. We intend to conduct surveys in village from second priority list to assess knowledge, attitude and practices towards grassland, and wish to examine the change(s) in their attitude after sensitization and outreach programs. Questionnaire was divided into four sections on the basis of which data was analysed and are listed below:

Section I (Socioeconomic profile)- The section would assess people's livelihood and their dependencies on natural resources within GIB habitats. This information would help identify alternative livelihoods for local people, positive attitude towards conservation of GIB and grasslands. Grazing resources (grasslands, market fodder or harvested crops) would be mapped to calculate their economy and for scope of community fodder farms. Additionally, it would be helpful to understand the nourishment provided to the cattle.

Section II (Human-animal conflict)- To win over local community for bustard conservation, we would investigate the current status of human animal conflict, in particular the severity of problem of free ranging dogs and pigs in the target areas so that control measures for problem animal population to reduce this conflict can be implemented.

Section III (Pastoralism and institutional arrangements)- We also aim to understand past pastoral practices and if they have changed currently. In case of change, we would try to understand the causes behind the change. Specifically, we would try to know if there is reduction in livestock holding/nomadism/herding. If pastoralists reported pasture reduction as the reason for change, we would like to examine if pastures that have better institutional arrangement/enforcement underwent less change. In such a case, institutional arrangements could be established for grassland conservation.

Section IV - Additionally, how much veterinary support they are getting from the government and if they are satisfied with that, so as to know the difference in livestock health and survival between aided and non-aided villages. If there is a difference that could be gauged after providing better veterinary

facilities from the project, would pastoralists forgo the surplus live stock against better veterinarian services. We would assess the scope of this intervention and identify sites where livestock could be translocated if such intervention succeeds.

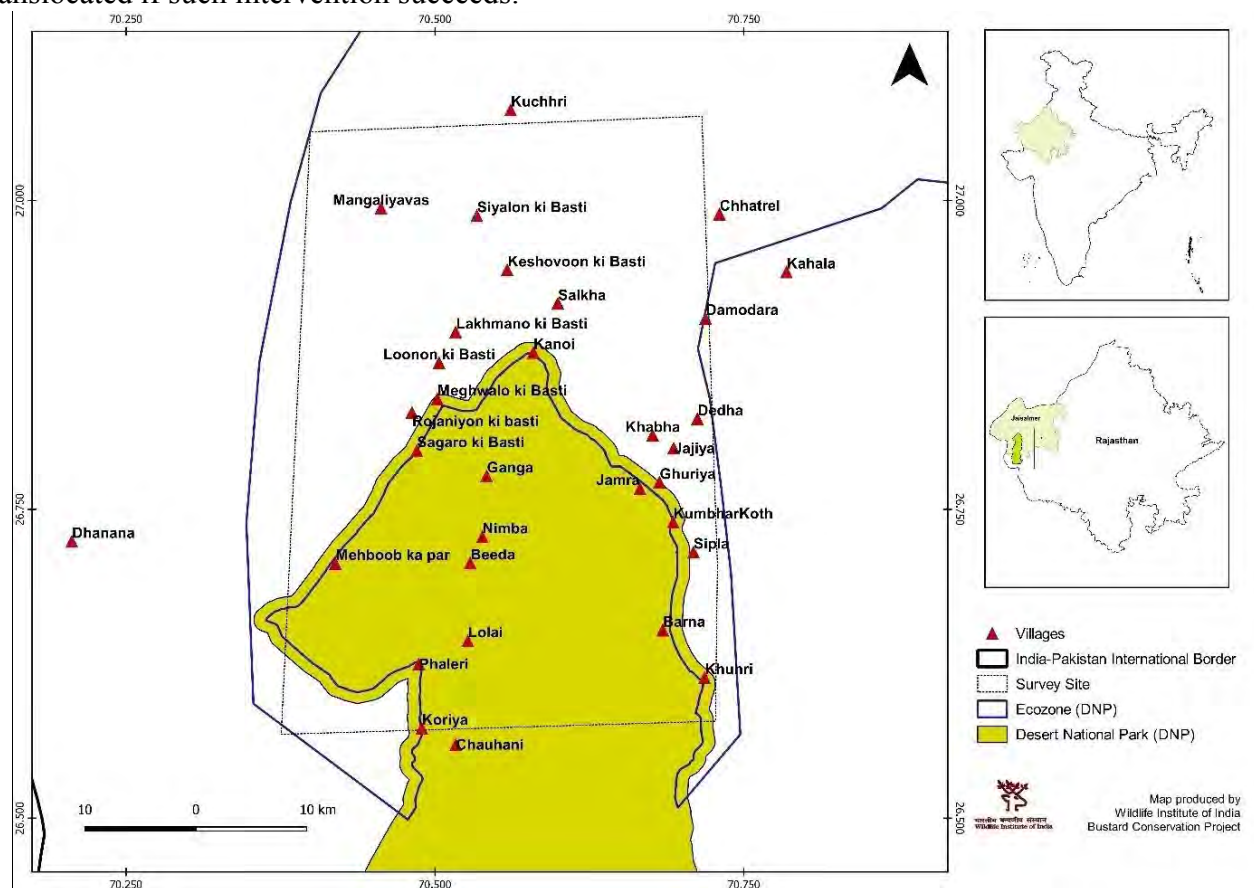


Figure 46. Map showing villages where household surveys were conducted in and around Desert National Park, Jaisalmer

2.3.3.2. Assessing attitudes and perceptions of local community towards conservation

Perception studies among communities in and around the Protected Area are valuable due to their ability to disclose awareness regarding conservation and existing attitudes toward conservation efforts. Gaining a better understanding of human behaviour manifested towards the Protected Area and properly incorporating them in future management could increase conservation effectiveness.

It is important to know the attitudes and perceptions of people towards wildlife, local species conservation, and purpose of Protected Areas and towards the Forest Department which is the regulatory body to understand the extent of antagonism and the level of awareness and the possibilities on reconciling communities can be understood. Our main focus would be, (a) To examine whether they are open to alternative income sources and if they have the infrastructure and skills for those livelihoods so that alternate livelihood programme could be offered to reduce their dependency on grassland resources and also win them over for conservation. (b) To understand the spectrum of problems they are facing to neutralize the current park vs people narrative. (c) Grazing pressure on grassland and (d) Conserving the grassland.

2.3.3.3 Preliminary results of the questionnaire

A total of 158 semi-structured questionnaires were conducted in and around DNP. The landscape is known to be rainfall deficient region, being part of a arid ecosystem. Local communities are highly dependent on monsoon rains for irrigation of agriculture which is their main livelihood (47%). On an average, 4.84 acres of agriculture land is owned by each family. People are also involved in daily wage labor (40%), for additional financial support (Figure 47). The villagers are also dependent on animal husbandry for their livelihood (13%) and indulge in seasonal sale of goats and sheep as a supplementary source of income. Sheep was the most abundant livestock reared by a household (Mean= $36.43 \pm 2.89SE$) followed by goat (Mean= $23.26 \pm 1.85SE$). Traditionally a pastoralist society, they generate additional revenue by selling milk and its by-products. Desert ecosystem is known to provide low agriculture productivity, and crop raiding by pigs, nilgai Boselaphus tragocamelus, chinkara and free ranging cattle make the situation worse.

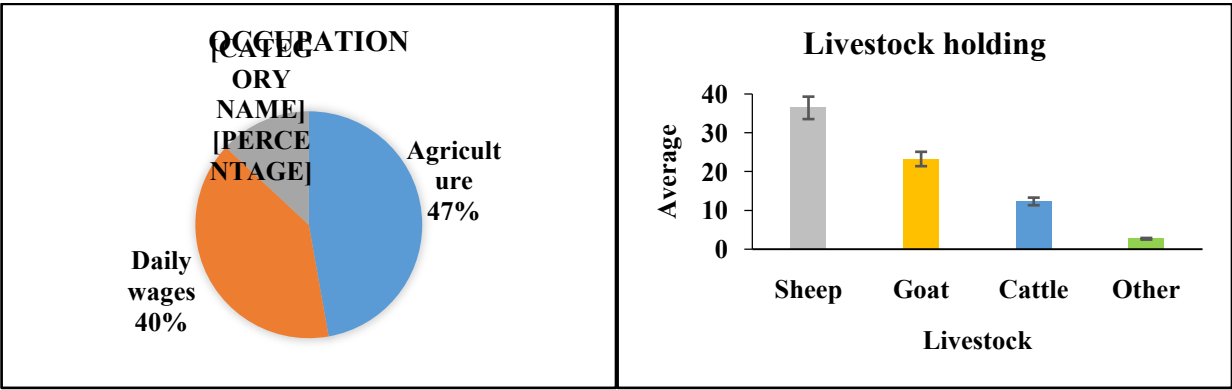


Figure 47. (a) Livelihood of villagers in and around Desert National Park, Jaisalmer **(b)** Livestock holding of villagers in and around Desert National Park, Jaisalmer (Error bars are standard errors)

Dairy farming being the most reliable source of income to the farmers, the disappearing grasslands have turned out to be a major cause of concern for animal husbandry as they are facing a severe shortage of fodder and are gradually being forced into stall feeding. Within the village society, livestock plays an important role in improving the socioeconomic status. The market rate of milk can vary from Rs. 30 to 45 per litre depending upon the consistency of the milk.

Since grazing is prevalent in and around DNP, livestock from the villages are totally dependent on the grasslands in their vicinity and on an average the animals were found to be travelling 5.5 km (0.64SE) to the grazing land. But due to degradation of pasture resulted by years of grazing, the villagers have shifted to alternate means of feeding their livestock. Majority of the respondents suggested purchasing fodder from market (80%) as an alternative to reduce grazing pressure. The other respondents suggested growing fodder in their land and reducing the livestock numbers by selling them (Figure 48).

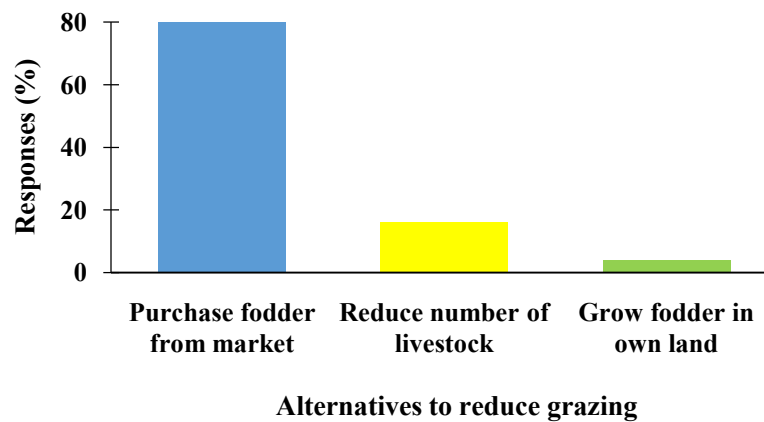


Figure 48. Alternatives suggested by respondents to reduce grazing pressure on village pasture land in and around Desert National Park, Jaisalmer (n=158)

A total of 1657 mortality cases of livestock were reported by villagers in a span of two years (2017 and 2018). Contrary to common perception across the country regarding livestock loss to wildlife, mostly livestock mortality was due to disease (90%) followed by depredation (10%) (Figure 49). Thirty-six cases of depredation were reported by people, out of which 83% cases were depredated by dogs.

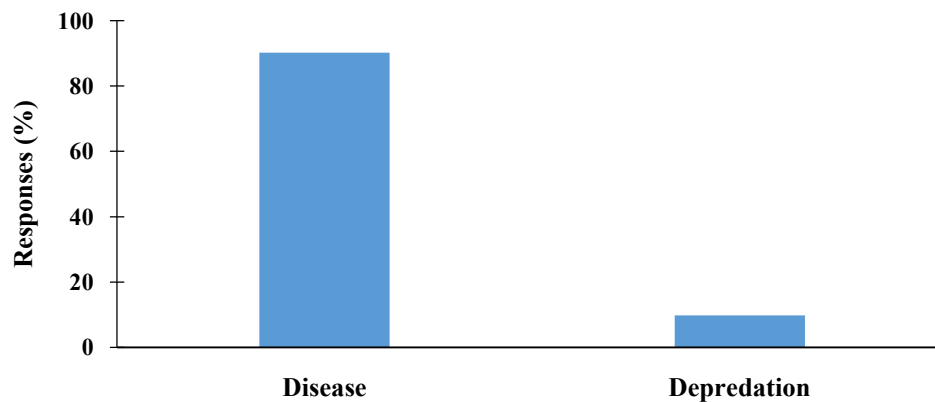


Figure 49. Causes of livestock mortality according to villagers in and around Desert National Park, Jaisalmer

To understand the perception of local villagers for conserving grasslands, we compared the responses of interviews inside and outside the Protected Area. Through the questionnaire we made efforts to identify the societal and employment issues. Regarding the problems local villagers face, they primarily responded about no direct revenue from DNP (10.13%) followed by depletion of grassland (10.1%), minimal involvement in management (10.1%), drinking water (9.45%) and dearth of veterinary hospital (9.4%). Overall, people inside perceiving relatively more problems than outside park (Figure 50).

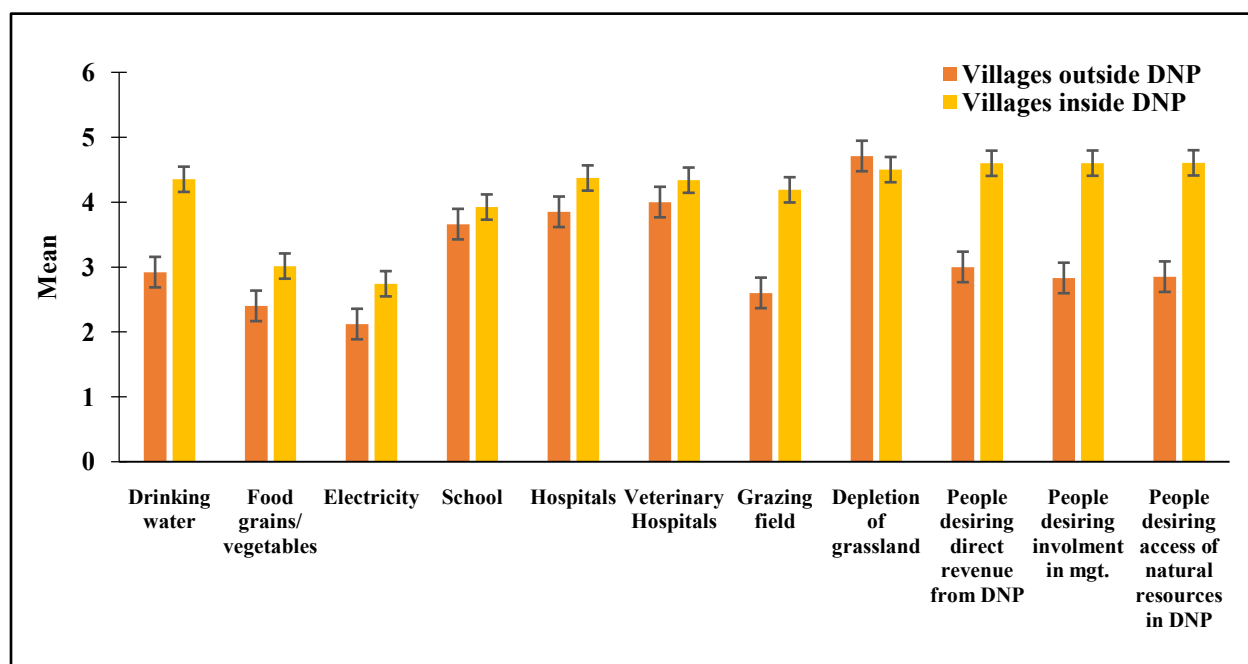
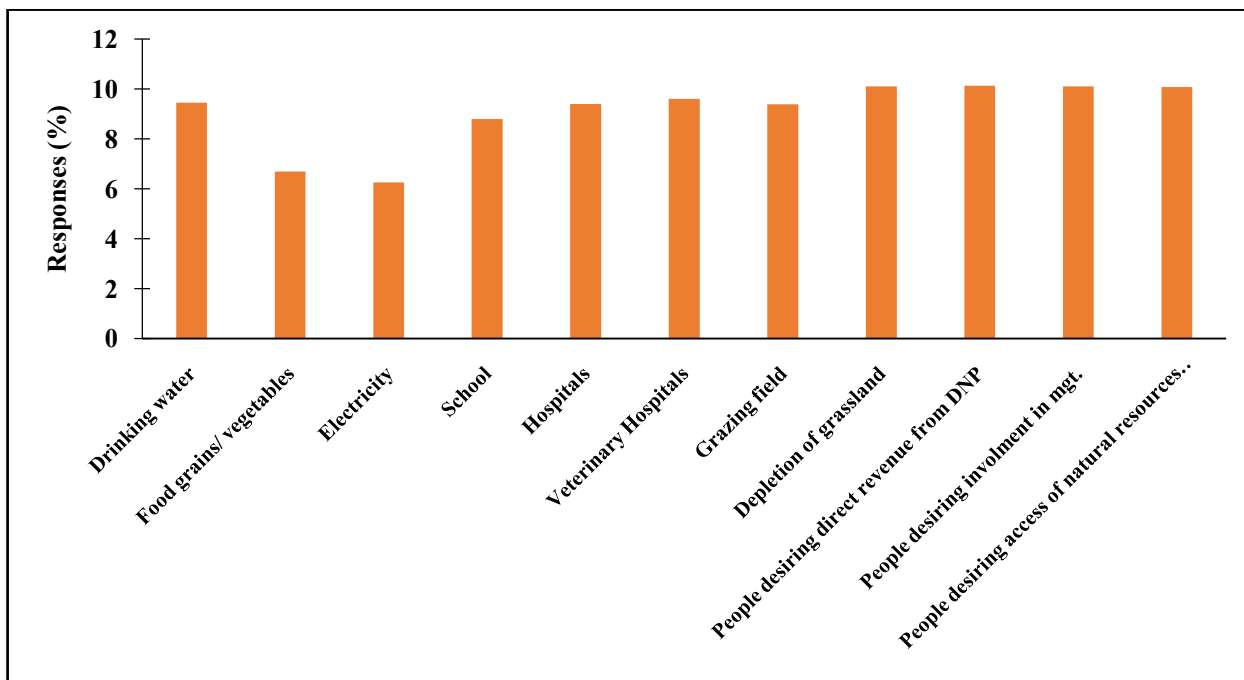


Figure 50. Problems perceived by villagers inside and outside Desert National Park, Jaisalmer (Error bars are standard errors)

According to the survey, 97% of the villagers residing around DNP mentioned that they are not benefited by the Protected Area whereas, remaining drew benefit from the Park. The locals responded that tourism has also not been able to help their daily needs as the record shows 77% people said that they are not drawing any benefit from tourism whereas, the remaining 23% people believe they are benefitting from it. If given an opportunity, locals are willing to shift from agriculture to any other source of income. Most of the villagers believed the major cause of grassland degradation is untimely or lack of rainfall (36%), extensive agriculture and illegal encroachment of grasslands for farming (33%), interestingly one villager also protested to the fact that they were not allowed to take their

livestock in the forest enclosures and blame it for the degradation of grasslands around them (Figure 51).

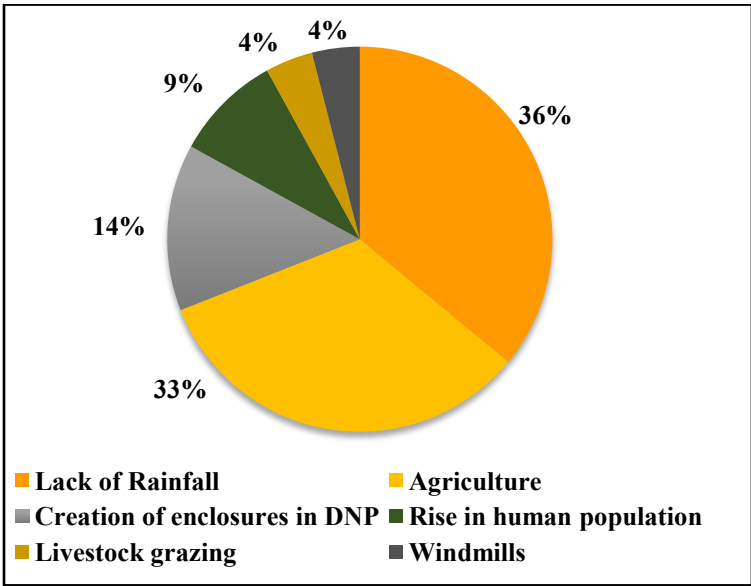


Figure 51. Reasons behind degradation of grasslands according to respondents in and around Desert National Park, Jaisalmer

Majority of villagers believed that over a period of time, the wildlife populations in the area has been drastically reduced. The main reason they attribute for decline is creation of enclosures in DNP, followed by lack of resources, poaching and predation by free ranging dogs (Figure 52)

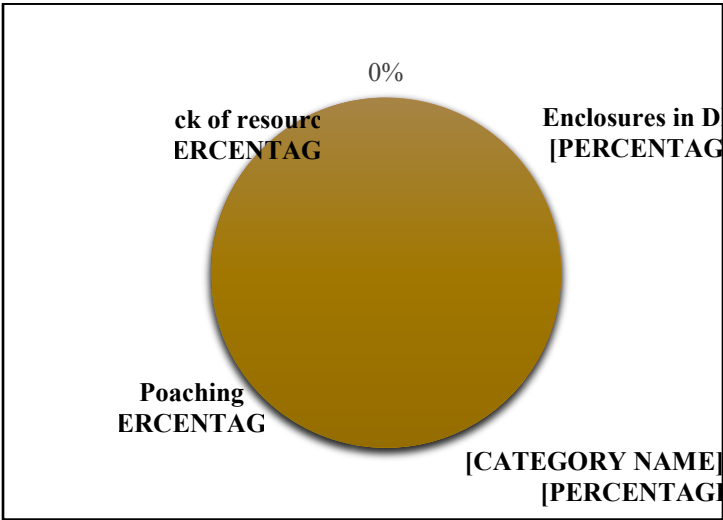
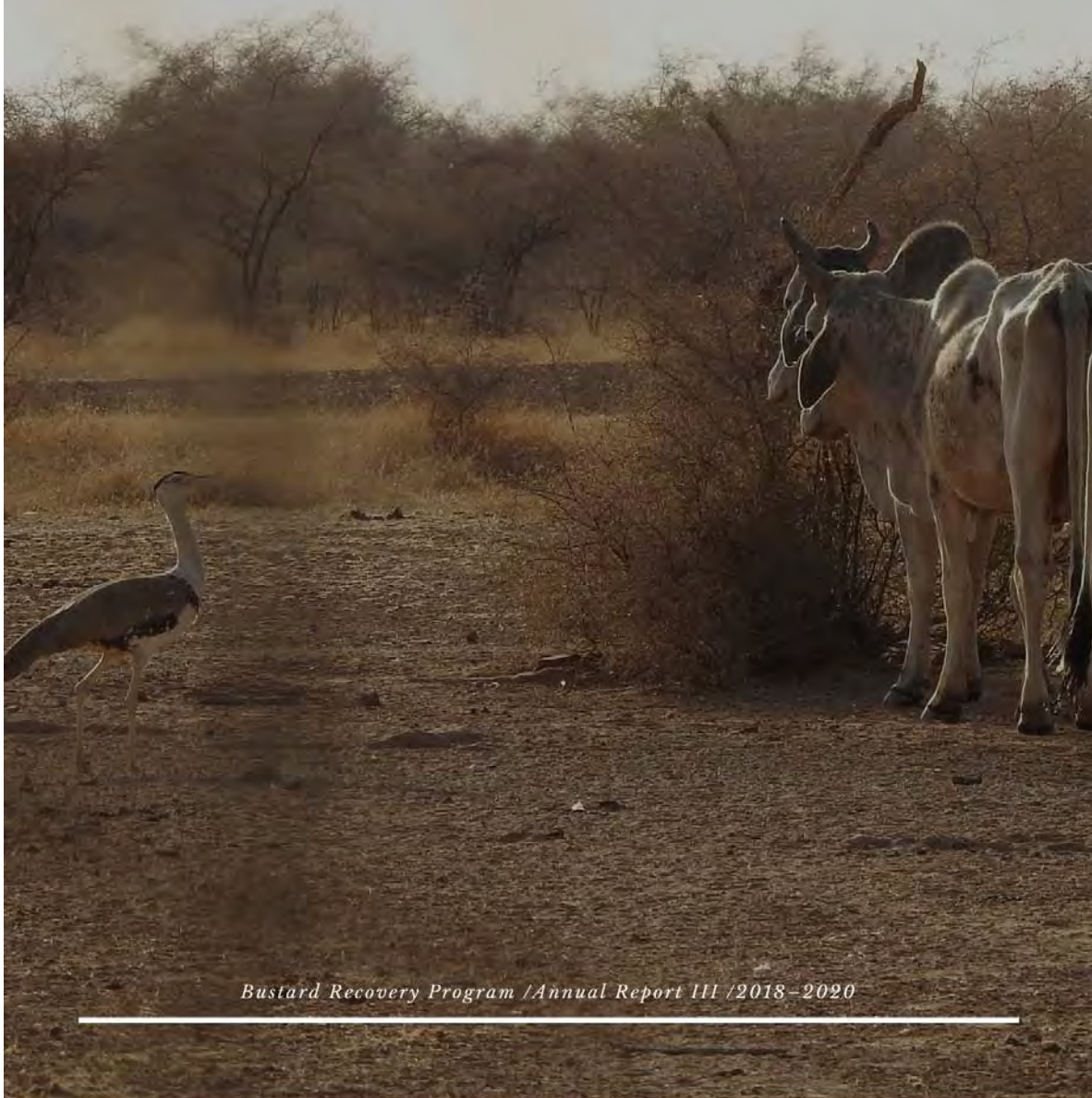


Figure 52. Reasons behind decline in the number of wild animals according to respondents in and around Desert National Park, Jaisalmer

PILOT HABITAT MANAGEMENT



Bustard Recovery Program /Annual Report III /2018-2020

2.4. Pilot habitat management

2.4.1. Dog population control in and around Desert National Park, Jaisalmer

Free ranging dogs are a known threat to wildlife. Our assessment from 2017 showed that the free ranging dogs around DNP are responsible for hunting ~33% of chinkara population annually from DNP and surrounding areas (presented in Annual Progress Report 2017-18). To mollify the dog issue, we initiated the sterilization of dogs in & around DNP in collaboration with Humane Society International (HSI)-India and Rajasthan Forest Department (October 2018 – January 2019). For the first phase of sterilization, 23 villages/ settlements were targeted (Image 51). A temporary post-op facility was setup in Sam village. The surgeries were performed in a well-equipped mobile operation theatre van. The highest number of dogs captured for sterilization were from Sam (133) followed by Khuri (117) and Kanoi (95) (Table 15). Interestingly, the vicinity of these three villages also have maximum tourism activities in the above order around DNP. A total of 801 dogs (454 • & 347 •) were spayed/neutered and vaccinated against rabies from 20 villages which surround the enclosures in DNP. Post-sterilization the dogs were monitored in the post-op facility till they recuperated. Operated dogs were marked with an ear notch for future identification and released back in their respective villages. To evaluate the effectiveness of sterilization program and to assess the ratio of sterilized and non-sterilized dogs mark- resight based abundance surveys in six major villages (Sam, Kanoi, Salkha, Neemba, Bida, Keshawon ki Basti) and crude count in all the treatment villages were conducted in February- March 2019 (see 2.4.2).



Image 51. Humane Society International (HSI)-India team capturing dogs for sterilization in and around Desert National Park, Jaisalmer © WII

Table 15. Number of dogs captured for sterilization village wise in and around Desert National Park, Jaisalmer

S No.	Village	Dogs captured
1	Sam	133
2	Khuri	117
3	Kanoi	95
4	Sipla	93
5	Neemba	66
6	Kumbhar Kotha	60
7	Ghuriya	54
8	Barna	38
9	Salkha	38
10	Khaba	32
11	Bida	21
12	Jamra	20
13	Bhilon ki dhani	13
14	Keshawon ki Basti	13
15	Meghwalon ki Basti	13
16	Ganga	6
17	Raydhan ki Dhani	6
18	Balanio ki Dhani	4
19	Singhalon ki Basti	4
20	Haider ki Dhani	1
Total		827

2.4.2. Dog population surveys in Thar landscape, Jaisalmer

The GIB landscape in Thar holds a large population of free-ranging dogs that partially depend on village-based resources but also depredate wildlife, and a potential predator of GIB eggs/chicks, thereby being an important threat that needs to be urgently managed. To assess and control this problem, we estimated the population status of free-ranging dogs in/around DNP in 2017-2018 and again in 2019 after dog spay neuter program to check the effectiveness of program and to estimate the sterilized, unsterilized dog ratio and number of lactating female which will in future add up more dogs in the population. We conducted the dog population assessment using crude count and mark-resight survey

2.4.2.1. Count surveys

Dogs were counted in 11 settlements where dog sterilization program was conducted, wherein observers walked on predesigned routes recording the number of dogs sighted with consistent walking effort of ~ 6 km (at average speed of 2 km h^{-1}) in the settlement area. Age and sex class of dogs were documented. This activity generated crude counts of dogs in all settlements dispersed across GIB habitat in/around DNP. Detection probability obtained from dog population survey we had conducted using mark-capture-recapture method in 2017 was used to estimate dog population.

2.4.2.2. Mark-resight surveys

Six villages (Meghwalon ki Basti, Salkha, Kanoi, Keshawon ki Basti, Neemba and Bida) in treatment block (villages with sterilization program) and two villages (Bandha, Soro ki Basti) in control block (villages without sterilization program) were targeted for estimation of dog abundance in mark-resight framework which is robust to imperfect detection. An 83X point 10 shoot digital camera, 63X point 10 shoot digital camera and DSLR camera with 300 mm lens was used to capture photos and sightings of dogs was recorded based on distinguishable natural body marks (flanks, head, tail, other body marks). Four replicates were completed for each selected settlement. Count and mark-resight abundance estimates in these settlements would yield a correction factor that can be used to estimate dog abundance in all settlements using double sampling approach. Data processing and analysis of this survey is under process. Data was analysed for four villages using Program Mark.



Figure 53. Photo capture of three sides of a village dog for individual identification © WII

2.4.2.3. Dog population

A total of 351 dogs were counted during the survey. The highest ratio of unsterilized dogs was found in Ghuriya Village (0.87) followed by Ganga Village (0.81). From count surveys, maximum number of dogs were estimated for Meghwalon ki Basti with 177 (5.3SE) dogs, followed by Salkha and Bida villages (Table 16). Majority of the villages sampled (55%) were found to harbor more than 35 dogs and almost all the villages showed high ratio of unsterilized dogs. Preliminary findings from mark-resight survey showed that the highest as well as least number of adult dogs were found in villages (Meghwalon ki Basti and Bida) where sterilization was undertaken (Table 17).

Table 16. Estimated population of dogs in 11 villages/settlements in and around Desert National Park using count surveys

Village/ Settlement	Count				Ratio			Abundance ± SE (Count ÷ detection probability)	95% CI
	Sterile dog	Unsterili- zed dog (with pup & lactating female)	Uniden- tified dog	Total	Sterile dog	Unsterili- zed dog (with pup & lactating female)	Uniden- tified dog		
Meghwalon ki Basti	24	82	1	107	0.22	0.77	0.01	176.55 ±5.3	166 - 187
Salkha	24	67	2	93	0.26	0.72	0.02	153.45 ±4.6	144 - 163
Bida	14	26	0	40	0.35	0.65	0	66 ±1.98	62 - 70
Keshawon ki basti	8	30	0	38	0.21	0.79	0	62.7 ±1.88	59 - 66
Ganga	2	21	3	26	0.08	0.81	0.12	42.9 ±1.29	40 - 45
Ghuriya	3	20	0	23	0.13	0.87	0	37.95 ±1.14	36 - 40
Jamra	2	7	0	9	0.22	0.78	0	14.85 ±0.45	14 - 16
Lolai	0	6	0	6	0	1	0	9.9 ±0.3	9 - 11
Lakhmanon ki Basti	1	4	0	5	0.2	0.8	0	8.25 ±0.25	8 - 9
Loonon ki Basti	2	0	0	2	1	0	0	3.3 ±0.1	3 - 4
Sagaron ki Basti	0	2	0	2	0	1	0	3.3 ±0.1	3 - 4

Table 17. Estimated population of adult dogs in four villages/settlements in and around Desert National Park using mark- resight survey

Village/ Settlement		Adult dog population (SE)	95% CI
Treatment (Sterilization)	Meghwalon ki Basti	105 (5.58)	94 - 116
	Bida	26 (0.90)	24 - 28
Control (No Sterilization)	Bandha	62 (1.69)	59 - 65
	Soro ki Dhani	32 (0.51)	31 - 33

2.4.3. Assessment of nest predators using camera trap in and around Desert National Park

As per the recommendations of the National Bustard Recovery Plan (Dutta, et al., 2013), the Forest Department enclosures in Thar are managed with the objective of improving GIB recruitment. The eggs and chicks of bustards are known to face high mortality due to predation and other causes (Morales et al. 2002) and as shown by the dummy nest experiment conducted in DNP during 2015-16. It is important to assess the abundance of potential nest/chick predators in and around the enclosures so that subsequently their population could be controlled for the improvement of GIB recruitment rate. Camera traps were deployed following the Random Encounter Model sampling framework (Rowcliffe et al. 2008) inside and outside enclosures in Thar which had previous GIB breeding records. For camera-trapping inside the enclosures, we systematically placed one camera trap at the center of 500m × 500m grid-cells. For placing camera traps outside the enclosures, similar placement was done around the enclosure after leaving a buffer of 1km (Figure 54). Reconyx HC500 Hyperfire Semi-covert passive infrared camera-traps at the height of 0.18–0.23m from ground were placed. The cameras were operated for 30–40 days at each location. Since the commencement of the camera trap work in December 2016 till May 2018, camera-trapping has been done at 12 locations which includes nine enclosures and three areas outside enclosures; with 311 unique camera placements covering an area 80 km² (Table 18)

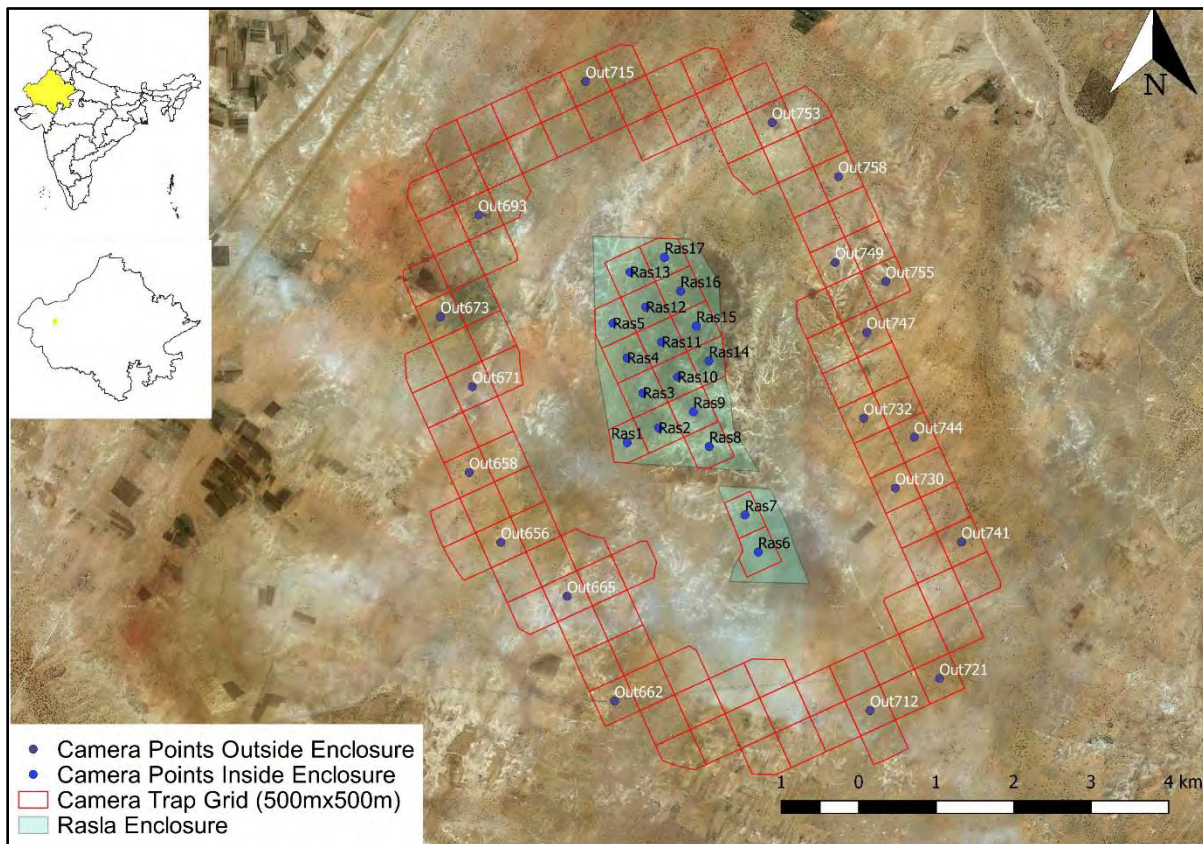


Figure 54. Sampling design of camera trap survey conducted inside and outside one of the Great Indian Bustard enclosures in Thar, Jaisalmer

Table 18. Sampling effort and number of photographs obtained inside and outside enclosures in Desert National Park

S.No.	Area	No. of camera traps deployed	No. of Photographs obtained
1.	Sudasari enclosure	59	139,224
2.	Kanoi enclosure	36	83,562
3.	RKVY enclosure	36	183,028
4.	Gajaimata enclosure	15	83,125
5.	Ramdevra enclosure	26	162,450
6.	Chauhani enclosure	16	43,295
7.	Gajaimata_PPC enclosure	8	10,362
8.	Rasla enclosure	17	63,050
9.	Miajlar enclosure	23	78,789
10.	Outside Rasla enclosure	19	70,461
11.	Outside Sudasari enclosure	32	101,199
12.	Outside Miajlar enclosure	24	71,523

Photo-captures of potential nest predators (Desert fox *Vulpes vulpes pusilla*, Indian fox *Vulpes bengalensis*, Indian grey mongoose *Herpestes edwardsii*, Indian Desert cat *Felis silvestris or nata*, Jungle cat *Felis chaus*, pig and dog), GIB, chinkara, nilgai, Indian hare *Lepus nigricollis*, Indian Desert jird *Meriones hurrianae*, spiny-tailed lizard and livestock were obtained during the sampling. Photo-capture data will be analyzed using Random Encounter Modeling approach that uses independent capture rate and speed to estimate abundance. To enable this, calibration exercises were carried out at the time of camera-trap placement to characterize camera viewing frames that would be used to generate triaxial location, distance from camera, and speed from animal photo-captures.



Image 52. Camera trap sampling using random encounter model design to assess the abundance of potential Great Indian Bustard nest/chick predators in Thar, Jaisalmer © WII

Data from eight enclosures have been completely tagged and ready for analysis. The maximum photo-capture rate among active nest predators was obtained for pig followed by Desert fox. Overall, highest photo-capture rate was obtained for sheep & goat, followed by chinkara and cattle. For the remaining four locations, tagging of the photographs have been completed and the process of assigning pixelated axial values to the calibrated photographs is underway.

Table 19. Photo capture rates of different species from 165 cameras deployed inside eight enclosures and outside three enclosures with a total of 5768 camera days in Thar, Jaisalmer

Category	Species	No of photo captures	Encounter Events	Photo-capture rate (No. of photo captures per 100 days)
Priority species	Great Indian Bustard	10	7	0.17
Active nest-predators	Pig	465	368	8.06
	Desert fox	448	440	7.77
	Dog	188	180	3.26
	Desert cat	149	148	2.58
	Indian fox	112	111	1.94
	Indian grey mongoose	33	29	0.06
	Jungle cat	2	2	0.03
Passive threats to nest	Chinkara	2253	2058	39.06
	Nilgai	679	544	11.77
Anthropogenic threats to nest	Sheep & Goat	27740	9233	480.93
	Cattle	1638	748	28.40
Others	Indian hare	442	439	7.66
	Spiny-tailed lizard, Jird, Camel, other birds	1931	1166	33.48

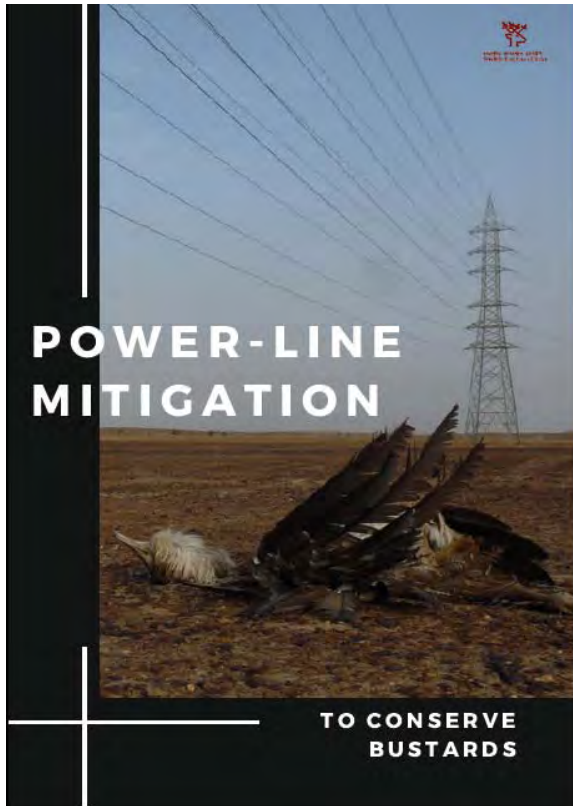


Image 53. Photographs of various species obtained during camera trap sampling in Thar, Jaisalmer © WII

2.4.4. Power line mitigation

2.4.4.1. Report on power line mitigation

A booklet on power line mitigation to conserve bustards based on our findings categorizing detrimental power lines and incorporating various mitigation measures to prevent bird mortality was published. Maps with identification of critical power lines for mitigation, information regarding various bird diverters and installation design were detailed in this quick reference guide. The brochure was widely disseminated to power agencies, State Forest Departments, defence personnel, conservation agencies and media.



(a)



(b)

Figure 55. Booklet on power line mitigation to conserve bustards

2.4.4.2. GIB landscape maps for power line mitigation

Based on our long term GIB surveys in Jaisalmer, Rajasthan and Kachchh, Gujarat, maps depicting priority and potential GIB landscape for power line mitigation were developed. The priority area and potential area identified in Rajasthan spans $\sim 13,100 \text{ km}^2$ and $\sim 78,500 \text{ km}^2$ respectively (Figures 55a & 56) whereas in Gujarat, the priority and potential area spans $\sim 500 \text{ km}^2$ and $\sim 2100 \text{ km}^2$ respectively (Figures 55b & 57). In priority areas which is intensively used by GIB, all power lines have to be underground or disallowed. The surrounding potential area require mitigation measures such as installation of bird diverters.

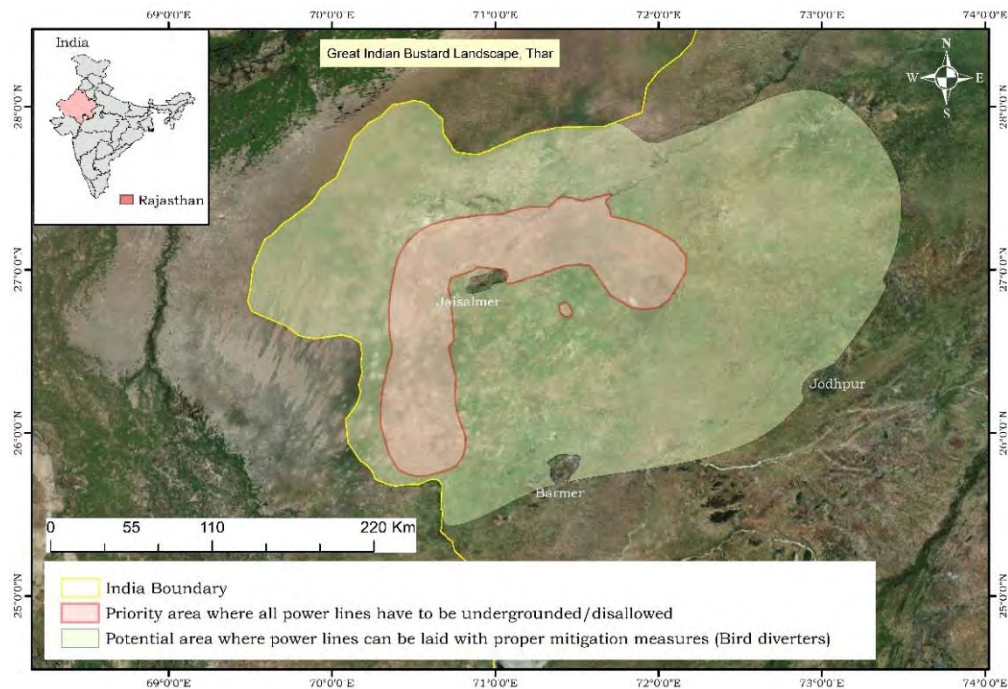


Figure 56. Great Indian Bustard landscape in Rajasthan delineating the priority and potential areas for power line mitigation



Image 54. Great Indian Bustard mortality due to power line collision in June 2018 at Ramdevra, Jaisalmer © Bipin C.M.

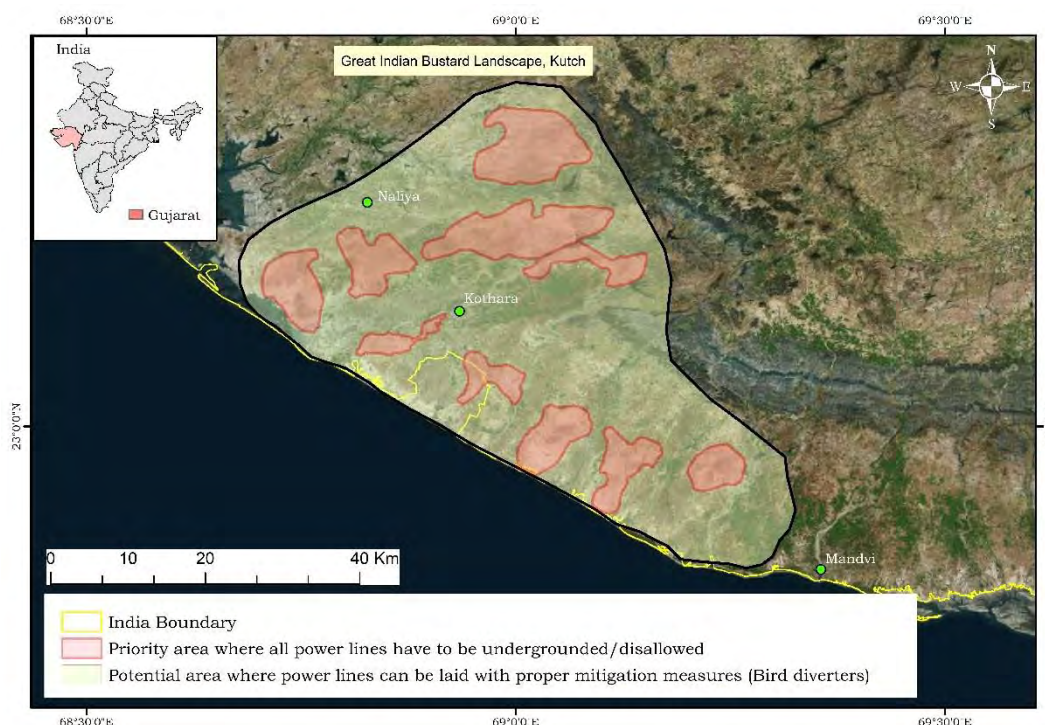


Figure 57. Great Indian Bustard landscape in Gujarat delineating the priority and potential areas for power line mitigation

2.4.4.3. Meetings and interactions with power agencies

i) A meeting was held on 20th December 2018 under the chairmanship of Principal Secretary Energy, Govt. of Rajasthan that was attended by RFD and WII representatives decided that the mitigation measures should be urgently implemented, and directed the power agencies to place proposals with cost-estimation for this action. Principle Secretary Energy directed power agencies to install time tested imported diverters on all priority power lines.

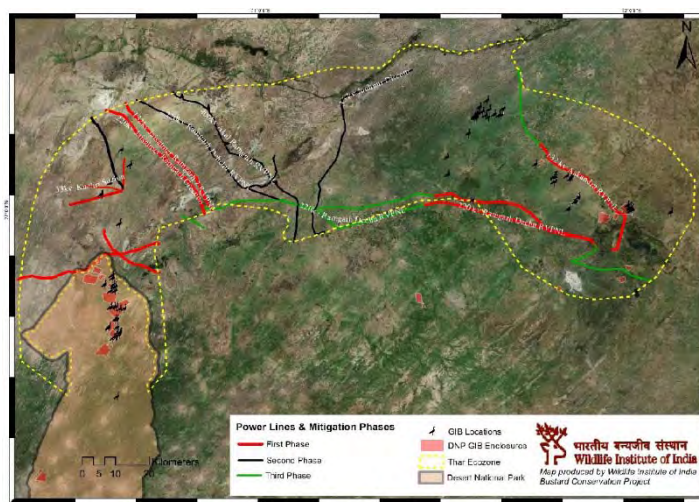


Figure 58. Map showing high tension (> 33 kV) power lines divided into three phases for undergrounding and bird diverter installation in Great Indian Bustard habitat, Rajasthan

A mitigation plan for high-tension power lines in GIB habitat of Thar Desert, Jaisalmer was developed. This plan identified critical power lines and prioritised for bird diverter installation and undergrounding in Thar, Jaisalmer (Figure 58) including the length and cost and was submitted to Rajasthan Vidyut Prasaran Nigam Limited (RVPNL) for further action.

ii) Meeting with representatives of Tata Power Mr. V.K. Nori- Chief (Corporate Affairs), Prashant Kokil- Head (Environment & Climate Change) and Mr. Amar Nayakvadi- Lead Associate (Environment & Forest, Trans. Project) on 08th July 2019 at WII regarding mitigation of power line in GIB habitat near Pokhran area in Jaisalmer. A site inspection of Tata power 150 MW Solar Power project and 220 KV transmission line was carried out by the team along with Dr. Asad Rahmani- Former Director of Bombay Natural History Society and renowned GIB expert, representatives from TATA Power- Mr. Abhishek Ashok Bhagat- Station head- Chhayan (Operations) and Mr. Saket Porwal- Project head (Large projects) on 22nd July 2019. As a mitigation measure based on our recommendations they have installed bird diverters on the transmission line.

iii) Meeting with Essel Infra official- Mr. Rajnish Mehrotra, Head (Environment, Forest & Wildlife) on 08th July 2019 at WII regarding mitigation of power line in GIB habitat in Jaisalmer.

iv) Meeting with officials from Actis Advisers Private Ltd - Mr. Rahul Agrawal, Director, Mr. Abhishek Bansal, Director, and Spring energy- Mr. Amit Gupta, Head (ESG) on 03rd October 2019 at WII for mitigation of power lines in Sardarpur Lesser Florican Wildlife Sanctuary in Dhar, Madhya Pradesh. They have decided to underground the 220KV transmission line of 3km length inside the Sanctuary as suggested by us (Figure 59).



Figure 59. Map showing ~3 km high tension power line (220KV) inside Sardarpur Lesser Florican Wildlife Sanctuary in Dhar District, Madhya Pradesh proposed to be placed underground

v) Meeting through skype on 31st May 2019 with representatives from Enel Green Power- Ms. Suvalaxmi Sen, Environmental Design Specialist, and other officials, for mitigation of power line in GIB habitat near Ramgarh, Jaisalmer. They decided to shelve the project which was situated inside the GIB priority zone (Figure 60).

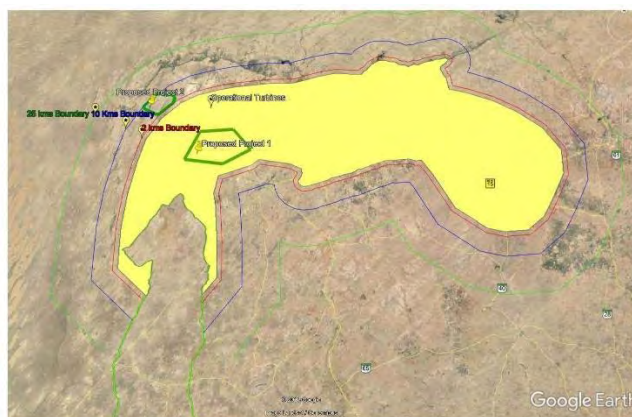


Figure60.Map showing the shelved power project proposed to be developed inside Great Indian Bustard habitat in Thar, Jaisalmer

vi) Sterlite power for procurement of bird diverters to install on power lines for prevention of bird mortality. Details regarding international and Indian bird diverter manufactures and suppliers, cost of procurement were shared with them.

vii) Meeting with representative from General Electric- Mr. Dheeraj Jain, Regulatory Leader- Turnkey at WII on 14th November 2019 for mitigation of power line to prevent bird mortality across India. Information on power line mitigation including the GIB priority and potential zones in Rajasthan and Gujarat, report on power line mitigation to conserve bustards, Lesser Florican status assessment report and details regarding international and Indian bird diverter manufactures and suppliers, cost of procurement were shared with the firm.

vii) Sitac Management & Development Private Limited for our assistance in identifying the habitats of GIB in India, whether their wind projects fall in the GIB habitat zone and accordingly take preventive measures. Information on power line mitigation for GIB priority and potential zones in Rajasthan and Gujarat were shared with them.

ix) Meeting with private companies for diverter procurement and manufacturing

- Nature tech for procurement and installation of bird diverters in Jaisalmer.

- Indolite and A & S tech for development of indigenous, low cost bird diverters in the country.

x) Meeting at MoEF&CC to draft a time bound action plan to conserve GIB as directed by NGT

To draft a time bound action plan to conserve GIB based on the recommendations by WII as directed by NGT, meetings were held at MoEF&CC on 04th September and 11th November 2019 under the chairmanship of Director General of Forest & Special Secretary. The participants included ADG (Wildlife), DIG (Wildlife), CWLW Rajasthan, officials from MoEF&CC, MNRE, Central Electricity Authority, R VPNL, Gujarat Energy Transmission Corporation, Essel Surya Uja Company of Rajasthan Ltd, Power Grid Corporation of India Ltd, Tata Power Renewable Energy Ltd, Sprng Energy Pvt. Ltd, Actis, Siemens Gamesa & WII representatives. The meetings concluded with suggestions such as exploring possibilities for declaring GIB priority zone or the area as Conservation or Community Reserve, principle of avoidance being the best option to adopt in GIB habitat and next is the techno- feasibility of the mitigation measures such as undergrounding high tension power lines.

xi). Indigenously manufactured bird diverters developed based on our suggestions have been procured from A & S tech and would be installed on power lines with the help of power agencies in Thar to check their efficacy.

2.4.5. Community conservation program meetings

2.4.5.1. Proposed Community Conservation Reserve in Khetolai village, Jaisalmer

First meeting was held in Khetolai village attended by village Sarpanch, villagers, Dr. Sutirtha Dutta and two project researchers on 28th January 2019, where initial idea about the Community Conservation Reserve (CCR) was discussed.

- Proposed land for Community Conservation Reserve was demarcated after consulting land owners who are interested in CCR.
- A long term plan was developed by WII after addressing the concerns of local villagers. This was also shared with the villagers during the second meeting in February 2019.
- Advocate Mr. Ramratan, a resident of Khetolai village agreed to develop Community Conservation Reserve on 120-hectare land owned by him for conservation of chinkara, GIB and other fauna of Thar Desert during 3rd meeting on 28th March 2019.
- Further communication by the WII team is in process.

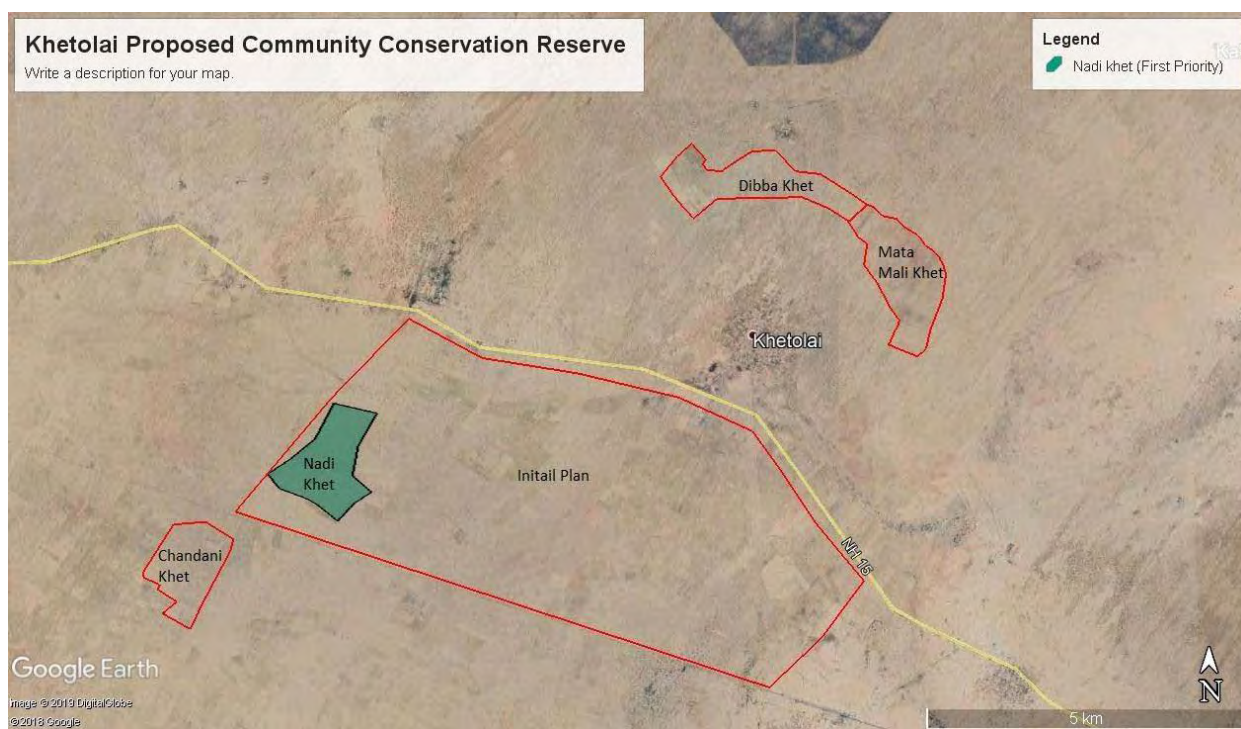


Figure61. Map of proposed Community Conservation Reserve in GIB habitat at Khetolai village in Jaisalmer

Initially Proposed area- 3030 Ha

Nadi Khet- 154 Ha, Dibba Khet- 183 Ha, Mata Mali Khet- 188 Ha, Chandani Khet- 134 Ha

Total Area- 659 Ha

3. Proposed project activities in 2020-21

S no	Project component	Proposed Activity	Prerequisites
1	Conservation Breeding	• Completion of Centre construction in Ramdevra • GIB chick rearing and routine husbandry activities at Sam facility • Signing of MoA with International Fund for Houbara Conservation, Abu Dhabi * • Collection of GIB eggs and incubation **	*Approval from MoEF&CC and Ministry of External Affairs ** Permission from CWLW Rajasthan
2	Applied Research	• Satellite tagging of GIB in Thar and Kachchh ** • Satellite tagging of Lesser Florican in Rajasthan ** • Phenological/ Behavioral observations of GIB in Thar • Tagging of nest predators in Thar	** Permission from CWLW Rajasthan and Gujarat
3	Capacity building and outreach	• Questionnaires for livelihood concerns and conservation attitude in Thar, • Village outreach programs, • Continued generation of publicity materials • Meetings and sensitization workshop with Armed Forces, • Continued sensitization of power agencies through national-level meeting and follow-ups	Support from local community and other interest groups
4	Pilot habitat management	• Removal of nest predators from GIB breeding enclosures in Thar *** • Second phase of spay neuter program for free-ranging dogs in Thar (collaboration with HSI) • Collaborative conservation actions with communities and Forest Department in Khetolai village, Jaisalmer	*** Predator proof fencing of GIB breeding enclosures by Rajasthan Forest Department

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APPENDIX

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**TRIPARTITE MEMORANDUM OF AGREEMENT
BETWEEN**

**THE MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE, GOVERNMENT OF
INDIA,**

**GOVERNMENT OF RAJASTHAN
AND WILDLIFE INSTITUTE OF INDIA**

FOR GREAT INDIAN BUSTARD CONSERVATION BREEDING AND RESEARCH PROGRAMME

The Great Indian Bustard *Ardeotis nigriceps* has a global population of less than 200 birds with only one viable population presently occurring in Thar Desert, Rajasthan. Ministry of Environment, Forests, and Climate Change (MoEFCC), Government of India, in consultation with concerned State Forest Departments, Wildlife Institute of India (WII), Bombay Natural History Society (BNHS) and Worldwide Fund for Nature-India (WWF), has developed a Recovery Programme for this Critically Endangered species. An important component of this programme is to initiate Conservation Breeding as an insurance against total extinction and possible restocking of wild populations in the future. Alongside Great Indian Bustard, this Programme will be utilized to simultaneously secure a captive population of the Endangered Lesser Florican *Sypheotides indicus* before their numbers become critically small.

At the very onset it is acknowledged that for survival of the critically endangered species like GIB, the two conservation paradigms, in-situ and ex-situ are intricately inter-related; the ultimate goal of Conservation Breeding being reintroductions in safe restored habitats and supplementation of wild populations. Investments in the Conservation Breeding Programme should in no way result in complacency towards in-situ conservation efforts and investments. The urgency of implementing the Conservation Breeding Programme bestows on the Centre and State Governments great responsibilities, effective discharge of which is essential. This tripartite memorandum between the Ministry of Environment, Forests and Climate Change, Government of India, Rajasthan Forest Department, and Wildlife Institute of India formalizes the respective roles, responsibilities and reciprocal commitments along with the flow of funds and resources to ensure effective implementation of the Great Indian Bustard and Lesser Florican Conservation Breeding and Research Programme.

The Memorandum of Agreement is between the President of India through Inspector General of Forests (Wildlife), Ministry of Environment, Forests and Climate Change as the First Party and Governor of Rajasthan through Chief Wildlife Warden, Forest Department, Rajasthan as the Second Party and Wildlife Institute of India, Dehradun through the Director as the Third Party.

ARTICLE I: Definitions

It is hereby stated that, in this document,

- (a) "Project" refers to the Conservation Breeding and Research Programme for the Critically Endangered Great Indian Bustard and the endangered Lesser Florican; restoration of habitat, and creation of inviolate spaces for safe release of bustards;
- (b) "Facility" refers to Captive Breeding and Research Facility with functional incubation, hatchery, chick rearing and adult bird cages, food processing room, staff quarters and store room with

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appropriate infrastructure and instruments for breeding Great Indian Bustard and Lesser Florican;

- (c) "Satellite Facility" refers to incubation and hatchery facility to be developed near egg collection site;
- (d) "Action Plan" refers to Great Indian Bustard and Lesser Florican Conservation Breeding Protocol document to be prepared by the Third Party in consultation with national and international bustard breeding experts and approved by the Steering Committee of the Project; the site specific "strategic management action plan" for *in situ* conservation to be prepared by the second party.

ARTICLE IIa: Agreement

It is hereby acknowledged and understood that by signing this document the Parties are agreeing to implement this Project. The Parties shall hereby collaborate and cooperate closely at all stages of development and execution of all mutually agreed activities under this Project, and shall share all relevant information with each other and facilitate each other for unhindered execution of Project activities.

ARTICLE IIb: Steering Committee

- (a) All parties agree to set up a Steering Committee for the Project with the following constitution:

(i)	Additional Director General (Wildlife), Ministry of Environment, Forests & Climate Change (MoEF&CC), Government of India, Delhi	Chair person
(ii)	Director, Wildlife Institute of India (WII), Dehradun	Member
(iii)	Chief Wildlife Warden, Rajasthan Jaipur	Member
(iv)	Inspector General of Forests (Wildlife), MoEF&CC, Government of India	Member
(v)	Member Secretary Central Zoo Authority, Delhi	Member
(vi)	Director, Desert National Park, Jaisalmer	Member
(vii)	One/Two representatives from International Bustard Breeding Center (to be nominated by the Wildlife Institute of India, Dehradun)	Member
(viii)	Lead Project Scientist (Great Indian Bustard), WII (to be nominated by the Wildlife Institute of India, Dehradun)	Member
(ix)	Dr. Asad Rahmani, Ex-Member, Bombay Natural History Society (BNHS), Mumbai	Member
(x)	Dr. Vibhu Prakash, Member, Bombay Natural History Society, Mumbai	Member
(xi)	CEO, Worldwide Fund for Nature-India, Delhi	Member
(xii)	Two representative from Indian Army, Western Command (to be nominated by the Commanding Officer Western Command)	Member
(xiii)	Project Scientist (Great Indian Bustard) based at the project site Rajasthan (to be nominated by the Wildlife Institute of India, Dehradun)	Member
(xiv)	Deputy Inspector General of Forests (WL) , Ministry of Environment, Forests & Climate Change (MoEF&CC), Government of India, Delhi	Member Convener

The members in serial number vii) shall be identified by Steering Committee and nominated through mutual agreement between collaborating International Bustard Breeding Centers and Chair of

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Steering Committee. In addition to the above members, upto two scientists/conservation practitioners of repute with expertise of topical relevance can be identified and invited as special invitees to Steering Committee meetings.

(b) Steering Committee shall determine its overall responsibilities during its inaugural and ensuing meetings, but these shall include:

- (i) Overseeing the entire programme,
- (ii) Determining future objectives of the Project;
- (iii) Develop a detailed project proposal and approve it.
- (iv) Review the progress of Project implementation from time to time;
- (v) Issue suitable directions / advice to Project management;
- (vi) Facilitate funding for the Project;
- (vii) suggesting suitable sites for habitat restoration,
- (viii) Approve suitable research proposals under the project and
- (ix) Any other matter as required.

The Steering Committee shall meet at least once a year. The cost of travel and other expenses for attending the meeting will be charged from the fund of the Project if required.

(c) All parties agree to the setting up of a Project Management Committee for day to day management of the project with the following constitution:

- (i) Chief Wildlife Warden, Rajasthan as the Chairman of the Project Management Committee
- (ii) Director Desert National Park (Deputy Conservator of Forests, Jaisalmer DNP Member Secretary)
- (iii) One representative from International Bustard Breeding Centers (to be nominated by the Chairperson of the Steering Committee)
- (iv) Lead Project Scientist (Great Indian Bustard), WII (to be nominated by the Chairperson of the Steering Committee)
- (v) Deputy Conservator of Forests, Baran (Kota Circle)
- (vi) Project Scientist (GIB) at Project Site Rajasthan

This committee will meet at least three to four times a year. The committee will supervise the field execution and timely completion of the project. The committee will examine and accord the research proposals and in-situ conservation proposals to be forwarded to Steering committee.

ARTICLE IIIa: Finances and logistics

- (a) Financial support for developing and executing the Project shall be provided by the First Party for about 35 years, extendable as required and as decided by the Steering Committee. The First and Second Party will also explore sharing of costs and provide assistance especially for travel of International experts and training of wildlife managers and project staff abroad.
- (b) Funds for developing main Facility and Satellite Facility, outreach, habitat restoration, capacity building, securing inviolate spaces and addressing livelihood issues as estimated and mutually agreed between Parties shall be transferred to Second Party while funds for executing the

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remaining activities of the project will be transferred to the Third Party. Additional funds (if required) for activities apart from the activities mentioned in the project proposal shall be provided by first party to second party.

- (c) Second Party shall provide unrestricted access and right to the third party to develop and use equal or more than two sqkm land at in Jaisalmer for establishing the egg collection and hatching Facility and in Sorsan, Kota for establishing the conservation breeding centre.
- (d) Second Party shall develop the Facility and egg hatching Satellite Facility at these sites following the design and quality recommendations by Steering Committee.
- (e) Second Party shall take responsibility of providing the Facility with adequate electricity, water, and metal road connectivity for unhindered transportation of Project personnel, equipment, eggs and birds as per the financial provision in the Project. Second party will also be responsible for developing the GIB & Lesser Florican release areas, with inviolate spaces. The first party will provide funds for habitat restoration in the landscape.
- (f) Upto two officials of the Rajasthan Forest Department not below the rank of Deputy Conservator of Forests shall be proposed by the Second Party for their training in India and/or abroad. These personnel shall be deputed to assist Project Scientist, in Project execution by the Second Party.
- (g) Funds for executing the Project shall be expended on following heads:
 - (i) Salaries, statutory benefits, travel costs, per-diems etc. of Project personnel and consultants;
 - (ii) Appropriate training of Project personnel at National/International Institutions and Conservation Breeding Centers;
 - (iii) Proper care of infrastructure, equipment and activities at the Facilities including all egg/bird management, veterinary care and administration (communication, electricity and water supplies, professional service fees, etc.) costs;
 - (iv) Necessary construction and maintenance of Facility, including furnishing and provisioning of infrastructure, purchase and maintenance of research equipment and vehicles, etc;
 - (v) Search, collection and transport of founder eggs/birds, maintenance and monitoring of captive-bred birds prior to their release to other mutually agreed conservation breeding Facilities, and/or future release of captive-bred birds into the wild;
 - (vi) Research both at the Conservation Breeding Facility as well as on wild population that are related to species ecology and breeding biology (which includes tagging of wild and captive birds, reproductive physiology, population monitoring, and advocacy) as prescribed in Action Plan and agreed by Steering Committee, including acquisition of equipment and running costs for these activities; and
 - (vii) Dissemination of information through documentation, seminars, research workshops and publication to other parties and partner agencies.
- (h) The Third Party will assist the second party in identifying the suitable habitats for Great Indian Bustard & Lesser Florican and suggest restoration measures to be undertaken. These habitats

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have to be made viable for in-situ population and suitable for releasing captive-bred birds (having a mosaic of inviolate areas connected with bustard friendly habitat within a large landscape) in the future by mitigating all current threats that have resulted in bird declines. The first party will provide adequate funds for restoration of the habitat and the second party will be responsible for implementation.

Third party will provide institutional support for training the official/staff of second party for in-situ conservation measures. Third party will also provide technical support to second party in-situ conservation.

- (i) First and Second Party shall take responsibility of identifying, & restoring bustard habitats and suggesting alternate habitats for release of birds within next 15-20 years as approved by Steering Committee. Second party will also implement outreach activities in collaboration with third party.
- (j) First Party shall facilitate funding and encourage other Great Indian Bustard and Lesser Florican range states for maintaining and restoring suitable Great Indian Bustard and Lesser Florican habitats.

ARTICLE IIIB: Permissions

- (a) The First and Second Party shall permit collection / capture of Great Indian Bustard and Lesser Florican eggs, and if advised by experts, juvenile / adult birds for the purpose of conservation breeding and research as per the provisions of the Wildlife (Protection) Act, 1972 and following appropriate protocols approved by the Steering Committee. In case, juvenile / adult birds are rescued anywhere from the species'-ranges, these may also be used for conservation breeding purpose as per the advice of the Steering committee. The First Party shall facilitate procurement of appropriate eggs / birds from other bustard range states.
- (b) As per the concept of minimum viable population in conservation biology and population viability analysis of Great Indian Bustard (Dolman et al. 2015, Dutta et al. 2011) and international guidelines (IUCN, 2013), a founder population of about 20 adult birds (15 females) is necessary to minimize the probability of extirpation of captive population and capture the genetic variability of the source population. Hence, considering 50-60 % mortality from egg to adult stage, a total of 40-55 eggs are required to build this founder population. To optimize the requirement of Conservation Breeding Programme and minimize the impact on *in-situ* population recovery, minimum 5 to maximum 8 eggs need to be collected every year for the first ten years. Egg collection shall be done by trained Project personnel from wild Great Indian Bustard breeding sites primarily in Rajasthan (and other States). In the case of Lesser Florican where wild populations are not as much depressed as that of Great Indian Bustard and clutch sizes are larger (2-4 eggs), a founder population of 30-40 adult birds is to be achieved. This target could be achieved in about 5-10 years with 10-20 eggs collected each year from the species range states. Wild-collected eggs shall be treated as per Action Plan, but shall include:
 - (i) Retention and incubation of eggs and, if required, their hatching and subsequent management in appropriate Facility;
 - (ii) Transportation of eggs / birds to Facility for building founder population;

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- (c) First and Second Party, in accordance with legal provisions, will provide necessary permits and facilitate in the continued development of all mutually agreed management and research activities at Facilities and in-situ conservation areas. In particular, Second Party will:
- (i) Grant long-term permits for field research at sites under their jurisdiction (e.g., Protected Areas), use of facilities (e.g. guest houses) at concessional rates (as applicable to forest department officials) and other assistance at their disposal, to Project personnel on duty.
 - (ii) Grant permit for capture, re-capture, marking and release of wild and / or captive-bred birds as may be required under the Wild Life (Protection) Act, 1972 for the purposes of conservation-breeding and research including satellite telemetry, monitoring studies, or translocation of eggs / birds as per the Action Plan approved by the Steering committee.

Article- IIIC: Habitat restoration and bird release

- (a) In due course of Project execution, as the captive-bred Great Indian Bustards and Lesser Floricans become ready for release into the wild, conservation areas in Rajasthan shall be prioritized for release, followed by conservation areas in Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Madhya Pradesh.
- (b) However, for the best interest of the species' persistence, choice of sites for releasing these captive-bred birds will depend on the degree of *in-situ* management actions implemented by the State Forest Departments and the level of habitat restoration in these conservation areas.
- (c) The release sites must have cumulatively 200 km² of inviolate space within the Great Indian Bustard landscape comprising of secured habitat patches exceeding 20 km² each and the connecting habitats in between these patches should be devoid of all hostile infrastructure. All potential threats to Great Indian Bustard at the release sites should have been mitigated to the best possible. Steering Committee shall set up a Task Force to assess these release sites for meeting the above mentioned criteria prior to the release of captive-bred birds. All captive bred released birds would be monitored using the best available technology to assess the success of the program.
- (d) The first and second party will endeavor to carryout voluntary relocation of communities in the habitat to create inviolate spaces.
- (e) A detailed landscape level management plan should be prepared by Second Party in consultation with First and Third Parties to ensure effective implementation of *in-situ* measures. This management plan should include actions required for (a) securing breeding enclosures in wild, (b) reducing threats in landscapes adjoining these breeding enclosures and (c) addressing livelihood concerns, as per the recommendations of the Guidelines for Resident Bustards' Recovery Programme.
- (f) First and Second Parties and GIB range states shall collectively provide financial support for implementing *in-situ* measures as per the landscape management plan.
- (g) The signing parties shall co-opt any other range states to be partners in the project with specific terms of agreement with that state.

ARTICLE IV: Project staff

Third Party shall engage staff for running Project facilities that includes:

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- (i) Project Scientist and Veterinary officer for running the Conservation Breeding Center who shall be trained at International Conservation Breeding Centers;
- (ii) International bustard captive breeding expert(s) as Project Advisor (s);
- (iii) And appropriate staff for running the Facilities.

Third party of the Project shall provide all salaries and allowances to Project personnel including approved project allowances to the personnel deputed by Second Party in the Project

Third party of the Project shall also arrange for appropriate training of Project personnel, including educational visits to International Bustard Breeding Centers, in order to develop a highly skilled team for execution of Project, as mentioned in Article IIIa.

ARTICLE V: Project staff responsibilities

Project Scientist(s), in consultation with the Lead Project Scientist, Advisors and team members, and in understanding with the Project Head, shall:

- (i) Assist in drafting Action Plan for Project and seeking approval from the Steering Committee;
- (ii) Supervise the construction of Facilities;
- (iii) Identify and procure infrastructure and equipment for running the Facilities as per Third Party rules;
- (iv) Assume responsibility for routine management and development of the Project;
- (v) In consultation with Project management committee to Identify Conduct relevant studies on species' biology, behavior, reproduction, genetics, ecology and management, both in captivity and in wild along with studies on socio-economy and other relevant topics on local community in liaison with other mutually agreed research institutions if required.
- (vi) Regularly report Project activities to Steering Committee, Project management committee and other relevant states (Gujrat, Maharashtra, Madhya Pradesh, Karnataka and Andhra Pradesh) authorities and interest groups. This will include preparation of annual and final reports, and supply of prompt response to any query concerning current status and activities of the Project;
- (vii) And facilitate training of Project personnel in conservation breeding techniques as well as *in-situ* management.

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ARTICLE VI: Addition of parties and dispute resolution

- (a) All Parties shall facilitate the involvement or contribution of representatives from relevant national and international institutions in this Project, provided such involvement does not in any manner compromise with the primary objectives of the Project.
- (b) Any dispute between Parties in respect of matters governed by this Memorandum of Agreement shall first be placed before the Steering Committee for amicable resolution. However, failing such resolution, the decision of Director General of Forests and Special Secretary to the Government of India, Ministry of Environment, Forests and Climate Change shall be final.

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 20.5.18
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 वन विभाग



ARTICLE VII: Validity of MoA

This Memorandum of agreement shall be effective from the date of signing of the agreement and remain valid for a period of five years from the date of signing and may be extended after review of progress every five years by all three parties for necessary adaptive management. Any of the Parties may give to others a written notice six months in advance of its intention to terminate the Memorandum of Agreement before the date of expiry. This Memorandum of Agreement may be modified or amended by mutual written consent of all Parties.

ARTICLE VIII: Projected financial obligations and commitments

The parties will commit funds (Rs. lakh) as under for the first four years of project implementation.

Year	Total fund requirement (in lakhs)	Commitment	
		First Party	Second Party
2017-18	803.00	773.00	30.00
2018-19	623.00	593.00	30.00
2019-20	532.00	512.00	20.00
2020-21	532.00	512.00	20.00

The financial commitment of first party includes construction of Conservation Breeding Center (CBC), running and maintenance of CBC, in situ pilot management and out reach. The commitment from Second party includes International Travel and training, and infrastructure for Conservation Breeding Center. Implementation of Conservation Breeding Programme Will be done by Third party. Detailed break-up of fund commitment by First Party is provided in annexure 1 and total fund requirements for executing the Conservation Breeding Programme for 40 years is provided in annexure 2.

IN WITNESS WHEREOF, the parties hereto have caused their representative duly authorized for that purpose to sign and execute this Memorandum of Agreement and affix hereto their seals on the dates and in the year herein above written.

Signatures of:

First Party

Inspector General of Forests
(On behalf of the President of India)
Ministry of Environment, Forest and Climate Change
Government of India, New Delhi

Second Party

Chief Wildlife Warden

(On behalf of the Governor of Rajasthan)

डा. वि.वि. माथुर/Dr. V.B. Mathur
निदेशक/Director
भारतीय वन्यजीव संस्थान
WILDLIFE INSTITUTE OF INDIA
देहरादून/Dehradun

Third Party

Director, Wildlife Institute of India



Annexure 1 - Budget break-up of fund commitment by First Party for initial years of project implementation

Head	Particulars	Yr-1					Yr-2					Yr-3					Yr-4					Yr-5					Total
		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	
Staff engagement	3 Project Scientists (1 CBC + 1 vet + 1 field)	20.16	22.18	24.39	26.83	29.52	32.50	35.75	39.25	43.00	46.90	50.90	55.00	59.25	63.60	68.00	72.50	77.10	81.75	86.50	91.30	96.10	101.00	105.80	110.60	115.40	123.08
	4 Project Associates (field)	10.85	11.93	13.13	14.44	15.86	17.38	18.95	20.57	22.25	23.95	25.65	27.35	29.05	30.75	32.45	34.15	35.85	37.55	39.25	40.95	42.65	44.35	46.05	47.75	49.45	66.23
	4 Project Assistant grade 2 (2 CBC + 2 field)	9.60	10.56	11.62	12.78	14.06	15.34	16.62	17.90	19.18	20.46	21.74	23.02	24.30	25.58	26.86	28.14	29.42	30.70	31.98	33.26	34.54	35.82	37.10	38.38	39.66	58.61
	8 Field assistant grade 1 (1 CBC + 3 field)	7.30	8.03	8.83	9.71	10.68	11.65	12.62	13.59	14.56	15.53	16.50	17.47	18.44	19.41	20.38	21.35	22.32	23.29	24.26	25.23	26.20	27.17	28.14	29.11	30.08	44.54
	3 Field assistant grade 2 (3 CBC + 3 field)	10.08	11.09	12.20	13.42	14.76	16.10	17.44	18.78	20.12	21.46	22.80	24.14	25.48	26.82	28.16	29.50	30.84	32.18	33.52	34.86	36.20	37.54	38.88	40.22	41.56	61.34
	Daily labour in field & CBC	2.88	3.17	3.48	3.83	4.22	4.61	5.00	5.39	5.78	6.17	6.56	6.95	7.34	7.73	8.12	8.51	8.90	9.29	9.68	10.07	10.46	10.85	11.24	11.63	12.02	17.58
	Project Management Unit (part cost)	3.06	3.37	3.70	4.07	4.48	4.89	5.30	5.71	6.12	6.53	6.94	7.35	7.76	8.17	8.58	8.99	9.40	9.81	10.22	10.63	11.04	11.45	11.86	12.27	12.68	18.68
	Total costs of staff engagement	15.36	16.65	18.00	19.40	20.85	22.30	23.75	25.20	26.65	28.10	29.55	31.00	32.45	33.90	35.35	36.80	38.25	39.70	41.15	42.60	44.05	45.50	46.95	48.40	49.85	77.29
	Center establishment costs	79.28	83.96	92.15	101.14	111.02	121.80	132.58	143.36	154.14	164.92	175.70	186.48	197.26	208.04	218.82	229.60	240.38	251.16	261.94	272.72	283.50	294.28	305.06	315.84	326.62	467.55
	Center running costs	414.00	270.00	225.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	1089.00
Conservation Breeding	Center maintenance costs	14.85	39.85	41.84	41.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	43.84	182.22
	Miscellaneous costs (training, collaboration & contingency)	0.00	0.00	4.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	49.50
	Total costs of conservation breeding	47.44	36.49	18.82	15.07	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	15.52	133.34
	Satellite telemetry costs (PTT & trapping costs)	476.29	346.34	290.16	169.41	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	171.85	1454.06
	Threat assessment surveys (vehicle charges)	33.34	52.09	16.05	14.85	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	131.86
	Population/habitat surveys (honorarium, vehicle, accommodation & tools - GPS & binocs)	13.50	13.50	14.85	14.85	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	15.53	72.23
	Surveys for land acquisition/rationalization, social aspects & other species status	18.43	3.00	0.00	0.00	24.64	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06	46.06
	General field equipment (camera traps, laptops, cameras, accessories & stationary)	0.00	5.40	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	5.94	17.28
	Accommodation & travel	17.70	2.07	2.28	2.28	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	2.38	26.70
	Research/conservation laboratory (genetics & pesticides) equipment (part cost) & analysis charges	7.92	7.92	8.53	8.72	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	42.23
Applied research	Contingency (collaborative service charges & miscellaneous)	58.35	13.35	14.69	14.69	34.82	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89	135.89
	Total costs of applied research	10.46	7.87	6.42	6.37	8.55	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66	39.66
	Training of Forest Conservation Staff (wildlife specialization & other trainings)	159.70	105.20	68.75	67.69	110.58	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92	511.92
	Technology aided patrolling (developing tools, conducting training workshops for implementation & equipments)	0.00	20.00	21.00	21.00	23.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
	Workshops to sensitize non-forest officers (materials, travel & accommodation) - 3 workshops/yr & 15 participants/workshop	13.14	17.14	13.35	4.40	4.60	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63	52.63
	Mobile workshops to sensitize local people (equipment, materials, travel & logistics) - 15 villages/yr & 500 people/yr	8.94	8.94	9.83	9.83	10.28	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83	47.83
	Awareness materials (posters, boards & documentary film)	4.00	3.60	3.96	3.96	4.14	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66	19.66
	Contingency (collaborative services & miscellaneous)	0.40	7.40	8.14	2.20	0.00	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14	18.14
	Total costs of capacity-building & awareness	6.32	7.85	8.31	7.57	7.85	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91	17.91
	Proctor-proof-fencing in critical enclosures	32.80	64.93	64.60	48.96	49.87	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18	261.18
Plant habitat		108.00	144.00	0.00	0.00	0.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00	252.00

2: office memo (B.M.) forest final 28.5.2018 d/05.docx

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management		Predator population management (traps, drugs, darting guns & neutering costs)									
Creation of breeding areas	Marking power-lines with Bird Diverters										
	Agro-environmental Incentives & food provisioning in enclosures										
	Total costs of pilot implementation of habitat management										
	Identification of suitable spaces										
	Quantifying relocation of families for suitable breeding areas										
TOTAL		995,008	773,444	592,666	512,455	511,157	3,385,200				

Annexure 2 Proposed long-term (40 years) budget for Bustard Conservation Breeding Programme

Head	Specifications	Yr 1-5	Yr 6-	Yr 11-	Yr 16-	Yr 21-	Yr 26-	Yr 31-	Yr 36-	Program
Center establishment costs	Enclosures (Open predator-proof fence)	total	total	total	total	total	total	total	total	total
	Buildings (reception, office, staff quarters, store, shower, eggs, food, & chick chambers) with furnitures	144	0	0	0	0	0	0	0	144
	Juvenile, adult & quarantine pens (cages)	300	0	60	0	90	0	0	0	450
	Enclosure & building modification costs	225	0	45	0	68	0	0	0	338
	Incubation, hatchery & food-processing facilities (furniture, equipment, partition, electrical appliances, etc.)	140	0	42	0	63	0	0	0	245
	Water facility	120	0	12	0	18	0	0	0	150
	Security system	40	0	0	0	0	0	0	0	40
	Power provision (incl generator)	40	0	0	0	0	0	0	0	40
	Infrastructure (water, security, power) modification costs	40	0	0	0	0	0	0	0	40
	Subtotal center establishment costs	1089	0	171	0	257	0	0	0	1517
Center running costs	Labware & consumables	42	97	142	209	307	451	663	0	1911
	Bird food	21	48	71	104	154	226	331	293	1249
	Vehicle (with driver) & POL	66	52	77	113	166	244	358	526	1602
	Travel expenses for project personnel	11	16	24	35	52	76	111	164	489
	Subtotal center running costs	140	214	314	461	678	996	1464	983	5250
Center maintenance costs	Enclosures, buildings & cages	22	70	103	152	223	328	482	0	1381
	Incubation, hatchery & food-processing facility	11	35	52	76	112	164	241	0	691
	Water facility	6	18	26	38	56	82	121	177	523
	Security system	6	18	26	38	56	82	121	177	523
	Power provision	6	18	26	38	56	82	121	177	523
	Subtotal center maintenance costs	50	158	233	342	502	738	1085	531	3640
Capacity building	Training of staff	32	10	0	0	14	0	0	0	56
	Consultation for 3-4 months on 1st yr & 1 follow-up visit/yr & visits of Steering Committee members	43	18	26	38	56	82	121	177	560
	Awareness material (posters & bill-boards)	2	8	11	17	25	36	53	78	230
	Publication	2	8	11	17	25	36	53	78	230

Signature
Date 12.5.18



Release & research	40 PTs & satellite team	0	0	0	320	0	0	0	0	320
Contingency	Transportation facility & logistics for bird release & release site preparation	0	0	0	53	52	114	111	247	577
	Miscellaneous expenses & overhead charges	64	19	36	40	72	87	127	76	520
	Subtotal training, collaboration, documentation, release & contingency costs	143	61	85	485	243	355	465	655	2192
Staff engagement	2 Project Scientists, 1 Project Associate (Conservation officer), 1 Project Assistant Grade 2 (Facility superintendent), 6 Project Assistant Grade 1 (security, husbandry, cleaning, food processing) & 3 Casual labour	135	198	291	428	629	924	1358	1995	5824
Budget requirement	TOTAL COSTS	1558	632	1094	1716	2309	3014	4372	4165	18723
	Average annual cost	312	126	219	343	462	603	874	833	468

Signatures of:

First Party

Inspector General of Forests
 (On behalf of the President of the Wildlife Institute of India)
 Dr. V.B. Mathur
 Director, Wildlife Institute of India, Dehradun

Second Party

Chief Wildlife Warden
 (On behalf of the Governor of Rajasthan)

Third Party

Director, Wildlife Institute of India



राजस्थान सरकार
वन विभाग

कमांक 40.4(2)वन/2005 पार्ट

जयपुर दिनांक 05-06-2018

अतिरिक्त प्रधान मुख्य वन संरक्षक एवं
मुख्य वन्य जीव प्रतिपालक,
राजस्थान, जयपुर।

Sub-Approval of the MoU for Captive Breeding Center of
GIB

Ref:-Your Letter No. 8554 Dated 26.04.2018

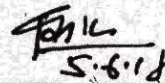
महोदय,

उपरोक्त विषयान्तर्गत सन्दर्भित पत्र द्वारा राजस्थान में ग्रेट इण्डियन
वरटर्ड (GIB) का ब्रीडिंग सेन्टर की स्थापना हेतु प्रेषित एमओयू को विधि विभाग
से विधिक्षा कराया जाकर विधिक्षित एमओयू की प्रति संलग्न कर आपके स्तर से
अग्रिम आवश्यक कार्यवाही कराये जाने हेतु परतृत है।

संलग्न -उपरोक्तानुसार

भवदीय




(रामकरण खैरवा)
विशेषाधिकारी



Government of India
Ministry of Environment, Forest and Climate Change
(Wildlife Division)

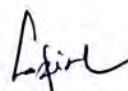
6th Floor, Vayu Wing,
Indira Paryawaran Bhawan
Jor Bagh Road, New Delhi-110003

F. No. 15-7/2015- WL (pt-ii)

Date: 30th July, 2018

Sub: Meeting of the Steering Committee under the Great Indian Bustard and Lesser Florican Conservation Breeding and Research Programme- regd.

Kindly, find the enclosed copy of Summary records of the Meeting of the Steering Committee under the Great Indian Bustard and Lesser Florican Conservation Breeding and Research Programme held on 19th July, 2018 at MoEF&CC, New Delhi.


(Dr. R. Gopinath)
Joint Director (Wildlife)
E-mail: jd-wl@nic.in

Distribution:

- I. Additional Director General (Wildlife), MoEF&CC, Government of India
- II. Director, Wildlife Institute of India (WII), Dehradun
- III. Chief Wildlife Warden, Government of Rajasthan, Jaipur
- IV. Inspector General of Forests (Wildlife), MoEF&CC, Government of India, Delhi
- V. Member Secretary, Central Zoo Authority, Government of India, Delhi
- VI. Director, Desert National Park, Jaisalmer
- VII. Lead Project Scientist (Great Indian Bustard), WII (to be nominated by WII, Dehradun)
- VIII. Dr. Asad Rahmani, Ex-Member, Bombay Natural History Society (BNHS), Mumbai
- IX. Dr. Vibhu Prakash, Member, Bombay Natural History Society
- X. C.E.O. & Secretary General, WWF-India, Delhi
- XI. Project Scientists (Great Indian Bustard) based at the project site Rajasthan (to be nominated by WII, Dehradun)

Summary Records of the first meeting of Steering Committee under the Great Indian Bustard & Lesser Florican Conservation and Breeding Programme

The first meeting of the Steering Committee for Great Indian Bustard & Lesser Florican Conservation and Breeding Programme was convened under the Chairmanship of Shri M.S. Negi, Addl. DGF (Wildlife), MoEF&CC on 19th July, 2018 at MoEF&CC. List of participants is at **Annexure**.

2. Dr. R. Gopinath, Joint Director (Wildlife), MoEF&CC welcomed all the members of the meeting and outlined the roles and responsibilities of the Steering Committee as per the Memorandum of Understanding under the Great Indian Bustard & Lesser Florican Conservation and Breeding Programme.
3. Dr. Y. V. Jhala, Lead Project Scientist & Senior Faculty, WII introduced the agenda points of the meeting and initiated the agenda wise discussions among members:

Agenda i. Land allocation at Sorsan and Jaisalmer:

4. Lead Project Scientist stated that a site at Sorsan (Anta tehsil, Baran district) was finalized as the optimum location to set up the GIB conservation breeding center. The site in Jaisalmer for setting up the hatchery and chick housing facility needs to be finalized. He informed that 4 km² area within Sorsan and 1 km² area in Jaisalmer is needed for this purpose. Dr. Asad Rahmani, ex-officio member raised the issue of land ownership.
5. Dr. G.V. Reddy, Chief Wildlife Warden, Rajasthan responded that there is an area of about 22 km² at Sorsan which largely comprises of Revenue lands and controlled by Gram Panchayats. He agreed to provide about 4 sq.km area within that area. He emphasized that, WII team should finalize and pin-point the site for setting up of GIB National Breeding Centre and inform the Rajasthan Forest Department so that the process of transfer of revenue land to forest department could be initiated at the earliest.
6. Lead project investigator mentioned that 1 sq.km of land would be required for setting up of a hatching facility near Ramdeora/ Mokhla at Jaisalmer. He mentioned that the Ramdeora site is preferable, since its proximity to egg collection sites in enclosure and Field Firing Range, and accessibility to Jodhpur/Jaisalmer Airbase for expeditious air transfer of eggs/chicks.
7. Dr. Sutirtha Dutta, Project co-investigator/scientist mentioned that lands around Ramdeora are leased from Gram Panchayats and not owned by Forest Department and this could complicate the land transfer. To this, CWLW Rajasthan assured that it will not be difficult to transfer 1sq.km land to the Project, and this site can be chosen close to any existing enclosure in that area.
8. Dr. Vibhu Prakash, ex-officio member highlighted that the site should not be very close to areas used by the wild birds or existing poultry, to avoid disease transmission. Dr. Ravi Singh, ex-officio member highlighted that the site should not be very close to settlements to avoid human interventions.

9. Shri D.N. Singh, Member Secretary CZA suggested to use the existing hatchery facility at Pinjore till the new facility is set up. Dr. Rahmani clarified that the distance between egg collection site and Pinjore is too far for this. All members agreed to this.

Decision taken: (a) WII team will finalize the site for setting up of breeding facility at Sorsan with area of around 4 sq.km within a week and intimate the same to the Rajasthan Forest Department.
(b). Rajasthan F.D. would complete the process of transfer of land and laying of Foundation Stone ceremony for the facility would take place on fourth week of August 2018.
(c) WII team will finalize the site for setting up of a hatching facility at Jaisalmer with area of around 1 sq.km by first week of August, 2018 and intimate the same to the Rajasthan Forest Department.

Agenda ii. Design of Main and Satellite Facilities

10. Lead Project Scientist presented the draft of the design for the Conservation Breeding Center and the draft design for the Incubating/Chick Housing Facility. He informed that this is a preliminary design and is based on organization of other bustard breeding centers such as "International Fund for Houbara Conservation" (IFHC) in Uzbekistan, U.A.E., and Morocco to breed the Houbara Bustard, the Great Bustard in Spain etc. He mentioned that the Project team is collecting different ideas from various centers for designing the Indian GIB and LF Breeding Center. Some fine tuning in designing the center as per site specific attributes will be needed.

Decision taken: Project team would consult C.Z.A, CCU and ex-situ architects on refining and finalizing the designs and if required may visit the site. An interpretation center within the office building should be there at the Satellite Facility that is remotely located from the egg holding area to avoid disturbances.

Agenda iii. Training for centre staff

11. Lead Project Scientist stated that two training visits are required urgently. First a sensitization visit for senior officials of MoEF&CC and Rajasthan Forest Department associated with the project at IFHC during September – October 2018. Second, a training visit of a few months for hands on training of the project and field-level staff at IFHC & other appropriate international breeding centers such as Abu Dhabi, Uzbekistan, Smithsonian Institution etc. Site visits to understand *in-situ* good management practices for bustard conservation is also required. This will help in ensuring that the GIB conservation breeding centers are run by competent and skilled staff.

12. CWLW, Rajasthan mentioned that two senior officers such as Dr. G. S. Bhardwaj and Dr. Sunil Chidre / Dr. Kavita Singh / Sh. Pradhan could be associated with the Project on a long-term (10-20 years period) basis, and can be nominated for the sensitization visit. He also mentioned that up to two Forest Guards can be sent along with the Project team for the training visit so that their service can be utilized on a long-term basis for the Project. Shri Soumitra Dasgupta, IGF (WL) mentioned that it is necessary that an officer which will get the training should be in service for a longer period.

13. Project co-Investigator highlighted the importance of participation of senior officers of MoEFCC in the sensitization visit to galvanize the MoU between IFHC and WII for executing the Project activities.

14. CWLW Rajasthan mentioned that the first year funding from Rajasthan FD will be limited as for the proposals since the prior allocation was not available during the planning of Forest Department annual budgets. However, he will allocate some funds on post-hoc basis for the training of Project staff in the current year, and include this funding requirement in the upcoming annual budgets. IGF (WL) and Lead Scientist highlighted on the need of this fund sharing to enable training as proposed in the MoU, since CAMPA funding does not cover the expenditure on international travel.

Decision taken: (a) The funds for travel as committed by Rajasthan FD needs to be transferred to WII.

(b) Process of international centres exposure and training of staff will be started within next 4-6 months.

(c) WII will send proposals for the sensitization and training visits to CWLW Rajasthan with a copy to MoEF&CC.

Agenda iv. Egg/chick/adult collection permits

15. Lead Project Scientist stated that collection of eggs and individuals from the wild are required to populate the satellite and main facilities. At least 5 - 8 eggs from the Thar population of GIB are needed annually, and this exercise will continue for the next 10 years. While collecting eggs is the main goal, permissions to collect chicks and adults are also necessary. He also mentioned there are remnant populations, of at times single individuals, in the states of Maharashtra, Andhra Pradesh, Madhya Pradesh and Karnataka. These populations have negligible breeding potential. Capturing them safely and then transporting them to the center is logical as these populations are beyond recovery and it is a matter of time before they become locally extinct. At the breeding center they may breed and contribute to the conservation of the species.

Decision taken: (a). MoEF&CC agrees to permit collection of 5-8 eggs of GIB from its Thar Population under Section 12 of Wildlife (Protection) Act, 1972. WII will submit proposal to State Government of Rajasthan seeking approval for collection of 5-8 eggs from Thar population of GIB to the Government of Rajasthan specifying time and period of collection of these egg and State Government will complete the process of granting approval preferably within a fortnight of receipt of proposal.

(b). The activity to transfer the remnant populations should commence after a few years once the breeding facility is started and competent to handle these rescued birds.

Agenda v. Permitting radio tagging

16. Lead Project Scientist mentioned that it is difficult to locate GIB nests within the first week of incubation to optimize the relaying probability and successful artificial hatching of eggs. To ensure this, CWLW was requested to allow the tagging of females for nest location. Besides, understanding movement patterns of GIB, it will also aid in habitat restoration. He mentioned that

the delay in signing up of MoA and permissions precluded the egg collection for the current year (2017-2018) and with every passing year, the wild population is declining and chances of success will decline.

Decision taken: CWLW Rajasthan will initiate the process of renewal of permissions to radio tag GIB and the internal process of sanctioning this permission will be completed by second week of August.

Agenda vi. Loaning of eggs/chicks to the International Fund for Houbara Bustard Conservation Breeding Centre at Abu Dhabi

17. Lead Project Scientist stated that, since the window of opportunity to collect eggs is diminishing and the Indian facilities will take at least 1.5-2 years to be fully developed, it will be prudent to send 10-20 eggs/chicks to IFHC bustard breeding center till Indian facility is ready and staff trained to house them. IFHC has high levels of expertise to breed bustards, and this activity will ensure successful establishment of an offshore founding population as insurance, thereby reducing the risk of extinction further. These eggs and their progenies will be the sovereign property of Govt. of India and Rajasthan and can be brought back whenever required. The members deliberated and agreed on the suggestions of Lead Project Scientist.

18. Dr. Rahmani suggested that eggs and individuals of houbara, kori or other closely related species can be brought to India for the practical learning of the Project team on husbandry and incubation techniques, once the Indian Facilities are developed and before GIB breeding is commenced in these Facilities. The Chair agreed that houbara eggs should be brought in to Indian center to learn the rearing technique and GIB eggs/chicks will be reared in Abu Dhabi.

Decision taken: It was agreed to make WII the nodal agency from India for collection and transferring of eggs to IFHC. For this purpose, WII will formulate a MoU between WII and IFHC for transferring of eggs to IFHC. Prior permissions under CITES norms for transfer of eggs/chicks to IFHC would be taken. The timeline for these prerequisites (permits and MoU) should be completed by September-October 2018.

Agenda vii. Mitigation of effects by power lines

19. Lead Project Scientist stated that power lines have been identified as the primary threat to bustards. Between 2017 and 2018 there have been 5 known mortalities of GIB on account of collisions with power lines. Current death rates suggest that up to 18 GIB could potentially be killed annually by collision with power lines. With a population of 120 individuals in Thar, this is of grave concern. An urgent action is required to underground cables in most risky segments and to add bird diverters to power lines and to notify the Ministry of Power to take swift action. Radio telemetry on GIB will also provide details of flight paths (as has happened in Kachchh) and help prioritise sites for mitigation.

20. CWLW, Rajasthan suggested that an amendment be made to the Wildlife (Protection) Act, 1972 under which legal proceedings can be done against power agencies for not implementing necessary mitigation measures.

21. The Chair informed that a circular has been sent for installing new transmission lines or upgrading existing ones by following the linear infrastructure mitigation guidelines of WII. He also stated that the need to expeditiously mitigate power lines in GIB habitats should be taken to NBWL and the decision subsequently communicated to Central Power Corporations / Central Electricity Authority for necessary policy interventions.

Decision taken: It was decided that a meeting among the CPCs is required and the matter should also be taken to NBWL.

Agenda viii. Predator removal from enclosures

22. Lead Project Scientist stated that predators are a threat to survival of GIB eggs/chicks. Predominantly feral dogs, desert foxes, wild pigs and similar carnivores destroy GIB eggs and attack juveniles and even adults. Under natural conditions the density and diversity of nest predators were few due to the extreme arid nature of the habitat. However, now with surface water available, predators that were never found in the Thar (dogs, pigs, and Indian fox, etc) are now present. Removing predators from these areas is essential after fencing is done as otherwise predation pressure from enclosed predators can potentially increase.

23. Permission is requested for the non-lethal extirpation of these predators from GIB breeding enclosures. Predators live captured will be released back outside the predator proof fence with the help of professionals who are well versed in capture and translocation of wildlife.

Decision taken: CWLW Rajasthan stated that the permission to remove predators from enclosures was ongoing and will be issued soon. It was decided that Project team would facilitate Rajasthan Forest Department by providing/sourcing appropriate expertise to execute this activity.

Agenda ix. Construction funds transfer and agency

24. It was discussed that Civil Construction Unit (CCU) for MoEF&CC is the designated agency to construct using government funds. CWLW, Rajasthan was of the view that construction work of the Breeding centre should be taken up by the Civil Construction Unit (CCU) for MoEF&CC.

Decision taken: The task of construction of conservation breeding centres and hatching facilities could be delegated to the CCU, and the construction funds along with site specific designs will be communicated/ transferred to CCU by WII. The construction will be supervised and assisted by Rajasthan FD while WII will provide the designs and advice, as required.

Agenda x. Empowerment of Project Management Committee for details of day to day work

25. The steering committee approves the setting up of a Project Management Committee for the field execution and timely completion of the project with the following constitution:

- i. Chief Wildlife Warden, Rajasthan as the Chairman of the Project Management Committee
- ii. Director Desert National Park
- iii. Deputy Conservator of Forests, Baran (Kota Circle)
- iv. One representative from International Bustard Breeding Centers (To be nominated by the Chairperson of the steering committee)
- v. Lead Project Scientist/Investigator (Great Indian Bustard), WII (Member Secretary)
- vi. Project Scientist (GIB) at Project Site Rajasthan

Decision taken: The PMC will function under the guidance of steering committee and shall meet every 4 months. The WII GIB species recovery project team will be responsible for day to day operation of the conservation breeding center. It was also decided that CWLW will nominate a senior officer/s who will be associated on long-term basis with the Project. It was also decided that an ex-officio member may also be nominated by the PMC with the approval of the Steering Committee.

Agenda xi. Nomination of International Experts

26. It was decided that WII will nominate two leading experts on bustard conservation and breeding to act as the consulting international experts on the Project.

Agenda xii. Process Documentation

27. It was decided that considering the significance of this project, there is a need to document the process through a proper audio-visual documentation including filming done by competent agency. The WII will take necessary steps for process documentation.

Agenda xiii. Timeline of activities

- (a) The Committee decided that WII will draft a detailed project work plan along with month-wise activities breakups and responsible persons for the initial year's activities and share it by first week of September.
- (b) A tentative future work plan should also be prepared and communicated as a draft plan, which needs to be flushed out in a rigorous manner by involving appropriate consulting experts as a project road map document. This document should include the plan of habitat restoration and release of birds in future, and exit plan for the Project.
- (c) This new plan should explicitly identify the sites for conservation activities and outline the required site-specific management activities.
- (d) CWLW Rajasthan suggested that one representative of the Project Team be deputed at the Rajasthan site to facilitate the proposed activities. He also emphasize on the need of developing a robust in-situ conservation plan in consultation with the Project team based on the earlier proposal developed and submitted for CAMPA funding by WII.

- (e) CWLW suggested that local representatives including students/researchers of Rajasthan be engaged in the Project. Lead Scientist offered to conduct an interview in Rajasthan to enable this process.
- (f) MoEF&CC will write to Commanding Officer, Western Command of Indian Army and request to nominate a representative of Indian Army as a member in the Steering Committee under the Great Indian Bustard & Lesser Floricorn Conservation and Breeding Programme

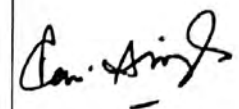
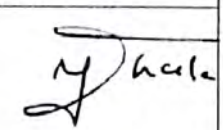
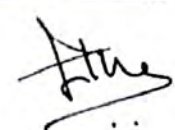
. The meeting ended with a vote of thanks to the Chair.

FIRST MEETING OF THE STEERING COMMITTEE UNDER THE GREAT INDIAN
BUSTARD AND LESSER FLORICAN CONSERVATION BREEDING AND RESEARCH
PROGRAMME

Date: 19th July 2018

Time: 3:00 P.M.

Venue: 'Indus' Conference Hall, Ground floor, Jal Wing, Indira Paryavaran Bhawan, Jor
Bagh, New Delhi.

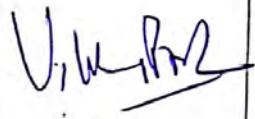
Sl. No	Name	Address, Tel. No. & E-mail	Signature
1.	Dr. G.V. Reddy CWLW, Rajasthan	State Forest Department Jaipur, Rajasthan	
2.	Ravi Singh Secy. Gen & CEO NWFG-India	172, B, Lodi Estate, N-Delhi - 110003. 4150 4777 98103 - 72632	
3	Dr D.N. Singh MS, CZA	CZA, New Delhi	
4	Y. V. Thakur	WII jhalag@wii.gov.in	
5	S. Datta	WII sutirtha@wii.gov.in	

**FIRST MEETING OF THE STEERING COMMITTEE UNDER THE GREAT INDIAN
BUSTARD AND LESSER FLORICAN CONSERVATION BREEDING AND RESEARCH
PROGRAMME**

Date: 19th July 2018

Time: 3:00 P.M.

Venue: 'Indus' Conference Hall, Ground floor, Jal Wing, Indira Paryavaran Bhawan, Jor
Bagh, New Delhi.

Sl. No	Name	Address, Tel. No. & E-mail	Signature
6	VIRBH PRAKASH	F-25, HMT Colony, PTN JOR - 134101 Tel No - 09416044924 Vilkhuprakashmatkar@gmail.com	
7	ASAD RAHMANI	c/o Bombay Natural History Society Hornbill House Shahad Bhagat Singh Road Mumbai - 400 001	
8	Sh. M.S. Negi ADG(WL), MoEFCC	MoEFCC, New Delhi adgwl-mef@nic.in	
9	Sh. Soumitra Dasgupta IGF(WL), MoEFCC	MoEFCC, New Delhi igfwl-mef@nic.in	
10	Dr. R. Carpinath Joint Director MoEFCC	MoEFCC, New Delhi jd-wl@nic.in	

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**Government of India
Ministry of Environment, Forest and Climate Change
(Wildlife Division)**

6th Floor, Vayu Wing,
Indira Paryawaran Bhawan
Jor Bagh Road, New Delhi-110003

F. No. 15-7/2015- WL (pt-i) GIB

Date: 16th August, 2019

Sub: Summary records of the 2nd meeting of the Steering Committee under the Great Indian Bustard and Lesser Florican Conservation Breeding and Research Programme- regd.

Kindly find enclosed a copy of Summary records of the 2nd meeting of the Steering Committee under the Great Indian Bustard and Lesser Florican Conservation Breeding and Research Programme held on 21st July, 2019 at Jaisalmer, Rajasthan.



(V.L. Roui Kullai)
Deputy Inspector General of Forest (Wildlife)
E-mail: vlrouil@gmail.com

Encl: as above

Distribution:

- i. Additional Director General (Wildlife), MoEF&CC,
- ii. Director, Wildlife Institute of India (WII), Dehradun
- iii. Chief Wildlife Warden, Government of Rajasthan, Jaipur
- iv. Inspector General of Forests (Wildlife), MoEF&CC,
- v. Member Secretary, Central Zoo Authority, New Delhi
- vi. Director, Desert National Park, Jaisalmer, New Delhi
- vii. Dr. Y.V. Jhala, Lead Project Scientist, Great Indian Bustard-CAMPA Project, WII, Dehradun
- viii. Dr. Asad Rahmani, Ex-Member, Bombay Natural History Society (BNHS), Mumbai
- ix. Dr. Vibhu Prakash, Member, Bombay Natural History Society
- x. C.E.O. & Secretary General, WWF-India, Delhi
- xi. Dr. Suthirtha Dutta, Project Scientist (Great Indian Bustard-CAMPA Project) based at the project site Rajasthan
- xii. Mr. Frederic Lacroix from IFHC/ Reneco, Abu Dhabi
- xiii. Mr. Juan Carlos Alonso, International Bustard Scientist, University of Spain

Copy to:

- i. The PCCF & CWLW, Government of Gujarat, Gandhinagar
- ii. The PCCF & CWLW, Government of Maharashtra, Nagpur
- iii. The PCCF & CWLW, Government of Karnataka, Bengaluru

Summary Records of the second meeting of the Steering Committee under the Great Indian Bustard & Lesser Florican Conservation and Breeding Programme

The second meeting of the Steering Committee for Great Indian Bustard & Lesser Florican Conservation and Breeding Programme was convened under the Chairmanship of Shri M.S. Negi, Addl. DGF (Wildlife), MoEF&CC on 21st July, 2019 at Jaisalmer, Rajasthan. Before the meeting, a field visit to the existing GIB enclosures at *Sudashri* and temporary egg incubation and hatchery facility at *Sam* Forest Chowki, Jaisalmer was conducted on 20th July, 2019. The minutes also include the discussion held during the Visit. List of participants is at **Annexure**.

2. The Chairperson welcomed all the participants in the meeting. Then, the DIG (Wildlife), MoEF&CC and Member Secretary of the Committee initiated the meeting as per the Agenda.

Confirmation of the 1st meeting of the Steering Committee under the project: The Member Secretary informed that 1st meeting of the Steering Committee was held on 19th July, 2018 at MoEF&CC. The summary records of the meeting was shared with all the members. No comments were received and therefore, the decisions of the meeting were considered to be accepted by the members. Thereafter, discussion on Action Taken Report (ATR) of the 1st meeting of the Steering Committee proceeded as per the following:

a. Land allocation at Sorsan and Jaisalmer and design of main and Satellite facilities:

Dr. Suthirtha Dutta, Co Project Investigator and faculty, WII informed that construction works at Satellite facility, Ramdevra has started with the incubation, chick-rearing and office rooms. Other rooms will be designed by WII in consultation with IFHC/ Reneco based on the learnings from the *Sam* Facility. Shri Arindam Tomar, APCCF & CWLW, Rajasthan informed that the forest land finalized for establishing/construction of the Conservation Breeding Centre (CBC) at Sorsan is yet to be handed over to WII for the construction of the centre. He informed that around 3.43 hectare of land would be required from the adjoining revenue land. The land transferring process is under process. He also informed that cattle proof fencing will be developed around the CBC once, the land is transferred. Dr. Asad Rahmani highlighted that the fencing should be such that it may not hinder the movement of the wild animals.

b. Training for centre staff: Shri Arindam Tomar informed that Dr. S. Rathore, Veterinary officer from Rajasthan Forest Department has been trained along with project personnel at National Avian Research Centre, Abu Dhabi in May, 2019 and their services would be utilized in the present programme.

c. Egg/ Chick/ adult collection permits: Dr. Jhala informed that the requisite permits have been obtained from the Ministry.

d. Permitting radio tagging: Issue of one tagged bird not sending any signal after 24th June was discussed. WII was asked to extensively search the missing bird. Idea was floated for use of satellite tags instead of the current ones, to which WII informed about the difficulty in procurement process. It was discussed that tagging process of GIB and Lesser Florican has to be expedited. Shri Tomar asked WII to tag Lesser Floricans in Rajasthan this year only, to which WII agreed.

e. Loaning of eggs/ chicks to IFHC, Abu Dhabi: Dr. Jhala informed that considering the urgency in the matter, it was decided in consultation with Rajasthan Forest Department that instead of sending the eggs to Abu Dhabi, a temporary facility would be developed at *Sam* where the eggs could be artificially incubated and hatched. In the present breeding season, seven eggs of GIB were collected. Out of these, five of them have hatched in the temporary facility at *Sam* and two are still in incubation process.

f. Mitigating the effects of powerlines: All the members opinioned that existing power lines in the GIB habitats are a major threat to the population. The Chairperson mentioned that the Ministry through Secretary, EF&CC has requested the Ministry of New & Renewable and Ministry of Power to direct the Power/ transmission Agencies to implement the mitigation measures including the undergrounding of power lines upto 33 KV and installation of bird diverters etc. Shri Tomar informed that the State Forest Department is also taking care that no new power lines are allowed to pass through GIB habitat areas.

g. Predator removal from enclosures: Shri Tomar informed that the removal of predators with support from WII is under process.

h. Construction funds transfer and agency: Dr. Dutta informed that funds for construction of the Satellite Facility at Ramdevra, Jaisalmer has been transferred to CPWD

(CCU) Jaisalmer to the tune of Rs. 92 Lakh for the first phase building (Office, incubator, Chick rearing). The construction works are under process.

i. Empowerment of Project Management Committee (PMC) for details of day to day work: Dr. Dutta informed that Rajasthan Forest Department and WII are coordinating on a regular basis to implement *ex-situ* and *in-situ* actions for GIB and Lesser Florican conservation breeding programme. He mentioned that a formal PMC would be constituted after the 2nd meeting of the Project Steering Committee.

j. Nomination of International experts: Dr. Jhala informed that Mr. Frederic Lacroix from IFHC/ Reneco and Mr. Juan Carlos Alonso, International Bustard Scientist, University of Spain have been nominated by WII as the International experts (Members) for the Steering Committee. All the members agreed to their nominations in the Steering Committee.

k. Process documentation: Dr. Jhala informed that the process of photo documentation of the project activities has been started as part of the project.

l. Timelines of activities: Dr. Jhala informed that detailed project work plan has been developed in consultation with Rajasthan Forest Department as a preliminary basis in accordance with meeting held at Jaipur during January, 2019. He also informed that detailed action plans will be developed on the basis of experimental work at CBC and since this is a learning phase for all, a flexible work plan would be required which could be refined at every step.

Decision Taken: After deliberate discussions, the Committee approved the Action Taken Report.

3. Discussion on the present status of project:

Dr. Suthirtha Dutta made a brief presentation highlighting the updates of project activities in the States of Rajasthan, Gujarat and Maharashtra. Copy of presentation is attached at **Annexure II**. Dr. Jhala, requested the Chair to allow for purchase of one vehicle under the project. Shri Tomar, CWLW Rajasthan was of the view that in order to avoid the decline in Lesser Florican, it will be appropriate that *ex-situ* breeding of Lesser Florican should be started simultaneously. Dr. Jhala, was of the view that breeding of GIB in initial stage and requires a lot of attention to bring it out of the critical stage and to ensure success, all the scientists of WII and IFHC are presently engaged in the task. Diversion of their attention towards Lesser Florican may

jeopardize the success of the GIB breeding. Thereafter, Shri Tomar, CWLW Rajasthan stated that he wishes to take up this activity independently in Jaipur with available expertise with him.

Decision Taken: It was decided that approved budget heads under the project do not require sanctions again and again. Since the provision of vehicle was already in the project activities which were approved by CAMPA, therefore, there is no separate need of approval for vehicle again. After deliberation, it was also decided that CWLW, Rajasthan can take up this *ex-situ* breeding of Lesser Florican independently of this project and in no case the arrangements made for engagement of scientists in Sam facility should be disturbed. In case the scientists are ready to facilitate the *ex-situ* breeding activities being taken up by CWLW, they should do it in spare time available with them without hampering the activities at Sam Facility.

4. Status of GIB *in-situ* conservation programme in the States of Gujarat, Maharashtra and Karnataka:

Shri A. Tomar, CWLW, Rajasthan informed that the project has gained momentum during the last few months and is being implemented by WII in a satisfactory manner. He informed that recently 5 chicks of GIB have been hatched in the temporary facility at Sam. He opined that WII should place more trained staff at the centre to look after the birds and the centre. He also informed that Forest Department is taking all necessary steps to stop the issue of “Locust” attack from entering the Desert National Park (DNP) so that the GIB are not affected due to it. He said that Forest Department is working towards the development of GIB habitats and also highlighted the increasing threats of mortality of GIB due to collisions from the power lines.

Shri Sanjay Mohan, PCCF & CWLW, Karnataka appreciated the efforts of WII in implementation of the programme. He informed that the State of Karnataka has a small population of GIB and desired that their State may also be included in the ongoing programme of GIB conservation.

Shri Ansari, Deputy Conservator of Forest, Gujarat State Forest Department informed that there are around 6 females GIBs left in the Kachchh Bustard Sanctuary. Forest Department is taking all necessary steps for their conservation and protection. He highlighted the threat of power lines to GIB and informed that the Forest Department has conducted the meeting with the power agencies and directed them to install the mitigation measure for GIBs protection. He told the

Committee that if a male GIB from Rajasthan could be released into the Kachchh Bustard Sanctuary, it would be helpful in initiating the natural breeding of the GIBs in Gujarat again.

Shri Sunil Limaye, APCCF, Maharashtra informed that during the survey held in 2018 in his State, no GIB was sighted but, as per the information received from the villagers, 2 males and 1 female GIB are sighted.

Dr. Jhala informed that the genetic biodiversity of GIBs found in Karnataka is totally different from the GIBs found in rest of the India.

All the stakeholders opined that transferring a male GIB to Gujarat in the present scenario where the population is very less and there is threat of collision with power lines would be risky and un-viable in present situation. The request for a male can only be considered after appropriate mitigation of power lines is undertaken in Kachchh. All the GIB range States including the Gujarat Forest Department should take appropriate mitigation measures to conserve and protect their existing population of GIB. The GIB birds after their 2nd-3rd generation from the CBC would be later transferred to GIB range States including Gujarat.

Decision taken: After thorough deliberations, following was decided:

- i. State Government of Karnataka should be included in the project. The State Government should prepare an *in-situ* conservation programme for GIB in consultation with WII which should be placed before the Steering Committee in its next meeting or should be submitted to the Ministry by 31st November, 2019. As per decision taken in 6th meeting of National CAMPA advisory council where this GIB recovery project was approved, funding will be considered from State plan or State CAMPA. Ministry can also consider partial funding from DWH.
- ii. For the purpose of *ex-situ* conservation of the GIB in Gujarat and Karnataka, WII in consultation with State Government of Gujarat and Karnataka should explore the possibility of and plan for
 - a. Shifting the female birds/male birds from Gujarat/ Karnataka to the current breeding facility for the purpose of captive breeding or breeding through artificial insemination, or
 - b. Establishing satellite breeding centres in these States itself

- iii. WII may submit the report and suggestions about decision (ii) above after consultation with Gujarat/Karnataka by 31st November, 2019.

5. Discussion about the physical/financial status of GIB Conservation Breeding Centre works; including temporary facility for incubation of GIB:

Shri A. Tomar, CWLW, Rajasthan informed that considering the urgency of GIB's egg collection in the present breeding centre, it was discussed with WII and other partner agencies like IFHC to establish a temporary egg incubation and hatchery facility at Sam Forest Chowki, Jaisalmer till the permanent CBC and Satellite facility at Sorsan, Kota and Ramdevra in Jaisalmer are set up respectively. He informed that the construction works at Ramdevra are going on in good pace but the works at Sorasan Kota are yet to be initiated. He also informed that an additional expenditure of Rs. 56 Lakhs has been happened due to setting up of the emergency temporary facility at Sam.

Decision taken: It was decided that since the establishment of existing emergency temporary facility was not in the project plan as it was done to utilize the present breeding season to avoid further delay in recovery program and the additional expenditure on its establishment was also not pre-planned for the current financial year, hence, the amount so incurred would be adjusted from next financial year's budget. A proposal with appropriate justification for the extra expenditure be put up to CAMPA by WII & RFD. Further, in view of facility already created at Sam, WII & RFD may consider reviewing the size of the facility at Sorsan where work is yet to be started. But in no case compromise in construction quality of enclosures shall be made.

6. Discussion about status of different permissions related to the project:

Dr. Y.V. Jhala informed that with the permission of MoEF&CC and Rajasthan Forest Department, 7 eggs of GIB were collected for artificial incubation. Out of these, 5 eggs have hatched successfully. Two are still in incubation. He requested CWLW, Rajasthan to permit the collection of two more eggs during the present breeding season. He also informed that Ministry has also permitted the removal of predators from the GIB enclosures. Shri Tomar, CWLW, Rajasthan suggested that WII should also consider lifting of eggs from Ramdeora/Pokhran area.

Mr. Frederic Lacroix, in the discussions held during the visit to breeding facility, was of the view that to achieve desired success in the project in shorter time period, more eggs from the field will be required. On being enquired, he opined that it is possible to transport the eggs from longer distances but we need to take sufficient safety measures. Rajasthan FD may consider the request of WII to permit collection of two eggs of GIB.

Decision taken: With a view to make the *ex-situ* breeding programme a success, RFD and WII may consider increase in collection of eggs but collection of eggs should be from different areas and sub populations so that natural breeding does not hamper. Rajasthan Forest Department should consider the request of WII to permit collection of two eggs of GIB from the current area of egg collection. Also, WII should consider collection of eggs from Ramdeora/Pokhran areas as advised by CWLW Rajasthan.

7. Status of training and capacity building of the officials and staff of Forest Department:

Senior Veterinary Officer from Rajasthan Forest Department and Scientists from WII were trained in IFHC, Abu Dhabi. Two Scientists from IFHC are also providing his services at temporary facility at Sam, Jaisalmer and helping the Forest Department and WII team in capacity building and monitoring of health of the birds. ADG (WL) was of the view that suitable employees Rajasthan Forest Department should be exposed to the practical training in Sam facility.

Decision taken: If required, other officials from the Forest Department would be sensitized at International Bustard centres. Further, it was also decided that two or three employees of RFD identified by CWLW should be attached to the Scientists of WII handling the egg hatching and rearing of hatchlings in the Sam breeding facility so that they get first hand experience of the process involved in artificial hatching of eggs and rearing of birds.

8. Formulation of guidelines for developmental projects (transmission lines/ road/solar projects etc. in GIB Arc) and conditions to be imposed on them:

Dr. S. Dutta informed that a meeting was held under the Chairmanship of Principal Secretary, Energy, Government of Rajasthan on 20.12.2018 at Jaipur, based on which a proposal

for power line mitigation in Jaisalmer was prepared and submitted by WII to Rajasthan Vidyut Prasaran Nigam Limited (RVPNL), Jaisalmer, Rajasthan. A copy of which was also shared by Rajasthan Forest Department to the MoEF&CC. The Chairperson informed that Ministry has taken the matter of deaths of GIB due to collision from transmission lines with the concerned Ministries. The matter of new transmission lines coming up in the GIB arc area was raised by CWLW Rajasthan. He said that without any legal sanctity of the GIB arc, it is difficult to stop the projects and requested the Ministry to come up with legal notification/order in this matter. He also informed that there are several agencies which are approaching the forest department for granting permissions/NOCs for implementing their projects falling within/ outside the GIB arc prepared by WII.

Decision taken: A case is pending in the NGT, Delhi on the deaths of GIBs due to collisions from high tension power lines wherein Ministry has filed a report prepared by WII on the same. The matter is sub-judice. A similar type of case has been filed in Hon'ble Supreme Court of India wherein a Committee has been constituted by the Apex court to look into the issue. The proposal of WII submitted to RVPNL would be considered in the Ministry for taking up matter with MNRE, GoI and RVPNL, Govt. of Rajasthan.

9. GIB *in-situ* Conservation Project submitted by Rajasthan Forest Department:

Shri A. Tomar, CWLW, Rajasthan informed that Rajasthan Forest Department has prepared an *In-situ* conservation Plan for GIB in Desert National Park for a period of 2019-20 to 2028-29 in consultation with WII. He highlighted the major components of the proposal and informed that the proposal has provision of voluntary incentivized translocation of villages from the GIB habitats.

Decision taken: The Committee 'in-principle' approved the Plan prepared by Rajasthan Forest Department and suggested that the same should be approved from the State Board for Wildlife for consideration of funding support from State plan and / or State CAMPA funds as per the decision taken in 6th meeting of National CAMPA Advisory Council where this project was approved. Ministry will also explore the possibilities of funding under CSS-DWH.

Project submitted by WCS:

This was discussed as part of the additional agenda of the meeting. Mrs. Prakriti Srivastava, Country Director, WCS-India highlighted the brief points of the project proposal. She informed that the proposal was formulated after the observations made by their team during the field visits with 'Birdlife International' to the GIB habitats at Jaisalmer. She also informed that the proposal includes the provision of relocation of villagers from the GIB habitats. She mentioned that, if the proposal of WCS is considered by the Committee, they could act as a bridge between the State Government and local people in translocation and community mobilization.

Dr. Rahmani highlighted that too much restriction on the local people/ translocation may adversely affect the population of GIB. This will be against the conservation of GIB. Shri Sunil Limaye mentioned that this type of incident happened in Nanaj bustard sanctuary, Maharashtra. He also mentioned that Bustards may share the habitats with human presence but the actual threat to their population is from the power lines.

Representatives from the RBS Foundations mentioned that if they are involved in the project, they could support the project in community outreach and mobilization.

Shri Tomar informed that the activities like village translocation, community outreach etc. are also the part of the In-situ conservation project submitted by Rajasthan Forest Department.

Decision taken: It was decided that Rajasthan Forest Department may consider the involvement/support of the NGOs such as WCS and RBS as part of the their *in-situ* conservation project.

10. Support of Indian Army in Jaisalmer (Pokhran Field Firing Range):

Dr. S. Dutta informed that some population of GIB is found in Pokhran Field Firing Range. It was informed that the population in firing range is undisturbed and efforts should be made to get support from the Army in conservation efforts for protection of GIB.

Decision taken: Ministry would seek support of Indian Army in the conservation and breeding programme of GIB at Ministerial level.

The meeting ended with a vote of thanks to the Chair.

List of Participants

Second meeting of the Steering Committee under the Great Indian Bustard & Lesser Floricorn Conservation and Breeding Programme

Date: 21st July, 2019

Venue: Jaisalmer, Rajasthan

S. No.	Participants	Designation
1	Shri M.S. Negi	ADG (WL), MoEF&CC and Chairman of the Steering Committee
2	Shri Sanjay Mohan	PCCF & CWLW, Government of Karnataka
3	Shri Arindam Tomar	APCCF & CWLW, Government of Rajasthan
4	Ms. V.L. Roui Kullai	DIG (WL), MoEF&CC and Member Secretary of the Committee
5	Shri Asari	DCF, Government of Gujarat
6	Shri Tushar	ACF, Government of Gujarat
7	Shri Asad Rahmani	Former Director, BNHS
10	Shri Sunil Limaye	APCCF, Government of Maharashtra
11	Shri Priya Ranjan	CCF, Jodhpur
12	Dr. Y.V. Jhala	Scientist 'G', WII
13	Dr. Sutirtha Dutta	Scientist 'D', WII
14	Shri Federic Lacey	IFHC
15	Shri Lesobre Loic	IFHC
16	Shri Bipin C.M.	WII
17	Dr. Shravan Singh Rathore	Veterinary Officer, Rajasthan Forest Department
18	Ms Tanya Gupta	WII
19	Shri Kapil Chandrawal	DFO, Jaisalmer
20	Mrs. Prakriti Srivastava	Country Head, WCF
	Shri Sagar Panwar	Deputy Conservator of Forest, DNP
21	Shri Bhanu Bansal	RBS
22	Shri Tushar	RBS
23	Shri Aditya Bisht	WII-MoEF&CC
24	Shri. Ravi	
25	Shri Vijay borana	

Preliminary Report on ground surveys for missing tagged Great Indian Bustard ID 5946

Great Indian Bustard Recovery Project, Wildlife Institute of India, Dehradun

Ref: Letter No. F(Misc./DCFWLJSM/2019-20/3047 dt. 6/8/19

Background: Two Female Great Indian Bustard were tagged with GSM based tags successfully on 31st March and 11th April 19 and their tag ID's are 5949 and 5946 respectively. They were programmed to transmit data once in every 24 hours at 7:30 am according to Indian Standard time. Tag ID 5949 (152240 Points) has transmitted data of 140 days till 18th Aug 19 and have recorded 152240 GPS locations till 18th August 19. Tag ID 5946 has transmitted data for 74 days till 24th June 19 and have recorded 88816 GPS locations, after which the tag has stopped transmitting data. Data transmission is completely dependent on mobile network connectivity, and since the tag was functioning normally prior to the last transmission, it is likely that the bird is no network zone as 21 % of the of the entire homerange of the bird does not have good mobile network i.e area in and around Chauhani TFC, Chauhani PPC and small part of Gajaimata enclosure. Among four different core areas of the homerange (very intensively used location) of the bird, one core falls in Chauhani area. Most of the times, when the bird was using that area, data was only transmitted after bird came back in network zone or data were downloaded using UHF base station.

Methods: Based on the movement data of 74 days and 88816 GPS points, the bird's home range was determined. Bird's home range is 140 sqkm which includes Sudasri , RKVY, PPC, Gajaimata enclosures and area around enclosures Khaba in north, farm lands of Barna Village in South (see figure 1).

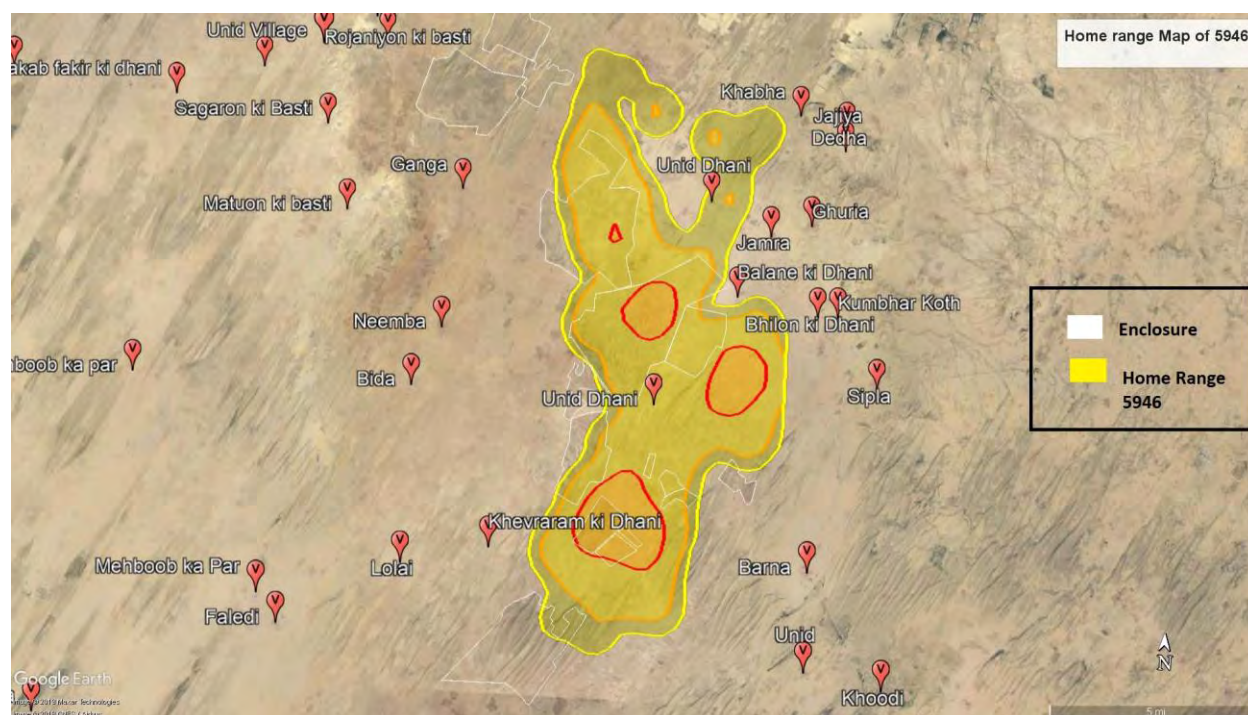


Figure 1 Home Range Map of tagged Great Indian Bustard ID 5946 in Desert National Park, 2019

Figure 1 indicates that bird was using some areas very intensively, such as Sudasri ACD enclosure, Small part in RKVY enclosure, Bhilon ka khet, PPC and around.

Initially these core areas were targeted to search the bird using VHF receiver and binoculars. Thereafter, the entire home range was divided into 4 sqkm grids that were sampled by three teams - one with VHF receiver and other teams monitoring and searching birds manually with the help of remote vantage observations and active search method. The VHF antenna can detect signals from up to 1.5 km under ideal conditions. Thus, the vehicle transect covered 3 kms belt transect to detect signals, but sometimes it's difficult to detect signal beyond 0.5 km (if bird is behind a hillock). All the elevated points were visited by the search team to detect the signals, as it has been tested that signal reception is improved at elevated points. Some known usage areas of GIB in general were also visited outside the home range of 5946. Areas between Chattrel and Salkha village are a known GIB habitat outside DNP that were scanned using VHF receiver. Multiple visits were made to same locations to intensify the search and decrease the chance of non-detection.

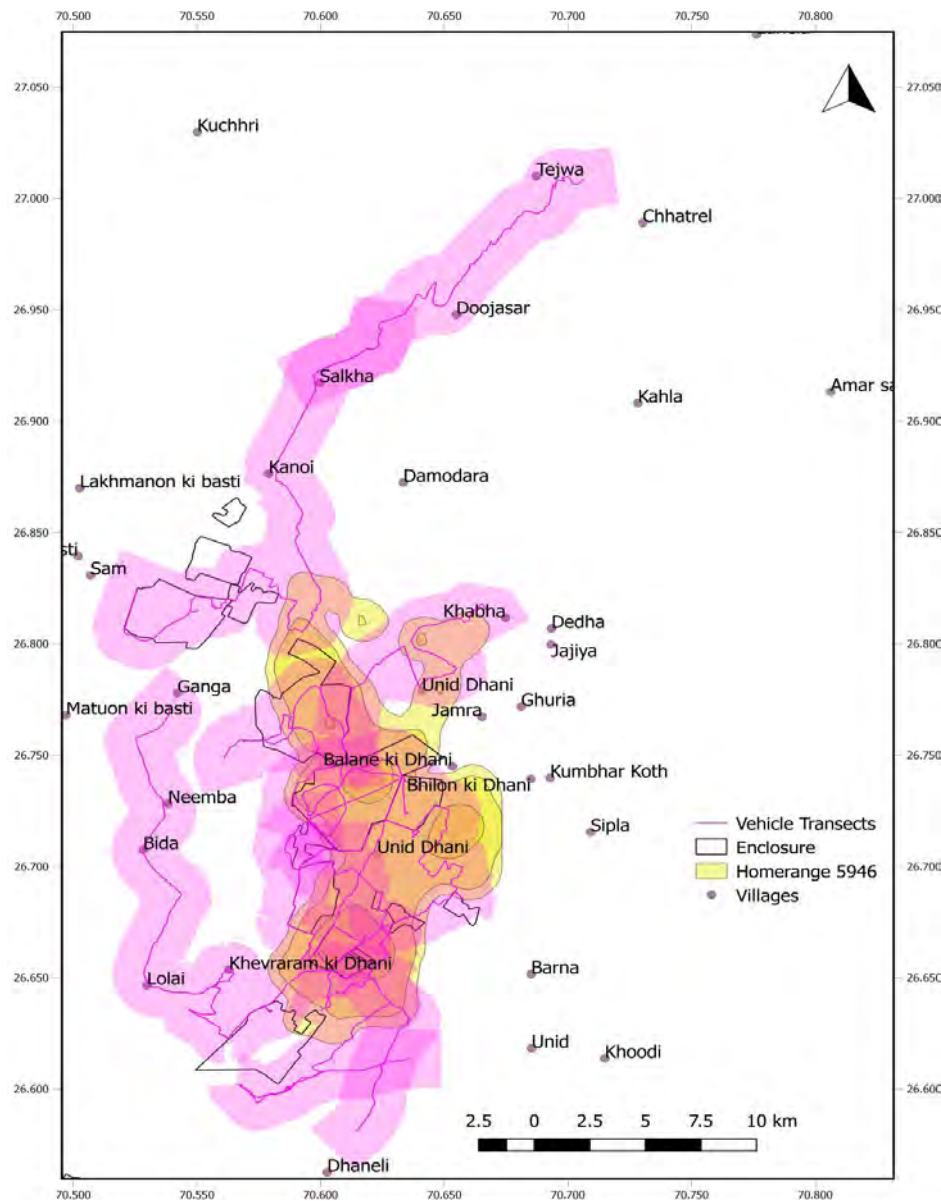


Figure 2 Map Showing vehicle transect made to search tagged Great Indian Bustard 5946 in Desert National Park, 2019.

The figure 2 displays the effort made in pink line with its buffer.

Along with such surveys, camera traps were also deployed in Sudasri ACD enclosure from 7th August to 21st August. 22 camera traps including five on Guzzlers were deployed to check for the missing tagged bird (see Figure 3).

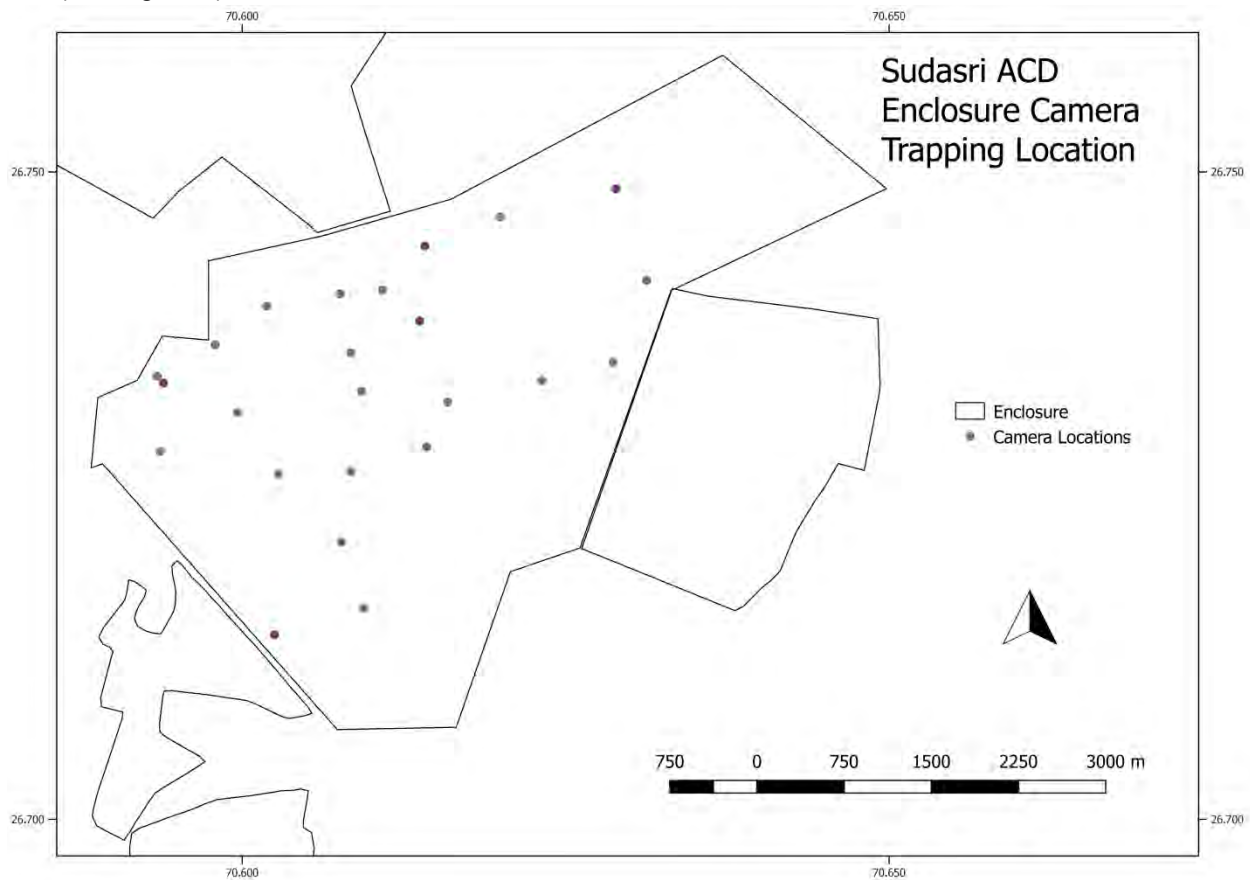


Figure 3 Camera trap locations in Sudasri ACD enclosure, one of the core usage area of the tagged Great Indian Bustard 5946 in Desert National Park, 2019

Outcome of the Survey: Bird has not been detected using visual, VHF search and camera trapping. Further search efforts are ongoing.

The reasons behind this incident can be one of the following:

- 1) Bird may be localized due to nesting and chick rearing in an area without cellular connectivity;
- 2) The transmitter has failed due to technical problems; or
- 3) The bird is dead in an area of no cellular connectivity.

Out of the above, possibility 1 is more likely since the bird is a breeding age female, the event has occurred in the nesting season, the tag was acting normal prior to the last transmission (no deterioration over time), and such non-transmission has been observed before albeit for much shorter periods. We can only wait and see if the bird comes into connectivity which can take about 2-3 months.

Further search efforts are ongoing, following similar methods.

Annexure: Daily field log of survey teams engaged in searching the missing tagged Great Indian Bustard in Desert National Park, 2019

Date	Team	KM	Route	Observation
26/07/2019	Bipim, Mayuri		Sam-Sudasri-Nadi-B chowki-A guzzler-Sam	1 male GIB near Sudasri Jhopa
26/07/2019	Anjali, Krishnan	38	Sam-Digga Maggra-RKVY Guzzler- Digga Magra- Sam	No sighting
26/07/2019	Mohib	45	Sam-Naga dariya-C2 Guzzler-bhagu magra-Thor-RKVY-Sam	No sighting
26/07/2019	Bipin, Krishnan	55	Sam-Digga Magra-RKVY-Bhagu Magra- Sam	3 female GIB near Bhagu magra
27/07/2019	Krishnan, Mayuri	38	Sam- Digga Magra- RKVY-Sam	No Sighting
27/07/2019	Bipin, Anjali	36	Sam-Bhagu Magra-A guzzler-Sam	3 female GIB Bhagu Magra, 1 female GIB A Guzzler, 1 male GIB near Naga Dariya
27/07/2019	Mohib	70	Sam-PPC Chauhani-B encl- C2 Guzzler- A chowki-Sam	4 males GIB in PPC
27/07/2019	Krishnan, Anjali	42	Sam-Bhagu Magra-Watch tower-Sam	1 male GIB near naga Dariya, 2 female GIB Bhagu Magra
27/07/2019	Bipin	55	Sam-Naga Dariya- C chowki - Sam	1 male in A encl
27/07/2019	Mohib, Vishal	65	Sam- Naga Dariya- ACD guzzlers-Sam	No sighting
28/07/2019	Anjali, Mayuri		Naga Dariya- C chowki-A guzzler-Naga Dariya-RKVY-Digga Magra- Sam	No Sighting
28/07/2019	Mohib	50	Sam- RKVY- ACD-Sam	No sighting
28/07/2019	Krishnan, Anjali	45	Sam-Digga Magra-RKVYguzzler-Sam	No sighting
28/07/2019	Mohib	40	Sam-Sudasri-Sam	No sighting
28/07/2019	Bipin		Sam-Bhagu Magra- C corner-Sam	2 female GIB near Bhagu Magra
29/07/2019	Mohib, Tarun	82	Sam-Gajaimata-Lolai-Chauhani-PPC-Dharamthali-Bheelon ka khet- ACD-Sam	2 Male GIB and 2 female GIB in ppc, 1 male near C2 Guzzler
29/07/2019	Bipin, Mayuri		Sam-PPC-Gajaimata-Sam	No sighting
29/07/2019	Anjali, Krishnan	55	Sam, B chowki, A guzzler, Naga Dariya	1 male and 1 female GIB
29/07/2019	Krishnan, Anjali	66	Sam-PPC-Sudasri-Sam	No Sighting
29/07/2019	Mohib, Tarun, Dev	70	Sam-PPC-Sudasri-Sam	1 maler GIB in PPC
30/07/2019	Mohib	80	Sam- Kanoi Powerline- 20 KM till Dedha- Khaba- Sam	No sighting
30/07/2019	Anjali, krishnan	53	Sam- Kalimali-RKVY-Khaba-Sam	No sighting
30/07/2019	Krishnan	80	Sam-ACD- B Encl- Chelasar-PPC	No sighting

30/07/2019	Dev, Tarun	70	RKVY-ACD-Dharamthali-Bheelon ka Khet-Siplaencl-Sam	2 male and 1 female(5949) GIB on Gada Magra, 1 male GIB Bhagu magra
31/07/2019	Anjali		Sam- ACD-RKVY-Sam	1 male GIB, 5 male GIB RKVY
31/07/2019	Dev, Tarun, varun	82	Gajaimata-PPC-TFC-near dhaneli-Sam	1 female GIB Gajaimata
31/07/2019	Dev, Tarun, varun	50	RKVY-ACD-Dharamthali-Sam	1 Female(5949) on Gada Magra
01/08/2019	Anjali		Sam-Bhagu Magra-Sam	5 female GIB Bhagu magra
01/08/2019	Mohib	47	Sam-RKVY-Sam	No sighting
01/08/2019	Mohib	44	Sam-ACD-Sam	2 female GIB Bhagu magra
01/08/2019	Dev, Tarun, Varun	82	Chelasar-PPC-TFC-Lolao-Khevraram ki Dhani- Bhura Khan Ki Dhani- Sam	No sighting
01/08/2019	Dev, Tarun	40	Kalimali-Sam	No sighting
02/08/2019	Dev, Tarun	42	Bhagu Magra- Naga dariya-Sam	No sighting
03/08/2019	Mohib	48	Sam-RKVY-ACD-Sam	1 female GIB RKVY guzzler
03/08/2019	Mohib	59	Sam-ACD-RKVY	1 male GIB ACD, 3 Male GIB RKVY guzzler
03/08/2019	Dev, Tarun	30	Ganga Encl, Kanoi 1 st – Kalimali-Sam	No sighting
03/08/2019	Dev, Tarun	120	Chattrel- Doojasar-Salkha-Kanoi-Sam	No sighting
04/08/2019	Dev, Tarun	75	Lolai-TFC- Near Dhaneli- Near Chauhani-Sam	No sighting

List of participants in National lesser florican status survey 2018

Wildlife Institute of India (WII)					
No.	Name	Designation	No.	Name	Designation
1	Suthirtha Dutta	Scientist D	34	Nirav Jain	Volunteer
2	Sujit Narwade	Project Scientist	35	Jay Gajela	Volunteer
3	Bipin C.M.	Project Associate	36	Harshit Rupapra	Volunteer
4	Vineet Singh	Project Associate	37	Harish Kumar	Volunteer
5	Mohib Uddin	Project Assistant	38	Kalyani Sharma	Volunteer
6	Devendra Pandey	Project Assistant	39	Aakansha Verma	Volunteer
7	Tanya Gupta	Project Assistant	40	Mansi Jadon	Volunteer
8	Sourav Supakar	Project Assistant	41	Vikram Singh	Volunteer
9	Tarun Singh	Field Assistant	42	Parul Sen	Volunteer
10	Arnab Chatterjee	Project Intern	43	Sukanya Bhuyan	Volunteer
11	Hrishika Sharma	Project Intern	44	Anindita Roy	Volunteer
12	Anjali Nagar	Project Intern	45	Megha Sharma	Volunteer
13	Tasso Rimung	Project Intern	46	Shantanu Sharma	Volunteer
14	Hemlata Joshi	Project Intern	47	Mahesh Gujjar	Volunteer
15	Arif Siddiqui	Project Intern	48	Deval Kadam	Volunteer
16	Partha Sarathi Mondal	Project Intern	49	Ankita Bhatt	Volunteer
17	Rishikesh Tripathi	Project Intern	50	Kamran Hussain	Volunteer
18	Malvika Colvin	Project Intern	51	Devendra Mistry	Volunteer
19	Sweta Iyer	Project Intern	52	Vijay Patel	Volunteer
20	A. Krishnan	Project Intern	53	Akshay Chauhan	Volunteer
21	Chiging Pilia	Project Intern	54	Anuj Raina	Volunteer
22	Pratima Kumari	Volunteer	55	Salim Mandhera	Volunteer
23	Rizwan Ali Khan	Volunteer	56	Paradi Shyamji Kalyanji	Volunteer
24	Dev Jyoti Gupta	Volunteer	57	Siddik Kasam Hussain	Volunteer
25	Avinash Yadav	Volunteer	58	Prasad Bolde	Volunteer
26	Gaurav Singh	Volunteer	59	Tanmay Gokhale	Volunteer
27	Garima Singh	Volunteer	60	Vedang Saikhedkar	Volunteer
28	Vikram Kumar	Volunteer	61	Praneti Khardekar	Volunteer
29	Ravi Patel	Volunteer	62	Jason Coutinho	Volunteer
30	Rajesh Kathad	Volunteer	63	Akshay Waghmare	Volunteer
31	Vanya Joshi	Volunteer	64	Sourav Mehra	Volunteer
32	Malyasri Bhattacharya	Volunteer	65	Chenaram Jat	Volunteer
33	Shantanu Ekbote	Volunteer	66	Avni Kulshreshtha	Volunteer

Bombay Natural History Society (BNHS)		
No.	Name	Designation
67	Nandkishore S. Dudhe	Programme Officer
68	Ajinkya Waskar	Coordinator
69	Jagdish Dharane	Coordinator
70	Aradhya Sardesai	Volunteer
71	Aniruddha Bade	Volunteer
72	Abhyudaya Kelkar	Volunteer
73	Neeraj Bagwan	Volunteer
74	Sunil Patel	Volunteer
75	Neelkanth Bora	Volunteer
76	Shilpa Gadgil	Volunteer
77	Ravi Dhongle	Volunteer
78	Samish Dhongle	Volunteer
79	Siddharth Khopkar	Volunteer

The Corbett Foundation (TCF)		
No.	Name	Designation
80	Kedar Gore	Director
81	Devesh Gadhvi	Deputy Director
82	Dushyantsinh Jhala	Manager
83	Sharad Kumar	Deputy Director
84	Bertrand Horne	Researcher
85	Zeenal Vajrinkar	Researcher
86	Priya Warekar	Researcher

Hyderabad Tiger Conservation Society (HyTiCoS)		
No.	Name	Designation
87	Madhuri Mondal	Research Associate
88	Sridhar Dupadu	Research Associate
89	Nandini Singh	Intern
90	Santosh Edupuganti	Conservation Consultant
91	Vinay Kumar Medda	Field Assistant
92	Chandu Bandi	Field Assistant

Rajasthan State Forest Department		
No.	Name	Designation
93	Sarjor Singh Gujjar	Forest Guard
94	Rajendra Singh Rathore	Forest Guard
95	Vimla Kumari	Forest Guard
96	Abdul Gani	Forest Guard
97	Ram Babu Sharma	Forest Guard
98	Paras Sen	Forest Guard
99	Durga Shankar Parik	Forest Guard
100	Ramshobh Kamar	Forest Guard
101	Basrilal Khati	Forest Guard
102	Satyanarayan Devilal Bhat	Forest Guard
103	Rekha	Forest Staff
104	Ramchandra	Forest Staff
105	Anandilal	Forest Staff
106	Rakesh	Forest Staff
107	Vishal	Forest Staff

Madhya Pradesh State Forest Department		
No.	Name	Designation
108	Rakesh Dinder	Forest Guard
109	Pappu Devada	Forest Guard
110	Kimaji	Forest Guard
111	Umesh Moyal	Forest Guard
112	Wasuniya	Forest Guard
113	Dilip Jat	Forest Guard
114	Anil Verma	Forest Guard
115	Nandakishore Karmaria	Forest Guard
116	Lakhand Singh	Forest Guard
117	Phulji	Forest Guard
118	Kamal	Beat Guard
119	Raju	Beat Guard
120	Mangilal	Volunteer

Maharashtra State Forest Department		
No.	Name	Designation
121	P. B. Bhagwat	Forest Guard
122	R. V. Rathod	Forest Guard
123	D. M. Giri	Forest Guard
124	P. N. Lahamge	Forest Guard
125	Jayant Lokhande	Forest Guard
126	Rakesh Lokhande	Forest Guard
127	Bharti Pandharam	Forest Guard
128	Vishakha Sanap	Forest Guard
129	Nandkishore More	Forest Guard
130	S. N. Jitkar	Forest Guard
131	A. S. Lembhale	Forest Guard
132	S. L. Shinde	Forest Guard
133	V. R. Shinde	Forest Guard
134	D. R. Pinjarkar	Forest Guard
135	V. V. Hagle	Forest Guard
136	D. V. Bawanthole	Forest Guard
137	G. C. Jamukar	Forest Guard
138	Phartade	Forest Guard

Gujarat State Forest Department		
No.	Name	Designation
139	Saddik	Forest Staff
140	Sadam	Forest Staff
141	M. Balgariya	Forest Staff
142	Pratap	Forest Staff
143	Ranjeet	Forest Staff

LESSER FLORICAN



SURVEY HANDBOOK 2018



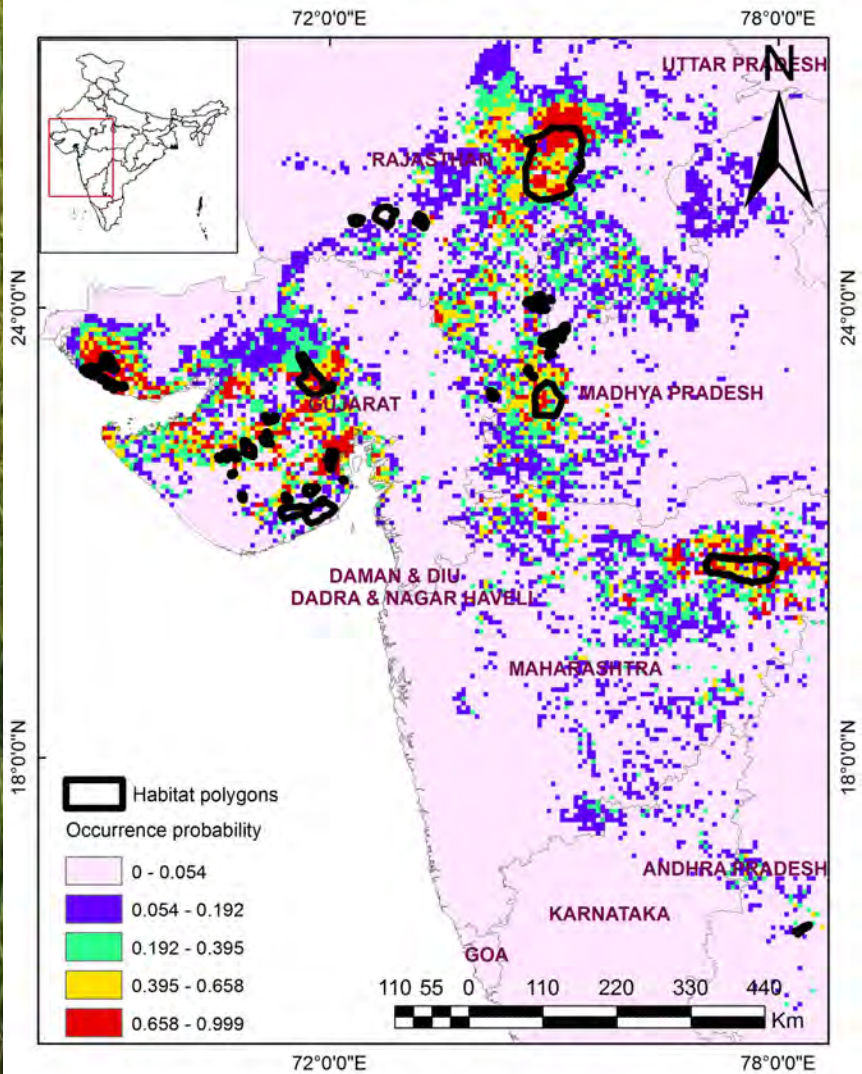
Contents

- About the species
- Distribution map
- 2017 Survey summary
- Why this survey?
- What are the threats to floricans?
- Bustard recovery plan and best conservation practices
- Associate species
- Graphical representation of occupancy and density sampling
- Essential field tips

1. ABOUT THE SPECIES

Lesser florican (*Sypheotides indicus*) is the smallest bird of bustard family (*Otididae*). It is one of the three resident bustard species of India, all of which are threatened (IUCN), and is endemic to this country. Though lesser florican has been given the highest degree of protection under Schedule-I of the Wildlife (Protection) Act 1972, its numbers have declined, necessitating its declaration as an endangered species in the IUCN Red list.

2. DISTRIBUTION MAP



3. WHAT ARE THE THREATS TO FLORICANS?

Major problems are habitat loss and alteration, paucity of ecological information and lack of proper policy and governance of grasslands. The other threats include:

- **Poaching, trapping and egg collection**
- **Pesticides** – rampant use of pesticides is affecting the food chain of floricans
- **Inappropriate conservation incentive schemes brought out by Forest Department**
- **Land use changes** – because of intensification of agriculture, change in crop pattern, encroachment of grasslands, inappropriate grassland management and rapid development, floricans are losing their habitat
- **Overgrazing** – there are chances of trampling of eggs because of over grazing in florican areas
- **Mining** - especially the open cast mines are one of the main causes for loss of habitat for this species
- **Inadequate knowledge of current distribution, population status, demography, movement-dispersal and habitat use**
- **Inadequate research on association of Lesser Florican with grass species/vegetation**

- **Power projects** - in order to use the wind power to generate electricity through erection of Wind Mills,, the heavy electric line connected with tall towers as part of power transmission has also taken over some parts of the grasslands. These have resulted in loss of habitat as well as death of the birds during flight due to electrocution or collision.
- **Afforestation** - Plantation not only occupies the space in the grasslands, but also fragments the grassland landscape. It also forms as a visual intrusion for the bustards, in addition to loss of prime habitats, which is very crucial for breeding.
- **Less research-attention** - Presently the research on the LF ecology and behavior are restricted to only one or two sites or areas and are conducted by Bombay Natural History Society and Wildlife Institute of India. Such research is of high priority and needs to be carried out in other parts of the distribution range of this species. Presently there is little attention towards filling this gap. This information is necessary for better conservation and long-term survival of this species throughout its range.
- **Disturbance from unethical photography** – because of revolution in digital photography and social media many people are found engaged in unethical photography

4. BUSTARD RECOVERY PLAN AND BEST CONSERVATION PRACTICES

Lesser Florican has been included as a priority species in the Species Recovery plan by the Ministry of Environment, Forest and Climate Change, Government of India (Dutta et al. 2013). 'Guidelines for State Action Plan for Resident Bustards' Recovery Programme' comprise a review of the species' biology, threats, and conservation recommendations. The document has been prepared after consultative workshops involving wildlife scientists, forest department officials and non-governmental organizations from nine bustard range States. Since bustards are landscape dependent species, they cannot be conserved solely by a Protected Area approach as they also inhabit agro-pastoral systems. The Guidelines provide direction to a holistic management approach wherein an optimal balance needs to be struck with traditional livelihoods and modern development using smart green infrastructure, and Protected Areas through policy, legislation, local management, awareness, and research. If earnestly implemented, these Guidelines will help save bustard and grassland resources of India for posterity.

5. ASSOCIATE SPECIES



Great Indian Bustard
Ardeotis nigriceps



Chinkara
Gazella bennettii



Blackbuck
Antelope cervicapra,



Nilgai
Boselaphus tragocamelus

5. ASSOCIATE SPECIES



Golden Jackal
Canis aureus



Fan-throated Lizard
Sitana ponticeriana



Indian Fox
Vulpes bengalensis

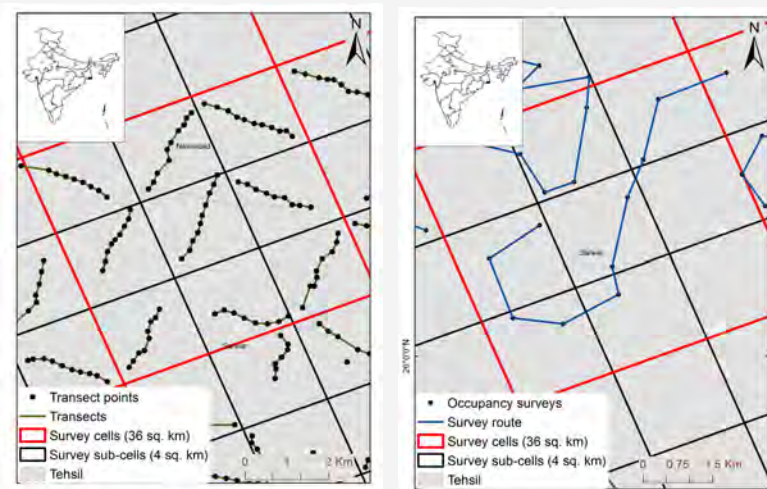
6. NEED FOR SURVEY ?

Endangered species conservation entails regular and objective assessment of their distribution, abundance, and current threats to identify priority habitats, develop conservation strategies, and routinely assess management effectiveness. However, the last population assessment of the lesser florican was conducted in 2006 by late Ravi Sankaran, following which a distribution survey was carried out by the Wildlife Institute of India in 2010 (Bhardwaj *et al.* 2011).

7. 2017 SURVEY SUMMARY

The status survey was conducted during the breeding season (July–September, 2017) with a team of 121 observers, who were trained on the standard data collection protocol through state-level workshops at Bhavnagar, Ujjain, Ajmer and Akola. Lesser florican occupancy was assessed at 428 sites (36 sq km) spread across ~20,000 sq km range, using 5564 stop-overs, and density was assessed in 32 sites (where the species was detected) using 479 km transect-walks that yielded 70 sightings (64 males, 6 females). With a conservative estimate of 264 individuals that indicates ~80% population decline in last 3–4 generations (since 2000). Regional assessments indicated that the population was largely restricted to: Velavadar (Bhavnagar, Gujarat) having 96–115 territorial males and Shokaliya-Bhinai (Ajmer, Rajasthan) having 110–136 territorial males.

8. GRAPHICAL REPRESENTATION OF OCCUPANCY AND DENSITY SAMPLING



10

Note: A sample lesser florican site in Ajmer landscape, overlaid with 2x2 km² grid-cells, showing vehicle routes for occupancy surveys, and line transect routes for distance sampling. For line transects, two alternate designs can be followed – one with 9 km walk across 4 cells (preferable since we will sample larger area in short time but relatively difficult and can induce observer fatigue) or 4.5 km walk across 1 cell (relatively easier, more intensive, more time consuming). These designs ensure logistic convenience (since observers will end their survey close to the start point, making drop/pick-up easy) and full utilization of sampling hours (since 1 km transect walk requires 20-30 mins, a 9 km walk can be completed in ~4 hours)

9. ESSENTIAL FIELD TIPS

1. Ensure about saving of the trail/transect data after every field visit
2. In case of non-accessibility to trail/transect surveyors can slightly take diversion but try to be on trail/transect as possible
3. If surveyor should try to cover trail between 5.30 am to 11.00 am as well as 4.00 to 6.30 pm when florican is active. He/she should stop at particular point after above mentioned time and cover remaining part later on
4. Surveyors need to undergo orientation/sensitization/training programme before starting actual field surveys
5. In case of any data collection discrepancies, team leader should be informed well in advance
6. Proper care should be taken for field equipment being used during the survey
7. Get feedback and opinions from local subject experts before starting the surveys
8. Avoid surveys in heavy rainfall and very strong winds, as bird may not get detected
9. Teams should have at least one experienced field researcher/birdwatcher with one or two inexperienced volunteers
10. Special attention should be given on expansion of new renewable energy projects such as solar and windmills as its associate infrastructure like power lines.

- 
- A person is visible in the background, standing in a field of tall grass and trees, looking towards the left. The background is slightly blurred, emphasizing the text in the foreground.
11. All survey personnel should be equipped with field gears like raincoats, gumboots, umbrella, waterproof bags, etc.
 12. Surveyors should keep watch on weather conditions (some of the surveyors experienced flood in some of the areas in year 2017)
 13. In field, do talk with farmers but avoid talking with children and women
 14. In case of confusion ask villagers about type of crop or name of place
 15. Avoid unnecessary adventures in field which may lead to physical injuries
 16. Do not talk anything against government or forest department, especially related to human-animal conflict
 17. Carry a letter of survey in Hindi and English and your Identity card at all times
 18. Check your survey trails/ grids/ access routes well in advance before heading out
 19. Carry extra cells for your equipment and adequately charged power bank
 20. Ensure that you carry water, some food if necessary, and your survey vehicle has enough fuel
 21. Strictly avoid unnecessary conversation during the survey, you need all your senses alert to navigate and detect the bird
 22. Remember, true data collection is the primary reason you are here and is of utmost importance for conservation of the species

**Patterns of bird community structure in relation to
land-use driven habitat changes in the arid grasslands
of Thar Desert.**

Dissertation submitted to the
Saurashtra University Rajkot, Gujarat
in partial fulfillment of
Master's Degree in Wildlife Science

By
Varun Kher

Under the Supervision of

Dr. Sutirtha Dutta

Dr. Navendu Page

Dr. Malvika Onial



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

June 2019

CERTIFICATE

This is to certify that **Mr. Varun Kher** has carried out an original piece of research in partial fulfilment of Master's Degree in Wildlife Science of the Saurashtra University, Rajkot, Gujarat. The topic of her dissertation is **"Patterns of bird community structure in relation to land-use driven habitat changes in the arid grasslands of Thar Desert"**. The study was carried out under our supervision from December 2018 to June 2019. We hereby certify that this work has not been submitted for any degree to any university

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Date: 30th June 2019

Place: Dehradun

DECLARATION

I, **Varun Kher**, hereby declare that the research work entitled “**Patterns of bird community structure in relation to land-use driven habitat changes in the arid grasslands of Thar Desert**”, carried out in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University, Rajkot is an original piece of research. This research work was carried out under the supervision of **Dr. Sutirtha Dutta** and co-supervision of **Dr. Navendu Page** and **Dr. Malvika Onial**, at the Wildlife Institute of India from December 2018 to June 2019. I hereby declare that this work has not been submitted for any other degree of any university.

Date: June 30, 2019
Place: Dehra Dun

Mr. Varun Kher
(XVI M.Sc. Course)

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This six-month journey was only possible because of all the good folks who shared their knowledge to build my thoughts and kept my back at critical moments. I thank them all.

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Executive Summary

1. The Indian Thar desert has seen a massive loss of grassland habitat in the last few decades. The main driver of this habitat loss has been the large-scale change in land-use from pastoralism to agriculture, leading to expansion of cultivated land over grasslands. This expansion, further compounded by a simultaneous rise in livestock population has drastically increased grazing pressure on the remaining rangelands. To complicate things further, irrigation schemes (notably the Indira Gandhi Canal) have led to intensification of agriculture in many areas. Protected area network in this landscape is minimal and ineffective, making the multiple-use agro-pastoral landscapes very important for conservation of wildlife. The largest protected area in the landscape – the “DNP WLS” – is also a multiple-use landscape and home to more than 50k people whose livelihood is tied to the federal mandate of conservation in the sanctuary. Understanding the impact of land use change on native biodiversity is thus very important for conservation of biodiversity in this critical habitat. In this context, my study tries to find effects of land-use change on community structure of birds in the arid grassland of Jaisalmer district in the Thar Desert.
2. Understanding ecology or distribution and abundance of species is incomplete without holistically understanding the patterns and processes occurring at the community level. To this end, I explored the patterns of bird community structure in the Thar Desert and tried to understand how these properties change with land-use driven habitat change, by comparing fundamental properties of biological communities like species richness, abundance and composition. Additionally, I tried to find out potential habitat correlates of these properties, so as to shed some light on the processes that might be driving community assembly in response to land-use change.
3. Bird community structure: My results indicate that local-scale species richness, abundance and composition did not differ significantly between protected grasslands, rangelands and rain-fed croplands, during either of the seasons. However, intensive irrigated croplands had a notably different community

structure with higher species richness and abundance, during both winter and summer. The change in community structure of irrigated croplands was influenced by the change in native species along with ingression of newly colonised species. Most of the newly colonised species were restricted to areas with intensive agriculture where their survival was potentially facilitated by the new microhabitats created by irrigation and associated changes (Rahmani & Soni, 1997).

4. Regional species pool: Intensive agriculture increased the overall species of birds in the region by sustaining newly colonised bird species; while the number of native species in this pool was only marginally lower than protected grasslands and comparable to all the other land-uses in both the seasons. Considering both the seasons together, protected grasslands had the highest naïve and estimated number of native species while the naïve and estimated number of native species in other three land-uses – Rangelands, rainfed croplands and irrigated croplands – was only marginally lower. This signifies that most species found in the region can use the entire gradient of land-use types at their current levels of intensification. Although this result by itself does not indicate that, all land-use types can sustain all the native species.
5. Seasonality of patterns: In winter, protected grasslands, rangelands and rainfed croplands had similar bird communities, which together were significantly different from the communities in irrigated croplands. The same pattern repeated in summer, but the magnitude of difference between bird communities in intensive agriculture and other land-uses was much lower. This pattern was correlated to the pattern shown by vegetation structure of intensive agriculture, which also became more similar to other land-uses after harvesting of crops in the summer. This potentially suggests that bird communities are influenced by vegetation structure and areas with similar vegetation structure would have similar bird communities.
6. Habitat correlates of species richness and bird community composition: In both the seasons, species richness was positively associated with the foliar volume of woody vegetation and negatively associated with forb volume (which in turn was negatively correlated with grass volume). During winter, species richness

was positively related to crop volume and during summer, with compositional diversity of vegetation. Community composition like richness was influenced significantly by woody plant foliar biomass in both the seasons. Crop volume also had a significant influence on bird communities during both winter and summer, whereas grass volume was significantly influential only in winters.

7. Conservation implications: This study corroborates many others in indicating that low-impact land-uses are important secondary habitats for conservation of grassland species (Dutta & Jhala, 2014; Wright, Lake, & Dolman, 2012). The inferences further support the commonly advocated approach of conserving grasslands at a landscape scale by strategically placing them as mosaics of low-impact agro pastoral land-use with small protected areas embedded within them (Dutta & Jhala, 2014; Dutta, Rahmani, & Jhala, 2011; Singh et al., 2006).

1. Introduction

1.1 Community ecology as a conceptual framework to assess effects of land use change on biodiversity

Understanding the effects of anthropogenic land use on the distribution and abundance of species at different scales of organisation is an important aspect of modern ecological research (Gaston, Blackburn, & Klein Goldewijk, 2003; Laurance, Sayer, & Cassman, 2014; Newbold et al., 2015). Achieving this understanding by studying species individually is an arduous undertaking, which is further complicated by the fact that species do not live in isolation, and are influenced both by their abiotic environment and by biotic interactions (Krebs, 1972; Vellend, 2010). Thus, understanding patterns, processes and mechanisms at the scale of “biological communities” is ubiquitous to holistically understand the impacts of anthropogenic activities on biodiversity (Green, Cornell, Scharlemann, & Balmford, 2005; Lima, Dallimer, Atkinson, & Barlow, 2013; McGill, Dornelas, Gotelli, & Magurran, 2015). The body of science dealing with this subject - community ecology - aims to gain integrative understanding of how biotic and abiotic factors mould local species pools at different spatiotemporal scales (Vellend, 2010). This involves scientific enquiry on two fronts viz. a) Descriptive – involving exploration and analysis of patterns and b) Functional – dealing with the deterministic and stochastic processes that lead to a particular pattern.

The field of community ecology has often been termed a “mess” due to its overwhelming complexity and fine-scale contingency of patterns (Lawton, 2007). Moreover, the functional component of community ecology has lacked a generalised universal theory to explain how community assembly takes place (Lawton, 2007; Vellend, 2010). However, with recent progress in empirical and experimental investigations, advancements in theoretical underpinnings and modern statistical methods, community ecologists have converged on a synthesis that acknowledges the role of both deterministic and stochastic processes in driving community assembly (Vellend, 2010). These processes include deterministic processes of speciation, dispersal and selection, which occur due to abiotic environmental filtering and biotic

interactions; along with stochastic processes like ecological drift and neutrality. All these forces working at different scales, interact at different hierarchical levels to give rise to individual local communities.

As proposed by Zobel (1997) and explained by Ovaskainen (2017), “the assembly processes can be envisaged as ‘filters’ operating at different scales. In this scheme, the ‘global species pool consists of all existing species, the ‘regional pool’ of all species able to colonise a given area, and the ‘local species pool’ of the set of species found at the finest scale considered (Cornell & Harrison 2014). Clearly, the species pools found at finer scales are filtered also by assembly processes acting at broader scales (Cornell & Lawton 1992). Of these hierarchical sieves, ‘environmental filters’ correspond to those abiotic factors which prevent the establishment or persistence of species in local communities (Kraft et al. 2015) and thus outline the fundamental niche of a species. ‘Biotic filters’ refer to interspecific and intraspecific competitive and facilitative interactions that determine the set of species in local communities (Wisz et al. 2013; Garnier et al. 2016) and thus determine their realised niches. These two types of forces may interact, as environmental filters may modify biotic interactions (e.g. Callaway & Walker 1997). Beyond the deterministic processes selecting species from regional to local scales, stochastic processes create additional variation in the local communities. These processes – related to colonisation, extinction, ecological drift and environmental stochasticity – generate divergence among communities occupying identical environments (Chase & Myers 2011). The responses of the species to abiotic and biotic filters vary depending on species-specific characteristics known as the response traits, including e.g. their dispersal propensity and competitive abilities (Lavorel & Garnier 2002) (Figure 1). Thus, they will determine what species reach and colonise given areas, and what species succeed in securing adequate resources (McGill et al. 2006; Bolnick et al. 2011).” This elaborate process of community assembly finally results in discrete groups of organisms that we call biological communities - defined as ‘a group of organisms representing multiple species living in a specified place and time’ and characterised by the number, identity, traits and abundances of species.

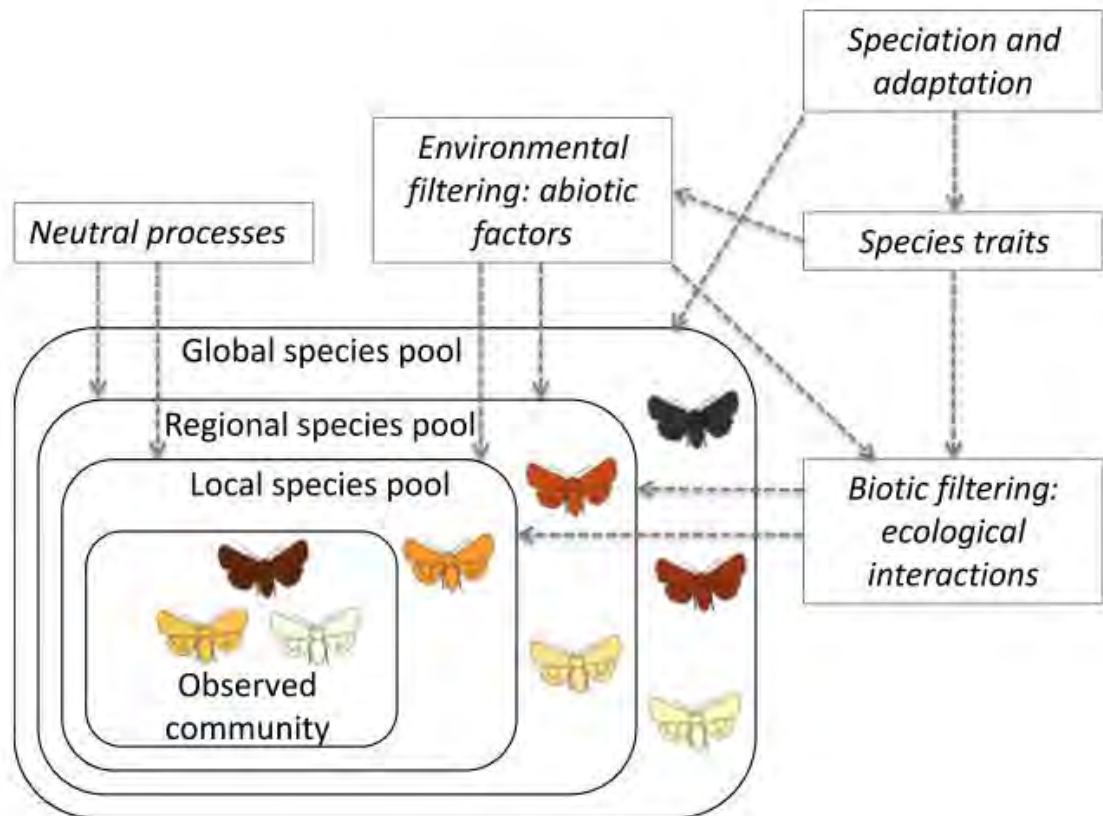


Figure 1: Conceptual synthesis of community ecology as published in Ovaskainen, Roy, Fox, & Anderson (2016)

The primary (biotic) filter driving the process of community assembly in animals is the local-scale habitat. The habitat can be visualised as an n-dimensional niche space with every axis being a particular resource. This niche space is then divided into realised niches of many animal species and individuals, in proportions decided by various deterministic (eg. Competition) and stochastic (eg. Ecological drift) processes, which are further influenced by response traits of the potentially interacting organisms. Thus, any change in the niche space or habitat results in a change in the process of community assembly and changes various parameters of the community. Different land-use types alter the primary habitat in different ways, thus changing the niche space in a contingent manner. Considering this, the realised magnitude of impact caused by a land-use change on functioning of a particular ecosystem can be measured by assessing the effects of it on various biological communities.

Bird communities are perfectly suited for assessing the magnitude of impact caused by different types and intensities of land-use as they are sensitive to subtle

changes in habitat and show a perceivable difference with change in habitat components (Newbold et al., 2015). Additionally, bird communities contain numerous species having unique ecological traits and exhibit diverse response traits when exposed to a particular change (Newbold et al., 2012). Bird communities are hence one of the best-studied groups among all animal communities and have been commonly used as a model groups to understand impacts of land use change on biodiversity (Gaston et al., 2003; Green et al., 2005; López-Ricaurte, Edwards, Romero-Rodríguez, & Gilroy, 2017; Phalan, Onial, Balmford, & Green, 2011).

1.2 Two land-uses that changed the world

Domestication of plants and animals for producing food marks a remarkable step in human history, as it gave man the ability to engineer natural ecosystems (Ellis & Ramankutty, 2008). Today, anthropomorphically engineered ecosystems cover more than 50% of the terrestrial surface and are constantly expanding (Ellis, 2011; Ellis & Ramankutty, 2008). A vast majority of these human-dominated systems are under croplands and rangelands, with a smaller portion coming from pastures, settlements and miscellaneous land-uses (Ellis, 2011; Jeuken, van den Berg, Alkemade, de Leeuw, & Reid, 2012; Laurance, 2007). With the expected populations rise, the expansion and intensification of production land-uses for food production are considered inevitable (Laurance et al., 2014; Tilman, Cassman, Matson, Naylor, & Polasky, 2002). The expansion is expected to be the highest in developing countries, which are expected to hold half of the globe's population by 2050 (Laurance et al., 2014). Further, developing countries of the tropics hold a disproportional 78% of the world's biodiversity, while feeding more than half of the world's hungry population (Barlow et al., 2018; Laurance et al., 2014).

Contemporary food security concerns have led to rapid conversion of primary habitats into agriculture over the last few decades. Grasslands and savannahs which cover around 20% of the world's terrestrial surface have been the frontiers of this crisis due to their fertility and relative ease of clearing. Conversion to croplands changes the habitat drastically, first due to frontier clearing and then by changing the microhabitat through various means (DeFries et al., 2005). Further intensification of croplands causes more frontier clearing and large-scale homogenization of habitat.

Farming practices associated with agricultural intensification such as pesticide usage deplete food for birds, thereby degrading the habitat quality. Similar to croplands, livestock grazing also has a massive footprint on natural habitats and affects more than 25% of the globe. Unnatural levels of grazing degrade the habitat by causing changes in productivity, biomass, stand structure and community composition.

In India, grasslands and savannahs have been the largest recipients of land-use change since the green revolution of the 1970s and their extent has drastically reduced since then (Tian, Banger, Bo, & Dadhwal, 2014). Most grasslands have been converted to croplands during this time and an ever-increasing number of domestic cattle now heavily grazes the remaining few (Singh et al., 2006). Semi-arid and arid grasslands now remain only in certain pockets of India, with the largest expanse being in the arid zone of Thar Desert and Kutch (Rawat, Adhikari, & (Eds.), 2015). Agriculture expansion and intensification, compounded by grazing intensification are progressively threatening these grasslands as well (Dutta et al., 2017; Singh et al., 2006). However, quantification of the impact of such agricultural expansion and intensification on bird communities is scanty in India.

1.3 Reconciling wildlife conservation with human livelihoods

Biodiversity conservation and food production are generally considered contradictory mandates. Efficient food production through intensive agriculture is often very detrimental to wildlife whereas low-intensity and wildlife-friendly agriculture don't always produce enough food (DeFries et al., 2005). From the wildlife perspective, protected areas hold significantly more wildlife but are inadequate in their expanse whereas the more expansive human-dominated areas are mostly not suitable for a bulk of wildlife. These mutual contradictions often invoke the academic debate on how to sustainably reconcile biodiversity conservation with adequate food production (Fischer et al., 2008; Green et al., 2005).

In India, 86% of farmers are marginal land-owners with less than 2ha of land and more than 60% live on rain-fed farming. This extensive form of agriculture produces bulk of India's food and also sustains a large number of domestic livestock. In the drier regions, livestock forms the backbone of the rural economy and pastoralism on rangelands and community-owned grasslands is a major livelihood. This human-

dominated rural countryside is also the interface where wildlife and humans often co-occur. On the other hand, protected areas cover only 4% of India's terrestrial area and are considered the considered sentinels of wildlife conservation. Most of them are less than 100 sq.km and inadequate to conserve biodiversity by themselves. In Western India, where most of India's last remaining dry grasslands occur, these social and ecological statistics are much grimmer. Landscape-scale conservation is thus the widely advocated strategy for these systems (Dutta et al., 2011). Such a strategy must invariably assess the effects of land-uses on biological communities, and find solutions to reconcile food production and biodiversity conservation concerns.

1.4 The newly tame desert

The Thar Desert lying towards the north-western border of India is an important biogeographic region of India and contains large stretches of arid grasslands home to variety open-habitat flora and fauna. The region is especially important for birdlife as it marks the eastern range limit of many arid zone species while also marking the western range limit of many semi-arid species of the Indian subcontinent. At the same time, it is an important wintering ground for many Palearctic migrants and falls on two migratory flyways. Grasslands of Jaisalmer district in Thar Desert are the last remaining stronghold of critically endangered Great Indian Bustard and many other threatened and range-restricted species. The largest protected area in the region encompassing ~3000 sqkm area – Desert National Park WLS - is listed as an Important Bird Area by Birdlife International.

Till recently, these harsh grasslands of Thar Desert were sparsely populated and nomadic pastoralism was the most dominant land-use. But from 1980s, lifestyle of people took a sedentary shift and agriculture started expanding on the vast rangelands. Simultaneously human and livestock populations rose rapidly, thus increasing the pressure on land that was amply available earlier. The reduction in area available for grazing due to expansion of croplands and the simultaneous rise of livestock populations drastically increased the grazing pressure on the remaining rangelands of the region. At the same time, various irrigation schemes, notably the Indira Gandhi Canal removed the primary limiting factor on intensive agriculture, and caused large-scale intensification of croplands in the irrigated zone. Irrigation canal has

also brought in forestry and agroforestry plantations for combating desertification and this has created new microhabitats in irrigated agricultural landscape.

As of today, majority of the landscape is under extensive rain-fed agriculture which is left fallow in the dry season and in drought years. The remaining area is primarily used as rangelands and is grazed intensively by domestic livestock, which includes cattle, goat, sheep and free-ranging camel. The irrigated zones of the Indira Gandhi Canal and some low-lying areas are under intensive year-round cultivation. Hunting, agriculture expansion and intensification, overgrazing along with expansion of surface water, energy/power and mining projects are considered the largest threat to the wildlife of the region (Dutta et al., 2017). However, very little scientific enquiry has gone into assessing the effects of these threats on native wildlife.

1.5 Studying bird communities in the contemporary land use scenario of the Thar Desert

Like all grasslands ecosystems of India, Thar Desert is human-dominated and largely unprotected landscape. Even the largest protected area in the region, the Desert National Park Wildlife Sanctuary, is home to more than 50 thousand people and has only ~200 sq.km under strict control of the Forest Department. Thus, to effectively conserve biodiversity in the larger landscape, it is essential to find out sustainable thresholds of anthropogenic land-use that can sustain wildlife while achieving other mandates of the greater multiple-use landscape (Dutta & Jhala, 2014). To do so, it is necessary to understand the impact caused by each land-use on native biodiversity. It is also necessary to scientifically investigate both traditional and recently introduced land-use regimes for their ecological value and understand the trade-offs between livelihoods and conservation holistically. Information on these lines will potentially aide policymakers to manage land uses in the area sustainably with the help of strategies that achieve sustainability through optimisation of food security, social equity and ecological protection.

In this context, my study looks at how bird communities change with the intensifying progression of land-use in Thar Desert. To understand this, I compared different parameters of bird community structure like species richness, abundance and composition across different land-use types of the region and assessed the relative

impact that progression of land-use has on native bird communities. I further looked at the potential drivers of these community patterns with the perspective of finding potential management solutions to maximise native bird diversity in the human-dominated landscape.

1.6 Aims and objectives:

1.6.1 Objectives:

1. To compare bird community parameters between different land-use types of the region.
2. To find potential habitat drivers of local-scale species richness, abundance and community composition.

1.6.2 Questions:

1. How does local species richness, abundance and community composition vary across different land-use types?
2. What effect does land use have on regional species pool of birds?
3. What are the habitat correlates of bird community parameters like species richness, abundance and composition?

2. Literature Review

2.1 Birds in croplands and rangelands

Conversion of natural habitats by crop-based farming and livestock grazing is considered the most voluminous land-use change on the globe (Laurance et al., 2014). Croplands cover more than 25% of global terrestrial area today and are constantly expanding all around the world, resulting in tremendous change of primary habitats (Defries, Foley, & Asner, 2004). In line with the magnitude of change, a lot of research has gone into documenting the effects of agricultural expansion and intensification on native biodiversity. Studies dealing with this subject have focused on a variety of taxa including birds (Kamp et al., 2015; Mendenhall, Sekercioglu, Brenes, Ehrlich, & Daily, 2011; Phalan et al., 2011), plants (Egan & Mortensen, 2012; Kleijn et al., 2012; Phalan et al., 2011), mammals (Decarre, 2015; MacDonald, Tattersall, Service, Firbank, & Feber, 2007) and insects (Hodgson, Kunin, Thomas, Benton, & Gabriel, 2010). In this spectrum, effects of land-use on birds have been assessed in most detail and these studies have been synthesized in numerous reviews and meta-analyses at both regional (Chamberlain, Fuller, Bunce, Duckworth, & Shrubbs, 2000; Donald, Green, & Heath, 2001) and global scales (Gaston et al., 2003; Newbold et al., 2012). The literature in this field is mainly dominated by studies conducted in European or North-America, where agricultural land-use change has caused precipitous declines of birds in the last few years (Chamberlain et al., 2000). Barring a few recent studies, systematic research from other regions of the world is largely lacking (Decarre, 2015; Elsen, Kalyanaraman, Ramesh, & Wilcove, 2017; Kamp, Urazaliev, Donald, & Hölzel, 2011; Karanth et al., 2016; Mendenhall et al., 2011; Phalan et al., 2011).

A meta-analysis by Newbold et al. (2012) showed that intensification of land-use change reduces the species richness, probability of occurrence and abundance of forest birds all across the world (Newbold et al., 2012). Another study estimates that global bird populations have declined by 20-25% due to the conversion of primary habitats to other land-uses, mainly agriculture (Gaston et al., 2003). A global synthesis also suggests that different ecological groups respond differently to land-use change, and in forests, species that are large, long-lived, non-migratory, insectivorous,

frugivorous or habitat specialist show the highest declines (Newbold et al., 2012). While most studies have reported negative effects of agriculture land use on bird communities and populations, a few studies have also documented positive impacts of these changes on a select set of species (Kamp et al., 2011; Wolff, Paul, Martin, & Bretagnolle, 2001).

While the importance of primary habitats for conservation of bird diversity has been rarely questioned, recent studies have shown that low-intensity land-uses like sustainably grazed pastures, agroforests, extensive organic croplands etc. can also support substantial biodiversity (Chang, Karanth, & Robbins, 2018; Karanth et al., 2016; Mendenhall et al., 2011; Wright et al., 2012). Many studies from the forested tropics have examined the conservation value of these low-impact/sustainable land-uses and have found them to be important habitats for bird conservation (M. O. Anand, Krishnaswamy, Kumar, & Bali, 2010; Bhagwat, Willis, Birks, & Whittaker, 2008; Daily, Ehrlich, & Sánchez-Azofeifa, 2001; Elsen, Ramesh, & Wilcove, 2016; Ranganathan, Daniels, Chandran, Ehrlich, & Daily, 2008). Some other studies have focused on finding the drivers of abundance and richness in production landscapes and have found that heterogeneous landscapes mimicking natural habitat structure are used extensively by many bird species (Mandyam Osuri Anand, Krishnaswamy, & Das, 2008; Benton, Vickery, & Wilson, 2003; Ranganathan et al., 2008; Tschardtke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005).

Production landscapes and human-dominated agro-ecosystems have globally attracted a lot of academic attention but multiple gaps have remained in terms of regions and habitats surveyed. In the tropics, most of the studies have assessed impacts of agricultural land-use change on forested ecosystems (Chang et al., 2018; Elsen et al., 2016; Karanth et al., 2016; Mendenhall et al., 2011). Tropical grassy biomes (Parr, Gray, & Bond, 2012), which are equally threatened by land-use changes, have been sparsely surveyed so far. The intimate linkages of grassy biomes with human livelihoods, food security and biodiversity conservation necessitate studying impacts of land-use change on these underappreciated systems in greater detail (Murphy, Andersen, & Parr, 2016; Parr et al., 2012).

In India, most studies have investigated the effects of agriculture on the forested landscapes of the Western Ghats and North-east India, which are global biodiversity hotspots (Myers, Mittermeier, Mittermeier, Fonseca, & Kent, 2000). In Western Ghats, number of studies have primarily focused on assessing conservation value of landscapes modified into commodity agriculture like tea (Sreekar, Mohan, Das, Agarwal, & Vivek, 2013; Sreekar et al., 2015) and coffee plantations (M. O. Anand et al., 2010; Mandyam Osuri Anand et al., 2008; Bali, Kumar, & Krishnaswamy, 2007; Chang et al., 2018; Karanth et al., 2016). Impacts of shifting cultivation (jhum) and palm oil plantation on native biodiversity has been studied in Mizoram (Mandal & Shankar Raman, 2016; Raman, 2001). Some recent work on agroecosystems has been reported from the Greater Himalaya (Elsen et al., 2017, 2016) and the Terai belt of North India (Phalan et al., 2011). Few others have studied the biodiversity of agricultural landscapes in different contexts like man-animal conflict (Athreya, Odden, Linnell, Krishnaswamy, & Karanth, 2013; Kshetry, Vaidyanathan, & Athreya, 2017) and sustainable development (Bawa, Joseph, & Setty, 2007).

Similar to the trend across the globe, most studies have focused on birds as a model taxon followed by mammals and plants (M. O. Anand et al., 2010; Elsen et al., 2017; Mandal & Shankar Raman, 2016; Sreekar et al., 2015). There is a great disparity of research when it comes to the spatial coverage of investigation, with nearly all the systematic studies restricted to the biodiversity-rich Western-Ghats, North-Eastern forests and Himalaya. There exist no systematic studies which evaluate the impact of agricultural land-use changes on the bird communities of arid and semi-arid regions of the country. Even in the forested landscapes, most studied have focused on commodity agriculture which accounts for relatively little in terms of area under cultivation.

Like croplands, rangelands also cover over about 25% of global landmass, and in variety of forms including secondary grasslands, savannahs, woodlands, scrublands etc.(Ellis, 2011; Jeuken et al., 2012) But in contrast to agriculture, studies investigating effects of livestock grazing on biodiversity have been fewer and have mostly focused on plants (Jeuken et al., 2012; Rutherford & Powrie, 2013; Song et al., 2016; Yan & Lu, 2015) and mammals (Eccard, Walther, & Milton, 2000; Song et al., 2016), with

relatively fewer studies on birds (Kamp et al., 2011). With regards to birds, available scant evidence suggests that rangelands grazed at sustainable intensities can sustain avifaunal diversity and are important habitats for grassland birds (Dutta & Jhala, 2014; Kamp et al., 2011). In spite of the large extent in which rangelands are found, studies looking at effect of livestock grazing intensification on native biodiversity (especially birds) are exceptionally few.

3. Study Area and Study Species

3.1 Location

The study was conducted over an extensive study area of 2016 sq.km, spread across an arid landscape of ca7000 sq.km (27.42 to 26.56 N, 70.89 to 70.14 E) in Thar desert of Jaisalmer district (Rajasthan) in north-western India. Jaisalmer district is located at the northwestern boundary of India and is flanked by Barmer district on the southeast and Bikaner district on the northeast. The extent of the study area was bound by two towns on its edges – ‘Jaisalmer’ in the West and ‘Ramgarh’ to the North. The southern part of the study area comprised of the Desert National Park Wildlife Sanctuary (DNP WLS henceforth). Large parts of the study area fell under the extent two proposed Thar Ecozone and Thar Biosphere Reserve. Parts of the Indira Gandhi Canal, a flagship irrigation scheme were situated towards the northwest of the study area. Close to the western edge was the sub-divisional administrative headquarter of ‘Sam’. Other important villages in the study area included Bandha, Habur, Jamra, Kanoi, Mokla, Neemba, Kuchhri, Sanu, and Siambar.

3.2 Distal features of the study area

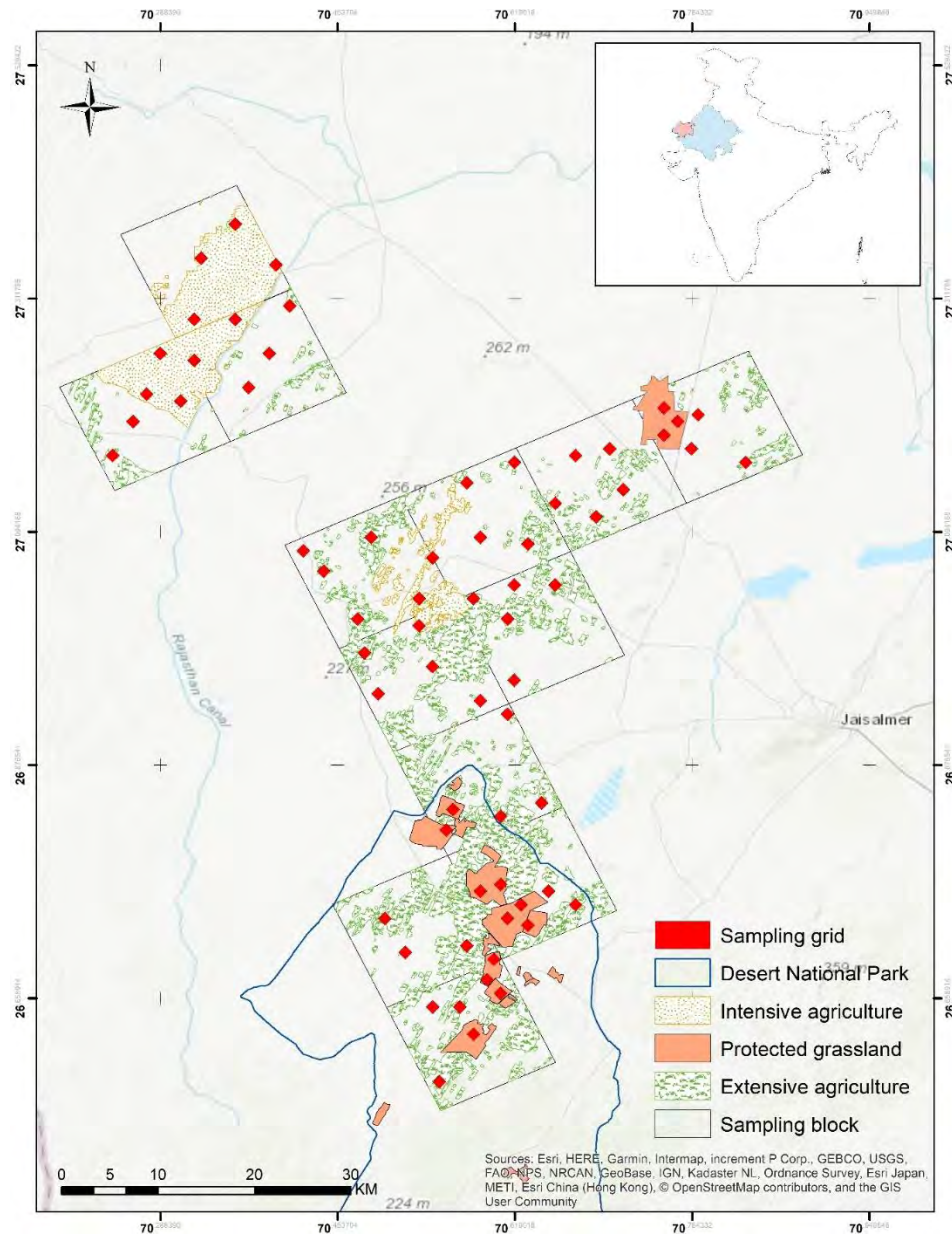
3.2.1 Physical features

The entire desert consists of level to gently sloping plains broken by sand dunes and low barren hills. The blown sand, due to aerodynamic processes and biotic interferences, forms shifting sand dunes i.e. with the progress of time they change positions or shift from one place to another. The inter-dunal depressions are formed by wind depletion of surface soils and by dried-up beds of desert streams. Seasonal streams, locally called ‘*Nalas*’ flow for a few days immediately after the rains. The rainwater is collected and held up in low-lying areas called ‘*Khadeens*’ and ‘*Nadis*’ and is then used for drinking and also for cultivation in the moist water catchments. Rocky outcrops (Locally called “Magra”) are seen in a few locations.

3.2.2 Climate

The regions of Thar desert falling in the Jaisalmer district are typically characterised by an arid climate. The summers are hot and dry with temperatures reaching up to 50C, whereas winters are cold and windy with temperatures reaching as low as 0C. The

daily temperature fluctuations are considerably high during all seasons with nights and early mornings being cold throughout the year. Rainfall is erratic and largely ranges between 100 and 350 mm in the Jaisalmer district. Most of the rainfall occurs during the passage of southwestern monsoon in the months of July and August. Rainfall during other times of the year is negligible. Hot winds and dust storms are a common occurrence during the summers.



Map 1: Map of study area in Jaisalmer district of Western Rajasthan, India. The map depicts the dominant land-use types in the area along with important boundaries. Please note the Rajasthan Canal running along the Western edge of the map. The uncoloured area inside the sampling blocks is a mix of rangelands, sand dunes and rocky/gravelly outcrops.

3.3 Habitats and wildlife

3.3.1 Natural habitats

The natural habitat in the region is arid grasslands and savannahs mainly dominated by the grass *Lasiurus scindicus* and the tree *Capparis decidua*. Stabilised sand-dunes have a typical habitat dominated by *Panicum turgidum* grass and with interspersed shrubs like *Crotalaria buhria* and *Leptadenia pyrotechnica*. Some stabilised areas are covered with prostrate woody forbs *Calligonum polynoides* and *Haloxylon salicornium*. The short grass layer consists of *Dactyloctenium aegyptium* and *Cenchrus biflorus*. *Zizyphus nummularia* is also common in many places, especially in the community protected grasslands or sacred groves. The iconic *Prosopis cineraria* is found in low lying areas and inter-dunal valleys which have largely been converted to agriculture. *Calotropis procera* is another common tree which mainly grows in disturbed areas. *Salvadora persica*, *Salvadora oleanoides* and *Euphorbia* sp. are found in some rocky areas. The riverine vegetation consists of all the aforementioned trees along with some specialists like *Tamarix* sp.

The neo-biota in the desert includes the invasive *Aerva javanica* and the weedy *Dipteris glauca*, which mostly grow on regenerating croplands and overgrazed areas. Additionally, forestry plantations of *Acacia tortilis* and *Tecomella undulata* have naturalised in many places. *Prosopis juliflora*, commonly planted as a firewood tree, is seen around villages but has not invaded other areas in the desert. Other weeds like *Tephrosia purpurea* and *Cassia senna* are also potentially introduced to the area by the nomadic livestock that moves through the area.

3.3.2 Anthropogenic habitats

As large parts of the Thar Desert have been converted to croplands, there is a wide array of anthropogenic habitats available for the wildlife. This includes the croplands itself which in the low-intensity form are structurally very similar to the grasslands but devoid of grassy understory. Large trees of *Prosopis cineraria* and *Zizyphus nummularia* are often seen in these extensive agricultural fields. On the other hand, intensive agriculture has brought in agro-forestry trees like *Acacia nilotica*, *Acacia senegal*, *Acacia tortilis* and *Prosopis juliflora* which create new habitat due to their dissimilarity with the native trees of the region. Forestry plantations carried out

through the Desert Development program are also new anthropogenic habitats that have been created very recently.

3.3.3 Wildlife

Thar desert harbours a variety of wildlife which is important from ecological and conservation perspective. The flagship species of the landscape is the critically endangered Great Indian Bustard (*Ardeotis nigriceps*), whose 90% global population is restricted to the arid grasslands of Jaisalmer district. Notable mammal species in the region include rodent Indian desert jird *Meriones hurrianae*, ungulates like chinkara *Gazella bennettii*, nilgai *Boselaphus tragocamelus* and wild pig *Sus scrofa*, and carnivores like the Desert fox *Vulpes vulpes pusilla*, Indian fox *Vulpes bengalensis*, desert cat *Felis sylvestris ornata*. The herpetofauna is represented by a wide range of arid species, notably the Desert Monitor *Varanus griesius*, Persian Dwarf-Gecko *Microgecko persicus*, Saw-scaled viper *Echis carinatus sochureki*, Spiny-tailed lizard *Saara hardwickei* etc.

3.4 Study species

The Indian Thar desert is the eastern boundary of the extensive arid tract comprising the Sahara-Sindian Desert complex of Northern Africa and Western Asia. Unsurprisingly, the resident avifauna of the Indian Thar desert is very similar to the avifauna of these Afro-Asian deserts. It is also the easternmost range limit for many of these desert species from the extensive Afro-Asian arid region (eg. Black-crowned Sparrow-lark, White-eared bulbul etc.). At the same time, it forms the penultimate western range limit of some birds from the semi-arid regions of the Indian subcontinent (Eg. Great-Indian Bustard, Rufous-fronted Prinia etc.). This area is also an important wintering ground for large number of migratory grassland species (eg. Desert Wheatear, Desert Warbler etc.) especially from Eurasia; and also a critical stopover site for passage migrants using the Central Asian and East Asia-East Africa flyway (eg. Rufous-tailed scrub robin, Black-headed bunting etc.). It is an important nesting ground for many raptors such as Tawny Eagle *Aquila rapax*, Red-headed vulture *Sarcogyps calvus*, Laggar Falcon *Falco jugger* etc.

With the advent of Indira Gandhi Canal or the Rajasthan Canal, new species from neighbouring regions have colonised into the erstwhile inhospitable desert

(Rahmani & Soni, 1997). These species include forest/woodland generalists like Jungle Babbler *Turdoides striatus*, White-browed Fantail *Rhipidura aureola*, Asian Paradise Flycatcher *Terpsiphone paradise* etc. and wetland birds like White-throated Kingfisher *Halcyon smyrnensis*, Common Sandpiper *Actitis hypoleucos* etc.

4. Methods

This study was aimed at understanding the patterns of bird community structure in the Thar Desert, with special emphasis on effects of increasing land use change. To achieve this, community structure was explored on three dimensions - species richness, abundance and composition. Further, to understand what factors led to the observed patterns, bird community parameters were tested against various ecologically meaningful environmental variables. Data on environmental variables was collected by vegetation sampling. All this information was analysed using appropriate analytical techniques to understand the patterns of and factors affecting community assembly of local bird species.

4.1 Selection of study area and reconnaissance

To understand the effects of land-use on dry grasslands, it was necessary to select a study area which had a gradient of land-use in close proximity to a federally regulated near-natural control area. After a thorough review of literature to find such sites, the following sites were shortlisted: 1. Naliya Grasslands and 2. Banni Grasslands of Gujrat, 3. Bustard sanctuaries of Nannaj, Rehekuri, Karmala in Maharashtra, 4. Desert National Park and environs, Rajasthan. Among these Nannaj, Rehekuri and Karmala were discarded due to absence of near-natural environments in the form of relatively large enclosures which were critical for the study. Banni grasslands were discarded as they are sea inundated and have little agricultural intensification, thus reducing the land-use-gradient that could be examined. Between Desert National Park and Naliya grasslands, the former was selected as it had larger homogenous area with a well-defined gradient of land-use. Moreover, DNP had many regulated enclosures which could provide the study with near-natural control plots. All this coupled with logistic feasibility owing to ongoing research projects in Desert National Park and its environs in Jaisalmer district rendered it to be selected as the Study Area.

4.1.1 Reconnaissance

A reconnaissance survey was carried out in September 2019 to ascertain the suitability of the study area to meet the objectives. Certain changes were made to the original objectives based on observations during this survey. Bird species and

abundances were recorded to decide suitable sampling method and design. Discrete land-use strata were visually determined and then compared with remotely sensed data, to get a better picture of the extensive study area. The extent of the study area was roughly decided after the reconnaissance survey.

4.2 Study Design

4.2.1 Delineation of sampling strata

The 7000 sq.km extent of the study area was divided into 50 blocks of 144 sq. km. each, of which 14 blocks amounting to an area of 2206 sq.km were further selected as the extensive study area. The selection criteria for these blocks was mainly based on logistic feasibility and accessibility, but conscious effort was made to choose blocks that broadly cover different habitats so that maximum heterogeneity of the landscape is covered in the sampling. The chosen blocks covered all the habitat and land-use types of the region and were a good representation of the study area as well as much of the Thar desert Landscape.

The selected extensive study area was further divided into 1 sq. km. cells, the scale at which further sampling was done. The habitat and land-use types in the study area were largely homogenous at this scale and the smallest homogenous patches were also of approximately this size. From this set, cells containing non-arable land – settlements, forestry plantations, rocky/gravelly barren land and shifting dunes - were removed. Additionally, cells with roads and canals were also excluded to reduce confounding factors. After these exclusions, the remaining suitable sampling area was stratified based on dominant land-use type at the at 1 sq.km scale. Boundaries of the protected areas and irrigated lands were obtained from government records. The remaining area was classified using remotely sensed land cover data and visual inspection of satellite imagery. The resultant classified imagery was further validated by inspection of satellite imagery. This elaborate process of classification resulted in delineation of four dominant land-use categories in the study area, which are mentioned below along with brief descriptions –

1. **Protected Grasslands:** Protected grasslands in the study area were confined to the graze-proof enclosures built up by the Desert National Park and Desert

Development Program of the Forest Department. Grazing was 'regulated' inside these areas and agriculture was strictly prohibited. The grazing pressure in these areas was much lower than the rangelands even during prevalent drought conditions. Additionally, no logging was allowed inside these areas and illegal hunting was unlikely due to strict protection. These enclosures were built at different times and had different histories of management. Many of these enclosures were reseeded with perennial grass *Lasiurus scindicus* to aid recovery of grassland after enclosing.

2. **Non-irrigated croplands/Rainfed croplands:** Most parts of the Thar desert are not irrigated and receive erratic rainfall, thus limiting farming to the monsoon or the 'Kharif' cropping season, that too in years of good rainfall. The land is left fallow after cropping and allowed to regenerate through the dry months. Grazing is also allowed on these lands after harvest and during the fallow period. Most fields lie fallow during the years of erratic and low rainfall which is a common occurrence in this region. All the non-intensive/rainfed croplands in the study area were fallow at the time of sampling. In majority of cases, the last crop cultivated on these non-irrigated farmlands was Guar (*Cyamopsis tetragonoloba*), which is a cash crop that has been recently introduced to this region. Some fields were tilled for the upcoming monsoon whereas some other were regenerating after remaining fallow for more than a year.
3. **Rangelands** or Grazing Lands: Rangelands were primarily used for grazing domestic livestock –goat, sheep, cattle and camel and for collection of firewood and timber for household needs. They did not have any recent history of farming and were not subjected to any management intervention concerning the habitat. These areas differed from the conserved grasslands due to their much high grazing pressure and human disturbance. Most of these areas were highly stocked with domestic livestock and were often grazed to the ground. Goat, sheep, cow and camel were the major livestock animals with the first two being more numerous. These areas were also used for grazing by wild herbivores – Chinkara (*Gazzella bennetti*), Nilgai (*Boselaphus tragocamelus*) and Desert Jird (*Meriones hurrianae*).

4. **Irrigated croplands:** This category included croplands irrigated either by canal water or through tube-wells. Most of this land was under cultivation during the winter, and the dominant crops were Bengal gram (*Cicer arietinum*), jeera (*Cuminum cyminum*) and mustard (*Brassica sp.*). A distinct feature of irrigated croplands was presence of hedges with introduced trees like *Acacia nilotica*, *Acacia senegal*, *Prosopis juliflora* and *Dalbergia sisoo*. In most cases, native vegetation was completely cleared or left only on the hedges. A majority of these areas were fallow during the summer, after the harvest of 'rabi' crops in April.

4.2.2 Transect placement

Seventy line transects of 1km length were placed across the study area to conduct bird and vegetation surveys. A total of 5 (± 1) transects were laid randomly in each of the 14 blocks (144 sq.km), with proportional coverage given to each land-use type within the block. This approach of proportional randomization within the block resulted in placing 26 transects in rain-fed croplands, 18 in rangelands, 15 in protected grasslands and 9 in irrigated croplands. All transects were oriented in a North-South direction and were placed at least 3km apart from each other (1 km in case of protected grasslands) to maintain spatial independence.

Bird transects were conducted in two seasons – winter (December 25 to February 20), when the migrants were present and summer (21 March to 21 April), when many resident species started breeding. All transects were repeated three times in every season to achieve adequate temporal replication. Habitat sampling for trees and shrubs was conducted only once for all transects whereas the understory was surveyed twice – once in every season since the latter underwent significant seasonal variation.

4.3 Field methods

4.3.1 Bird Surveys

All perched birds present along the 1km line transects and following readings of each sighting were recorded - species, count of individuals, distance of bird from the observer, angle of the bird with respect to the transect and position of observer. All

the positions were realised using a handheld GPS device (Garmin etrex 30), while distances were calculated using a laser rangefinder (Yukon HRS300). Angles were measured using a handheld Sunnto compass or a compass enabled mobile handset. Bird surveys were conducted from dawn until four hours after sunrise in the morning and during last two hours before sunset in the evening. These sampling times coincided with the time when the birds were most active. Predefined line transects were walked at a uniform slow speed of approximately 2km/hr (30-40 minutes per 1km transect), and all birds were recognized on field using a binocular (Nikon Monarch 8x42). The birds that could not be identified on field were photographed and identified later with the help of field guides – Birds of Indian subcontinent, Handbook of the birds of the world, BNHS Salim Ali. Clements Checklist was followed for names and taxonomy. Detection covariates like weather conditions, time of transect and name of observer(s) were noted during each replicate.

4.3.3 Vegetation Surveys

Vegetation sampling was carried out on all 70 line transects to assess the structural and floristic composition of vegetation that might have an influence on the avifauna. Five rectangular belt transect were laid perpendicular to the main line, starting at 100m and then at an interval of every 200 m. The belt-transect had dimensions of 100 × 25 m on either side of the line making it a rectangular plot of 1 ha (200 × 10 m). This plot was used for recording trees, which were defined as plants with GBH greater than 30cm and height more than 2m. All the trees were identified and recorded along with their GBH, height, diameter of the crown and canopy start height (Sutherland, 2006). The GBH was rounded off to the closest multiple of 5cm for every stem, while tree height, diameter of crown and canopy start height was rounded off to the closest multiple of 10cm. Shrubs and forbs were counted on a nested 200 x 10 m plot located at the centre of aforementioned 200 x 50 m tree plot. For every shrub, the highest diameter and dominant height were recorded along with the name of the species. Grasses were sampled by laying 1 x 1 m transect at four predefined locations on the central axis of the tree plot. To surrogate grass biomass, I recorded the height and percentage cover of grass inside the 1x1m quadrat. Some grasses were identified only till the genus level due to absence of distinct identification features in the

phonological stage prevalent during sampling. Other habitat variables like type of substrate, availability of surface water and anthropogenic disturbance were noted down for every transect. In total, an effective area of 350 hectares was sampled during the entire study.

Table 1: Habitat variables collected during field sampling and the rationale of collecting them.

<u>Plant form</u>	<u>Variables Collected</u>	<u>Field sampling</u>	<u>Rationale</u>
<u>Trees</u>			
1	Girth at breast height (GBH)	GBH was collected separately for every (stem of a) tree by measuring the circumference	GBH further converted to Basal area is a fundamental property of vegetation and also surrogates the age of the stand and size of the tree.
2	Diameter of the crown	As the GBH was not a good surrogate for foliar biomass, diameter of the crown was measured to then calculate the foliar volume of the tree	As foliar biomass and GBH were superficially uncorrelated in the study system, foliar volume was calculated for each plant. To obtain this the dominant diameter length of each tree was measured.
3	Height of the tree	The height of the tree measured with rangefinder or by ocular estimation	Height was a parameter used for measuring foliar volume and even to understand the structure of the habitat.
4	Canopy start height	Height at which the canopy started	The canopy start height, often defined by the browse line was used to calculate foliar volume
<u>Shrubs & Forbs</u>			
1	Diameter of the plant	Measured as the diametric length of the plant	Foliar volume of shrubs and forbs were calculated separately using the diameter data. The diameter was also used to get cover of forbs
2	Height of the tree	Height of the plant.	To calculate foliar biomass
<u>Grasses</u>			
1	% cover	Percentage cover in 1x1 m quadrat	To calculate grass biomass
2	Grass Height	Height of grass measured as ordinal variable in distinct classes (0-5,5-10,10-30,30-60, >90)	To calculate grass biomass

4.4 Analytical Methods

Different techniques of comparison, modelling and ordination were used to answer specific questions relating to species richness, abundance and composition of bird communities. All the procedures were conducted on a dataset with all the recorded species and then with a dataset having only the originally native species. I

used the ‘species recorded in Protected grasslands’ as a yardstick to differentiate originally present species from the newly colonised ones. The analyses were done separately for each season and for the overall year-long data.

All the analyses were conducted on two nested datasets – 1. Dataset with all the recorded species and 2. Dataset having only the originally native species. Native species were defined as species recorded in the protected grasslands and mentioned in literature as originally present before advent of Indira Gandhi canal (Rahmani & Soni, 1997).

Table 2: List of native and non-native species as classified by empirical data from current study and Rahmani & Soni (1997)

Native species		
1	Greater Hoopoe-lark	<i>Alaemon alaudipes</i>
2	Desert Lark	<i>Ammomanes deserti</i>
3	Tawny Pipit	<i>Anthus campestris</i>
4	Long-billed Pipit	<i>Anthus similis</i>
5	Great Indian Bustard	<i>Ardeotis nigriceps</i>
6	Trumpeter Finch	<i>Bucanetes githagineus</i>
7	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>
8	Houbara Bustard	<i>Chlamydotis undulata</i>
9	Rock Pigeon	<i>Columba livia</i>
10	House Crow	<i>Corvus splendens</i>
11	Cream-coloured courser	<i>Cursorius cursor</i>
12	Black Drongo	<i>Dicrurus macrocercus</i>
13	Black-crowned Sparrow-lark	<i>Eremopterix nigriceps</i>
14	Gray Francolin	<i>Francolinus pondicerianus</i>
15	Southern Grey Shrike	<i>Lanius meridionalis</i>
16	Indian Silverbill	<i>Lonchura malabarica</i>
17	Bimaculated Lark	<i>Melanocorypha bimaculata</i>
18	Little Green Bee-eater	<i>Merops orientalis</i>
19	Purple sunbird	<i>Nectarinia asiatica</i>
20	Desert Wheatear	<i>Oenanthe deserti</i>
21	Isabelline Wheatear	<i>Oenanthe isabellina</i>
22	Variable Wheatear	<i>Oenanthe picata</i>
23	Red-tailed Wheatear	<i>Oenanthe xanthopyrma</i>
24	House sparrow	<i>Passer domesticus</i>
25	Chestnut-shouldered Petronia	<i>Petronia xanthocollis</i>
26	Rufous-fronted Prinia	<i>Prinia buchanani</i>
27	Chestnut-bellied sandgrouse	<i>Pterocles exustus</i>
28	Red-vented Bulbul	<i>Pycnonotus cafer</i>
29	White-eared Bulbul	<i>Pycnonotus leucotis</i>

30	Common stonechat	<i>Saxicola torquatus</i>
31	Laughing dove	<i>Stigmatopelia senegalensis</i>
32	Eurasian Collared-Dove	<i>Streptopelia decaocto</i>
33	Rosy starling	<i>Sturnus roseus</i>
34	Lesser Whitethroat	<i>Sylvia curruca</i>
35	Desert Warbler	<i>Sylvia nana</i>
36	Common Babbler	<i>Turdoides caudata</i>
<u>Newly colonised/Non native/Neobiota</u>		
37	Richard's Pipit	<i>Anthus richardi</i>
38	Cattle Egret	<i>Bubulcus ibis</i>
39	Common Rosefinch	<i>Carpodacus erythrinus</i>
40	Pied Kingfisher	<i>Ceryle rudis</i>
41	Indian Roller	<i>Coracias benghalensis</i>
42	Rufous Treepie	<i>Dendrocitta vagabunda</i>
43	Black-headed Bunting	<i>Emberiza melanocephala</i>
44	Crested Lark	<i>Galerida cristata</i>
45	Demoiselle Crane	<i>Grus virgo</i>
46	White-throated Kingfisher	<i>Halcyon smyrnensis</i>
47	Booted Warbler	<i>Hippolais caligata</i>
48	Sykes's Warbler	<i>Hippolais rama</i>
49	Eurasian Wryneck	<i>Jynx torquilla</i>
50	White Wagtail	<i>Motacilla alba</i>
51	Citrine Wagtail	<i>Motacilla citreola</i>
52	Yellow Wagtail	<i>Motacilla flava</i>
53	Indian Peafowl	<i>Pavo cristatus</i>
54	Black Redstart	<i>Phoenicurus ochruros</i>
55	Common Chiffchaff	<i>Phylloscopus collybita</i>
56	Dusky Warbler	<i>Phylloscopus fuscatus</i>
57	Greenish Warbler	<i>Phylloscopus trochiloides</i>
58	Plain Prinia	<i>Prinia inornata</i>
59	Red-naped Ibis	<i>Pseudibis papillosa</i>
60	Rose-ringed Parakeet	<i>Psittacula krameri</i>
61	White-browed Fantail	<i>Rhipidura aureola</i>
62	Pied Bushchat	<i>Saxicola caprata</i>
63	Brahminy Starling	<i>Sturnus pagodarum</i>
64	Orphean Warbler	<i>Sylvia hortensis</i>
65	Common Greenshank	<i>Tringa nebularia</i>
66	Green Sandpiper	<i>Tringa ochropus</i>
67	Large Grey Babbler	<i>Turdoides malcolmi</i>
68	Eurasian Hoopoe	<i>Upupa epops</i>
69	Red-wattled Lapwing	<i>Vanellus indicus</i>

4.4.1 Comparison of vegetation composition and structure

Vegetation composition of sites was visualised using Non-metric multidimensional scaling (NMDS) carried out on a site vs species matrix having volume of the plant as the abundance value. A Bray-Curtis index of similarity was used to plot the NMDS ordination. The differences in composition of sites from each land-use type were statistically checked using multi-response permutation procedure (MRPP). The habitat difference was inferred to be significant at 95% C.I. if the p-value was less than 0.0125, taking into account a Bonferroni correction. The magnitude of difference between cluster was inferred by looking at the A-value which increased with difference from 0 to 1. Additionally, some other vegetation composition parameters like vegetation diversity or woody plant diversity were calculated to relate vegetation composition to bird community parameters. Compositional diversity was calculated by the Shannon-weinner index of diversity used on the vegetation dataset.

Similar to composition, structure of vegetation was compared between land-use types using NMDS and then statistically tested using ANOSIM. The following structural variables were calculated for every site:

1. Foliar volume of woody plant: Foliar volume for each individual plant was calculated as the product of canopy cover and canopy height. Canopy cover was derived by multiplying the maximum canopy diameter by 2π . Canopy height was calculated by subtracting canopy start height from the total tree height. Finally, foliar volume of each plant was added up and standardised to 1ha, to get this index which surrogated foliar biomass of woody plants.
2. Woody plant stem density: The GBH for each stem was converted into area and then added up, to get woody plant density for a hectare. The woody plant density was a surrogate for productivity and age of the habitat.
3. Average GBH: As larger GBH indicated presence of larger trees, the average GBH informed about the stand structure of vegetation in the area.
4. Herbaceous volume: The volume of each forb was calculated by multiplying height by cover and then added up to get Herbaceous volume per hectare.
5. Grass volume: Similar to herbaceous volume, grass cover was multiplied by height to get volume which surrogated biomass.

6. Crop volume: Similar to grass and herbaceous volume.
7. Average height for each plant-form: The average height of each phenotypic form was calculated for each transect.

4.4.2 Bird species richness analysis

To compare local bird species richness across different land-use types, Analysis of Variance (ANOVA) was conducted. This was followed by a post-hoc multiple comparisons by Tukey's HSD to check for pairwise differences in species richness. Seasonal differences in species richness were compared using a paired Wilcoxon sign-ranked test on species richness of every site.

A species accumulation curve was used to check whether species richness has reached asymptote at a landscape scale. Since the asymptote was not reached for some land-uses, landscape-scale richness of bird communities was estimated using sample-based rarefaction with bootstrap method on site-level data. This data was analysed separately for both the seasons and for the overall data.

4.4.3 Bird community composition

To visualise the differences in community composition of sites with individual land use types, ordination of the data was performed using non-metric multidimensional scaling NMDS. Bray-Curtis index of similarity was used estimate the ecological distance between the communities of two sites. The differences were then statistically tested using non-parametric multivariate analysis of variance (npMANOVA) or permutation multivariate analysis of variance (perMANOVA) with each community as the response variable and land use type as the explanatory variable. To ensure that the perMANOVA results were robust and not affected by heterogeneous multivariate dispersion between different groups, a permutational multivariate test of dispersion was conducted using the betadisper function in vegan package of R. The results of this test were subjected to multiple comparisons using Bonferroni correction of p-values and also by Tukey HSD. After performing the perMANOVA analysis, the results were compared for pairwise differences after Bonferroni correction of p-values.

4.4.4 Habitat correlates of species richness and community composition

To understand the relation of species richness with underlying habitat factors, Generalised Linear Models were used on richness data with preselected habitat factors as predictor covariates. The predictor covariates tested were foliar biomass of woody plants, forb biomass, overall vegetation diversity and grass biomass. Quadratic functions of some of the variables were also tested as predictors, to check whether there was any peaking at intermediate levels. The predictors were scaled prior to performing the analysis so that the output represented relative importance of each predictor variable.

*Table 3: Hypothesized relationship of predictor variables with species richness.
Note: Forb volume was inversely correlated with grass biomass.*

<u>Variables</u>	<u>Hypothesized relationship</u>	<u>Rationale</u>
Foliar biomass of woody vegetation	+	Higher foliar biomass would represent higher productivity and was expected to increase species richness (Sekercioglu, 2002)
Crop volume	-	Increasing crop volume represented increasing gradient of agriculture intensification and was expected to negatively influence bird richness (Flynn et al., 2009)
Forb volume	Quadratic	To a certain threshold, forb intensity was expected to be beneficial for bird richness. Forb volume increase beyond a certain threshold would potentially indicate a biome switch and was expected to negatively influence species richness. Additionally, the forb species in the study area were unpalatable and either weedy or invasive. (Sirami, Seymour, Midgley, & Barnard, 2009)
Compositional diversity	+	Compositionally more diverse habitats were expected to be associated with more bird species. (Terborgh, 2015)
Grass biomass	+	Grass biomass was expected to be associated with higher species richness.

Model selection was based on the information theoretic approach and was performed in the following way: a) A global model with all covariates was created and all simpler combinations of this model were produced using the dredge function in MuMIN package of R. b) Ecologically sensible models with delta-AIC less than 2, when

compared to the best model, were selected for multimodal selection. C) The variables that potentially affect the species richness were identified using a step-wise backward selection of models.

To understand habitat correlates of community composition, a Canonical Correspondence analysis was conducted. Structural attributes of vegetation used for checking relation with species richness were again used as predictor variables for this analysis. A global model with all the variables was run and visualized as a biplot. Multicollinearity between variables was then tested by calculating variance inflation factor with the “vif.cca” function in vegan package on R statistical Platform. If correlation was found, one of the collinear variables was dropped. The remaining were tested for significance by performing permutational MANOVA using the “cca.anova” function in vegan package. A simple model was then created with only the significantly influencing variables. A CCA biplot was used to understand the influence on specific variables on different bird species.

5. Results

5.1 Comparison of vegetation across land-use types

A total of 19 woody plant, 18 forb, 10 grass and seven crops species were recorded in the study area during vegetation sampling. Most transects were very homogenous with very few species of plants occurring within them. The mean species richness (species / sq.km) of all plant forms together was largely similar across all land uses (Table 4). A peculiar difference between land use types was in terms of Forb species, which were higher in rainfed croplands. Intensive agriculture was devoid of grass but had higher number of tree species.

Table 4 Mean(SE) Species Richness (per sq.km) of each plant form grouped according to the land-use type.

Plant Form	Irrigated croplands	Rainfed croplands	Protected Grasslands	Rangelands
Crop	2.77 (0.43)	NA	NA	NA
Forb	3.75 (0.36)	4.68 (0.29)	3.07 (0.44)	3.2 (0.42)
Short_Grass	NA	1.86 (0.19)	1.66 (0.15)	1.44 (0.16)
Shrub	2.22 (0.36)	3.08 (0.24)	2.83 (0.54)	2.22 (0.23)
Tall_Grass	NA	1.05 (0.05)	1.4 (0.13)	1.38 (0.14)
Tree	5.33 (0.62)	3.03 (0.25)	2.73 (0.26)	2.94 (0.20)

There were stark differences in different land-use types when volumes (surrogate of biomass) of plant forms were compared against each other. Mean foliar biomass of woody plants was much higher in intensive agriculture as compared to other land uses whereas forb biomass was highest in rangelands. However, none of these means was significantly different from each other at $\alpha=0.05$. Grass biomass was notably higher in protected grasslands as compared to other land uses (Table 5).

Table 5: Mean(SE) volume in cu.m per ha for each plant form (column) in every land use type (rows), during winter (Top) and summer (bottom)

Winter					
Type	Crop	Diversity	Forb	Grass	Woody Plant
Rainfed croplands	13846.15 (10153.85)	1.05 (0.09)	342.68 (114.59)	44.67 (15.91)	427.54 (131.15)
Intensive croplands	1146666.67 (242926.4)	0.59 (0.13)	4.9 (2.81)	0 (0)	1497.02 (1004.45)
Protected Grasslands	0 (0)	1.19 (0.06)	294.8 (96.36)	1107.38 (317.16)	512.8 (163.34)
Rangelands	0 (0)	0.99 (0.13)	738.5 (454.98)	337.14 (164.65)	637.48 (360.28)
Summer					
Type	Crop	Diversity	Forb	Grass	Woody Plant
Extensive_croplands	0 (0)	1.14 (0.07)	342.68 (114.59)	44.67 (15.91)	427.54 (131.15)
Intensive_croplands	779.17 (540.25)	1.38 (0.11)	38.22 (10.84)	170.83 (158.48)	1497.02 (1004.45)
Protected_Grasslands	0 (0)	1.19 (0.06)	294.8 (96.36)	1107.38 (317.16)	512.8 (163.34)
Rangelands	0 (0)	0.99 (0.13)	738.5 (454.98)	337.14 (164.65)	637.48 (360.28)

5.1.1 Vegetation composition and structure

Vegetation composition of different land uses was compared visually using NMDS and statistically using perMANOVA and ANOSIM. The results showed clear segregation between plant community compositions of intensive agriculture as compared to all the other land-uses (perMANOVA: $p_{\text{summer}} < 0.001$, $p_{\text{winter}} < 0.001$). Protected grasslands and rangelands had very similar local community composition of plants whereas composition in non-intensive agriculture was significantly different. The magnitude of compositional difference between intensive agriculture and other land-uses was much higher during winter and reduced notably during the summer (Figure 2).

Vegetation structure showed a similar pattern across land-uses. Intensive agriculture had distinct vegetation structure compared to other land-uses during winter (perMANOVA: $p < 0.001$). Protected grasslands also had unique structure, which was different from rangelands and non-irrigated croplands during both seasons (Figure 2). The structure of rangelands and rainfed croplands was very similar. In summer, the vegetation structure of intensive agriculture was similar to rangelands and extensive agriculture but remained different from that of protected grasslands and other land uses (perMANOVA: $p < 0.001$).

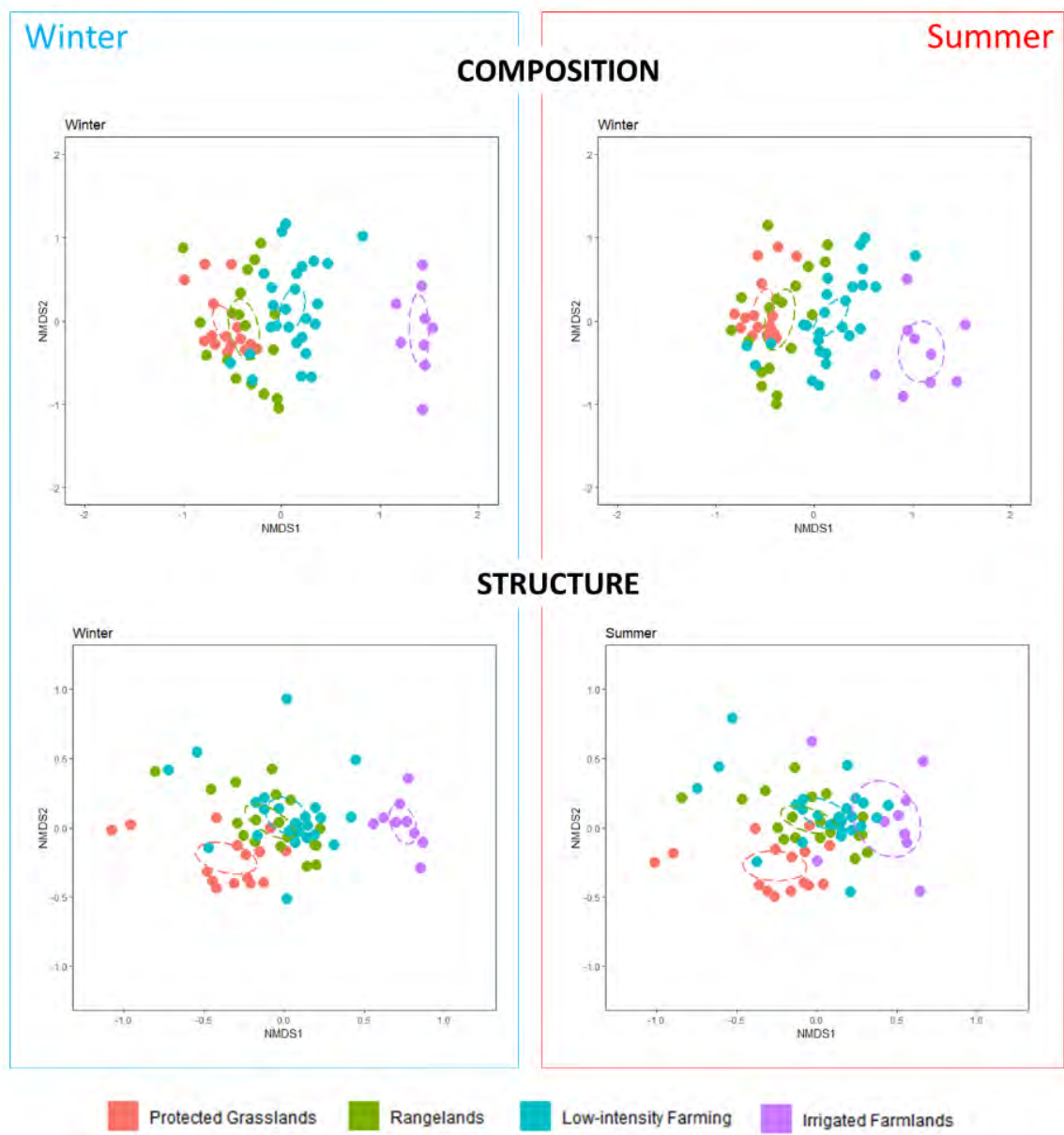


Figure 2: NMDS ordination showing differences in composition (above) and structure (below) of vegetation in different land-use types during winter (left) and summer (right). The ellipsoids are centred at mean MDS value of both axis and the radius is determined by the standard error of mean at 95% C.I. Stress values of all plots were less than 0.25 and the non-metric fit was more than 90%.

5.2 Bird Species Richness

A total of 1521 individuals belonging to 51 species were recorded during winter sampling (January 2019 to March 2019), while 1834 individuals belonging to 52 species were recorded during summer sampling (March 2018 – May 2019). Overall, 3555 individuals belonging to 72 species were recorded during the entire study period (December 2018 to May 2019). Thirty-three species out of the overall 72 were recorded in both seasons.

5.2.1 Local bird richness

Result of paired Wilcoxon Sign Test on sample species richness during winter and summer showed that median of local-scale species richness was different between seasons ($V = 1145.5$, $df = 67$, $p = 0.0045$), and the mean richness was slightly higher during winter (9.47 ± 0.51 SE) than summer (8.353 ± 0.532). Considering this seasonal difference in species richness, further comparisons were conducted separately for seasons.

Mean species richness was different between land-use types during both seasons (Winter: $F = 10.97$, $df = 67$, $p < 0.05$; Summer: $F = 11.27$, $df = 67$, $p < 0.05$). Tukey's HSD post-hoc test indicated that mean bird species richness was significantly higher in irrigated high-intensity agriculture as compared to other land uses (Table 6, Figure 3). There was no significant difference in mean species richness between other land use types. Year round, the pattern of local scale mean species richness was similar to the one observed during individual seasons.

However, these patterns changed after controlling for non-native species. In winter, mean species richness of irrigated croplands was not different from protected grasslands whereas extensive agriculture and rangelands had lower species richness than protected grasslands and irrigated croplands (

Figure 3, Table 6). In summers, only rangelands and irrigated croplands had significantly different mean species richness. The year-round patterns were similar to that in summer. In both seasons, mean richness of native species richness in high-intensity croplands reduced drastically when non-native species were not included,

but the same was not true for any other land-use; indicating that intensive agriculture attracted non-native species in particular (

Figure 3, Table 6).

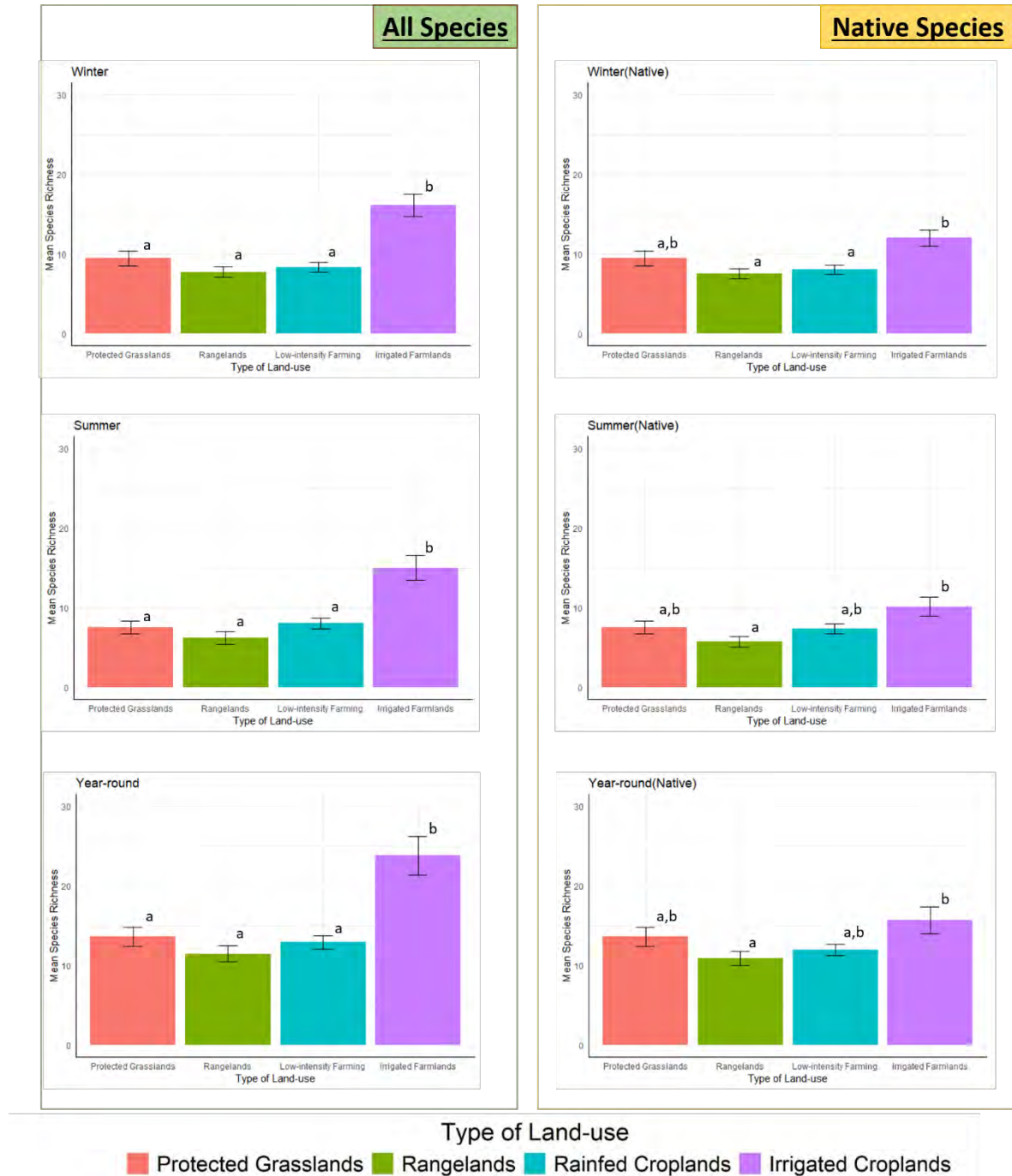


Figure 3: Bar plot representing the mean species richness of all species (left) and native species (right) across land-use types during winter (top), summer (middle) and both seasons together (bottom). The error bars represent the standard error on them

Type	Parameter	Protected Grasslands	Rangelands	Low-intensity agriculture	Intensive agriculture	ANOVA pvalue
Winter	Mean(SE) Overall	9.46 (0.92) ^a	7.72 (0.67) ^a	8.3 (0.60) ^a	16.11 (1.45) ^b	<0.001
	Mean(SE) Native	9.46 (0.92) ^{a,b}	7.56 (0.62) ^a	8.03 (0.55) ^a	12 (1.02) ^b	0.003
Summer	Mean (SE) Overall	7.53 (0.76) ^a	6.16 (0.8)	8.88 (0.68) ^a	15 (1.53) ^b	<0.001
	Mean (SE) Native	7.53 (0.76) ^{a,b}	5.72 (0.66)	7.34 (0.58) ^{a,b}	10.11 (1.18) ^b	0.008
Year Round	Mean (SE) Overall	13.6 (1.17) ^a	11.44 (1.04)	12.88 (0.82) ^a	23.78 (2.40) ^b	<0.001
	Mean (SE) Native	13.6 (1.17) ^{a,b}	10.88 (0.89)	11.92 (0.7) ^{a,b}	15.67 (1.67) ^b	0.026

Table 6: Mean (SE) species richness of all bird species and native bird species in different land-use types during winter and summer. Subscripts along the means indicate grouping according to Tukey's post-hoc test at 95% significance level.

5.2.2 Landscape-scale bird richness

Visual examination of species accumulation curves suggested that sampling could not capture the entire set of species for all land-use types. During winter, the naïve and bootstrapped estimated species richness was significantly higher in intensive agriculture as compared to all other land-uses. Protected grasslands and rangelands had similar estimated and naïve species richness, whereas non-intensive agriculture had slightly higher species richness. In summer, the naïve and estimated species richness was highest in intensive agriculture followed closely by low-intensity agriculture. Protected grasslands and rangelands had much lower species richness than two agricultural land-uses (Figure 4).

After controlling for newly colonised species, protected grasslands had the highest species richness in all seasons, indicating loss of certain native species in other land-use types. The estimated species richness among the three non-protected land-uses was largely similar. The drastic reduction in species richness of irrigated croplands after controlling for native species shows that nearly half the species seen in this land-use are newly colonised. Similarly, the species richness in non-irrigated croplands during summer reduced sharply when non-native species were excluded.

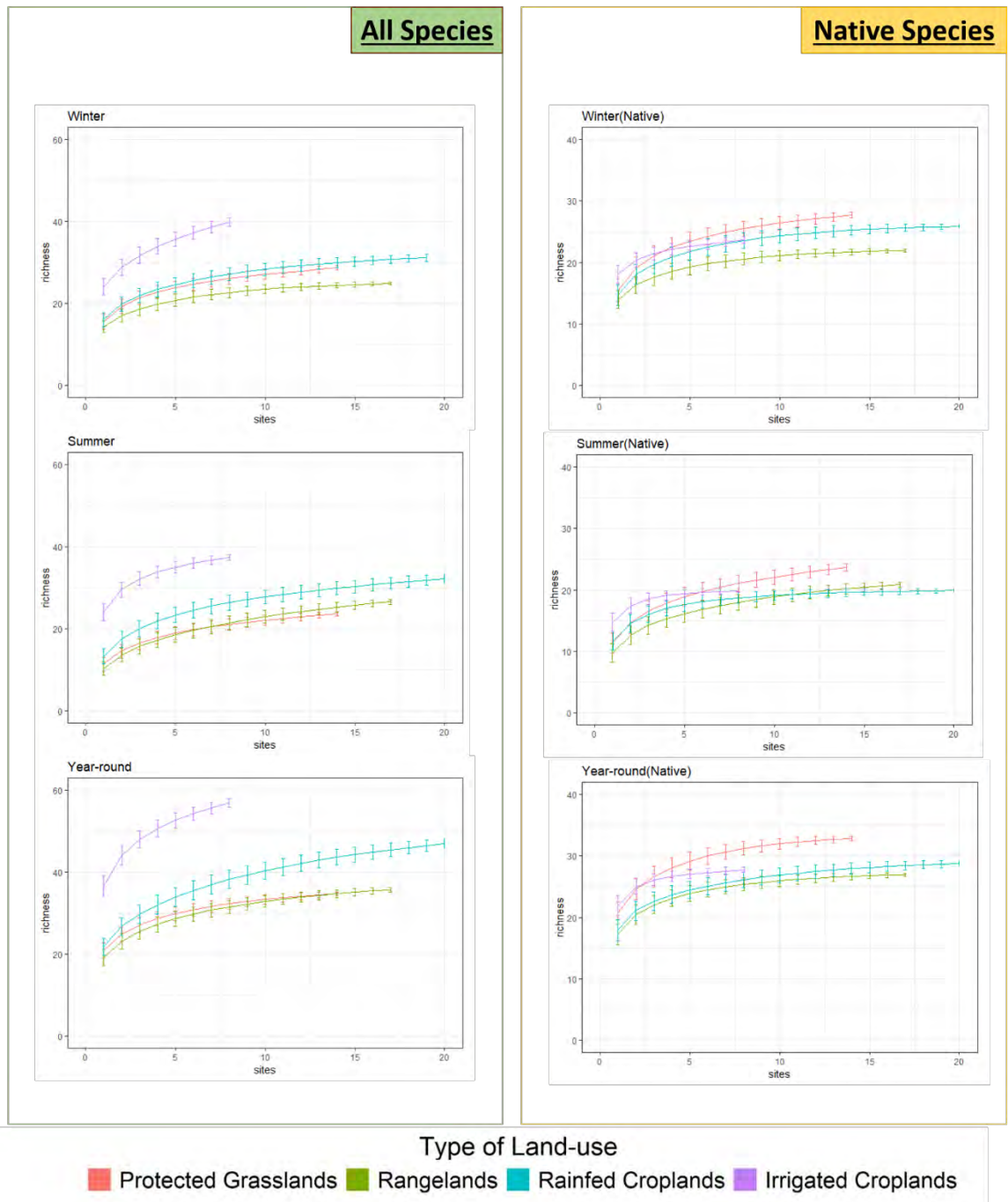


Figure 4: Species accumulation curve with sites in the x-axis and accumulated landscape-scale species richness on the y-axis. The plots represent landscape-scale species richness of all species (left) and native species (right) in winter (above), summer (middle) and across both seasons (bottom). The error bars represent the standard error on the mean at every position.

Season	Species richness	Protected Grasslands	Rangelands	Low-intensity agriculture	Intensive agriculture
Winter	Naïve Overall	28	25	32	41
	Mean (SE) Overall	31.24 (1.80)	27.71 (1.56)	35.88 (1.93)	46.35 (2.93)
	Naïve Native	28	22	26	24
	Mean (SE) Native	31.24 (1.80)	23.64 (1.09)	27.95 (1.18)	25.54 (1.35)
Summer	Naïve Overall	24	27	34	38
	Mean (SE)	27.33 (1.95)	31.13 (2.48)	38.96 (2.82)	42.26 (2.59)
	Naïve Native	24	21	20	20
	Mean (SE)	27.33 (1.95)	23.46(1.83)	20.70 (0.74)	21.05 (1.29)
Overall	Naïve Overall	34	36	49	58
	Mean (SE)	36.98 (1.53)	40.07 (2.69)	56.52 (3.45)	64.53 (3.39)
	Naïve Native	34	28	30	29
	Mean (SE)	36.98 (1.55)	29.68 (1.28)	31.93 (1.13)	30.26 (1.34)

Table 7: Naïve and estimated species richness of different land-use types at a regional scale. The estimated richness was calculated using bootstrap methods for sample-based rarefaction.

5.3 Overall Bird Abundance

Average bird abundance was higher in intensive agriculture as compared to other land uses during both seasons (Table). The difference between intensive agriculture and protected grasslands was marginally non-significant at $\alpha = 0.05$ in winter but was significant during the summers (Range_{intensive agriculture} = [333.8,616.5]; Range_{Protected Grasslands} = [177.5,396.4]). Rangelands and non-irrigated croplands had notably low average abundance during both the seasons (Figure 5, Table 8).

After controlling for non-native species, the average abundance in different land-uses was only marginally different during winter (ANOVA: F-value=2.07, p-value=0.053), but was significantly higher in irrigated croplands during summer (ANOVA: F-value=9.14, p-value <0.0001). Controlling for non-native species resulted in roughly 30% reduction in mean abundance of birds in irrigated croplands but did not change the abundance in other land uses significantly (Table 8).

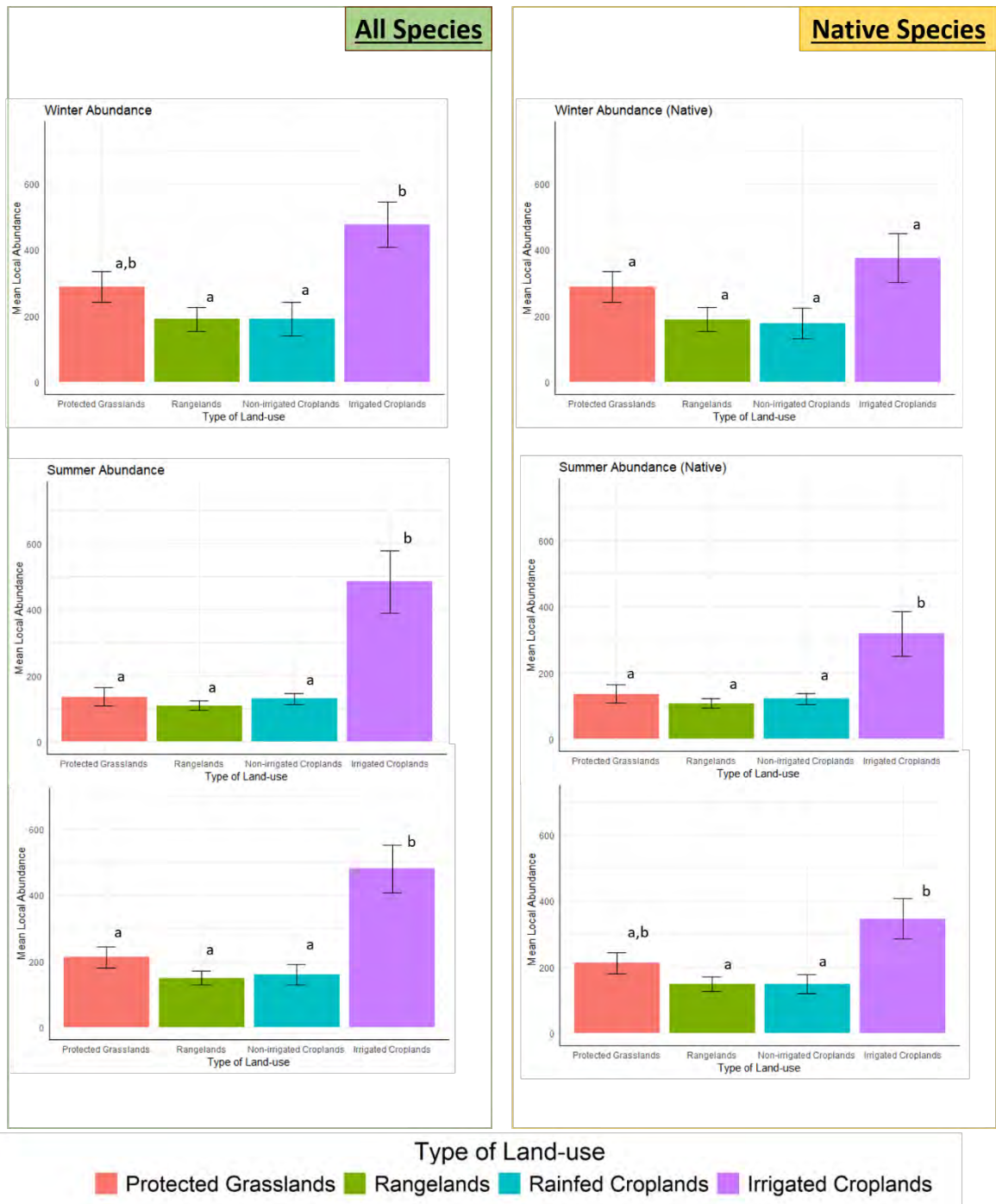


Figure 5: Bar plot representing the mean abundance (per sq.km) of all species (left) and native species (right) across land-use types during winter (top), summer (middle) and both seasons together (bottom). The error bars represent the standard error on the mean. The superscript on the error bars represents the grouping of different land-uses according to multiple comparisons with Tukey's post-hoc test.

Season	Parameter	Protected Grasslands	Rangelands	Non-irrigated Croplands	Irrigated Croplands	p-value
Winter	Mean (SE) Overall	287 (46.14)	189.3 (36.7)	189.5 (50.95)	475.2 (68.37)	0.005
	Mean (SE) Native	287 (46.14)	188.8 (36.75)	176.8 (47.11)	374.7 (73.5)	0.053
Summer	Mean (SE) Overall	135.9 (26.88)	109.5 (14.59)	130 (16.59)	484.2 (94.4)	<0.0001
	Mean (SE) Native	135.9 (26.88)	107 (14.4)	121.4 (16.4)	317.9 (68.2)	<0.0001
Overall	Mean (SE) Overall	211.4 (32.22)	149.4 (21.61)	159.7 (30.48)	479.7 (71.8)	<0.0001
	Mean (SE) Native	211.4 (32.22)	147.9 (21.57)	149.1 (28.87)	346.3 (61.7)	0.002

Table 8: Estimated mean abundance (per 1km transect) of all bird species and native bird species in different land-use types during winter and summer. Subscripts along the means indicate grouping according to Tukey's post-hoc test at 95% significance level.

5.4 Bird community composition across land uses

Community composition, at the landscape scale, changed progressively with intensification of land use. Protected grasslands had two unique species across the year that were not found in any other land-use, while low-intensity agriculture and rangelands respectively had two and one unique species. However, this could be an artefact of detection and more sampling could've revealed these unique species in other land uses. On the other hand, fourteen species were unique to Intensive agriculture, which is substantial even after considering the species that could have been missed due to imperfect detection in other land-uses. Two threatened species – Great Indian Bustard (Critically Endangered) and McQueen's Bustard (Vulnerable) – were recorded during the study and both were found only in protected grasslands.

Ordination using NMDS displayed perceivable differences in bird communities of different land use types during both seasons. Permutational test of multivariate dispersion showed that multivariate dispersion amongst the groups was homogenous and the data was suitable for performing perMANOVA analysis (Permutational test for multivariate dispersion: $p_{\text{winter}} = 0.83$, $p_{\text{summer}} = 0.64$, $p_{\text{overall}} = 0.41$). The perMANOVA results indicated strong evidence against the null hypothesis that 'there is no significant difference in bird communities between land use types' (perMANOVA: $p_{\text{winter}} = <0.001$, $p_{\text{summer}} = <0.001$, $p_{\text{overall}} = <0.001$). Pairwise post-hoc comparison of perMANOVA results with Bonferroni correction of p-values suggested that during both

the seasons and year-round, the communities of Irrigated croplands were significantly different from the communities of all other land use types (perMANOVA – All combinations: $p_{\text{winter}} = <0.01$, $p_{\text{summer}} = <0.01$, $p_{\text{overall}} = <0.01$). Communities in protected grasslands did not differ significantly from communities in rangelands (perMANOVA: $p_{\text{winter}} = 1.00$, $p_{\text{summer}} = 1.00$, $p_{\text{overall}} = 1.00$) and low-intensity croplands (perMANOVA: $p_{\text{winter}} = 0.43$, $p_{\text{summer}} = 0.26$) during individual seasons, but year-round species composition in protected grasslands differed from that of low-intensity croplands (perMANOVA: $p_{\text{overall}} = <0.01$). Bird communities in rangelands were not significantly different from the communities in low-intensity croplands (perMANOVA: $p_{\text{winter}} = 1.0$, $p_{\text{summer}} = 1.0$, $p_{\text{overall}} = 1.0$) during any season or year-round.

The inferences remained largely similar to the earlier results even after controlling for non-native species, showing difference in native community for at least one land use type (perMANOVA – All combinations: $p_{\text{winter}} = <0.01$, $p_{\text{summer}} = <0.01$, $p_{\text{overall}} = <0.01$). The average community structure of native species was different in intensive cropland than any other land-use type during all seasons (perMANOVA – All combinations: $p_{\text{winter}} = <0.01$, $p_{\text{summer}} = <0.01$, $p_{\text{overall}} = <0.01$). Low-intensity croplands had different native communities than protected grasslands in winter (perMANOVA: $p_{\text{winter}} = 0.024$) but similar communities in summer (perMANOVA: $p_{\text{summer}} = 1.0$). Native communities in rangelands were very similar to communities in both protected grasslands and non-irrigated croplands during both the seasons.

The significant difference in community composition even after controlling for non-native species indicated that the change in overall community composition between land-uses is partly driven by change in composition of native species. To further substantiate the claim, Analysis of Similarity was carried out between combinations of land uses in both seasons and all species as well as only native bird species. The magnitude of difference between Irrigated croplands and other land uses reduced when non-native species were excluded. This shows that newly ingressed species are also influencing the overall community structure to a significant extent in irrigated croplands but not in other land-use types (Figure 7).

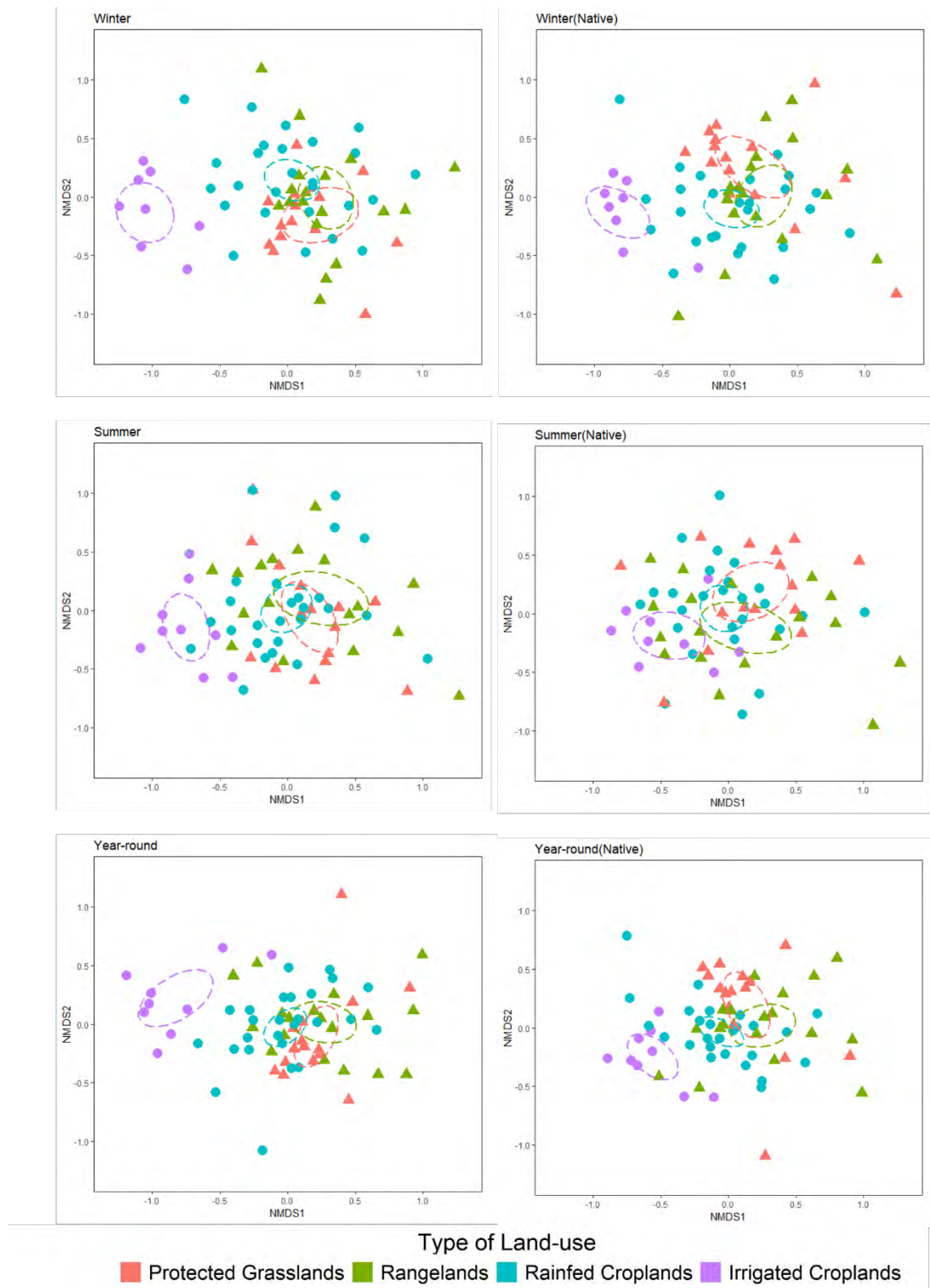


Figure 6: NMDS ordination showing bird community composition (above) of all bird species (left) and native bird species (right) in different land-use types during winter (top), summer (middle) and both seasons together (bottom). The ellipsoids are centred at mean MDS value of both axis and the radius is determined by the standard error of mean at 95% C.I. Stress values of all plots were less than 0.25 and the non-metric fit was more than 90%.

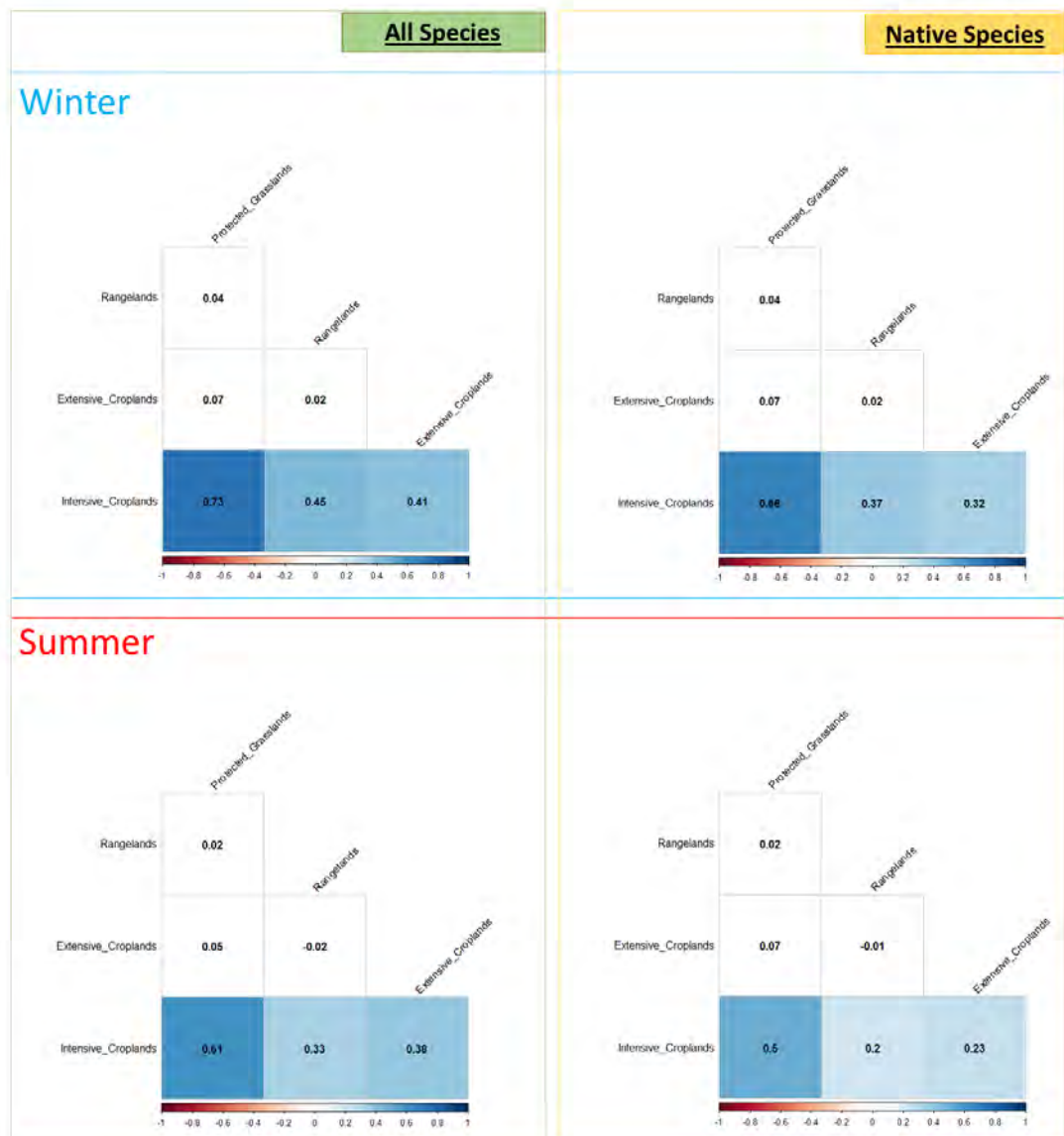


Figure 7: ANOSIM R-values indicating similarity of bird communities between respective combinations of land-use types during winter (above) and summer (below), with all species (left) and only native species (right). The values range from -1 to 1 with values close to 0 indicating random grouping or low dissimilarity in communities and values closer to the extremes indicate grouping or higher dissimilarity in communities. Every square has two land-use types associated with it and indicates the R-value between the particular combinations. The values in colour represent significantly different values at 95% significance and the values without any colour (white) represent an insignificant difference.

5.5 Drivers of species richness and abundance

The factors influencing species richness varied between the two seasons. In winter, comparison of alternate hypotheses showed that species richness was positively influenced by crop volume ($\beta_{\text{top model}} = 0.12$ (0.03), $p < 0.05$) and foliar biomass of woody plants ($\beta_{\text{top model}} = 0.10$ (0.03), $p < 0.05$) and negatively influenced by

forb volume ($\beta_{\text{top model}} = -0.15$ (0.005), $p < 0.05$). The best fitting model explained the data fairly well with a McFadden's R^2 value of 0.40 (Figure 8, Table 9)

Table 9: Comparisons of best fitting models with the global model. The model was selected based on the AICc criterion.

<u>Season</u>	<u>Model</u>	<u>d</u> <u>f</u>	<u>logLik</u>	<u>AICc</u>	<u>delta</u>	<u>R²</u>
Winter	~Crop+Forb+wpd (Best)	4	- 165.47	339.60	0	0.5 2
	~Crop+Forb+GBH+wpd	5	- 164.69	340.40	0.80	0.5 3
	~Crop+veg_diversity+Forb+I(Forb^2)+ GBH+ Grass+wpd (Global)	8	- 164.22	347.02	7.41	0.1 6
Summer	~wpd+Forb+veg_diversity (Best)	4	- 162.97	334.60	0	0.6 5
	~Crop+veg_diversity+Forb+wpd	5	- 162.96	336.95	2.34	0.6 5
	~Crop+veg_diversity+Forb+I(Forb^2)+ GBH+ Grass+wpd (Global)	8	- 162.66	343.90	9.29	0.6 5

During summer, the species richness was positively affected by foliar volume of woody plants ($\beta_{\text{top model}} = 0.18$ (0.03), $p\text{-value} < 0.0001$), compositional heterogeneity of vegetation ($\beta_{\text{top model}} = 0.10$ (0.04), $p\text{-value} = 0.01$) and negatively affected by the forb biomass ($\beta_{\text{top model}} = -0.28$ (0.07), $p\text{-value} < 0.001$) (Figure 8)

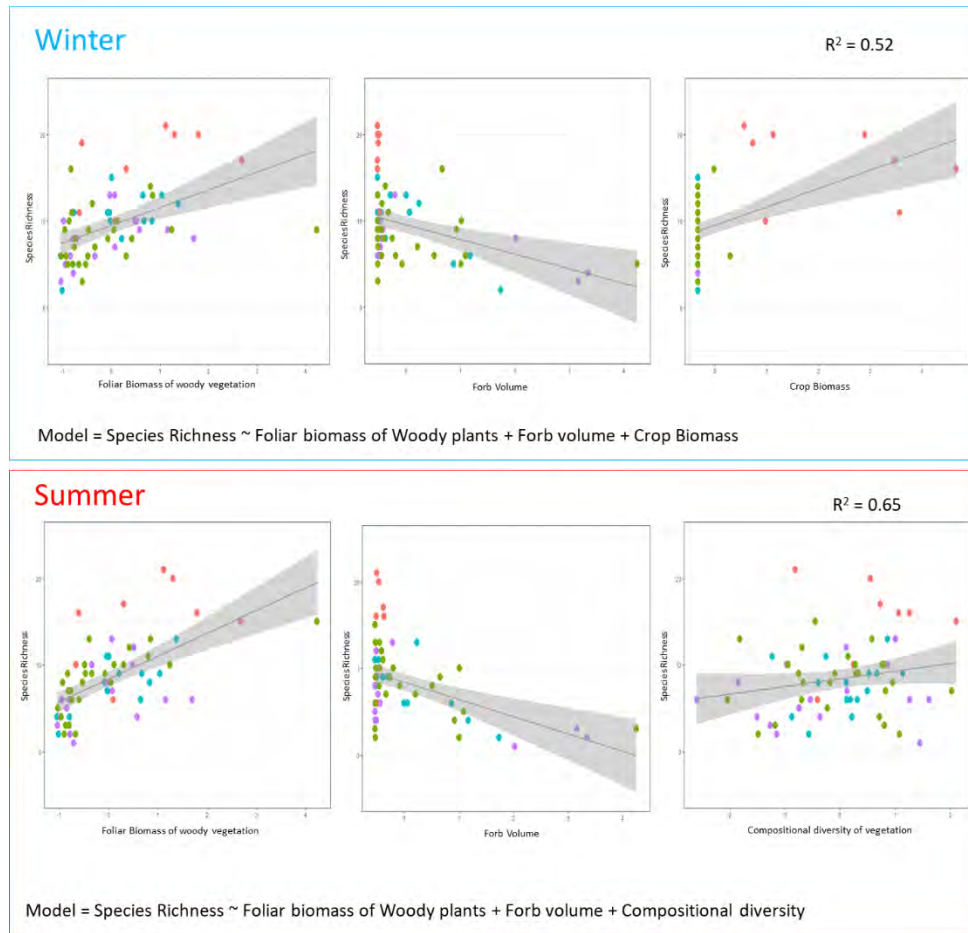


Figure 8: Habitat correlates of species richness during winter (top) and summer (bottom). The parameters were based on the best fitting model for each season. The significantly influential variables in winter were foliar biomass of woody vegetation (left), forb biomass (middle) and crop biomass (right). Similarly, the explanatory variables in summer were foliar biomass of woody vegetation (left), forb biomass (middle) and compositional heterogeneity of vegetation (right).

Results of canonical correspondence analysis, conducted to understand the habitat correlates of bird composition are depicted in Table 7. In winter, the global model with all the variables explained 19% of the variance after constrained ordination but had two variables that were correlated (Variance inflation factor (GBH_winter and wpd = 3.4). Term-wise permutational MANOVA on the models suggested that Crop volume, Grass volume and woody plant foliar volume were significantly influencing bird community composition in winters (Table 10). The final constrained ordination with three significantly influential variables explained 14% variance in the data (Figure 1).

Table 10: Results of Canonical Correspondance Analysis for both the seasons. a) represents the entire global model; b) represents the global model without collinear variables and c) is the simple model with only significantly influential variables

Model	Formula				Proportion (constrained)
Winter	a) Winter_spe ~ Crop_winter+ grass_winter + wpd + Forb_volume_Diversity_winter+GBH_winter				0.19
	b) Winter_spe ~ Crop_winter + grass_winter + wpd + Forb_volume_Diversity_winter				0.17
	c) Winter_spe ~ Crop_winter + grass_winter + wpd				0.14
	Variable	dF	F	Pr	
	Crop_winter	1	6.2739	0.001	
	grass_winter	1	2.4758	0.005	
	Wpd	1	1.758	0.107	
Summer	a) Summer_spe ~ Crop_summer+grass_summer+ wpd + Forb_volume_Diversity_winter+GBH_winter				0.18
	b) Summer_spe ~ Crop_summer+grass_summer+ wpd + Forb_volume_Diversity_winter				0.15
	b) Summer_spe ~ Crop_summer+ wpd				0.11
	Variable	dF	F	Pr	
	Crop_summer	1	4.409	0.001	
	Wpd	1	4.1341	0.016	

The same procedure was repeated in summers, and the results indicated that crop volume and woody plant foliar biomass were significantly affecting bird community composition in summer (Table 10). The final model with two variables explained 11% of the constrained variance in community composition data (Figure 10).

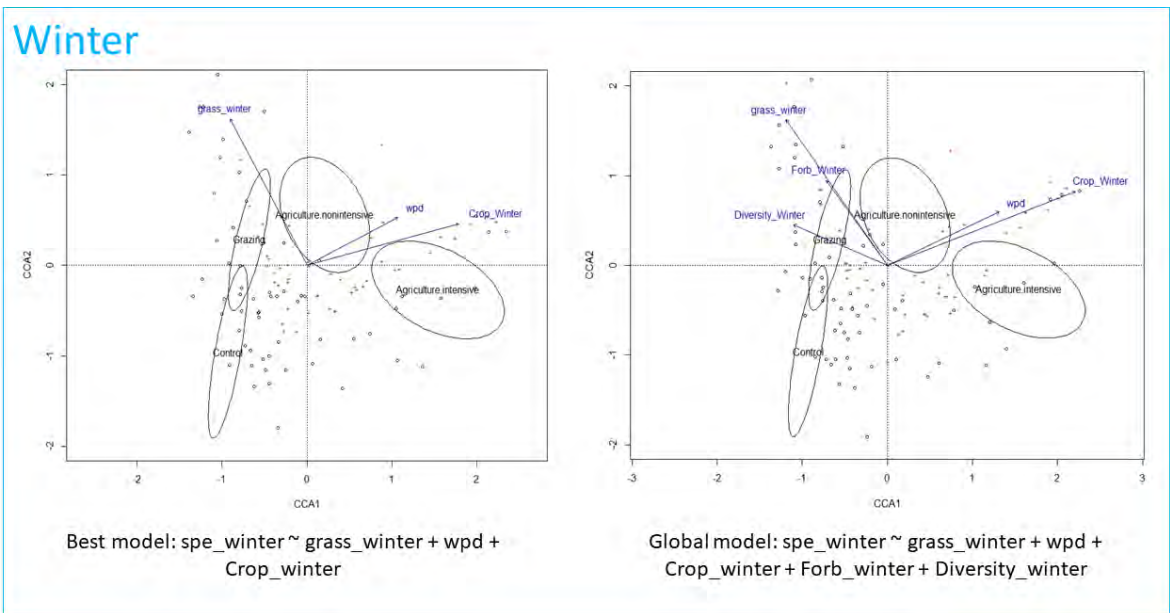


Figure 9: CCA biplot for Winter with full global model (left) and simple model with significantly influential variables (right).

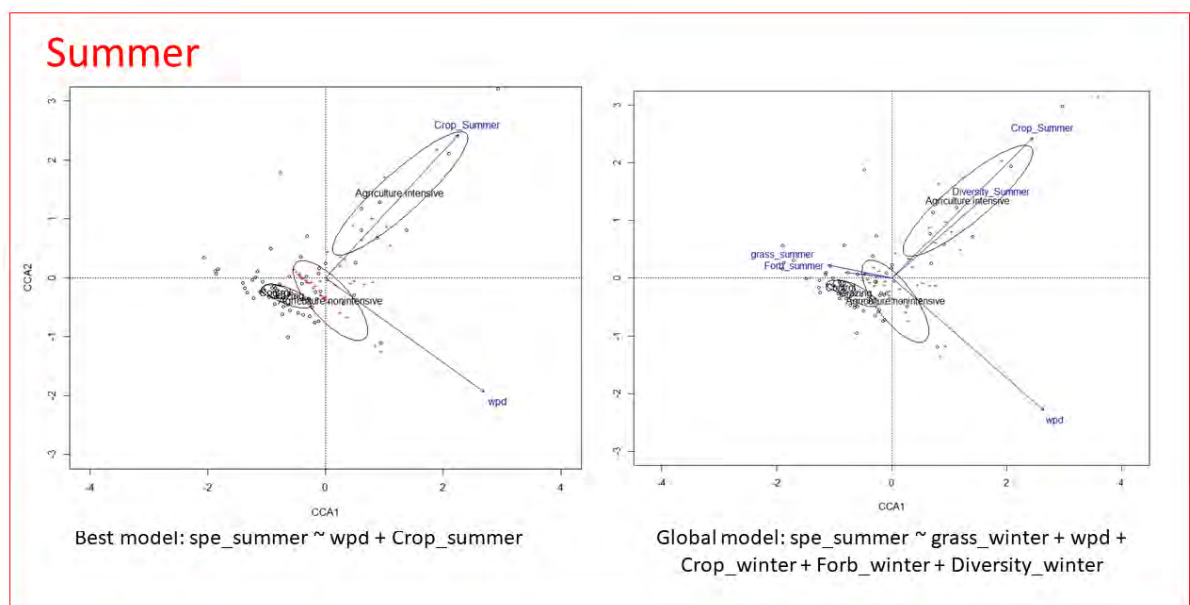


Figure 10: CCA biplot for Summer with full global model (left) and simple model with significantly influential variables (right).

6. Discussion

The results of the study broadly suggested that bird communities do not change significantly in response to low-impact land-uses like pastoralism and extensive agriculture but change drastically as agriculture intensifies with the advent of irrigation. This pattern is conserved across different seasons, although the magnitude of difference within communities changes with season. The change in bird communities correlates with the sequential change in structure and composition of vegetation in both the seasons. Analysing patterns of species richness against environmental variables suggests that the process of community assembly across land-uses is affected by habitat factors such as forb biomass, crop biomass, vegetation heterogeneity and woody plant foliar biomass. The results of this study provide novel information regarding the effects of land-use change on avifauna of the landscape and progresses our understanding of how anthropogenic processes lead to change in community assembly.

6.1 Patterns of vegetation across space and time

The composition and structure of vegetation changed progressively with intensifying change in land use. The similarity in vegetation structure of rangelands and rainfed croplands is superficially caused by two factors: 1) High pressures of grazing in rangelands have reduced the grass biomass so drastically that the understory is now very similar to the largely tilled understory of rainfed croplands. 2) Low-intensity farming does not change woody plant species like *Capparis decidua*, *Zizyphus nummularia*, significantly. The slight difference of bird composition in rainfed croplands and rangelands was potentially due to loss of perennial grass species after tilling and due to presence of early successional species like *Aerva pseudotomentosa*, *Dipterygium glaucum* in the fallow regenerating croplands. On the other hand, the vegetation composition of intensive agriculture was expectedly different from all the other land uses. This was due to four reasons: 1) Progressive clearance of original vegetation over the course of agriculture intensification; 2) Plantation of new, originally non-native species such as *Acacia nilotica*, *Dalbergia sisoo*, *Acacia senegal*, *Prosopis juliflora* etc. on hedges; 3) Change in understory due to farming and presence

of crops. 4) The selective proliferation of certain native species (eg. *Calotropis procera*, *Zizypus nummularia*) owing to changed conditions. This change in composition was also associated with a change in structure as farm-crops and newly planted were very different from originally present plants in their structural profile.

Temporally, two major changes were likely to occur in the vegetation of the study area during the sampling period. The most noticeable change that predictably occurred was the change in structure of vegetation understory in intensive agriculture after harvest of crops in late winter. Most croplands were left fallow after harvest and thus became structurally very similar to extensive agriculture. Additionally, succession of vegetation in these newly fallow fields resulted in structural and compositional convergence between intensive agriculture and the other land-uses, especially non-intensive agriculture (Figure 2). The second change that could have potentially changed vegetation was removal of biomass due to livestock grazing in rangelands and rainfed croplands. However, this change was minimal in the current scenario as most of the palatable biomass in the rangelands and rainfed croplands was already grazed out by the start of winters. Thus, the grass biomass was largely unchanged across seasons in these two land-uses. Protected grasslands remained unaffected by both these changes and were similar in composition and structure during both the seasons. Vegetation in rangelands and rainfed croplands also did not differ significantly between the two seasons. Intensive agriculture, however, changed notably in structure during the two seasons and became structurally similar to other land uses in the summer.

To summarise, the results suggest that rangelands and rainfed croplands are very similar to protected grasslands in terms of vegetation structure and composition during both seasons. Intensive agriculture at the current levels has notably distinct habitat during the winter but become relatively more similar to extensive agriculture and other two land-uses after turning fallow during the summer.

6.2 Bird community responses to intensifying land use

The patterns of species richness, abundance and composition of local bird communities can be summarised on two distinct fronts –

a) Protected grasslands with regulated low-intensity grazing and rangelands with unregulated high-intensity grazing had very similar bird communities in terms of species richness, abundance and composition. This suggests that livestock grazing does not notably alter the niches available for bird species. However, notably, the current year being a drought resulted in many protected grasslands being grazed by livestock reducing the herbaceous height and cover; and making it more similar to rangelands with unregulated grazing compared to good rainfall years. Thus, it would be important to replicate the study in good rainfall years when protected grasslands are actually less grazed, to see if these inferences hold true. Similarly, bird communities in rainfed croplands having low-intensity unirrigated agriculture were also not very different from communities in protected grasslands and indicated only a slight change in the niche space. These results did not differ even after controlling for non-native species, thus confirming that the converging parameters were not due to replacement of native species by new ones. The almost identical community parameters also show that livestock grazing and extensive agriculture at the current level of intensity is not very detrimental for bird communities and alternately provides secondary habitat for many bird species. This compatibility of low-intensity land-uses with birds may have resulted from a very long association as these landscapes have experienced human footprint and moderate human modification of landscape from historical times, allowing wildlife to adapt and co-occur (Rangarajan 2017, Dutta 2018).

b) On the other hand, irrigated croplands with high-intensity agriculture had much higher species richness and abundance at the local scale but also had significantly different community composition. The higher species richness and overall abundance were due to ingression of originally non-native mesic species, whose colonization was potentially facilitated by the presence of surface water and the associated creation of a new microhabitat. Local bird richness and abundance remained significantly higher even after controlling for non-native species and indicated that the new habitat can fundamentally be used by the native species. However, the significant change in bird community composition even after controlling for newly colonised species suggested that individual species respond differentially to this new habitat and some native species are negatively affected or lost entirely due to this intensification of land-use.

These patterns at the local scale species richness, abundance and composition apparently indicate that expansion of low-impact land-use does not have negative impacts on native bird communities until irrigation driven intensification sets in. However, this notion cannot be fortified without looking at these patterns from a landscape perspective, while also checking seasonal differences in patterns and studying effects on populations of individual species. Apart from this caveat, my results at the local scale indicate that – a) intensively grazed grasslands and rainfed croplands can be important habitats for grassland birds as the communities of these land-uses are very similar to protected grasslands in terms of richness, abundance and community composition. b) Irrigated high-intensity croplands can also sustain native bird communities but cause significant change in community structure potentially due to differential changes in abundance of individual species. c) High-intensity/Irrigated agriculture supports the colonisation of erstwhile non-native bird species, thus increasing local-scale species richness and abundance. The potential causes, mechanisms and correlates of these patterns are discussed in the upcoming sections.

The findings of this study corroborate results of many others across the globe in suggesting that low-impact land use types like rangelands and low-intensity croplands can provide important habitat for open-habitat species (Dutta & Jhala, 2014; Kamp et al., 2011; Leonard A. Brennan, 2005; Wright et al., 2012). Similarly, the results are also congruent with studies that have found intensification of agriculture beyond a certain threshold to have negative impacts on native bird communities in both grasslands (Chamberlain et al., 2000; Donald et al., 2001; Kamp et al., 2011; Phalan et al., 2011) and forests (Elsen, Ramesh, & Wilcove, 2018).

6.3 Effect of changing land-use on regional bird species pool

As the local composition of birds was not very different between protected grasslands, rangelands and extensive agriculture, it is fair to assume that the latter can act as secondary refugia for most of the species. However, community composition at the local scale does not tell us the effects of land use on all species especially the intrinsically rare species. Hence, it is important to check the effects of land use on regional species pool to check whether some species get lost due to change in

habitats. This would essentially involve checking the landscape scale species richness and how it changes with change in habitats.

Similar to local species richness, landscape-scale species richness was also highest in intensive agriculture, followed by extensive agriculture. However, this regional species richness reduced drastically in both seasons when non-native species were excluded from the analysis, and was significantly lower than protected grasslands. The higher naïve and estimated species richness in protected grasslands suggests that none of the production land uses can independently sustain all species in the native regional pool. But at the same time, the presence of only two unique species in protected grasslands indicates that a combination of multiple low-impact production landscapes, extensive agriculture and rangelands in this case, can together sustain most of the regional species pool. This further highlights the importance of these two low-impact land-uses as secondary habitats for bird species.

6.4 Seasonality of patterns

The patterns of local community structure in terms of species richness, abundance were fairly similar between two seasons for protected grasslands, rangelands and rainfed croplands. The major change in patterns was with intensive agriculture. Community composition in intensive agriculture was very different during the winter but became similar to other land-uses during the summer. The use of intensive agriculture by native birds during summer suggests that at the current level of intensity, it can still form a secondary habitat for birds during the breeding season. Unlike many other studies which show the ubiquity of primary habitat during the breeding season (Elsen et al., 2016), the results of this study suggest that native birds use production land-uses even during the breeding season. My observations indicate that some species such as Black-crowned Sparrow-Lark, Common Babbler, White-eared bulbul etc. were using them as their breeding sites. Many other species such as Purple sunbird, Eurasian collared-dove, Indian silverbills locally migrated to these irrigated croplands in cropping season because of the availability of food. Their presence however could've been due to the availability of natural habitats in the vicinity that could act as a potential refugia. In the absence of such natural habitats in

surroundings, as would be the case for complete agricultural landscape, these birds are unlikely to persist.

6.5 Habitat correlates of species richness and composition at local scales

Species richness across all land uses was influenced by crop biomass, woody plant biomass and forb biomass. During winter, species richness increased with crop biomass, a parameter intimately associated with intensification of agriculture; probably because of the associated increase in productivity and creation of new microhabitats due to irrigation. Increase in foliar biomass of woody trees expectedly increased species richness as they provide important resources in terms of food (especially insects) and cover (nesting substrate, thermal refugia). Whereas, forb biomass was inversely related to the bird richness, during both the seasons. The decrease in species richness with increase in forb biomass was due to proliferation of unpalatable species like *Aerva javanica*, *Haloxylon salicornium* and *Dipterigyium glaucum*, which did not allow regeneration of other trees or grass in the vicinity. These species commonly colonise regenerating agricultural fields and overgrazed grasslands and are hence a direct consequence of land use. During summer, compositional diversity of vegetation also increased bird species richness potentially suggesting that birds use more heterogeneous habitats during the breeding season. . This may perhaps result from the need of different microhabitats to complement contrasting ecological needs of breeding birds that would corroborate the concept of landscape complementation.

Similar to species richness, community composition was also affected significantly by crop volume and woody plant foliar volume. Additionally, grass volume also had an effect on composition in the winter season. During summer, crop volume and woody plant foliar biomass were influential in driving bird community composition. Most native species had lower than average optimum for crop volume during both the seasons suggesting that farming and associated factors negatively influence native bird communities.

6.6 Conservation implication: Reconciling human needs with wildlife conservation

Primary habitats are often associated with greater richness and abundance as compared to production land-uses and considered irreplaceable for biodiversity conservation (Lee et al., 2011). Results from my study suggest that although primary grassland habitat is essential to save the full spectrum of the regional species pool, low-impact land-uses can act as important secondary habitats for conservation of bird species. The local level patterns suggest that livestock grazing and extensive agriculture do not have drastic negative impacts on bird community structure and are together able to sustain most of the species even at a regional scale. My findings further support the notion that strategically managed production landscapes can be important sites for conservation, and a secondary alternative to protected areas where the creation of one is not feasible (Dutta & Jhala, 2014; Elsen et al., 2016; Wright et al., 2012). However, these findings need to be augmented with species-level population data that examines how species' densities and not just occurrence (as reflected by species richness) depends on land-use types and habitat structure, as proposed by Green et al, Phalan et al.

A landscape approach for conservation has often been advocated for the conservation of grasslands in India but very few studies have investigated whether such an approach is ecologically feasible (Dutta et al., 2011). Evidence from this study supports the approach of conserving grasslands as large-landscapes strategically managed as agro-pastoral mosaics with small protected areas embedded in them. This strategy can potentially conserve all the regional species while not compromising on the human needs, as shown by empirical evidence gathered in this study and many others (Dutta & Jhala, 2014).

In the Thar desert, the Desert National Park Wildlife Sanctuary is the largest protected area with more than 3000 sq.km. under protection (Dutta et al., 2017). However, it is also home to more than 50,000 people who depend completely on agro-pastoralism within the sanctuary. Unsurprisingly, the use of land within the sanctuary has been the epicentre of unrest between the local people and the local forest department for many years. Evidence from this study suggests that low-impact use of

land coupled with habitat management like removal of forb species, controlling logging by provision of alternate firewood supply and reseeding of grass in forb affected area can help conserve general bird diversity without hampering livelihood needs. Another alternative could be setting up sustainable community farms where agro pastoralism can be strategically managed to achieve biodiversity conservation while also sustaining human livelihoods.

6.7 Caveats and methodological issues

The biggest caveat of the study comes from the fact that birds can travel large distances and are not bound to a particular habitat. Thus, the landscape scale species richness estimate can only be interpreted as the number of species able to use a particular habitat and does not indicate whether the habitat or land-use is able to sustain a particular species. Similarly, mean local richness also indicates the number of species using the habitat on an average, without giving any information about the identity or abundance of the species. Further the results are averaged across a large number of sites and can potentially be inflated by rare species, abnormal plots or by species which are vagrant to the habitat. This problem can be overcome by additionally inferring results from the ordination of community composition data, in which every independent point is at the site level and then grouped at the habitat level. Community composition data can reveal the broad patterns with consideration of species identity and is robust to some of the problems associated with univariate measures such as species richness. However, most common ordination techniques are not sensitive to individual species and similar compositional patterns of dominant species can often mask a differential pattern shown by a relatively rare species. Considering these caveats, it is essential to look at all the community parameters like species richness, abundance and composition together before making generalised inferences. Data on occurrence and abundance of individual species and other community-level properties like functional diversity can make the inferences even more robust.

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FACTORS THAT SHAPE VEGETATION IN THE ARID ZONE OF INDIA

Dissertation submitted to Saurashtra University, Rajkot
in partial fulfilment of
Master's Degree in Wildlife Science

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CERTIFICATE

This is to certify that **Ms. S. Aaranya Gayathri** has carried out an original piece of research in partial fulfilment of Master's Degree in Wildlife Science from the Saurashtra University, Rajkot, Gujarat. The topic of her dissertation is "**Factors that shape vegetation in the arid zone of India**". The study was carried out under our supervision from December 2018 to June 2019. We hereby certify that this work has not been submitted for any degree to any university



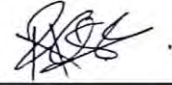
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-S. Aaranya Gayathri

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Executive Summary:

In the current era of Anthropocene, it has become increasingly important to make predictions in plant-animal distributions as a function of the predicted changing conditions. Thus, the need to determine what shapes different vegetation structures are recognised, but, the results are often scale specific and rarely single factor determined. We investigate what causes a vegetation structure shift from a grassland to savanna and their possible intermediate transitions in the Thar Desert, North-Western Rajasthan, India. We sampled for vegetation in 67 one km² grids spread across a 10,235 km² study area capturing heterogeneity in precipitation. We analysed soil samples collected from sampled grids for soil texture, water holding capacity, total organic carbon, rodded and loose bulk densities. We collared three types of livestock (n=28) to determine potential grazing pressure in the sampled grids as one of the determinants. We used generalized linear models and non-metric multidimensional scaling to determine the determinants of vegetation structure and community. Our results show a clear scale dependence on how the determinants act– precipitation defines the larger community attributes such as species richness ($R^2=0.39$, $p= 1.029e^{-06}$); soil compaction under the precipitation umbrella defines the vegetation structure (and hence shift from grassland to savanna etc.) and grazing pressure (especially from the smaller livestock) defines the proportion of the life forms within each vegetation structure.

The role of environmental determinants in determine vegetation shifts assures that the transitions are going to be gradual. This precludes the frequent finding of grasslands shifting to a shrubland or forest due to livestock grazing. This could be attributed to our finding of livestock having no forage preference to any particular species ($\chi^2=25.76$, $df=18$, $p=0.1003$) or life forms ($\chi^2= 5.1939$, $df = 2$, $p = 0.0745$) or possibly due to the low variation in livestock grazing in this landscape. We also found that change in the environmental determinants, however, can lead to two or three possible structure types. A predictive modelling shows the presence of mixed grassland, soft grassland, tree savanna, and tree-shrub savanna in the study area. However, the map also indicates that 62.7% of it is already lost to agriculture/settlement. Enclosures of Desert National Park protects only one vegetation structure type and covers less than 1%. We

emphasize the urgent need to delineate conservation areas based on requirements of faunal species of interest and its habitat requirements before a complete wipe-out of vegetation structure types occur.

1. INTRODUCTION

Grasslands, savannas and forests (refer to Box 1.1 for definitions) occur as alternative stable states (Da Silveira Lobo Sternberg, 2001; Warman and Moles, 2009), but the transitions are disturbance driven and are fine-lined (Hirota et al., 2011; but see Zak and Nippert, 2012). However, these vegetation structures have distinct significance and their distributions are not easily reversible (Staver et al., 2011). Percent cover is considered one of the important vegetation structure defining characteristic (Fig.1). The trimodal distribution of %tree cover distinguishes grasslands, savannas and forests and defines where the transition between two structure types would occur.

The %tree cover is considered, however, to be predominantly determined by precipitation (Lehmann et al., 2014). Lehmann et al. synthesized that the tree cover increases linearly with precipitation until a saturation point which differs between the sampled continents, namely, Africa, Australia and South America. Nevertheless, there are other factors, sometimes their interactive effects that have been attributed to determining the vegetation structure. For instance, in just the South-African grasslands, the transition between grassland and savanna is debated to be limited by fire (Smit et al., 2010), soil properties or nutrient availability (Pellegrini, 2016) or mega-herbivory (Skarpe, 1992) or excessive grazing (Staver et al., 2009), or may be CO₂ (Bond and Midgley, 2000). Failing to come to a consensus on what prevents a vegetation structure shift from the grassland to savanna is termed the grassland-savanna problem (Mills et al., 2006). A similar resistance prevails while solving the savanna-forest problem (Bond, 2008; Veldman, 2016). In both these cases, it is not unapparent that the responses might just be scale dependent and/or an adaptive feedback that is locally determined as suggested by Mills et al. (2006).

In this anthropocene era, where land-use changes and predicted climatic changes are multiple, there is a pressing need to address the grassland-savanna-forest problem. This holds true for India which a home to five different types of grasslands (Chandran et al., 2016), savanna, forest and their transitional stages. Even though, the grasslands support some of the last remaining populations of many threatened fauna (Rawat and Adhikari, 2016), the

Box 1.1: Recent stance on what differentiates a grassland, savanna and forest

Tropical grasslands: 'grassland is defined as a non-wetland type with at least 10% vegetation cover, dominated or co-dominated by graminoid and forb growth forms, and where the trees form a single-layer canopy with less than 40% cover and 8 m height' (Dixon et al., 2014).

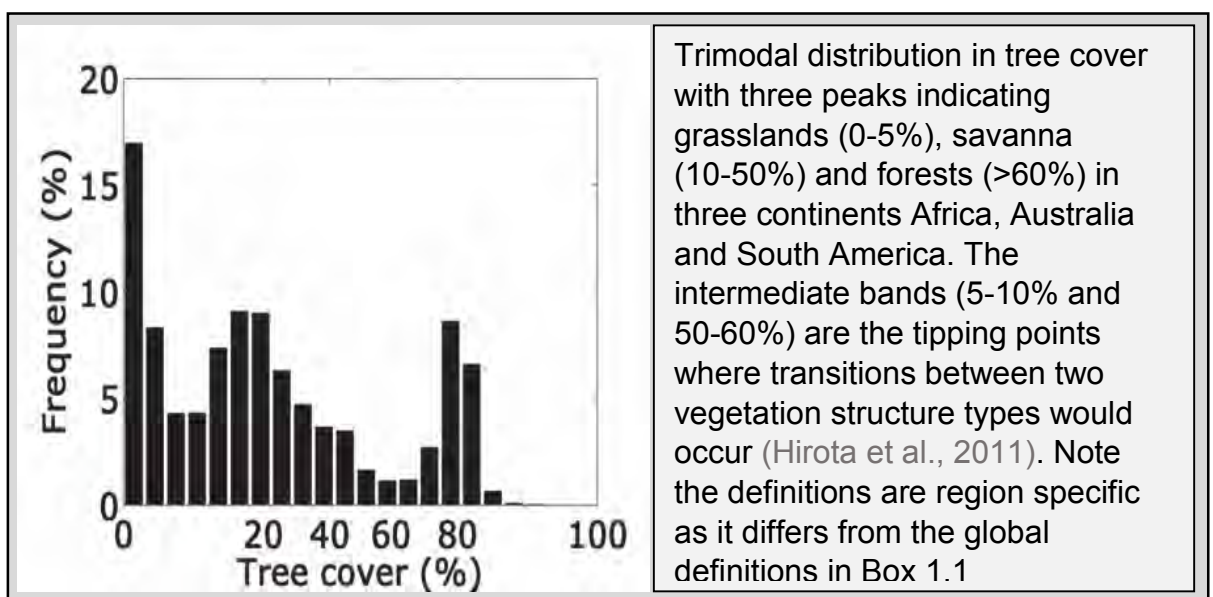
Tropical savannas: 'savannah has tree canopy cover between 20 and 80% and above-ground grass biomass exceeds 0.5 tonnes ha⁻¹' (Moncrieff et al., 2016)

Tropical forests: 'Forests are distinguished from savanna by having a tree cover of more than 80% with or without a continuous layer of grass'

Other similar terms:

Tropical grassy biomes: 'open grassland to densely canopied savanna with up to 80% tree cover. TGBs are distinguished from other tropical biomes principally through the presence of continuous C4 grass cover, widespread shade-intolerant plant species and the prevalence of fire (and frequently too, megaherbivory)' (Parr et al., 2014).

Fig. 1.1: Defining vegetation structure type based on tree cover percent



grasslands along with savanna are one of the most neglected ecosystems in the country (Singh et al., 2006). Owing to their less tree cover, they are often excluded from the 'forest' management policies in the country. A 50% wipe out of grasslands (including shrublands and pasturelands) is predicted to have occurred in India in the last 130 years (Tian et al., 2014). On the other hand, while a vegetation structure shift from grassland to savanna to forest could occur, Misra (1983) reported a reverse vegetation structure shift with the dry deciduous forests shifting to savanna due to excessive human-induced fires. A thorough description and map of the distinct vegetation structures are available for India (Gaussen et al., 1972, Roy et al., 2015). However, a few studies recognised the need to determine the factors that shape the diverse and distinct vegetation structures of India, though few in the light of preventing vegetation structures shifts.

Dabadghao and Shankarnarayan (1973) detailed in great depth the environmental conditions in which the graminoid communities in India exist, though not pertaining to any specific vegetation structure. Meher-Homji (1975) recognized the close relationship between the number of species and the aridity index while delineating the arid zones of India. This was further bolstered by the findings of Reddy et al., (2011) which indicate an apparent increase in tree species as precipitation increases in Rajasthan. With regard to vegetation structure shift, from wetland, tree-savanna, shrub-savanna to scrub-woodland, Perennou and Ramesh (1987) reported that salinity and moisture were major drivers causing ecosystem transitions in Keoladeo National Park, Rajasthan.

In Thar desert grasslands, many studies have highlighted that the climax graminoid, *Lasiurus indicus* are declining (Krishna et al., 2014; Mertia et al., 2006; Roy and Roy, 1996) and is gradually being supplanted by the shrub *Aerva pseudotomentosa* (Wada et al., 1995) due to excessive livestock grazing.

In this study, we address a part of the grassland-savanna problem. We investigate the relative importance of factors that shape the grassland, savanna and their transitional stages in the Thar desert of India with the following questions:

i) What determines vegetation composition in the arid grassland-savanna regions of India?

a) How do species richness and species composition change with climatic and edaphic factors, and livestock grazing?

ii) What determines vegetation structure in the arid grassland-savanna regions of India?

a) How do proportion of different life forms i.e. grass, shrub, tree, etc. change with climatic and edaphic factors, and livestock grazing?

b) How do vegetation structure i.e. grassland, savanna etc. change with climatic and edaphic factors, and livestock grazing?

Considering that livestock grazing is fairly a recent phenomenon in the landscape occurring rampantly only in the last three decades, we assume livestock grazing to have a negative impact on the grasslands. We assume the livestock grazing to be specific to some species or life-forms and hence reduce species richness and subsequently increase compositional similarity. Alternatively, we expect a positive relationship for richness and a negative relationship for compositional similarity as precipitation or the gradient in edaphic factors increase.

We expect grass density to decrease with increase in livestock grazing intensity, but, we expect an increase for shrubs and trees. We expect a similar relationship with soil rodde and loose bulk densities which determine soil compaction. We expect grass and tree to have a positive relationship and shrubs to have a negative with soil water holding capacity and precipitation. But we expect grass and shrub to have a positive relationship and tree to have negative with total organic carbon. We expect a coarse soil texture (i.e., more %sand) to support more shrub than grass or trees. Based on this we hypothesise the outcome of the interactions to give different vegetation structures (Table 1.1).

Table 1.1: Hypothesis for the vegetation structure we expect as a result of the interactive effect of the considered covariates

Vegetation structure type	Precipitation	Water holding capacity	%sand	Soil total organic carbon	Grazing intensity	Soil bulk density
Grassland	+	+	-	-	-	-
Shrubland	-	-	+	-	+	+
Forest	+	+	-	+	+	+

*We expect every other combination to result in a savanna. The savanna could be a shrub-savanna or a tree-savanna depending on the weightage of covariates that satisfies shrub density or tree density. eg., if grazing intensity and bulk density increases in a grassland, it satisfies two more criteria for becoming a forest, hence yielding a tree-savanna instead.

2. STUDY AREA

2.1. Study area

The study was conducted in the Thar desert grasslands of the North-Western Rajasthan, India. The Thar experiences 0 - 300 mm rainfall with temperatures ranging from 0°C in winter to 51°C in summer. A five year drought cycle is prevalent in this region. It is reported to have a floral diversity of 628 species belonging to 87 families (Bhandari et al., 1995). The region supports two dominant grassland communities, a climax *Lasiurus indicus* – *Panicum turgidum* (Roy et al., 2015; Reddy et al., 2011) and a non-climax *Dactyloctenium* sp. – *Cenchrus* sp. (Roy et al., 2015). Some of the distinct fauna this region supports include chinkara (*Gazella bennettii*), Indian hedgehog (*Paraechinus micropus*), spiny tailed lizard (*Saara hardwickii*) and a considerable population of the great Indian bustard (*Ardeotis nigriceps*) (Dutta et al., 2010). However, only 7.45% of the Thar Desert is under the protected-area network of India, all being wildlife sanctuaries. Among these, the 'Desert National Park' is the largest wildlife sanctuary (3162 km²), of which a small fraction of 170.25 km² of area is protected as enclosures and is technically inviolate.

2.2. Land-use changes in the region

In Jaisalmer alone there has been a 602% increase in croplands in 40 years from 1972-2012 (Status of Agriculture, 1974). This has especially been drastic in the recent years post the establishment of the Indira Gandhi Canal (IGC) which aimed at irrigating 9.5 lac ha of land in 7 districts of Rajasthan (Shrivastava et al., 2013). The consequences are however, not few. A combined effect of the canal and subsequent agricultural expansion has reportedly caused severe fluctuations in the ground water table (Santra et al., 2014; Tyagi, 2004 in Jaisalmer district, Rajasthan) and possibly increased precipitation (Rao, 1996 in Ganganagar district, Rajasthan). It has also been reported to have changed the soil properties from sandy to alluvial type in the Thar landscape (Tyagi, 2004) and accelerated plant encroachment especially by the planted *Prosopis* species. Further, due to reduced recognition of the grasslands as distinct vegetation structures, large scale plantations of *Vachellia tortilis* have been practiced in this landscape (Mohan et al., 2016). Solanki (1990), in an account of Jaisalmer, reported that

“..agriculture is rudimentary..”, with pastoralism being the only economy with about 2000 livestock constituting the migratory herds. However, the 2012 livestock census reported of a density of 83 livestock per km² in Jaisalmer. More than half of India’s livestock is dependent on natural fodder (Roy and Singh, 2013).

With rampant land-use changes occurring in this landscape, there are a few pressing concerns that need to be addressed i) with edaphic properties changing due to the IGC, which vegetation structures will shift and to what? ii) with the supposed severe increase in livestock grazing, will the grasslands incline to becoming a shrubland or a forest, a process termed as shrub invasion or woody plant encroachment (Bestelmeyer, 2005)?

3. METHODS AND ANALYSIS

3.1. Study Design

To obtain an optimal sampling block that provides a gradient in the environmental factors as well as be logistically less intensive, we chose a 10,235 km² (~150 x 90 km) area stretching from the IGC in the north to the Desert National Park in the south, henceforth intensive study area (26° 04' - 27° 34' N and 70° 10' – 71° 02' E) (Fig. 3. 1). We gridded the study block into 1 km² grids. Grids that overlapped with the 50 m buffer around croplands and settlements from the LULC map available were excluded from the intensive study area leaving 3186 potential grids for sampling (non-empty grids in Fig. 3.1(c)). We then extracted soil texture and precipitation indices for the centroids of these grids from the available maps using QGIS (QGIS, 2014) and RStudio (RStudio, 2019). Soil texture maps were obtained from Rajasthan NRSC website at 1 sq. km resolution (NRSC, 2016) while, precipitation data for August month (averaged across 30 years 1970-2000) was obtained from WorldClim at 2.5 km² resolution (Fick and Hijmans, 2017). We then performed a two factorial clustering of the grids, first by soil texture and then by precipitation (see supplementary information S1 for details on the procedure). This resulted in 53 unique soil texture-precipitation clusters. We then randomly selected a proportional sample of grids from each of the clusters to sample, keeping total required sampling grids as 70 and minimum for each soil texture-precipitation clusters as one. Four grids were sampled inside the enclosures of the Desert National Park which are expected to have regulated grazing. Grids with plantations were eliminated on visit and the closest possible adjoining grid from the same cluster were chosen for sampling.

In each of the grid, four 1 hectare plots of 50 x 200 m each were laid. A complete sampling was adopted for trees within the 1 hectare cell (henceforth ha). Shrubs were sampled at 5 x 5 m and grasses at 1 x 1 m with 5 spatial replicates within each 1 ha plot. Within each 1 ha plot we recorded data on species identity, girth (GBH for trees taller than 1.34 m and at base for otherwise), height from ground to the lower margin of the crown as well as min and max diameter of the crown using a 3 m measuring tape. The total height was estimated by keeping a reference stick of 1 m. The shrub and grass plots were made by creating a frame

using PVC pipes of desired dimensions joined in the corners using elbow connectors. Within the 5 x 5 m shrub plots we recorded species identity, min and max diameter and total height using a 3 m measuring tape, while for grasses we recorded species identity, dominant height and a visual estimation of the percentage cover (a visual representation of the sampling design is given in supplementary information S2). Visual estimation was carried out by visually dividing the 1 m² plot into 4 quarters and fitting all the grasses in these quadrats and estimating the total percent cover, i.e. if the grasses would fit into one quadrat completely it is taken as 25% cover. Species that tend to grow more than 2 m in height in this landscape and obtain a GBH of more than 10 cm were considered as trees, while the otherwise were considered as shrubs. Soil was collected up to a depth of 15 cm at five locations within each of the cells. Soil collected was sun-dried and labelled for later analysis.

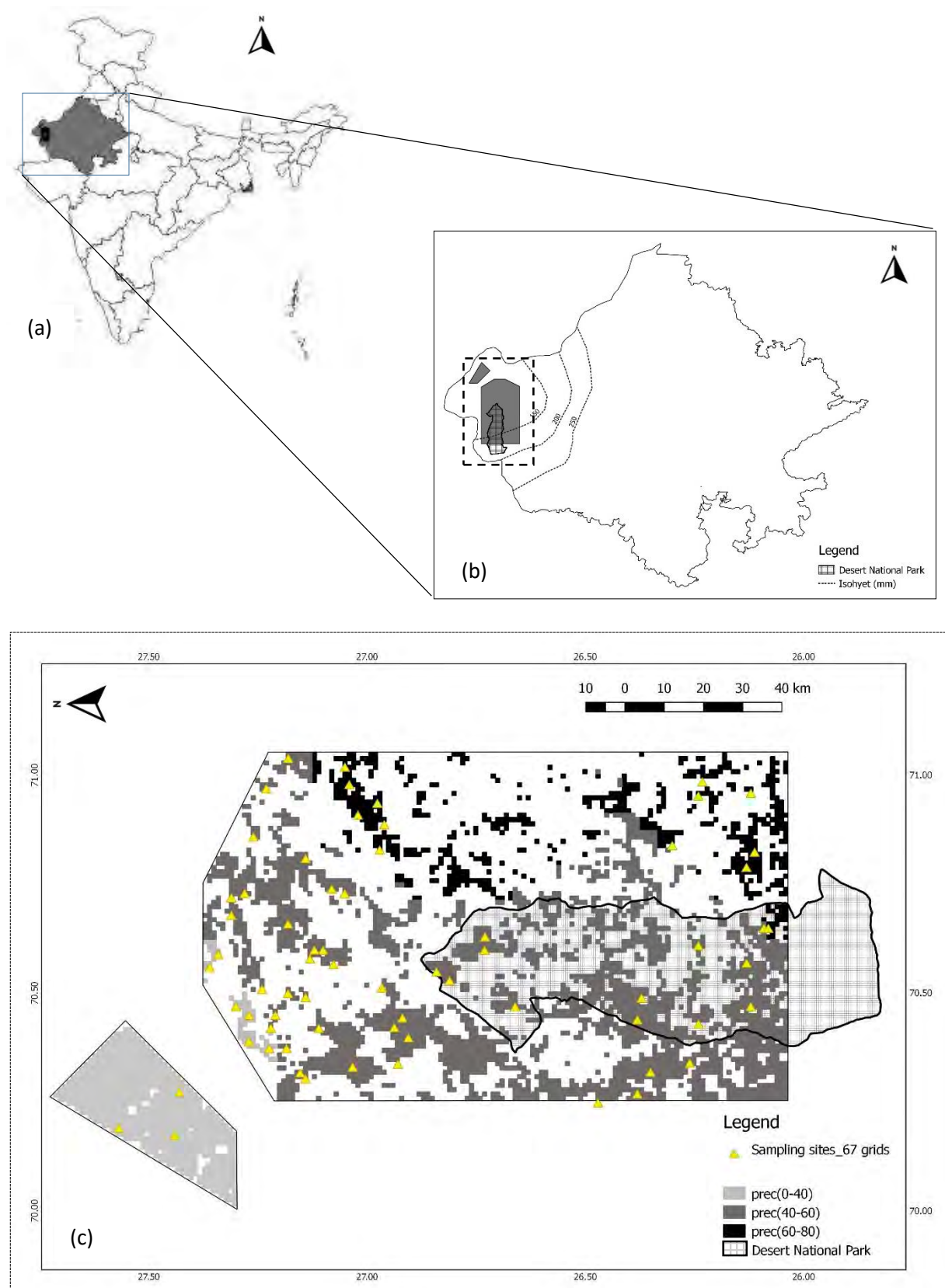


Fig. 3.1: Intensive study area (c) in State of Rajasthan (b), India (a)

The isohyet lines in (b) show 150 mm, 200 mm and 250 mm precipitation, empty space in (c) are grids that fell within 50m buffer of agricultural land/settlement that were excluded for sampling

3.2. Collection of covariates

3.2.a. Soil properties and precipitation

The 20 soil cores from each grid (5 samples x 4 ha) were composited into one by mixing soil cores equally either by weight or volume to represent the grid. The mixture was then sieved in 8 micron mesh. We analysed the sieved mixture for soil texture, total organic carbon, water holding capacity, loose and rodded bulk density. We used precipitation at a lower resolution, 1 km² resolution from WorldClim as one of the covariates.

3.2.b. Livestock grazing intensity

We assumed potential livestock density (number of livestock that might forage in the grid) to be a surrogate for livestock grazing intensity. To calculate potential livestock density, we performed a two-step process – i) determine the maximum daily ranging distance ii) determine the number of livestock that have potential access to our sampling grid.

To determine the maximum ranging distance, we tagged 28 livestock (7 cattle, 10 goats and 11 sheep) with Holux RCV 3000 GPS logger for 1-2 days each. The loggers were set to record and store GPS locations along with time, date, elevation and speed every two minutes. We mapped settlements *a priori* based on their type viz., village, dhani (hamlets) or isolated corrals to obtain a spatial spread as well as obtain variation in ranging pattern between livestock type and/or between settlement type. We tagged 1-3 livestock per day in the morning before the herding begins. The loggers were retrieved after the herd returns in the evening. The livestock type and time of deployment and retrieval were recorded. The ranging tracks were retrieved using Holux ezTour software and trimmed using QGIS.

To determine potential number of livestock, we initially assumed the maximum daily ranging distance from settlement to be 3 km. We created 3 km buffers around the selected sampling grids and mapped all the settlements that were visible on Google Earth satellite imagery. We visited all the mapped locations and surveyed 1-2 people to determine the number of each livestock type stocked in the settlement.

3.2.c. Livestock foraging strategy

To determine livestock foraging preference, we adopted a focal sampling on individuals (n=22) picked at random both in space and time. The sampling involved counting the number of bites of every plant species taken by the livestock in one minute. We assumed that area available for foraging for an individual in a given time is restricted by its average moving speed. For instance, if the average speed of cattle is 7 m/min, the area available for foraging is only 7 m on the three cardinal axis in that one minute, assuming there is no backward movement. Hence, we computed the average speed from the collared livestock and the forage availability was estimated in that area for every individual sampled.

3.3. Data Analysis

3.3.a. Vegetation Component

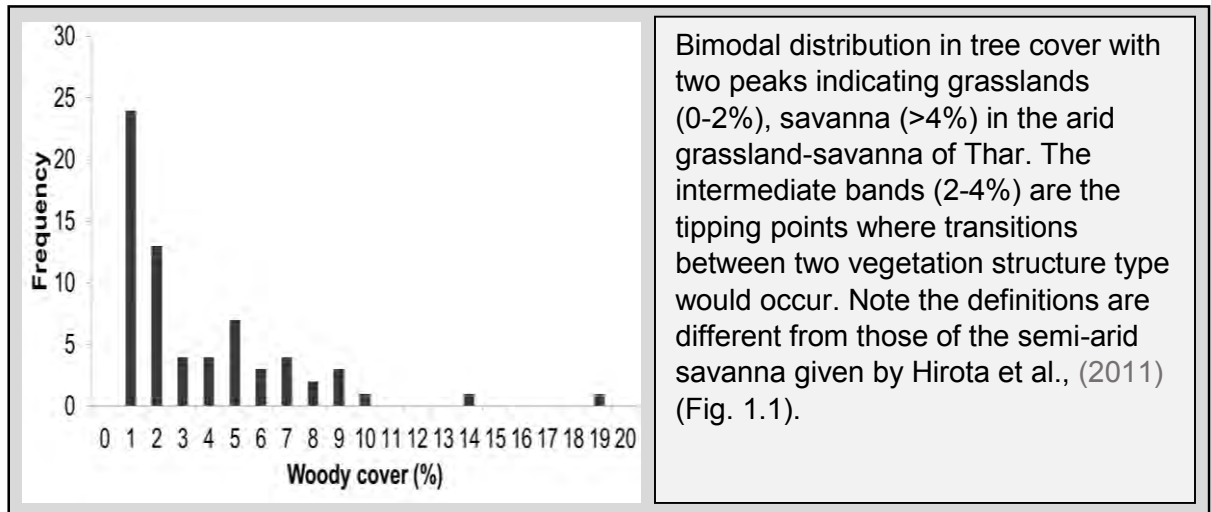
To determine vegetation composition, we calculated total tree basal area, tree and shrub abundances, and species wise tree, shrub and grass volume and cover in our sampled ha plots. We extrapolated shrub and grass data from their sub-plots to standard 1 ha. All the analyses that are at grid scale were carried out at 4 ha per grid without extrapolating it further to 1 km².

We transformed the data into community matrices of incidence, abundance and cover for compositional analysis.

We computed species richness using iNEXT package in RStudio.

To define vegetation structure, we computed frequency of woody cover (sum of tree cover and shrub cover) from the 67 sampled grids (Fig. 3.2). It shows that the distribution is bimodal and with transition between vegetation structures would occur between 2-4% in the arid landscape, grasslands have than 2% woody cover and savanna more than 4%. Using this information, we developed a key to classify the grids into distinct vegetation structure classes (Box. 3.1). The 67 grids were classified into mixed grassland (n=5), soft grassland (n=22), woody grassland (n=2), transition (n=6), shrub savanna (n=6), tree savanna (n=5) and tree shrub savanna (n=10).

Fig. 3.2: Defining vegetation structure type based on tree cover percent in the study area



Box 3.1: Key used to classify vegetation community into distinct vegetation structural types

Criteria	Resulting vegetation structure
a) Woody cover less than 2%	<u>Grassland</u>
i) Rel. tussock grass cover more than 75%	<i>Tussock grassland</i>
ii) Rel. tussock grass cover between 25% and 75%	<i>Mixed grassland</i>
iii) Rel. tussock grass cover less than 25%	<i>Soft grassland</i>
b) Woody cover between 2% and 4%	<u>Transition</u>
c) Woody cover more than 4%	<u>Savanna</u>
i) Rel. tree cover more than 75%	<i>Tree savanna</i>
ii) Rel. tree cover between 25% and 75%	<i>Tree shrub savanna</i>
iii) Rel. tree cover less than 25%	<i>Shrub savanna</i>

*Types are underlined, while sub-types are italicized

3.3.b. Covariate component

i. Determining maximum grazing daily distance

We computed maximum daily livestock distance for every tagged herd. We regressed the maximum distance against livestock type and settlement type using generalized linear model to check for variation. We found that the maximum distance vary only among livestock type. The maximum daily grazing distance for

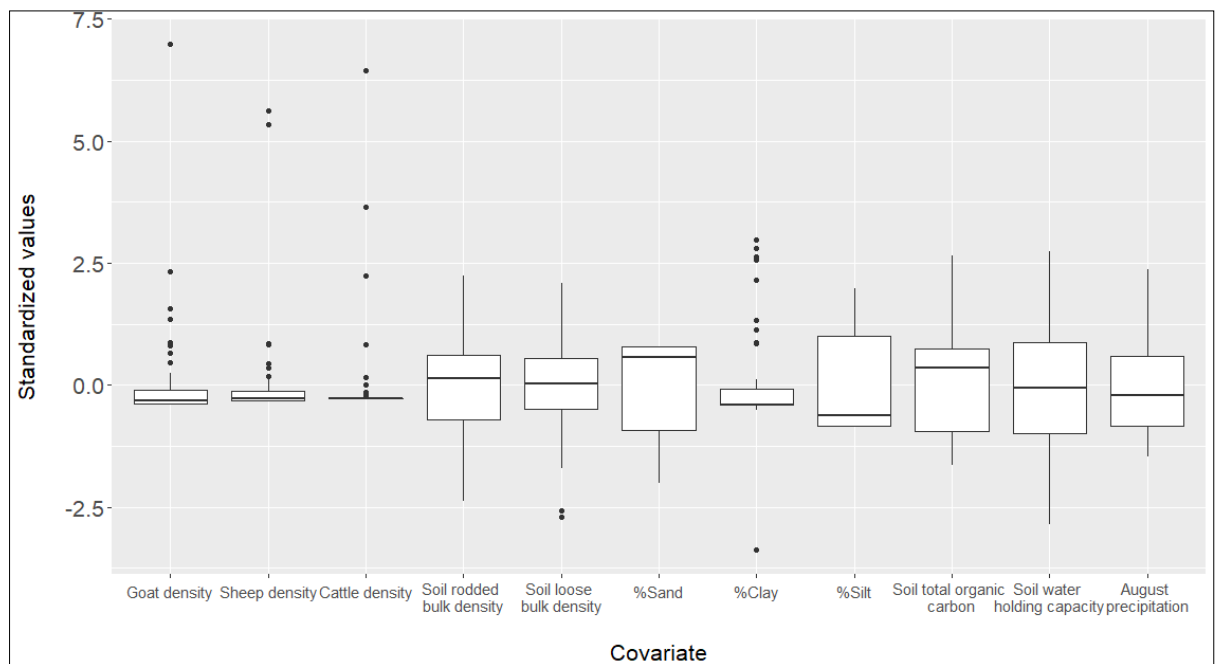
cow, goat and sheep predicted from the chosen model are 685 m, 1700 m and 1590 m, respectively. The results of all the models are presented in Annexure 1. For all the settlements that were mapped and surveyed for stocking numbers, we drew buffers using this maximum grazing distance on QGIS for every livestock type. Then for each buffer we calculated livestock density i.e. dividing the total livestock present by the area of the buffer. We then created 100 m² vector grids spanning our intensive study area and obtained the livestock density for every livestock by summing the densities of the underlying buffers in each of the grid. Then for all the sampled 1 km² grids, we averaged the livestock densities for the underlying 100 m² grids to obtain the maximum potential livestock grazing pressure for every grid.

ii. Treating collinearity in covariates

We had a total of 11 covariates, viz., precipitation, soil water holding capacity, %sand, %silt and %clay in soil, rodded bulk density, loose bulk density, soil total organic carbon, cattle, goat and sheep densities. Apart from the livestock densities and %clay, the variation captured in the remaining seven covariates seem to be similar (Fig. 3.3). A spearman rank correlation test indicated significant collinearity among livestock densities, rodded and loose bulk density and among different soil texture (Annexure 2). To remove collinear variables, we eliminated %clay and %silt from the analysis. We summed goat and sheep densities into small livestock densities. And, from rodded and loose bulk density, we calculated the potential soil compaction by using the following formula. Following this process, we found no significant strong collinearity among the reduced seven covariates (Annexure 3). The variance inflation factor for the seven covariates calculated using 'MuMIn' package in RStudio were less than 1.29 and the correlation coefficient ranged between 0.011 and 0.33.

$$\text{Potential soil compaction} = \frac{\text{Rodded Bulk density} - \text{Loose Bulk Density}}{\text{Loose Bulk Density}} \times 100$$

Fig. 3.3 : Variation of covariates in the sampled grids



3.4. Analytical Methods

We used ordinary least square and generalized linear models to test relationships between our explanatory covariates, namely environmental variables and livestock densities, and (i) species richness, (ii) vegetation structure and (iii) percent cover of different life-forms. The models were built by forward selection and backward selection or by dredging models and performing a model averaging. Model selections were based on Akaike's Information Criteria (AIC). To test compositional similarity across the explanatory covariates, we used non-metric multidimensional scaling (NMDS) and tested the significance using *adonis* under 'vegan' package in RStudio. All statistical tests were tested at $p = 0.05$ significance. We used Anderson-Darling test to check for normality. To remove collinear variables we used Spearman rank correlation test. We use chi-squared test to check for livestock forage preference.

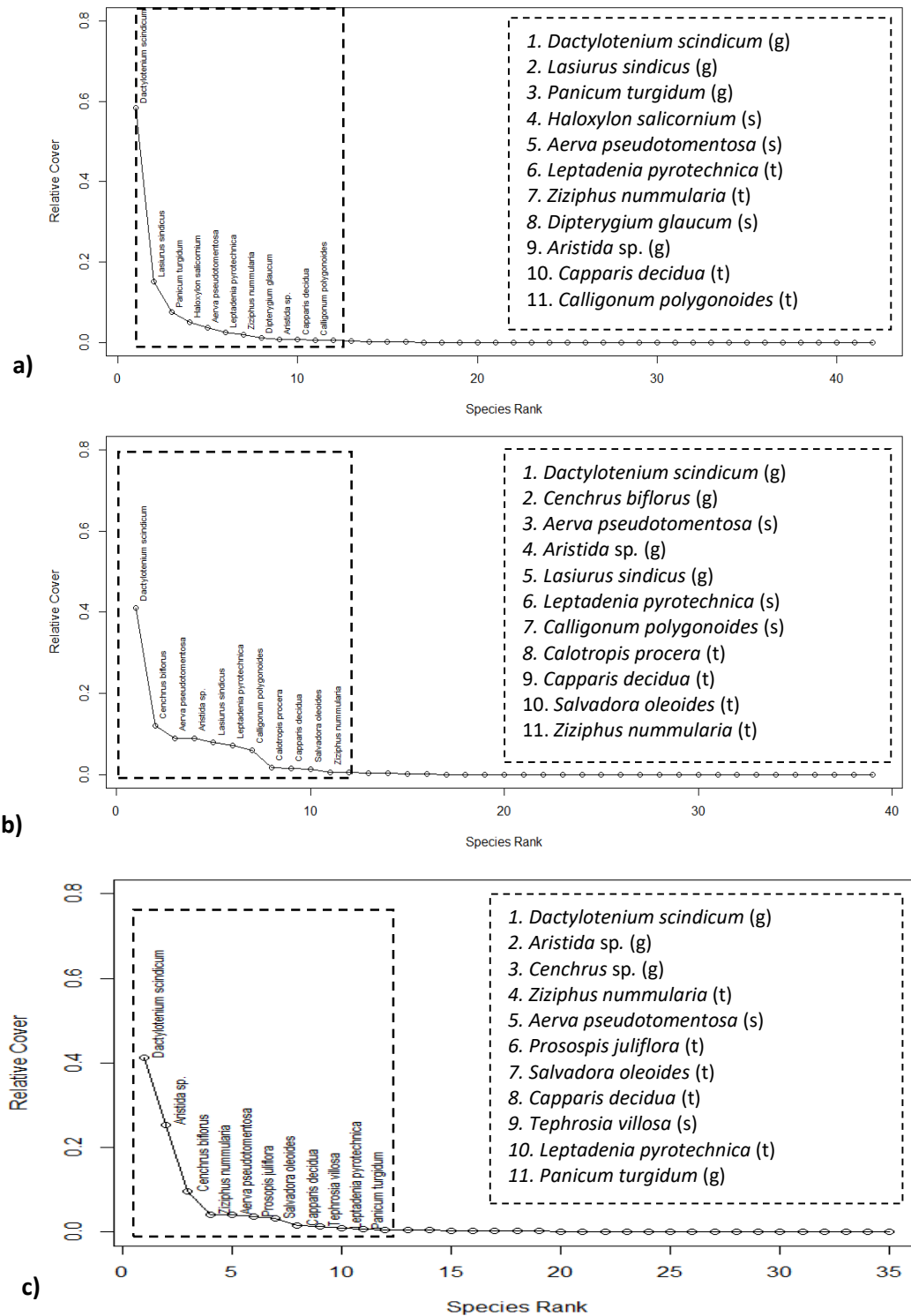
4. RESULTS

4.1. Overall pattern in the vegetation community

A total of 61 species were recorded during the sampling (Annexure 4). The rank-abundance curves (Fig. 4.1) show that the *Dactyloctenium aegyptium* is the dominant graminoid across precipitation classes. However, the sub-dominant grasses vary across the three precipitation classes. While *Lasiurus sindicus* - *Panicum turgidum* occur in the low precipitation class, *Cenchrus biflorus* - *L.sindicus* - *Aristida* sp. occur in the medium precipitation class and *Aristida* sp. - *Cenchrus* sp. occur in the high. With respect to shrubs, relative cover of *Haloxylon salicornium* declines as precipitation increases.

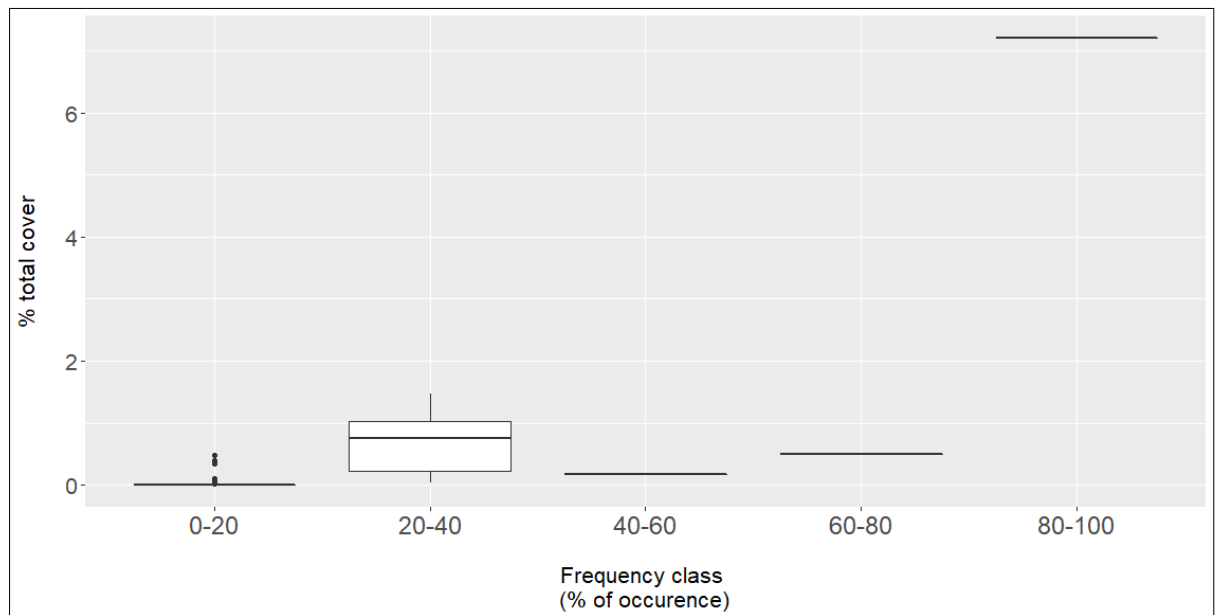
The dominance-frequency relationship shows that apart from one species that is both dominant (in % total cover) as well as frequently occurring, most other species despite being abundant occurred in less than 40% of the plots sampled indicating a high dominant species turnover (Fig. 4.2).

Fig. 4.1: Rank-abundance curve across precipitation classes



*the habit for the species is indicated in parenthesis: g - grass, t – tree, s – shrub. Panel (a) corresponds to low precipitation gradient (0-40 mm), panel (b) with medium (40-60 mm) and panel (c) with high (60-80 mm)

Fig. 4. 2 : Dominance-frequency relationship of all species (in 255 ha plots)



4.2 Observed trends in species diversity

4.2.a. Species richness

Our regression results show that species richness has a significant relationship with precipitation among the seven covariates (Table 4.1). The relative importance of the variables further show that the precipitation to be the most important variable that explains species richness (Table 4.2) and that it is a linear increase with increase in precipitation ($R^2=0.39$, $p= 1.029e^{-06}$) (Fig. 4.3). However, the increase in richness is not uniform across all life forms. Species accumulation is shallow in grasses and shrubs, however, steeper in trees and herbs (Fig. 4.4). Species reaches near saturation in herbs at about 55 mm and only richness in trees increases beyond that. The increase in tree richness is not due to non-native species.

Table 4.1: Conditional average coefficients from models with $<10 \Delta AIC$

	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	-4.59277	14.61593	14.95635	0.307	0.759
Aug_prec	0.23657	0.04870	0.04980	4.750	2e-06 ***
Soil.compaction	0.09424	0.09140	0.09358	1.007	0.314
WHC	0.23409	0.22858	0.23404	1.000	0.317
Cow_dens	-0.44651	0.63514	0.65036	0.687	0.492
Small_livestock	-0.31584	0.66749	0.68255	0.463	0.644
TOC	-0.38094	1.77788	1.81966	0.209	0.834
x.sand	0.01385	0.30012	0.30729	0.045	0.964

*significant relationship is highlighted. Abbreviations used in the models: Aug_prec – precipitation, Soil.compaction – soil compaction, WHC – soil water holding capacity, Cattle_dens – cattle density, Small_livestock – small livestock density, TOC – soil total organic carbon, x.sand – %sand in soil.

Table 4.2: Relative importance of variables in explaining species richness

	Aug_prec	Soil compaction	WHC	Cow_dens	Small livestock	TOC	x.sand
Importance	1.00	0.34	0.34	0.31	0.29	0.23	0.23
N containing models	61	30	30	29	29	0.29	0.29

*total dredged models – 128, models with $<10 \Delta AIC$ – 61. Abbreviations used: Aug_prec – precipitation, Soil.compaction – soil compaction, WHC – soil water holding capacity, Cattle_dens – cattle density, Small_livestock – small livestock density, TOC – soil total organic carbon, x.sand – %sand in soil.

Fig. 4.3: Species richness along precipitation gradient

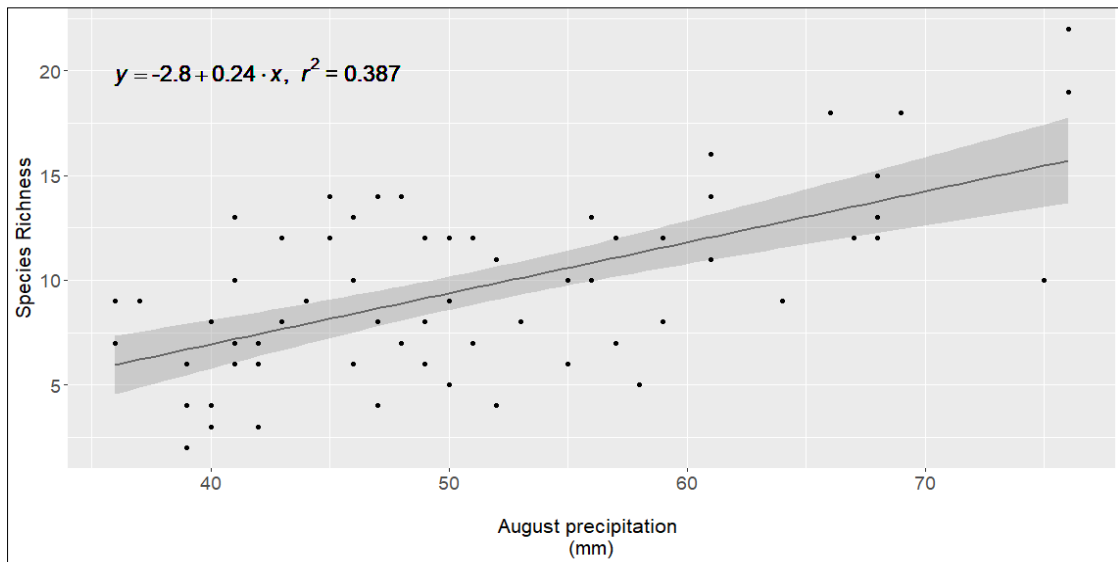
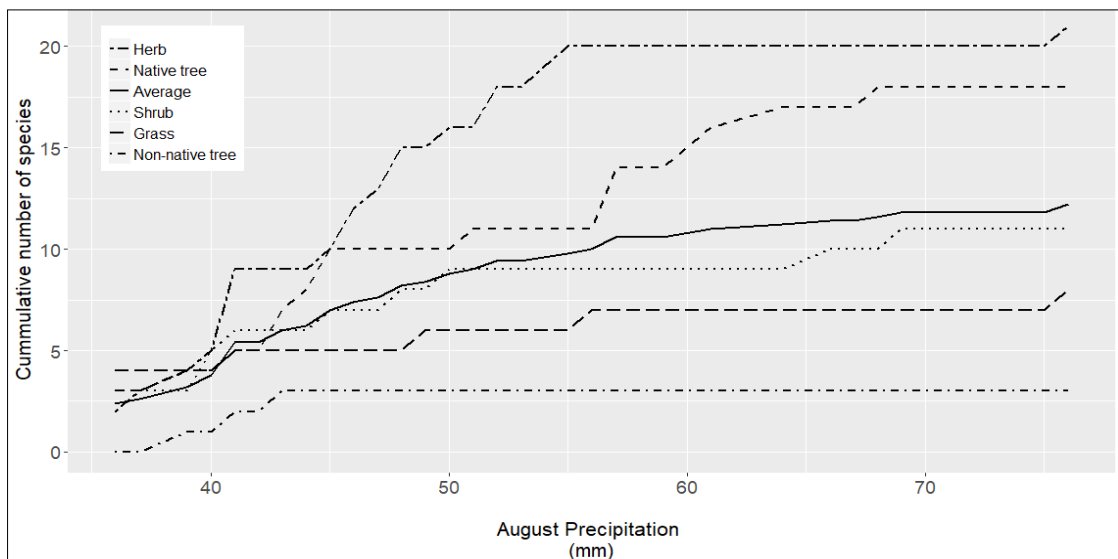


Fig. 4.4: Species accumulation curve of life forms along precipitation gradient



4.3 Overall trends in compositional similarity

Compositional similarity among the sampling grids were checked across the seven covariates. The results of the non-metric multidimensional scaling are given in Table 4.3. Precipitation and soil compaction were found to be the primary determinants for rendering vegetation communities dissimilar from each other (Fig. 4.5 – 4.6).

Table 4.3: Response of compositional similarity to the considered covariates

Covariate	Number of clusters	Bins of the clusters	p-value
Soil texture (%sand)	3	93.8 - 95.2, 95.2 - 96.6, 96.6 - 98	0.196
Total organic carbon (%)	3	0 - 0.364, 0.364 - 0.73, 0.73 - 1.09	0.628
Soil compaction	2	1.52-12.5 12.5 - 23.5	0.001*
Water holding capacity (%)	3	14 - 18, 18 - 22, 22 - 26	0.223
August precipitation (mm)	3	37 - 50, 50 - 63, 63 - 76	0.001***
Cattle density (per km ²)	2	>100, <100	0.831
Small livestock density (per km ²)	2	>75, <75	0.625

*significant relationships are highlighted.

Fig. 4.5: Vegetation compositional similarity across precipitation classes

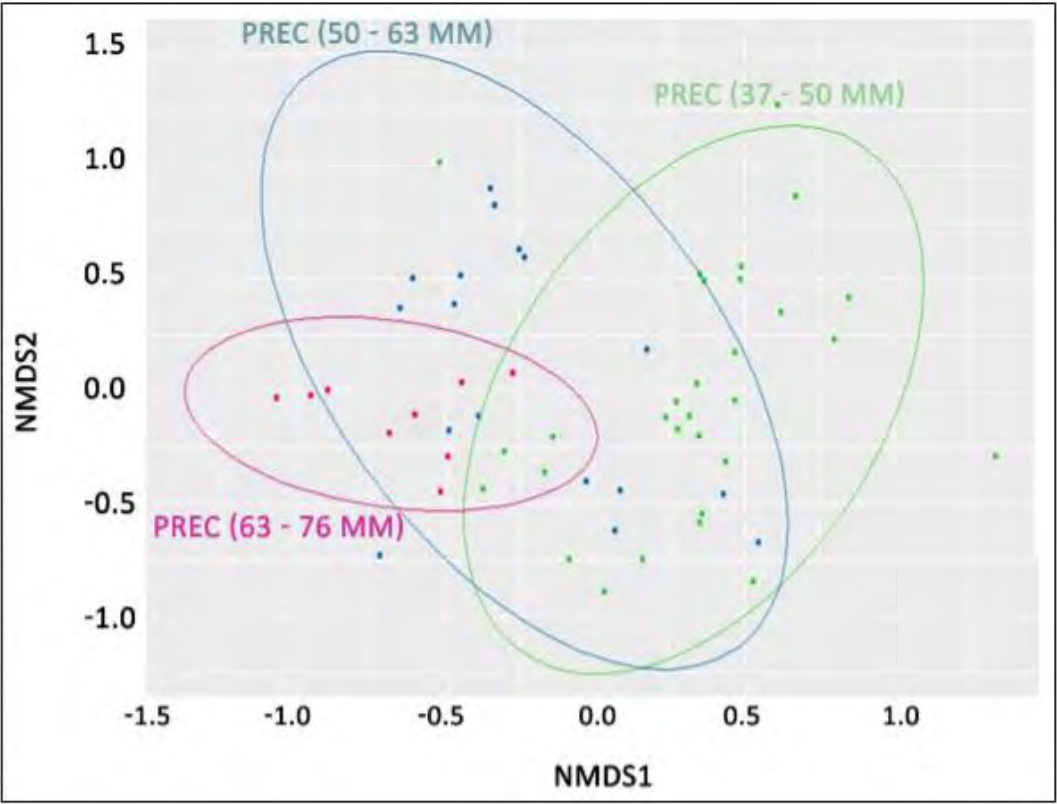
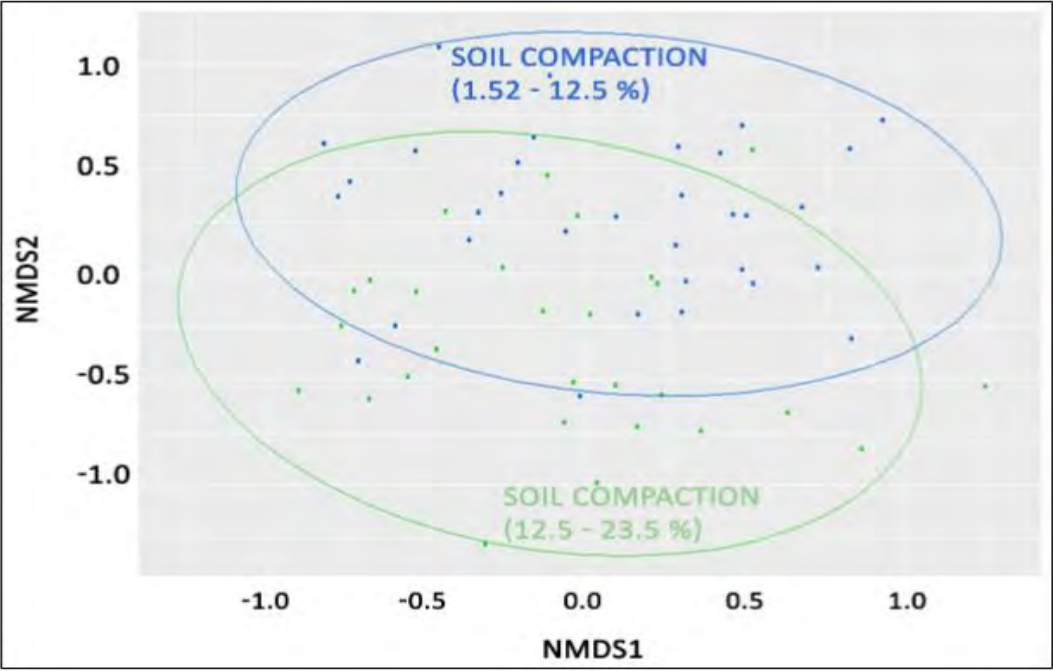


Fig. 4.6: Vegetation compositional similarity across soil compaction classes



4.4. Observed trends in vegetation structure

4.4.a. Densities of life form

Results from univariate regression against all explanatory variables show that the abundances of woody species and tree cover increase linearly with precipitation ($p = 0.02e-02$ and $p = 0.002$, respectively) (Table 4.4 gives the p-values for all the univariate regression carried out testing relationship between the vegetation variable in the rows and explanatory variable in the columns; Table 4.5 gives the coefficients for the significant relationships). Shrub cover is found to have a negative relationship with both soil compaction ($p = 2.86e-07$) and small livestock grazing intensities ($p = 0.00815$). Grass cover was found to be not determined by livestock grazing intensity or environmental factors. However, grass cover shows a negative relationship with shrub cover ($p=2.86e-05$ ***) with no significant relationship with tree cover ($p = 0.251$).

Table 4.4: Response of the vegetation to environmental factors and grazing

	Prec	WHC	%sand	TOC	Cattle density	SL density	Soil comp
Tree-shrub abundances	0.000207 ***	0.583	0.653	0.169	0.366	0.209	0.641
Tree cover	0.00209 **	0.365	0.922	0.294	0.136	0.229	0.519
Shrub cover	0.3	0.083	0.805	0.522	0.605	0.00815 **	2.86e-07 ***
Grass cover	0.682	0.511	0.787	0.934	0.351	0.491	0.616

*the significant relationships are highlighted. Abbreviations used: Prec – precipitation, WHC – soil water holding capacity, %sand – %sand in soil, TOC – soil total organic carbon, SL density – small livestock density, Soil comp – soil compaction

Table 4.5: Relationship between life forms and their significant explanatory variables

	Intercept	Variable	Estimate	Std. Error	z value	Pr(>|z|)	Pseudo R ²
Tree shrub abundance	3.1158	Prec	0.0458	0.0123	3.710	0.0002 ***	0.169
Tree cover	3.8330	Prec	0.0523	0.0170	3.077	0.0020 **	0.089
Shrub cover	6.5748	SL density	-0.0014	0.0005	-2.646	0.00815 **	0.026
Shrub cover	9.1882	Soil comp	-0.2332	0.0454	-5.132	2.86e-07 ***	0.172
Grass cover	8.6727	Shrub cover	-0.0005	0.0001	-4.185	2.86e-05 ***	0.157

*Abbreviations used: Prec – precipitation, SL density – small livestock density, Soil comp – soil compaction. Pseudo R² calculated by 1-(residual deviance/null deviance)

4.4.b. Determinants of vegetation structure

Based on the key, the 67 grids belonged to 7 vegetation types. A multinomial regression showed that the vegetation structure can be modelled best with precipitation and soil compaction (Table 4.6). The nature of the relationships with the determinants indicates that two or three vegetation structure types respond similarly to change in the determining variables. From the table (Table 4.7), it is evident that possibility of tree savanna or a tree shrub savanna increases with an increase in precipitation and soil compaction (Fig. 4.7).

Table 4.6: Top 8 models with the lowest AIC tested for determinants of vegetation structure

Model	df	AIC	Δ AIC	Pseudo R ²
Model 5: Vegetation.Structure ~ Aug_prec	12	190.4852	0	0.127
Model 10: Vegetation.Structure ~ Aug_prec + comp	18	191.0714	0.5862	0.187
Model 12 : Vegetation.Structure ~ Cattle_dens	12	196.0751	5.5899	0.098
Model 14: Vegetation.Structure ~Aug_prec + WHC + x.sand + comp	30	196.8653	6.3801	0.282
Model 22: Vegetation.Structure ~ small_livestock_dens * comp	24	197.1835	6.6983	0.218
Model 16 : Vegetation.Structure ~Aug_prec * comp	24	198.8948	8.4096	0.209
Model 32: Vegetation.Structure ~ small_livestock_dens	12	200.1134	9.6282	0.077
Model 4: Vegetation.Structure ~ Cow.Dens + small_livestock_dens	18	200.9256	10.4404	0.135

*chosen model is highlighted. Abbreviations used in the models: Vegetation.Structure – type of vegetation structure, Aug_prec – precipitation, comp – soil compaction, WHC – soil water holding capacity, Cattle_dens – cattle density, small_livestock_dens – small livestock density, TOC – soil total organic carbon, x.sand – %sand in soil.

Table 4.7: Relationship between type of vegetation structure and the environmental determinants

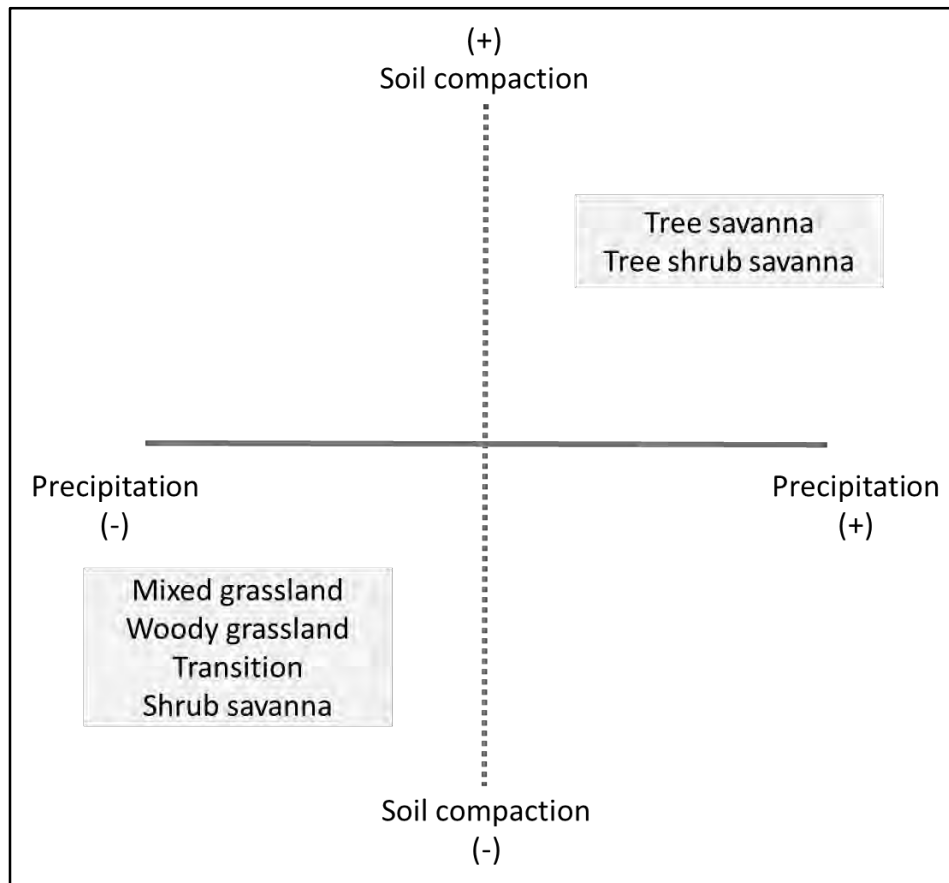
Chosen model: Vegetation.Structure ~ Aug_prec^2 + comp,

	Intercept	Std.Error	Aug_prec	Std.Error	comp	Std.Error
Shrub savanna (n=6)	0.3973	5.9304	0.0604	0.1353	-0.2468	0.1612
Soft grassland (n=22)	-8.9955	5.1126	0.2133	0.1146	0.0335	0.1275
Transition (n=6)	-6.8238	5.5187	0.1878	0.1230	-0.1246	0.1515
Tree savanna (n=5)	-17.2979	6.2237	0.3381	0.1301	0.0136	0.1667
Tree shrub savanna (n=10)	-11.8887	5.4996	0.3063	0.1216	-0.1842	0.1473
Woody grassland (n=2)	1.2681	8.4827	0.0139	0.1951	-0.2416	0.2181

*the intercepts are of the binomial link function and are untransformed. The number in parenthesis indicates the samples sized from which the model was built along with mixed grassland (n=5).

Pseudo *R*-squared computed from deviance: 0.187. The prediction using the chosen model was 42% accurate.

Fig. 4.7: A visual representation of the factors that determine vegetation structure shifts



*The grey boxes indicate the resulting vegetation structure due to the determining factors that lie on the axes viz., precipitation and soil compaction. (+) indicates increase in the determining factor and (-) indicates a decrease.

Predicting vegetation structure for the study area:

From the chosen model, it is evident that vegetation structure could be predicted with 42% accuracy using two determinants, namely, precipitation of August month and soil compaction. Data on precipitation is available at WorldClim data. To estimate soil compaction we used regression analysis to check its relationship with the remote sensed soil texture data available at NRSC website (Annexure 5). Our regression analysis showed that the soil compaction could be predicted using the index of the soil loam content ($R^2 = 0.1092$, $p = 0.01027$). We extracted precipitation and index for loam content for all the grid centroids in the study area. We predicted soil compaction using loam content. Then by using precipitation and soil compaction, we predicted the vegetation structure in the study area.

The predicted reveal the presence of four vegetation structures in the landscape, namely, mixed grassland, soft grassland, tree savanna and tree shrub savanna with the Desert National Park covering one of the vegetation types (Fig.4.8). Superimposing the human-dominated land-use types, namely agriculture and settlement, the map shows a 62% loss in the vegetation types to agriculture and settlements (empty cells in Fig. 4.9).

Fig. 4.8: Predicted vegetation structure in the study area highlighted with the regions protected by the Desert National Park

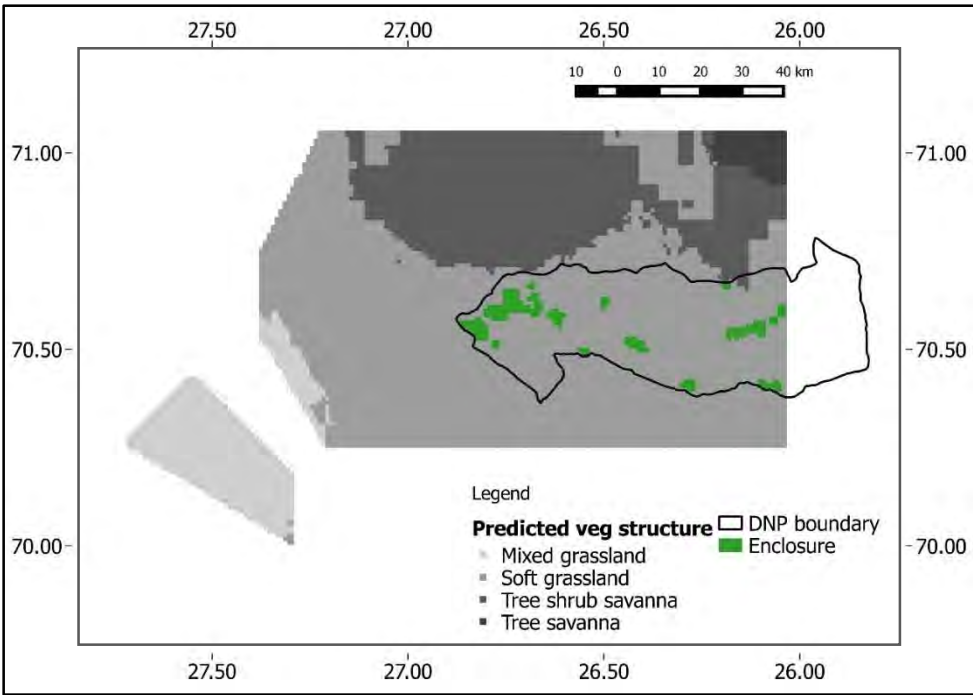
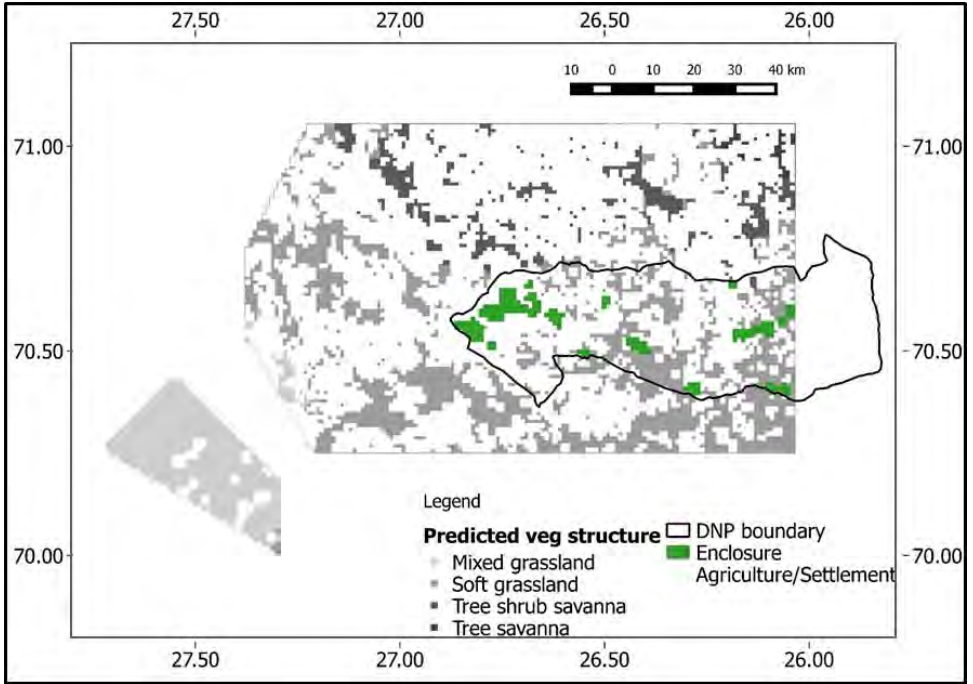


Fig. 4.9: Land-use types masking the vegetation structure types in the study area



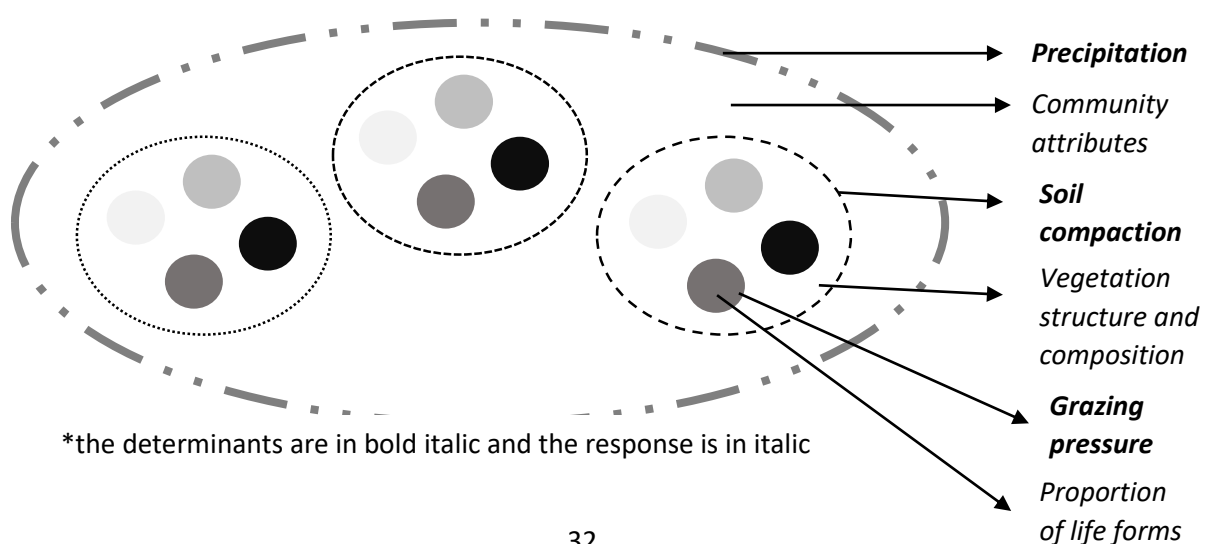
4.5. Livestock foraging preference

The conducted bite count studies on livestock show no preference for any plant species within any of the livestock types (cow: X-squared = 16.272, df = 15, $p = 0.3642$, Goat: X-squared = 9.4513, df = 15, $p = 0.8528$, Sheep: X-squared = 8.2269, df = 11, $p = 0.6928$, all livestock: X-squared = 25.976, df = 18, $p = 0.1003$). The analysis show no preference for any life forms within any of the livestock types (cow: X-squared = 4.3526, df = 2, $p = 0.1135$, Goat: X-squared = 1.4216, df = 2, $p = 0.4912$, Sheep: X-squared = 2.3215, df = 2, $p = 0.3133$, all livestock: X-squared = 5.1939, df = 2, $p = 0.0745$). An Ivlev selectivity index calculated for all the plant species foraged by each of the livestock types are given in Annexure 6 and 7.

5. DISCUSSION

We find that precipitation plays a dominant role in determining many of the community attributes as it was found to significantly explain species richness (global pattern by Beier et al., 2012), compositional similarity between regions as well defining vegetation structure shifts. Soil compaction determined vegetation composition (Cuevas et al., 2012) and structure (From Fig. 4.5, 4.6 and 4.7). We also found that the proportion of life forms depend on livestock grazing pressure (from table 4.4). But as Mills (2006) noted, the determinants of these attributes are scale-dependent and never single factor determined. From the significant covariates we found, namely, precipitation, soil compaction and grazing pressure, precipitation operates at the largest scale as differences in precipitation are more observable as distance increases. Whereas, changes in soil compaction changes occurs within a precipitation belt eg. within the 0-40 precipitation belt, the soil compaction ranged from 3 - 21% in the sampled grids. The grazing operates at much finer scales i.e, within a soil compaction belt, the grazing pressure can vary considerably. Hence, we put forth the scale dependent and nested relationship between the covariates and the vegetation composition and structure in the arid zones (an indicative visual representation of how the determining factors of vegetation varies with scale is given in Fig. 5.1).

Fig. 5.1: A visual representation of how the determining factors varies with scale -the **precipitation** defines **community attributes**, **soil compaction** under the precipitation umbrella defines **vegetation structure and composition**, the **grazing pressure** especially the smaller livestock defines the proportion of the **life forms** within each vegetation structure



5.1 Inferences from the large scale patterns in species composition

The vegetation composition is defined by the species richness, the proportion of their respective life-forms and their relative abundances (or in this study, percent cover). While species richness was defined by the precipitation, an interplay of precipitation and edaphic factors determine the evenness of the life forms and species. It is seen that there is a linear increase in species richness along precipitation which is consistent pattern globally (Field et al., 2009) and for deserts (Xia et al., 2010 in Chihuahuan desert) and it is contributed by increase in tree species. However, though it is not evident whether the species turnover in trees is gradual or abrupt, an apparent pattern seem to exist with the grasses. This is indicated by the rank abundance curves plotted against differing precipitation which show a rather gradual replacement of sub-dominant grass species instead of an abrupt replacement of species.

5.2 Inferences from the smaller scale patterns in vegetation structure

Two primary determinants of vegetation structure were found to be soil precipitation and soil compaction. Our results show that the resulting vegetation structure depends on the directionality of the determinants. However, two or more structures are found to occur under similar conditions indicating that they exist as alternate stable states (Bond et al., 2005). Hence, simulating and predicting vegetation structure shifts using the determinants will be a 50% or in some cases 33% accurate considering that there are 2 or 3 possible results.

This leads us to emphasize that vegetation structure transition, if occurs, will be a result of environmental factors and not due to the recent livestock grazing. Hence, the vegetation structure shifts will be gradual. However, there are very few regions of natural vegetation left unconverted from the growing human-dominated land-use types. Predicted vegetation structure using estimated soil compaction (with 42% accuracy) for the study area show that it is composed of four vegetation structure types, namely, mixed grassland, soft grassland, tree savanna and tree shrub savanna. However, 62% of the grids were found to have changed to human-dominated land-use types namely agriculture and settlement. The enclosures of the Desert National Park protects less than 1% of the cover

and only covers three of the vegetation types. Hence, the threat posed by land conversions would wipe out the distinct vegetation structures, in comparison to the gradual transition that may occur due to changing environmental factors.

5.3 Inferences from the smallest scale patterns in life form

The trees are found to respond positively to precipitation both as abundance and cover and shrub cover is found to reduce with soil compaction and grazing pressure. Grass cover shows no response to any of the covariates considered in the study however it is found to be dependent on shrub cover. Woody cover is also found to be dependent on precipitation and edaphic properties, namely, soil total organic carbon and soil compaction. There are three noteworthy findings here i) Shrub cover reduces with increase in soil compaction and grazing pressure specific to the smaller livestock namely, goat and sheep. ii) Though shrub cover shows a negative response with both soil compaction and grazing pressure, we found no correlation between livestock grazing intensities and soil compaction. This is yet another contrasting result that stands out of the popular notion that grazing pressure increases soil compaction (Castellano and Valone, 2007), iii) grass cover, though not dependent on the environmental factors, shows a decrease with the increase in shrub cover. This reveals that the grazing pressure rather increases the grass cover by a two-step process, first by reducing the shrub cover and thereby increasing grass cover. One possible explanation to this finding is that the grazing pressure especially of the smaller livestock is more on shrubs than grasses. This may be due to the non-availability of grasses in summer and since the livestock are predominantly dependent on natural fodder, they might have adopted an 'adaptive foraging strategy' foraging on the abundant life-forms irrespective of their species. This is seen by the low preference exhibited by all the livestock types towards foraging on particular species or life forms. This leads us to state that we did not find a reduction in grasses due to livestock grazing in this study area (Krishna et al., 2014; Mertia et al., 2006; Roy and Roy, 1996, but see (Cipriotti and Aguiar, 2005)).

6. CONCLUSION

1. Arid grasslands are found to be characterised by less tree cover compared to that of semi-arid grasslands. While semi-arid grasslands are known to have less than 5% tree cover, we found that arid grasslands have less than 2% tree cover. Also the transition zone between grasslands and savanna is smaller, 5% in the case of semi-arid grasslands to shift to a savanna and 2% in the case of arid grasslands to shift to a savanna.

2. The determinants of vegetation community composition are scale dependent. Precipitation plays the dominant role in determining community attributes. The species richness increases with precipitation, and is associated with a gradual species turnover. The composition similarity decreases with precipitation and increases with soil compaction.

3. Vegetation structure transitions can be determined with precipitation and soil compaction. But, there are two or more stable states that are possible to result under similar environmental conditions. Vegetation structures being determined by environmental variables would, hence, be gradual. However, the land use change to agriculture and settlements has wiped out 62% of the study area and the Desert National Park is protecting less than 1% of the grasslands as enclosures. The loss of vegetation structure poses a larger threat to these grasslands than the expected vegetation structure transitions.

4. Grazing pressure from smaller livestock (goat and sheep) decreases shrub densities, and grass cover increases with decrease in shrub densities. This, we hypothesise could be due to an 'adaptive foraging strategy' by smaller livestock that feed on the most abundant species leading to no apparent selection pressure on specific life-forms.

7. CONSIDERATIONS AND METHODOLOGICAL LIMITATIONS

The grazing pressure is an estimated measure and hence, the difference between the maximum grazing pressure and the on-ground grazing pressure might be highly variable. Also the variation in livestock grazing was not large among the sampled grids, especially with cattle that were absent in 75% of the grids. Further, the vegetation structure predicted only 4 out of the 8 possible vegetation structures though it had an overall 42% accuracy. An equal effort in all the vegetation structures may improve the model.

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Annexure 1: Results of regression models to determine maximum daily grazing distance

Table: Models tested for maximum daily grazing distance

Model	df	AIC	Δ AIC
maxdist~ani_type	4	541.60	0
maxdist~ ham_type	4	545.45	3.85
maxdist~1	2	551.26	9.66
maxdist~ ani_type + ham_type	6	555.02	13.42

*chosen model is highlighted. Abbreviations used in the models: maxdist – maximum daily grazing distance, ani_type – livestock type (cattle/goat/sheep), ham_type – settlement type (settlement/hamlet/isolated corral)

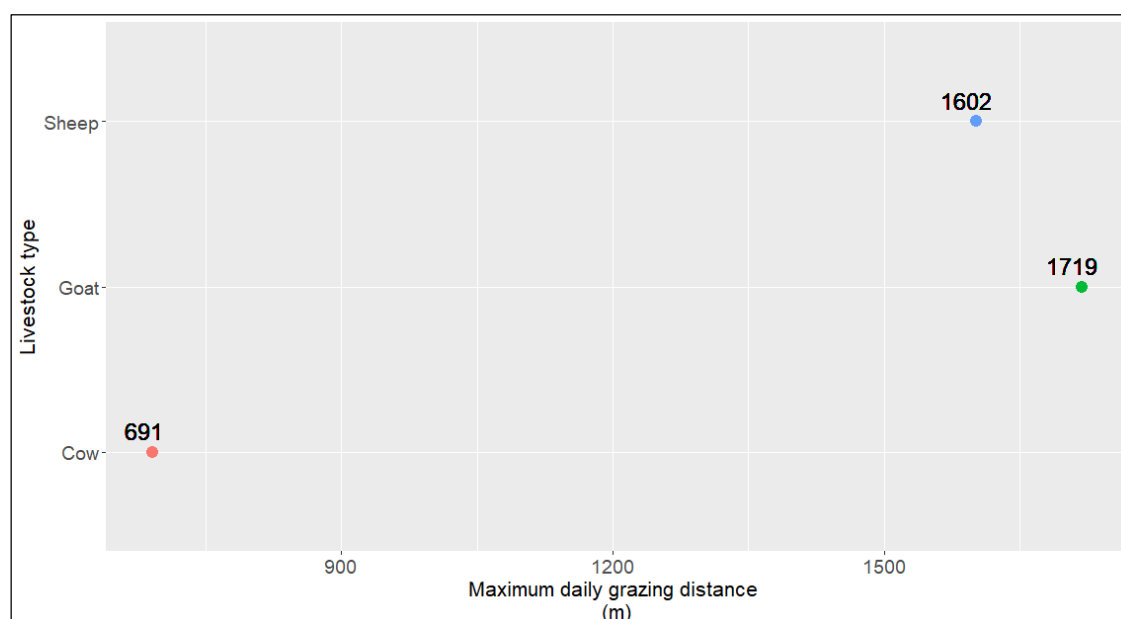
Table: Relationship between maximum daily grazing distance and livestock type

Chosen model: maxdist~ani_type

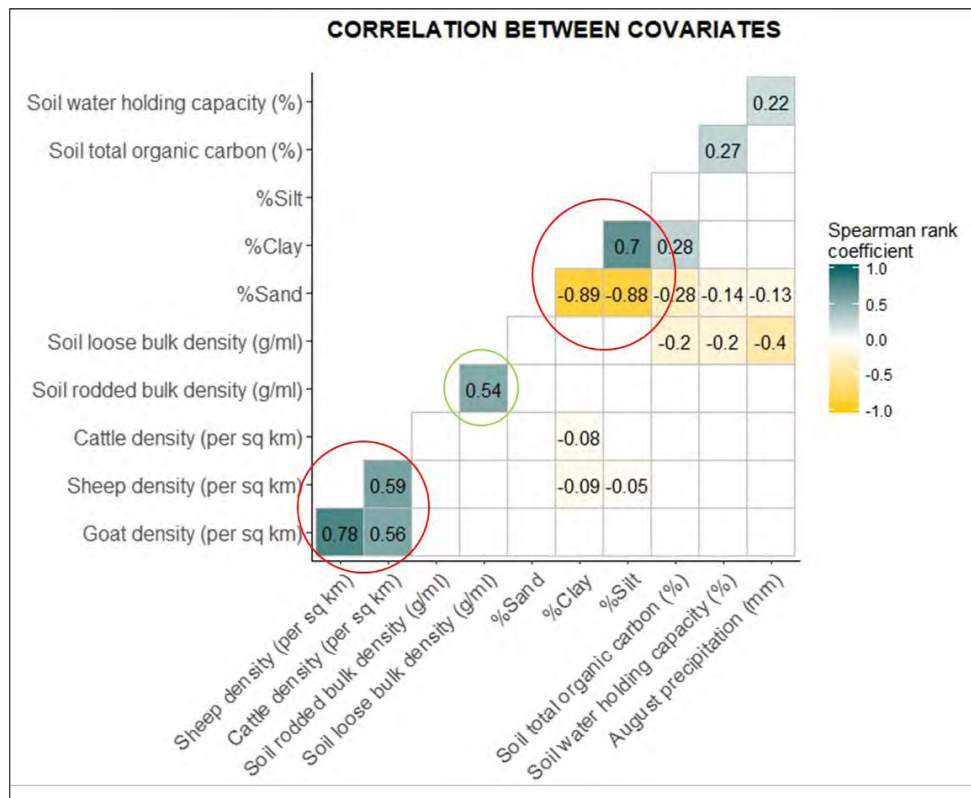
	Estimate	Std.Error	z value	Pr(>|z|)
(Intercept)	6.5388	0.1724	37.927	< 2e-16 ***
maxdist\$ani_typeGoat	0.9105	0.2241	4.063	4.85e-05 ***
maxdist\$ani_typeSheep	0.8400	0.2279	3.685	2.28e-04 ***

*the intercepts are of the negative binomial link function (log) and are untransformed.

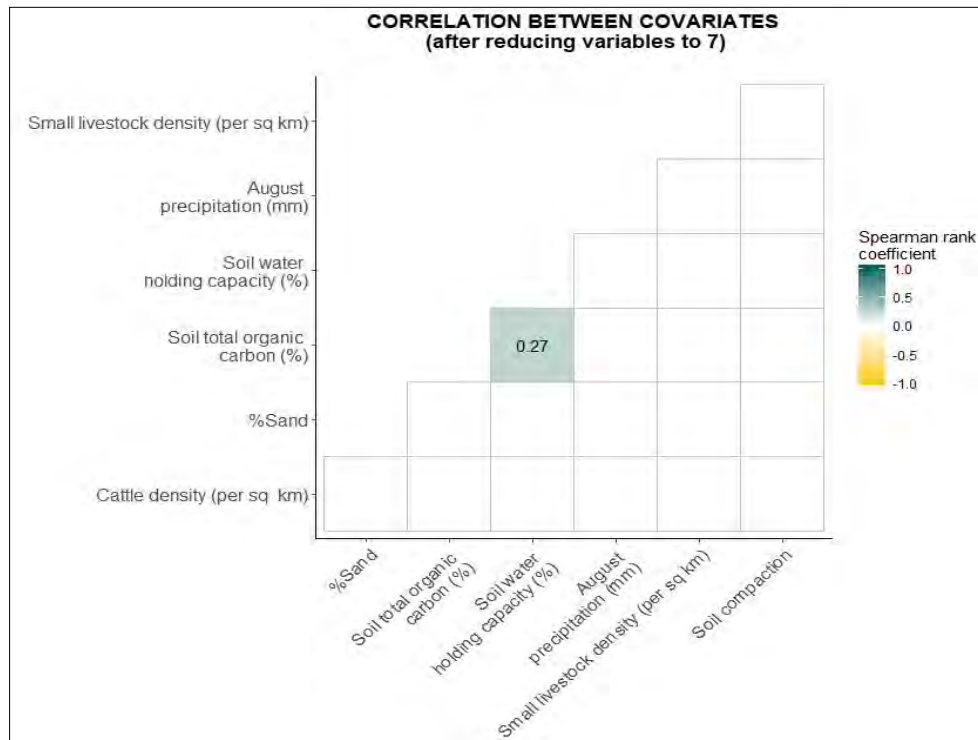
Fig : Predicted maximum daily grazing distance from chosen model



Annexure 2: Correlation of initial covariates before treatment



Annexure 3: Correlation of covariates after treating the autocorrelation and reducing to 7

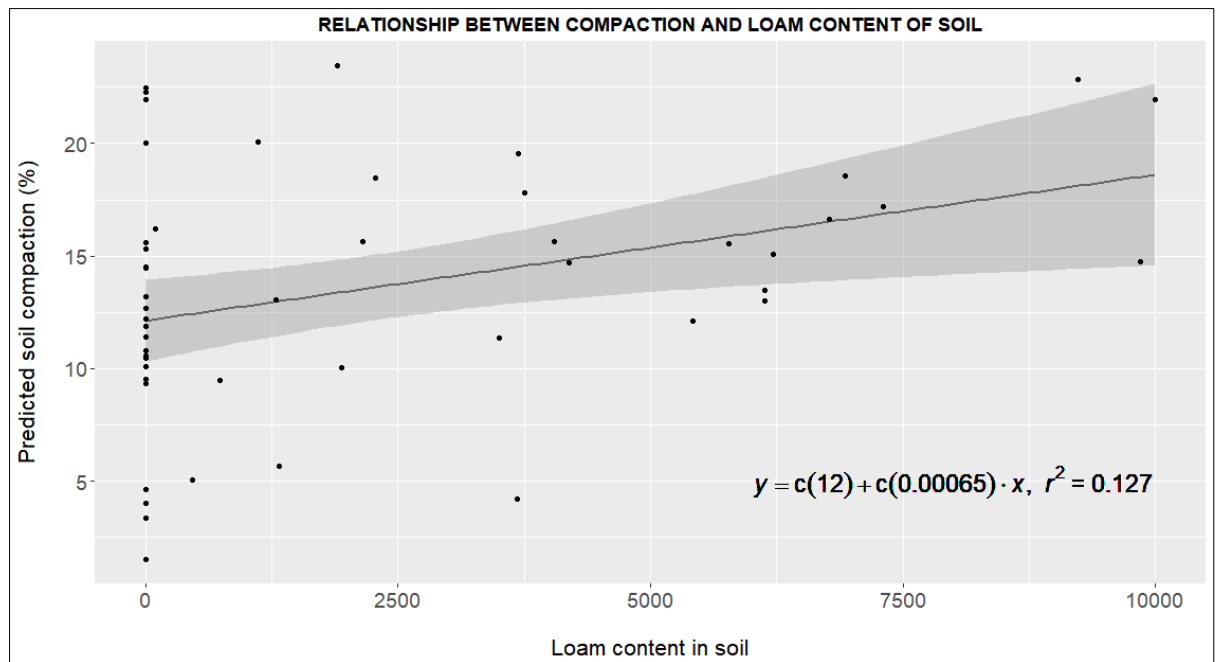


Annexure 4: Plant species recorded during the study

Scientific Name	Family	Habit
<i>Calotropis procera</i> (Aiton)	Apocynaceae (Asclepiadaceae)	Tree
<i>Leptadenia pyrotechnica</i> (Forssk.) Decne.	Apocynaceae (Asclepiadaceae)	Tree
<i>Tecomella undulate</i> (Sm.) Seem.	Bignoniaceae	Tree
<i>Commiphora wightii</i> (Arn.) Bhandari	Burseraceae	Tree
<i>Capparis decidua</i> (Forssk.) Edgew.	Capparidaceae	Tree
<i>Seddera latifolia</i> Hochst. & Steud.	Convulvulaceae	Tree
<i>Euphorbia caducifolia</i> Haines	Euphorbiaceae	Tree
Acacia Grey Stem	Fabaceae: Mimosoideae	Tree
UNID (Acacia red)	Fabaceae: Mimosoideae	Tree
<i>Mimosa hamate</i> Willd.	Fabaceae: Mimosoideae	Tree
<i>Prosopis cineraria</i> (L.) Druce	Fabaceae: Mimosoideae	Tree
<i>Prosopis juliflora</i> (Sw.) DC.	Fabaceae: Mimosoideae	Tree
<i>Senegalia senegal</i> (L.) Britton	Fabaceae: Mimosoideae	Tree
<i>Vachellia eburnea</i> (L.f.) P. Hurter & Mabb.	Fabaceae: Mimosoideae	Tree
<i>Vachellia tortilis</i> (Forssk.) Galasso & Banfi	Fabaceae: Mimosoideae	Tree
<i>Calligonum polygonoides</i> L.	Polygonaceae	Tree
<i>Ziziphus nummularia</i> (Burm. f.) Wight & Arn.	Rhamnaceae	Tree
<i>Salvadora oleoides</i> Decne.	Salvadoraceae	Tree
<i>Maytenus</i> sp. Molina	Solanaceae	Tree
<i>Tamarix</i> sp. L.	Tamaricaceae	Tree
<i>Grewia tenax</i> L.	Tiliaceae	Tree
<i>Barleria</i> sp. L.	Acanthaceae	Shrub
<i>Aerva pseudotomentosa</i> Blatt. & Hallb.	Amaranthaceae	Shrub
<i>Haloxylon salicornium</i> moq. Bunge ex Boiss (Rimth)	Amaranthaceae	Shrub
<i>Heliotropium</i> sp. L. (star flowered)	Boraginaceae	Shrub
<i>Heliotropium</i> sp. L. (yellow flowered)	Boraginaceae	Shrub
<i>Dipterygium glaucum</i> Decne.	Capparidaceae	Shrub
<i>Crotalaria burhia</i> Benth.	Fabaceae: Faboideae	Shrub
<i>Indigofera cordifolia</i> Roth	Fabaceae: Faboideae	Shrub
<i>Tephrosia villosa</i> (L.) Pers.	Fabaceae: Faboideae	Shrub
<i>Fagonia cretica</i> L.	Zygophyllaceae	Shrub
UID (Helio type)		Shrub
UID (Hygrophila)	Acanthaceae	Herb
UID (Star F)	Brassicaceae	Herb
<i>Citrullus colocynthis</i> (L.) Schrad.	Cucurbitaceae	Herb
<i>Chrozophora</i> sp. A. Juss.	Euphorbiaceae	Herb
<i>Euphorbia clarkiana</i> Hook	Euphorbiaceae	Herb

Scientific Name	Family	Habit
<i>Indigofera</i> sp. L.	Fabaceae: Faboideae	Herb
UID (Purple stalk grass)	Poaceae	Herb
<i>Tribulus</i> sp. L. (red)	Xygophyllaceae	Herb
<i>Tribulus terrestris</i> L.	Zygophyllaceae	Herb
UID (2 leaved)		Herb
UID (3 leaved)		Herb
UID (Bagri)		Herb
UID (Champri)		Herb
UID (Dhakle)		Herb
UID (Purple underneath)		Herb
UID (Silver stem)		Herb
UID (Wrinkled)		Herb
UID (Unidentified shrub)		Herb
UID (phone)		Herb
UID (white flower)		Herb
UID (small pink flowers)		Herb
<i>Aristida</i> sp. L.	Poaceae	Grass
Broom Grass (Eleusine type)	Poaceae	Grass
<i>Cenchrus biflorus</i> Roxb.	Poaceae	Grass
<i>Cenchrus</i> sp. L.	Poaceae	Grass
<i>Dactyloctenium scindicum</i> Boiss.	Poaceae	Grass
Eleusine type	Poaceae	Grass
<i>Lasiurus sindicus</i> Henr.	Poaceae	Grass
<i>Panicum turgidum</i> Forssk.	Poaceae	Grass

Annexure 5: Predicting soil compaction from sand and loam content of soil texture map available from NRSC



Correlation between actual compaction and predicted using loam content: 0.36

Model selection for relationship between soil compaction using soil texture and precipitation available from remote sensed data

Table: Top 8 models with the lowest AIC tested for soil compaction

Model	d f	AIC	Δ AIC	Loglik
Comp ~ Loam_content	3	316.148 9	0	- 155.0744
Comp ~ Loam_content+Aug_prec	5	318.470 5	1.81	- 154.8005
Comp ~ Sand_content	3	318.561 3	1.90	- 156.0253
Comp ~ Sand_content+Loam_content	4	318.749 9	2.09	- 154.9402
Comp ~ Sand_content +Aug_prec	4	319.649 6	2.99	- 155.3900
Comp ~ Sand_content + Loam_content +Aug_prec	5	320.606 3	3.95	- 154.6365
Comp ~ 1	2	321.324 0	4.66	- 158.5370
Comp ~ Aug_prec	3	321.433 5	4.77	- 157.4614

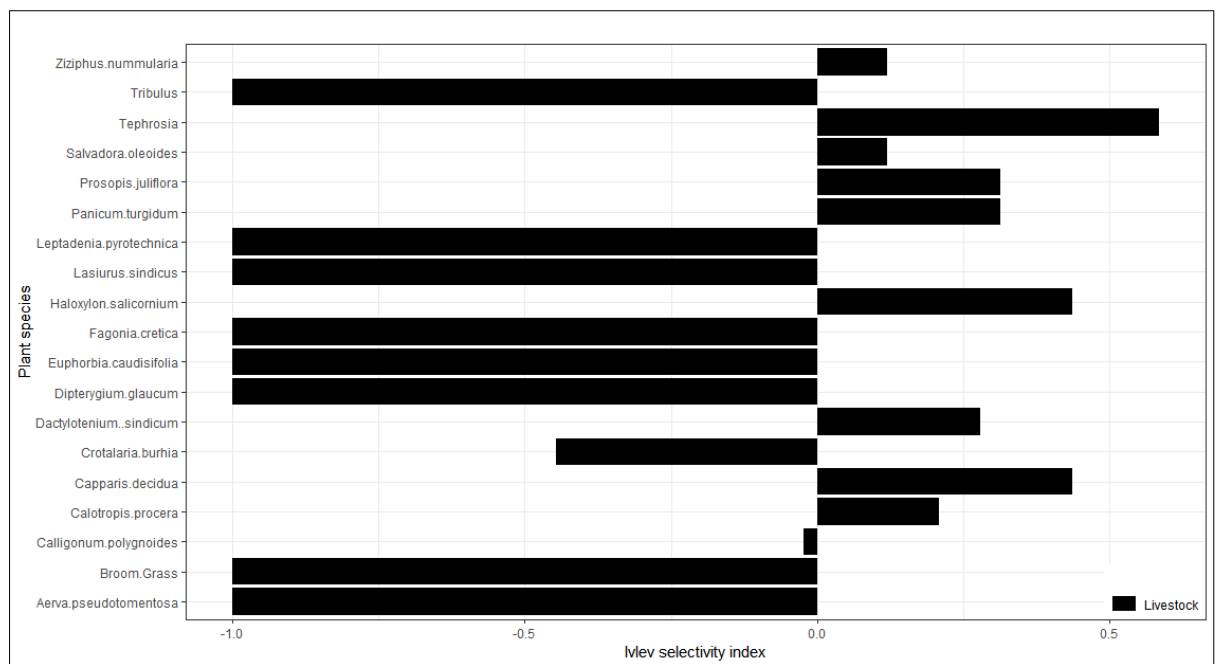
*chosen model is highlighted. Abbreviations used in the models: Comp – soil compaction, Aug_prec – precipitation, Sand_content – Sand content in soil from remote sensed soil texture data (NRSC), Loam_content – Loam content in soil from remote sensed soil texture data (NRSC),

Table: Relationship between soil compaction and loam content in soil
Chosen model:

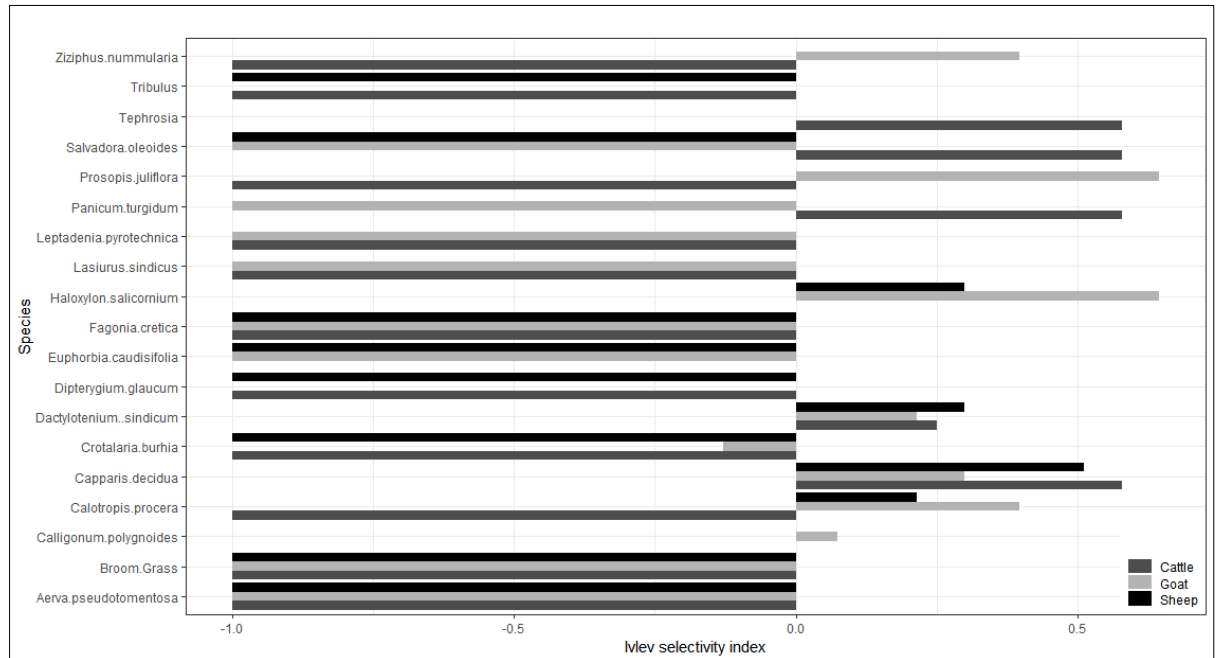
	Estimate	Std.Error	t value	Pr(>|t|)
Intercept	1.214e+01	9.095e-01	13.34	<2e-16 ***
Loam_content	6.481e-04	2.428e-04	2.67	0.0103 *

Adjusted R-squared: 0.1092; p-value: 0.01027

Annexure 6: Ivlev selectivity index for all livestock



Annexure 7: Ivlev selectivity index for every livestock type



Supplementary S1: Two factorial clustering of grid centroids by soil texture-precipitation

i) Extracting soil texture values for grids:

Three soil maps, one of sand, loam and clay were available at Rajasthan NRSC website. The raster maps had different ranges (sand ranging 0 to 4090, loam 0 to 9840 and clay 0 to 9750). We extracted values for each of the grid centroids from the three maps using QGIS. We then standardized the three values to range between 0 and 10000 each. The intensive study area had no gradient in clay and hence was excluded from this procedure. Since sand and loam are theoretically mutually exclusive, the total for standardized sand and loam should amount to 10000. However, there were some grids that didn't add up to 10000, possibly due to presence of other unmapped texture such as gravel or rocks. This led to a third soil texture component named 'unknown'. Then, we split the three values into classes of 1000 each leading to 10 classes for sand, loam and unknown each. The 3186 grids were then clustered based on the combination of classes the centroid yielded eg. One of the clusters is Class1 Class8 Class1 (i.e. sand index ranging from 0 to 1000, loam ranging from 7000 to 8000 and unknown ranging from 0 to 1000 for a particular centroid). This resulted in 36 unique soil texture clusters in the intensive study area among the 1000 possible permutations (Table s1).

Table s1: Frequencies of the unique soil texture clusters in the intensive study area

	Soil texture clusters	Frequency
1	Class1 Class1 Class10	48
2	Class1 Class10 Class1	2240
3	Class1 Class2 Class9	9
4	Class1 Class4 Class7	5
5	Class1 Class5 Class6	14
6	Class1 Class6 Class5	4
7	Class1 Class7 Class3	4
8	Class1 Class7 Class4	1
9	Class1 Class8 Class3	5
10	Class1 Class9 Class1	3
11	Class1 Class9 Class2	24
12	Class10 Class1 Class1	206
13	Class2 Class1 Class9	7
14	Class2 Class8 Class1	12
15	Class2 Class9 Class1	24
16	Class3 Class1 Class7	3
17	Class3 Class1 Class8	36

18	Class3 Class3 Class6	14
19	Class3 Class8 Class1	62
20	Class4 Class1 Class7	26
21	Class4 Class6 Class1	23
22	Class4 Class7 Class1	50
23	Class5 Class1 Class6	35
24	Class5 Class6 Class1	25
25	Class6 Class3 Class2	3
26	Class6 Class5 Class1	45
27	Class7 Class1 Class4	9
28	Class7 Class3 Class1	6
29	Class7 Class3 Class2	12
30	Class7 Class4 Class1	46
31	Class8 Class1 Class3	73
32	Class8 Class2 Class1	3
33	Class8 Class3 Class1	41
34	Class9 Class1 Class1	9
35	Class9 Class1 Class2	26
36	Class9 Class2 Class1	33
	Total	3186

*Classes are in the order of sand, loam and clay.

ii) Extracting precipitation values for grids:

Month wise precipitation data was available at WorldClim at 2.5 sq km resolution. We extracted August month precipitation data (being maximum) for the grid centroids. The grids were then classed into three classes of 20 mm intervals, namely 0-40, 40-60, 60-80 (Fig. s1).

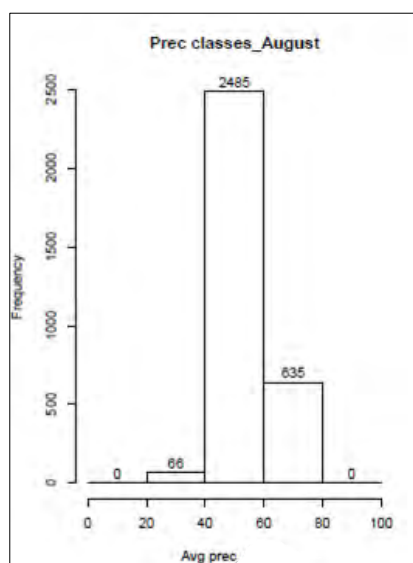


Fig. s1: Histogram of the precipitation classes in the intensive study area

iii) Obtaining soil texture-precipitation clusters:

We performed a two factorial clustering of the grids using the soil texture and precipitation clusters. For this, we classified the grids belonging to the 36 unique clusters obtained in (i), further by the precipitation clusters obtained in (ii). This resulted in 53 unique soil texture-precipitation clusters in the intensive study area. eg. Class1 Class10 Class1 prec(0-40), Class1 Class10 Class1 prec(40-60). The frequencies of the 3186 cells belonging to the different soil texture-precipitation clusters in the intensive study area are given in (Table s2). We then selected a proportionate sample of the grids as sampling units keeping required sampling units as 75 and minimum per class as one. Apart from this, three more grids were selected from a new sub-block to get enough sample size for the 0-40 precipitation gradient (smaller sub-block in Fig. 1(c)).

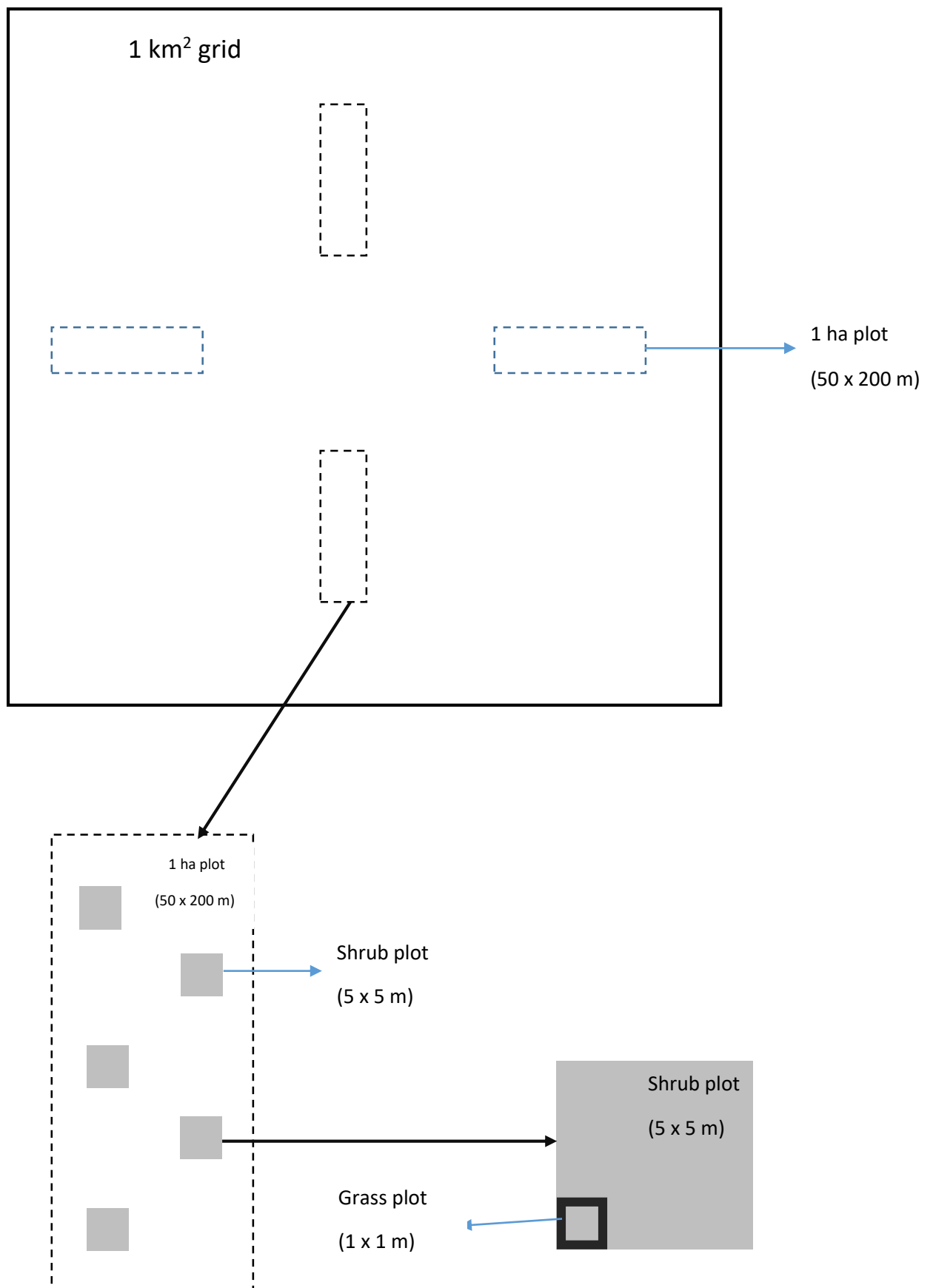
Table s2: Frequencies of the unique soil texture-precipitation clusters in the intensive study area and the number of sampling units selected per cluster

	Soil texture-precipitation clusters	Frequency	Selected no. of samples
1	Class1 Class1 Class10 prec(40-60)	48	2
2	Class1 Class10 Class1 prec(0-40)	11	1
3	Class1 Class10 Class1 prec(40-60)	1808	16
4	Class1 Class10 Class1 prec(60-80)	421	4
5	Class1 Class2 Class9 prec(0-40)	9	1
6	Class1 Class4 Class7 prec(40-60)	5	1
7	Class1 Class5 Class6 prec(40-60)	14	1
8	Class1 Class6 Class5 prec(40-60)	4	1
9	Class1 Class7 Class3 prec(40-60)	4	1
10	Class1 Class7 Class4 prec(60-80)	1	1
11	Class1 Class8 Class3 prec(40-60)	5	1
12	Class1 Class9 Class1 prec(40-60)	3	1
13	Class1 Class9 Class2 prec(0-40)	10	1
14	Class1 Class9 Class2 prec(40-60)	2	1
15	Class1 Class9 Class2 prec(60-80)	12	1
16	Class10 Class1 Class1 prec(0-40)	14	1
17	Class10 Class1 Class1 prec(40-60)	106	2
18	Class10 Class1 Class1 prec(60-80)	86	2
19	Class2 Class1 Class9 prec(40-60)	7	1
20	Class2 Class8 Class1 prec(40-60)	1	1
21	Class2 Class8 Class1 prec(60-80)	11	1
22	Class2 Class9 Class1 prec(0-40)	2	1
23	Class2 Class9 Class1 prec(40-60)	12	1
24	Class2 Class9 Class1 prec(60-80)	10	1
25	Class3 Class1 Class7 prec(40-60)	3	1
26	Class3 Class1 Class8 prec(40-60)	36	1

27	Class3 Class3 Class6 prec(0-40)	14	1
28	Class3 Class8 Class1 prec(0-40)	3	1
29	Class3 Class8 Class1 prec(40-60)	45	1
30	Class3 Class8 Class1 prec(60-80)	14	1
31	Class4 Class1 Class7 prec(40-60)	26	1
32	Class4 Class6 Class1 prec(40-60)	18	1
33	Class4 Class6 Class1 prec(60-80)	5	1
34	Class4 Class7 Class1 prec(40-60)	36	1
35	Class4 Class7 Class1 prec(60-80)	14	1
36	Class5 Class1 Class6 prec(40-60)	35	1
37	Class5 Class6 Class1 prec(40-60)	25	1
38	Class6 Class3 Class2 prec(40-60)	3	1
39	Class6 Class5 Class1 prec(40-60)	27	1
40	Class6 Class5 Class1 prec(60-80)	18	1
41	Class7 Class1 Class4 prec(40-60)	9	1
42	Class7 Class3 Class1 prec(40-60)	6	1
43	Class7 Class3 Class2 prec(40-60)	12	1
44	Class7 Class4 Class1 prec(40-60)	37	1
45	Class7 Class4 Class1 prec(60-80)	9	1
46	Class8 Class1 Class3 prec(40-60)	73	2
47	Class8 Class2 Class1 prec(0-40)	3	1
48	Class8 Class3 Class1 prec(40-60)	40	1
49	Class8 Class3 Class1 prec(60-80)	1	1
50	Class9 Class1 Class1 prec(60-80)	9	1
51	Class9 Class1 Class2 prec(40-60)	26	1
52	Class9 Class2 Class1 prec(40-60)	9	1
53	Class9 Class2 Class1 prec(60-80)	24	1

*Classes are in the order of sand, loam and clay.

Supplementary S2: Sampling design adopted for vegetation sampling



**ASSESSING IMPACTS OF POWER-LINES ON BIRDS IN A MULTIPLE-USE
GRASSLAND LANDSCAPE OF ABDASA, GUJARAT, INDIA**

THESIS
SUBMITTED TO THE
FOREST RESEARCH INSTITUTE (DEEMED) UNIVERSITY
DEHRADUN, UTTARAKHAND



FOR
THE PARTIAL FULFILLMENT OF THE DEGREE OF
MASTER OF SCIENCE IN ENVIRONMENT MANAGEMENT

BY
AISHWARYA JOSHI
2017-19

UNDER THE SUPERVISION OF

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Dehradun

Co-Supervisors: Dr. Sutirtha Dutta
Scientist-D, Animal Ecology and
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Mr. Devesh K. Gadhavi
Deputy Director
The Corbett Foundation
(Kutch Division)

DECLARATION

This is to certify that the thesis entitled, “**Assessing impacts of power-lines on birds in a multiple-use grassland landscape of Abdasa, Gujarat, India**” is submitted to Forest Research Institute (Deemed) University, Dehradun for the partial fulfillment of award of the degree of **M.Sc. (Environment Management)**. The work was carried out at Wildlife Institute of India, Dehradun.

No part of this work has been submitted for the award of any degree or equivalent.

Date: 18 June 2019

Place: Wildlife Institute of India, Dehradun

AISHWARYA JOSHI



CERTIFICATE

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No part of the thesis has been submitted for any other degree or diploma.

She bears a good moral character and is sincere and hardworking. I wish her success in all endeavors.

Malvika Onial

Date- 18 June 2019

Place- Wildlife Institute of India, Dehradun

Dr. Malvika Onial

**Scientist- D, UNESCO C2C Centre, EIA
Nodal Officer, Wildlife Institute of India,
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Date: 18 June 2019
Place: FRI, Dehradun

Dr. H.S. Ginwal

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Aishwarya

ABSTRACT

Avian mortalities due to power-lines are fast becoming an important conservation issue worldwide. With several new power-line projects coming up in the ecologically sensitive Kachchh region in Gujarat, a two and a half month study (March-May 2019) was conducted to assess the impacts of power-lines on the avian fauna in Abdasa taluka of Kachchh district.

Belt transects of 2 km were laid at randomly generated 23 high tension, 23 low tension and 25 control (having no power-lines) points to compare power-line induced bird mortality against natural mortality. A total of 169 carcasses were found by surveying 310 km on foot, of which highest number of mortalities belonged to members of the Phoenicopteridae family. Surveys preceded by carcass clearance 30 days prior, yielded carcass encounter rates of 0.27 (SE= 0.14) and 0.25 SE= 0.06) carcasses/ km for high tension and low tension power-lines respectively. Experiments were performed for correcting carcass decomposition and non-detection biases to estimate the actual number of mortalities. Mean persistence and detection (if available) probabilities were calculated as 0.36 and 0.29 respectively for an average bird carcass over 30 exposure days. Using these statistics, the corrected bird mortality rate was estimated as 2.34 (SE= 0.66) carcasses/ km/ month. Extrapolating this value to a conservative figure of power-line coverage in the study area (1123 sq.km), it was estimated that 1818 birds die per month because of power-lines in the study area. Habitat co-variates and power-line characteristics were found out to be weakly correlated with carcass encounter rate. Large variations were found in bird crossing rates (no. of individuals crossing the power-lines/ hr) across different families. Highest crossing rate was found in Columbidae family (8.27 crossings/ hr). Small birds (<100g) had higher crossing rate (6.27, SE= 2.3 crossings/ hr) than birds weighing >100g (4.23, SE= 2.11 crossings/ hr). Crossing rate of birds was higher at low- tension power-lines (1.60, SE= 0.58 crossings/ hr) than high tension power-lines (0.45, SE= 0.58 crossings/ hr).

Results indicated very high avian mortalities in the multiple-use landscape of Abdasa, Kachchh, Gujarat. The area holds high conservation significance owing to the presence of the critically endangered Great Indian Bustard *Ardeotis nigriceps*, but is treated as wastelands and managed to maximize revenue generation. We found that high-tension power-lines acted as a barrier to bird movements and resulted in threefold greater mortalities per bird crossing compared to low-tension power-lines. Finally, my study adds to the growing body of literature that highlights some negative

ecological impacts of ‘green energy’, and recommends necessary mitigation measures to balance biodiversity and developmental concerns.

Keywords – Birds, power-lines, mortality, carcass encounter rate, detection and persistence bias.

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LIST OF ABBREVIATIONS

WII	Wildlife Institute of India
GETCO	Gujarat Energy Transmission Corporation Limited
GPS	Global Positioning System
AIC	Akaike Information Criterion
PCA	Principal Component Analysis
SE	Standard Error
GIB	Great Indian Bustard
BACI	before-after-control-impact
GoI	Government of India
Ckm	Circuit Kilometer
GDP	Gross Domestic Product
kWh	Kilowatt-hour
CEA	Central Electricity Authority

1. INTRODUCTION

Today India is one of the fastest growing countries in the world both in terms of GDP growth and population. To facilitate the growth of such a large economy, it is important to meet its energy requirements. India consumes 1160 billion kWh per year, making it the third largest electricity consumer in the world (Singh et al. 2018). To fulfill our energy requirements the transmission line capacity expanded from 52,034 ckm in 1987 to 3,99,142 ckm in 2018 (Ministry of Power- GoI 2019), thus making the development of power-line linear infrastructure a necessity, but the growth of the power infrastructures is not without problems, especially ecological. With power-lines increasingly covering more land, bird habitats have become fragmented, restricting bird movement. Many birds die as a consequence of trying to make their way through these network of wires, making bird mortalities due to power-lines a common phenomenon (WII 2016). Bird mortalities caused by power-lines is increasingly becoming an important conservation issue for avian species worldwide. The problem becomes all the more grave for species that are under serious threats from habitat loss, poaching combined with factors such as a limited distribution or small global ranges.

These power-line corridors have led to varied effects on avian species worldwide, however, the most apparent impact of power-lines on birds is bird mortality caused due to electrocution and collision with overhead wires. Electrocution occurs when a bird, perched on live wire, power pole or on the metal cross arm, comes in contact with another live or earth wire, power pole or cross arm (WII 2016). Other structural components of an electric pylon such as pin-type insulators and jumpers also cause bird mortalities (Tinto et al. 2010; Sporer et al. 2013).

Collision occurs when a bird in flight, collides with overhead wires, often resulting in immediate death or serious injury to the bird. Collision generally occurs with the earth wire, as it is less visible to birds.

Thus, among the first steps in assessing the impact of power-lines on birds is to estimate the total number of mortalities that occur per km stretch of power-line network yearly (bird mortality rate), find out which bird species are more susceptible to power-line mortalities, and outline the critical areas where maximum bird mortalities are taking place.

In this regard, my study was undertaken to assess the impacts of power-lines on the avian fauna of the Kachchh region in Gujarat. This area was selected for the study due to a fast-growing network for power transmission in the region (GETCO 2017) and its hosting a variety of avifauna including

rare and threatened bird species. Kachchh is a unique region as it houses both grassland and coastal birds. It is also an important habitat for all the three bustards found in India, Great Indian Bustard (*Ardeotis nigriceps*), MacQueen's Bustard (*Chlamydotis macqueeni*), and Lesser Florican (*Sypheotides indicus*), all of which are threatened species and are under severe stress. Apart from this, the area houses a number of other globally threatened avifauna including Stoliczka's or White-browed Bushchat (*Saxicola macrorhynchus*), Black-tailed Godwit (*Limosa limosa*), Eurasian Curlew (*Numenius arquata*), Indian Vulture (*Gyps indicus*) and White-rumped Vulture (*Gyps bengalensis*). With 100 new substations being added each year in the state of Gujarat (GETCO 2017), it becomes paramount that we assess the impact of power-lines on birds in this region.

The study also aimed to help in identifying priority areas where maximum bird mortalities are taking place and in planning mitigation strategies for the landscape.

1.1. Research Questions

This study aims to explore the impact of power-lines on birds in the Abdasa Taluka of Kachchh landscape. This will address the following research questions-

1. What are the carcass encounter rates under high- and low-tension power-lines?
2. What is the difference between mortality due to power lines and natural mortality rate?
3. How to quantify and correct the carcass decomposition and non-detection biases involved in mortality surveys?
4. Do habitat co-variates (land-cover, terrain, substrate and distance from water-body) and power-line characteristics (number of wires and height of the electric pole) play an important role in influencing bird mortality?
5. What are the crossing rates for different species and how crossing rate changes across various taxonomic families, bird weight class and power-line type?
6. What proportions of different species use power-lines for crossing (exposed to collision risk) as opposed to perching on poles (exposed to electrocution risk), and what proportions of different species cross through parallel wires (greater risk of collision) as opposed to above/below the lines?

1.2. Objectives

To address the aforementioned research questions, a two and a half month (March 2019-May 2019) study in Abdasa Takula of Kutch District, Gujarat was conducted to fulfill the following objectives-

- A. To assess carcass encounter rates due to power-lines.
 - To compare the difference in bird mortality due to power-lines with that due to natural causes.
 - To find out the difference in carcass encounter rate between high tension and low tension power-lines.
 - To understand the effects of habitat co-variates and power-line characteristics on bird mortality.
- B. To perform persistence and detection experiments to obtain a correction factor for carcass encounter rate to estimate actual bird mortalities that occur due to power-lines in the Kachchh landscape.

Carcasses under power-lines disappear with time due to scavenging or removal by vertebrate predators and decomposition by invertebrates/microbes, at rates that vary with the bird size, resulting in carcass persistence bias. The number of mortalities found during such surveys are also found to be heavily dependent on the ability, experience and efficiency of the observer, which varies greatly with habitat covariates such as vegetation cover, and factors including the size, and colour of the carcass, thereby contributing to detection bias.

- C. To find out crossing rate for avian species across power-lines.
 - To calculate crossing rate across different taxonomic families and species.
 - To understand how crossing rate varies with power-line type, bird weight class
 - To compare the relative abundance of species crossing wires with those perching on the electric poles.
 - To compare the relative abundance of species crossing through wires with those crossing above/ below lines.

2. REVIEW OF LITERATURE

Power-lines are increasingly expanding, causing fragmentation of bird habitats worldwide (D'Amico et al. 2018). Several studies point out the negative impacts of power-lines on birds (Bevanger 1998; Janss 2000; Rioux et al. 2013) but the most apparent or visible impact of power-lines on birds is direct mortality occurring due to power-line structures (Janss and Ferrer 2000; Shaw et al. 2010; Martin and Shaw 2010; Rubolini et al. 2005; Shobrak 2012).

Electrocution and collision with overhead wires are the main reasons behind bird mortalities caused by power-line structures. Electrocution occurs when a bird comes into contact with two phase conductors or one phase conductor and an earth wire simultaneously (Bevanger 1998). Collision occurs when a bird collides directly into the wire or a pylon and dies instantly or by injuries resulting from falling on the ground. Collision with earth wire, which is usually thinner and hence less visible, is a major cause of avian mortality. Rate of birds dying from collision is far greater than electrocution (Dixon et al. 2013).

There are a plethora of factors affecting collision and electrocution rates. The extrinsic factors affecting avian deaths are mostly meteorological, habitat and power-line characteristics. Fog and mist increase collision risk by reducing visibility (Drewitt and Langston 2008; Jenkins et al. 2010) and heavy rains and thunder-storms increase electrocution risk (Lehman et al. 2007).

Altitude, topography, land use, type and amount of vegetation and occurrence of characteristic landscape elements such as river, pond, hedgerow etc. are important landscape covariates which affect power-line mortalities. Habitat proximity also plays an important role as species are more likely to be killed near power-lines adjacent to their preferred habitat (Ray et al. 2006; Coffin 2007; Rytwinski et al. 2015).

Orientation of power-lines, distance between the two wires, total number of wires, distance between upper and lower wires and presence of earth wire are also some of the power-line characteristics which determine bird mortality rates (Loss et al. 2014).

Species behavior and morphology are two intrinsic factors affecting mortality rates. Available scientific literature points out that wing loading (body mass of given bird species divided by the area of its wing) and low frontal vision are most important morphological factors that enable us to predict the species probability to collide with power-lines (Bevanger 1998, Janss 2000, Martin and Shaw 2010, Martin 2011). Research has shown that species with high wing loading and

low frontal vision have low maneuverability in flight, leading to increased risk of power-line collision (Bevanger 1998).

Research also shows that the behavioral traits that affect the species probability to collide with the power-lines are flight height, flocking height, foraging height, circadian height and use of power-lines for nesting or perching (D' Amico et al. 2019; Bernadino et al. 2018).

Species that fly at higher height have much less chances of colliding with the overhead wires as compared to low flying species. Species foraging in flight generally have high maneuverability and thus have lower collision probability. Species that fly in groups have higher collision probability than solitary flying species. Nocturnal species are much more likely to collide with overhead wires than diurnal species owing to low visibility during night time (Bevanger 1998).

Death rate due to collision does not drastically affect most species, but it can be a matter of concern for threatened, endangered or rare species (Shobrak 2012). Long-lived slow reproducing species face higher extinction risk from collision than short-lived fast reproducing species (D' Amico et al. 2019).

Worldwide a lot of studies have been conducted on bird mortalities due to power-line collisions, but these studies are either generally limited to a particular species (Dixon et al. 2013; Rollan et al. 2010) or simply provide a long list of species affected in a particular area (Savereno et al. 1996; Harness and Wilson 2001; Rubolini et al. 2005). Only a few studies look at avian mortality rate at a landscape level (Loss et al. 2014; Bevanger 1998).

Such studies are important as they provide us with data on avian mortalities caused by power-lines and help policy makers in planning more effective mitigation measures. But almost all of these studies point out that there is a gross underestimation in the numbers of power-line related bird mortalities. These anomaly of numbers are because of the presence of two major biases- carcass persistence bias and observer detection bias (Beckmann and Shine 2015). The detectability of a carcass on field by researchers depends on its rate of persistence, called carcass persistence rate. Persistence of a carcass is the probability that the carcass will still be available for detection on field between surveys (Guinard et al. 2012). There are a lot of factors at play which affect the carcass persistence rate, such as, the rate of decomposition of carcass (Santos et al. 2016; Antworth et al. 2005), rate of carcass removal by scavengers, variations in mean temperature and precipitation levels etc. The ability of an observer to detect a carcass on the field depends heavily on the ability, experience and efficiency of the observer. The efficiency of the observer varies

greatly with vegetation cover, size and colour of the carcass, thus contributing to a major source of detection bias in such studies (Teixeira et al. 2013).

Other biases involved in mortality surveys such as- crippling bias i.e. birds that get injured by power-lines but die elsewhere and remain undetected, and background mortality i.e. natural mortality were not accounted for, since they are assumed to be relatively small.

Correction of these biases is necessary to obtain accurate estimates of avian mortality in the region (Ponce et al. 2010).

Review of literature in the Indian scenario

There is a dearth of studies focusing on assessing the impact of power-lines on the avian fauna in Indian context. Mortality of the Critically Endangered Great Indian Bustard (*Ardeotis nigriceps*) due to powerlines has been documented in the Thar region of Rajasthan (Dutta et al. 2014). An intensive study was conducted by Wildlife Institute of India (Uddin M. 2017) in the Thar landscape to assess threats to birds from powerlines with a focus on the Great Indian Bustard. A handful of studies in the published literature have also documented instances of collision of species such as the Sarus crane (*Grus antigone*) with powerlines (Sundar and Choudhury 2001, 2005), electrocution of birds on electricity distribution lines in western Rajasthan (Harness et al. 2013), and an incidence of electrocution of flamingos in the Rann region of Gujarat (Tere and Parasharya 2011).

3. STUDY AREA

3.1. Location

The study has been conducted in Abdasa Taluka, which is situated in the south western province of Kachchh District (between 22°50'–23°15'N and 68°32'–69°01'E) in Gujarat. Abdasa is one of the 10 talukas in Kachchh district. This area lies in the Biogeographic Zone 3B (Kachchh Desert) (Rodgers et al. 2000) and serves as the habitat of several important fauna. A total of 1123 sq. km. area was surveyed for this study. Abdasa taluka primarily consists of a mainland region and salt pans area (Jakhau). The salt-pan area is devoid of human settlements and is occupied on lease by a private company for salt extraction.

3.2. Climate

The area falls under arid and semi-arid climatic zone. Winters start from November and last till February, followed by hot summers from March till June. The annual mean temperature of the region is 26.3 degree Celsius, with temperatures reaching 45 – 48 degrees during peak summers (May). The area receives rainfall once a year during the months of July – September. The average rainfall that the Taluka receives is 379 mm. The area suffers from a dry spell every few years. January is usually the coldest month with temperatures ranging from 9 – 16 degree Celsius.

3.3. Habitat

The area falls under the ecological zone 5A/DS 4-dry grassland with a few scattered patches of 5A/DS 2-dry savannah (Champion & Seth 1968). Broad habitat types present in the area are- grassland, scrubland, shrubland, open land, wetland and agricultural fields. Major grass species present in the area include species of the genus *Cymbopogon*, *Aristida*, *Dicanthium* and *Chrysopogon*. Scrubland is dominated by *Zizyphus*, *Acacia*, *Capparis*, *Salvadora*, *Euphorbia* and the introduced highly-invasive *Prosopis juliflora* shrubs.

In Kachchh, major crops grown are Jowar (*Sorghum bicolor*), bajra (*Pennisetum glaucum*), maize (*Zea mays*), wheat (*Triticum* spp.), groundnut (*Arachis hypogaea*), sugarcane (*Saccharum officinarum*) and til (*Sesamum indicum*), Castor bean (*Ricinus communis*), cotton (*Gossypium* spp.) tomato (*Solanum lycopersicum*), Pomegranate (*Punica granatum*), Watermelon (*Citrullus lanatum*) and chili (*Capsicum frutescens*).

3.4. Fauna

The mammalian species occurring in the area include Chinkara (*Gazella gazelle*), Indian Grey Wolf (*Canis lupus pallipes*), Caracal (*Caracal caracal*), Honey Badger (*Mellivora capensis*), Striped Hyena (*Hyaena hyaena*), Golden Jackal (*Canis aureus*), Jungle Cat (*Felis chaus*), Desert Cat (*Felis silvestris ornata*), Nilgai (*Boselaphus tragocamelus*), Wild Pig (*Sus scrofa*) and Indian Fox (*Vulpus bengalensis*). Apart from the above mentioned mammals, the area is also home to a variety of reptiles such as Banded Gecko (*Cryptopodion kachhensis*), Bengal Monitor (*Varanus bengalensis*), Garden Lizard (*Calotes versicolor*), Saw-scaled Viper (*Echis carinatus*) and Spiny tailed lizard (*Saara hardwickii*).

Important avifauna include the Great Indian Bustard (*Ardeotis nigriceps*), Lesser Florican (*Sypheotides indicus*), MacQueen's Bustard, (*Chlamydotis macqueeni*), Stoliczka's Bushchat (*Saxicola macrorhynchus*), Indian Courser (*Cursorius coromandelicus*), Black Francolin (*Francolinus francolinus*), White-backed Vulture (*Gyps bengalensis*), Greater Flamingo (*Phoenicopterus roseus*), Lesser Flamingo (*Phoenicopterus minor*), and several species of raptors, sandgrouses, partridges, quails, wheatears, larks and pipits (Pandey et al. 2008; Collar et al. 2015). Several coastal birds like Eurasian Curlew (*Numenius arquata*), Bar-tailed Godwit (*Limosa lapponica*), seagull spp. and Dalmatian Pelican (*Pelecanus crispus*) are found exclusively in the salt-pan region.

3.5. People

Abdasa Taluka has a population of 1,17,538 individuals residing in a total of 133 villages (Census 2011). Population in Abdasa Taluka comprises mainly of Hindus and Muslims. Major occupations of local community in this area are cattle breeders (Maldharis) and farmers. Traditionally, the people of Kachchh were pastoralists and depended on grasslands for their survival, but over the past few years, mechanized farming and better irrigation facilities have led to increase in agricultural practices. This has led to alterations in land use patterns and illegal encroachment of grasslands and their subsequent conversion into agricultural fields (Dutta 2012).

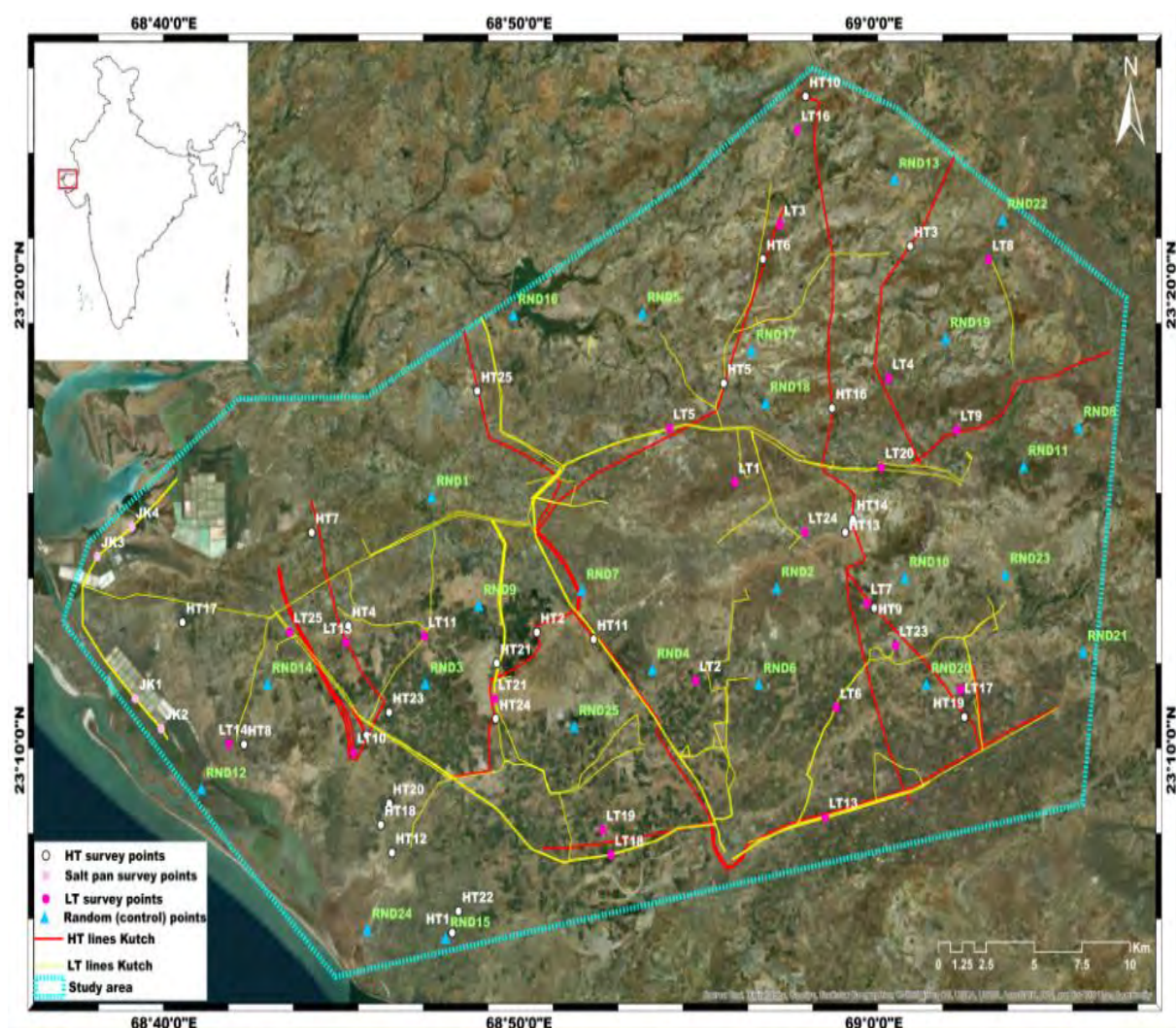


Figure 1: Map of the study area showing the geographic location (Abdas taluka, Kachchh district in Gujarat, India) with the High tension, Low tension and random points in Kachchh landscape, March-May 2019.

4. METHODOLOGY

To find out the actual number of avian mortalities occurring due to power-line networks in the study area, we conducted routine field mortality surveys. Carcass detection and persistence experiments were then conducted to quantify and correct the biases involved in such mortality surveys. Bird movement near the power-lines was also observed to assess the rate at which different species move along the power-lines.

4.1. Field surveys to assess power line bird mortality rate

4.1.1. Selection of samples

For selection of samples, I used the ongoing digitization of high tension and low tension power-lines carried out by WII's Great Indian Bustard Recovery Project using field surveys and very high resolution satellite imagery in Google Earth. I randomly generated 23 points each of high tension power-lines and low tension power-lines and 25 control points (areas with no power-lines) from the digitized power-line map in QGIS 3.6. Fixed transects of 2km length were laid at each of these points. Survey of these power-line segments was undertaken thrice, first in the month of March, then in April and lastly in May 2019.

4.1.2. Field Surveys

Field surveys were conducted by four observers, including me, walking on either side of sampled power-lines in a zigzag manner within a belt of 30m. This belt-width was selected based on an earlier study (Uddin 2017) that documented maximum deposition distance of carcasses up to 30 m from a power-line. On spotting a carcass, observers recorded the exact location of the carcass using GPS, distance of carcass from the power-line, habitat co-variates and condition of the carcass (whether the carcass was fresh, old, and intact or predated upon) and if possible the carcass was identified up to species level or the finest possible taxonomic group. After noting all observations, carcasses were subsequently removed from the segment, so that we do not count the same carcass again in the next survey.

Carcass identification was generally difficult due to decomposition, possible predation by scavengers or electrocution. Because of these factors, sometimes only few feathers attached to a limb, a blackened charred body or just a bunch of feathers were found. Such carcasses require genetic identification of the species. Cases where less than 10 feathers were found, were not recorded as mortality as they could have been blown by wind or deposited by birds during preening, moulting or fighting (Bevanger 1998).

To find out the effect of habitat co-variates on power-line mortality, at every 200m on power-line segment, habitat characteristics like land-cover (barren, agricultural land, grassland, wood-land, shrub-land, wetland or scrub-land and distance from water-body), terrain (flat, undulating, moderately sloping or very sloping) and substrate (rocky, gravel, soil or sand) were noted. Power-line characteristics, namely number of wires, height of the pylon and power-line type were also noted to see how they affect carcass encounter rate (no. of carcasses found/ km of power-line).

4.1.3. Carcass Persistence Experiments

To estimate carcass decomposition bias, we conducted experiments in which we placed 23 freshly procured carcasses of birds of varying sizes in 8 randomly selected power-line segments (4 high-tension lines and 4 low-tension lines). Since smaller birds are believed to have lower rate of carcass persistence, carcasses of size varying from 15 to 8000g were used, to represent wide spectrum of body mass. In the experiment wild birds corresponding to 2 weight classes were used- small (0-100g) and large (>100g) to represent different weight classes of birds. The carcasses placed included wild birds that were detected very fresh (less than 24 hrs. old) while doing the mortality surveys. Domesticated country chicken that were free from the odor characteristic of poultry farm birds were used, so that the carcass removal rate by scavengers is not affected (Ponce et al. 2010; Bevanger 1998). Before placement of carcasses, each bird was tagged (so as to differentiate it from other carcasses which may get deposited naturally during the conduction of experiments) and its geographic location, date and time of placement was noted while placing it within the power-line segment. After placing the carcasses, they were monitored on 1, 4, 7, 12, 17, 22, 30th days after the day of placement. The persistence of carcasses was monitored by searching the 30m radius around the placement location to avoid chances of missing the carcasses that got displaced during scavenging. A carcass was considered to have disappeared if it was not found near the placement area or less than 10 feathers remained. The distance between subsequent carcasses, distance of carcass from the power-line and no. of carcasses placed in the power-line segment were kept random in order to mimic natural conditions.

4.1.4. Carcass detection experiments

In order to estimate carcass detectability, 23 bird carcasses of varying body sizes in 8 randomly selected power-line segments were surveyed by 3 observers. These carcasses were placed under 8 randomly selected power-lines using completely randomized placement decision (number and location of carcass under each power-line was random) by an observer, after tagging each carcass and noting down its exact geographical location. Three observers (other than the one who placed

the carcass) searched carcasses with tags in the power-line segments without knowing where the carcasses were placed by the first observer. These observers searched for carcasses in the 30m belt-width around the power-lines, thereby mimicking actual power-line surveys. The number and location of carcasses found by the third observer was compared with the data of the first and second observer to find out how many of the placed carcasses the observer was able to detect.

4.1.5. Quantifying the rate of bird movement (crossing rate) across power-lines

To quantify the crossing rate (no. of individuals crossing the power-line/ hr) for different species, bird movement and activities near power-lines were noted using binoculars. Two observers, including me, observed bird activities near four randomly selected high tension and four low tension power-lines. To avoid any alteration in bird behavior and movement that may occur because of the presence of observers, the observers were placed in a camouflaged mobile hide, 50 meters from the power-lines. Observers noted bird activity near power-lines from sunrise till sunset (12 hrs.), with observers taking a 30 minute break after every two hours to prevent fatigue. Temperature and wind velocity were noted every hour to see the effects of changing temperature and wind velocity on bird activity. Birds of the Indian subcontinent second edition (Grimmett R, Inskipp T. 2011) was used for bird identification.

On sighting a bird near power-lines, observers recorded the following variables- position of bird with respect to wire (above, below, through the line), vertical distance of bird from wire (<1, 1-5, 5-10, 10-20 m and >20m), horizontal distance of bird from observer measured as the distance class between the proximate and distant pole/pylons through which the bird has crossed, number of wires in power line, height of lower and upper wire, and the usage of power line by the bird (perching, crossing, chasing and soaring).

4.2. Statistical analyses

4.2.1. Detection and persistence experiments

For the purpose of obtaining correction factor to estimate the actual number of bird mortalities occurring in the study area, detection and persistence experiments were conducted. The data from these experiments were then used to calculate detection and persistence probabilities for birds belonging to different weight classes.

I modeled the declines in carcass persistence probability and detection probability with time since deposition and the additional effect of carcass weight using binomial generalized linear models. Models with time and/or carcass weight class (<100g, >100g) were constructed and ranked using Akaike Information Criterion (Akaike 1974). The least AIC model was used to predict carcass persistence and detection probabilities for exposure periods of 1-30 days and carcass weight class. Thereafter, we estimated mean probabilities of carcass persistence and detection on a survey by summing the persistence/detection probability of a carcass on the i^{th} day leading to a survey (i ranging from 1-30 days) given the deposition probability of the carcass on that day, which was assumed to be uniform. All these analyses were done in R software (version 3.6.0).

4.2.2. Carcass encounter rate

Mean and standard error of carcass encounter rate (no. of carcasses found/ km of power-line) was calculated based on the data found in the base and replication surveys. This estimate was then divided by the product of average detection and persistence probability (correction factor) to find out the bird mortality / km / month. The value obtained was then extrapolated to estimate the monthly bird mortality/km. of power-lines in the entire study area.

Mean and standard error of carcass encounter rate under power-line transects were compared with to that under natural conditions using the base survey (larger sample size due to longer exposure period), to test if power lines contributed significantly more to bird mortality than natural factors. All these analyses were done by using Microsoft Excel.

4.2.3. Effect of habitat and power-line characteristics on carcass encounter rate

To assess the factors influencing bird mortality rates, additional information on habitat and power-line characteristics were collected and analyzed. The co-variates assessed were distance to water-bodies, land-cover (barren, wetland, grassland, shrubland, scrubland, agriculture), terrain (flat, undulating and sloping) and substrate (sandy, soil, gravel and rocky). Principal component analysis (PCA) was conducted to extract the components explaining maximum variance (Franklin et al. 1995) and then a factor analysis was done to synthesize few meaningful factors that

described the latent habitat gradients. The values of each factor was then correlated with the corresponding values of carcass encounter rate of each power-line, to find out the association of these factors with bird crossings/mortalities. Spearman's rank of correlation test was used for this purpose. To understand the role power-line characteristics play in influencing bird mortality, a similar correlation test between power-line variables such as number of parallel wires and height of the utility pole, and carcass encounter rate was conducted.

4.2.4. Bird crossing rate

To estimate the bird crossing rate at power-lines, mean and standard error of bird crossings/ hr was calculated species wise. To find out if difference in body mass affects the movement rate in birds, mean and standard error of crossing rate was computed separately for birds belonging to lower weight class (<100g) and larger weight class (>100g). Bird crossing rate was also computed based on family, to identify which bird families are using the power-lines more owing to difference in abundance or attraction/avoidance response to power-lines. Crossing rates were calculated separately for high tension and low tension power-lines, to find out if power-line type had any effect on bird usage.

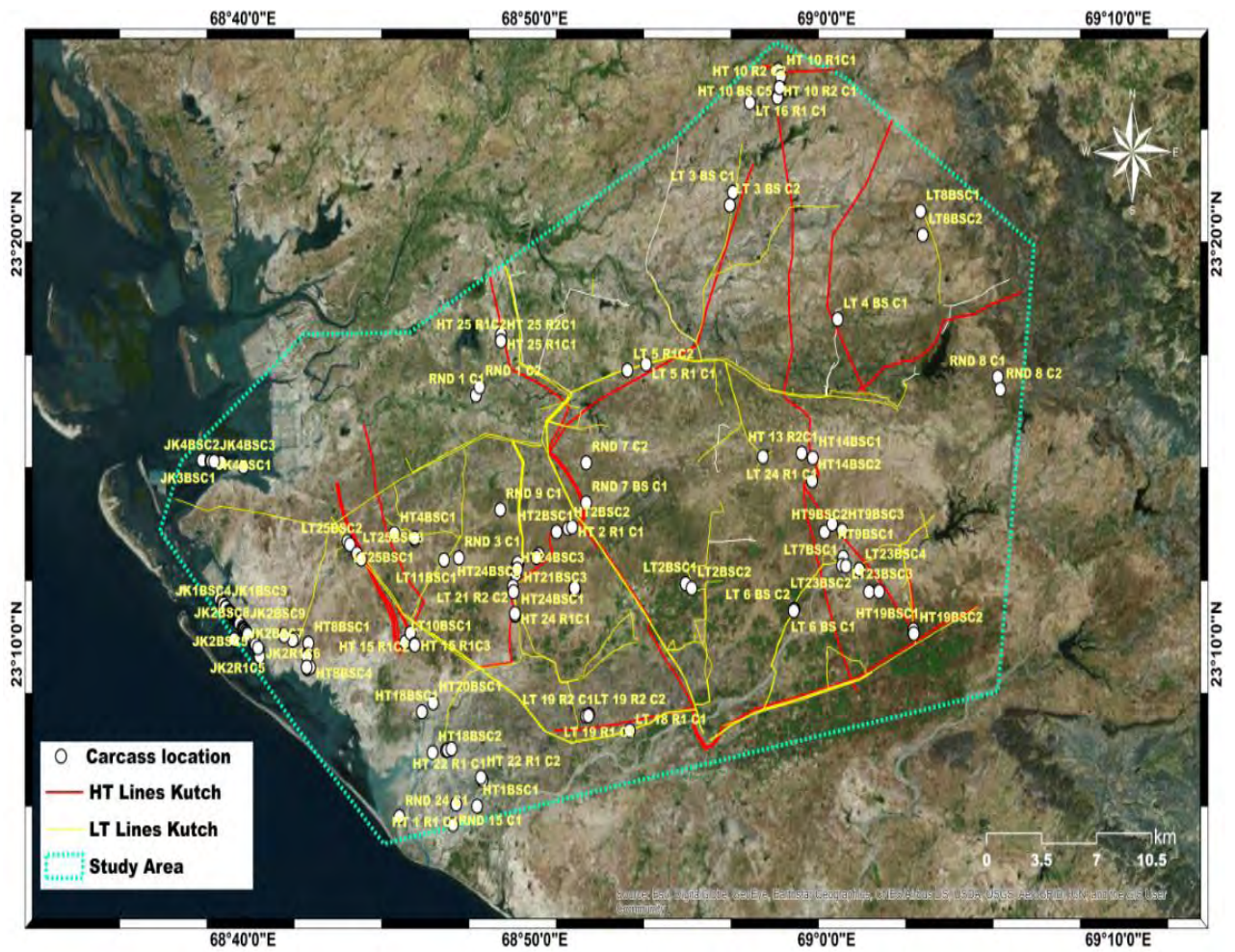


Figure 3: Map showing carcass location of all the birds found on power line transects in Kachchh landscape during March - May 2019.

5. RESULTS

I surveyed 310 km on foot and recorded 169 avian mortalities from 9th March 2019 till 7th May 2019, inclusive of base survey (where carcasses were not removed prior to survey) of power-lines and random transects, first replication and second replication survey (where carcasses were removed before conducting the surveys). Out of these, only 40 birds (24% cases), belonging to 11 species and 9 families could be identified in the field; while the rest requires genetic identification. Highest number of carcasses found belonged to Phoenicopteridae family, followed by Gruidae family, i.e., large-bodied birds (Table 1).

Table 1: Summary of carcasses found during power line surveys in Kachchh landscape during March – May 2019.

S.No.	Species	Scientific name	Family	No. of carcasses	Relative abundance	% of individuals
1.	Black kite	<i>Milvus migrans</i>	Accipitridae	1	0.006	0.6
2.	Greater Flamingo	<i>Phoenicopterus roseus</i>	Phoenicopteridae	28	0.166	16.6
3.	Grey francolin	<i>Francolinus pondicerianus</i>	Phasianidae	1	0.006	0.6
4.	Common crane	<i>Grus grus</i>	Gruidae	3	0.018	1.8
5.	Indian peafowl	<i>Pavo cristatus</i>	Phasianidae	1	0.006	0.6
6.	Laughing dove	<i>Streptopelia senegalensis</i>	Columbidae	1	0.006	0.6
7.	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	Pteroclididae	1	0.006	0.6
8.	Southern Coucal	<i>Centropus (sinensis) parroti</i>	Cuculidae	1	0.006	0.6
9.	Parakeet sp.	-	Psittaculidae	1	0.006	0.6
10.	Roller sp.	-	Coraciidae	1	0.006	0.6

11.	Eagle sp.	-	Accipitridae	1	0.006	0.6
12.	UN	-	-	129	0.763	76.3

5.1. Carcass encounter rate

Base power-line surveys that were not preceded by carcass removal showed that carcass encounter rate was higher in power-line transects (mean=0.78 carcass/km, SE=0.18, n=23 in high-tension power-lines and 0.50 carcass/km, SE=0.12, n=23 in low-tension power-lines) than random transects (mean=0.25 carcass/km, SE=0.08, n=25 power-lines), indicating relatively greater power-line induced mortality than natural mortality (Fig4).

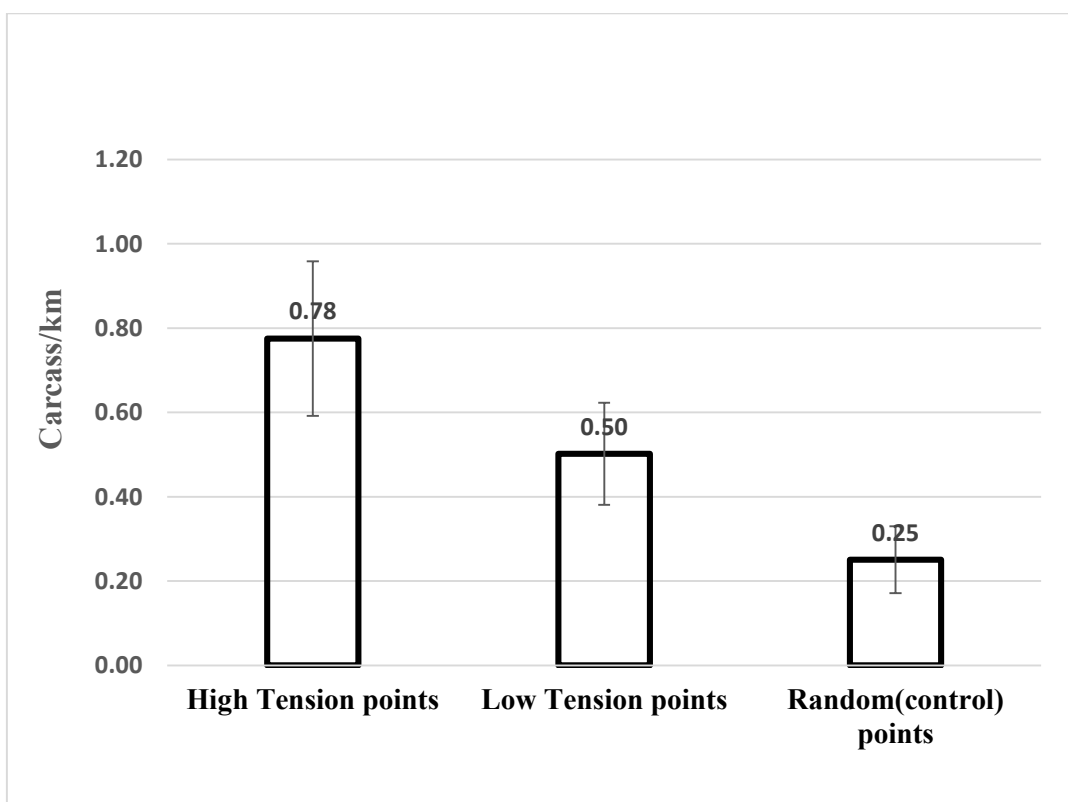


Figure 4: Mean and SE of carcass encounter rate under power line and random transects during base survey in Kachchh during March - May 2019.

Based on power-line surveys preceded by carcass removal (20-30 days prior), we estimated carcass encounter rate at high tension power-lines (mean= 0.40 carcass/km, SE= 0.12, n= 19) to be similar to low tension power-lines (mean= 0.31 carcass/km, SE= 0.09, n= 19) in the first replication survey, as well as the second replication survey (high tension: mean= 0.13, SE= 0.06, n= 19 and low

tension: mean= 0.19, SE= 0.08, n= 19) (fig 5). However, there was difference in carcass encounter rates between first and second replication that reflected seasonal differences in bird abundance. Bird mortalities found in the salt-pan region were analyzed separately because of large differences in its habitat characteristics and avian diversity. Carcass encounter rate for salt-pan area was found out to be five times greater (mean= 5.25 carcasses/km, SE= 2.54, n=4) than the encounter rate in rest of the study area.

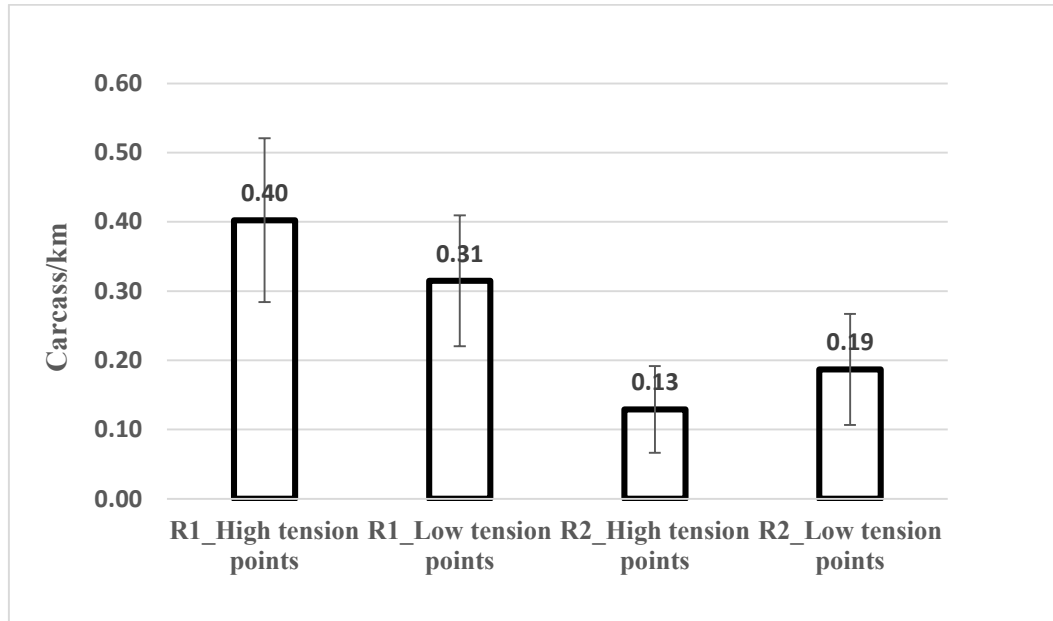


Figure 5: Mean and standard error of carcass encounter rate for high and low tension power-lines in the first and second replication surveys in Kachchh during March-May 2019.

5.2. Persistence of carcasses

I carried out carcass persistence and detectability experiments using 23 carcasses (Table 2). The probability of carcass persistence decreased with carcass age ($\beta = -0.06$, SE = 0.02) and increased with bird weight class ($\beta = -1.17$, SE = 0.47) (Table 2, Fig 6). The average persistence probability of carcass belonging to <100g weight class for exposure period of 1-30 days is 0.23, and that for carcasses weighing >100g is 0.48. The average probability of a carcass persisting for exposure period of 1-30 days irrespective of its body mass was estimated to be 0.36.

Table 2: Details of bird carcasses used for carcass decomposition / persistence experiment in Kachchh landscape during March - April 2019

Weight Class	Species	Number of carcasses
<100g	Country Chicken	2
	Unidentified	1
	Common Babbler	1
	Rosy Starling	1
>100	Country Chicken	17
	Laughing Dove	1

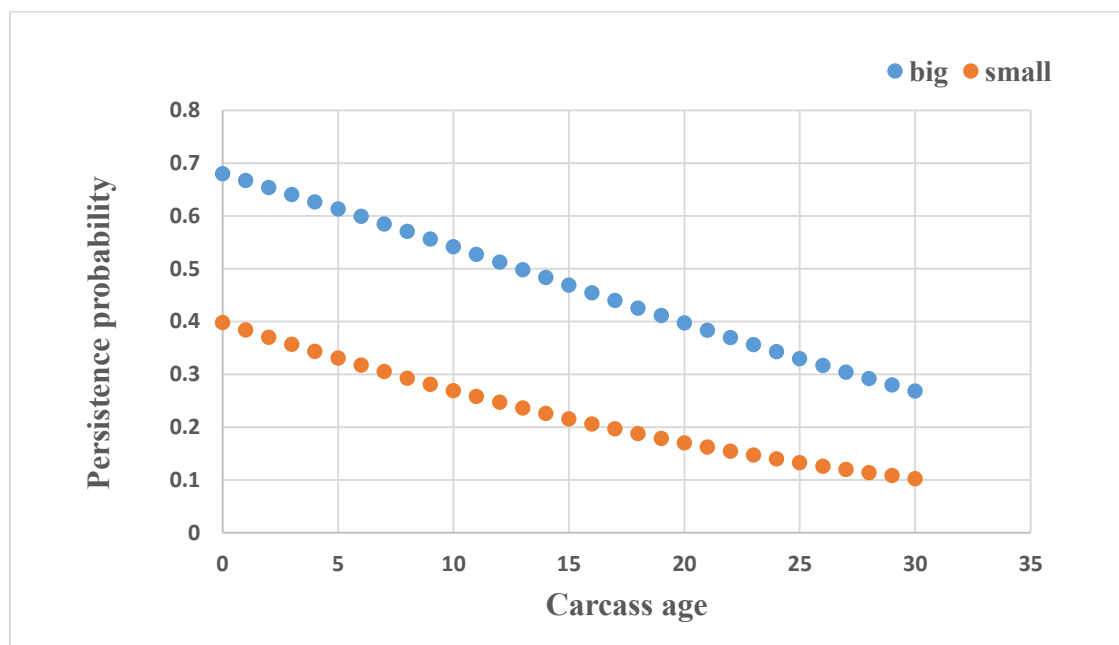


Figure 6: Probability of carcass persistence along time since placement under power lines for small (<100 g) and large (>100 g) birds in Kachchh landscape during April 2019.

5.3. Detectability of carcasses

The probability of carcass detection depended on carcass age and bird weight class. Detectability of a carcass decreased with exposure time ($\beta = -0.02$, $SE = 0.01$) and increased with bird weight class ($\beta = -2.42$, $SE = 0.62$) (Table 2). The average detection probability of <100g carcass during exposure period of 1-30 days was estimated to be 0.08, and that for >100g carcasses was estimated

at 0.49 (Fig 7). The average detection probability of a carcass irrespective of its body mass was estimated to be 0.29.

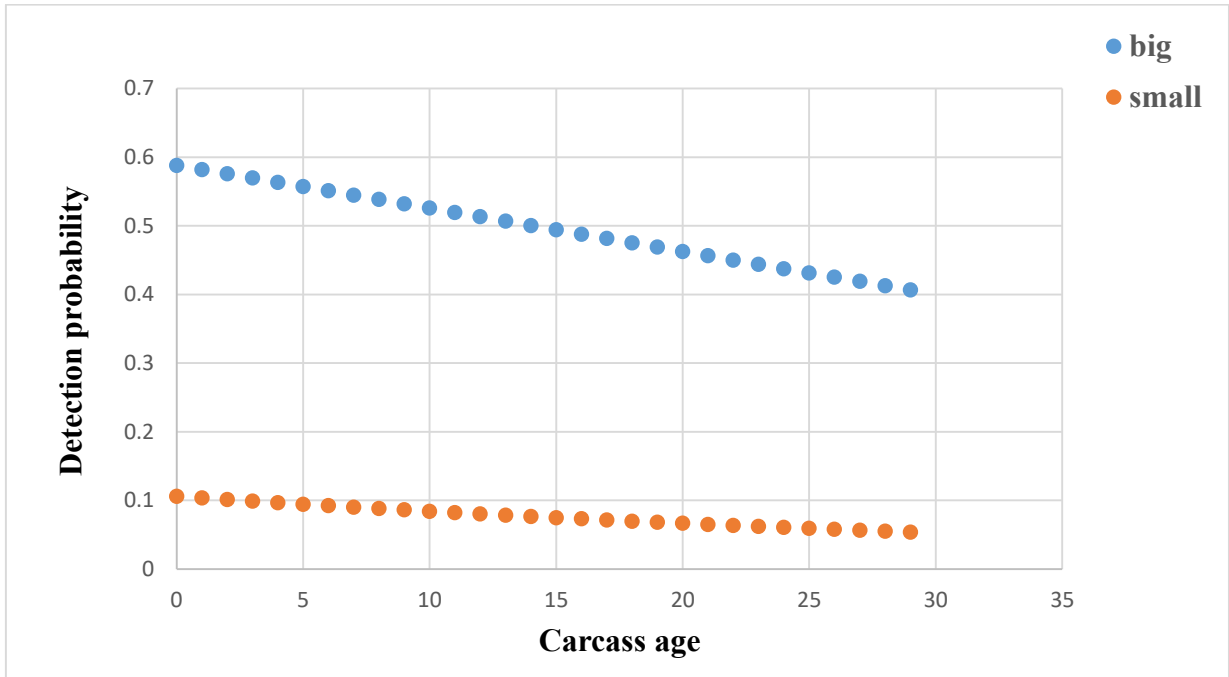


Figure 7: Probability of detection along body mass of birds estimated from carcass detection experiment in Kachchh landscape during April 2019.

5.4. Corrected mortality rate

Power-line samples cleared of existing carcasses one month prior to the survey showed that 0.25 (SE = 0.08) bird carcasses / km were available and detected. However, the average carcass persistence and detection probabilities for 30 days were found to be 0.36 and 0.29 respectively. To correct for these biases and obtain actual bird mortality rate, we used the product of detection and persistence probabilities as the correction factor. The carcass encounter rate divided by the correction factor yielded actual bird mortality rate of 2.34 bird mortalities/km/month (SE= 0.66). Extrapolating this encounter rate to 777 km of power-line (a conservative estimate of power-line length in the GIB habitat of Kachchh based on an incomplete digitization exercise), we obtained a total of 1818 mortalities per month in the entire study area (1123 km² area), or ~22000 mortalities in a year.

Table 3: Corrected carcass encounter rate (birds / km with 95% confidence intervals) in Kachchh landscape during March–May 2019. Carcass encounter rate was corrected for detection probability and persistence probability to estimate true bird mortality / km / month.

Parameter	Unit / details	Estimate
Carcass encounter rate	Birds / km / month	0.25 birds/km/month
Detection probability (d)	(mean of <100 g & >100 g bird weights over 30 days)	0.29
Persistence probability (p)	(mean of <100 g & >100 g bird weights over 30 days)	0.36
Correction factor	d*p	0.11
Corrected bird mortality	Carcass encounter rate / correction factor	2.34
Total length of power-line in the study area (digitized)	Conservative estimate (in km) based on WII's incomplete digitization exercise (2017)	777
Total bird mortalities	Corrected bird mortality / month in 1123 sq km area	1,818

5.5. Effect of habitat co-variables and power-line characteristics on carcass encounter rate

In the earlier section, I established that salt pan habitat had greater bird mortality rates than inland agro-grassland habitats. Here, I report results of the analysis to test if there is any association of bird mortality rate with habitat covariates within inland agro-grasslands. Principal component analysis (PCA) of the covariates agriculture (Agr), scrubland (scr), shrubland (shr), barren (brn), grassland (grs), soil, gravel (grvl), undulating (undl), sloping (slpn), rocky (rcky) and flat (flt) resulted in five components that explained 91% variability in habitat data. Thereafter, we used five factors in a factor analysis framework to synthesize variables that explained the dominant habitat gradient.

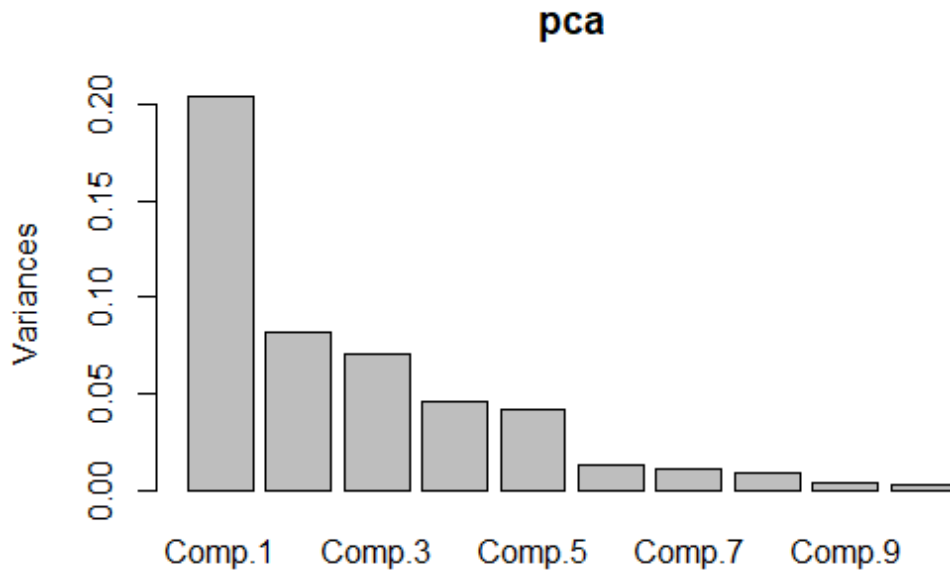


Figure 8: Results of PCA showing that five PCs cumulatively explained 91% variance in habitat data in Kachchh during 2019.

Table 4: Results of factor analysis

Habitat variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Agriculture	-0.721		-0.186	-0.500	0.435
Scrubland			0.944		
Shrubland	0.861		-0.262	-0.156	
Barren	0.543	0.319		0.125	
Grassland		-0.110		0.912	0.127
Soil substrate					0.755
Gravel substrate	0.777	0.187	0.275	-0.163	
Rocky substrate			0.558		
Undulating terrain	0.206	0.891			0.147
Sloping terrain	0.119	0.447			
Flat terrain		-0.852			0.509
Proportion variance explained	0.20	0.17	0.13	0.11	0.10

The factors along with another covariate distance to water-bodies (dwb) were then correlated with carcass encounter rate using Spearman's rank correlation. Spearman correlation coefficient (ρ) measures the strength of association between two variables with -1 indicating a strong negative relation, 0 meaning no relation and +1 indicating a strong positive relation. Results indicated weak association between carcass encounter rate and habitat factors (Table 6), indicating that habitat characteristics measured in the study did not explain variation in carcass encounter rates among transects.

Table 5: Results of Spearman's rank correlation test examining the association between carcass encounter rate with habitat heterogeneity in Kachchh landscape during March - May 2019.

Variable	Sample estimate (ρ)	P value
dwb	-0.17	0.25
Factor 1	-0.02	0.92
Factor 2	-0.16	0.28
Factor 3	0.08	0.60
Factor 4	0.15	0.31
Factor 5	0.05	0.72

Power-line characteristics, no. of wires and height of utility pole, were also found to be weakly correlated with carcass encounter rate (Table 7), indicating a limited role of number of wires and height of electric pole in affecting carcass encounter rate.

Table 6: Results of simple correlation test examining the association between carcass encounter rate with power-line characteristics in Kachchh landscape during March - May 2019.

Variables	Correlation coefficient	P value
Number of wires	0.15	0.28
Height of utility pole	0.12	0.22

5.6. Crossing rate (No. of individuals crossing the power-lines/ hr)

While observing bird activity near power-lines, I recorded a total of 3140 individuals belonging to 48 species and 31 families (a few individuals could only be identified generically e.g. ‘seagull’, ‘swallow’, ‘pipit’, ‘swift’, ‘lark’). The most abundant species recorded was Indian Robin (20.86%), Eurasian Collared Dove (13.95%), Lark (10.83%), Laughing Dove (9.84%) and Red-vented Bulbul (9.27) with an average hourly crossing rate of 6.82, 4.56, 3.54, 3.22 and 3.03 respectively (Table 8).

Table 7: List of species with family, number of individuals, crossing rate and percentage of individuals detected during flight observation at power lines in Kachhh landscape in April 2019

S.no.	Species	Scientific name	Family	Individuals Detected	Crossing rate	% individuals
1	Ashy-crowned Sparrow Lark	<i>Eremopterix griseus</i>	Alaudidae	23	0.24	0.73
2	Barn Swallow	<i>Hirundo rustica</i>	Hirundinidae	7	0.07	0.22
3	Baya Weaver	<i>Ploceus philippinus</i>	Ploceidae	1	0.01	0.03
4	Black Drongo	<i>Dicrurus macrocercus</i>	Dicruridae	121	1.26	3.85
5	Black-crowned Sparrow Lark	<i>Eremopterix nigriceps</i>	Alaudidae	1	0.01	0.03
6	Bluethroat	<i>Luscinia svecica</i>	Muscicapidae	4	0.04	0.13
7	Brahminy Starling	<i>Sturnia pagodarum</i>	Sturnidae	4	0.04	0.13
8	Cattle Egret	<i>Bubulcus ibis</i>	Ardeidae	15	0.16	0.47

9	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	Pteroclididae	41	0.43	1.30
10	Common Babbler	<i>Turdoides caudate</i>	Leiothrichidae	165	1.72	5.25
11	Common Kestrel	<i>Falco tinnunculus</i>	Falconidae	4	0.05	0.13
12	Blue Rock Pigeon	<i>Columba livia</i>	Columbidae	44	0.46	1.40
13	Common Stonechat	<i>Saxicola torquatus</i>	Muscicapidae	1	0.06	0.03
14	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	Phalacrocoracidae	10	0.10	0.32
15	Dalmatian Pelican	<i>Pelecanus crispus</i>	Pelecanidae	1	0.06	0.03
16	Demoiselle Crane	<i>Anthropoides virgo</i>	Gruidae	2	0.02	0.06
17	Eastern Imperial Eagle	<i>Aquila heliaca</i>	Accipitridae	11	0.11	0.35
18	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	Columbidae	438	4.56	13.95
19	Green bee-eater	<i>Merops orientalis</i>	Meropidae	225	2.34	7.17
20	Grey Francolin	<i>Francolinus pondicerianus</i>	Phasianidae	27	0.28	0.86
21	Grey Heron	<i>Ardea cinerea</i>	Ardeidae	1	0.06	0.03
22	Seagull sp.	-	Laridae	1	0.06	0.03
23	House Crow	<i>Corvus splendens</i>	Corvidae	48	0.50	1.53
24	House Sparrow	<i>Passer domesticus</i>	Passeridae	14	0.15	0.45
25	Indian Robin	<i>Copsychus fulicatus</i>	Muscicapidae	655	6.82	20.86

26	Indian Silverbill	<i>Euodice malabarica</i>	Estrildidae	31	0.32	0.99
27	Lark sp.	-	Alaudidae	340	3.54	10.83
28	Little Egret	<i>Egretta garzetta</i>	Ardeidae	5	0.05	0.16
29	Minivet sp.	-	Campephagidae	1	0.06	0.03
30	Pipit sp.	-	Motacillidae	4	0.04	0.13
31	Purple Sunbird	<i>Cinnyris asiaticus</i>	Nectariniidae	95	0.99	3.03
32	Red-naped Ibis	<i>Pseudibis papillosa</i>	Threskiornithidae	35	0.36	1.11
33	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Pycnonotidae	291	3.03	9.27
34	Red-wattled Lapwing	<i>Vanellus indicus</i>	Charadriidae	10	0.10	0.32
35	Rose-ringed Parakeet	<i>Psittacula krameri</i>	Psittaculidae	6	0.06	0.19
36	Rosy Starling	<i>Pastor roseus</i>	Sturnidae	38	0.40	1.21
37	Iberian grey Shrike	<i>Lanius meridionalis</i>	Laniidae	19	0.20	0.61
38	White-browed Bushchat (Stoliczka's bushchat)	<i>Saxicola macrorhynchus</i>	Muscicapidae	1	0.06	0.03
39	Swallow sp.	-	Hirundinidae	16	0.17	0.50
40	Swift sp.	-	Apodidae	1	0.06	0.03
41	Tree Pipit	<i>Anthus trivialis</i>	Motacillidae	5	0.05	0.16
42	Unidentified	-	-	18	0.19	0.57
43	Variable Wheatear	<i>Oenanthe picata</i>	Muscicapidae	5	0.05	0.16

44	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	Alcedinidae	3	0.03	0.10
45	White-eared Bulbul	<i>Pycnonotus leucotis</i>	Pycnonotidae	30	0.31	0.96
46	Wire-tailed Swallow	<i>Hirundo smithii</i>	Hirundinidae	5	0.05	0.16
47	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	Charadriidae	2	0.02	0.06
48	Red Collared Dove	<i>Streptopelia tranquebarica</i>	Columbidae	5	0.05	0.16
49	Laughing Dove	<i>Streptopelia senegalensis</i>	Columbidae	309	3.22	9.84

Crossing rate was also calculated separately for each family. Most abundant family recorded was Columbidae (25.35%), Muscicapidae (21.21%) and Alaudidae (11.59%) with a crossing rate of 8.27, 6.94 and 3.79 respectively (Fig 9).

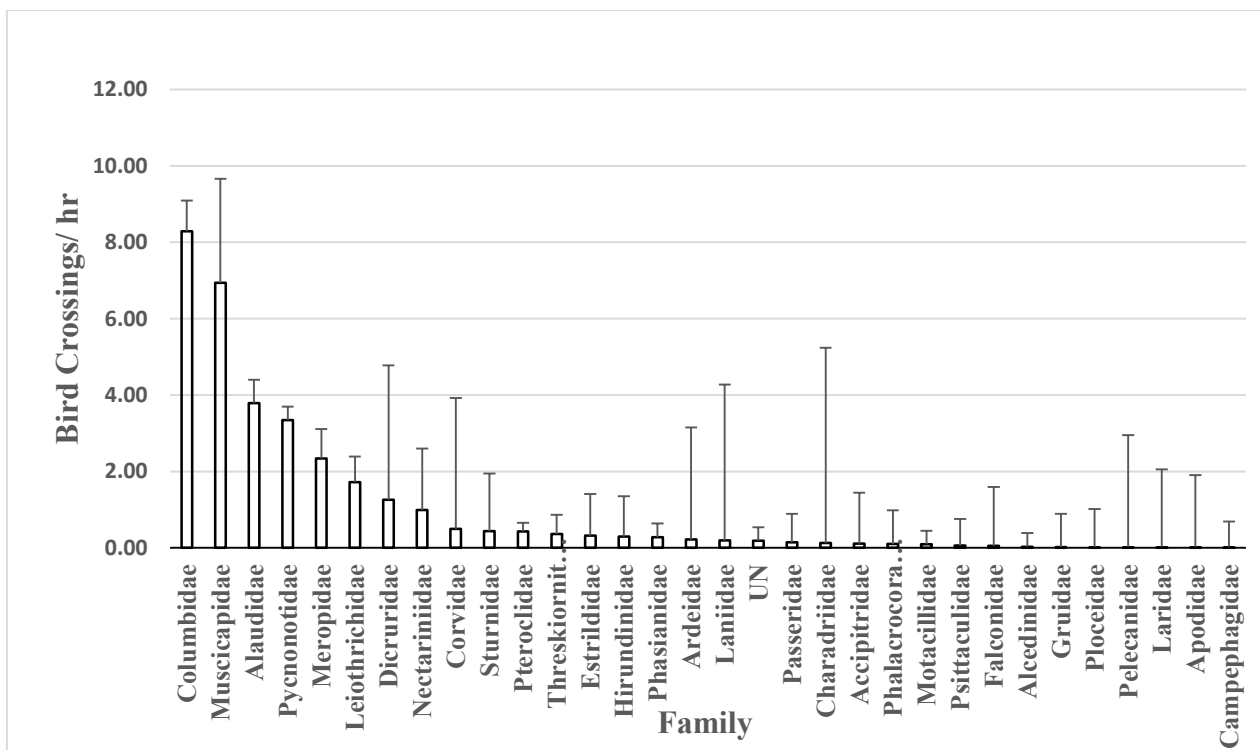


Figure 9: Mean and standard error of crossing rate across various taxonomic families in Kachchh landscape in April 2019.

Crossing rate tended to be higher for birds belonging to lower weight class (<100g) (mean= 6.27 crossings/hr, SE= 2.3, n= 28) as compared to birds belonging to larger weight class (>100g) (mean= 4.23 crossings/ hr, SE= 2.11, n= 20), although not statistically significant.

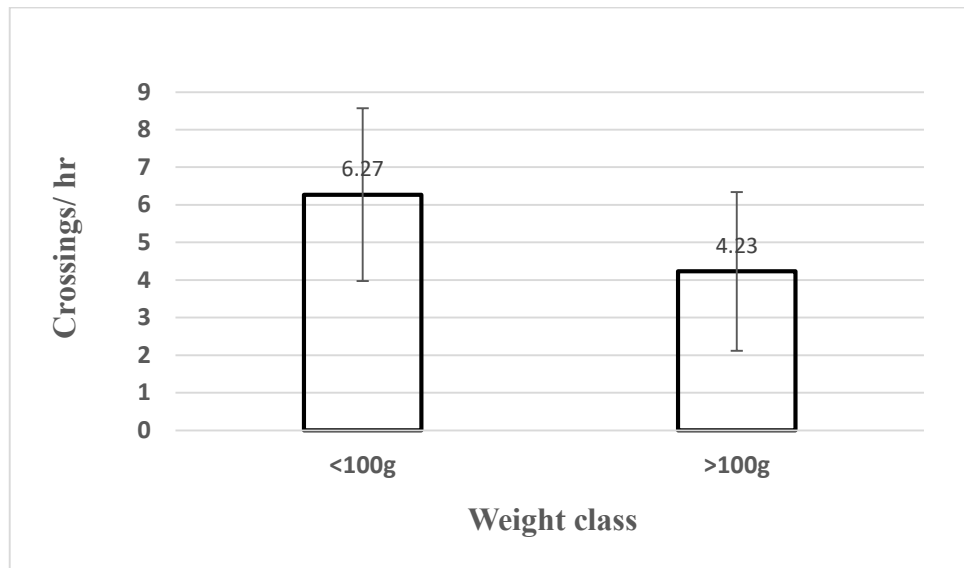


Figure 10: Mean and standard error of crossing rate for small (<100 g) and large (>100 g) birds in the Kachchh landscape during April 2019.

Crossing rate was significantly lower for high tension power-lines (mean= 0.45 crossings/hr, SE= 0.17) in comparison to low tension power-lines (mean= 1.60 crossings/hr, SE= 0.58). The reason behind low crossing rate at high tension power-lines could be that majority of the birds observed were small perching birds which do not fly high (Fig 11).

The crossing rate was generally more than the rate of perching for most species, however the trend was reverse for a few species including Indian robin, Eurasian collared dove and Red vented bulbul. Number of birds passing through the wires (1314 individuals) was relatively more than the number of birds crossing above (646 individuals) or below (1174 individuals) the power-line. Indian Robin (23%, n=8 and SE= 22.11), Eurasian Collared Dove (15%, n=8, SE= 10.05), Green bee-eater (12%, n=8 and SE= 16.96), Laughing Dove (11%, n=8 and SE= 9.22) and Red-vented Bulbul (11%, n=8 and SE= 10.57) were among those having a higher rate of crossing through the wires (Table 9, Fig 12).

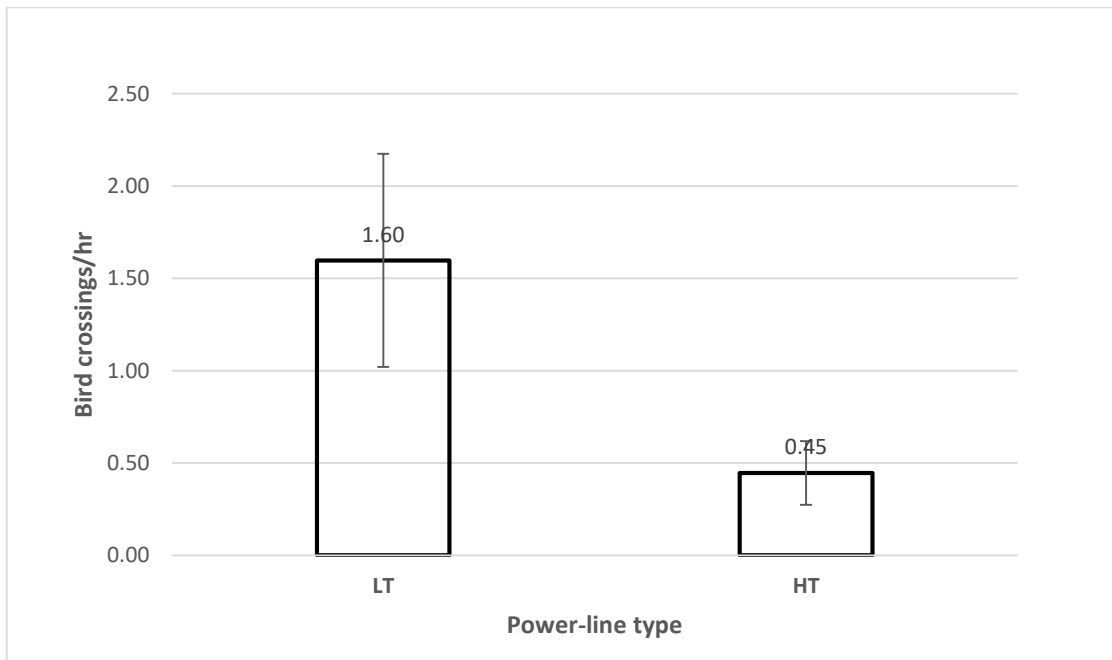


Figure 11: Mean and standard error of crossing rate at low tension (LT) and high tension (HT) power-lines in the Kachchh landscape in April 2019.

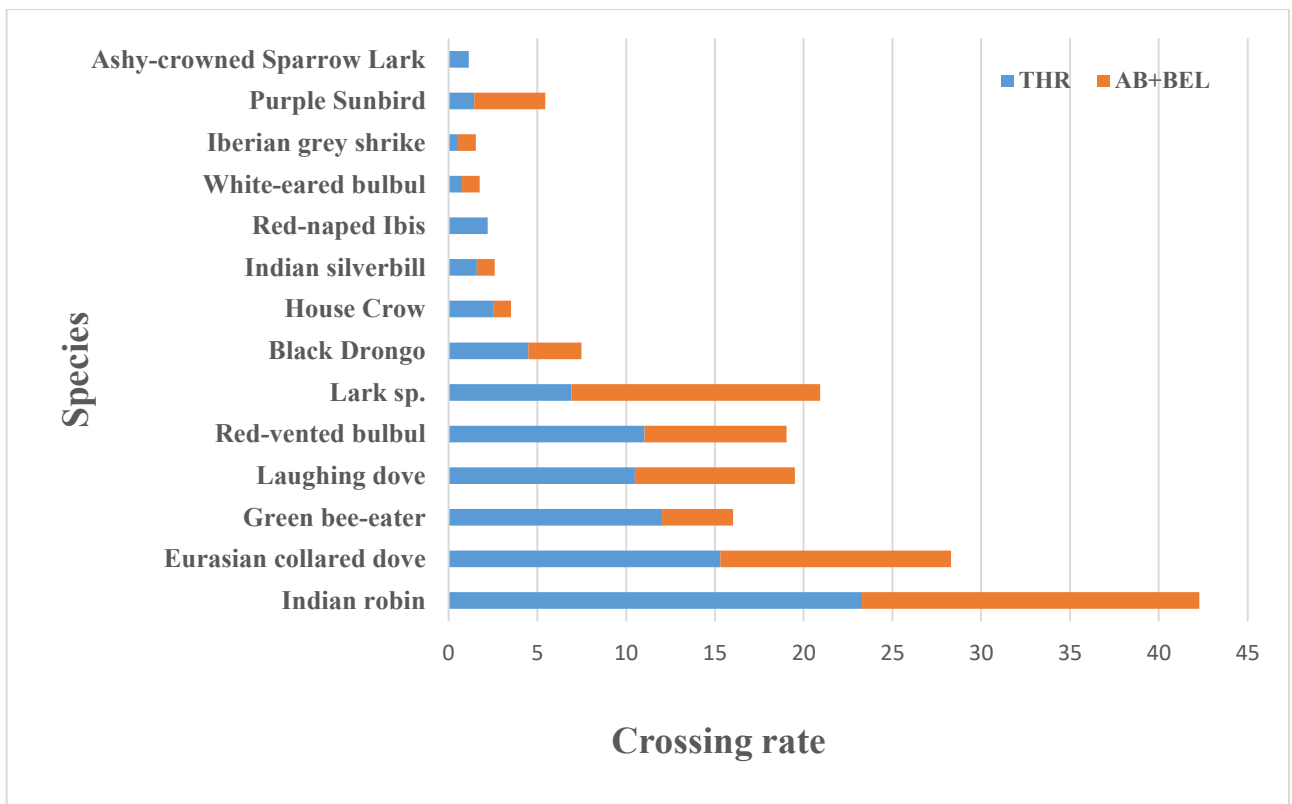


Figure 12: Comparison of abundance of species crossing through the power-lines (blue bars) with those crossing above/below (orange bars) in Kachchh landscape in April 2019.

Table 8: Relative abundance of species crossing the power-lines with those seen perching on the power-lines.

Species	Relative abundance of individuals crossing the power-lines	Relative abundance of individuals perching on the power-lines
Indian Robin	19.70	25.82
Eurasian Collared Dove	13.27	16.90
Lark spp.	12.14	5.95
Laughing Dove	10.53	7.36
Red-vented Bulbul	8.48	12.52
Green bee-eater	6.23	10.95
Common Babbler	5.99	2.50
Black Drongo	3.34	5.95
Purple Sunbird	3.30	2.03
Chestnut-bellied Sandgrouse	1.65	0.00
Blue Rock Pigeon	1.73	0.16
Rosy Starling	1.53	0.00
Red-naped Ibis	1.37	0.16
House Crow	1.33	2.35
Grey Francolin	1.09	0.00
White-eared Bulbul	1.05	0.63
Indian Silverbill	0.76	1.88
Swallow sp.	0.64	0.00

UN	0.64	0.31
Cattle Egret	0.60	0.00
Ashy-crowned Sparrow Lark	0.56	1.41
House Sparrow	0.52	0.16
Iberian grey Shrike	0.52	0.94
Red-wattled Lapwing	0.40	0.00
Cormorant	0.36	0.16
Barn Swallow	0.24	0.16
Rose-ringed Parakeet	0.24	0.00
Little Egret	0.20	0.00
Red Collared Dove	0.16	0.16
Pipit sp.	0.12	0.16
Tree Pipit	0.12	0.31
Variable Wheatear	0.12	0.00
Wire-tailed Swallow	0.12	0.31
Bluethroat	0.12	0.16
White-breasted Kingfisher	0.08	0.31
Yellow-wattled Lapwing	0.08	0.00
Demoiselle Crane	0.08	0.00
Brahminy Starling	0.08	0.31
Common Kestrel	0.08	0.00

Baya Weaver	0.04	0.00
Black-crowned Sparrow Lark	0.04	0.00
Common Stonechat	0.04	0.00
Minivet sp.	0.04	0.00
Grey Heron	0.04	0.00
Seagull sp.	0.04	0.00
Dalmatian pelican	0.04	0.00
Eastern Imperial Eagle	0.04	0.00
White-browed Bushchat (Stoliczka's bushchat)	0.04	0.00
Swift sp.	0.04	0.00

6. DISCUSSION

It was found that the carcass encounter rate under power lines were significantly higher as compared to that in random transects (areas without power-lines). This result is indicative of significantly greater mortality of birds due to power-lines than due to other/natural factors. The problem becomes graver when the species is already under stress or has limited geographic distribution.

The results show that the probability of detecting a carcass decreases with increasing time period and decreasing bird body mass, which was expected and is in the accordance with several published literature (Ponce et al. 2010; Santos et al. 2016, Uddin 2017). The detection probability for small birds (<100g) was 0.08 and for large birds (>100g) was 0.50, meaning that the observers were able to detect only 8% of the small birds and 50% of the large birds. The reason behind such poor detectability can be credited to massive invasion of *Prosopis juliflora* in the study area due to which the area becomes inaccessible with low visibility.

The average persistence probability of carcass belonging to <100g weight class for 1-30 days was 0.23, and 0.48 for carcasses weighing >100g, these results indicate that the probability of a carcass persisting decreases with increasing carcass age and decreasing body mass. Only 67% of the large sized birds (>100g) and 38% of the small sized birds (<100g) persisted on the 1st day after carcass placement, indicating a high scavenging rate in the study area.

After incorporating the values of detection and persistence probability in the monthly carcass encounter rate found during the surveys and extrapolating it to the total length of power-lines in the study area, 1818 bird mortalities per month in the entire study area were estimated.

However, the value is on a lower side as the digitization of power-lines in the study area is not yet complete, but according to my visual observations the actual length of power-lines is at-least thrice the length of digitized power-lines. So, the number of mortalities would be thrice of what I estimated and even then it is a conservative estimate as we do not have corrected carcass encounter rate based on bird weight class. We could not classify carcasses in field based on its weight class, and averaged the detection and persistence probabilities for small and large birds. In nature, small birds are more abundant than larger ones (Nee and Read 1991), and therefore, the number of small birds dying from power-lines should be more. Indeed, the crossing rate for small birds (<100g) tended to be more than large sized birds (>100g) in this study. However, the average detection and

persistence probabilities do not account for the higher proportion of smaller birds whose mortality rates would be underestimated in this study.

I found large seasonal variation in mortality rate, as reflected from the difference between the first (early summer) and second (late summer) surveys. In fact, bird numbers and diversity in this area are higher in winter (Gadhavi pers. obs., Dutta pers. obs.) when mortality rates are likely to be higher. Moreover, the past year was a drought, resulting in generally low primary and secondary production that might have lowered the resident/breeding and wintering bird population. All these factors indicate that the study might have captured a snapshot of relatively lower bird abundance, and the actual bird mortality might be even higher. Thus, more robust estimates of bird mortality are required based on annual, and preferably multiple year surveys that accommodate such seasonal and inter-annual variations in bird numbers.

My results indicated a weak correlation between habitat covariates and carcass encounter rate. The reason behind this could be that bird distribution and numbers were independent of the measured habitat characteristics. Alternatively, it could be that the scale at which I measured habitat co-variates (200m plots) were smaller as compared to the scale at which habitat covariates affected bird numbers and thereby mortality rates.

Crossing rate at low tension power-lines was twice compared with high tension power-lines, indicating that high tension power-lines probably acted as barrier to bird movement. Despite lower crossing rate at high-tension power-lines, their carcass encounter rate was similar to that of low tension power-lines. These results indicated that more birds die per crossing at high tension power-lines, making them particularly lethal for birds. Result also showed no correlation between number of power-line wires and carcass encounter rate, probably because of the same reason that the lower crossing rates and higher mortality per crossing associated with more wires, nullify each other.

Number of birds crossing through wires is more than those crossing above or below wires, making them more prone to power-line collisions. The crossing rate for small birds (<100g) tended to be more than large sized birds (>100g). This may be because small birds are much more abundant in nature as compared to larger ones (Nee and Read 1991). The results also showed large variations in crossing rate between families, which may result from differences in family abundances and/or their biological attributes (Bevanger 1998).

Out of 169 mortalities, 59 were found by surveying 16km of the salt-pan region, bringing the carcass encounter rate of that area to 5.25, which is almost 5 times the remaining study area. The reason behind such high rate of mortality is that the area hosts a variety of coastal birds and this year due to drought, even more birds from the neighboring area are migrating to the salt-pan area as no other wetlands have water. Since the number of birds here are much more than the remaining area, the chances of a bird colliding with power-line are also higher. During high tide the birds come to these salt-pans to rest and go back to the sea during low tide to forage. This continuous movement to and fro salt-pans makes the birds especially vulnerable to power-line mortalities.

Of the 59 mortalities found in the salt-pan area, 28 were identified as that of Greater Flamingo, which is a matter of serious concern as Kachchh is one of the few important breeding site of flamingoes in India. It is also the State Bird of Gujarat. Flamingos are habitat specialists that prefer salt-pans as their feeding grounds (Tere 2005). They are large sized birds that fly under poor light conditions (Ogilvie and Ogilvie 1986), making it difficult for them to see the overhead wires, thus increasing chances of collision. Flamingos are slow-reproducing species (Tere 2005) that makes it difficult to cope with such high rates of mortality, thus creating a significant impact on the population at local level. I also found relatively higher mortality of Common cranes, which travel all the way from Mongolia to Gujarat, to spend its winters. Out of 40 carcasses identified, 3 belonged to Common cranes, their large body size makes them vulnerable to collisions with power-lines (Bevanger 1998). Thus, my study further corroborates reveals that some large bodied birds are particularly vulnerable to power-line mortality. Studies done elsewhere on the impact of power-lines on birds have found similar results (Bevanger 1998; Tere and Parasharya 2011; Shaw et al 2010). This is a cause of concern as studies have shown that high mortality rates during migration can induce a species to alter its migration pattern (Palacin et al. 2017).

In this study, I did not carry out persistence and detection experiments and bird observations in the salt-pan region due to time constraints, but the same should be undertaken subsequently. Most of the mortalities found on field could not be identified as we mostly found a bunch of feathers. However, genetic analyses of these samples can help in identifying carcasses up to species level.

7. MITIGATION

Several studies have been conducted around the world on effectiveness of various mitigation measures with an aim to reduce the negative impact of power-lines on birds. Some of these mitigation measures that can be implemented in the study area include- retrofitting of existing electric poles and the new ones that are yet to come up with bird diverters that make the power-lines more visible to birds. There should be diversion of power-line routes passing through high risk area like wetlands, salt-pans, habitat of an endangered or critically endangered species and in and around Protected Areas. There is an urgent need to underground the existing power-line network in the salt-pan region and to avoid construction of any new power-line network in and around the salt-pan area. There is a need of before-after-control-impact (BACI) studies to find out the effectiveness of various mitigation measures such as wire marking devices, bird diverters, reflectors etc. Earlier studies conducted on the effectiveness of bird diverters found 60% reduction in collision victims after the installation of diverters at every 10m of power-line (Janss and Ferrer 1998; Alonso 1994). Using these studies as a reference, if diverters are installed at every 10 meters of power-lines and if the cost of a single diverter is 3500 Rupees, then the total cost of installation of bird diverters in the entire study area will be approximately 27.2 Crores. The cost of laying underground cables per kilometer is approximately 4 times as that of overhead wires (CEA 2018). Underground wires are buried deep in the ground so the cost of repair and line modifications is several times more as compared to overhead wires (CEA 2018), making it difficult to convince various stakeholders involved to lay underground wires in high priority areas. Thus, we need more studies on impact of power-lines on bird population at regional levels and covering larger spatial and temporal extents to make our case stronger. Keeping in mind the above cost analysis, the cheapest and most effective way to protect avian populations from dwindling is strategic route planning of upcoming power-grids. There is a need to establish a collaborative dialogue between scientific community, policy makers and electricity companies with an aim to strike a balance between conservation and development.

8. CONCLUSION

We are at the crossroads between conservation and development, and more often than not development is given priority over conservation. Power-line networks are essential to meet the growing energy needs of the country. However, this study, along with some others, shows the significant detrimental impact of power-line networks on birds. Thus, with more power-line projects coming up, there is an urgent need to safeguard avifauna. Therefore, identification of high-risk priority areas in view of bird conservation must be taken up and construction of power-line networks in and around these high-risk priority areas should be avoided. In cases where the development is inevitable or unavoidable, appropriate mitigation measures should be used to avoid the deleterious impact that power-line structures have on avifauna. There is an urgent need for studies focusing on the impact of power-lines at local level and to identify critical areas having high mortality rate for fine-tuning of mitigation measures.

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10. PLATE

Plate 1: Bird carcass of a Eurasian collared dove having mark of collision found during mortality surveys.



Plate 2: Fully scavenged bird mortalities found during carcass surveys.



Plate 3: Fully scavenged bird mortality found in the salt-pan region during mortality surveys.



Plate 4: Glimpses of bird carcass surveys.



Plate 5: Fully scavenged bird carcasses found during power-line surveys



Plate 6: Observer noting down the bird movement and activities around power-lines



Plate 7: Observers performing mortality surveys by walking at the distance of 30m on either side of the power-lines



Plate 8: Invasion of *Prosopis* spp. in the study area.



Plate 9: Power-line infrastructures in the study area

**Identification of species of dead Bird from tissue, feather and intestine
samples based on molecular tools**

Report By

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Dehradun

Reference No. : 208-2019/5229
Place : DFO, Jaisalmer
Wild Part : Tissues, Intestine and Feather
Analytical procedures : DNA based technique

D:\Sequencing data\DNA sequences- P1760_Srinivas_YVJ_24012019

Work done date **DNA Extraction** : 03rd January, 2019
 PCR Amplification : 10th Januray, 2019
 DNA Sequencing : 23rd Januray, 2019

Case history and Sample details

DFO, Jaisalmer has sent sealed packet containing tissue, intestine and feather samples. The samples was received in Wildlife Forensic and Conservation Genetics cell on 20th December, 2018 and marked as D3080-1, D3080-2, D3080-3 (Sample details given below)

Sample list:

Sno.	LAB ID	Sample Type	Remarks
1	D3080-1	Tissue & Feather	Sample taken for species identification
2	D3080-2	Tissue	Sample taken for species identification
3	D3080-3	Feather	Sample taken for species identification
4	D3080-4	Intestine	



Snapshots of Samples sent to WII

Aim: To identify the species of dead bird whose feather, intestine and tissue samples were sent by DFO, Jaisalmer (File no-2018-19/5229) to the Wildlife Institute of India (WII) for forensic examination on 20/12/2018, using molecular tools.

DNA extraction:

DNA was extracted from three samples D3080-1, D3080-2 and D3080-3 (feathers and tissue) using DNeasy Blood and Tissue Kit (QIAGEN, Germany) kit.

Identification of Bird species:

Conserved regions of mitochondrial DNA were used to identify the species of the dead bird samples. Primers to amplify mt DNA conserved sequences includes,

1. Control region II (L438 and H772; Wenink et al. 1993) of 323 base pairs fragment

2. Cytochrome b gene (LCyt-B4 and LCyt-B6; Broderick et al. 2003) of 399 base pairs fragment.

We selected these markers because of sole reason that these primers had been used in other bustard species and data can be comparable.

Polymerase Chain Reaction (PCR) amplification:

PCR amplification was carried out in a 10 µl reaction volume containing 4µl PCR mix; 10µM of each primer; and varying quantities (2 µl) of DNA to ensure that the optimum amount for amplification would be present. PCR cycles for primers Control region II with initial denaturation at 95⁰C at 15 min followed by 35 cycles for 15 sec at 94⁰C, 20 sec at 50⁰C, and 45 sec at 72⁰ and 7 min at 72⁰C with final extension. PCR cycles for primers Cytochrome b gene primers was performed at initial denaturation at 95⁰C at 15 mins followed by 45 cycles of 45 sec at 92⁰C, 30 sec at 55⁰C, 60 sec at 72⁰C and 5 min at 72⁰C with final extension. Finally PCR amplified products were visualized on a 2% agarose gel.

DNA Sequencing:

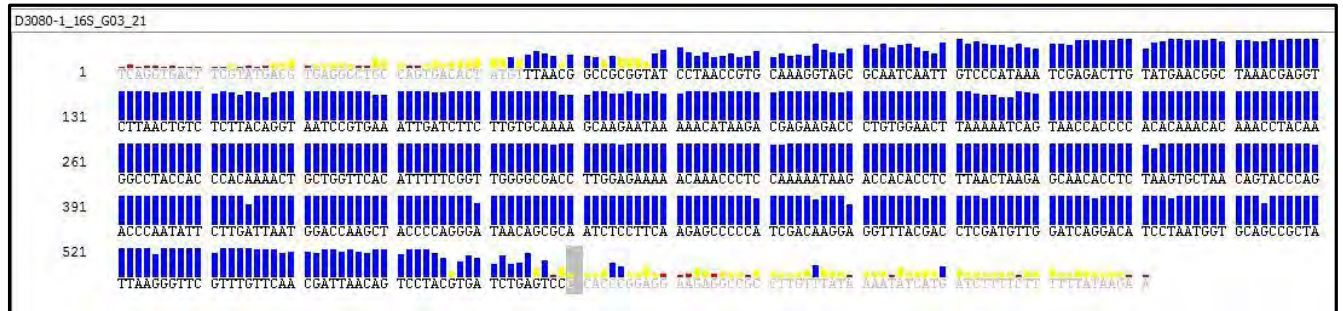
Amplified PCR products were purified using QIAquick® PCR Purification Kit (QIAGEN, Germany). Cycle sequencing was done with purified PCR products adding primers and chemicals following protocols of Applied Biosystems 3223 Genetic Analyzer. Cycle sequencing PCR products were then cleaned using "BigDye terminator clean-up" method. Finally all the cleaned products were then subjected for sequencing. PCR products were purified using QIAquick. The generated sequences were aligned and assembled using Sequencing Analysis 6.0 (Applied Biosystems).

Results:

16S results

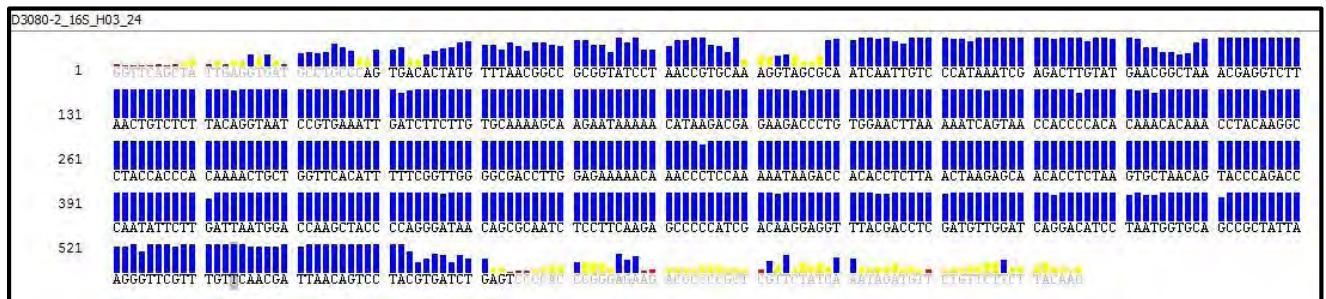
1. DNA sequence of D3080-1_16S region
GTTTAACGGCCGCGGTATCCTAACCGTGCAAAGGTAGCGCAATCAATTGTCCCATAA
ATCGAGACTTGTATGAACGGCTAAACGAGGTCTTAAGTGTCTCTTACAGGTAATCCG
TGAAATTGATCTTCTTGTGCAAAAGCAAGAATAAAACATAAGACGAGAAGACCCT
GTGGAAGTTAAAAATCAGTAACCAACCCACACAAACACAAACCTACAAGGCCTACC
ACCCACAAAACCTGCTGGTTCACATTTTTCGGTTGGGGCGACCTTGGAGAAAAACAAA

CCCTCCAAAAATAAGACCACACCTCTTAAGTGAAC
 AGTACCCAGACCCAATATTCTTGATTAATGGACCAAGCTACCCAGGGATAACAGC
 GCAATCTCCTTCAAGAGCCCCATCGACAAGGAGGTTTACGACCTCGATGTTGGATC
 AGGACATCCTAATGGTGCAGCCGCTATTAAGGGTTCGTTTGTTCACGATTAACAGT
 CCTACGTGATCTGAGT



2. DNA sequence of D3080-2_16S region

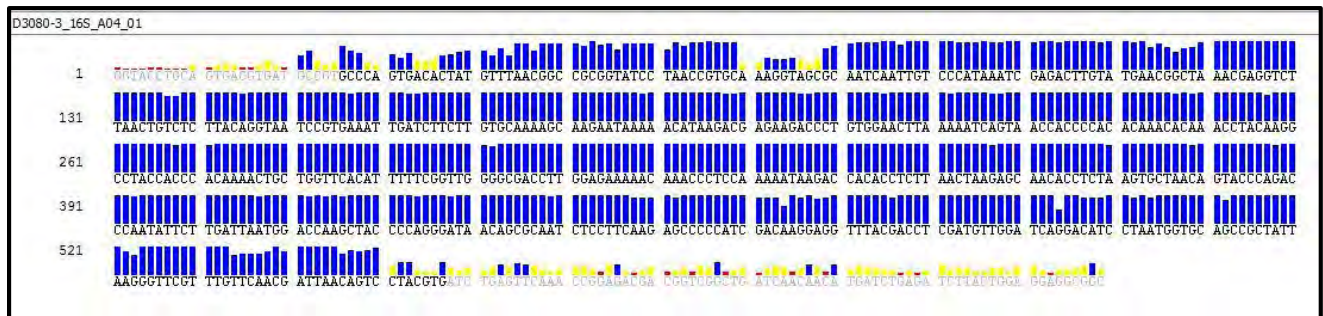
GCCTGCCCAGTGACACTATGTTTAAACGGCCGCGGTATCCTAACCGTGCAAAGGTAGC
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 ACACCTCTAAGTGCTAACAGTACCCAGACCCAATATTCTTGATTAATGGACCAAGCT
 ACCCCAGGGATAACAGCGCAATCTCCTTCAAGAGCCCCATCGACAAGGAGGTTTA
 CGACCTCGATGTTGGATCAGGACATCCTAATGGTGCAGCCGCTATTAAGGGTTCGTT
 GTTTCACGATTAACAGTCCTACGTGATCTG



3. DNA sequence of D3080-3_16S region

GCCGTGCCCAGTGACACTATGTTTAAACGGCCGCGGTATCCTAACCGTGCAAAGGTAG
 CGCAATCAATTGTCCCATAAATCGAGACTTGTATGAACGGCTAAACGAGGTCTTAACT
 TGTCTCTTACAGGTAATCCGTGAAATTGATCTTCTTGTGCAAAAGCAAGAATAAAAA
 CATAAGACGAGAAGACCCTGTGGAACCTAAAAATCAGTAACCACCCACACAAACA
 CAAACCTACAAGGCCTACCACCCACAAAACCTGCTGGTTCACATTTTTCGGTTGGGGC
 GACCTTGGAGAAAAACAAACCCTCCAAAAATAAGACCACACCTCTTAAGTGAAC
 AACACCTCTAAGTGCTAACAGTACCCAGACCCAATATTCTTGATTAATGGACCAAGC
 TACCCAGGGATAACAGCGCAATCTCCTTCAAGAGCCCCATCGACAAGGAGGTTT

ACGACCTCGATGTTGGATCAGGACATCCTAATGGTGCAGCCGCTATTAAGGGTTCGT
TTGTTCAACGATTAACAGTC



Alignment of DNA Sequence of Case sample with other sequences

The following generated case sequences were aligned with the other available birds and Great Indian Bustard sequences derived from own database (Wildlife Forensic and Conservation genetics lab).

Based on the constructed maximum likelihood phylogenetic tree, 16S sequences of the case samples (D3080-1, D3080-2, D3080-3) matched with the Great Indian Bustard.

Dendrogram (MEGA 3.1, S Kumar et al, 2004)

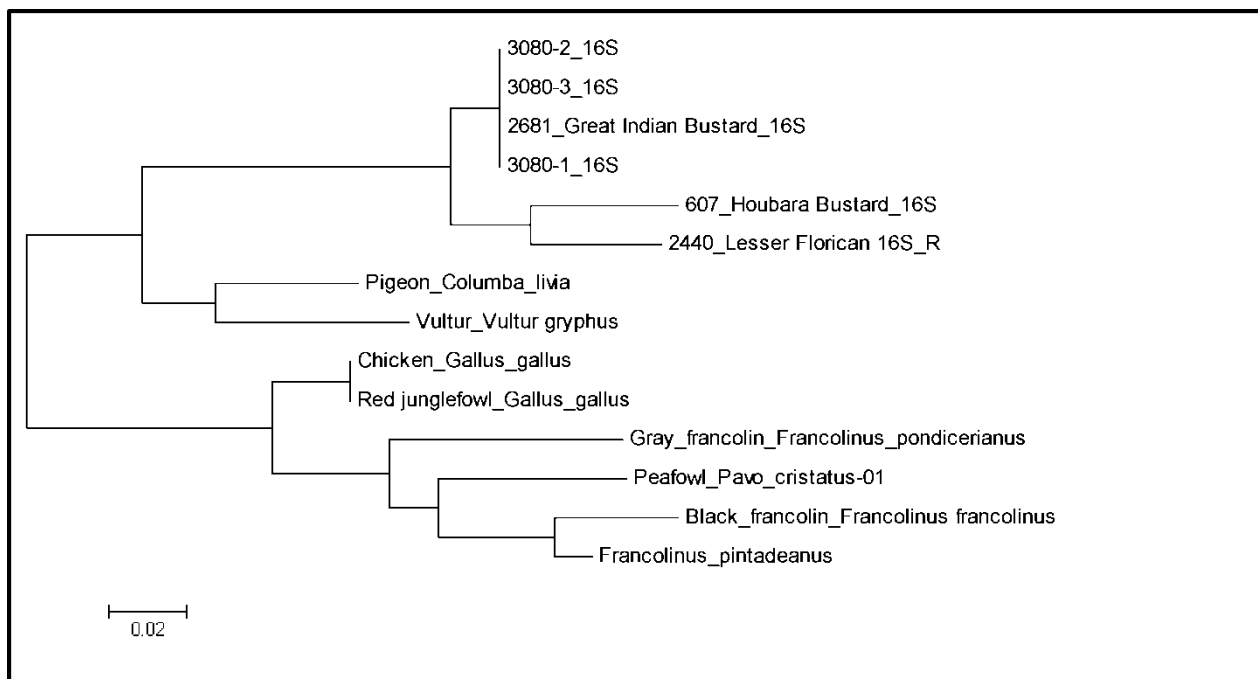


Fig 1.Dendrogram generated based WII-WFCGC data base for 16S sequences

Alignment of case sample sequence with 16S sequences of other birds

	10	20	30	40	50	60	70	80	90	100
3080-1_16S	ATCCTTAACCGT	GCAAAGGT	AGCGCAAT	CAATTGT	CCCATAAAT	CGAGACTT	GTATGAAC	CGCTAAAC	GAGGTCTT	AACTGTCTCTTACAGGTAATCCGTG
3080-2_16S										
3080-3_16S										
2681_Great Indian Bustard_16S										
Peafowl_Pavo cristatus-01		G.....	.....	T.....	.....	T.....	.....	C.....	G.....	A.....
Chicken_Gallus gallus		G.....	.....	G.....	T.....	.....	T.....	C.....	GT.....	TA.....
Red junglefowl_Gallus gallus		G.....	.....	G.....	T.....	.....	T.....	C.....	GT.....	TA.....
Gray francolin_Francolinus pon		G.....	.....	T.....	.....	T.....	.....	G.....	C.....	G.....
Black francolin_Francolinus fr		G.....	.....	T.....	.....	C.....	T.....	C.....	G.....	A.....
Francolinus pintadeanus		G.....	.....	T.....	.....	C.....	T.....	C.....	G.....	G.....
Pigeon_Columba livia									T.....	.....
Vultur_Vultur gryphus		G.....	.....	.....	.....	T.....	.....	G.....	A.....	A.....
607_Houbara Bustard_16S									T.....	.....
2440_Lesser Florican_16S_R						T.....	.....	.....	T.....	T.....

	110	120	130	140	150	160	170	180	190	200
3080-1_16S	AAATTGATCTTCTTGTG	CAAAAGCAAGAAT	AAAAACAT	AAGACG	AGAGAC	CCCTGG	GAAGCTT	AAAAAT	CAGTAA	CCACCACACAAACAAACCT
3080-2_16S										
3080-3_16S										
2681_Great Indian Bustard_16S										
Peafowl_Pavo cristatus-01		AG.A.C.CC.....	A.GG.G.....	GTG.C.....	.....	T.....	CG.....	T.....	TT.T.C.CTC.CTC.C	C
Chicken_Gallus gallus		AG.A.....CC.....	A.G.....	GTG.....	.....	T.....	CG.....	T.....	T.....	C.....
Red junglefowl_Gallus gallus		AG.A.....CC.....	A.G.....	GTG.....	.....	T.....	CG.....	T.....	T.....	C.....
Gray francolin_Francolinus pon		AG.AC.....C.....	A.G.....	GTG.T.....	.....	C.....	C.....	T.....	TC.C.CTCCTTTTC.C	C
Black francolin_Francolinus fr		AG.A.....	A.....	GTG.C.....	.....	T.....	C.....	T.....	TC.T.C.....	TCCCCCT.C
Francolinus pintadeanus		AG.A.C.....	A.....	GTG.C.....	.....	T.....	CG.....	T.....	TC.T.C.....	TCCCA.C
Pigeon_Columba livia		C.C.C.....	G.....	GTG.....	.....	C.....	G.....	T.....	C.....	GCCCA.C
Vultur_Vultur gryphus		C.C.....	G.....	GC.....	.....	C.....	G.....	.....	G.....	C.CC.....
607_Houbara Bustard_16S			A.....	GGC.....	.....	G.....	C.....	.....	C.....	.....
2440_Lesser Florican_16S_R				G.....	.....	GG.....	.....	G.....	.....	.....

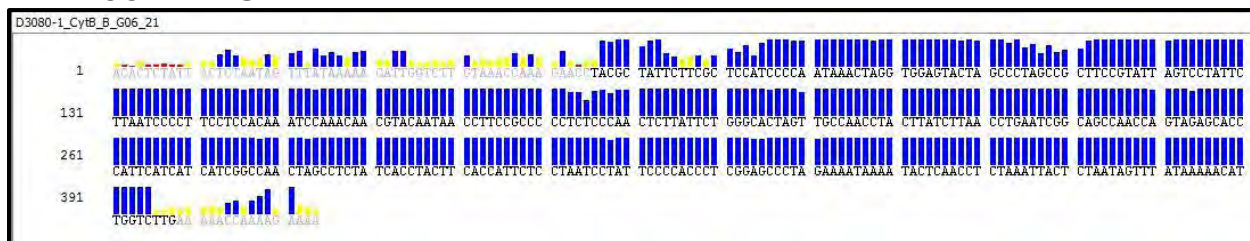
	210	220	230	240	250	260	270	280	290	300
3080-1_16S	ACAAGGCTTAC	CACCACAAA	ACTGCTGGT	TACACA	TTTTTCGGTT	GGGCGACCTT	GGAGAAAAAC	AAACCCCT	CCAAAAAT	AAGACCACACCTCTTA
3080-2_16S										
3080-3_16S										
2681_Great Indian Bustard_16S										
Peafowl_Pavo cristatus-01		TG.AT.C.C.CT..	A.CA..GC.....	CTC.....	CG.T.....	.....	.....	CC.....	.....	G.....
Chicken_Gallus gallus		TG..T.C.C.C..	A..T..GC.....	CTC.....	CG.T.....	.....	.....	A.....	.....	T.....
Red junglefowl_Gallus gallus		TG..T.C.C.C..	A..T..GC.....	CTC.....	CG.T.....	.....	.....	A.....	.....	T.....
Gray francolin_Francolinus pon		C.CG.AA.C.C.G.A.	A.GC.....C.C.....	G.T.....	.....	.....	.....	CCGC.....	A.....	C
Black francolin_Francolinus fr		TG.A.....C..	TAT.A.GGC.....	C.C.....	G.T.....	.....	.....	A.....	T.....	A.....
Francolinus pintadeanus		TG.ATTC.C..TA.	A.GGC.....C.C.....	CG.T.....	.....	.....	GA.....	T.....	C.A.....	T
Pigeon_Columba livia		C.....C.....	TT.A.....	GCAC.T.....	C.C.....	GTTA.....	.....	C.....	.....	A.....
Vultur_Vultur gryphus		TT.....TC.....	T..A.CT..GC.....	CGC.CCCG.TT	.....	.....	.....	T.....	A.....	C.....
607_Houbara Bustard_16S		C.....TG.TT.....	.....	C.T.....	T.....	.....	G.....	T.....	.....	C.....
2440_Lesser Florican_16S_R		TC.....TG.TA.T.....	.....	.....	.....	.....	T.....	.....	.....	T.....

	310
3080-1_16S	ACTAAGAGCA

Cytochrome B Results:

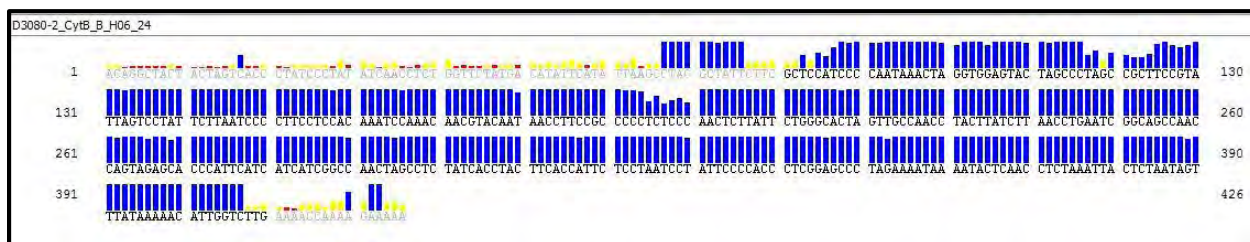
1. DNA sequence of D3080-1_Cyt B region

ACGCTATTCTTCGCTCCATCCCCAATAAACTAGGTGGAGTACTAGCCCTAGCCGCTT
CCGTATTAGTCCTATTCTTAATCCCCTTCCTCCACAAATCCAAACAACGTACAATAA
CCTTCCGCCCCCTCTCCCAACTCTTATTCTGGGCACTAGTTGCCAACCTACTTATCTT
AACCTGAATCGGCAGCCAACCAGTAGAGCACCCATTCATCATCATCGGCCAACTAG
CCTCTATCACCTACTTCACCATTCCTAATCCTATTCCCCACCCTCGGAGCCCTAGA
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AAAACCAAAGA



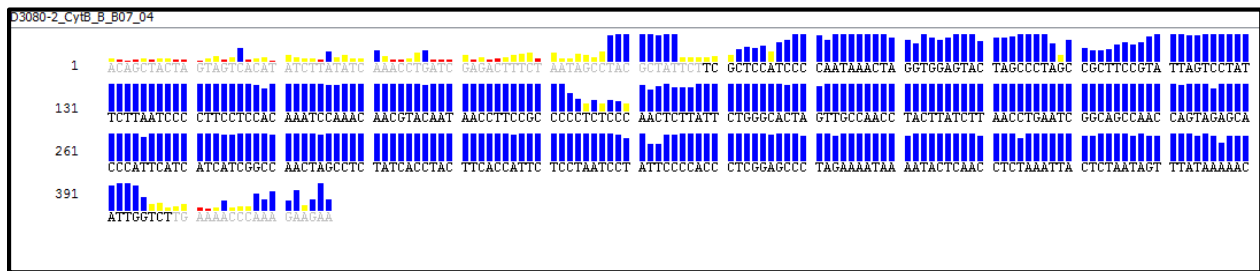
2. DNA sequence of D3080-2_Cyt B region

CTACGCTATTCTTCGCTCCATCCCCAATAAACTAGGTGGAGTACTAGCCCTAGCCGC
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ACCTTCCGCCCCCTCTCCCAACTCTTATTCTGGGCACTAGTTGCCAACCTACTTATCT
TAACCTGAATCGGCAGCCAACCAGTAGAGCACCCATTCATCATCATCGGCCAACTA
GCCTCTATCACCTACTTCACCATTCCTAATCCTATTCCCCACCCTCGGAGCCCTAG
AAAATAAAATACTCAACCTCTAAATTACTCTAATAGTTTATAAAAAACATTGGTCTTG
AAAACCAAAGA



3. DNA sequence of D3080-3_Cyt B region

TACGCTATTCTTCGCTCCATCCCCAATAAACTAGGTGGAGTACTAGCCCTAGCCGCT
TCCGTATTAGTCCTATTCTTAATCCCCTTCCTCCACAAATCCAAACAACGTACAATAA
CCTTCCGCCCCCTCTCCCAACTCTTATTCTGGGCACTAGTTGCCAACCTACTTATCTT
AACCTGAATCGGCAGCCAACCAGTAGAGCACCCATTCATCATCATCGGCCAACTAG
CCTCTATCACCTACTTCACCATTCCTAATCCTATTCCCCACCCTCGGAGCCCTAGA
AAATAAAATACTCAACCTCTAAATTACTCTAATAGTTTATAAAAAACATTGGTCTTGA
AAACCCAAAGA



Alignment of DNA Sequence of Case sample with other sequences

The following generated case sequences were aligned with the other available birds and Great Indian Bustard sequences derived from own database (Wildlife Forensic and Conservation genetics lab).

Based on the constructed maximum likelihood phylogenetic tree, Cyt-B sequences of the case samples (D3080-1, D3080-2, D3080-3) matched with the Great Indian Bustard.

Dendrogram (MEGA 3.1, S Kumar et al, 2004)

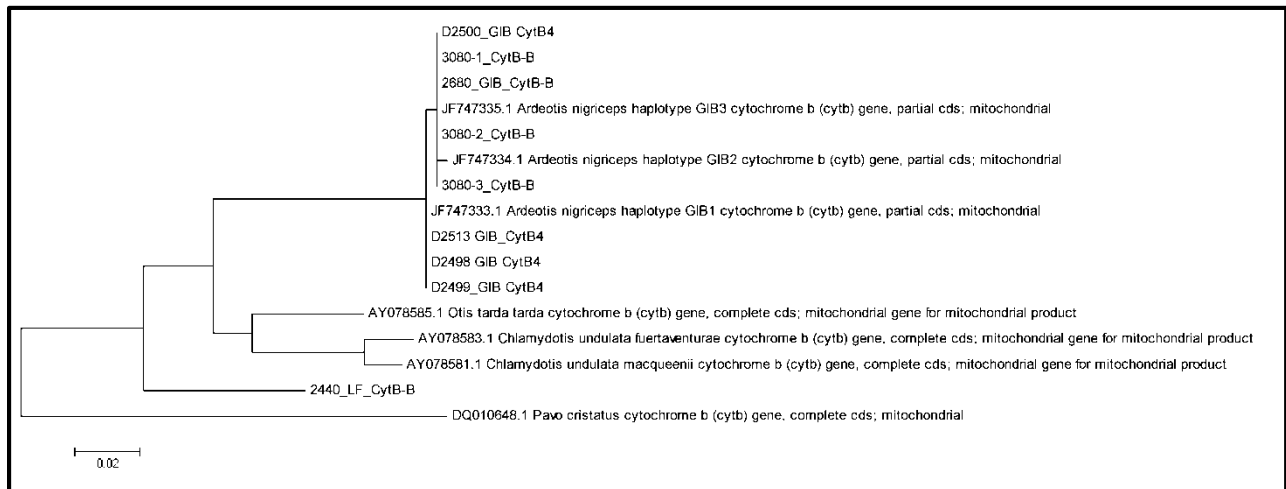


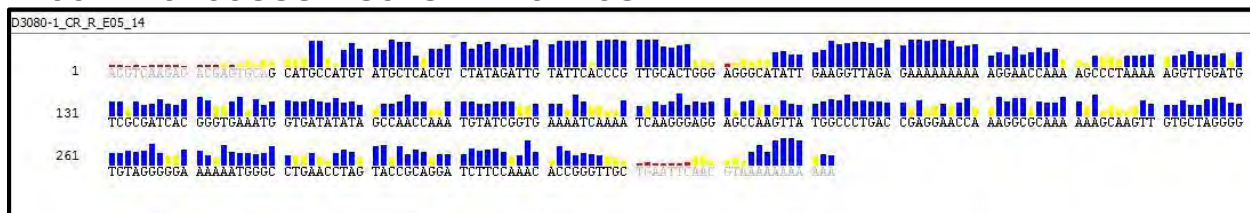
Fig 2. Dendrogram generated based WII-WFCGC data base for CytB sequences

[illegible]

Control region Results:

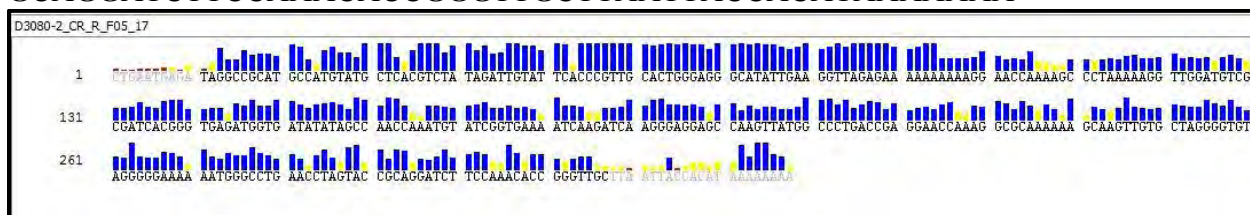
1. DNA sequence of D3080-1_CR region

GCCATGTATGCTCACGTCTATAGATTGTATTACCCCGTTGCACTGGGAGGGGCATATT
GAAGGTTAGAGAAAAAAGGAACCAAAGCCCTAAAAAGGTTGGATGTCGCG
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CAAGGGAGGAGCCAAGTTATGGCCCTGACCGAGGAACCAAAGGCGCAAAAAAGCA
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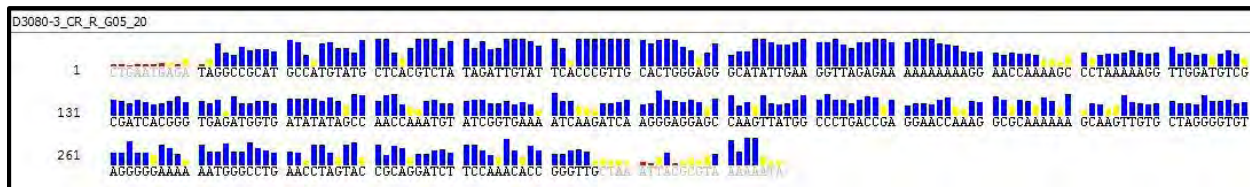
2. DNA sequence of D3080-2_CR region

GGCCGCATGCCATGTATGCTCACGTCTATAGATTGTATTACCCCGTTGCACTGGGAG
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ATGTCGCGATCACGGGTGAGATGGTGATATATAGCCAACCAAATGTATCGGTGAAA
ATCAAGATCAAGGGAGGAGCCAAGTTATGGCCCTGACCGAGGAACCAAAGGCGCA
AAAAAGCAAGTTGTGCTAGGGGTGTAGGGGGAAAAAATGGGCCTGAACCTAGTACC
GCAGGATCTTCCAAACACCGGGTTGCTTAATTACCACATAAAAAA



3. DNA sequence of D3080-3_CR region

GGCCGCATGCCATGTATGCTCACGTCTATAGATTGTATTACCCCGTTGCACTGGGAG
GGCATATTGAAGGTTAGAGAAAAAAGGAACCAAAGCCCTAAAAAGGTTGG
ATGTCGCGATCACGGGTGAGATGGTGATATATAGCCAACCAAATGTATCGGTGAAA
ATCAAGATCAAGGGAGGAGCCAAGTTATGGCCCTGACCGAGGAACCAAAGGCGCA
AAAAAGCAAGTTGTGCTAGGGGTGTAGGGGGAAAAAATGGGCCTGAACCTAGTACC
GCAGGATCTTCCAAACACCGGGTTGCTAAATTACGCGTAAAAA



Alignment of DNA Sequence of Case sample with other sequences

The following generated case sequences were aligned with the other available birds and Great Indian Bustard sequences derived from own database (Wildlife Forensic and Conservation genetics lab).

Based on the constructed maximum likelihood phylogenetic tree, CR sequences of the case samples (D3080-1, D3080-2, D3080-3) matched with the Great Indian Bustard.

Dendrogram (MEGA 3.1, S Kumar et al, 2004)

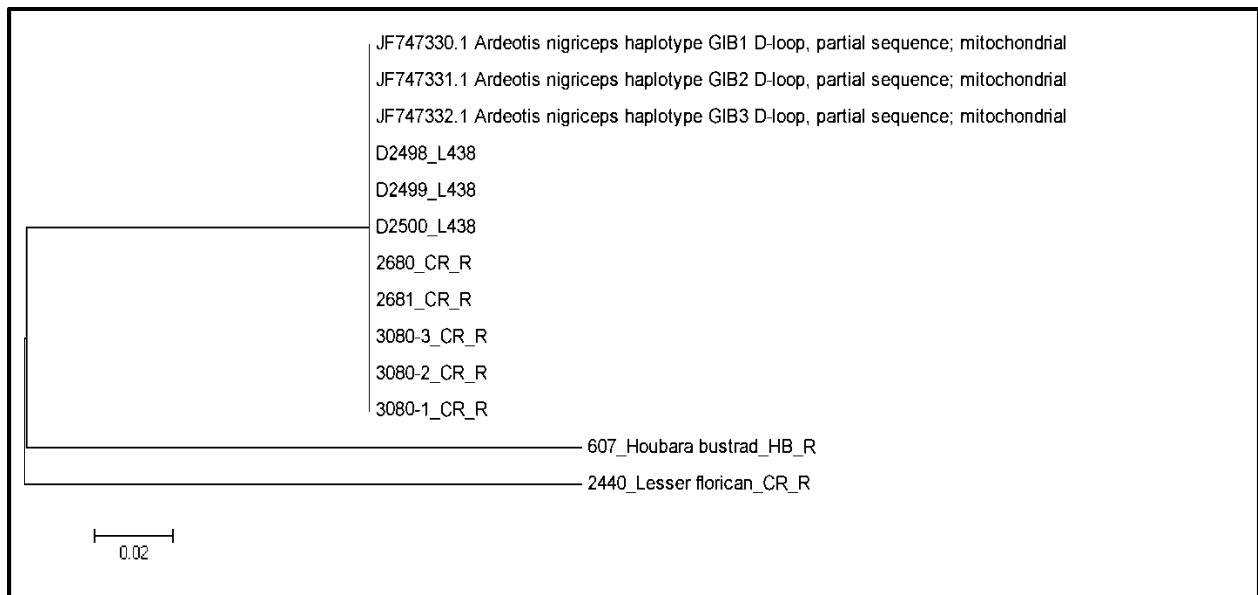
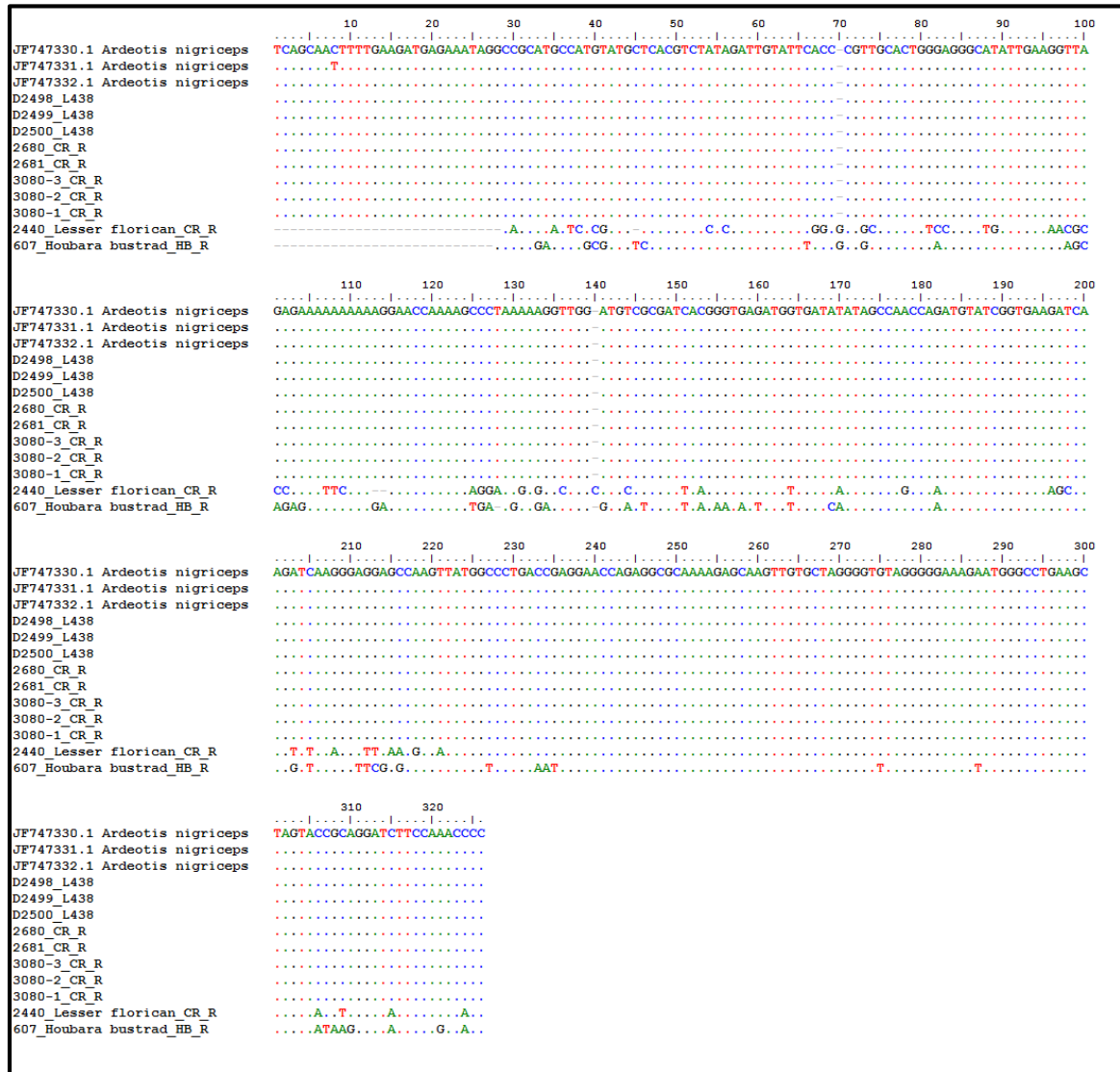


Fig 3. Dendrogram generated based WII-WFCGC data base for CR sequences

Alignment of case sample sequence with CR sequences of other birds



Conclusion

On the basis of the above analysis, sequences determined for the case samples (D3080-1, D3080-2, D3080-3) based on 16S, CytB and CR fragments of mitochondrial DNA matched with Great Indian Bustard in comparison with other species examined.

**HIGH COURT OF JUDICATURE FOR RAJASTHAN AT
JODHPUR**

For Petitioner(s) : Suo Moto
Mr. Vikas Balia

For Respondent (s) : Mr. Sandeep Shah, Additional
Advocate General

Mr. Sanjeet Purohit, Assistant
Solicitor General



14701/2019

**HON'BLE MR. JUSTICE SANGEET LODHA
HON'BLE MR. JUSTICE DINESH MEHTA**

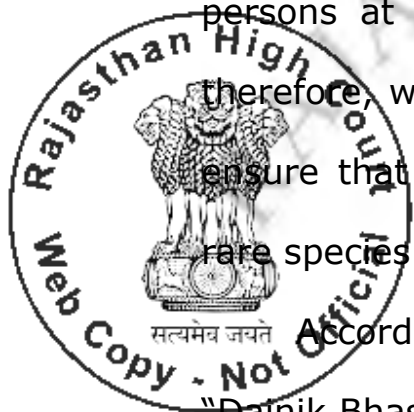
Order

The Great Indian Bustard, locally known as "Godawan", once common on the dry plains of the Indian subcontinent has been categorized as critically endangered species by the International Union for Conservation of Nature ('IUCN'). The population of the species estimated 250 individuals in 2011 stood reduced to estimated 150 individuals in 2018. The species is leading to extinction on account of hunting and loss of its habitat.

A write up published in a leading newspaper of the State "Dainik Bhaskar" dated 13.1.19, depicts a bizarre situation. It is reported that its population of 250 individuals now stands reduced to 60-70 and it is surviving only in the State of Rajasthan. As per the report a project was prepared for protection, conservation and breeding of the species, 8 years back and a sum of Rs.22 crore were sanctioned for the project 2 years back but at the ground level the project has not been made operative till this date. As mentioned in the write up, the money for the project is disbursed

to Wildlife Institute of India ('WII') but it has not cared to proceed with the work under the project so far.

It is really unfortunate that the project launched for conservation of the critically endangered species which has status of "State Bird" in the State of Rajasthan, is being run in such a casual and negligent manner. The apathetic attitude on the part of persons at helm of affairs is a matter of serious concern and therefore, we are constrained to take cognizance of the matter to ensure that all serious efforts are made for conservation of this rare species.



Accordingly, the write up published in daily newspaper "Dainik Bhaskar" dated 13.1.19 with the heading "8 साल पहले प्रोजेक्ट बना, 2 साल पहले पैसा आया, फिर भी जान बचाने को फाइलों में छटपटा रहा राज्य पक्षी गोडावण" is taken on record. The Registry is directed to register the present petition as D.B. Civil Writ Petition (PIL).

Issue notice to the Principal Secretary, Department of Forest, Government of Rajasthan, the Principal Secretary, Ministry of Environment, Forest and Climate Change, Government of India and the Wildlife Institute of India, Dehradun through its Director.

Mr. Sandeep Shah, Additional Advocate General accepts notices on behalf of the Principal Secretary, Department of Forest, Government of Rajasthan. Mr. Sanjeet Purohit, Assistant Solicitor General accepts notices on behalf of Ministry of Environment, Forest and Climate Change, Government of India.

Let notice be issued to the Director, Wildlife Institute of India, Dehradun, returnable on 25.1.19. Notice shall be accompanied by a copy of this order. A copy of the order may also be supplied to learned counsel appearing for Department of

Forest, Government of Rajasthan and the Department of Environment, Forest and Climate Change, Government of India.

We request Mr. Vikas Balia, learned counsel to assist the Court as Amicus curiae in the matter.

List the matter on 25.1.19.



(DINESH MEHTA),J

(SANGEET LODHA),J



सत्यमेव जयते

<u>PETITIONER:</u>	VS.	<u>RESPONDENTS:</u>
Suo Moto		The Principal Secretary & Ors.

WRITTEN SUBMISSIONS ON BEHALF OF
RESPONDENT WILDLIFE INSTITUTE OF INDIA.

THE HON'BLE THE CHIEF JUSTICE AND HIS OTHER
COMPANION JUDGES OF RAJASTHAN HIGH COURT,
AT JODHPUR.

The answering respondent above named respectfully submits as infra :-

That on 13.01.2019, a news item was published in one of the leading news paper in the State of Rajasthan 'Dainik Bhaskar' highlighting the concern regarding the reduce of population of the State Bird i.e. The Great Indian Bustard (hereinafter referred as GIB) commonly known as 'Godawan'. It was highlighted in the said news item that the said endangered species is in danger and only 60-70 birds are left in State of Rajasthan. It was further stated that although, funds to the tune of Rs. 22 Crore was sanctioned, however, no conservation and

protection activities for the said bird were undertaken. Concern was also expressed regarding breeding facilities of the said bird.

This Hon'ble High Court vide its order dated 14.01.2019 has taken cognizance of the said issue and while issuing notices to the State as well as Central authorities including the answering respondent has called upon to explain the status of the action taken for protection and conservation of GIB.

With a view to appraise this Hon'ble Court regarding the present status of the GIB, Desert National Park (DNP), the ongoing projects and the proposed activity in relation to GIB, the present written submissions are filed on behalf of the answering respondent.

ABOUT GREAT INDIAN BUSTARD (GIB)

ECOLOGY:

The great Indian bustard (GIB) is one of the heaviest flying birds' endemic to the Indian subcontinent. They are primarily terrestrial birds with adult males as tall as 122 cm and 11-15 kg and adult females reach up to 92 cm and 4-7 kg. The Plumage is predominantly brown and white, and adult males are characterised by thicker and whiter

neck with black eyebrow. The Great Indian Bustard is an omnivorous bird primarily feeding on insects, fruits and harvested crops. They live in dry, open landscapes comprising of short grasslands, scrub and rain-fed agriculture. Sexual maturity is attained at the age of 5-6 years in males and 2-3 years for females. They are traditional to their breeding grounds, where, males display in open, well-grazed grasslands to attract females who prefer moderately tall and less-grazed grassland for nesting. Thus, a mosaic of short and tall vegetation with little disturbance is ideal for breeding. Existing research on GIB and related species shows that large heterogeneous agro-grassland patches have highest conservation value. Research conducted by Rahmani (1989) and Dutta (2012) show that GIB is a long-lived species with very slow reproductive rates - it lays one egg every 1-2 years, and the success rate of these eggs under ideal situation is around 60-70%. However, the current nesting habitats have high density of predators such as fox and dogs because of availability of more surface water that has reduced the nest success rate to 40-50% based on dummy nest experiment conducted in GIB habitat. Because of such slow reproductive rate and specific habitat requirements, the species is inherently vulnerable and cannot sustain any added nest predation.

STATUS AND DISTRIBUTION:

The Great Indian Bustard GIB is a critically endangered bird with less than 150 individuals left in India/World and in urgent need of conservation actions. These numbers are based on surveys conducted by the Wildlife Institute of India's research team in Rajasthan in 2017-18, Maharashtra in 2017 and information collation by Collar et al in 2018. Long term surveys (2014-18) conducted by the WII and the Rajasthan Forest Department show that the majority of this population is found in Jaisalmer district within and around the Desert National Park, and the Indian Army controlled Field Firing Range near Pokhran. Other populations are very small and less than 10 individuals each, found in Abdasa tehsil, Kutch district, Gujarat, Nagpur, Amravati and Solapur districts of Maharashtra, Bellary and Koppal districts in Karnataka, and Kurnool district in Andhra Pradesh. These surveys indicate that the species' numbers have reduced by 75% in last 30 years. The species is listed as Critically Endangered (IUCN 2011) and Schedule-I that accords it the highest level of legal protection under Wildlife (Protection) Act, 1972).

THREATS:

For such long-lived and slow reproducing species, adult mortality is the most decisive

parameter for population persistence. Historically, this bird was hunted as game and their population was reduced because of this threat. After the implementation of Wildlife Protection Act 1972, their hunting has been reduced but not eliminated. However, adult mortality is still very high due to collisions with power-lines that criss-cross their flypaths. All bustard species in the world are prone to collision with power-lines due to their poor frontal vision and inability to see power-lines from a distance, along with their large size and heavy flight that make it difficult to maneuver in the nick of the time. WII's research has shown that power-lines, particularly high-voltage (33-440 KV) transmission lines with vertical alignment are the biggest threat to GIB as of now. GIB habitats have a high density of transmission lines because of the impetus on renewable energy production in GIB habitats of Rajasthan and Gujarat. This study found four GIB deaths in 2017-18 in Jaisalmer district alone based on systematic surveys and anecdotal information, and calculated that ~15% of the GIB population may be dying because of this threat. Since the natural death rate of large bustards is about 4-8%, the current additive mortality rate due to transmission lines is significantly higher, and if not controlled can result in the species' extinction. Apart from GIB, many other birds also die because of

collision/electrocution with these transmission lines at a rate of ~10 birds/km/month according to this study. A copy of study so conducted named *“Bustards, Wires, and the Flight to Extinction”* is annexed herewith and marked as **Annexure-R3/1**.

While these are the two most important current threats to the species, prevailing habitat loss remains an important threat to the long-term persistence of the species. Earlier, agriculture used to be monsoonal and sparse in bustard habitats and fallow periods used to be prolonged when fields were naturally regenerated. This allowed plenty of food (insects, fruits, crop residues) and grass vegetation cover for the species. But recent developments in irrigation and farming technologies have intensified agriculture and changed cropping practices from seasonal to year-round, intensive crops. Because of frequent ploughing and cropping or use of pesticides, there is lack of food and cover for the ecological requirements of the species. There is a need to regulate such intensive agricultural land-uses to achieve long-term GIB persistence. Moreover, development activities like mining, industries, wind turbines, and associated infrastructure growth (buildings, electricity and road networks) have caused severe habitat degradation and disturbance to birds. Furthermore, management authorities in many areas exhibit poor

enforcement ability due to inadequate staff and infrastructure, lack of motivation, and inaccessibility. Ill-informed forestry practices by State Forest Departments such as plantation of exotic shrub/tree species in deserts and grasslands in the name of afforestation have degraded the habitat of GIB, Chinkara and other open habitat species that prefer visibility and openness.

RECOMMENDED CONSERVATION MEASURES:

Conservation circles have been discussing actions required to save the GIB since 1980s, when eight bustard Sanctuaries were established for the species' conservation. However, these sanctuaries included agro-pastoral landscapes where private land rights were not properly settled, and the ensuing legal stringency on land-uses resulted in public antagonism and the extirpation of the species from some of these Sanctuaries. The above cited research highlighted the need of a landscape level conservation approach which was missing from the earlier plan and the habitat around these Sanctuaries became hostile due to intensive land-uses and detrimental infrastructure. GIB conservation received a fresh impetus around 2010-13, with the constitution of the Bustard Task Force and the development of the National Guidelines for Recovery of Resident Bustards

through consultative meetings of conservation agencies under the umbrella of the Ministry of Environment, Forest and Climate Change. In this regard, a National Plan came to be formulated which suggested:

- a) Consolidating known breeding areas of the species by chain-link predator-proof fencing to improve the species' recruitment rate,
- b) Prioritizing the species' landscape through surveys and telemetry, and mitigating threats such as power-lines and poaching therein,
- c) Promoting bustard-friendly land-uses/practices by sensitizing and incentivizing local communities.
- d) Finally, while these actions are required on ground, the species is declining at such a rapid rate due to the existing threats, that recovery actions cannot reverse the decline considering the expected time delays of these actions.

Hence, a conservation breeding programme should be undertaken to secure a captive population as an insurance against total extinction and to leave the possibility of reintroducing birds in the wild in favourable times when the habitats have been restored by effective field management actions.

ABOUT DESERT NATIONAL PARK

Desert National Park Wildlife Sanctuary was established in year 1980 over an area of 3162 sq km across Jaisalmer and Barmer districts, with the mandate of conserving desert biodiversity. During the time of its establishment, land rights of people residing inside the Park, then 88 settlements, were not settled. Subsequently, the population size and demand for land increased. Currently, there are 88 villages with 13,000 households in and around the Park. Forest Department controls only 5% of the Park area, in the form of enclosures that are now being managed with the mandate of GIB conservation. The remaining 95% of Park area comprises of private and Revenue lands, with the latter largely being encroached by villagers for agriculture. Earlier, the local people depended on pastoral livelihoods, and would occasionally engage in farming during good rainfall years, when they grew seasonal food crops such as gram, ground nut and millets. However, in the recent years, the market value of Guar or Cluster Beans has increased dramatically due to their industrial use in hydraulic fracturing. This has led to escalated encroachment by villagers to cultivate and sell Guar. Because of agricultural encroachment, pastures have depleted, and the herbaceous vegetation are currently largely

restricted to Forest Department enclosures. The livestock of local settlements trespass into these enclosures for fodder that creates friction between the Forest Department and local people. This antagonism was exacerbated due to restriction on infrastructure development and in turn constructions detrimental to GIB conservation started cropping up haphazardly. A proposal to rationalize the boundary of DNP to exclude the Barmer area, which has lost much of its wildlife values due to large scale agricultural conversions, annexing an equal area in Shahgarh bulge in replacement, and to create an inviolate area of 200 sq km (WII proposal- 500 sq km) in northern DNP as a National Park with the mandate of conserving GIB. This proposal was viewed by a State Committee and was later shelved. However, given the continuous growth of human demands inside the Park and the need of undisturbed areas by GIB, creating an inviolate area for their conservation through voluntary and incentivized relocation of local people has been proposed by some conservation groups as well as promoting GIB friendly infrastructure development (eg. solar electrification) in villages may be a good solution to the continuing problem of people versus Park.

WILDLIFE INSTITUTE OF INDIA

GENERAL INTRODUCTION

Wildlife Institute of India (WII), established in 1982, is an autonomous organization under the Ministry of Environment, Forest and Climate Change (MoEFCC), Govt of India, and the technical hand of the former body. The institute is mandated by Government of India to carry out research on various aspects on Wild Life conservation, conduct training programmes for capacity building of Wild Life managers, build up repository of knowledge of Wild Life and provide technical and advisory services to the State and Central Governments in the country. WII's programmes are field based and seek an integration of biological, socio-economic and human aspects of large regional landscapes. As a result, wildlife conservation today means not just providing protection mainly to a few splendid species but that it be holistic and have considerations for humans living in the vicinity as well. WII's research projects being conducted in field sites across the length and breadth of the country are the primary sources of scientific information to help conservation.

WII's aims and objectives are to:

- Build up scientific knowledge on wildlife resources.

- Train personnel at various levels for conservation and management of wildlife.
- Carry out research relevant to management including the development of techniques appropriate to Indian conditions.
- Provide information and advice on specific wildlife management problems.
- Collaborate with international organizations on wildlife research, management and training.
- Develop as a regional centre of international importance on wildlife and natural resource conservation.

ACTION REGARDING GIB CONSERVATION.

For the GIB, research carried out by WII during 2007 - 11 highlighted the plight of the species and the subsequent advocacy programs resulted in the formulation of the species' recovery guidelines that were used to develop State level recovery plans.

Later, in March 2016, WII launched the project "Habitat Improvement and Conservation Breeding of Great Indian Bustard: An Integrated Approach" in collaboration with MoEFCC, State Forest Departments and NGO partners, with financial support from National CAMPA Funds, and a sum of Rs. 9.95 crores was released for the project implementation, and a commitment of 33.85 crore INR . A national launch workshop was organized at

WII, Dehradun on 16 May 2016 to appraise partner agencies on the proposed activity plans under the Project.

This Project has an in-situ component including

1) Applied research that aims at :-

- a) Prioritizing conservation areas for GIB and the endangered Lesser Florican (LF),
- b) Characterizing threats to these species,
- c) Monitoring bustard populations and habitats,
- d) Understanding population genetics to inform conservation management;

2) Pilot habitat management to demonstrate best practices of managing GIB habitats including:-

- a) Pilot mitigation of critical threats,
- b) Breeding enclosure management, and
- c) Strategizing land acquisition for conservation;

3) Capacity-building and awareness that aims at

- a) Improving protection enforcement,
- b) Sensitizing stakeholders on bustard conservation,
- c) Raising public awareness on bustard conservation, and-
- d) Incentivizing local land-users to adopt bustard-friendly land-uses.

The Project has an ex-situ component that aims at developing a Conservation breeding program for the Great Indian Bustard as an insurance against extinction and potential reintroduction. WII's Project team commenced activities on both in-situ and ex-situ components since March 2016 in collaboration with Rajasthan Forest Departments and NGO partners.

PRESENT STATUS OF GIB PROJECTS

AND FUTURE STRATEGY

Existing status of the GIB Project.

1. Tagging of GIB.

- The Dean, WII has written a communication dated 27.06.2018 to the State Forest Department and requested for permission to tag four GIB and DNP. A copy of communication dated 27.06.2018 is annexed herewith and marked as **Annexure-R3/2.**
- The Director, WII through its communication dated 16.08.2018 has asked for permission in relation to implementation of the species recovery programme of GIB and Lesser Florican. A copy of communication dated 16.08.2018 is annexed herewith and marked as **Annexure-R3/3.**

- With regard to the activities of Wildlife Institute of India's (WII) for Great Indian Bustard Conservation, permission to tag up to four Great Indian Bustard (GIB) has been issued by the Chief Wildlife Warden, Rajasthan (CWLW) to WII on 06.02.2019. A copy of communication dated 06.02.2019 is annexed herewith and marked as **Annexure-R3/4**

2. Habitat improvement and breeding conservation programme.

- The Director, WII through its communication dated 01.01.2019 has requested for grant of permissions for all project activities under the Tripartite memorandum of agreement signed between MoEF&CC, WII and Rajasthan Forest Department(Annexure R/5).
- Vide Communication dated 17.01.2019, the DIG Forest (Wildlife) of MoEF&CC has requested the PCCF, Government of Rajasthan to grant permission for collection Eggs/Chicks/Birds of GIB and Lessor Florican for conservation. A copy of communication dated 17.01.2019 is annexed herewith and marked as **Annexure-R3/5.**

- Permission for unrestricted access and right to develop and use >2 sq km land at Ramdevra, Jaisalmer for establishing Satellite (egg collection and hatching facility) site has been issued by CWLW to WII on 05.02.2019. A copy of communication dated 05.02.2019 is annexed herewith and marked as **Annexure-R3/6**.
- Since this land is Ooran land, Forest Department has sought a resolution from the Gram Panchayat and the later has granted approval on the use of the land for conservation breeding purpose. Further to this permission, Rajasthan Forest Department has expressed willingness to construct predator-proof fence around the GIB Conservation Breeding Center, and has requested for the release of 65 lakh INR towards this activity vide its communication dated 13.02.2019. A copy of communication dated 13.02.2019 is annexed herewith and marked as **Annexure-R3/7**.
- Immediately after receiving the said request, the fund to the tune of 65 Lakh INR has been released from WII on 15.02.2019. A copy of communication dated 15.02.2019 is annexed herewith and marked as **Annexure-R3/8**. It is

further submitted that the construction work of the Satellite site will commence soon.

3. Electrocution

- That since the High Transmission Electric Power Lines have been proved to be great threat to the GIBs and constant reason for deaths of GIBs, the issue was regularly discussed at the level of MoEF&CC and various solutions were proposed to be implemented including the identification of critical power lines, putting up of Bird Diverters as well as shifting of the power lines. The Secretary, MoEF&CC through its communication dated 07.01.2019 addressed to Chief Secretary, Government of Rajasthan; Secretary, Ministry of Power; Secretary, Ministry of New and Renewable Energy has requested to take immediate steps in this regard. A copy of communication dated 07.01.2019 is annexed herewith and marked as **Annexure-R3/9** collectively.

4. Budget Grant

- That WII has also proposed for staff training programme of the Forest Department of State of Rajasthan and in this regard, has requested the State Forest Department to issue the

annual budget to cover the activities for international travel of the staff. A copy of communication dated 23.08.2018 is annexed herewith and marked as **Annexure-R3/10**.

5. Other Activities

- That Rajasthan Forest Department conducted a workshop on 22-23 January 2019 that involved WII Project team, other field specialists, managers, decision-makers and conservationists, to develop a detailed in-situ project document for landscape-scale GIB conservation, through working group discussions/deliberations. This project document is being prepared by WII Project team, a draft of which has been shared with the Rajasthan Forest Department.

PERMISSIONS REQUIRED

Following permissions are required from the State Authorities:

- a. WII requires permission to conduct project activities that includes, apart from tagging, collection of GIB eggs for the purpose of conservation breeding as approved by ADG(WL), MoEFCC, long-term field research as per the approved project proposal.

- b. Further permissions are required for conducting relevant studies on the species biology, behavior, reproduction, genetics, ecology and management in wild and captivity, and collection of biological samples for species identification from carcasses.
- c. WII requires permission of unrestricted access to Forest land in Sorsan for construction of Main Conservation Breeding Center and managing the habitat and wildlife in this area. This area has been selected by an expert team comprising ADG(WL), CWLW Rajasthan, CZA Member Secretary, CCU Chief Engineer, Scientist and Project personnel of WII and local field officers. Later, some concerns on the land delineation were expressed by HoFF (Rajasthan), because of which, a follow-up visit was conducted by Chief Wildlife Warden Rajasthan, Scientist and Project personnel of WII and local community and conservation representatives on 10/2/19. The revised Forest land boundary was delineated during this visit that needs to be allocated by Rajasthan Government to WII for commencing geophysical/hydrological surveys, fencing, and subsequently construction of Center.
- d. Additionally, WII has requested for the allocation of 20-30 lakh INR from Rajasthan Government annually, as approved in the MoA between MoEFCC, Rajasthan Government and WII, to cover international travel and training of Project staff in conservation breeding techniques. **(Annexure-R3/10).**

- e. Permission to capture and translocate nest/chick is required to protect the GIB from predators such as dogs, foxes, cats and mongooses within Forest Department enclosures in Thar to create a safe zone for breeding and improve GIB recruitment rate, has been sought from Forest Department under the provisions of Wildlife Protection Act 1972 (Annexure X).
- f. WII has developed a financial and technical proposal on power-line mitigation that involves burying of high risk segments and diverter installation on medium risk segments in collaboration with power agencies that has been communicated to the Superintendent Engineer of RVPNL, Jaisalmer for necessary approvals from the Energy Department, Government of Rajasthan. These approvals and the follow-up actions need to be expedited to urgently remove this most pressing threat from priority GIB habitats, as decided in the 20th December 2018 meeting under the chairmanship of Principal Secretary, Energy Department, Rajasthan.

PROPOSED ACTIVITIES

- a) WII has commenced fieldwork to tag GIB immediately after receiving the permission. The success of tagging is unpredictable given the rarity, shy and sensitive nature of the bird that make it very difficult to be captured. Regular follow-up

attempts will be carried out throughout the year. This activity is important to identify priority areas for mitigation, and to track birds for identifying nests and sourcing eggs for the Conservation Breeding Center.

- b) Activities towards construction of the Centers have commenced. Funds have been transferred by WII to Rajasthan Forest Department for fencing the Satellite Site. Project team are corresponding with CPWD Jaisalmer for commencing construction of the incubation, hatchery, chick rearing, veterinary and staff outpost facilities within the Satellite Site. Tendering for architect hiring to design the Facilities has commenced. The basic construction of the Satellite site to a functional state will take about six months.
- c) WII has sent a team of scientists to formalize the collaboration and MoA with IFHC at Abu Dhabi during 28/2/19 - 2/3/19, subsequent to which, training of the Project staff in conservation breeding techniques can be planned and the first training can be achieved within a period of six months.
- d) Collection of eggs/chicks for artificial incubation at Ramdevra satellite site and/or transfer to IFHC center in Abu Dhabi for creating an offshore insurance population in the initial years can commence in the current (2019) or next (2020)

breeding season provided the required permissions for egg/chick collection and transfer are obtained from CWLW Rajasthan.

e) Following awareness and outreach programs have been conducted in the recent past and similar awareness projects will be conducted throughout the year:

i) School awareness campaigns involving >1000 students of 5-12 standards from 16 schools in 12 settlements in priority GIB habitats, (Jan-Feb 2019)

ii) Sensitization and skill development of nature guides in DNP (Feb 2019),

iii) Sensitization of local public in the Desert Festival during 17-19 February 2019, and

iv) Sensitization workshop for media and power agencies on GIB conservation in New Delhi on 21/02/19 have been conducted/planned, and such activities will continue throughout the year, to generate awareness among local communities and important stakeholders on GIB conservation.

f) Follow up regarding the sensitization meetings with power agencies for power line mitigation: Project team and Rajasthan Forest Department have organized several collaborative meetings to

sensitize power agencies for mitigating power lines for GIB conservation. A detailed exercise was undertaken by the Project team to map GIB habitats, wind turbines, power-line networks, and priority mitigation areas/segments using very high resolution satellite imagery. Subsequently, Project team attended meeting with CWLW Rajasthan and Principal Secretary Energy Department at Jaipur (December 2018), where it was decided that power agencies must mitigate all priority lines mapped by WII in Thar, and a fund of Rs. ca. 100 crores was sanctioned for this action. As decided in this meeting, Project team has worked with RVPNL (State Power Agency) for developing proposals with power-line agencies detailing mitigation measures and costs for various power agencies (December 2018-January 2019) so that this action can be taken up by the Government for approval and expeditious implementation. Based on the request of Director WII to ADG (WL), MoEFCC has also issued directives with supporting information to Central and State Ministries of Power and State Government Chief Secretaries, for expediting this much needed mitigation measure. (Annexure-R3/9).

FINANCIAL UPDATE

Till date, an amount of Rs. 5.95 crores has been spent to implement various in-situ and ex-situ activities proposed

in the project out of Rs. 9.95 Crore released by MoEFCC in the first installment. The second installment of Rs. 7.16 crores has recently been sanctioned by MoEFCC and will be sufficient to cover the proposed activities in the coming year .

RECOMMENDATIONS

Keeping the above scientifically established threats in mind, the following evidenced based actions are recommended by WII that are required to be taken up in time bound manner to achieve the species recovery:

1. Mitigate all power transmission lines passing through priority bustard habitats by undergrounding cables or installing bird diverters to make them prominent to birds. The priority areas where this intervention is required has been mapped by the Wildlife Institute of India and a technical-cum-financial proposal has been submitted to RVPNL for necessary approvals from Rajasthan Energy Department for mitigation. This action must be expeditiously implemented in the short-term (1-3 years), as power-line mortality is currently the biggest threat to the species.
2. Disallow new wind turbines from priority GIB habitats and remove existing ones that are in the critical areas. The priority areas where this

intervention is required has been mapped by Wildlife Institute of India. This action needs to be implemented in the long-term spanning 5-10 years from present.

3. Develop predator-proof enclosures of 5-10 sq km area in known breeding sites to improve GIB recruitment, and keep away nest predators by routinely translocating dogs, foxes, mongoose and other species outside the enclosures using professional trappers. Also establish such enclosures in the larger Thar (Jaisalmer) landscape, as identified by joint surveys of WII and RFD. These enclosures need to be developed and will serve as breeding sites and stepping stones for movement across the larger landscape.
4. Delineate priority GIB habitats as Ecosensitive Zones where agro-pastoral practices are regulated to low-intensity and expanse through Zonal Management Plans and detrimental infrastructure such as wind turbines and overhead transmission lines are curtailed. This action needs to be implemented in the short-term (1-2 years).
5. Engage with local communities to promote bustard-friendly practices such as stall-feeding of livestock during monsoon - chick-rearing and grass growing season - and cultivating food crops preferred by GIB during monsoon such as gram, ground nut and

millets while leaving the fields fallow for the remaining period. These land-uses can be promoted by Rajasthan Forest Department in conjunction with other State Departments, through appropriate financial and other incentive schemes, such as provisioning of fodder for stall feeding or compensatory payments to foregone production cost by opting for low-intensity farming. This action needs to be implemented in the longer scale (4-8 years).

6. Reduce poaching of GIB and other wildlife in the Thar landscape by improving protection enforcement through training of Forest Department frontline staff in smart patrolling tools with the help of conservation organizations such as WII and WWF, provisioning of better patrolling equipment, enrolling frontline staff from non-wildlife divisions of Forest Department and local volunteers in this activity, and ensuring trials of convicts. Further, it is to bring to the notice that areas controlled by Armed forces in Jaisalmer District harbor about 50% of the GIB population found in Rajasthan. This secure zone under the control of Army where human activities are minimal is a blessing for the bird on the verge of extinction. Thus, the corporation of Army to conserve the GIB and control the incidents of poaching could play a vital role as well.

6. Implement the conservation breeding programme by creating an immediate offshore insurance population by shipping a batch of about 10 GIB eggs to a state-of-the-art international breeding center such as IFHC houbara breeding center at Abu Dhabi that produces up to 30,000 houbara chicks every year (short-term solution 3-5 years), and meanwhile, establish a national breeding center by training staff, developing a state-of-the art center at Sorsan (main facility) and Ramdevra (satellite facility), where eggs collected from wild can be artificially incubated, hatched, reared and captive bred to create an insurance population that can be reintroduced into the wild.
7. To further conduct targeted research on GIB to characterize threats spatio-temporally, understand landscape use patterns using satellite telemetry, and objective monitoring of their population status by involving research organizations.

It is thus submitted that the key to conserve is a vital balance and combination of stringent protection measures, scientific habitat management, sensible land use planning and providing of basic amenities and livelihood options to local people in priority conservation areas.

Jodhpur

SANJEET PUROHIT

Assistant Solicitor General

NOTES:

1. No such reply has been filed in the above matter before this Hon'ble Court.
2. Pf, notices and extra copies shall be filed within the prescribed time.
3. This has been typed by my private Stenographer on my personal computer,
4. As the pie papers are not readily available, print was taken on stout papers.
5. Internal paging and titling has been made on each page of the petition.
6. The matter pertains to the Jodhpur jurisdiction.
7. E-mail Id is uoi.jurisorbis@gmail.com and Mob. No. is **9414131630**.

Jodhpur

SANJEET PUROHIT

Assistant Solicitor General

IN THE HIGH COURT OF JUDICATURE FOR RAJASTHAN

AT JODHPUR

D.B. CIVIL WRIT PETITION NO. 825 /2019

PETITIONER:

VS.

RESPONDENTS:

Suo Moto

The Principal Secretary & Ors.

AFFIDAVIT IN SUPPORT OF REPLY

I, Bipin C.M. S/o C.A. Monnappa aged about 42 years, holding the post of Project Associate, Great Indian Bustard Recovery Project Wildlife Institute Of India, Dehradun; state on oath as under:-

1. I am authorized to sign in the above-named reply and am fully conversant with the facts and circumstances of the case.
2. The annexed written submissions has been drafted as per my instruction by my counsel. The contents of the written submissions have been read over to me and I have understood the same.
3. The contents of Para No. 1 to last of the written submission are true and correct to my personal knowledge and the legal submissions are true to my belief being based on legal advice.

VERIFICATION

I, the above named deponent do hereby verify that my above affidavit is true and correct, nothing has been concealed and no part of it is false. SO HELP ME GOD.

IN THE HIGH COURT OF JUDICATURE FOR RAJASTHAN

AT JODHPUR

D.B. CIVIL WRIT PETITION NO. 825 /2019

PETITIONER:

VS.

RESPONDENTS:

Suo Moto

The Principal Secretary & Ors.

AFFIDAVIT IN SUPPORT OF DOCUMENTS

I, Bipin C.M. S/o C.A. Monnappa aged about 42 years, holding the post of Project Associate, Great Indian Bustard Recovery Project Wildlife Institute Of India, Dehradun; state on oath as under:-

1. That I am authorised in the above-named reply and am fully conversant with the facts and circumstances of the case.
2. That the Annexure-R3/1 to last are the true and correct photocopies of their originals.

VERIFICATION

I, the above named deponent do hereby verify that my above affidavit is true and correct, nothing has been concealed and no part of it is false. SO HELP ME GOD.

IN THE HIGH COURT OF JUDICATURE FOR RAJASTHAN

AT JODHPUR

D.B. CIVIL WRIT PETITION NO. 825 /2019

<u>PETITIONER:</u>	VS.	<u>RESPONDENTS:</u>
Suo Moto		The Principal Secretary & Ors.

I N D E X

S. No.	Particulars	Page No.
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|----|---|--|
| 1. | Written Submission. | |
| 2. | Affidavit in support of Written Submission. | |
| 3. | Affidavit in support of Documents | |

DOCUMENTS

- | | |
|-------------|--|
| Annx.R3/1. | Copy of study so conducted named
“Bustards, Wires, and the Flight to
Extinction” |
| Annx.R3/2. | Copy of communication dated 27.06.2018. |
| Annx.R3/3. | Copy of communication dated 16.08.2018. |
| Annx.R3/4. | Copy of communication dated 06.02.2019. |
| Annx.R3/5. | Copy of communication dated 17.01.2019. |
| Annx.R3/6. | Copy of communication dated 05.02.2019. |
| Annx.R3/7. | Copy of communication dated 13.02.2019. |
| Annx.R3/8. | Copy of communication dated 15.02.2019. |
| Annx.R3/9. | Copy of communication dated 07.01.2019. |
| Annx.R3/10. | Copy of communication dated 23.08.2018. |

Jodhpur

SANJEET PUROHIT

Assistant Solicitor General

**HIGH COURT OF JUDICATURE FOR RAJASTHAN
JODHPUR**

D.B. Civil Writ No. 825/2019

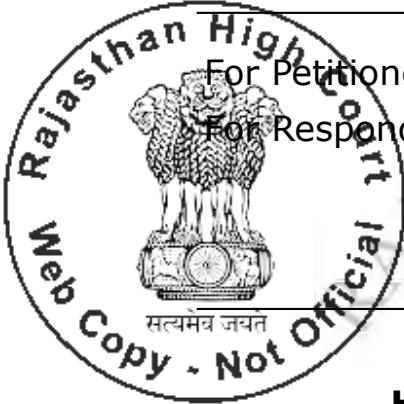
Suo Moto

----Petitioner

Versus

The Principal Secretary & Ors.

----Respondents



For Petitioner(s)	:	Mr. Vikas Balia
For Respondent(s)	:	Mr. Sandeep Shah, Additional Advocate General Mr. Sanjeet Purohit, Assistant Solicitor General

**HON'BLE MR. JUSTICE SANGEET LODHA
HON'BLE MR. JUSTICE DINESH MEHTA**

Order

12/03/2019

Mr. Sanjeet Purohit, learned Assistant Solicitor General submits that the written submissions on behalf of Union of India has been filed today.

Office is directed to place it appropriately.

List the matter on 15.4.19, as prayed.

(DINESH MEHTA),J

(SANGEET LODHA),J

77-Vij/-

Item Nos.11

Court No. 1

**BEFORE THE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI**

Original Application No. 385/2019

Centre for Wildlife and Environment Litigation

Applicant(s)

Versus

Union of India & Ors.

Respondent(s)

Date of hearing: 04.04.2019

**CORAM: HON'BLE MR. JUSTICE ADARSH KUMAR GOEL, CHAIRPERSON
HON'BLE MR. JUSTICE K. RAMAKRISHNAN, JUDICIAL MEMBER
HON'BLE DR. NAGIN NANDA, EXPERT MEMBER**

For Applicant(s): Mr. Gaurav Kumar Bansal, Advocate

For Respondent (s):

ORDER

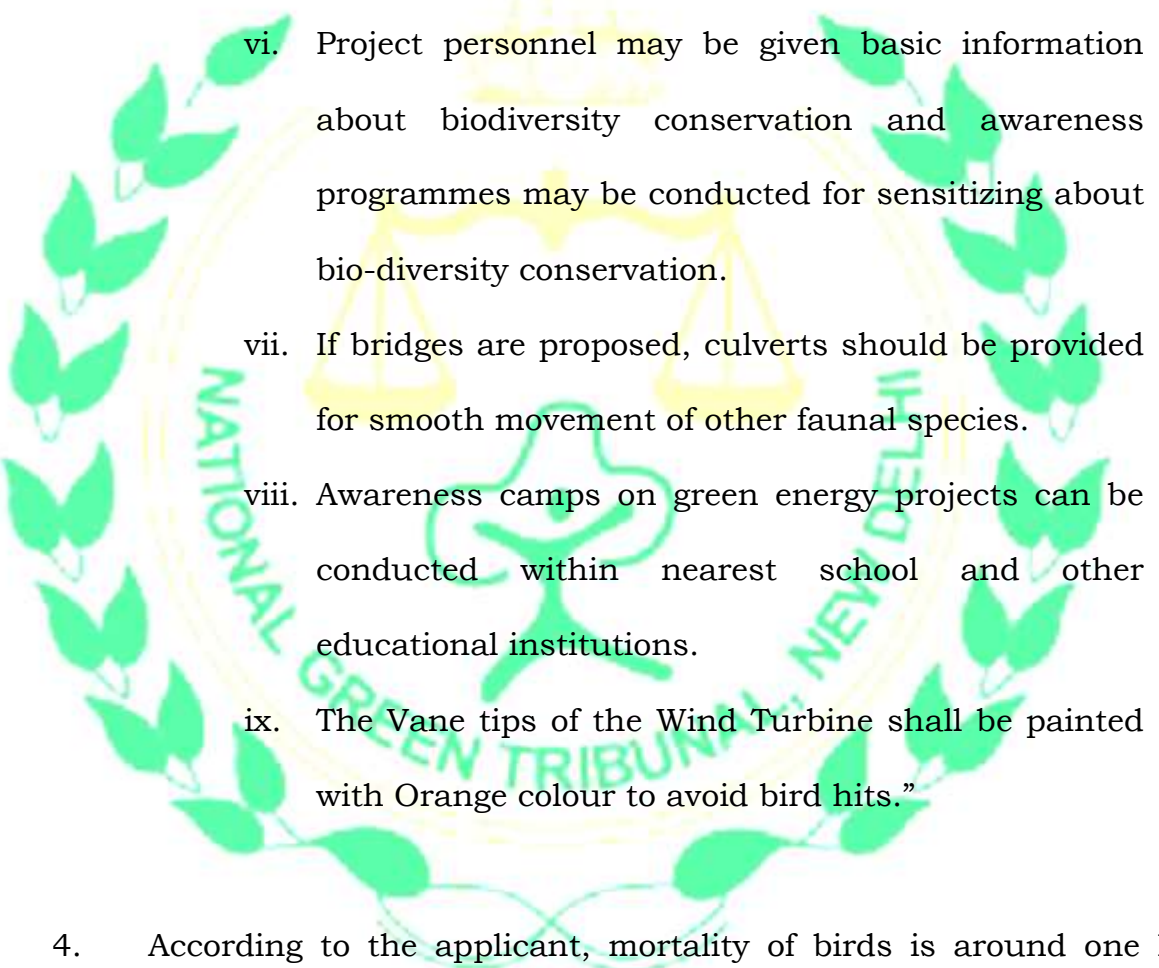
1. The grievance in this application is against adverse impact being caused by power and wind projects on Great India Busturd Birds and bio-diversity.
2. According to the applicant, Great Indian Bustard (GIB) is one of the rarest birds in the world and is an endangered species. It is listed as Critically Endangered Species in Schedule I to the Wildlife Protection Act, 1972. Its population has steadily declined by 75% in last thirty years. The said birds face fatal accidents with the power lines. This requires habitat improvement and conservation breeding. A project has been adopted by the Ministry of Environment, Forest and Climate Change (MoEF&CC) in August, 2015 called "Habitat Improvement of Great Indian Bustard-An Integrated Approach". It was found in a review meeting on 19.07.2018 that one of the

potential danger was that wind projects did not require any EIA studies. There was no substitute mechanism to ensure safeguards of such birds on 'Precautionary' principle of Environment. Forest Advisory Committee, Government of India had considered the matter in its meeting on 10.11.2016 and recommended study of impact of proposed project on wildlife. Birds face threat from high tension transmission lines. The preventive measures identified are:

- “ i. Route planning
- ii. Underground cabling
- iii. Removal of ground/earth wires
- iv. Line modifications
- v. Mandatory installing of bird flight diverters on all transmission and high voltage lines with large constructions with tall pylons (35m or higher for 150kv or more) on regular intervals on conductors in order to make them more visible.
- vi. Vane tips of the wind turbine shall be painted with orange colour to avoid bird hits.”

3. The 'Great Indian Bustard and Lesser Florican' Conservation and Breeding Programme recommendations are as follows:

- “i. As directed by the Forest Department, compensatory afforestation should be carried out by using local species which will help to enhance/improve biodiversity.
- ii. Immediate surrounding area (around 50 meter) of each WTG should be maintained vegetation free area to avoid faunal movement.

- 
- iii. Fruit tree species should be avoided near WTGs; otherwise this may attract bird and bats which may result in mortality of bats and birds.
 - iv. Dead animal and carcasses (if any) should be removed immediately from WTG site to prevent attraction of carnivore birds/raptors towards sites.
 - v. No water bodies/pond formation allowed within site/near turbines this may attract water birds and lead to collision.
 - vi. Project personnel may be given basic information about biodiversity conservation and awareness programmes may be conducted for sensitizing about bio-diversity conservation.
 - vii. If bridges are proposed, culverts should be provided for smooth movement of other faunal species.
 - viii. Awareness camps on green energy projects can be conducted within nearest school and other educational institutions.
 - ix. The Vane tips of the Wind Turbine shall be painted with Orange colour to avoid bird hits.”

- 4. According to the applicant, mortality of birds is around one lakh annually.
- 5. Let the MoEF&CC furnish a factual report in the matter within two months by email at ngt.filing@gmail.com. The Report may also cover the subject of safeguarding and protection of other biological life

falling in Schedule I to the Wildlife Protection Act, 1972 listing critically endangered species.

6. A copy of this order be sent to the MoEF&CC by email. The applicant may furnish a set of papers to the MoEF&CC and file an affidavit of service within one week.

List the matter for further consideration on 16.07.2019.



Adarsh Kumar Goel, CP

K. Ramakrishnan, JM

Dr. Nagin Nanda, EM

April 04, 2019
Original Application No. 385/2019
AK

FACTUAL REPORT ON THE GREAT INDIAN BUSTARD RECOVERY PROGRAM

1. INTRODUCTION

As directed by the Hon'ble National Green Tribunal Principal Bench regarding the conservation of the Great Indian Bustard on 04.04.2019, this factual report on the "Habitat improvement and Conservation Breeding of the Great Indian Bustard- An integrated approach" project carried out by Wildlife Institute of India (WII) is submitted on behalf of the Ministry of Environment, Forest and Climate Change (MoEFCC).

1.1. GREAT INDIAN BUSTARD (GIB)

1.1.1. STATUS AND DISTRIBUTION

The Great Indian Bustard (GIB) is a critically endangered bird with less than 150 individuals left in India/World and in urgent need of conservation actions. These numbers are based on surveys conducted by the Wildlife Institute of India (WII) research team in Rajasthan in 2017-18, Maharashtra in 2017 (Please refer Appendices 3 & 5 in Annexure 1). and information collation by Collar et al in 2018 (Please refer Annexure 2). A copy of the WII's report titled "*Habitat improvement and Conservation Breeding of the Great Indian Bustard- An integrated approach- Annual Progress Report II- 2017-18*" and research paper by Collar et al. in 2018 titled "*Averting the extinction of bustards in Asia*" is annexed herewith and marked as Annexure 1 and Annexure 2 respectively. Long term surveys (2014-18) conducted by the WII and the Rajasthan Forest Department show that the majority of this population is found in Jaisalmer district within and around the Desert National Park, and the Indian Army controlled Field Firing Range near Pokhran. A copy of the survey report titled "*Status assessment of Great Indian Bustard, associated fauna and habitat of Thar – 2016*" is annexed herewith and marked as Annexure 3. Other populations are very small and less than 10 individuals each, found in Abdasa tehsil, Kutch district, Gujarat, Nagpur, Amravati and Solapur districts of Maharashtra, Bellary and Koppal districts in Karnataka, and Kurnool district in Andhra Pradesh. These surveys indicate that the species' numbers have reduced by 75% in last 30 years (Please refer Annexure 4). A copy of research paper Dutta *et al.* in 2010 titled "*Running out of time? The Great Indian Bustard *Ardeotis nigriceps*- status, viability, and conservation strategies*" is annexed herewith and marked as Annexure 4. Historically, GIB was distributed throughout the western half of India. Currently, the species' range has reduced to 10% of the historical range according to Dr. Asad Rahmani, former director of Bombay Natural History Society and GIB expert from India in the report titled- "*The Great Indian Bustard. Final Report in the study of ecology of certain endangered species of wildlife and their habitats-1989*". The species is listed as Critically Endangered (International Union for Conservation of Nature, 2011) and Schedule-I that accords it the highest level of legal protection under Wildlife (Protection) Act, 1972.

1.1.2. ECOLOGY

The Great Indian Bustard (GIB) is one of the heaviest flying birds' endemic to the Indian subcontinent. They are primarily terrestrial birds with adult males as tall as 122 cm and 11-15 kg and adult females reach up to 92 cm and 4-7 kg. The plumage is predominantly brown and white, and adult males are characterised by thicker and whiter neck with black eyebrow. The Great Indian Bustard is an omnivorous bird primarily feeding on insects, fruits and harvested crops. They live in dry, open landscapes comprising of short grasslands, scrub and rain-fed agriculture. Sexual maturity is attained at the age of 4-5 years in males and 3-4 years for females. They are traditional to their breeding grounds, where, males display in open, well-grazed grasslands to attract females who prefer moderately tall and less-grazed grassland for nesting. Thus, a mosaic of short and tall vegetation with little disturbance is ideal for breeding. Existing research on GIB and related species shows that large heterogeneous agro-grassland patches have highest conservation value and GIB conservation is compatible with traditional, low- intensity land uses. As evidence of this, a copy of the PhD dissertation of Dr. Sutirtha Dutta and research paper by Dutta and Jhala in 2014 titled "*A Planning agriculture based on landuse responses of threatened semiarid grassland species in India*" are annexed herewith and marked as Annexure 5 a & b, respectively.

1.1.3. THREATS

Research conducted by Rahmani (1989) and Dutta *et al.* (2010) show that GIB is a long-lived species with very slow reproductive rate – it lays one egg every 1-2 years, and the success rate of these eggs under ideal situation is around 60-70%. However, the current nesting habitats have high density of predators such as fox and dogs because of availability of more surface water that has reduced the nest success rate to 40-50% based on dummy nest experiment conducted in GIB habitat (Dutta, *unpublished data*). Because of such slow reproductive rate and specific habitat requirements, the species is inherently vulnerable and cannot sustain any added nest predation.

For such long-lived and slow reproducing species, adult mortality is the most decisive parameter for population persistence. Historically, this bird was hunted as game and their population was reduced because of this threat. After the implementation of Wildlife (Protection) Act 1972, their hunting has been reduced but not eliminated. However, adult mortality is still very high due to collisions with power-lines that criss-cross their flypaths. All bustard species in the world are prone to collision with power-lines due to their poor frontal vision and inability to see power-lines from a distance, along with their large size and heavy flight that make it difficult to maneuver in the nick of the time. WII's research has shown that power-lines, particularly high-voltage (33-440 KV) transmission lines with vertical alignment are the biggest threat to GIB as of now. GIB habitats have a high density of transmission lines because of the impetus on renewable energy production in GIB habitats of Rajasthan and Gujarat. This study recorded five GIB deaths in 2017-18 in Jaisalmer district alone based on systematic surveys and anecdotal information, and calculated that ~15% of the GIB population may be dying because of this threat (Please refer Appendix 7 in Annexure 1). Since the natural death rate of large bustards is about 4-8%, the current additive mortality rate due to transmission lines is significantly higher, and if not controlled can result in the species' extinction. Apart from GIB, many other birds also die because of collision/electrocution with these transmission lines at a rate of ~10 birds/km/month totaling nearly one lakh bird deaths annually in 4200 sq km according to this study. A copy of the study so

conducted named “*Bustards, Wires, and the Flight to Extinction*” is annexed herewith and marked as Annexure 6.

While these are the two most important current threats to the species, prevailing habitat loss remains an important threat to the long-term persistence of the species. GIB habitats comprising primarily of short grasslands and scrublands, which were traditionally the support system for rearing livestock have been marginalized as ‘unproductive wastelands’, progressively converted to other land uses since colonial times, and are not sensibly managed. Earlier, agriculture used to be monsoonal and sparse in bustard habitats and fallow periods used to be prolonged when fields were naturally regenerated. This allowed plenty of food (insects, fruits, crop residues) and grass vegetation cover for the species. But recent developments in irrigation and farming technologies have intensified agriculture and changed cropping practices from seasonal to year-round, intensive crops. Because of frequent ploughing and cropping or use of pesticides, there is lack of food and vegetation cover to meet the ecological requirements of the species. There is a need to regulate such intensive agricultural land-uses to achieve long-term GIB persistence.

Moreover, development activities like mining, industries, wind turbines, and associated infrastructure growth (buildings, electricity and road networks) have caused severe habitat degradation and disturbance to birds. Furthermore, management authorities in many areas exhibit poor enforcement ability due to inadequate staff and infrastructure, lack of motivation, and inaccessibility. Ill-informed forestry practices by State Forest Departments such as plantation of exotic shrub/tree species in deserts and grasslands in the name of afforestation have also degraded the habitat of GIB, chinkara and other open habitat species that prefer visibility and openness.

1.1.4. PROPOSED CONSERVATION MEASURES

Conservationists have been discussing actions required to save the GIB since 1980s, when eight bustard Sanctuaries were established for the species’ conservation. However, these sanctuaries included agro-pastoral landscapes where private land rights were not properly settled, and the ensuing legal stringency on land-uses resulted in public antagonism and the extirpation of the species from some of these Sanctuaries. GIB conservation received a fresh impetus around 2010-13, with the constitution of the Bustard Task Force and the development of the National Guidelines for Recovery of Resident Bustards through consultative meetings of conservation agencies under the umbrella of Ministry of Environment, Forest and Climate Change. A copy of the guidelines by Dutta *et al.* in 2013 titled “Guidelines for preparation of state action plan for resident bustards’ recovery programme” is annexed herewith and marked as Annexure 7. The above cited action plan highlighted the need of a landscape level conservation approach which was missing from the earlier plan and the habitat around these Sanctuaries became hostile due to intensive land-uses and detrimental infrastructure.

This Recovery Plan suggested:

- Prioritizing the species’ landscape through surveys and telemetry, and mitigating threats such as power-lines and poaching therein
- Consolidating known breeding areas of the species by chain-link predator-proof fencing to improve the species’ recruitment rate

- Promoting bustard-friendly land-uses/practices by sensitizing and incentivizing local communities
- Finally, while these actions are required on ground, the species is declining at such a rapid rate due to the existing threats, that recovery actions cannot fully reverse the decline in the wild considering the expected time delays of these actions. Hence, a conservation breeding programme should be undertaken to secure a captive population as an insurance against total extinction and to leave the possibility of reintroducing birds in the wild in favourable times when the habitats have been restored by effective field management actions.

1.2. DESERT NATIONAL PARK

Desert National Park (actually a Wildlife Sanctuary) was established in year 1980 over an area of 3162 sq km across Jaisalmer and Barmer districts, with the mandate of conserving desert biodiversity. During the time of its establishment, land rights of people residing inside the Park, then 88 settlements, were not settled. Subsequently, the population size and demand for land increased. Currently, there are 88 villages with 13,000 households in and around the Park. Forest Department controls only 5% of the Park area, in the form of enclosures that are now being managed with the mandate of GIB conservation. The remaining 95% of Park area comprises of private and Revenue lands, with the latter largely being encroached by villagers for agriculture. Earlier, the local people depended on pastoral livelihoods, and would occasionally engage in farming during good rainfall years, when they grew seasonal food crops such as gram, ground nut and millets. However, in the recent years, the market value of *guar* or Cluster Beans has increased dramatically due to their industrial use in hydraulic fracturing. This has led to escalated encroachment by villagers to cultivate and sell *guar*. Because of agricultural encroachment, pastures have depleted, and the herbaceous vegetation are currently largely restricted to Forest Department enclosures. The livestock of local settlements trespass into these enclosures for fodder that creates friction between the Forest Department and local people. This antagonism was exacerbated due to restriction on infrastructure development and in turn constructions detrimental to GIB conservation that have started cropping up haphazardly.

A proposal to rationalize the boundary of Desert National Park (DNP) to exclude the Barmer area, which has lost much of its wildlife values due to large scale agricultural conversions, annexing an equal area in Shahgarh bulge in replacement, and to create an inviolate area of 200 sq km (WII proposal- 500 sq km) in northern DNP as a National Park with the mandate of conserving GIB was prepared. This proposal was viewed by a State Committee and was later shelved. However, given the continuous growth of human demands inside the Park and the need of undisturbed areas by GIB, creating an inviolate area for their conservation through voluntary and incentivized relocation of local people has been proposed by some conservation groups as well as promoting GIB friendly infrastructure development (eg. solar electrification) in villages may be a good solution to the continuing problem of people versus Park.

1.3. WILDLIFE INSTITUTE OF INDIA

1.3.1. GENERAL INTRODUCTION

Wildlife Institute of India (WII), established in 1982, is an autonomous organization under the Ministry of Environment, Forest and Climate Change (MoEFCC), Govt of India, and the technical arm of the former body. The institute is mandated by Government of India to carry out research on various aspects on wildlife conservation, conduct training programmes for capacity building of wildlife managers, build up repository of knowledge of wildlife and provide technical and advisory services to the State and Central Governments in the country. WII's programmes are field based and seek an integration of biological, socio-economic and human aspects of large regional landscapes. As a result, wildlife conservation today means not just providing protection mainly to a few iconic species but that it be holistic and have considerations for humans living in the vicinity as well. WII's research projects being conducted in field sites across the length and breadth of the country are the primary sources of scientific information to help conservation.

WII's aims and objectives are to:

- Build up scientific knowledge on wildlife resources.
- Train personnel at various levels for conservation and management of wildlife.
- Carry out research relevant to management including the development of techniques appropriate to Indian conditions
- Provide information and advice on specific wildlife management problems
- Collaborate with international organizations on wildlife research, management and training
- Develop as a regional centre of international importance on wildlife and natural resource conservation

1.3.2. ACTION REGARDING GIB CONSERVATION BY WII

For GIB conservation, research carried out by WII during 2007 – 11 highlighted the plight of the species and the subsequent advocacy programs resulted in the formulation of the species' recovery guidelines that were used to develop State level recovery plans.

Later, in March 2016, WII launched the project "Habitat Improvement and Conservation Breeding of Great Indian Bustard: An Integrated Approach" in collaboration with MoEFCC, State Forest Departments and NGO partners, with financial support from National Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Funds, and a sum of Rs. 9.95 crores was released for the project implementation, with a five year commitment of 33.85 crore INR. A national launch workshop was organized at WII, Dehradun on 16 May 2016 to appraise partner agencies on the proposed activity plans under the Project.

A) This Project has *an in-situ* component including

A.1. Applied research that aims at: -

- Prioritizing conservation areas for GIB and the endangered Lesser Florican (LF)
- Characterizing threats to these species

- Monitoring bustard populations and habitats
- Understanding population genetics and species' ecology to inform conservation management

A.2. Pilot habitat management to demonstrate best practices of managing GIB habitats including: -

- Pilot mitigation of critical threats
- Breeding enclosure management
- Strategizing conservation planning through delineation of lands for conservation declaration/acquisition

A.3. Capacity-building and awareness that aims at

- Improving protection and enforcement
- Sensitizing stakeholders on bustard conservation
- Raising public awareness on bustard conservation
- Encouraging local land-users to adopt bustard-friendly land-uses

B) The Project has an *ex-situ* component that aims at developing a Conservation breeding program for the Great Indian Bustard as an insurance against extinction and potential reintroduction.

WII's Project team commenced activities on both *in-situ* and *ex-situ* components since March 2016 in collaboration with Rajasthan Forest Departments and NGO partners.

2. PRESENT STATUS OF GIB PROJECT

2.1. SUMMARY OF PROJECT ACTIVITIES CONDUCTED BY WII

Since 2016, WII Project team has conducted the following activities:

- Landscape scale surveys for the GIB in two cycles during 2016-18 and for the Lesser Florican in two cycles during 2017-18, in partnership with State Forest Departments and NGOs to monitor their population status and identify priority conservation areas and threats (Please refer to Appendix 3-5 of Annexure 1).
- Detailed assessment of threats such as power-lines, free-ranging dogs and nest predators in terms of landscape level mapping and their impacts on mortality of GIB and associated species (Appendix 6-8 and main text of Annexure 1).
- Telemetry in Kutch, Gujarat and Jaisalmer, Rajasthan to understand the species' ranging patterns, ecology and prioritize power-lines for mitigation.
- Examination of genetic composition and structure of GIB population.
- Examination of social aspects of local people residing in/around DNP.
- Pilot management measures such as pilot installation of bird diverters on power-lines for demonstration.
- Sterilization of 801 dogs in/around DNP to manage their population in partnership with Humane Society International (HSI).
- Designing predator-proof enclosures to improve GIB recruitment.
- Training of frontline Forest Department staff in wildlife surveys.
- Sensitization of Indian Army (Pokhran Field Firing Range) and power agencies on their roles in GIB conservation.
- Other awareness, training and workshop programs with various stakeholders for GIB conservation

All activities under the *in-situ* component have been initiated and most of the targets/milestones have been achieved. Please refer details of the above activities in Annexure 1.

2.2. DETAILS OF KEY PROJECT ACTIVITIES

2.2.1. LANDSCAPE SCALE SURVEYS FOR THE GREAT INDIAN BUSTARD AND LESSER FLORICAN 2017-18

Since 2014, Wildlife Institute of India and Rajasthan Forest Department have been conducting joint surveys to understand the current status, distribution patterns, and local contexts of key conservation-dependent species in Thar to develop scientific management plan. Persistence of GIB critically depends on Thar, where ~75 % of the global population resides. The project team assessed the status of native and conservation-dependent species such as the GIB, chinkara and desert fox. Non-native and 'problem' species such as free-ranging dogs, wild pigs and nilgai that live alongside the habitat of the GIB, in addition to anthropogenic pressures across 19,728 sq km of potential bustard landscape in Thar spanning Jaisalmer, Jodhpur and small parts of Bikaner and Barmer districts of Rajasthan were also assessed. Systematic surveys were conducted from slow-moving vehicle along transects to record species detections, habitat characteristics in sampling plots, and secondary information on species occurrences. Great Indian bustard and other key species detection data were analysed in Occupancy and Distance Sampling framework to estimate proportion of sites occupied and density/abundance.

During the last four surveys, 38 (2014), 40 (2015), 37 (2016) and 37 (2017) great Indian bustards were detected. Their detection/non-detection in 2-km transect segments (spatial surveys) across the area showed that $6.7 \pm 2.9\text{SE}$ % of sites were occupied in 2017. Bird density was estimated at $0.48 \pm 0.10\text{SE}$ per 100 sq km across all sites and $7.49 \pm 1.63\text{SE}$ per 100 sq km in used sites (sampling cells of 144 sq km where at least one bird was detected during 2017). Abundance was estimated at $95 \pm 21\text{SE}$ individuals in the 19,728 sq km landscape, pooling data across 2016-17. The current abundance estimate was lower than the past estimate ($140 \pm 53\text{SE}$ in 2015-16); this could be partly due to inadequate intensive surveys in high-density sites within the Field Firing Range. Hence, WII's GIB project team conducted follow-up distance based line transect surveys in the subset of landscape where the species is distributed (western Thar: 4,068 sq km area, and Pokhran Field Firing Range: 5,184 sq km area) jointly with Indian Armed Forces in March–April 2018, to refine the past estimate. Based on these surveys, abundance was estimated at $128 \pm 19\text{SE}$ individuals in 9,252 sq km great Indian bustard distribution area in Thar. But, there might be a real decline in numbers, as comparison of species' encounter rate across years, keeping sampled sites constant, indicated a non-significant but declining trend between 2014-15 ($1.00 \pm 0.41\text{SE}$ per 100km) and 2016-17 ($0.83 \pm 0.30\text{SE}$ per 100km).

Our surveys showed an expansion of human artefacts across survey years, wherein the proportion of sampling plots with water source, power-lines, farm-huts and wind turbines had increased annually by 0.12, 0.09, 0.07, and 0.03, respectively, over the last four years. Correspondingly, population of free-ranging dogs showed a remarkable expansion over these years, wherein the proportion of sites occupied increased from $0.15 \pm 0.04\text{SE}$ (2014) to $0.61 \pm 0.09\text{SE}$ (2017), and their encounter rate increased from $4.32 \pm 1.77\text{SE}$ to $23.11 \pm 9.39\text{SE}$ per 100km in sites that were monitored across all years.

The survey in Maharashtra (October 2017) did not yield any GIB detection and population was estimated to be less than 8 birds.

The national lesser florican survey was jointly conducted by the project team with partner agencies in July - September 2017 that yielded a conservative estimate of 264 male territories across the range and an abundance estimate of 340 male territories; highlighting the critical status of this species.

2.2.1. POWER-LINE IMPACTS AND ADVOCACY FOR MITIGATION

Carcass surveys under power lines by WII project team in Thar (2017-18) showed mortality of five GIB, and an estimated death of ~1 lakh birds of over 49 species annually in the ~4000 sq km priority GIB habitat. Power lines across GIB habitat in Thar are causing unsustainably high mortality of 15% of their population. Power lines, especially high-voltage transmission lines with multiple overhead wires, is the most important current threat for GIB. Results of this exercise has been published and widely disseminated to sensitize power agencies, managers, decision-makers and conservation agencies. A copy of this report titled *“Power line mitigation to conserve bustards”* has been annexed herewith and marked as Annexure 10a.

WII GIB project team and Rajasthan Forest Department have organized several collaborative meetings to sensitize power agencies for mitigating power lines for GIB conservation. A detailed exercise was undertaken by the Project team to map GIB habitats, wind turbines, power-line networks, and priority mitigation areas/segments using very high resolution satellite imagery. Subsequently, Project team attended meeting with CWLW Rajasthan and Principal Secretary Energy Department at Jaipur (December 2018), where it was decided that power agencies must mitigate all priority lines mapped by WII in Thar, and a fund of Rs. ca. 100 crores was verbally approved for this action, although the Minutes of this meeting is yet to be issued by the Energy Department, Rajasthan. As decided in this meeting, Project team has worked with RVPNL (State Power Agency) for developing proposals with power-line agencies detailing mitigation measures and costs for various power agencies (December 2018–January 2019) so that this action can be taken up by the Government for approval and expeditious implementation. WII has developed a financial and technical proposal on power-line mitigation that involves burying (undergrounding) of high risk segments and diverter installation on medium risk segments in collaboration with power agencies that has been communicated to the Superintendent Engineer of RVPNL, Jaisalmer for necessary approvals from the Energy Department, Government of Rajasthan. A copy of the proposal titled *“Action and budget proposal Mitigation plan for high-tension power lines in Great Indian Bustard habitat of Thar Desert, Jaisalmer”* is annexed herewith and marked as Annexure 10b. These approvals and the follow-up actions need to be expedited to urgently remove this most pressing threat from priority GIB habitats, as decided in the 20th December 2018 meeting under the chairmanship of Principal Secretary, Energy Department, Rajasthan.

Based on the research carried out by WII (Annexure 21) and request of Director WII to ADG (WL), MoEFCC has also issued directives with supporting information to Central and State Ministries of Power and State Government Chief Secretaries, for expediting implementation of mitigation measures.

Since the High Transmission Electric Power Lines have been proven to be great threat to the GIBs and constant reason for deaths of GIBs due to collision/electrocution with power-lines, the issue was regularly discussed at the level of MoEFCC and various solutions were proposed to be implemented including the identification of critical power lines, putting up of Bird Diverters as well as undergrounding and shifting of the power lines. Samples of various bird diverters were procured from abroad and distributed to power agencies for pilot installation. The Secretary,

MoEFCC through its communication dated 07.01.2019 addressed to Chief Secretary, Government of Rajasthan; Secretary, Ministry of Power; Secretary, Ministry of New and Renewable Energy has requested to take immediate steps in this regard. A copy of communication dated 07.01.2019 is annexed herewith and marked as Annexure 8 collectively. Following this, Ministry of New & Renewable Energy has also issued directives dt. 10.03. 2019 to power agencies to initiate mitigation measures in GIB habitats in consultation with WII. A copy of communication dated 22.02.2019 is annexed herewith and marked as Annexure 9. Subsequently, two power agencies-SITAC and Tata power contacted WII regarding this and have been provided maps of potential and priority GIB habitats in Gujarat and Rajasthan which require mitigation measures.

2.2.2. CONSERVATION BREEDING ACTIVITIES

WII GIB project team held meetings with MoEFCC, State Governments, national/international agencies/experts to initiate conservation breeding program. The tripartite MoA was signed between MoEFCC, Rajasthan Govt. and WII to implement the conservation breeding program and to delineate respective roles and responsibilities (June 2018). The WII in collaboration with International Scientists working on Bustards decided the criteria for selection of the area for the Conservation breeding facility. Fourteen possible sites were reviewed for different criteria and scored. Criteria like rainfall, accessibility, proximity to wild source, habitat and topographic suitability, land ownership, local support, local ecology, water facility, electricity, transportation, temperature, size and shape of site and local community support were all scored after making field visits. Sorsan was selected as the most potential site as it has higher humidity which will allow the birds to breed more frequently (unlike Jaisalmer where droughts are frequent when birds are unlikely to breed), has good road accessibility, a suitable flat grassland habitat in which GIB and Lesser Florican were both found till recent history, land ownership with the Forest Department (FD), local support of people, sufficient water supply and electricity and sufficient area for conservation breeding. Because of these criteria, the site was recommended by national and international scientists working on Bustards, and was later visited and finalized by the Additional Director General, MoEFCC, Chief Wildlife Warden, Rajasthan, Central Zoo Authority, Civil Construction Unit and WII scientists.

Permission to use ~2 sqkm land in Ramdevra, Jaisalmer was given by Rajasthan Forest Department to WII on 5th February 2019 for developing the Satellite incubation and chick-rearing facility. Subsequently, WII has released funds for fencing of the ~2 sqkm site to Rajasthan Forest Department Jaisalmer circle on 15th February 2019. Based on the construction estimate provided by CPWD Jaisalmer, WII has released funds of ~ 92 lakh INR to CPWD Jaisalmer on 4th March 2019, to commence construction of the Satellite Breeding Facility at Ramdevra. WII GIB Project team has subsequently developed, discussed and communicated the designs for the incubation, hatchery, chick-rearing and office facility construction. CPWD Jaisalmer has hired the contractor for this construction through tendering and is in the process of commencing the construction work. Rajasthan Forest Department has also granted permission to use Forest land at Sorsan for the construction of the Main Conservation Breeding Facility. Construction of this Facility will be taken up at a later stage after the completion of the Satellite Facility since wild-collected, captive-reared

birds will be transported to Sorsan that is not possible before the next (2020) breeding season (Please refer to Annexures 16-20),

WII is entering into a collaboration with International Fund for Houbara Conservation, who are the leading expert of bustard captive breeding in the world producing ~30,000 houbara chicks from a center every year. The involvement of IFHC as the technical collaborator will be critical in training the Project staff, handholding the project and providing critical inputs along the course of implementation. The Project investigators visited Abu Dhabi during 27 February – 2 March 2019 for discussing the terms of collaboration and the draft MoU was communicated to Rajasthan Government and MoEFCC for vetting. Following this meeting, a team of IFHC scientists visited Jaisalmer to inspect the *in-situ* areas for egg collection and *ex-situ* site at Ramdevra. Based on joint consultation between IFHC, WII and Rajasthan Forest Department, it was decided that a temporary facility be constructed at Sam, Desert National Park to collect and incubate the eggs from the current breeding season (2019) till the Satellite Facility at Ramdevra is completely constructed. Based on the design inputs provided by IFHC scientists (report attached herewith as Annexure 21), the temporary facility construction process has been initiated by Rajasthan Forest Department at Sam with a deadline for completing the construction by May 2019.

Further details on the above activities are given in section 2.3.

2.2.3 AWARENESS AND OUTREACH PROGRAMS

School awareness campaigns involving >1000 students of 5-12 standards from 16 schools in 12 settlements in priority GIB habitats in Jaisalmer have been carried out during Jan-Feb 2019.

Sensitization and skill development program has been carried out for nature guides in DNP (Feb 2019).

Sensitization of local public in the Desert Festival, Jaisalmer during 17-19 February 2019.

Sensitization workshop for media and power agencies on GIB conservation in New Delhi on 21.02.19 has been conducted, and such activities will continue throughout the year, to generate awareness among local communities and important stakeholders on GIB conservation.

Informal meetings with the Commanding Officer Pokhran Field Firing Range to sensitize Army and appraise them on various conservation activities and issues are ongoing.

2.3. RECENT IMPORTANT UPDATES OF THE GIB PROJECT

- With regard to the activities WII's GIB conservation project, permission to tag up to four GIB has been issued by the Chief Wildlife Warden (CWLW), Rajasthan to WII on 06.02.2019. A copy of communication dated 06.02.2019 is annexed herewith and marked as Annexure 11.

- Subsequently, two female GIB were tagged in DNP during March-April 2019 and their daily activities are being remotely monitored closely since the breeding season will commence. This activity is important to identify their fly paths for prioritizing areas for power line mitigation, develop conservation plans, and to track birds for identifying nests and sourcing eggs for the Conservation Breeding Center.
- The Director, WII through its communication dated 01.01.2019 has requested for grant of permissions for all project activities under the Tripartite memorandum of agreement signed between MoEFCC, WII and Rajasthan Forest Department. A copy of communication dated 01.01.2019 is annexed herewith and marked as Annexure 12.
- The DIG Forest (Wildlife), MoEFCC through its communication dated 17.01.2019, has requested the PCCF & CWLW, Government of Rajasthan to grant permission for collection Eggs/Chicks/Birds of GIB and Lesser Florican for conservation. A copy of communication dated 17.01.2019 is annexed herewith and marked as Annexure 13. Subsequently, permission for collection of six GIB eggs to implement the conservation breeding program has been issued by CWLW, Government of Rajasthan to WII on 03.05.2019. A copy of communication dated 03.05.2019 annexed herewith and is marked as Annexure 15.
- The Director, WII through its communication dated 29.04.2019 has requested for grant of permissions for conducting relevant studies on the species biology, behavior, reproduction, genetics, ecology and management in wild and captivity; collection of biological samples for understanding genetics, disease prevalence as well as develop disease prevention protocol, and forensic examination of mortalities; capture and translocate predators of GIB nest/chicks such as dogs, pigs, foxes, cats and mongooses within Forest Department enclosures in Thar and Sorsan to create a safe zone for breeding and improve GIB recruitment rate. A copy of communication dated 29.04.2019 is annexed herewith and marked as Annexure 14.
- A proposal to manage dog population across Thar Landscape (Jaisalmer) is being developed in collaboration with HSI by WII project team.
- Survey to assess the impact of power-lines on birds is being carried out by WII project team across GIB habitat in Kutch, Gujarat.
- Discussions with representatives from Khetolai village near Pokhran Field Firing Range to manage ~30 sq km agriculture land conducive for GIB conservation and develop a community conservation area model is in process.
- Permission for unrestricted access and right to develop and use >2 sq km land at Ramdevra, Jaisalmer for establishing Satellite Conservation Breeding Centre (egg collection and hatching facility) has been issued by CWLW, Government of Rajasthan to WII on 05.02.2019. A copy of communication dated 05.02.2019 is annexed herewith and marked as Annexure 16. Since this land is Ooran land, Forest Department has sought a resolution from the Gram Panchayat and the latter has granted approval on the use of the

land for conservation breeding purpose. Further to this permission, Rajasthan Forest Department has expressed willingness to construct predator-proof fence around the GIB Conservation Breeding Center, and has requested for the release of 65 lakh INR towards this activity vide its communication dated 13.02.2019. A copy of communication dated 13.02.2019 annexed herewith and is marked as Annexure 17. Immediately after receiving the said request, the fund to the tune of 65 Lakh INR has been released from WII on 15.02.2019. A copy of communication dated 15.02.2019 is annexed herewith and marked as Annexure 18. It is further submitted that the construction work of predator fencing has commenced and the Satellite Conservation Breeding Centre will commence soon. Project team are corresponding with CPWD Jaisalmer for commencing construction of the incubation, hatchery, chick rearing, veterinary and staff outpost facilities within the Satellite Site. Tendering for architect hiring to design the Facilities has commenced. The basic construction of the Satellite site to a functional state will take about six months. A temporary incubation and hatching centre is being set up in existing Rajasthan Forest Department land in Sam village DNP till the facility is constructed in Ramdeora.

- Order for reservation of 3.46 Ha land at Sorsan, Amalsara village, Baran District for establishing Main Conservation Breeding Centre has been issued by District Collector, Baran on 15.01.2019 in response to the request by Tahsildar, Anta Tehsil and Deputy Conservator of Forests, Baran. A copy of the communication dated 15.01.2019 is annexed herewith and marked as Annexure 19. Permission for use of 6.76 sq km land at Sorsan, Baran District for establishing Main Conservation Breeding Centre has been issued by PCCF & HoFF, Government of Rajasthan to WII on 06.03.2019. A copy of the order dated 06.03.2019 is annexed herewith and marked as Annexure 20.
- WII sent a team of scientists to formalize the collaboration and Memorandum of Understanding (MOU) with International Fund for Houbara Conservation (IFHC) at Abu Dhabi during 28/2/19 – 2/3/19, subsequent to which, IFHC team visited Jaisalmer during April- May 2019 to assist and train the project staff. IFHC is an organization of international repute specialized in Houbara bustard conservation breeding to assist and increase wild populations in its natural habitats across entire species range and is supported by the Government of Abu Dhabi. The MoU is being finalized and currently with the MoEFCC.
- WII has proposed staff training programme for the Conservation Breeding Centre and in this regard, has requested the State Forest Department to issue the annual budget (20-30 lakhs) to cover international travel for training of staff, as approved in the MoA between MoEFCC, Rajasthan Government and WII. A copy of communication dated 29.04.2019 is annexed herewith and marked as Annexure 14. Ex-situ project staff has been sent to IFHC Abu Dhabi for the initial training on incubation and chick-rearing techniques.
- Rajasthan Forest Department conducted a workshop on 22-23 January 2019 that involved WII Project team, other field specialists, managers, decision-makers and conservationists, to develop a detailed in-situ project document for landscape-scale GIB conservation, through working group discussions/deliberations. This project document is being prepared by WII Project team, a draft of which has been shared with the Rajasthan Forest Department.

3. FINANCIAL UPDATE

Till date, an amount of Rs. 9.95 crores has been spent to implement various *in-situ* and *ex-situ* activities proposed in the project out of Rs. 9.95 Crore released by MoEFCC in the first installment. The second installment of Rs. 7.73 crores has recently been sanctioned by MoEFCC and will be sufficient to cover the proposed activities in the coming year.

4. RECOMMENDATIONS

- 4.1. Keeping the above scientifically established threats in mind, the following evidenced based actions are recommended by WII that are required to be taken up in time bound manner to achieve the species recovery.
- 4.2. Mitigate all power transmission lines passing through priority bustard habitats identified by WII (Please refer Annexure 10) by undergrounding cables (where technically/technologically feasible) or installing bird diverters to make them prominent to birds. The priority areas where this intervention is required has been mapped by the Wildlife Institute of India and a technical-cum-financial proposal has been submitted to RVPNL for necessary approvals from Rajasthan Energy Department for mitigation. This action must be expeditiously implemented in the short-term (1-3 years), as power-line mortality is currently the biggest threat to the species.
- 4.3. Disallow new wind turbines, solar farms (photovoltaic power stations) from priority GIB habitats and remove existing ones that are in the critical areas. The priority areas where this intervention is required has been mapped by Wildlife Institute of India (Please refer Annexure 10). This action needs to be implemented in the long-term spanning 5-10 years from present.
- 4.4. Develop predator-proof enclosures of 5-10 sq km area in known breeding sites in and around DNP to improve GIB recruitment, and keep away nest predators by routinely translocating dogs, pigs, foxes, mongoose and other species outside the enclosures using professional trappers. Number of water guzzlers inside the enclosures need to be reduced to curtail availability of surface water that attracts non-native nest/chick predators such as dogs, foxes, pigs and mongooses. Also establish such enclosures in the larger Thar (Jaisalmer) landscape, as identified by joint surveys of WII and RFD. These enclosures need to be developed and will serve as breeding sites and stepping stones for movement across the larger landscape.
- 4.5. Create an inviolate area of 200 sq km (WII proposal- 500 sq km) in northern DNP as a National Park through voluntary and incentivized relocation of local people (if needed) with the mandate of conserving GIB.
- 4.6. Delineate priority GIB habitats outside DNP as Eco Sensitive Zones where agro-pastoral practices are regulated to low-intensity through Zonal Management Plans and detrimental

infrastructure such as wind turbines and overhead transmission lines are curtailed. This action needs to be implemented in the short-term (1–2 years).

- 4.7. Engage with local communities to promote bustard-friendly practices such as stall-feeding of livestock during monsoon – GIB chick-rearing and grass growing season – and cultivating food crops preferred by GIB during monsoon such as gram, ground nut and millets while leaving the fields fallow for the remaining period. These land-uses can be promoted by Rajasthan Forest Department in conjunction with other State Departments, through appropriate financial and other incentive schemes, such as provisioning of fodder for stall feeding or compensatory payments to foregone production cost by opting for low-intensity farming. This action needs to be implemented in the longer scale (4–8 years).
- 4.8. Reduce poaching of GIB and other wildlife in the Thar landscape by improving protection enforcement through training of Forest Department frontline staff in smart patrolling tools with the help of conservation organizations such as WII and WWF, provisioning of better patrolling equipment, enrolling frontline staff from non-wildlife divisions of Forest Department and local volunteers in this activity, and ensuring trials of convicts. Further, it is to bring to the notice that areas controlled by Armed forces in Jaisalmer District harbor about 50% of the GIB population found in Rajasthan. This secure zone under the control of Army where human activities are minimal is a blessing for the bird on the verge of extinction. Thus, continued cooperation of Army, Air Force and Border Security Force to conserve the GIB and control the incidents of poaching could play a vital role as well.
- 4.9. Implement the conservation breeding programme by creating an offshore insurance population (if needed) by shipping a batch of about 10 GIB eggs to a state-of-the-art international breeding center such as IFHC houbara breeding center at Abu Dhabi that produces up to 30,000 houbara chicks every year (short-term solution 3–5 years), and meanwhile, establish a national breeding center by training staff, developing a state-of-the-art center at Sorsan (main facility) and Ramdevra (satellite facility), where eggs collected from wild can be artificially incubated, hatched, reared and captive bred to create an insurance population that can be reintroduced into the wild.
- 4.10. To continue with targeted research on GIB to characterize threats spatio-temporally, understand landscape use patterns using satellite telemetry, and objective monitoring of their population status by involving research organizations, understanding of species biology, behavior, reproduction, genetics, ecology and management in wild and captivity of GIB, and collection of biological samples for species identification from carcasses, for disease screening for better understanding of threats, develop disease prevention protocol, and forensic examination of mortalities.

It is thus submitted that the key to conserve GIB is a vital balance and combination of stringent protection measures, scientific habitat management, GIB friendly land use planning, and providing basic amenities as well as livelihood options to local people in priority conservation areas.

5. Annexures

Annexure 1. WII-Habitat improvement and Conservation Breeding of the Great Indian Bustard- An integrated approach, Annual Progress Report II (2017-18)

Annexure 2. Collar et al. 2017. Averting the extinction of bustards in Asia

Annexure 3. Status assessment of Great Indian Bustard, associated fauna and habitat of Thar – 2016 survey report

Annexure 4. Dutta, Rahmani and Jhala 2010. Running out of time? The Great Indian Bustard *Ardeotis nigriceps*- status, viability, and conservation strategies

Annexure 5a. PhD thesis on Ecology and conservation of Great Indian Bustard by 'Sutirtha Dutta

Annexure 5b. Dutta and Jhala 2014. A Planning agriculture based in land use responses of threatened semiarid grassland species in India

Annexure 6. Bustards, wires and flight to extinction. Conservation India. January 2018

Annexure 7. Dutta et al. 2013. Guidelines for preparation of state action plan for resident bustards' recovery programme

Annexure 8. Demi Letters issued by MoEFCC to Secretary, Rajasthan and Ministry of Power and Renewable Energy. dt. 07.01.2019

Annexure 9. Circular issued by Secretary, Ministry of Power and Renewable Energy to Power agencies. dt. 22.02.2019

Annexure 10a. Power line mitigation to conserve bustards. WII Report

Annexure 10b. Action and budget proposal- Mitigation plan for high-tension power lines in Great Indian Bustard habitat of Thar Desert, Jaisalmer. January 2019

Annexure 11. Permission for radio tagging Great Indian Bustard from CWLW, Rajasthan. dt. 06.02.2019

Annexure 12. Permissions to conduct project activities as approved under the MoA for GIB conservation. dt. 01.01.2019

Annexure 13. Letter of permission for collection of eggs/ chicks/ birds of GIB & Lesser Florican from DIG (Wildlife), MoEFCC. dt. 17.01.2019

Annexure 14. Pending issues for undertaking GIB & LF conservation. dt. 30.04.2019

Annexure 15. Permission to collect GIB eggs for Conservation breeding programme from CWLW, Rajasthan. dt. 03.05.2019

Annexure 16a. Fund request for construction of predator proof fence around GIB CBC Ramdeora by CWLW, Rajasthan. dt. 13.02.2019

Annexure 16b. 16b. Fund release by WII to CPWD Jaisalmer

Annexure 17. Fund transfer to CWLW, Rajasthan for construction of predator proof fence around GIB CBC Ramdeora. dt.15.02.2019

Annexure 18. Grant of permission to WII at Ramdeora for CBC by CWLW, Rajasthan. dt. 05.02.2019

Annexure 19. Reservation of non-forest land for Sorsan CBC by District Collector Baran. dt.15.01.2019

Annexure 20. Sorsan forest land allotment for CBC by PCCF & HoFF, Rajasthan. dt. 06.03.2019

Annexure 21. IFHC mission report

**BEFORE THE NATIONAL GREEN TRIBUNAL
PRINCIPAL BENCH, NEW DELHI**

Original Application No. 385/2019

(With report dated 11.07.2019)

Centre for Wildlife and Environment Litigation

Applicant(s)

Versus

Union of India & Ors.

Respondent(s)

Date of hearing: 04.09.2019

CORAM:

**HON'BLE MR. JUSTICE ADARSH KUMAR GOEL, CHAIRPERSON
HON'BLE MR. JUSTICE S.P. WANGDI, JUDICIAL MEMBER
HON'BLE DR. NAGIN NANDA, EXPERT MEMBER**

For Applicant(s):

Mr. Gaurav Kumar Bansal, Advocate

For Respondent(s):

Mr. Attin Shankar Rastogi and Mr. Prateek
Yadav, Advocates for MoEF & WII

ORDER

1. The issue for consideration is the mitigation measures for protection of Great Indian Bustard (GIB) – rarest bird, critically endangered species as per Schedule-I to the Wildlife Protection Act, 1972. Though the Ministry of Environment, Forest and Climate Change (MoEF&CC) has taken up a project called “Habitat Improvement of Great Indian Bustard-An Integrated Approach”, wind projects are potential danger to the safety of the bird. Vide order dated 04.04.2019, this Tribunal sought a factual report from the MoEF&CC with regard to the allegation that steps taken are not adequate and there continues to be high mortality of the birds.

2. As per report dated 11.07.2019, the MoEF&CC has acknowledged the problem that adult mortality is still very high due to collisions with power-lines that crisscross their fly paths. The Wildlife Institute of India has made following recommendations:

“4. RECOMMENDATIONS:

4.1. *Keeping the above scientifically established threats in mind, the following evidenced based actions are recommended by WII that are required to be taken up in time bound manner to achieve the species recovery.*

4.2. *Mitigate all power transmission lines passing through priority bustard habitats identified by WII (Please refer Annexure 10) by undergrounding cables (where technically/ technologically feasible) or installing bird diverters to make them prominent to birds. The priority areas where this intervention is required has been mapped by the Wildlife Institute of India and a technical-cum-financial proposal has been submitted to RVPNL for necessary approvals from Rajasthan Energy Department for mitigation. This action must be expeditiously implemented in the short-term (1-3 years), as power-line mortality is currently the biggest threat to the species.*

4.3. *Disallow new wind turbines, solar farms (photovoltaic power stations) from priority GIB habitats and remove existing ones that are in the critical areas. The priority areas where this intervention is required has been mapped by Wildlife Institute of India (Please refer Annexure 10). This action needs to be implemented in the long-term spanning 5-10 years from present.*

4.4. *Develop predator-proof enclosures of 5-10 sq km area in known breeding sites in and around DNP to improve GIB recruitment, and keep away nest predators by routinely translocating dogs, pigs, foxes, mongoose and other species outside the enclosures using professional trappers. Number of water guzzlers inside the enclosures need to be reduced to curtail availability of surface water that attracts non-native nest/chick predators such as dogs, foxes, pigs and mongooses. Also establish such enclosures in the larger Thar (Jaisalmer) landscape, as identified by joint surveys of WII and RFD. These enclosures need to be developed and will serve as breeding sites and stepping stones for movement across the larger landscape.*

4.5. *Create an inviolate area of 200 sq km (WII proposal- 500 sq km) in northern DNP as a National Park through voluntary and incentivized relocation of local people (if needed) with the mandate of conserving GIB.*

4.6. *Delineate priority GIB habitats outside DNP as Eco Sensitive Zones where agro-pastoral practices are regulated to low-intensity through Zonal Management Plans and detrimental infrastructure such as wind turbines and overhead transmission lines are curtailed. This action needs to be implemented in the short-term (1–2 years).*

4.7. *Engage with local communities to promote bustard-friendly practices such as stall-feeding of livestock during monsoon – GIB chick-rearing and grass growing season – and cultivating food crops preferred by GIB during monsoon such as gram,*

ground nut and millets while leaving the fields fallow for the remaining period. These land-uses can be promoted by Rajasthan Forest Department in conjunction with other State Departments, through appropriate financial and other incentive schemes, such as provisioning of fodder for stall feeding or compensatory payments to foregone production cost by opting for low intensity farming. This action needs to be implemented in the longer scale (4–8 years).

4.8. Reduce poaching of GIB and other wildlife in the Thar landscape by improving protection enforcement through training of Forest Department frontline staff in smart patrolling tools with the help of conservation organizations such as WII and WWF, provisioning of better patrolling equipment, enrolling frontline staff from non-wildlife divisions of Forest Department and local volunteers in this activity, and ensuring trials of convicts. Further, it is to bring to the notice that areas controlled by Armed forces in Jaisalmer District harbor about 50% of the GIB population found in Rajasthan. This secure zone under the control of Army where human activities are minimal is a blessing for the bird on the verge of extinction. Thus, continued cooperation of Army, Air Force and Border Security Force to conserve the GIB and control the incidents of poaching could play a vital role as well.

4.9. Implement the conservation breeding programme by creating an offshore insurance population (if needed) by shipping a batch of about 10 GIB eggs to a state-of-the-art international breeding center such as IFHC houbara breeding center at Abu

Dhabi that produces up to 30,000 houbara chicks every year (short-term solution 3–5 years), and meanwhile, establish a national breeding center by training staff, developing a state-of the art center at Sorsan (main facility) and Ramdevra (satellite facility), where eggs collected from wild can be artificially incubated, hatched, reared and captive bred to create an insurance population that can be reintroduced into the wild.

4.10. To continue with targeted research on GIB to characterize threats spatio-temporally, understand landscape use patterns using satellite telemetry, and objective monitoring of their population status by involving research organizations, understanding of species biology, behavior, reproduction, genetics, ecology and management in wild and captivity of GIB, and collection of biological samples for species identification from carcasses, for disease screening for better understanding of threats, develop disease prevention protocol, and forensic examination of mortalities.”

3. The above recommendations need to be acted upon which requires preparation of a time bound action plan.
4. Let a joint Committee comprising Director General, Forest, MoEF&CC, Additional Director General, Forest (Wildlife), MoEF&CC, nominees of Ministry of Power, Ministry of New and Renewable Energy, Central Government and nominees of Energy Departments of Gujarat and Rajasthan prepare a time bound action plan in the matter within two months. The nodal agency for the purpose will be

the Director General, Forest, MoEF&CC and the Additional Director General, Forest (Wildlife), MoEF&CC will be member secretary of the nodal agency. Compliance report be furnished to this Tribunal before the next date by e-mail at judicial-ngt@gov.in.

A copy of this order be sent to the Director General, Forest, MoEF&CC, Additional General, Forest (Wildlife), MoEF&CC, nominees of Ministry of Power and Ministry of New and Renewable Energy, Government of India and nominees of Energy Departments of Gujarat and Rajasthan by e-mail for compliance.

The applicant may furnish a complete set of papers to the Director General, Forest, MoEF&CC, Additional Director General, Forest (Wildlife), MoEF&CC, nominees of Ministry of Power and Ministry of New and Renewable Energy, Government of India and nominees of Energy Departments of Gujarat and Rajasthan and file an affidavit of service within one week.

List for further consideration on 13.12.2019.

Adarsh Kumar Goel, CP

S.P. Wangdi, JM

Dr. Nagin Nanda, EM

September 04, 2019
Original Application No. 385/2019
DV

THROUGH SPEED POST / Dasti

MATTER FOR: 16.08.2019

SECTION PIL(WRIT)

IN THE SUPREME COURT OF INDIA
CIVIL ORIGINAL JURISDICTION

WRIT PETITION (CIVIL) NO. 838 OF 2019

(Under Article 32 of the Constitution of India)

WITH

L.A. No. 95438/2019- APPLICATION FOR CLARIFICATION/DIRECTION

M.K. Ranjitsinh & Ors.

Urgent
D.Y. V. Dole

Versus

Union of India and Ors.

Petitioner

... Respondents

To,

1. Union of India,
Through the Secretary,
Ministry of Environment,
Forest and Climate Change,
Having its address at Paryavaran Bhavan,
Jor Bagh Road,
New Delhi - 110003.

PID: 203890/2019/(SEC PIL-W)
W.P.(C) 838 of 2019

2. Union of India,
Through the Secretary, Ministry of Defence,
Having its address at Room No. 234,
South Block, Ministry of Defence,
New Delhi - 110011.

PID: 203891/2019/(SEC PIL-W)
W.P.(C) 838 of 2019

3. Union of India,
Through the Secretary, Ministry of Power,
Having its address at 4th Floor
Shram Shakti Bhavan, Rafi Marg,
New Delhi - 110001.

PID: 203892/2019(SEC PIL-W)
W.P.(C) 838 of 2019

4. Union of India,
Through the Secretary,
Ministry of New and Renewable Energy,
Having its address at Block-14
CGO Complex, Lodhi Road,
New Delhi - 110003.

PID: 203893/2019(SEC PIL-W)
W.P.(C) 838 of 2019

5. State of Rajasthan,
Through the Principal Chief Conservator of
Forests, Environment Department,
Having its address at Secretariat,
Jaipur, Rajasthan - 302004.

PID: 203894/2019(SEC PIL-W)

W.P.(C) 838 of 2019

6. State of Rajasthan,
Through the Chief Wild Life Warden,
Environment Department,
Having its address at Secretariat,
Jaipur, Rajasthan - 302004.

PID: 203895/2019(SEC PIL-W)
W.P.(C) 838 of 2019

OWII OFFICE	NO. 1799
DATE 29/7/19	

SYNOPSIS

The present writ petition under Article 32 of the Constitution of India is being filed in public interest to seek urgent directions to save two species that are on the brink of extinction, the Great Indian Bustard and the Lesser Florican. As of 2019, there are only, at most, 100-150 Great Indian Bustards, and around 700 Lesser Floricans left in the world, the majority of which live in India.

The Great Indian Bustard (*Ardeotis nigriceps*) is a critically endangered bird that was historically found throughout North, West and South India. The bird is now found only in Rajasthan with smaller numbers in Gujarat, Karnataka, Maharashtra and Andhra Pradesh. It is the state bird of Rajasthan. Over the last 50 years the population of the Great Indian Bustard has recorded a decline of over 82%, falling from an estimated 1260 Great Indian Bustards in 1969, to 100-150 in 2018.

The Lesser Florican (*Sypheotides indicus*) is an endangered bird, which is also endemic to the Indian subcontinent. The major population of the species is found in Gujarat and Rajasthan, with smaller numbers found in Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and potentially, Telangana. The population of the Lesser Florican has seen a sharp decline of 80% over the past three decades, from 3530 individuals recorded in 1999, to around 700 individuals, in 2018.

Despite being accorded the highest level of protection under national law under Part III of Schedule I of the Wild Life (Protection) Act, 1972, the two species continue to face the threat of extinction as a result of the actions and/or inactions of the Respondents. The State is duty bound to take all necessary measures to protect all species from extinction. Article 48A of the Constitution places a responsibility on the State "to endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country." Article 51A places a concomitant constitutional duty on citizens to protect and improve the natural environment, including wildlife.

The survival of these birds is threatened by: (i) collision with infrastructure, particularly powerlines and wind turbines in their flightpath; (ii) denudation of their habitat due to depletion of grasslands, classified as "wastelands", diverted for intensive agriculture, grazing, and other development; (iii) hunting; (iv) development of mines, saltpans and human habitation in and around their habitats; (v) ingestion of pesticides through the food chain threatening breeding capacity and survival in general due to depletion of main sources of food such as insects; (vi) predators, such as dogs and wild animals, attacking their young and eggs, and (vii) grazing livestock trampling of young and eggs.

D

This petition seeks the formulation and implementation of an Emergency Response Plan that incorporates adequate *in situ* and *ex situ* conservation measures to be implemented over the short term, in light of the upcoming breeding season. It further seeks conservation measures to be implemented over the long term to ensure the continuing survival of these birds. These measures are essential to recover, protect, and preserve these two endangered endemic species.

Unless the reliefs sought here are granted, it is almost certain that the Great Indian Bustard and the Lesser Florican will be lost to history forever, which would be an irreparable blow to the Constitutional conscience.

Allowing the extinction of two major species on "our watch" would be a blot on the discharge of citizens' duties by the present generation of Indians and a stain on the environmental record of this Court.

ITEM NO.12

COURT NO.2

SECTION PIL-W

S U P R E M E C O U R T O F I N D I A
RECORD OF PROCEEDINGS

Writ Petition (Civil) No.838/2019

M.K. RANJITSINH & ORS.

Petitioner(s)

VERSUS

UNION OF INDIA & ORS.

Respondent(s)

(FOR ADMISSION and I.R. and IA No.95435/2019-EXEMPTION FROM FILING
O.T. and IA No.95438/2019-CLARIFICATION/DIRECTION)

Date : 15-07-2019 This petition was called on for hearing today.

CORAM :

HON'BLE MR. JUSTICE S.A. BOBDE
HON'BLE MR. JUSTICE B.R. GAVAI

For Petitioner(s) Mr. Shyam Divan, Sr. Adv.
Ms. Sonia Dube, Adv.
Mr. S. Chakraborty, Adv.
Ms. Sugandha Yadav, Adv.
Ms. Ria Sawhney, Adv.
Ms. Surbhi Anand, Adv.
For M/s Legal Options, AOR

For Respondent(s)

UPON hearing the counsel the Court made the following
O R D E R

Issue notice on the instant writ petition as also on the
prayer for interim relief, returnable four weeks.

Dasti, in addition, is also permitted.

In the meantime, we consider it appropriate to appoint a
Committee comprising the following members/society for the
purpose of this petition :

- (1) Director, Bombay Natural History Society,
Hornbill House, Mumbai.
- (2) Dr. Asad R. Rahmani, former Director of
Bombay Natural History Society and Member of the

Governing Body of Wetlands International South Asia.

(3) Dr. Dhananjai Mohan, Chief Conservator of Forests, Wildlife Admn. Protection & Intelligence, Nainital, Uttarakhand.

The Registry is directed to furnish the copies of this writ petition to the aforesaid members of above Court appointed Committee forthwith.

(SANJAY KUMAR-II)
COURT MASTER (SH)

(INDU KUMARI POKHRIYAL)
ASSISTANT REGISTRAR

DRAFT
STATUS OF THE PROGRESS OF THE GREAT INDIAN BUSTARD
CONSERVATION BREEDING PROGRAM

INTRODUCTION

1. To conserve the critically endangered Great Indian Bustard, Wildlife Institute of India (WII), an autonomous organization under the Ministry of Environment, Forest and Climate Change (MoEFCC), launched the project “Habitat Improvement and Conservation Breeding of Great Indian Bustard: An Integrated Approach” during March 2016 in collaboration with MoEFCC, State Forest Departments and NGO partners, with financial support from National Compensatory Afforestation Fund Management and Planning Authority (CAMPA) Funds, and a sum of Rs. 9.95 crores was released for the project implementation, and a commitment of 33.85 crore INR. A national launch workshop was organized at WII, Dehradun on 16 May 2016 to appraise partner agencies on the proposed activity plans under the Project.

A) This Project has *an in-situ* component including

A.1. Applied research that aims at: -

- Prioritizing conservation areas for GIB and the endangered Lesser Florican (LF)
- Characterizing threats to these species
- Monitoring bustard populations and habitats
- Understanding population genetics to inform conservation management

A.2. Pilot habitat management to demonstrate best practices of managing GIB habitats including: -

- Pilot mitigation of critical threats
- Breeding enclosure management
- Strategizing land acquisition for conservation

A.3. Capacity-building and awareness that aims at

- Improving protection and enforcement
- Sensitizing stakeholders on bustard conservation
- Raising public awareness on bustard conservation
- Incentivizing local land-users to adopt bustard-friendly land-uses

B) The Project has an *ex-situ* component that aims at developing a Conservation breeding program for the Great Indian Bustard as an insurance against extinction and potential reintroduction.

2. As directed by the Hon'ble Supreme Court regarding the conservation of the Great Indian Bustard, this report on status of the progress of the Great Indian Bustard breeding centers at Jaisalmer and Sorsan carried out by Wildlife Institute of India (WII) is submitted on behalf of the Ministry of Environment, Forest and Climate Change (MoEFCC).
- The Director, WII through its communication dated 01.01.2019 has requested for grant of permissions for all project activities under the Tripartite memorandum of agreement signed between MoEFCC, WII and Rajasthan Forest Department. A copy of communication dated 01.01.2019 is annexed herewith and marked as Annexure 1.
 - The DIG Forest (Wildlife), MoEFCC through its communication dated 17.01.2019, has requested the PCCF & CWLW, Government of Rajasthan to grant permission for collection Eggs/Chicks/Birds of GIB and Lesser Florican for conservation. A copy of communication dated 17.01.2019 is annexed herewith and marked as Annexure 2.
 - Permission for collection of six GIB eggs to implement the conservation breeding program has been issued by CWLW, Government of Rajasthan to WII on 03.05.2019. A copy of communication dated 03.05.2019 annexed herewith and is marked as Annexure 3.
 - Permission for unrestricted access and right to develop and use >2 sq km land at Ramdevra, Jaisalmer for establishing Satellite Conservation Breeding Centre (egg collection and hatching facility) has been issued by CWLW, Government of Rajasthan to WII on 05.02.2019. A copy of communication dated 05.02.2019 is annexed herewith and marked as Annexure 4.
 - Since this land is Ooran land, Forest Department has sought a resolution from the Gram Panchayat and the latter has granted approval on the use of the land for conservation breeding purpose. Further to this permission, Rajasthan Forest Department has expressed willingness to construct predator-proof fence around the GIB Conservation Breeding Center, and has requested for the release of 65 lakh INR towards this activity vide its communication dated

13.02.2019. A copy of communication dated 13.02.2019 annexed herewith and is marked as Annexure 5.

- Immediately after receiving the said request, the fund to the tune of 65 Lakh INR has been released from WII on 15.02.2019. A copy of communication dated 15.02.2019 is annexed herewith and marked as Annexure 6. It is further submitted that the construction work of predator fencing has commenced and the construction of the incubation, hatchery, chick rearing is ongoing. The basic construction of the Satellite site to a functional state will take about six months.
- A pilot conservation breeding centre has been set up in existing Rajasthan Forest Department land in Sam village DNP to avail the current breeding season and is currently operational.
- Order for reservation of 3.46 Ha land at Sorsan, Amalsara village, Baran District for establishing Main Conservation Breeding Centre has been issued by District Collector, Baran on 15.01.2019 in response to the request by Tahsildar, Anta Tehsil and Deputy Conservator of Forests, Baran. A copy of the communication dated 15.01.2019 is annexed herewith and marked as Annexure 7.
- Permission for use of 6.76 sq km land at Sorsan, Baran District for establishing Main Conservation Breeding Centre has been issued by PCCF & HoFF, Government of Rajasthan to WII on 06.03.2019. A copy of the order dated 06.03.2019 is annexed herewith and marked as Annexure 8.
- WII sent a team of scientists to formalize the collaboration and Memorandum of Understanding (MOU) with International Fund for Houbara Conservation (IFHC) at Abu Dhabi during 28/2/19 – 2/3/19, subsequent to which, IFHC team visited Jaisalmer during April- May 2019 to assist and train the project staff. IFHC is an organization of international repute specialized in Houbara bustard conservation breeding to assist and increase wild populations in its natural habitats across entire species range and is supported by the Government of Abu Dhabi. The MoU is being finalized and currently with the MoEFCC.

- WII has proposed staff training programme for the Conservation Breeding Centre and in this regard, has requested the State Forest Department to issue the annual budget (20-30 lakhs) to cover international travel for training of staff, as approved in the MoA between MoEFCC, Rajasthan Government and WII. A copy of communication dated 29.04.2019 is annexed herewith and marked as Annexure 9.
- WII and Forest Department staff were sent to IFHC, Abu Dhabi for training in veterinary care and husbandry for a period of one month during May 2019.
- Permission for collection of 10 GIB eggs to implement the conservation breeding program has been issued by CWLW, Government of Rajasthan to WII.
- Eight GIB chicks have been artificially incubated and hatched at Conservation Breeding Centre at Sam Village from eggs collected in DNP, Jaisalmer by WII during June- August 2019 and are being hand reared with technical support of IFHC/Reneco Scientists.

EMERGENCY RESPONSE PLAN

- a) Urgent installation of diverters on powerlines in semi-critical habitats within a period of three months;
- b) Immediate embargo to be imposed on sanction of new projects, renewal of lease or expansion of area/capacity of any existing installed wind, solar, power projects in and around critical and semi-critical habitats
- c) Urgent direction to dismantle powerlines, wind turbines and solar panels in and around critical habitats, and to take underground existing powerlines within a period of six months;
- d) Installation of predator-proof enclosures/fencing of current breeding areas within critical habitats, within a period of six months, as per the design prescribed by Wildlife Institute of India.

Permission has been granted by the Chief Wildlife Warden, Rajasthan to capture and translocate predators of GIB nest/chicks such as dogs, pigs, foxes, cats and mongooses within Forest Department enclosures in Thar and Sorsan to create a safe zone for breeding and improve GIB recruitment rate. This task will be initiated from September 2019 after the current breeding season is over, as intensive trapping exercise can disturb nesting females. Furthermore, Rajasthan Forest Department has submitted a proposal to the State government for installing and maintenance of predator-proof fencing in GIB breeding areas.

- e) Immediate implementation of dog population control program, including sterilization, in and around critical and semi-critical habitat within a period of three months

The first phase of dog spay neutering has been completed by WII in collaboration with Humane Society International, in/around GIB habitat in DNP, resulting in sterilization of ~800 free-ranging dogs. A proposal to manage dog population across Thar Landscape (Jaisalmer) is being developed in collaboration with Humane Society International and with The Corbett Foundation in Kutch by WII project team. The sterilization program will commence from November 2019.

f) Provision of strict no-grazing zones and restricted grazing zones be declared in critical and semi-critical habitats within a period of six months

The proposed Eco Sensitive Zone/ GIB arc, and land use/cover map of Thar developed by Wildlife Institute of India and Rajasthan Forest Department will be used to identify areas for implementation of livestock grazing management with support from local community.

Discussions are in progress with representatives from Khetolai village near Pokhran Field Firing Range to manage ~30 sq km agriculture land conducive for GIB conservation on a pilot basis.

For other bustard range states, areas will be identified based on the information obtained from State Forest Departments and suggested by Wildlife Institute of India.

g) Prohibit use of insecticides and pesticides within a radius of 5 kilometers of critical within a period of three months

h) Prohibit encroachment of grasslands and *gauchar* areas in and around critical and semi-critical habitats, and their afforestation or diversion to other usages

FINAL REPORT

DOG STERILIZATION PROJECT IN GIB (Great Indian Bustard) HABITAT AREA, SAM VILLAGE, THAR, RAJASTHAN



BACKGROUND:

Humane Society International-India (HSI-India) on invitation from the Wild Life Institute of India (WII) conducted a preliminary street dog population survey around the western region of the Great Indian Bustard (GIB) habitat of Thar, Rajasthan in November-2015. The survey was done to determine “Detectability” of roaming dogs in the very unique situation like desert villages and we found that it is quite high (0.61) compared to normal city environment (0.44 for city), and based on the findings a simpler count data was collected by WII to estimate roaming dog population and with those data it has been estimated that there are total 900 dogs in 20 villages, which are close to known breeding locations of the Critically Endangered GIB.

During the non-tourist period (April-September) the street dogs in this belt are left with very minimal food sources and they start hunting the GIB eggs from the Desert.

GOAL:

- The main goal of this program is to reduce the dog density in this area. The controlled population of dog will have enough food sources to survive and that will improve the chances of survival of GIB.
- Sterilization of maximum number of dogs in the villages situated inside DNP (Desert National Park) rather than catching the dogs at random places.
- After doing all inside DNP villages, cover the other villages/Kasba/Dhani which are located on outside border of DNP as in this project, sterilization number were not important but sterilization in specific area was the key to get right impact.
- Deployed team must try to get support from local communities to support the catching as of from very first day since catching was a very challenging job in this project where the team was going to catch the dogs in wide open area.

OUTCOMES AND OUTPUTS:

Team deployed from Vadodara Dog Management Program consists of one vet (Dr. Sanjay Ahir) and four AWOs (Satish, Harshad, Ravi, Ashok). Team was equipped one mobile OT van (force traveler) and one catching vehicle (Bolero).

Team travelled to Sam, Thar, Rajasthan on 18th September 2019. HSI team met WII team on 19th and started their planning to commence work. In order to start dog sterilization work, team had to get permission from DFO Jaisalmer. We traveled to Jaisalmer on 20th September and met DFO where he asked us to submit a work proposal. He told WII to come back on 25th September with the proposal.

On other hand, HSI team were continuously looking for the place where they could set up post op facility. Team had seen 2-3 places for the same and chose one ideal place where they could set up post op facility. With the help of WII team, they cleaned the whole facility on 23rd September. Unfortunately WII could not manage to get that facility for next 2-3 months. And team started looking around for another place.



*Cleaning work by HSI and WII team members.

On 21st September early morning team has visited 5 villages (Neemba, sudasna, Berna, Sipla and Bhilo ki dhaani) near Sam to get an idea about dog population, dog behavior in particular area and community reaction.



*HSII team visit to villages near DNP to get an idea about dogs' behavior and population before they start catching.



*HSII AWO in field.

On 25th September, Dr. Sanjay Ahir and WII team (Dr. Tushna, Sourav and Hrishikesh) visited Jaisalmer again to submit the work proposal as well as to attend the meeting with DFO and Range Forest Officers. HSI and WII got the permission to start ABC work. DFO ensured all kind of help from forest department to the program.

On 26th September WII got one more place which consisted of three rooms. HSI team decided to not delay any more and both teams cleaned the whole place and fixed all issues related to electricity and water supply on same day. Next day, the place was fenced around the building with help of forest dept. which was necessary to prevent dog escape.



*The place which was going to be post op facility.



*Fencing around post op facility.



*Early morning dog catching: net as well as hand catching.

On 27th September team had done their first catching and caught 10 dogs.

During project tenure, team had two breaks- one (7th to 13th October) HSII retreat and other one for Diwali Break (4th November to 18th November). Team was continuously catching the dogs inside DNP boundary till November 4th and sterilized 266 dogs near GIB enclosure. After Diwali break, team had started their work outside but very close to DNP boundary.

On December 18th, Thar team got a new catching vehicle which had more dogs holding capacity. One vet and three AWOs were also added in the current team for speeding up and easing the task.



*Hand catching.

One interesting thing team had noticed during the project in dog's behavior was that dogs hardly fought for territory, locals would say that there is almost no territory for dogs. Dogs were roaming up to 10 Kms in search of food and probable reason was that the local communities are generally dog haters and large part of the local population don't believe in giving food to dogs.

Sterilization Numbers:

Catching Area and Sterilization Number Summary (September):

In September month team sterilized 30 dogs (17 Male, 13 female).

Date	Catch	Village
27/09/18	10	Sam
28/09/18	11	Neemba
29/09/18	11	Neemba
30/09/18	11	Neemba
	43	

In October month team sterilized 216 dogs (110 Male, 106 Female).

Date	Catch	Village
01/10/18	10	Nimba
02/10/18	12	3 Nimba, 9 Bhilo ki dhani
03/10/18	11	Kumbhar kotha
04/10/18	11	Kumbhar kotha
05/10/18	No catching (HSII retreat)	
06/10/18	No catching (HSII retreat)	
07/10/18	No catching (HSII retreat)	
08/10/18	No catching (HSII retreat)	
09/10/18	No catching (HSII retreat)	
10/10/18	No catching (HSII retreat)	
11/10/18	No catching (HSII retreat)	
12/10/18	No catching (HSII retreat)	
13/10/18	11	Kumbhar kotha
14/10/18	11	Kumbhar kotha
15/10/18	11	7 Kumbhar kotha , 4 Sam
16/10/18	11	2Jamda 9 Sipla
17/10/18	12	Sipla
18/10/18	12	Sipla
19/10/18	12	Sipla
20/10/18	12	Sipla
21/10/18	Suaday	

22/10/18	11	Sipla
23/10/18	8	6 Sipla, 2Sam
24/10/18	11	Berna
25/10/18	10	Berna
26/10/18	09	Berna
27/10/18	14	1 Berna,3 Sam,10 Beda
28/10/18	Sunday	
29/10/18	11	7 Beda 4 Nimba
30/10/18	10	4 Beda 6 Sam
31/10/18	10	Sam
	230	

In November month team sterilized 122 dogs (85 Male, 37 Female).

Date	Catch	Village
01/11/18	10	Sam
02/11/18	Only Surgery	
03/11/18	Only Release	
04/11/18	Diwali break start	
18/11/18	Diwali break end	
19/11/18	9	Sam
20/11/18	12	Sam
21/11/18	10	6 Kanoi, Sam sand dunes
22/11/18	12	Kanoi
23/11/18	11	Kanoi
24/11/18	11	Kanoi
25/11/18	Sunday	
26/11/18	10	Kanoi
27/11/18	12	Kanoi
28/11/18	9	8 Kanoi, 1 Sam sand dunes
29/11/18	11	Salka
30/11/18	11	Salka
	127	

In December 2018 team sterilized 352 dogs (Male 207, Female 145).

Date	Catch	Village
01/12/18	10	Salka
02/12/18	Sunday	
03/12/18	08	6 salka, 2 Kanoi
04/12/18	12	3 Bhilo ki Dhani, 9 Keshwo ki basti
05/12/18	11	Salka
06/12/18	10	1 Bhilo ki dhani, 1 Keshwo ki basti, 9 Sam
07/12/18	Election day off	
08/12/18	10	3 Keshwo ki basti, 8 Sam
09/12/18	Sunday	
10/12/18	9	1 Haidar dhani, 4 Shinghalo ki basti, 1 Keshwo ki basti, 1 Kanoi, 2 Sam sand dunes
11/12/18	10	Sam sand dunes
12/12/18	8	6 Sam sand dunes, 1 DNP chowki, 1 Army camp
13/12/18	10	2 Ganga, 6 Nimba, 2 Sam
14/12/18	11	5 Sam sand dunes, 6 Kanoi
15/12/18	13	Meghwalo ki Dhani
16/12/18	Sunday	2Jamda 9 Sipla
17/12/18	12	Kanoi
18/12/18	25	Sam
19/12/18	22	4 Kanoi, 18 Khabha
20/12/18	20	Dhuliya
21/12/18	25	6 Khabha, 14 Dhuliya
22/12/18	20	20 Dhuliya
23/12/18	Sunday	
24/12/18	21	8 Khabha, 13 Khuri
25/12/18	Christmas off	
26/12/18	23	23 Khuri
27/12/18	22	22 Khuri
28/12/18	19	19 Khuri
29/12/18	26	25 Khuri 1 Sam
30/12/18	15	15 Khuri
31/12/18	Day off	
	372	

In January 2019 team sterilized 81 dogs (Male 35, Female 46)

Date	Catch	Village
01/01/2019	off	
02/01/19	24	4 Ganga, 4 Bulano ki dhani, 16 Jamda,
03/01/19	24	10 Sipla, 7 Berna, 6 Kumhar Kota, 1 Sam
04/01/19	20	3 Kumhar kota, 1 Bheelo ki dhani, 6 Raydhan ki Dhani, 10 Nimba
	68	

Grand Total of the Project: 801 (Male 454, Female 347)

CHALLENGES:

- 1) Catching was and will be very difficult throughout the program as all villages/kasba/dhani are located in wide open area.
- 2) Sterilization number couldn't go up more than 10 – 12 dogs per day, as the vehicle team had was double cabin bolero till December 18th which had very small space for dog holding at back.
- 3) Roads to the villages are often filled with sand (catching vehicle got stuck many times during transfer where they took help of WII vehicle to get vehicle out).
- 4) Sam village is very interior place near Pakistan border where electricity was a very big concern. There were frequent power cuts and low voltage electricity issues. There were many issues working with autoclave and cautery machine inside the clinic due to electricity interruptions.



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

POWER-LINE MITIGATION

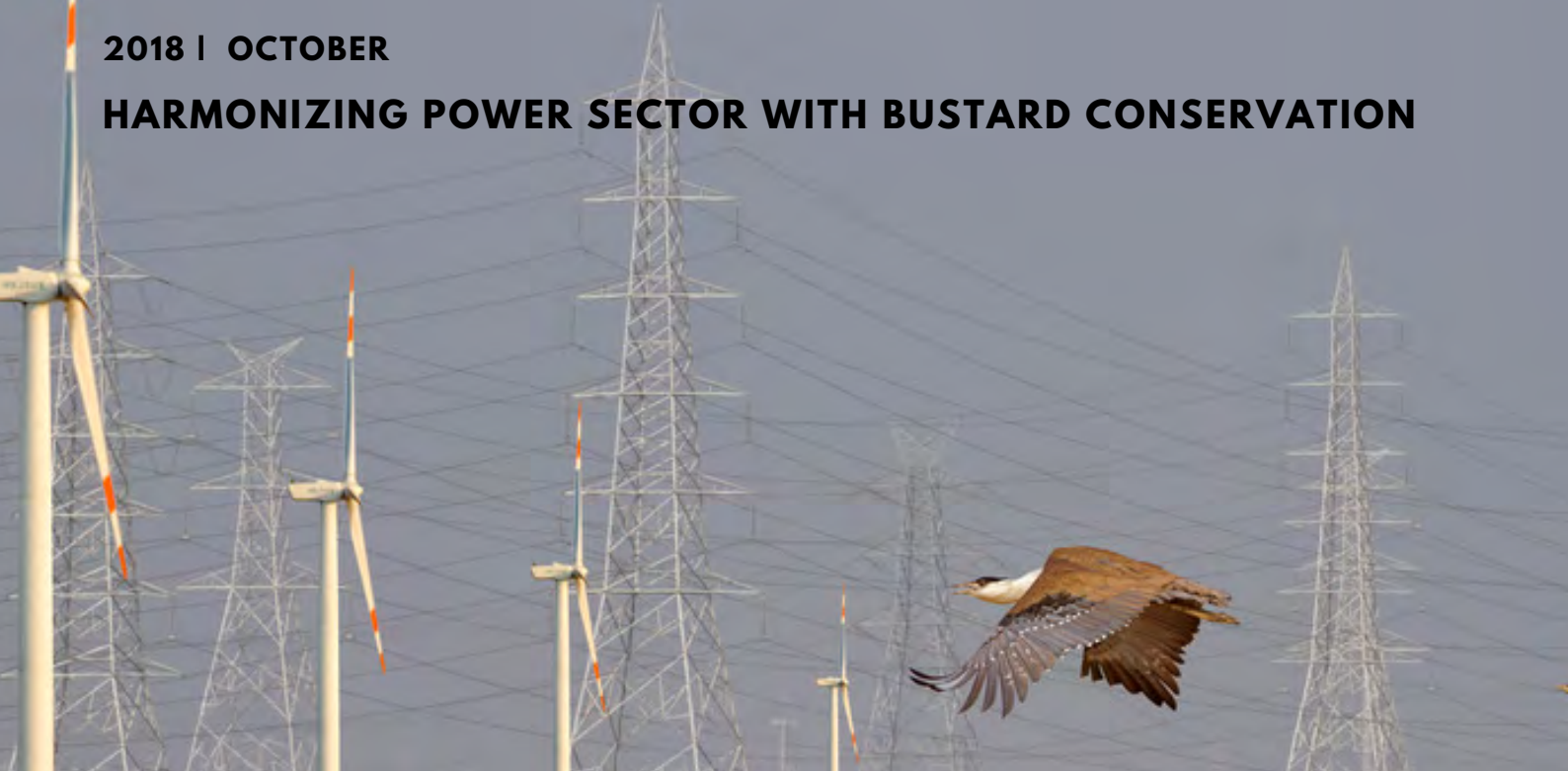


TO CONSERVE
BUSTARDS

Citation: Wildlife Institute of India 2018 Power-Line Mitigation Measures

Cover photo of dead male Great Indian Bustard due to power-line in Jaisalmer : Bipin C.M.

HARMONIZING POWER SECTOR WITH BUSTARD CONSERVATION



The Great Indian Bustard (GIB) is a critically endangered species of bird, with 129 (± 19) individuals remaining in the world. The GIB resides in the grasslands of India with the current majority of its population in Jaisalmer district of Rajasthan. There are several threats that are inching the bustard closer to extinction, however, powerlines seem to be the most significant.

EVIDENCE OF IMPACT

a) Bustards are prone to collision

Bustards have wide sideways vision to maximize predator detection, at the cost of narrow frontal vision. Because of this, and a habit of scanning the ground while flying, they cannot detect power-lines ahead of them, from far. Being heavy fliers, they fail to manoeuvre across power lines within close distances. The combination of these traits make them vulnerable to collision with power-lines. As a result, they collide with power lines and die from the impact, injuries/trauma or electrocution (Martin and Shaw 2010).

b) Evidence of bustard mortality due to power lines

Worldwide, studies have shown high mortality rates of several bustard species because of power-line collision. For example, 30% of Denham's bustards (*Neotis denhami*) die annually from power-line collisions in South Africa (Shaw 2009, Jenkins et al. 2010). In Spain, 8.5 km stretch of power-line killed a minimum of 25 Great Bustards in one year (JC Alonso pers. obs.). A review (Mahood et al 2017/18) of nine studies covering six bustard species from different parts of the world estimated 7 detected bustard mortalities per 10 km power-line per year. This factor causes 4 - 7% mortality of Great Bustard in areas with low power line density (Martin 2008) and 13% mortality in areas with high power line density (Alonso 2007).

c) Evidence of Great Indian Bustard collisions with power lines in India

Surveys conducted by Wildlife Institute of India (WII) in Thar covering 80 km of power lines repeated 7 times over a year found 289 carcasses of around 30 species including the Great Indian Bustard (GIB).

The study detected 8 carcasses/10 km for high tension and 6 carcasses/10 km for low tension power-lines. Correcting these mortalities for the proportion of carcasses that are decomposed before survey or are missed during survey, mortality rate was estimated to be ~5 bird/km/month and ~1 lakh bird per/year within 4200 km area of Desert National Park. In terms of GIB, 4 mortality were recorded, all due to high tension transmission lines - some of them connected to wind turbines.

Extrapolating these mortalities to the priority bustard habitat, intersected by ~150 km high tension lines, amounts to about **18 GIB deaths per year** from a population of about 128 ± 19 individuals in Thar. **Such high mortality rate is unsustainable for the species and a sure cause of extinction.** WII also tagged five Great Indian Bustard on pilot basis in Gujarat and Maharashtra, out of which two died from power line collision, corroborating the above findings.



d) Impact of power line collision on bustard population

Bustards are long-lived birds where adults have high annual survival probability (Palacín *et al* 2012) in human cultural non-impacted habitat. The excessive mortality due to power-lines are unsustainable and cause population declines or even extinction (Martin 2007). Power-line mortality can also disrupt important biological processes. Palacín *et al* (2012) shows that in a Great Bustard population in Spain, where migratory individuals suffered significant power-line mortality, the proportion of sedentary individuals increased over years against the reduction of migratory individuals. Here, power lines have reduced the propensity of a species to migrate, and can result in the loss of such intricate behaviors.

SOLUTIONS

e) No Power-line zones

Crucial breeding habitats of bustards have to be made free of overhead power-lines. Conservation of bustard is not possible in areas with power-lines which sooner or later kill the bird. Existing power-lines in such important habitats have to be moved underground or redesigned. No new power-lines should be permitted in such areas.

f) Mitigation of threat

Mitigation measures are available to reduce power-line mortality, such as under-grounding of cables and fitting overhead wires with bird diverters. Bird mortality and crossing rate through wires reduce, if lines are marked with diverters compared to unmitigated segments. While under-grounding of cables eliminates bird mortality, marking power line can reduce mortality by 10 % (Barrientos *et al* 2012) to 78 % (Barrientos *et al* 2011), depending on area and species, but not eliminate mortality.

IMPORTANCE OF TELEMETRY IN POWER-LINE MITIGATION

Great Indian Bustards range over large human-dominated landscapes that are facing rapid development and expansion of power-lines. Curtailing all infrastructural development across these large areas is impracticable and calls for prioritization of areas where these infrastructure should be avoided or mitigated. Use of bio-telemetry to understand GIB habitat can aide in this process, by generating fine-scale information on the birds' movement patterns that can overlaid on existing and proposed power-line maps to identify segments for mitigation measures. Thus, telemetry supplemented with bird surveys provide a powerful tool to prioritize habitats for infrastructure mitigation in particular, and conservation management in the wake of development.



Wildlife Institute of India demonstrated the potential of this tool for GIB conservation, by tagging two juvenile birds in Kachchh, Gujarat using solar powered GPS tags that weighed <1% of the bird's body weight. These tags have provided information on bird movements for >1 year (May 2017 onwards) and have also provided evidence of one bird mortality from collision with 33 kV power-line near Lala Bustard Sanctuary. Movement data obtained from tagged birds was overlaid on habitat and infrastructure maps to identify critical areas for mitigating power-lines (see figure 1). However, individuals vary in their movement patterns and more birds need to be tagged across bustard landscapes (Thar, Rajasthan and Kutch, Gujarat) to draw population-level inferences and achieve best conservation results with finite resources and bring about a harmony between development and conservation needs of the country.

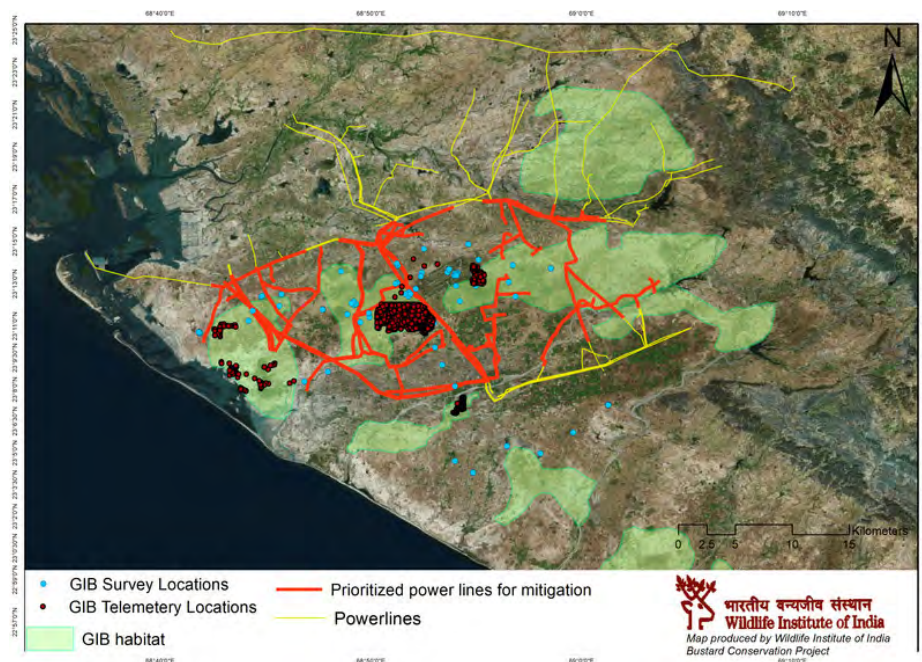


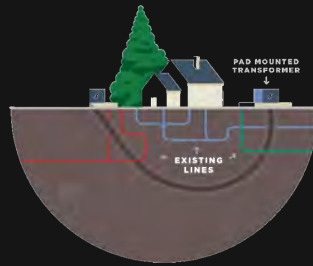
Figure 1 : Movement of tagged Great Indian Bustard overlaid on network of power lines and critical areas for mitigating power-lines (red lines).

SOLUTIONS

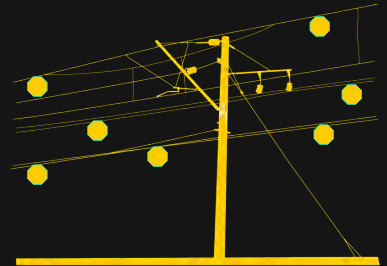
This crisis can be mitigated as follows:



Avoid/divert any high tension power line from priority Great Indian Bustard habitat. (Figure 2a & 2b).



Undergrounding of <66kv wires of most risky power-lines in priority GIB habitat.



Retrofitting of existing overhead wires with bird diverters (details of diverter makes and costs, and installation design in figure 3).

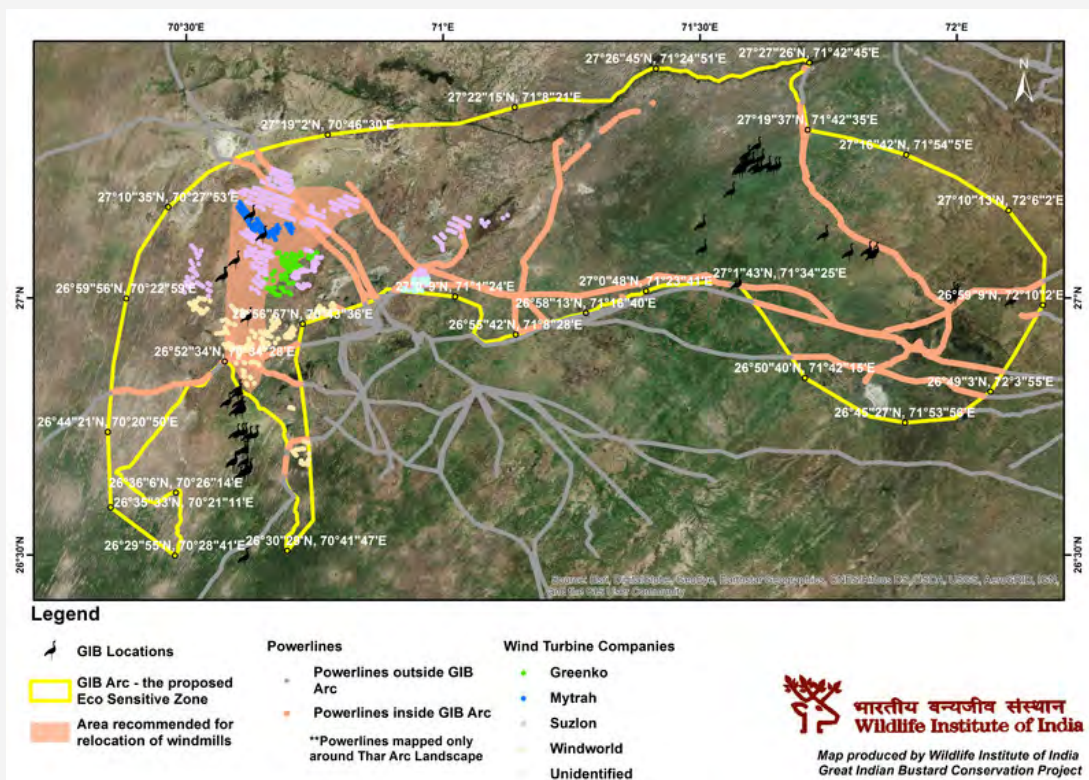


Figure 2a - Map showing proposed GIB Conservation Arc , High-tension power lines and Wind turbines in Thar, Jaisalmer.

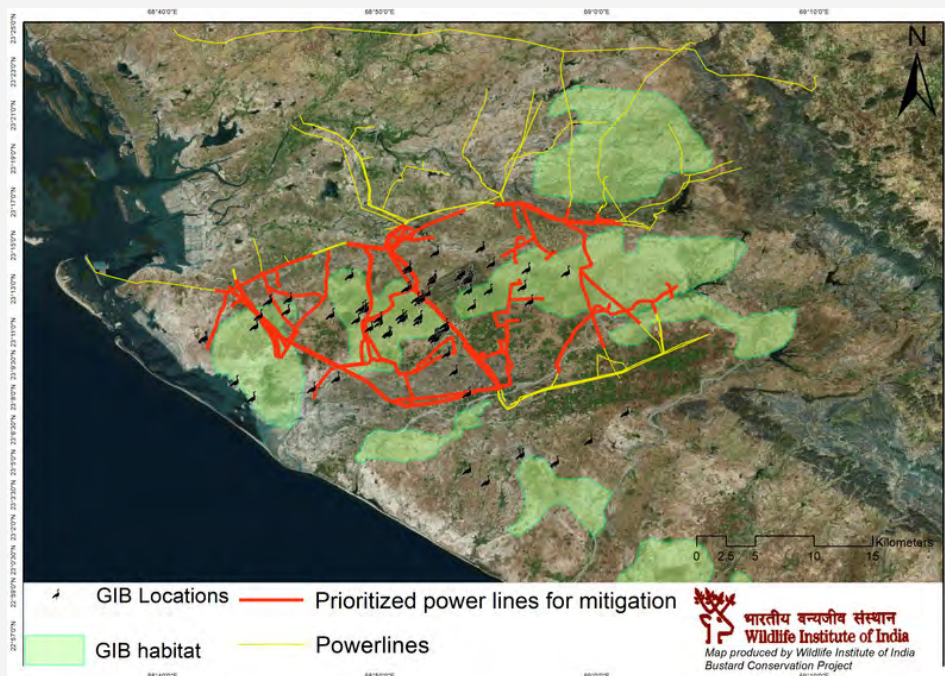
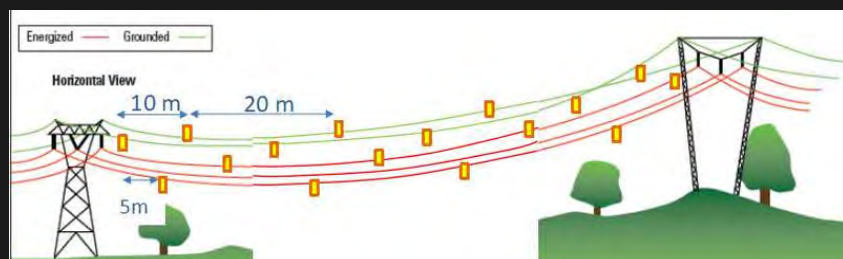
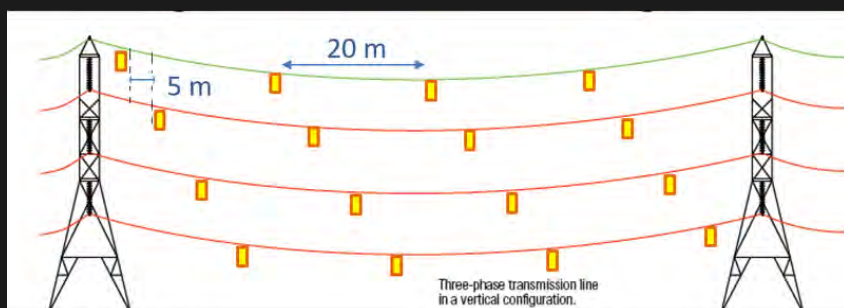


Figure 2b - Map showing Great Indian Bustard habitats in Abdasa, Kutch, with power-lines marked in white (incomplete mapping) and bustard locations as red (telemetry data) and blue (survey locations). Risky power-lines that need to be mitigated urgently have been marked in red lines.

Figure 3 : Details of diverter makes and costs, and installation design



Cost calculations:

Central 80% marking

~ 1 diverter/4m line

~4500 INR/unit + shipping charges (import)

~ 1000 INR / km (local)

Installation

Marking earth wire with 1 diverter at every 10m, and marking other wires with 1 diverter at 15 m in a staggered way, such that conductors as a whole have at least 1 diverter every 5-6 m on a line

**UNLESS POWER-LINES MORTALITY IS MITIGATED URGENTLY,
EXTINCTION OF GIB IS CERTAIN.**

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Acknowledgment

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Photo Credits

Graphic image of flying GIB through power-lines - Devesh Gadhavi

Dead GIB due to electrocution in Maharashtra - Devesh Gadhavi

Network of power-line and windmill - Tanya Gupta

Tagged GIB in Gujarat - Devesh Gadhavi



Action and budget proposal

Mitigation plan for high-tension power lines in Great Indian Bustard habitat of Thar Desert, Jaisalmer

Background: Power lines, especially high-voltage transmission lines with multiple overhead wires, is the most important current threat to the critically endangered Great Indian Bustard (GIB). Research shows that the poor frontal vision and heavy flight of bustards make them highly vulnerable to fatal collision with power-lines (Martin and Shaw 2010). Research on GIB carried out by Wildlife Institute of India (WII) shows that power-lines across their habitats in Thar are contributing to an unsustainably high mortality rate (mortality of ~15% of population and 5 deaths detected in 2017-18). Besides bustard, power-lines are causing mortality of ~1 lakh birds of over 49 species annually in ~4000 sqkm in/around Desert National Park (WII 2018). There is an urgent need of mitigating this threat by undergrounding high-risk power-lines and marking medium-risk power-lines with diverters. Without this immediate intervention, the GIB is likely to go extinct in the near future (WII 2018). Rajasthan Forest Department (RFD) and WII carried out joint sensitization meetings with power agencies (2016–18) to implement these mitigation measures, wherein prototype diverters procured by WII were pilot installed by power agencies for testing. A meeting held on 20th December 2018 under the chairmanship of Principal Secretary Energy, Govt. of Rajasthan that was attended by RFD and WII representatives decided that the mitigation measures should be urgently implemented, and directed the power agencies to place proposals with cost-estimation for this action.

Mapping activity: To mitigate this threat, WII had mapped power-lines across ~20,000 sqkm Thar landscape through digitisation of very high resolution Google Earth imagery in the first phase. Power-lines within the priority GIB habitat (GIB Arc or Ecozone), as identified by long-term collaborative surveys of WII and RFD (Dutta et al 2016) were then ground validated (2016–17). Since the chance of missing power-lines is high because of the vastness of GIB landscape, it was decided in the meeting that the available information on power lines should be verified by power line companies for preparing the project proposal on mitigation, and the same should be submitted by Superintendent Engineer (SE) Rajasthan Vidyut Prasaran Nigam Limited (RVPNL) within a month's time. A follow up meeting was called by SE RVPNL Jaisalmer on 31st December 2018 in Jaisalmer that was attended by representatives from WII and power line companies including RVPNL, SUZLON, Innercon, Jodhpur Discom, Today Green Energy Private Ltd, Siemens Gamesa and Greenko. The SE RVPNL Jaisalmer asked all power line authorities to submit details of power lines (name, length, GPS coordinates of powerlines) inside the GIB Ecozone to the Project staff of WII. WII team followed up with every power line company operating in this area and obtained available data by 15th January 2019. Whenever this data was non-existent, WII team digitised the risky power lines on ground and cross verified this information with the SE RVPNL Jaisalmer on 19th January 2019.

Cost calculation: Based on this information, cost of undergrounding power lines and installing bird diverters were separately calculated to aide in deciding the optimal mitigation strategy. Cost of undergrounding cables was computed based on information shared by the SE RVPNL Jaisalmer for medium voltage (33–66 kV) lines. However, the cost or technology of undergrounding high voltage lines (≥ 132 kV) were not available locally and could not be calculated. The cost of diverters were calculated at 10,000 INR/piece (inclusive of production and shipping costs), which is a liberal estimate, based on procurement of small numbers of high-quality devices by WII. Cost of installing diverters and undergrounding of cables is provided below.

Diverter installation	Undergrounding
Diverter cost calculated at 10000 INR/pc and number of diverters calculated as one at every 15 m on the earthwire and on conductors in a staggered design, i.e., 67 diverters/km wire, such that there is at least one diverter every 5 m on the powerline as whole. No. of diverters is calculated for 70% of the total length of power lines to leave pylons and their vicinity. The installation cost is 20% of diverter cost. However, diverter cost can be reduced to 40% of existing cost with the development of more economic local diverters	Undergrounding cable available for 33kV power lines cost ~ 21 lakh/km with the 40% installation cost of total power line cost

In total, 1342 km of power lines have been prioritised for mitigation by undergrounding 104 km of 33 kV lines in areas that are most intensively used by GIB and installing diverters on remaining 1238 km of overhead cables. The total cost of this implementation has been estimated at 287.16 Cr INR. However, this cost could be reduced to approx. 150 Cr INR by opting for economic but quality diverters.

The details of power lines with cost calculation and total costs of diverters and undergrounding are provided below (Annexure I), along with the priority map of mitigation (Annexure II), and image of a prototype diverter / reflector (Annexure III).

References:

Martin, G.R. and Shaw, J.M., 2010. Bird collisions with power lines: failing to see the way ahead?. *Biological Conservation*, 143(11), pp.2695-2702.

WII, 2018. Power-line mitigation to conserve bustards. Wildlife Institute of India, pp 8.

Dutta, S., Bipin C.M., Bhardwaj, G.S., Anoop, K.R., Jhala, Y.V. 2016. Status of Great Indian Bustard and Associated Wildlife in Thar. Wildlife Institute of India, Dehradun and Rajasthan Forest Department, Jaipur.

Annexure I

List of power-lines prioritised for bird diverter installation and undergrounding in Thar, Jaisalmer.

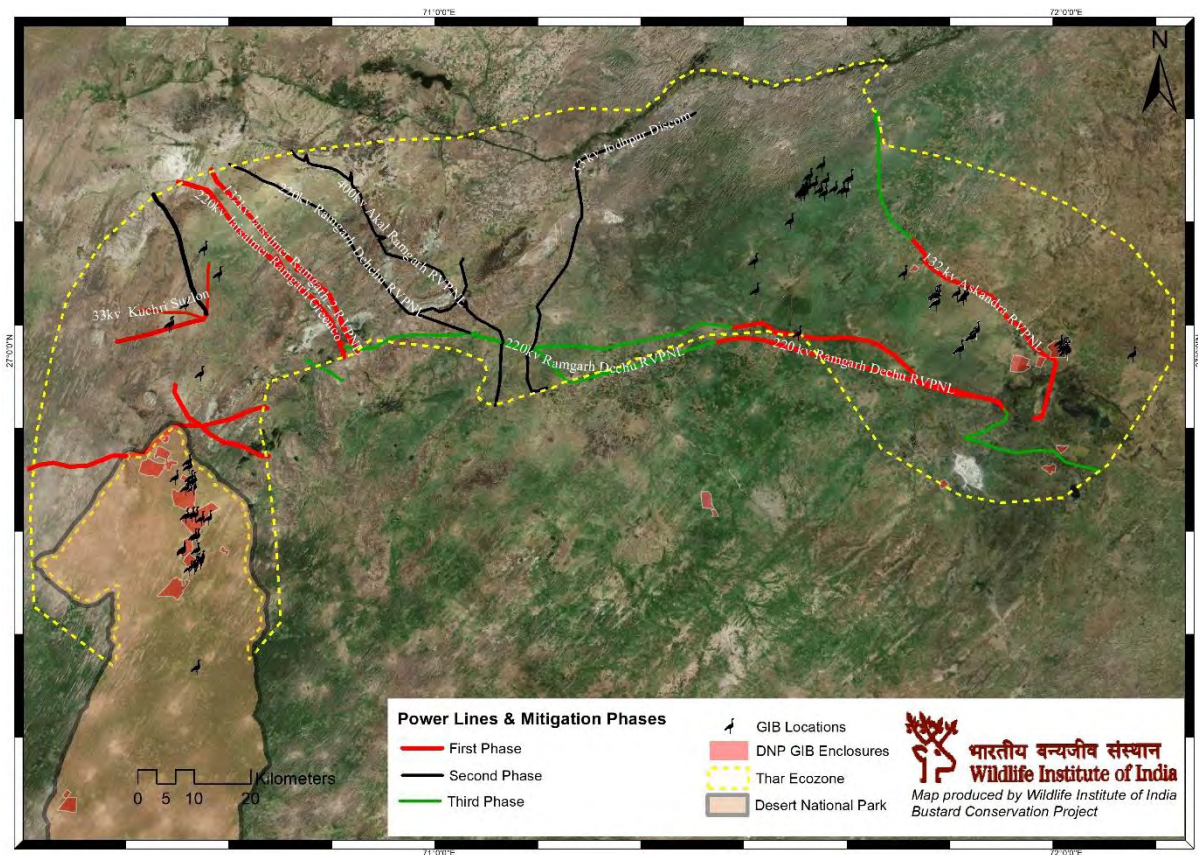
Phase	Power-line Company	Power in KV	Name of Line	No. of Wires	Length (km)	No. of Diverters	Cost of Diverter/ Undergrounding	Cost of Installation	Total Cost
Undergrounding									
I	Wind World/ Innercon	33	Kanoi – Salkha	13(7)	21	6895	20,41,400/km (4 Cables) 17,14,77,600 (Undergrounding)	40% of cost of wire 6,85,91,040 (Undergrounding)	24,00,68,640 (Undergrounding)
							10000/Diverter 6,89,50,000 (Diverter)	20% of Diverter Cost 1,37,90,000	8,27,40,000 (Diverter)
	Jodhpur Discom	33	Sam – Dhanana	4(3)	45	6332	20,41,400/km (1 Cables) 9,18,63,000 (Undergrounding)	40% of cost of wire 3,67,45,200 (Undergrounding)	12,86,08,200 (Undergrounding)
							6,33,20,000 (Diverter)	1,26,64,000	7,59,84,000 (Diverter)
	Suzlon	33	Tejuva-Kuchri	7(4)	17	3190	20,41,400/km (2 Cables) 6,94,07,600 (Undergrounding)	40% of cost of wire 2,77,63,040 (Undergrounding)	9,71,70,640 (Undergrounding)
							3,19,00,000 (Diverter)	63,80,000	3,82,80,000 (Diverter)
		33	Khuchri horizontal - parallel	6(3)	21	2955	20,41,400/km (2 Cables) 8,57,38,800 (Undergrounding)	40% of cost of wire 3,42,95,520 (Undergrounding)	12,00,34,320 (Undergrounding)
							2,95,50,000 (Diverter)	59,10,000	3,54,60,000 (Diverter)
Total (undergrounding)					104	19,372	41,84,87,000 (Undergrounding)	16,73,94,800	58,58,81,800 (Undergrounding)
							19,37,20,000 (Diverter)	3,87,44,000	23,24,64,000 (Diverter) ++
Diverter installation									
I	Rajasthan Vidyut Prasaran Nigam Limited (RVPNL)	132	132kv Jaisalmer – Ramgarh – 1	4(3)	40	5628	10,000/Diverter 5,62,80,000	20% of Diverter Cost 1,12,56,000	6,75,36,000
I		132	132kv Jaisalmer – Ramgarh – 2	4(3)	40	5628	10,000/Diverter 5,62,80,000	20% of Diverter Cost 1,12,56,000	6,75,36,000
I		132	132kv Askandra (Pokran to Askandra)	4(3)	30	4421	10,000/Diverter 4,42,10,000	20% of Diverter Cost 84,42,000	5,30,52,000
II		132	132kv Askandra (Pokran to Askandra)	4(3)	20	2814	10,000/Diverter 2,81,40,000	20% of Diverter Cost 56,28,000	3,37,68,000
I		220	220kv Amarsagar – Ramgarh	4(3)	40	5628	10,000/Diverter 5,62,80,000	20% of Diverter Cost 1,12,56,000	6,75,36,000
I		220	220kv Amarsagar – Lilo	7(4)	8	1501	10,000/Diverter 15,01,0,000	20% of Diverter Cost 30,02,000	1,80,12,000
I		220	220kv Amarsagar – Phalodi	4(3)	54	7598	10,000/Diverter 7,59,80,000	20% of Diverter Cost 1,51,96,000	9,11,76,000

III		220	220kv Amarsagar – Phalodi	4(3)	71	9990	10,000/Diverter 9,99,00,000	20% of Diverter Cost 1,99,80,000	11,98,80,000
I		220	220kv Ramgarh Dechu	7(4)	49	9193	10,000/Diverter 9,19,30,000	20% of Diverter Cost 1,83,86,000	11,03,16,000
III		220	220kv Ramgarh Dechu	7(4)	43	8067	10,000/Diverter 8,06,70,000	20% of Diverter Cost 1,61,34,000	9,68,04,000
II		220	220kv Ramgarh Dechu	7(4)	50	9380	10,000/Diverter 9,38,00,000	20% of Diverter Cost 18,76,0000	11,25,60,000
II		400	400kv Akai – Ramgarh	8(4)	55	10,318	10,000/Diverter 10,31,80,000	20% of Diverter Cost 2,06,36,000	12,38,16,000
Sub-total		500				80,166	80,16,60,000	1,60,32,000	96,19,92,000
III	Suzlon	33	Tejuva – Kuchadi	7(4)	138	25889	10,000/Diverter 25,88,90,000	20% of Diverter Cost 5,17,78,000	31,06,68,000
II		33	Kaladongar	4(3)	70	9849	10,000/Diverter 9,84,90,000	20% of Diverter Cost 1,96,98,000	11,81,88,000
III		33	Mokla – Habur – Sanu	4(3)	301	42,350	10,000/Diverter 42,35,00,000	20% of Diverter Cost 8,47,00,000	50,82,00,000
III		132	Tejuva – Kuchadi	4(3)	25	3518	10,000/Diverter 3,51,80,000	20% of Diverter Cost 70,36,000	4,22,16,000
II		132/220	Kaladongar	4(3)	47	6613	10,000/Diverter 6,61,30,000	20% of Diverter Cost 1,32,26,000	7,93,56,000
I		132/220	Mokla – Habur – Sanu	4(3)	43	6051	10,000/Diverter 6,05,10,000	20% of Diverter Cost 1,21,02,000	7,26,12,000
Sub-total		624				94,270	94,27,00,000	18,85,40,000	113,12,40,000
II	Jodhpur Discom	33	Chandan Via Bhagu ka Gaon to Mohangarh	4(3)	70	9849	10,000/Diverter 9,84,90,000	20% of Diverter Cost 1,96,98,000	11,81,88,000
Sub-total		70				9849	9,84,90,000	1,96,98,000	11,81,88,000
I	Greenko	220	Amarsagar – Ramgarh	4(3)	40	5628	10,000/Diverter 5,62,80,000	20% of Diverter Cost 1,12,56,000	6,75,36,000
Sub-total		40				5628	5,62,80,000	1,12,56,000	6,75,36,000
III	Gamesa	33	Amarsagar – Ludarva	4(3)	4	563	10,000/Diverter 56,30,000	20% of Diverter Cost 11,26,000	67,56,000
Sub-total		4				563	56,30,000	11,26,000	67,56,000
Total		1238 KMs of Power line for Diverter				1,90,476			228,57,12,000 228.57 Cr
		104 KMs of 33 kV lines (for Diverter)				19,372			23,24,64,000 23.25 Cr ++
		104 KMs for Undergrounding							58,58,81,800 58.58 Cr
Grand-total									287,15,93,800 (287.16 Cr)

* Diverter cost can be reduced to 40% of existing cost i.e. 91.43Cr with the development of more economic local diverters authenticated by Wildlife Institute of India and Rajasthan Forest Department. Expected time for producing these diverters is 6 months.

++ For 33 kV lines prioritized for undergrounding, cost of diverters have also been indicated.

Map showing high tension (≥ 33 kV) power-lines divided into three phases for undergrounding and bird diverter installation.



Annexure III

Photograph of a model Bird Diverter / Reflector with rotating, reflecting and night blinking properties that has been pilot installed and field tested by Wildlife Institute of India with the assistance of power agencies in Jaisalmer.



Report on the visit to Tata Power Renewable Energy Limited (TPREL) 150 MW solar power project and 220 kv transmission line site in Jaisalmer

A site visit was conducted by the Wildlife Institute of India project team on 22nd July 2018 along with Dr. Asad Rehmani, Former Director of Bombay Natural History Society (BNHS) and renowned Great Indian Bustard (GIB) expert to inspect the alignment of upcoming power line near Ramdevra in Pokhran Tehsil, Jaisalmer since the area was in the vicinity of the GIB habitat. Representatives from TATA power- Mr. Abhishek Ashok Bhagat- Station head- Chhayana (Operations) and Mr. Saket Porwal- Project head (Large projects) accompanied the team. The solar plant site and power line alignment was surveyed and mapped to assess the habitat from where the power line was being installed. We noticed that ~ 17 km of power line falls under GIB Arc and it crosses GIB Arc boundary at (Lat. 27°15'17.90"N, Long. 71°57'3.47"E) and the area comes under GIB flying zone, frequently used by the bird. The power line passes within 2 km of Nathji ka Tanka satellite enclosure (Lat. 27° 9'40.32"N, Long. 71°52'0.62"E) of Desert National Park. This enclosure is used by the bird very frequently and the power line is just adjacent to it. A 10 km segment of the power line from Lat. 27°11'5.21"N, Long. 71°50'27.58"E to Lat. 27°13'43.75"N, Long. 71°55'5.47"E is very critical and should be made underground to prevent collision of GIBs (Figure 14A).

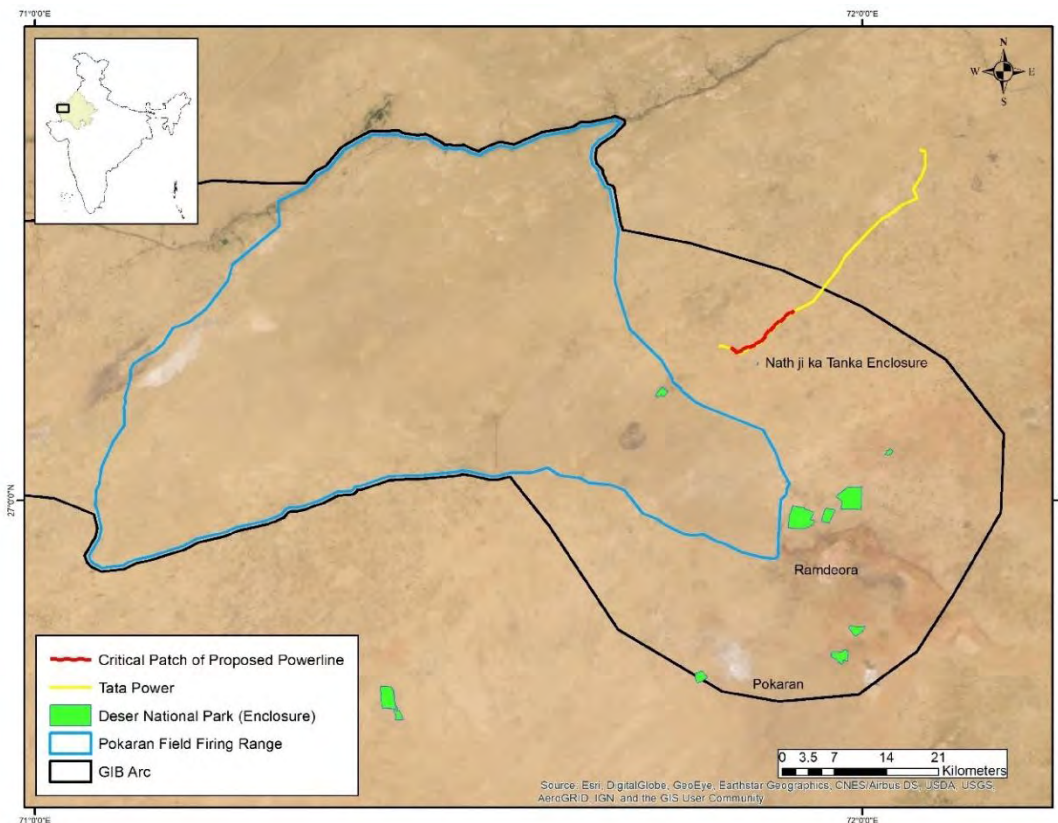


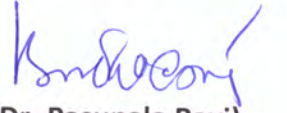
Figure 14A Map of the 220 KV transmission line cutting across Great Indian Bustard arc near Indian Army Field Firing Range in Pokhran Tehsil, Jaisalmer

F. No. 1-16/2019 WL
Government of India
Ministry of Environment, Forests and Climate Change
(Wildlife Division)

Indira Paryavaran Bhawan
Vayu Wing, Jor Bagh Road, Aliganj
New Delhi-110003
Date: 31 October, 2019

Sub: Summary records of the meeting of the committee constituted in pursuance of the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors.

The undersigned is directed to enclose the minutes of the meeting of the committee constituted in pursuance of the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors. held on 16th October, 2019 under the Chairmanship of Director General of Forest & Special Secretary, MoEF&CC at Krishna Conference Hall, Indira Paryawaran Bhawan, and New Delhi-03.



(Dr. Pasupala Ravi)

Scientist C

E-mail: ddwlmef@gmail.com

Telefax: 011- 24695379

Encl. As above

Distribution:

1. The Secretary, Ministry of Power, Govt. of India.
2. The Chairperson, Central Electricity Authority, New Delhi.
2. The Secretary, Ministry of New and Renewable Energy, Govt. of India
3. The Principal Secretary, Department of Energy, Govt. of Rajasthan.
4. The Principal Secretary, Department of Energy, Govt. of Gujarat.
5. The PCCF (Wildlife) & Chief Wild Life Warden, Government of Rajasthan, Jaipur.
6. The Secretary, Centre for Wildlife and Environment Litigation (CWEL).
7. Dr. Y.V. Jhala, Senior Scientist, Wildlife Institute of India, Dehradun.

Copy for kind information to:

1. PPS to DGF&SS/ PPS to ADGF (WL)/ PPS to IGF (WL)/ PS to DIG(WL)
2. Director, WII Dehradun

Summary records of the meeting of the committee constituted in pursuance of the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors.

Dated: 16th October, 2019

Venue: Krishna Conference Hall,
Indira Paryavaran Bhawan, MoEF&CC, New Delhi

A meeting of the committee constituted in pursuance of the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors. was held on 16th October, 2019 under the Chairmanship of Director General of Forest & Special Secretary, MoEF&CC at Krishna Conference Hall, Indira Paryavaran Bhawan, and New Delhi-03. The list of participants who attended the meeting is at **Annexure**.

2. Shri M.S. Negi, Addl. DGF (MoEF&CC) welcomed all the members of the meetings and initiated the discussion. The committee is mandated to prepare a time bound action plan on the recommendations of WII and on the issue raised in the prayer by the applicant.

3. Shri Bhanu Bansal, who represented the Centre for Wildlife and Environment Litigation (CWEL) made a brief presentation on the matter. He further highlighted the prayers made by them before the NGT in the petition:-

- I. Declaration of critical GIB habitat as an "involute area"
- II. Disallow new wind turbines ,solar farms(photovoltaic power stations) from priority GIB habitats and remove existing ones that are in the critical areas
- III. Undergrounding of power lines as per the WII recommendations in a time bound manner
- IV. Deployment of Bird Diverters in accordance with policy finalized by WII.
- V. Finalization of policy for undergrounding of power line cables from 33 kv to 440 kv
- VI. Imposition of Exemplary cost on Power Line Corporations who fails to oblige the way forward within the stipulated time limit as per the Pollution Pays Principle.

He stated that the reasons for the deaths of the GIB is high tension power lines and requested to disallow/underground the powerlines in high priority GIB Arc area and install bird diverters in the area outside the GIB arc as recommended by the WII to prevent the deaths of the GIB.

4. It was brought to the knowledge of Sh. Bansal that while appreciating the concerns about GIB conservation raised by him, the Joint Committee would restrict the discussion, suggestions, on the issues raised in the prayer of the Original Application filed in NGT.

5. Dr. Y.V. Jhala, Scientist G, WII stated that WII had submitted the report and made the following recommendations which are presented as below :-

“ 4.2. Mitigate all power transmission lines passing through priority bustard habitats identified by WII (Please refer Annexure 10) by undergrounding cables (where technically/technologically feasible) or installing bird diverters to make them prominent to birds.

4.3. Disallow new wind turbines, solar farms (photovoltaic power stations) from priority GIB habitats and remove existing ones that are in the critical areas. The priority areas where this intervention is required has been mapped by Wildlife Institute of India (Please refer Annexure 10). This action needs to be implemented in the long-term spanning 5-10 years from present.

4.4. Develop predator-proof enclosures of 5-10 sq km area in known breeding sites in and around DNP to improve GIB recruitment, and keep away nest predators by routinely translocating dogs, pigs, foxes, mongoose and other species outside the enclosures using professional trappers.

4.5. Create an inviolate area of 200 sq km (WII proposal- 500 sq km) in northern DNP as a National Park through voluntary and incentivized relocation of local people (if needed) with the mandate of conserving GIB.

4.6. Delineate priority GIB habitats outside DNP as Eco Sensitive Zones where agro-pastoral practices are regulated to low intensity through Zonal Management Plans and detrimental infrastructure such as wind turbines and overhead transmission lines are curtailed. This action needs to be implemented in the short-term (1–2 years).

4.7. Engage with local communities to promote bustard-friendly practices such as stall-feeding of livestock during monsoon – GIB chick-rearing and grass growing season – and cultivating food crops preferred by GIB during monsoon such as gram, ground nut and millets while leaving the fields fallow for the remaining period.

4.8. Reduce poaching of GIB and other wildlife in the Thar landscape by improving protection enforcement through training of Forest Department frontline staff in smart patrolling tools with the help of conservation organizations such as WII and WWF,

4.9. Implement the conservation breeding programme by creating an offshore insurance population (if needed) by shipping a batch of about 10 GIB eggs to a state-of-the-art international breeding center such as IFHC houbara breeding center at Abu Dhabi

4.10. To continue with targeted research on GIB to characterize threats spatio-temporally, understand landscape use pattern.”

He also highlighted that since, GIBs are slow breeding birds and if their mortality continues at this rate, it may lead to extinction of the species. He requested and recommended the Ministry of Power and Ministry of New and Renewable to instruct their companies to install bird diverters on the power lines and underground certain portions in critical bustard passage ways. He urged to implement the mitigation measures as suggested by WII. He also informed that WII would be undertaking the works of removal of predators from the GIB enclosures. He requested the Rajasthan Forest Department to complete the works of repairing of the enclosures after which removal of predators was relevant.

6. Shri Arindam Tomar, APPCF & Chief Wildlife Warden, Rajasthan informed that there are four court cases against the Rajasthan Forest Department related to the GIB. He also highlighted that WII has prepared a map showing the critical bustard habitats in Rajasthan

which is known as GIB Arc. He also mentioned that the bird diverters installed by the power agencies are needed to be monitored and regularly maintained. Although, the GIB Arc does not have legal sanctity, but Hon'ble N.G.T. has considered the Arc in OA no. O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors case and directed the agencies to follow the recommendations of the WII. Further, there are also cases regarding GIB conservation Writ Petition (C) No. 838 of 2019 titled M. K. Ranjitsinh & Ors. Vs. Union of India & Ors. filed in the Supreme Court of India. , a Suo moto petition filed in Jodhpur High Court and Original Application no. 63 of 2016 titled Mahendra Singh Borawat Vs. Union of India & Ors. in NGT Bhopal.

7. Officials from Rajasthan Rajya Vidyut Prasaran Nigam Limited(RRVPNL) informed that the powerline development agencies are not clear about the procedures/NOCs to be obtained before implementing the power projects as the area under the GIB Arc is not the part of ESZ or falling under any of the boundaries of the Protected Area. He also stated that Environment Clearances are being obtained before implementation of the power projects.

8. Joint Secretary, Ministry of New and Renewable informed that their Ministry had already issued a circular to the power supply agencies under them to take mitigation measures on the power lines to mitigate the mortalities of birds. He also highlighted that we should also look for other factors apart from the powerlines which are leading to the mortalities of birds.

9. Representative of CEA mentioned that there is a need to identify the powerlines as well as the owner of the powerline to assess the source of funding and cost involved for mitigation measures as well as undergrounding the powerlines.

He further stated that CEA after receiving the recommendations of the task force constituted under by the MoEF&CC to find out the problems of electrocution of animals, birds by the powerlines is planning to bring out the necessary modifications/amendments in CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010 (as Amended) for under grounding upto 33 KV in national parks, wildlife sanctuaries, forested areas, eco-sensitive zone etc.

He highlighted that, for the projects, which are already been contracted/initiated in the field, it will be difficult to initiate the mitigation like underground cable or aerial bunched cables or covered conductors as it will amount to revising the project cost and initiating a fresh process for financial clearance. This may lead to the undue delay in execution of important projects of alternate energy.

He further stated that, the powerlines passing through GIB area are of higher voltage and at present there is no technology which is techno-economically feasible or not for under grounding such power cables. However, we have to explore such possibilities in the future for safeguarding the critically endangered GIB.

10. Dr. Y.V. Jhala intimated that as already mentioned in the report that priority areas and powerlines intervention have already been identified, mapped and technical- techno financial proposal has been submitted to the RRVPNL for necessary approval from the Rajasthan energy department for mitigation.

He also intimated that one of the Mumbai based powerline development agencies working in Madhya Pradesh had consultation with WII and they have informed that they have the technology to underground powerlines upto 220KV.

11. Shri Siddhanta Das, DGF&SS and the Chairman of the Committee mentioned that declaration of the areas under the GIB Arc as Community Reserve or Conservation Reserve would help to make legal sanctity of the GIB Arc. He also highlighted to have time bound action plan for the implementation of the mitigation measures such as undergrounding of power lines, installation of bird diverters and their regular maintenance and monitoring by the power agencies.

12. After through deliberation, the committee decided the following:-

- (i) All the powerline development agencies already working in GIB habitat or intend to work should be invited especially to discuss and consider the technological and economic feasibility of undergrounding different capacity of power lines.
- (ii) WII will furnish the details about the powerlines identified for mitigation in the GIB habitat area along with the details of the powerline owner with the CEA, M/o Power and MNRE, so that necessary action may be initiated by them by planning the mitigation measures and arranging the financial.
- (iii) The representative of RRVNPL may please intimate the action taken by them on the techno-financial proposal submitted by the WII to the Govt. of Rajasthan in the next meeting.
- (iv) The Rajasthan Forest Department would explore the possibilities of declaration of area under the GIB Arc as Protected Area such as Conservation Reserve or Community Reserve
- (v) Representative of Gujarat Electricity Development Agency will bring about the details about the mitigation measure including undergrounding of the cables taken up by Govt. of Gujarat in GIB habitat area.

The meeting ended with the vote of thanks to the Chair.

List of Participants

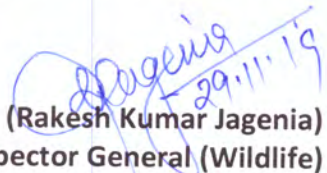
1. Sh. Siddhanta Das, DGF&SS
2. Sh. M.S.Negi Addl. DGF(WL)
3. Ms. Roui Kullai, DIG (WL)
4. Sh. Arindam Tomar, CWLW Rajasthan
5. Dr.Y.V. Jhala, Senior Scientist, WII.
6. Sh. Bhanu Bansal, Centre for Wildlife and Environment Litigation
7. Sh. V.K.Gupta, Centre for Wildlife and Environment Litigation
8. Sh. Y.K.Raizada, Director (Techno), Rajasthan Rajya Vidyut Prasaran Nigam Limited
9. Smt. Kanika Sharma, Superintending Engineer, Rajasthan Rajya Vidyut Prasaran Nigam Limited
10. Ms. S. Chhakchhuak, Director, Gujarat Energy Development Agency, Gujarat
11. Sh. Ravinder Gupta, Central Electricity Authority
12. Sh. A.S. Parira, Ministry of New and Renewable Energy
13. Sh.Dilip Nigam, Ministry of New and Renewable Energy
14. Dr. Pasupala Ravi, DD(WL)
15. Sh. Ravi Kumar, Legal Asst. (WL)

F. No. 1-16/2019 WL
Government of India
Ministry of Environment, Forests and Climate Change
(Wildlife Division)

Indira Paryavaran Bhawan
Vayu Wing, Jor Bagh Road, Aliganj
New Delhi-110003
Date: 29th November, 2019

Sub: Summary records of the 2nd meeting of the Committee constituted by the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors.

The undersigned is directed to enclose the minutes of the 2nd meeting of the Committee constituted by the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors. held on 11th November, 2019 under the Chairmanship of Director General of Forest & Special Secretary, MoEF&CC at Krishna Conference Hall, Indira Paryawaran Bhawan, New Delhi-03.


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Encl. As above

Distribution:

1. The Secretary, Ministry of Power, Govt. of India.
2. The Secretary, Ministry of New and Renewable Energy, Govt. of India
3. The Principal Secretary, Department of Energy, Govt. of Rajasthan.
4. The Principal Secretary, Department of Energy, Govt. of Gujarat.
5. The PCCF (Wildlife) & Chief Wild Life Warden, Government of Rajasthan, Jaipur.
6. Dr. Y.V Jhala, Senior Scientist, Wildlife Institute of India, Dehradun.
7. The CMD, Power Grid Corporation of India Limited.
8. The CEO, the Tata Power Renewable Energy, Ltd.
9. The CEO, Essel Sautya Urja Company of Rajasthan, Ltd.
10. The Nodal officer, Rajasthan Rajya Vidyut Prasaran Nigam Ltd., Jaipur.
11. The Nodal officer, Jodhpur Vidyut Vitran Nigam Ltd, Jodhpur.
12. The Actis, 12th Floor Birla Aurora, Dr. Annie Besant Road, Worli, Mumbai
13. The Sprng Energy Pvt Ltd, Pune.

Copy for kind information to:

1. PPS to DGF&SS/ PPS to ADGF (WL)/ PPS to IGF (WL)/ PS to JD(WL)/DD(WL)
2. Director, WII Dehradun

Summary records of the 2nd meeting of the Committee constituted by the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors.

Dated: 11th November, 2019

Venue: Krishna Conference Hall,
Indira Paryavaran Bhawan,
MoEF&CC, New Delhi

The 2nd meeting of the committee constituted by the Order of the Hon'ble National Green Tribunal, New Delhi dated 04/09/2019 in O.A. No. 385 /2019 in the matter of Centre for Wildlife and Environment Litigation (CWEL) Vs. Union of India & Ors. was held on 11th November, 2019 under the Chairmanship of Director General of Forest & Special Secretary, MoEF&CC at Krishna Conference Hall, Indira Paryawaran Bhawan, New Delhi-110003. The list of participants who attended the meeting is at **Annexure**.

2. Shri M.S. Negi, Addl. DGF (MoEF&CC) welcomed all the members of the committee, special invitee from the powerline development agencies and initiated the discussion. It was brought to the notice of the representatives of the power line development agencies that the Joint Committee constituted by the NGT has the mandate for preparing a time-bound action plan for protection of Great Indian Bastards.

3. The applicant, Centre for Wildlife and Environment Litigation (CWEL) in their application have prayed the Court to direct the Ministry of Environment, Forest & Climate Change to take various steps for the protection of the Great Indian Bastards and its habitats including undergrounding of power lines and deployment of bird diverters as per the recommendations in a time-bound manner.

4. The Wildlife Institute of India in its report filed before the Hon'ble NGT has, inter-alia, recommended to mitigate all power transmission lines passing through priority Bastard habitats identified by WII by undergrounding cables (where technologically feasible) or installing bird diverters to make them prominent to the birds and also to the new wind turbines, solar farms from priority GIB habitats.

5. The Committee has invited the power line development agencies to know their views about technical/technological feasibility of undergrounding of the power lines in priority GIB habitat areas.

6. The representatives of TATA Power briefed about their project and stated that they have taken NOC from the Rajasthan Forest Department for the project and already completed 90% of the work. They are using bird diverters at every 10 mtr. length of the wire. They categorically stated that their powerline is not going through the GIB arc.

7. On being enquired, they elaborated that within their solar farm, the electricity is being transmitted from solar panel to the transformer station through 33 KV underground cables and at the station, the electricity is being stepped up to the voltage of 220 KV and from there being transmitted through overhead transmission lines. On being asked whether it is feasible to adopt a hybrid system of transmission of electricity, they intimated that though it is feasible to have a hybrid system yet as per the present technology available with them, it is difficult for them to maintain such hybrid system efficiently and at the same time ensuring the uninterrupted supply of electricity without any transmission losses. It may not be possible for them to introduce such systems in the existing power lines since most of the work has been completed.

8. The representatives of Essel Surya Urja Company of Rajasthan Ltd. briefed about their project. They mentioned that their project is also outside the purview of the GIB arc. They also stated that though it is possible to have a hybrid stem of transmission of power through overhead and underground power lines yet the maintenance of such hybrid transmission lines is difficult and problematic. At this stage they are not in a position to make any change in their plan and to convert the transmission lines into hybrid transmission lines, as it may lead to delay in execution of project and unplanned rise in project cost.

9. The representatives of the Sprng Vayu Vidyut Pvt. Ltd. intimated that as part of their 200 MW Wind Power Project in District Dhar of Madhya Pradesh, they are laying 220 KV power evacuation line from wind farm in village Panda to Power Grid 220/400 KV Rajgarh Substation part (3 km) of which will be passing through Sardar Pur Wildlife Sanctuary. They are proposing for a hybrid 220 KV power transmission line including underground 220 KV line in 3 km stretch of Sardar Pur Wildlife Sanctuary. The proposal will shortly be submitted to the Standing Committee of NBWL. They intimated that it is technically feasible to have a hybrid power transmission line including underground as well as overground transmission line but maintenance of such power lines is difficult and cost of the underground lines is 3 to 4 times higher. They further explained that they have adopted this hybrid stem because the stretch of the transmission lines, which is to be made underground, is small and they have pre-planned the management of this stretch in advance.

10. The representative from Power Grid Corporation of India Limited (PGCIL) intimated that they have done undergrounding of 220 KV power lines upto 12 km and even in the city areas attempts have been made to underground 400 KV power lines, however, the hybrid system of power lines is problematic in maintenance.

11. Representative from Central Electricity Authority stated that it could be possible to introduce the hybrid system of power transmission lines only in the new project if sufficient provisions are made for taking care of the problems linked with the hybrid system and seeing the available technology in the present time, it will be difficult and non-economic to convert the current overhead transmission lines into the hybrid transmission lines.

12. On the claim of representatives of TATA Energy & Essel Surya Urja Private Limited that their projects are outside GIB, Shri Arindam Tomar, APPCF & Chief Wildlife Warden, Rajasthan reacted and informed that as per the maps of the Wildlife Institute which have been supplied to the power development agencies both projects of Tata Power are falling within the GIB arc.

13. The Scientists from WII informed that in GIB arc there is few kilometers area which can ensure bird security. They also informed that there are examples of technical feasibility of hybrid system, undergrounding of powerlines. In Gujarat, it has been done and also PGCIL has also done the same.

14. After this discussion it could be inferred that seeing the current available technology, it will be difficult to convert the existing overhead transmission lines into underground transmission lines immediately. However, with the introduction of new technology, it could be possible to underground these lines in future. The Committee also inferred from the discussion that new projects for undergrounding the transmission lines are feasible, if sufficient provisions are made in the project report for taking care of the problems linked with the underground/hybrid system of power transmission lines.

15. The representative of Ministry of New and Renewable mentioned that the whole discussion is centered on solar projects only. They also informed that there are many wind energy projects are operating in the GIB area. Therefore wind energy developers are also need to be called and heard. They further stated that high priority GIB area information may also be shared with MNRE so that the future projects can be awarded with due care.

16. It was also noticed that Gujarat Electricity Development Agency (GEDA) have not yet given the information about mitigation measures adopted by them including undergrounding of transmission lines.

17. After through deliberation, the Committee decided the following:-

(i) Rajasthan Forest Department along with the representatives of Tata Power and Scientists from WII will ascertain the position of transmission lines in GIB arc and submit the report to the Committee by 10th of December, 2019.

(ii) As requested by the representative of Ministry of New and Renewable, wind power agencies working in GIB habitat or intend to work would also be invited for the next meeting. Ministry of New & Renewable Energy will provide the list of such wind power agencies who can be invited for next meeting.

(iii) It was also brought to the notice of the committee that the information of powerlines agencies identified for mitigation in the GIB habitat area along with the details of the powerline owner has not been shared with the CEA, M/o Power and MNRE. WII is requested to share the requisite information with them at the earliest.

(iv) Gujarat Electricity Development Agency should send the requested information immediately.

The meeting ended with the vote of thanks to the Chair.

List of Participants

1. Sh. Siddhanta Das, DGF&SS
2. Sh. M.S.Negi Addl. DGF(WL)
3. Sh. Rakesh Kumar Jagenia, DIG (WL)
4. Sh. ArindamTomar, CWLW Rajasthan
5. Dr.Sutirtha Dutta, Scientist, WII.
6. Sh.Bipin C.M., Associate, WII
7. Sh. Kamal Maheshwari, CEO, ESUCRL.
8. Sh.S.N.Sunkari, Director, ESUCRL.
9. Sh.M.K.Singh, CGM, Powergrid India.
10. Sh. Mahesh D Paranjpe, CEO, Tata Power Renewable Energy Ltd.
11. Sh. Avinash D Mirajkar, Sprng Energy Pvt. Ltd.
12. Sh. Ravinder Gupta, Central Electricity Authority
13. Sh. A.S. Parira, Ministry of New and Renewable Energy
14. Sh.Dilip Nigam, Ministry of New and Renewable Energy
15. Sh.G.Upadhyay, Ministry of New and Renewable Energy
16. Sh. Ravi Kumar, Legal Asst. (Wildlife)
17. Sh. Aditya Bisht, Project Scientist, Wildlife

