भारतीय वन्यजीव संस्थान
Wildlife Institute of India

BUSTARD
RECOVERY PROGRAM

HABITAT IMPROVEMENT
AND CONSERVATION
BREEDING OF

GREAT INDIAN BUSTARD

:AN INTEGRATED APPROACH

PROGRESS REPORT III
(April 2018 – March 2020)

Wildlife Institute of India

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Contents

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, as 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 km^2 in Kachchh to 124 km^2 in Jaisalmer. The core usages for birds ranged between 13–29 km^2 in Jaisalmer and 15 km^2 in Kachchh. Movements were located mostly within protected enclosures that corroborate the recommendation of National Bustard Recovery Plans that enclosures of 10-20 km^2 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 $\pm$ 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 km^2 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 and around 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 km^2). 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 Vidyuth 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).

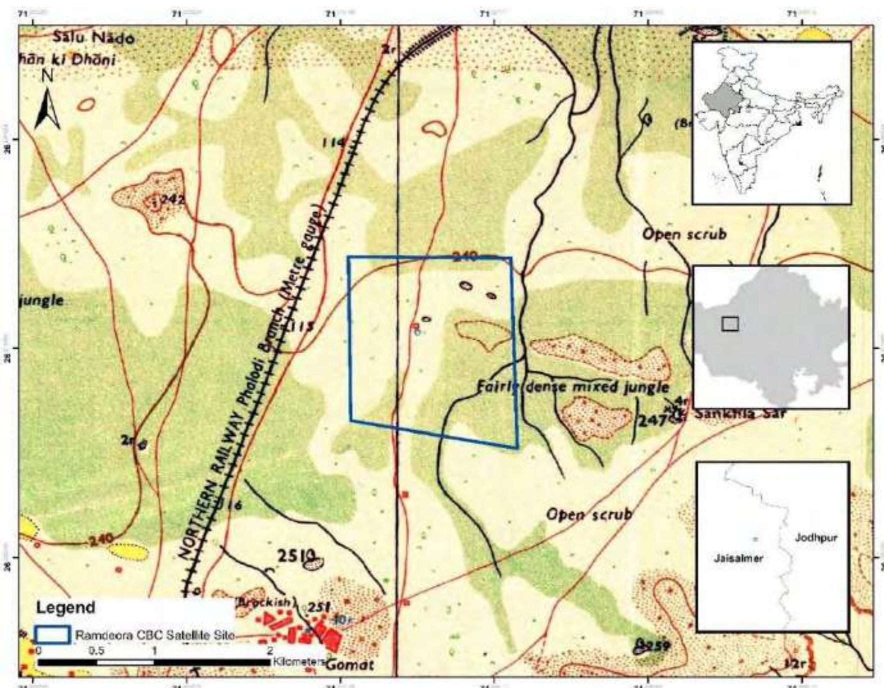

Figure 1. Topographic map of Satellite Conservation Breeding Centre site at Ramdevra in Jaisalmer District, Rajasthan

The land selected in Ramdevra spans 1.93 km^2 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 km^2 of forest land and 0.1 km^2 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.

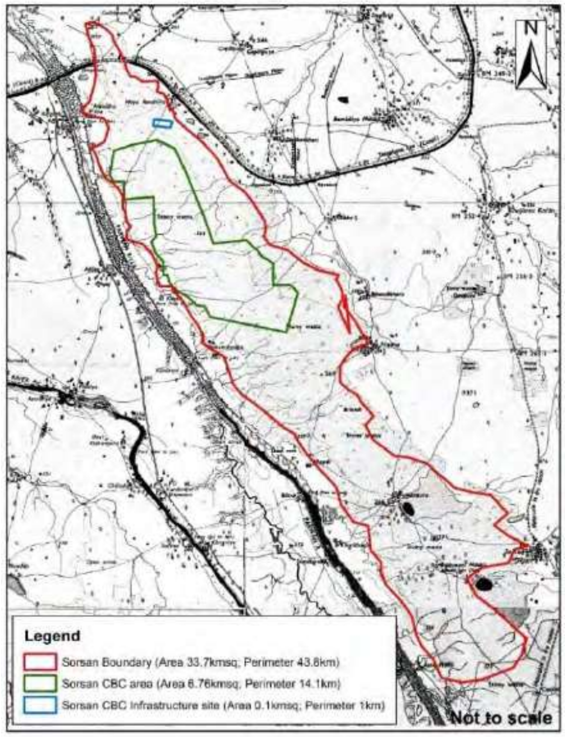

Figure 2. Topographic map of Conservation Breeding Centre site at Sorsan in Baran District, Rajasthan

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).

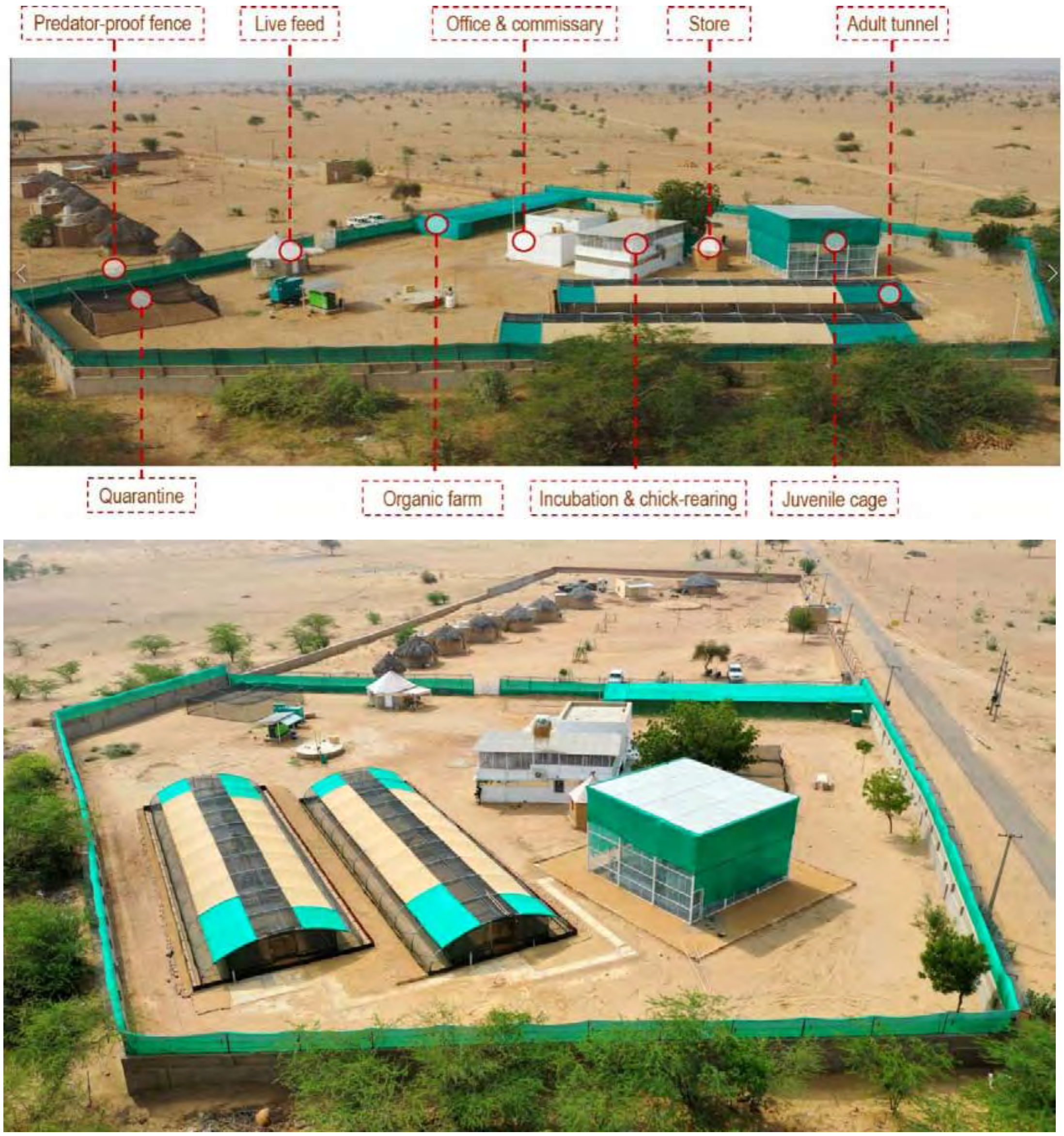

Image 5. Aerial photograph of the newly constructed Great Indian Bustard Conservation Breeding Centre at Sam in Jaisalmer District, Rajasthan (August 2019) © WII

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 m × 1.5 mdimension, 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 (≥ four months). A metal cage of 10m × 10m dimension was constructed to house juveniles (≥ 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 3m × 2m 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 out post 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 Consrvation/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).

(c)

(d)

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 interactionswith 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

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 ovation 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 hatchers (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

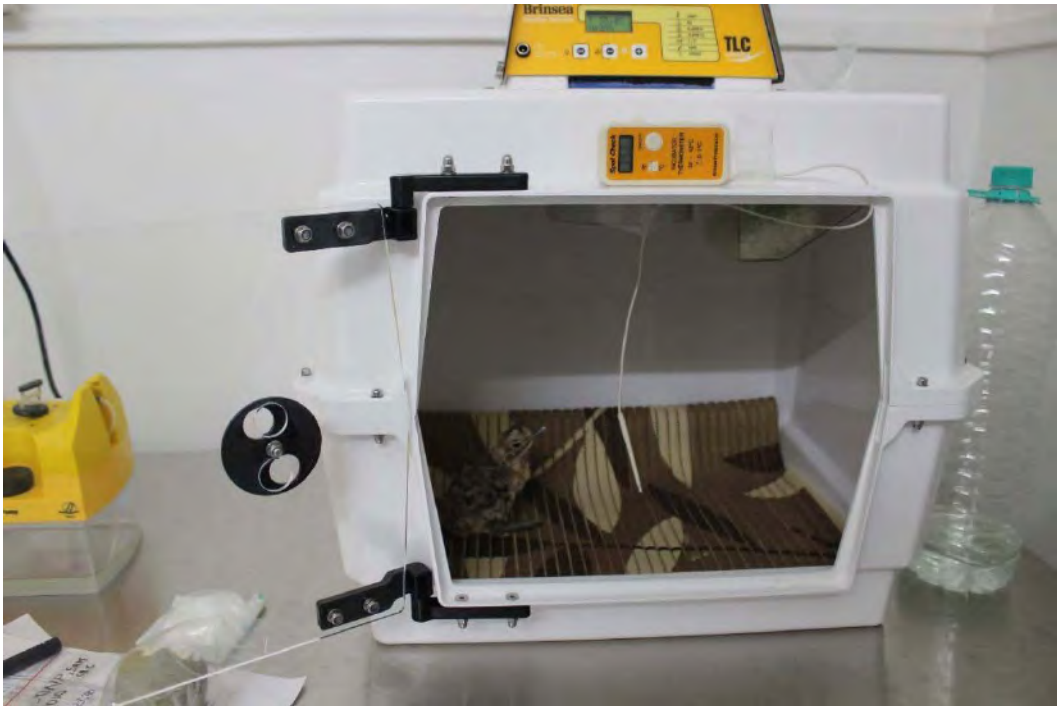

Image 21. Freshly hatched chick placed inside the brooder for drying at the Great Indian Bustard Conservation Breeding Centre in Sam, Jaisalmer © WII

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 birdson 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 chick 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.

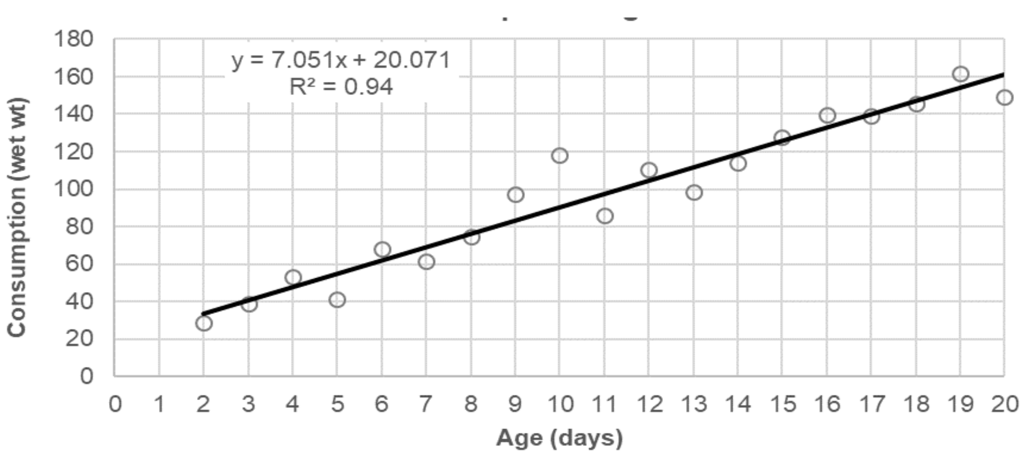

Figure 3. Relationship between age and consumption expressed as wet weight in grams of eight artificially hatched Great Indian Bustard chicks

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.

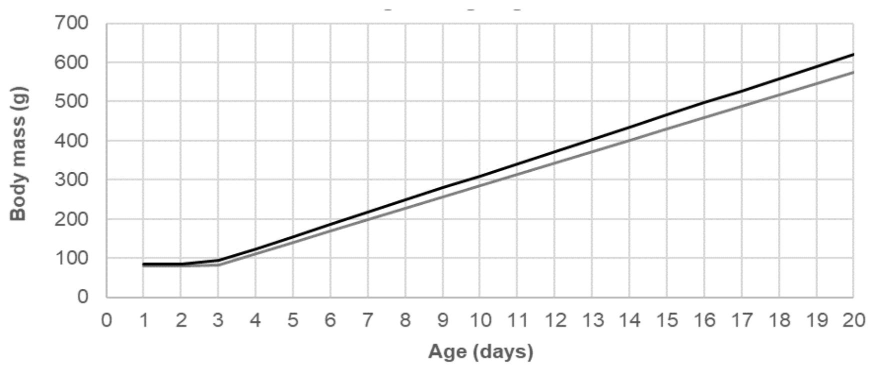

Figure 4. Body mass of average (grey line) and above average (top 25% birds in black line) captive female Great Indian Bustard chicks against age (days), showing the preferred growth rate

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 25^0 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 -35^0C and RH of 60 -80%, and provided with food 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.

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 fromthe 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 km^2 (three years' long-term usage of GIB-Kachchh-01) – 124 km^2 (three months' short-term usage of GIB-Thar-5946). The 50% usage areas of birds were relatively small, ranging between 13–29 km^2. 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 km^2. 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.

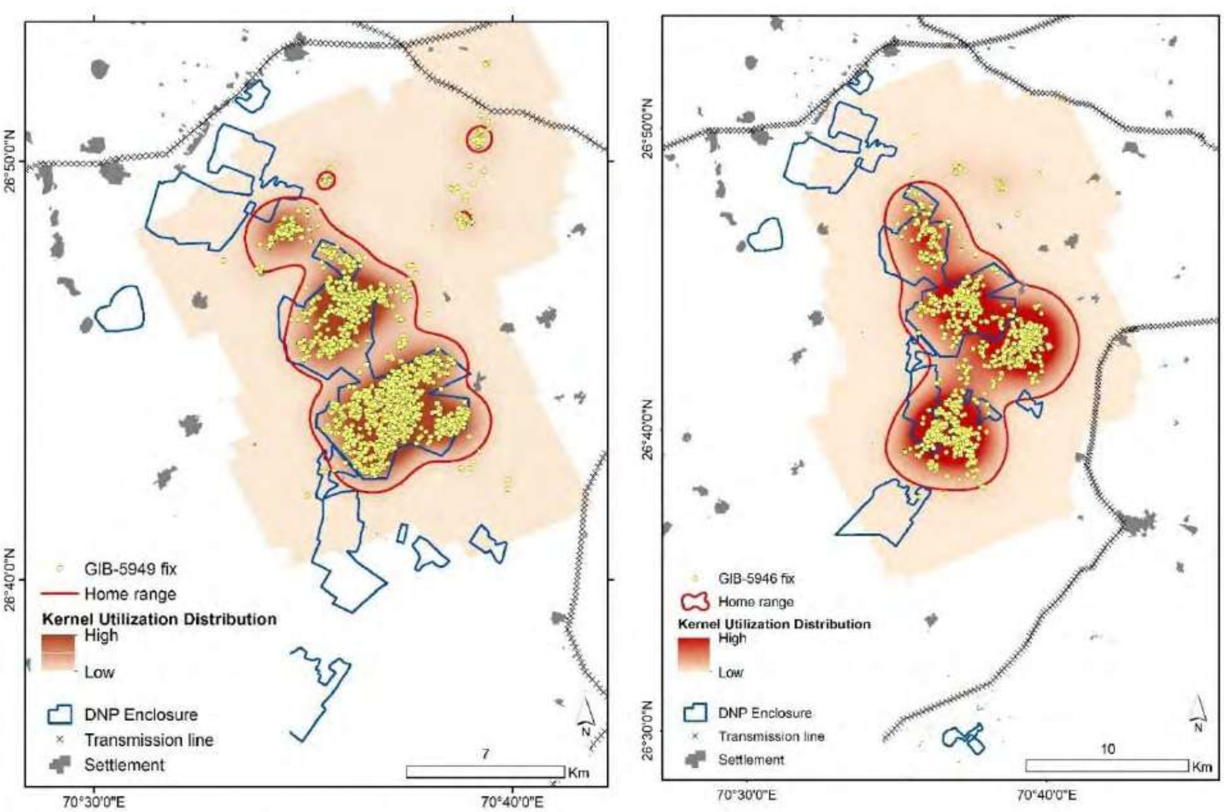

Figure 5. Space use (GPS fixes and home range estimated as Kernel 95% contour) of two tagged GIB females in Thar during March – October 2019

These results corroborate the recommendation of Dutta et al. (2013)'s National Bustard Recovery Guidelines that enclosures of 10-20 km^2 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.

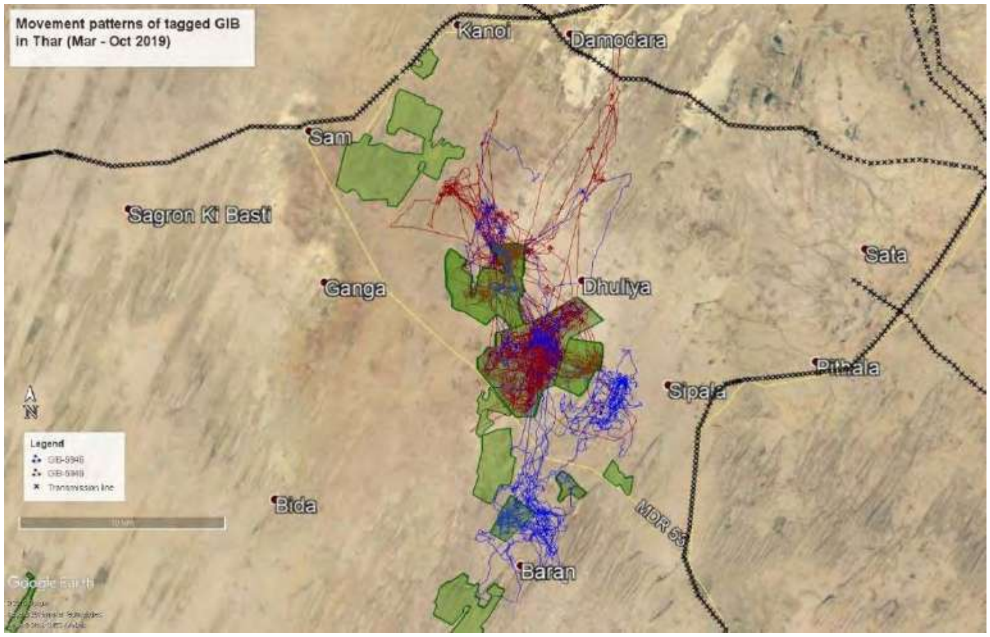

Figure 6. Movement paths of two tagged Great Indian Bustard females during March – October 2019 overlaid with high tension power line in Thar

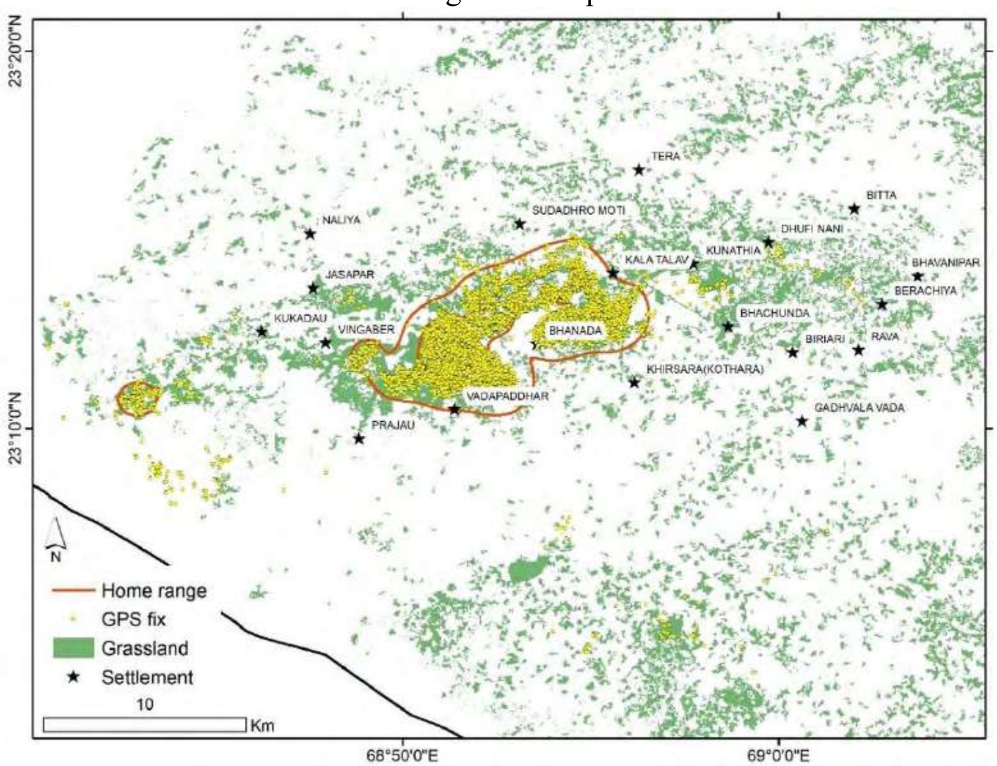

Figure 7. Space use (GPS fixes) of tagged Great Indian Bustard female in Kachchh from May 2017 to October 2019

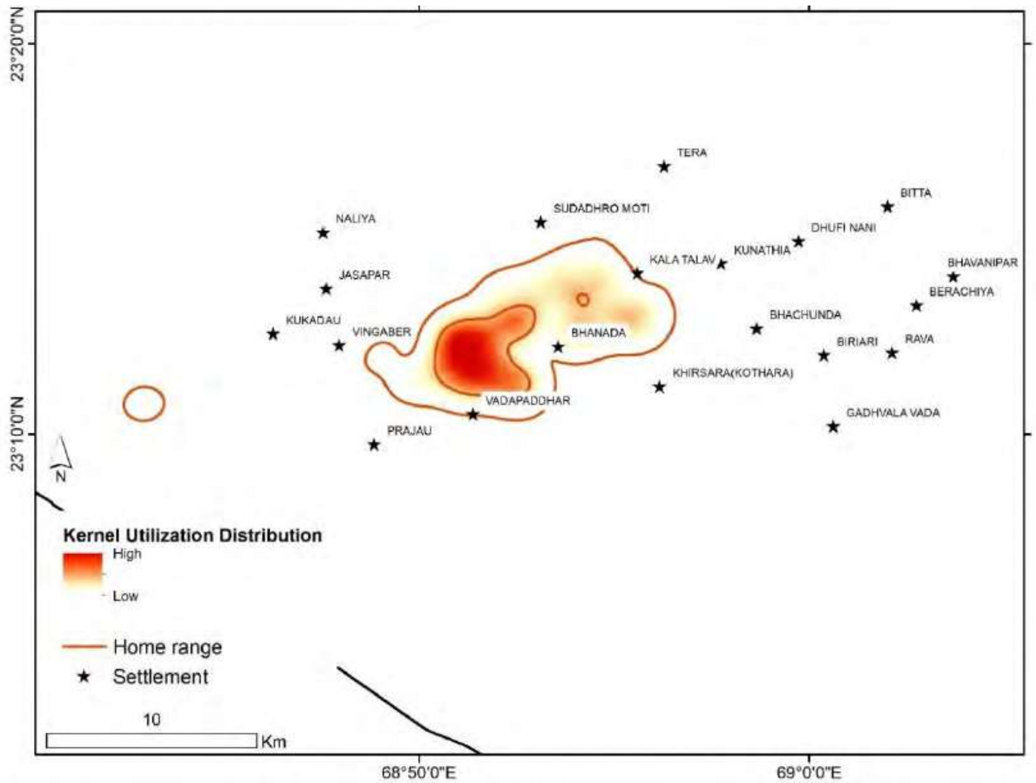

Figure 8. Space use (Home range estimated as Kernel 95% contour) of tagged Great Indian Bustard female in Kachchh from May 2017 to October 2019

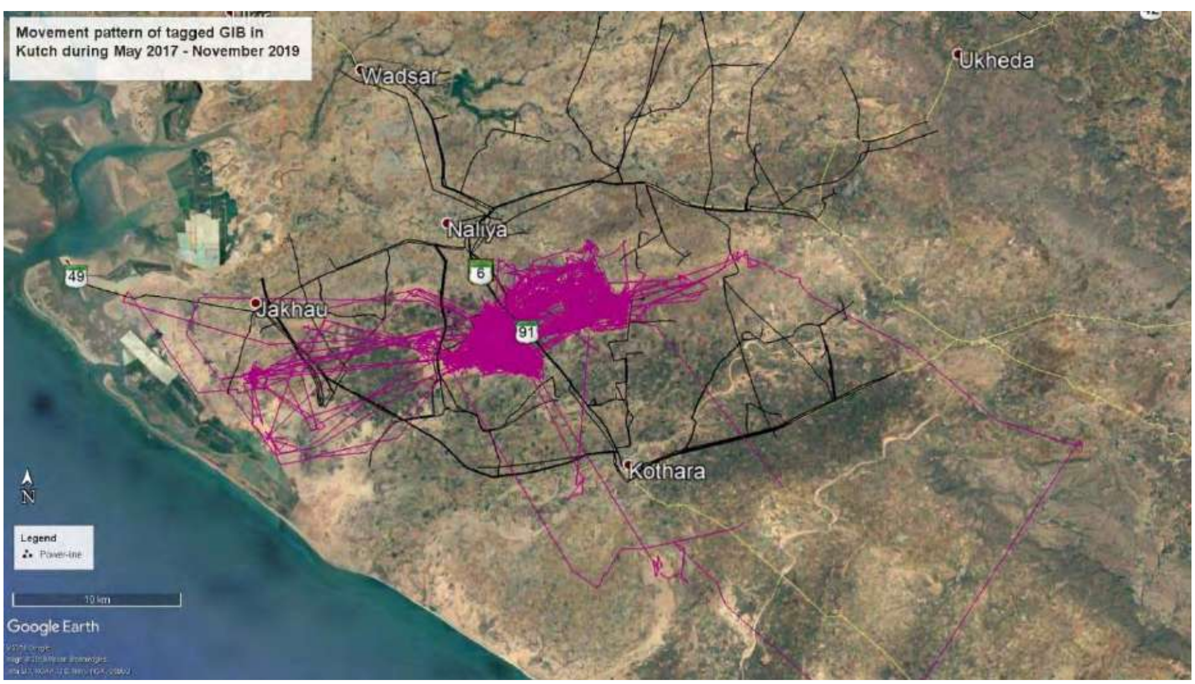

Figure 9. Movement path of tagged Great Indian Bustard from May 2017 to October 2019 overlaid on power line network (partially mapped) to prioritize power line mitigation in Kachchh.

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 collects 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)

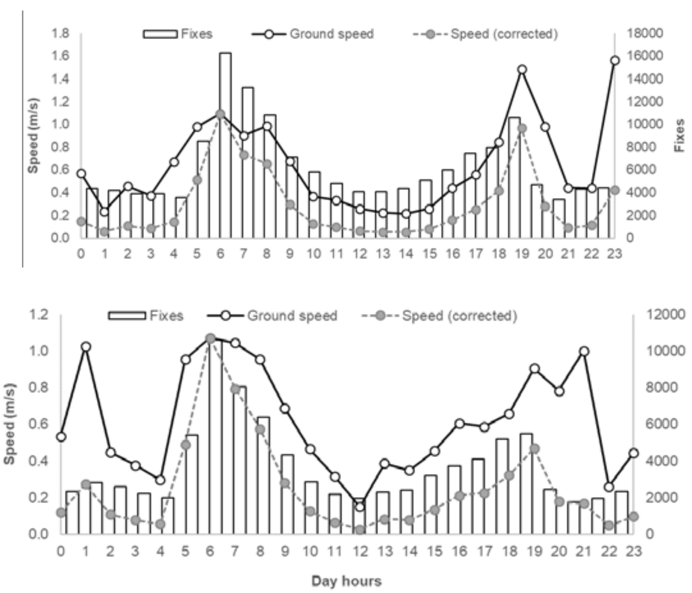

Figure 10. Ground speed: (i) estimated by tag using Doppler effect (black solid line), (ii) conservatively corrected for increased fix acquisition during peak movement hours (grey dotted line), and (iii) count of fixes (open bars) of tagged Great Indian Bustard(GIB-Thar-5949: top and GIB-Thar-5946: bottom) 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 ms^{-1} or >7 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).

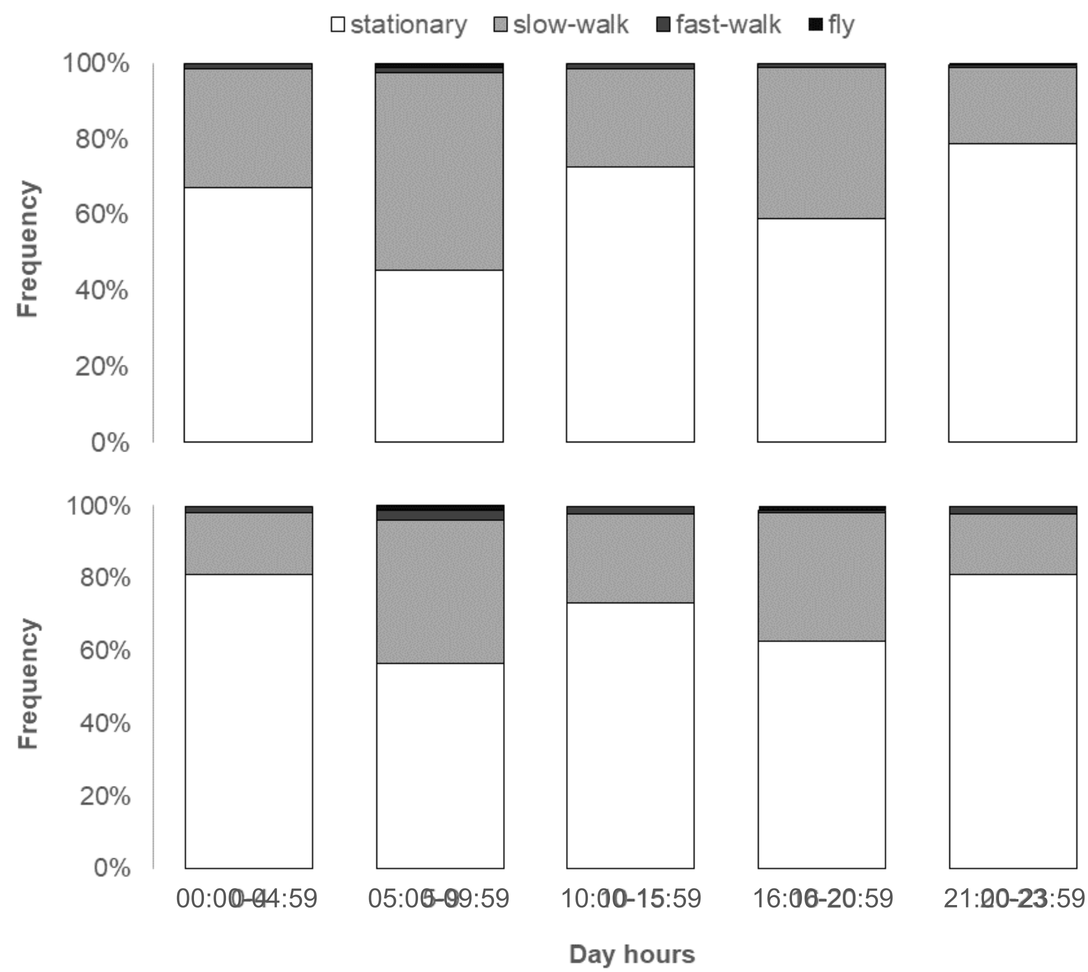

Figure 11. Frequency of independent events (separated by 1-hour for uniformity) classified into four movement classes: stationary (ground speed <0.3 ms^{-1}), slow-walk (0.3–1.0 ms^{-1}), fast-walk (1.0–2.0 ms^{-1}) and flight (>2 ms^{-1}) across hour of the day for tagged Great Indian Bustards(GIB-Thar-5949 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 ± 4.65SD for GIB-Thar-5949, 11.9 ± 4.7SD for GIB-Thar-5946 and 6.2 ± 4.1SD 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).

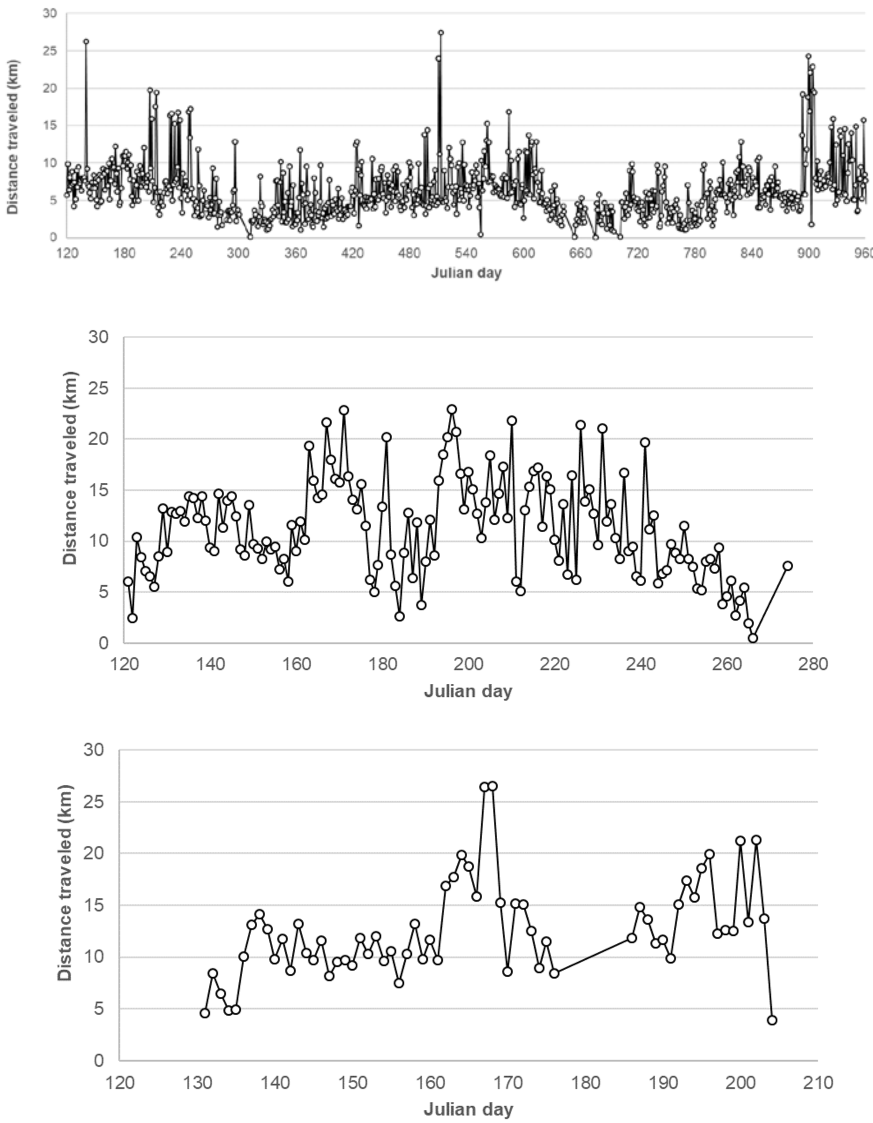

Figure 11A. Distance traveled by tagged Great Indian Bustard(top to bottom: GIB-Kachchh-01, GIB-Thar-5949 and GIB-Thar-5946) in Kachchh and Jaisalmer against Julian days starting from 30th April 2017 in Kachchh and 31st March 2019 in Jaisalmer to November 2019

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). Any 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.

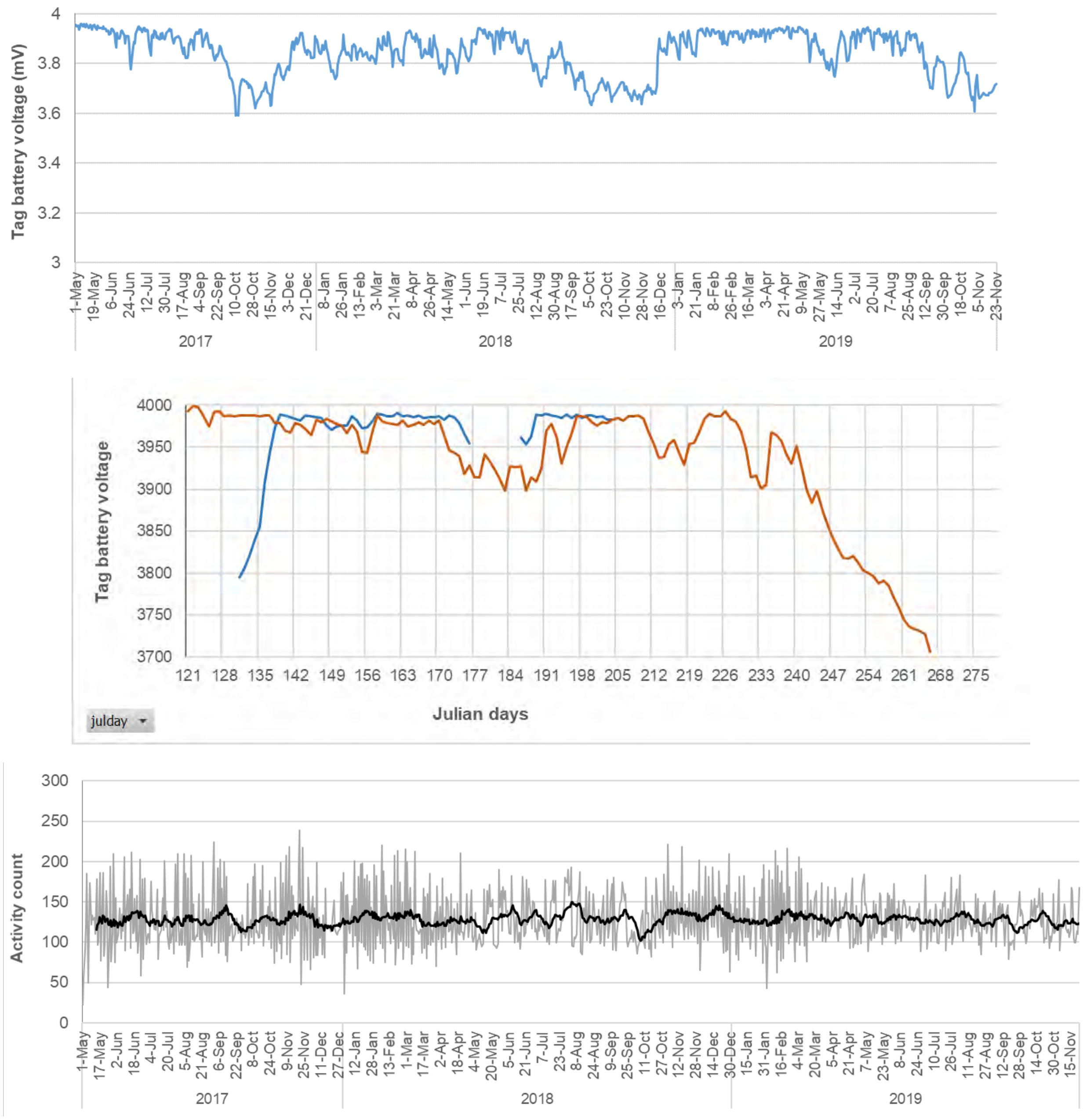

Figure 12. Tag performance diagnostics: battery voltage (top: GIB-Kachchh-01, middle: GIB-Thar-5946 in blue, GIB-Thar-5949 in red) and activity count based on activity sensor (bottom) of tagged Great Indian Bustard in Jaisalmer and Kachchh from March 2017 to November 2019

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 excercise, 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 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.

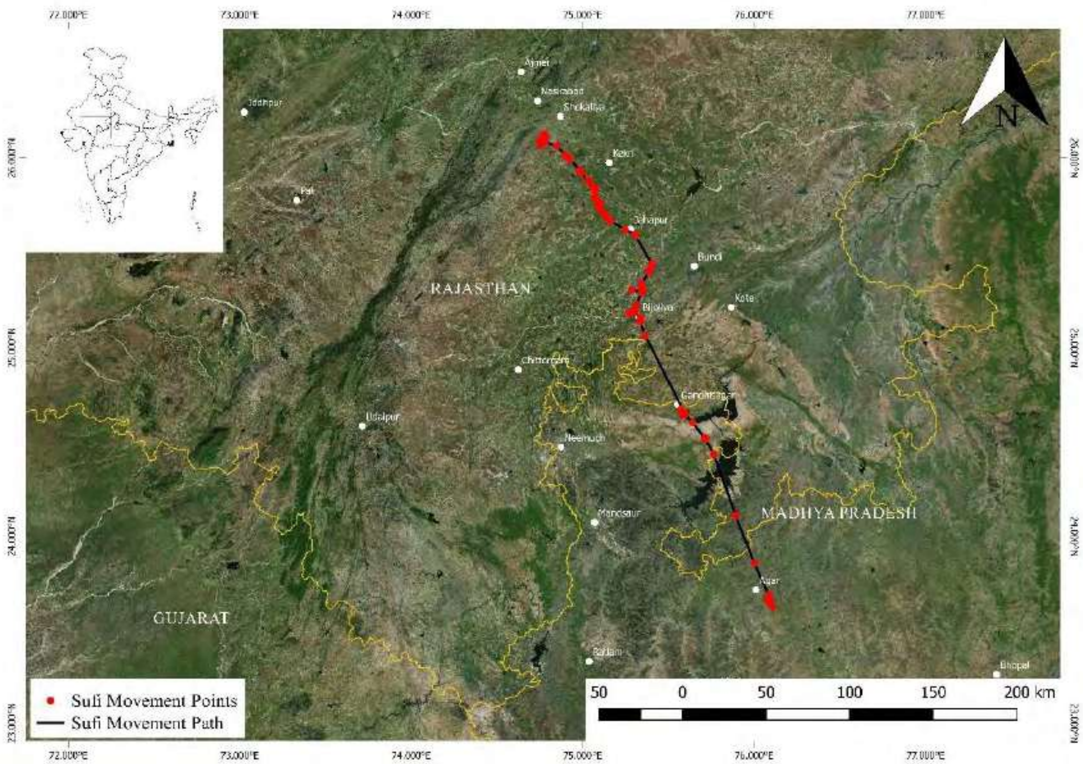

Figure 13. Movement of tagged Lesser Florican male (named Sufi) from 15th September, 2019 - 23rd February, 2020

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 Khera 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 Bijojiya till 18th November where after it moved inside Gandhi Sagar Wildlife Sanctuary, Mandsaur (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.

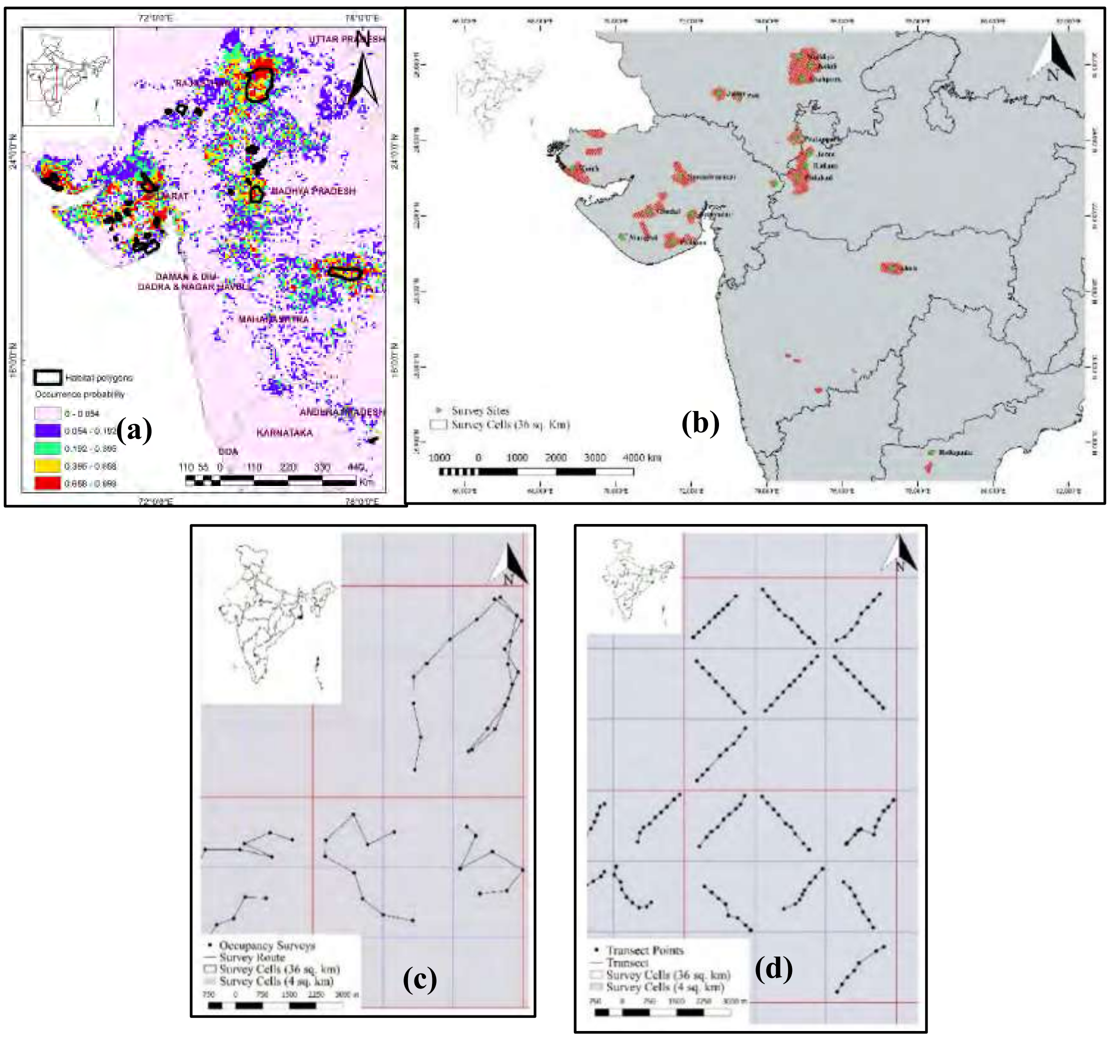

Figure 15. Habitat suitability map showing occurrence probability of Lesser Florican across its breeding range based on Maxent modeling along with digitized habitat polygons (b) Breeding range classified into survey regions, landscape and sites, Graphical representation of (c) point-count based occupancy 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 km^2 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 protocolthrough state-level workshops at Bhavnagar, Ujjain, Ajmer and Akola (Table 7). Lesser Florican occupancy was assessed at 545 sites (36 km^2) spread across ~31,000 km^2 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 km^2 area, at ecological density of 0.20 (0.07SE) territorial males per km^2 (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 SE) km^{-2} and clustered at high density in Gujarat - occupancy 4 (2 SE) % and ecological density 0.72 (0.32 SE) km^{-2}, mostly within a small grassland reserve and surrounding area in Bhavnagar (~100 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 ~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 pan 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	Pratap-garh	Ratlam	Rolla-padu	Saur-ashtra	Shah-pura	Sho-kaliya	Global
Land-uses	Grassland	Proportion cover	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		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	Frequency occurrence	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		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	Pratap-garh	Ratlam	Rolla-padu	Saur-ashtra	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)
Disturbances	Dog	Frequency occurrence	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		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)
	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)
Associated species	Blackbuck	Frequency occurrence	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)
	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		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

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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 km 2 into 50 blocks of 144 km 2 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,

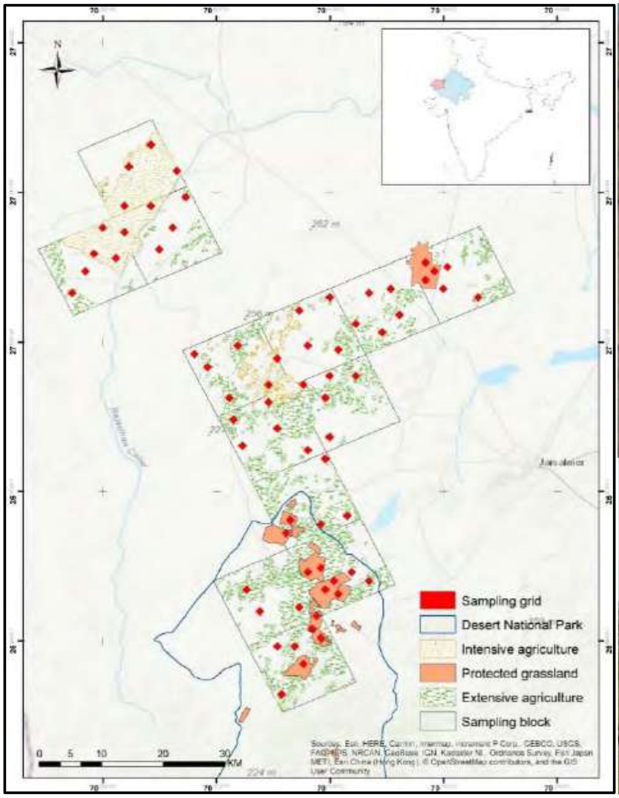


Figure 16. Map of surveyed area with dominant land-use types, **Image 32**. Protected grassland and agriculture, in Jaisalmer district of Western Rajasthan © Bipin C.M.

(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 land and 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 km^2 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 × 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 × 10m plot, grasses (genus, % cover, height) in four nested $1m^2$ 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 km^2) 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.

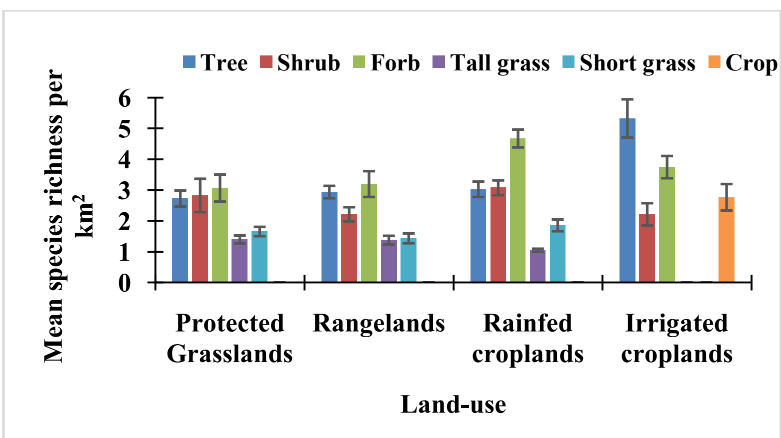


Figure17. Mean species richness per km^2 of each plant form according to the land-use type. Error bars are standard errors.

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).

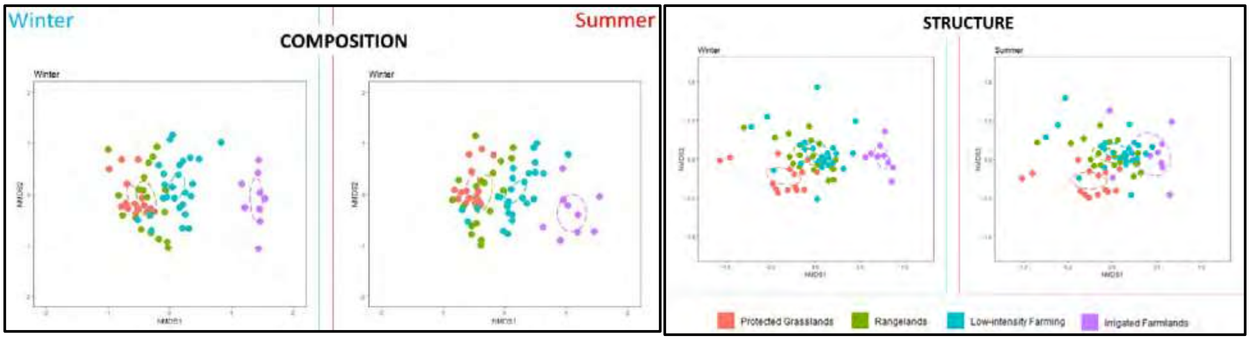
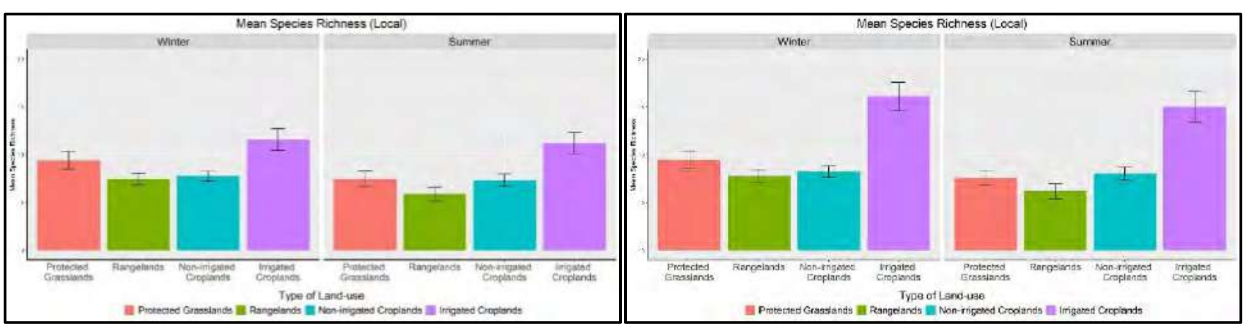
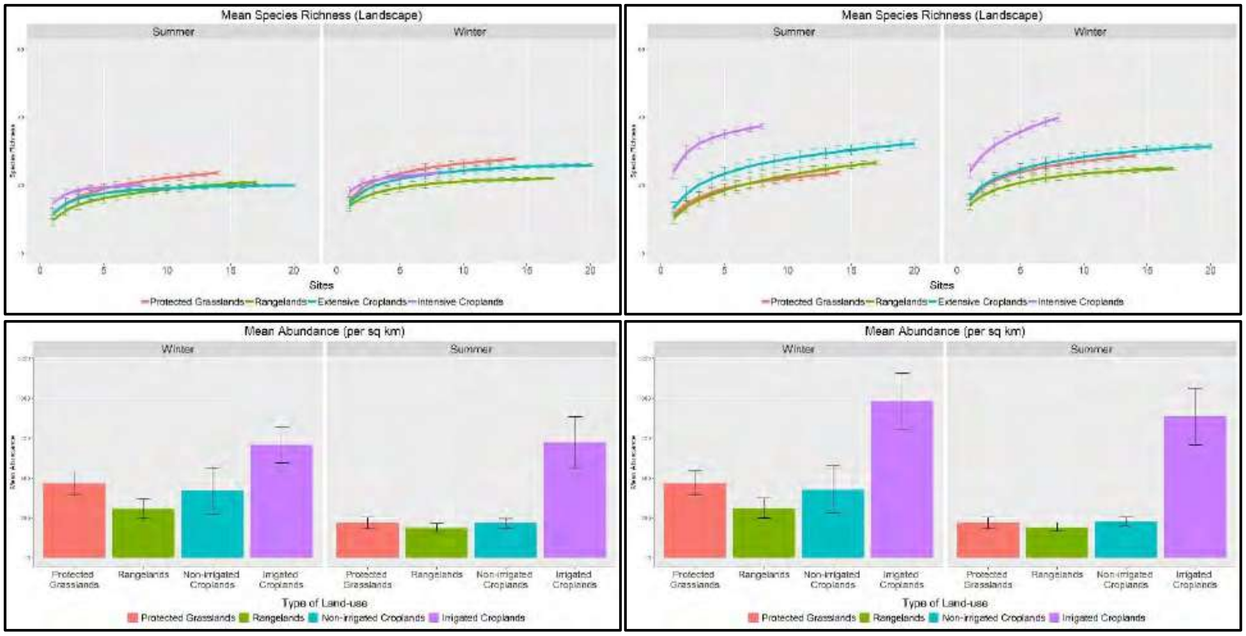


Figure 18. Non-metric multidimensional scaling ordination showing differences in composition and structure of vegetation in different land-use types during winter and summer.

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 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. 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.





Native species **All species**

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.

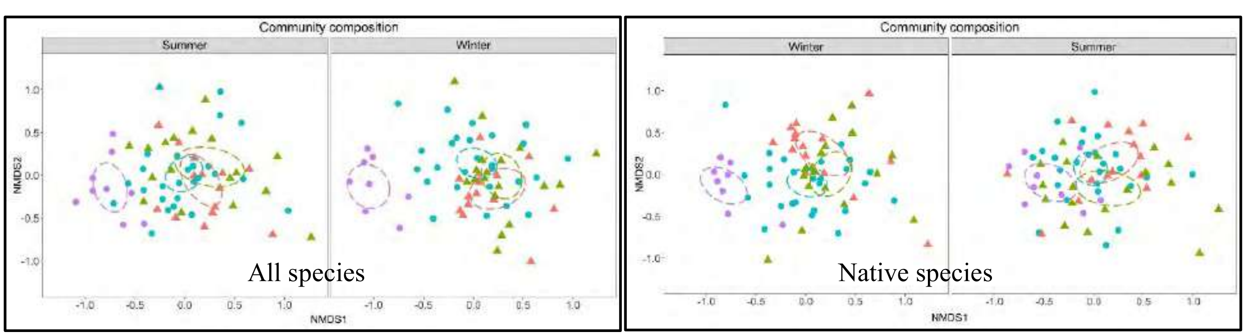


Figure 20. Non-metric multidimensional scaling ordination showing bird community composition of all bird species (left) and native bird species (right) in different land-use types during winter and summer seasons.

In both the seasons, species richness was positively associated with the foliar volume of woody vegetation and negatively associated with forbe 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.

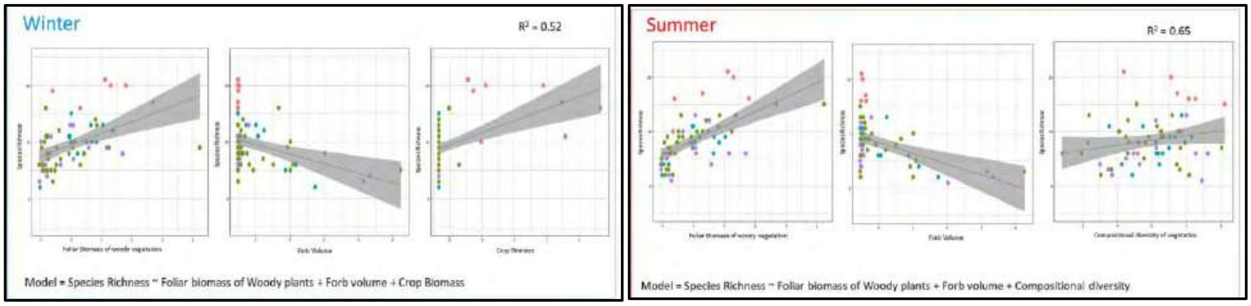


Figure 21: Habitat correlates of species richness during winter (left) and summer (right) based on the best fitting model.

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 lopping by provision of alternate firewood supply and reseeding 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-km^2 area spread across a 10,235 km^2 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 5m^2 plots and grasses (species, height, percentage cover) in five 1m^2 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 type 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.

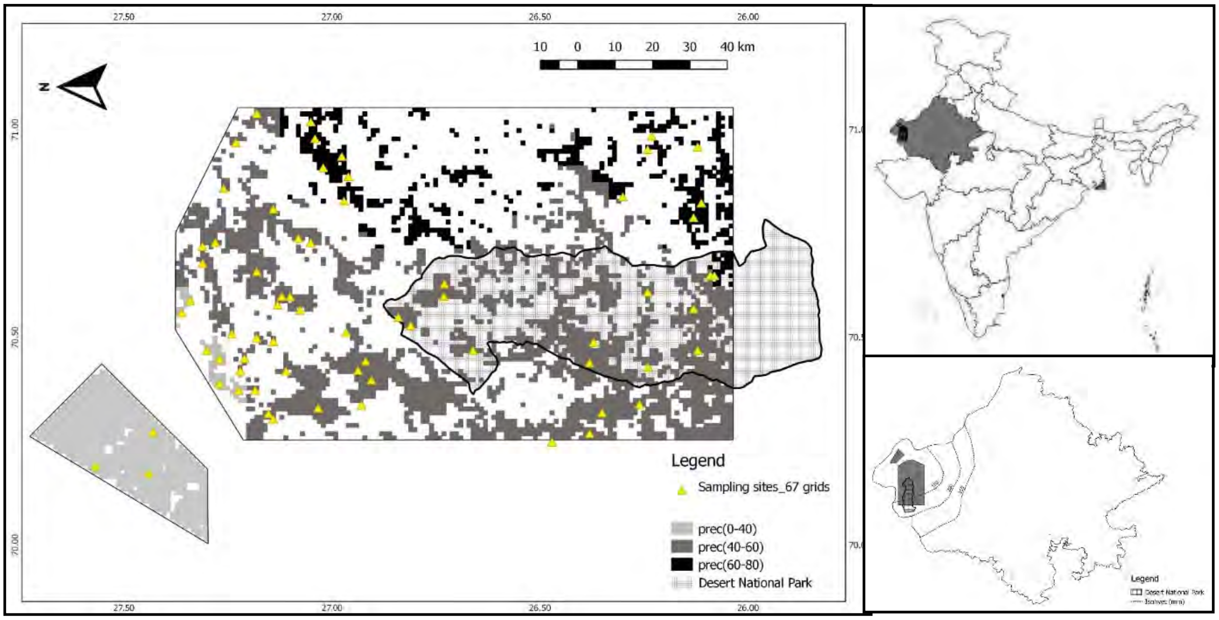


Figure 22. Map showing the plots sampled for vegetation characteristics in and around Desert National Park, Jaisalmer. The isohyet lines show 150 mm, 200 mm and 250 mm precipitation

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, rodded and loose bulk densities. 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 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 *Dactylotenium scindicum* 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 e^{-06}). 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).

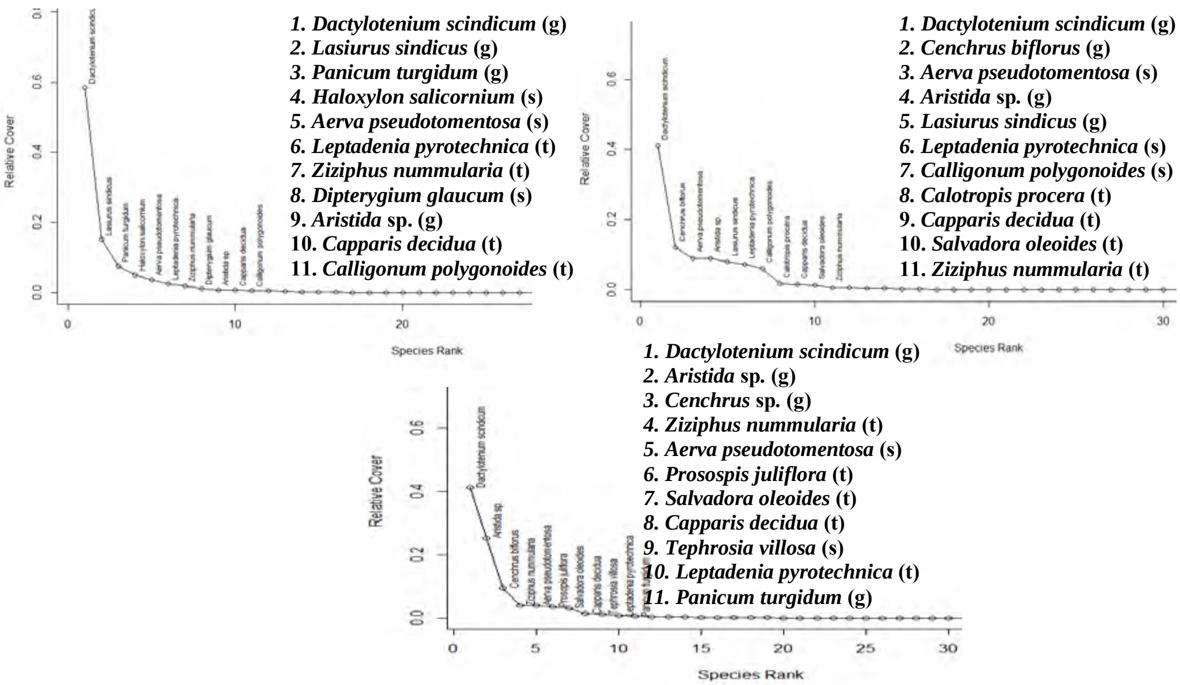


Figure 23. Rank-abundance curve across precipitation classes with the habit for the species indicated in parenthesis: g - grass, t – tree, s – shrub. (Top left) corresponds to low precipitation gradient (0-40 mm), (Top right) with medium (40-60 mm) and (bottom) with high (60-80 mm)

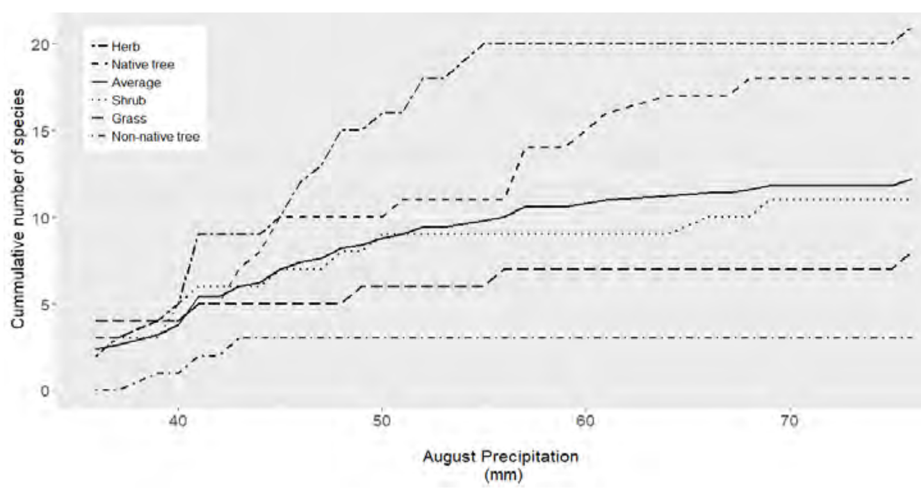


Figure 24. Species accumulation curve of all vegetation life forms along precipitation gradient

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

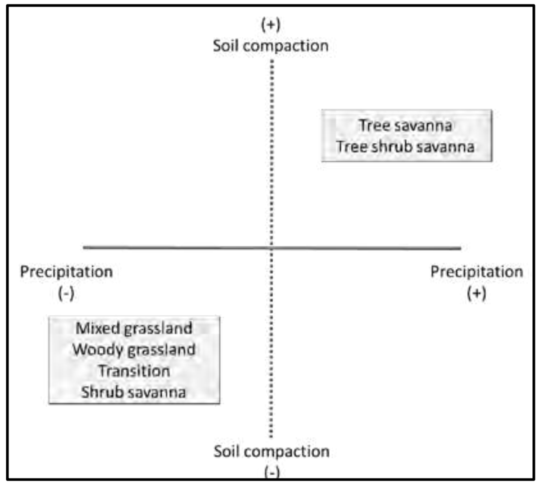


Figure 25: Visual representation of the factors that determine vegetation structure shifts (+) indicates increase in the determining factor and (-) indicates a decrease

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, 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). Shrubcover 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	Precip-itation	Soil				Density	
		Water holding capacity	% sand	Total organic carbon	Soil compact-ness	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 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.

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 (χ^2=25.76, df=18, p=0.1003) or life forms (χ^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.

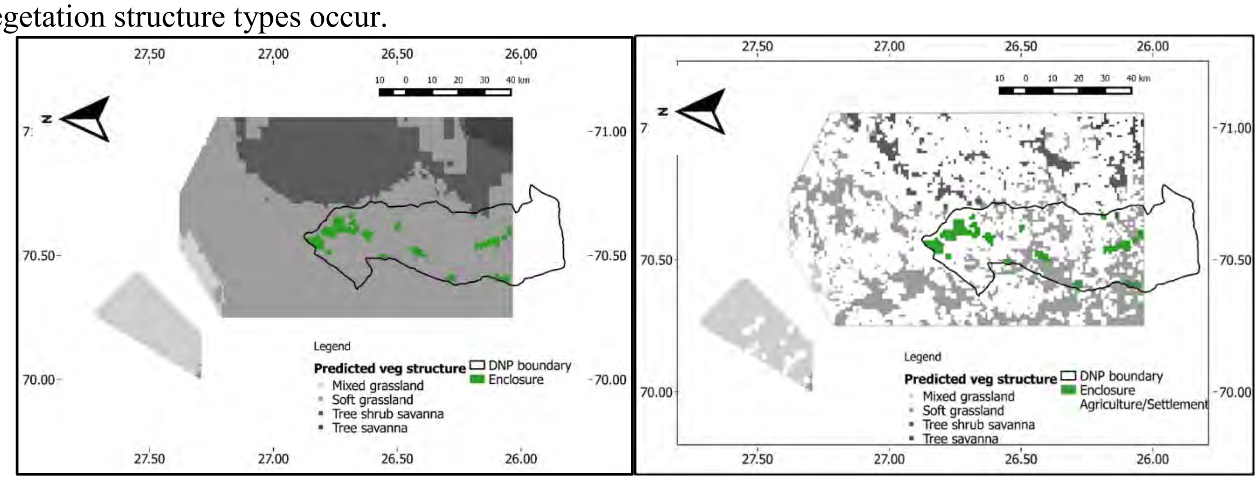


Figure 26. Predicted vegetation structure (left) and land-use types masking the vegetation structure types (right) in the study area highlighted with the regions protected by the Desert National Park

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 $1m^2$ 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).

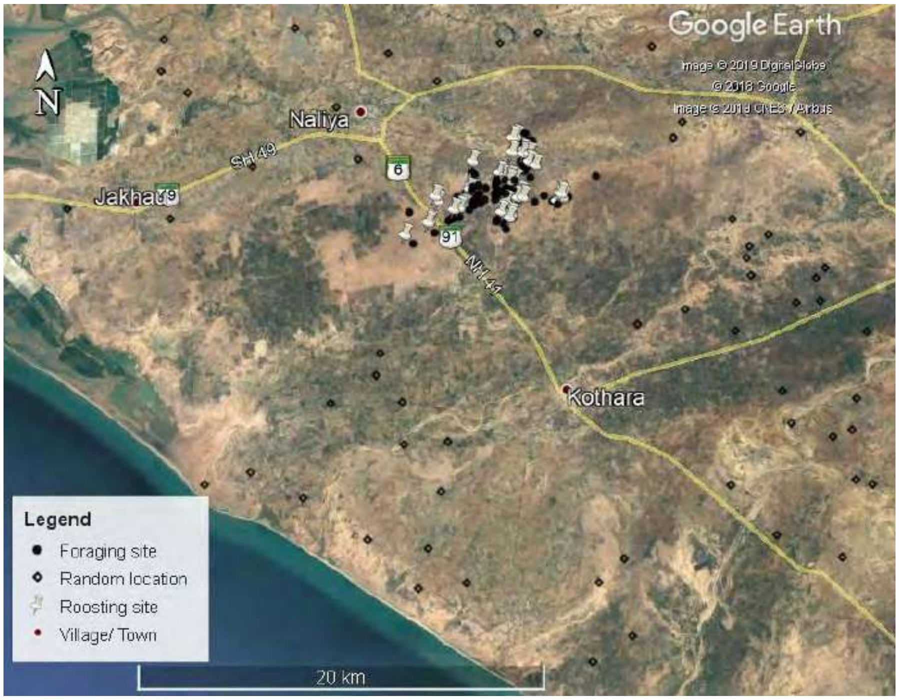


Figure 27. Map of locations sampled to assess the Great Indian Bustard habitat in Kachchh, Gujarat

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).

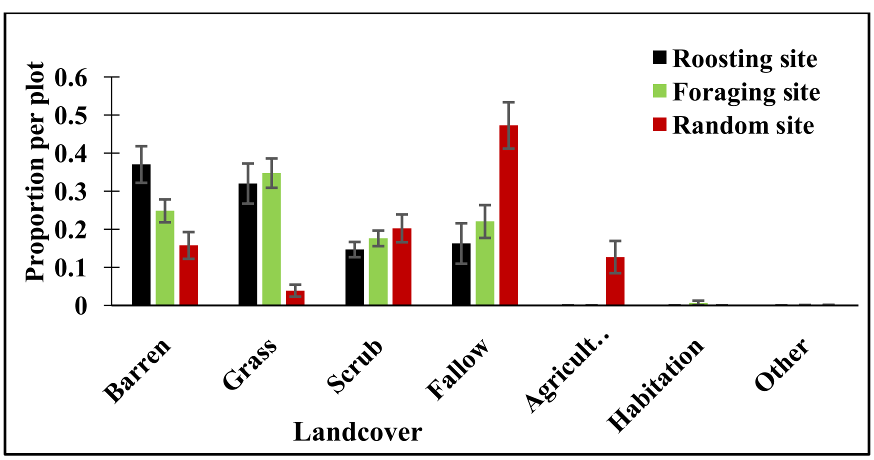
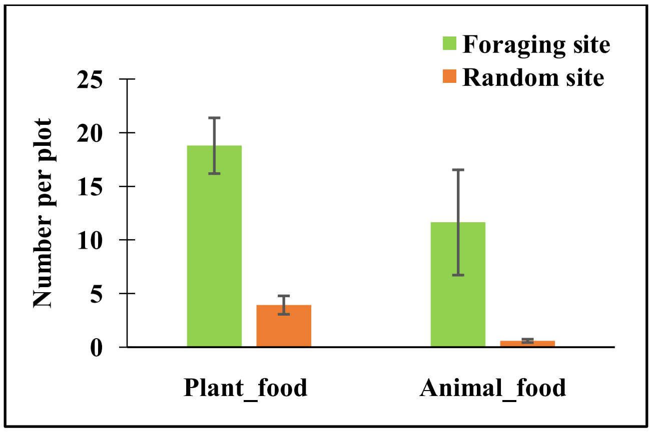


Figure 28. Comparison of proportion of different land-cover in Great Indian Bustard roosting, foraging sites and random locations during November-December 2018 in Kachchh, Gujarat (Error bars are standard errors)

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 *Capparisdecidua* fruits during winter (Figure 29). Termites were found only in one location and in high numbers.



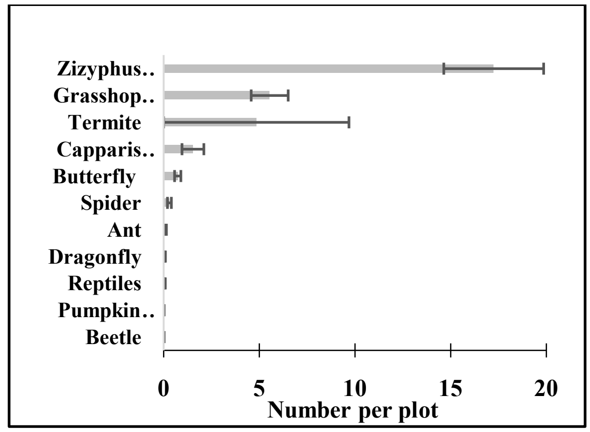


Figure 29. Comparison of Great Indian Bustard food available during November-December 2018 in Kachchh, Gujarat(Error bars are standard errors)

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.

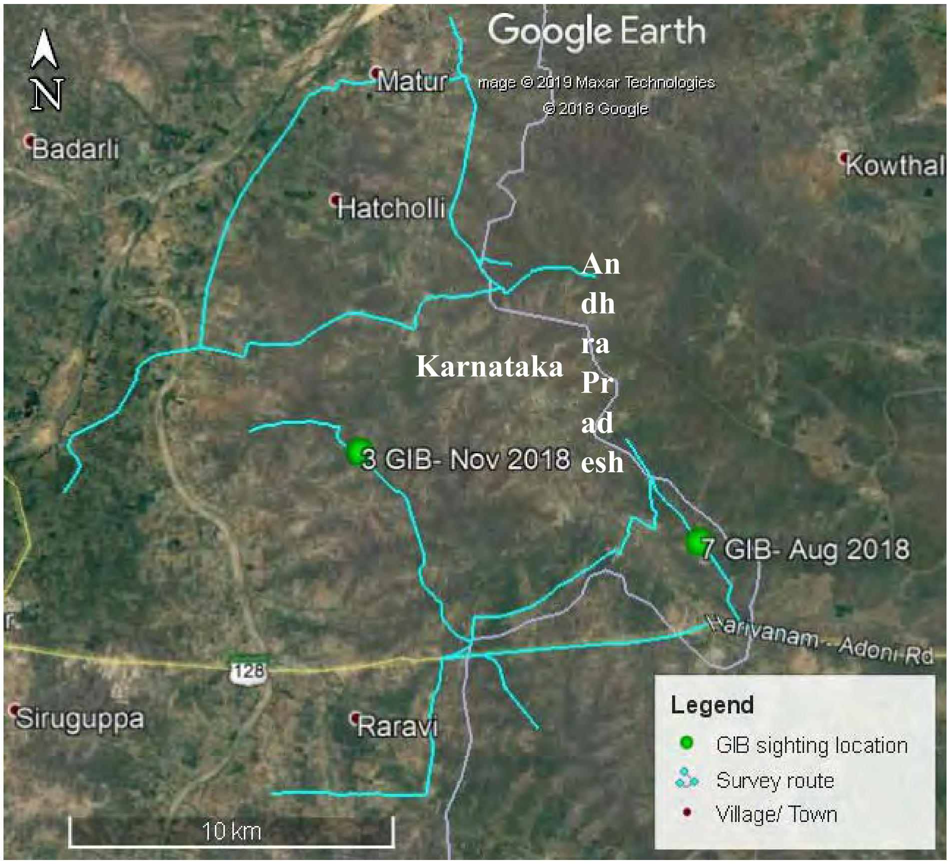


Figure 30. Map of the survey routes in Siruguppa Taluk, Ballari District with locations of Great Indian Bustard sightings in 2018

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, 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.

Image 38: Photographs of Great Indian Bustard by Prof. Abdul Samad Kottur, Mr. Santosh Martin, and members of their conservation organization in and around Ballari District

Source: Great Indian Bustard in Karnataka: A note prepared bySantosh Martin and Samad Kottor, Bellary District, Karnataka

2.2.3. Assessment of threats

2.2.3.1. A ssessing i mpacts of p ower l ines on birds i n a multiple-use gr assland l andscape of Abdasa, Gujarat

Mitigation of bi rd m ortality due t o pow er l ines i s i ncreasingly be coming a n i mportant c onservation issue across the world. In areas harboring avian species that are under serious threats from habitat loss, poaching c ombined w ith f actors s uch as a l imited di stribution or s mall g lobal r ange, i t be comes paramount to understand the impact of power lines on birds for planning strategic mitigation measures. Since s everal ne w pow er pr ojects ar e coming up i n t he e cologically s ensitive K achchh r egion i n Gujarat which hosts a variety of avifauna including rare and threatened bird species such as the GIB and Lesser Florican, we assessed the impacts of power lines on the avian fauna in Abdasa Taluka of

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 km^2 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.

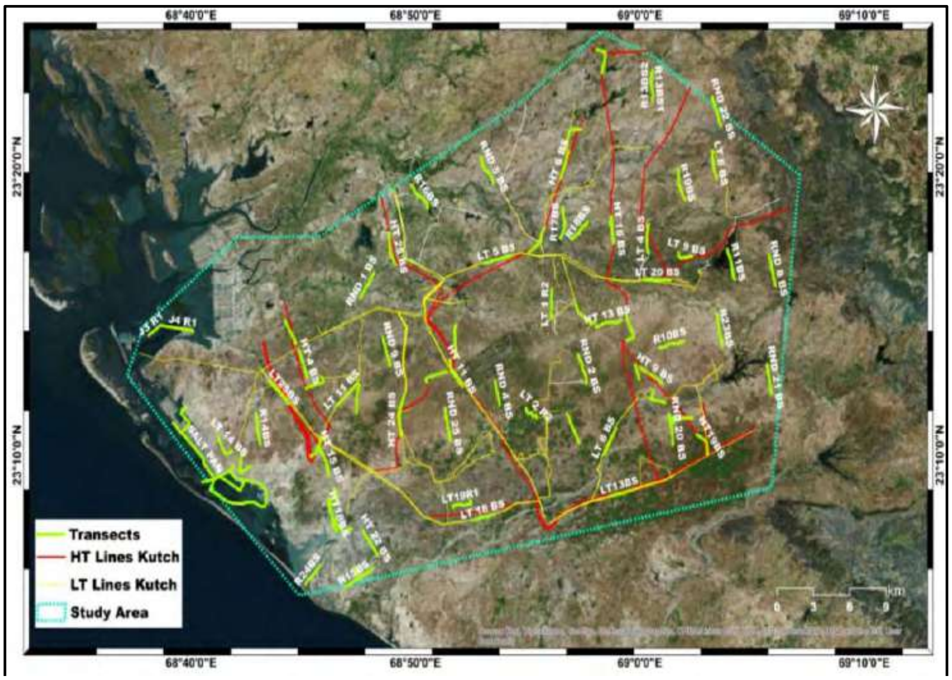
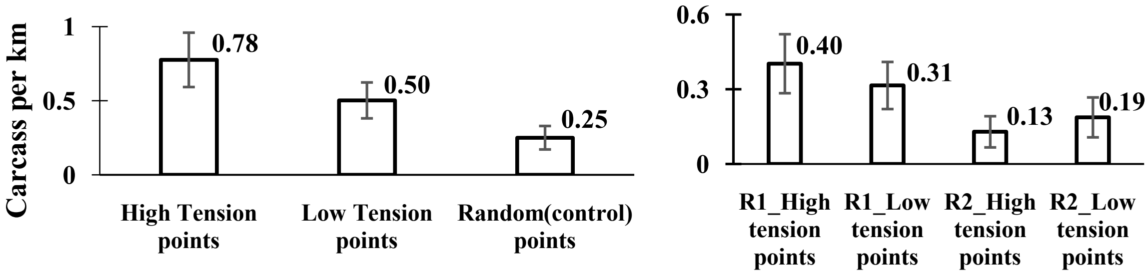


Figure 31. Map showing power line and random transects sampled during bird carcass survey in Kachchh landscape, Gujarat

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.



(a) (b)

Figure 32. Encounter rate of bird carcasses under power line and random transects during (a) base, (b) first and second replication surveysin 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 km^2), it was estimated that 1,818 birds die per month or ~ 22,000 mortalities annually because of power lines (Table 11).

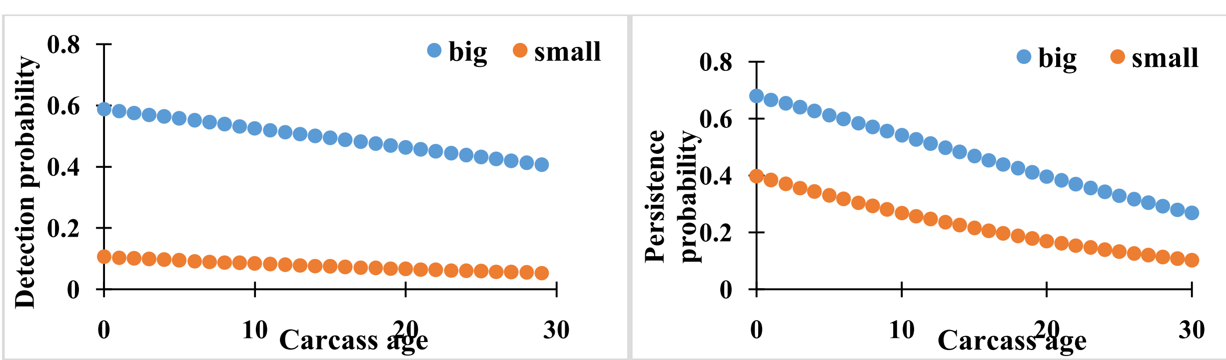


Figure 33. Probability of carcass detection and persistence of small (<100 g) and big (>100 g) birds estimated from carcass detection experiment in Kachchh landscape during April 2019.

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 × p	0.11
Corrected bird mortality	Carcass encounter rate ÷ 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 km^2 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.

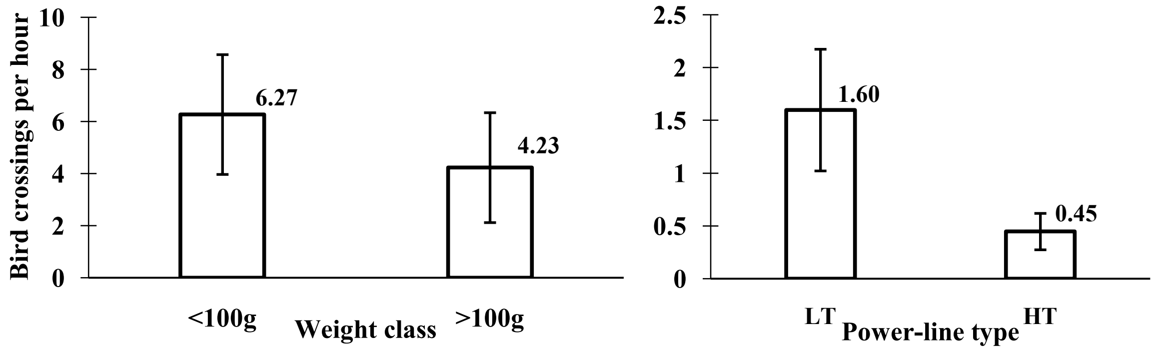


Figure 35. Bird crossing rate- (a) for small(<100g) and big (>100g) birds and (b) at low tension (LT) and high tension (HT) power lines in Kachchh landscape (Error bars are standard errors)

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 limited geographic distribution. The area holds high conservation significance owing to the presence of the endangered species such as GIB and Lesser Florican, 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), Nagarjusagar Srisailam 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 km^2 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.

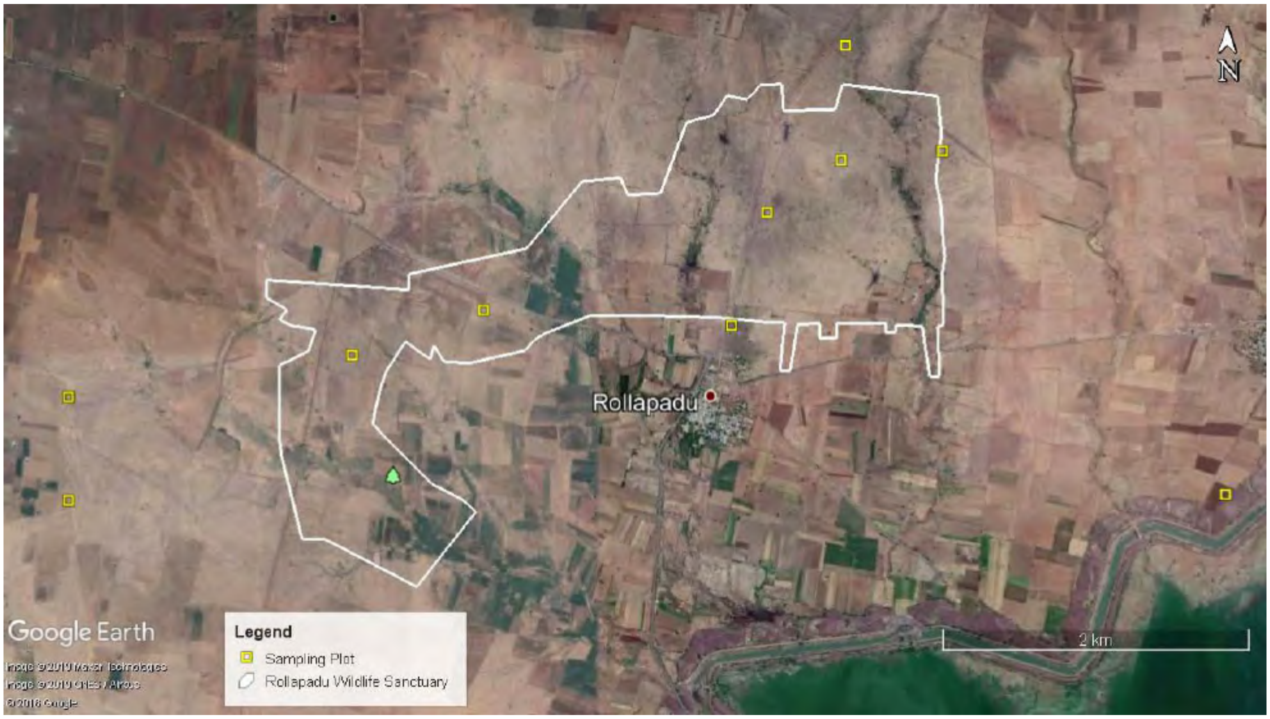


Figure 37. Map of the sampled locations for pesticide presence in and around Rollapadu Wildlife Sanctuary, Andhra Pradesh

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 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 E PA, 1989) . G uthion i s m oderately to xic to birds but a cute s ymptoms of thi s pe sticide 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		Ronnel		Chlorpyrifos	
Sample	**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	-	-	-	-	-	-	-	-	-	-	-	-
S- Soil sample, I- Insect sample, - Not detected/ Below detection limit												

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 had 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 km^2 (Figure 38). Different classes of pesticides use were reported (Table 13), especially in the agricultural areas of Rajasthan and Gujarat (Image 44).

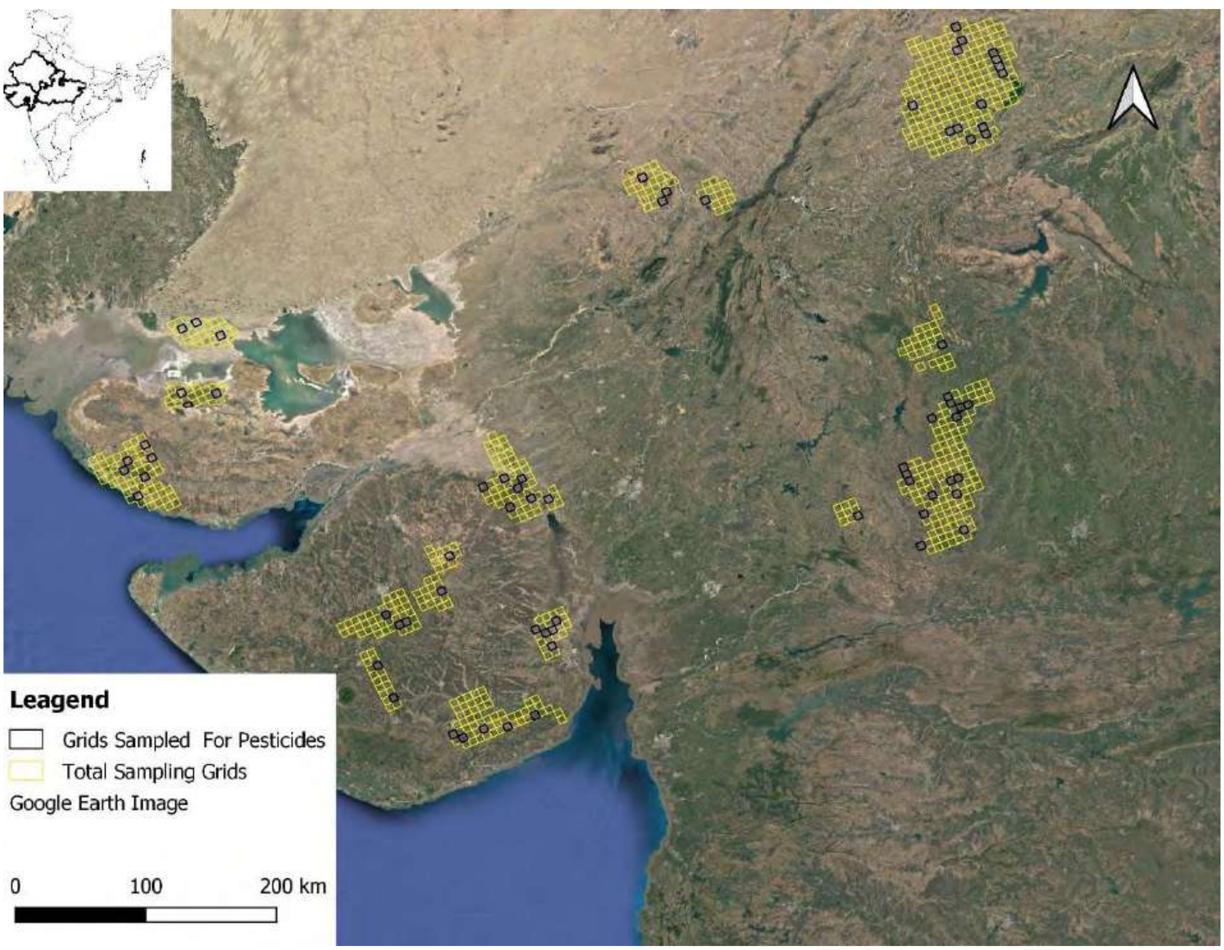


Figure 38. Map of areas sampled (in black) for pesticide use in Lesser Florican habitat (yellow) in Rajasthan, Gujarat and Madhya Pradesh

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 nicotinergic 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 12^{th} and 15^{th} 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 28^{th} May to 3^{rd} 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 km^2 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 m^2 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 km^2 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 km^2. Highest density was found in grid 66 (Figure 40) with 22000 locusts per km^2 followed by grids 67 and 78. Animal carcasses were not detected during the survey.

(a) **(b)**

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

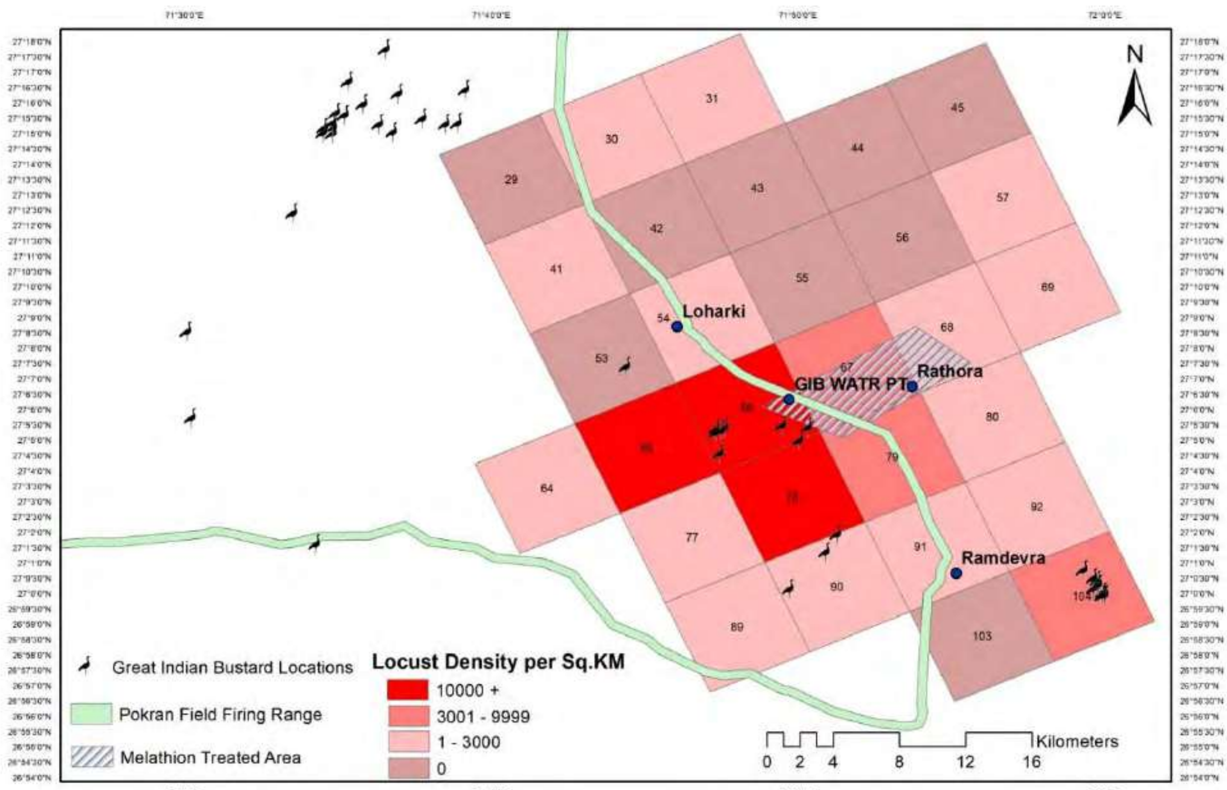


Figure 40. Map of the surveyed area for estimating locust abundance using grid based sampling in Thar, Jaisalmer

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 µl reaction mixture, each containing 5µl of 1x multiplex PCR Master mix buffer (QIAGEN Multiplex PCR kit, Germany), 1x of bovine serum albumin, 4 µm 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 $P_{(ID\text{-}sibs)}$ (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 (Na), mean number of alleles (MNA), expected (He) and observed (Ho) 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. ARLEQUIN 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 as 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 clustered 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 $P_{(ID\text{-}sibs)}$ value of 4.0×10^{-2} indicating sufficient power to discriminate individuals and siblings (Figure 41).

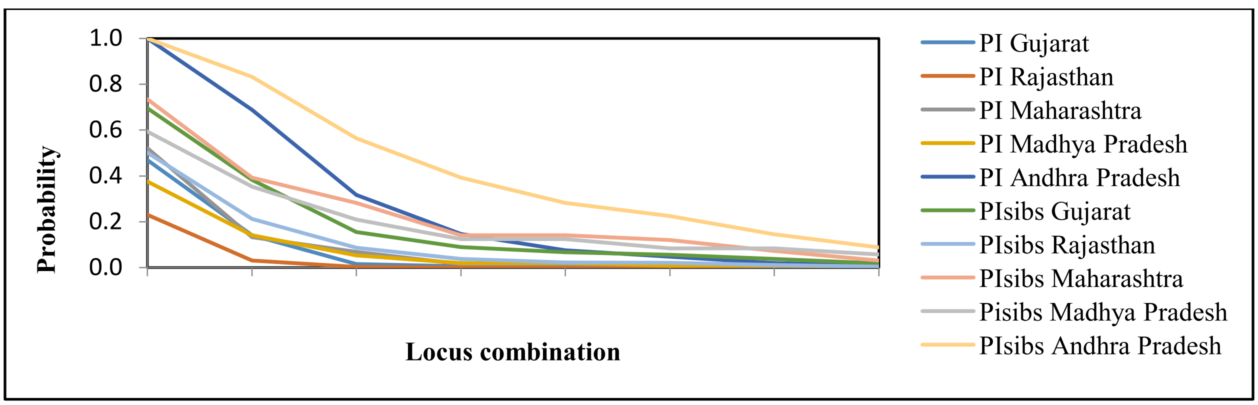


Figure 41. Population-wise Probability of- Identity ($P_{(ID)}$) and Identity of Siblings ($P_{(ID\text{-}sibs)}$)

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).

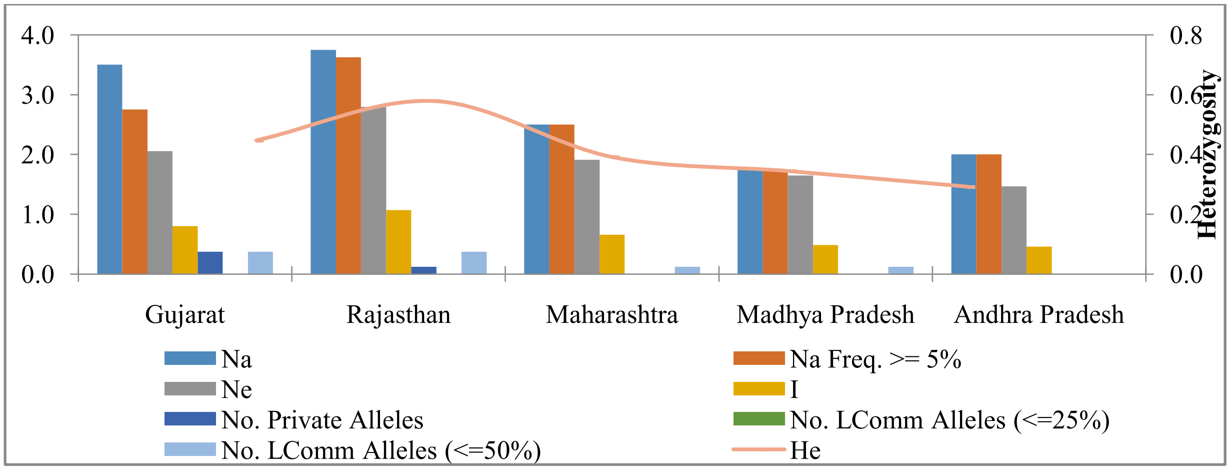


Figure 42. Population-wise allelic patterns and genetic diversity estimates

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 ± 0.0038SE) followed by Gujarat and Andhra Pradesh (F_{ST}: 0.30 ± 0.0SE) and Madhya Pradesh and Andhra Pradesh (F_{ST}: 0.278 ± 0.08SE) subpopulations. High levels of gene flow was observed between Rajasthan and Gujarat (F_{ST}: 0.06 ± 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
MaharashtraVs Madhya Pradesh	***0.06011 ± 0.48203**
MaharashtraVs 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).

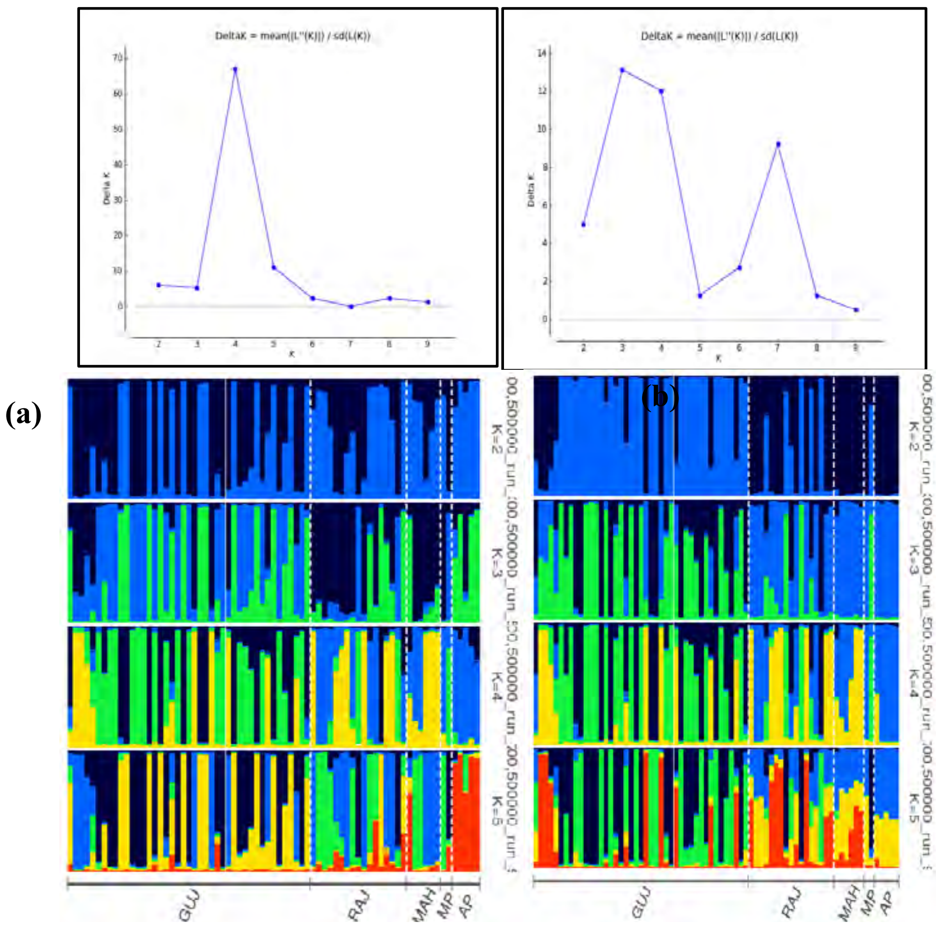
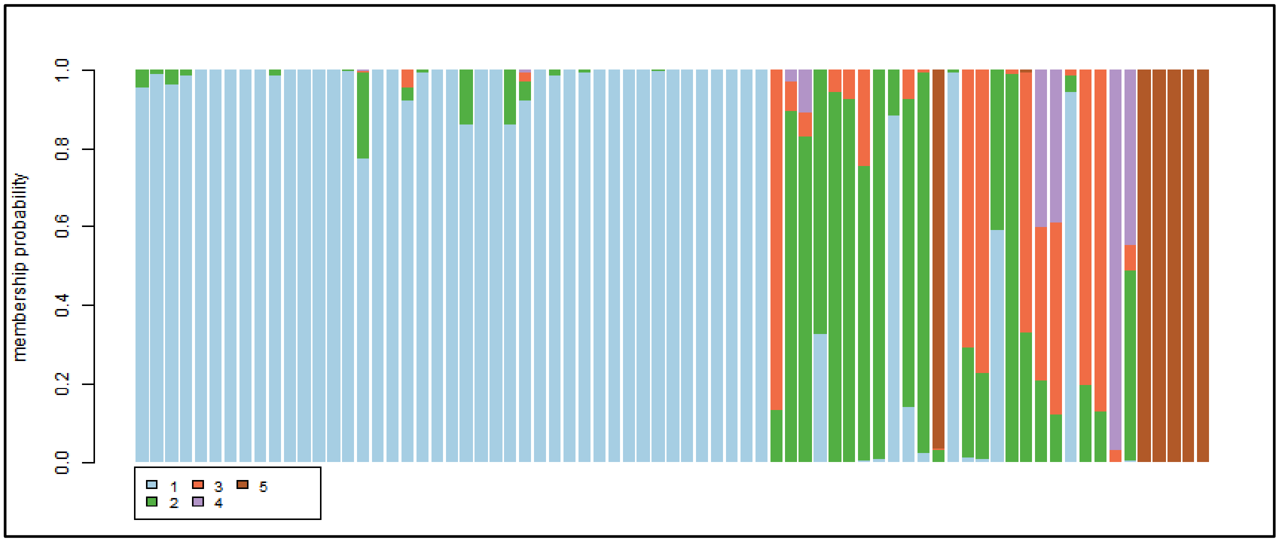


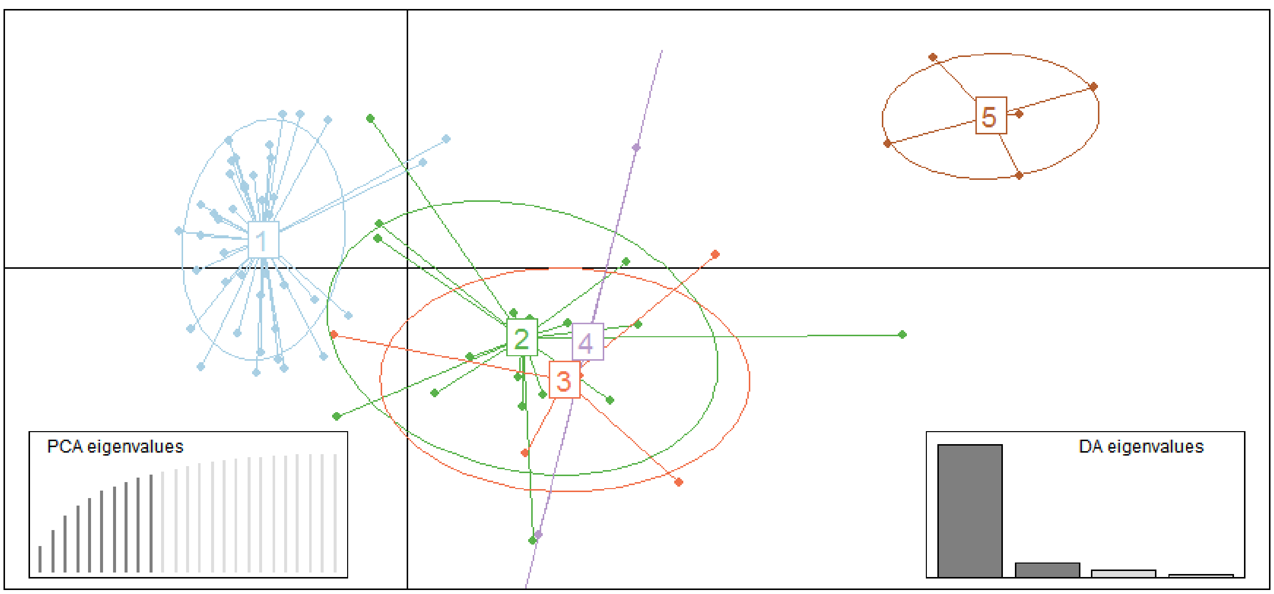
Figure 43. Bayesian clustering analysis result using STRUCTURE- (a) Delta K plot for without LOCPRIOR model (b) Summary bar plot of Structure run from K=2-5 using without LOCPRIOR model, (c) Delta K plot for with LOCPRIOR model, (d) Summary bar plot of Structure run from K=2-5 using with LOCPRIOR model (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.

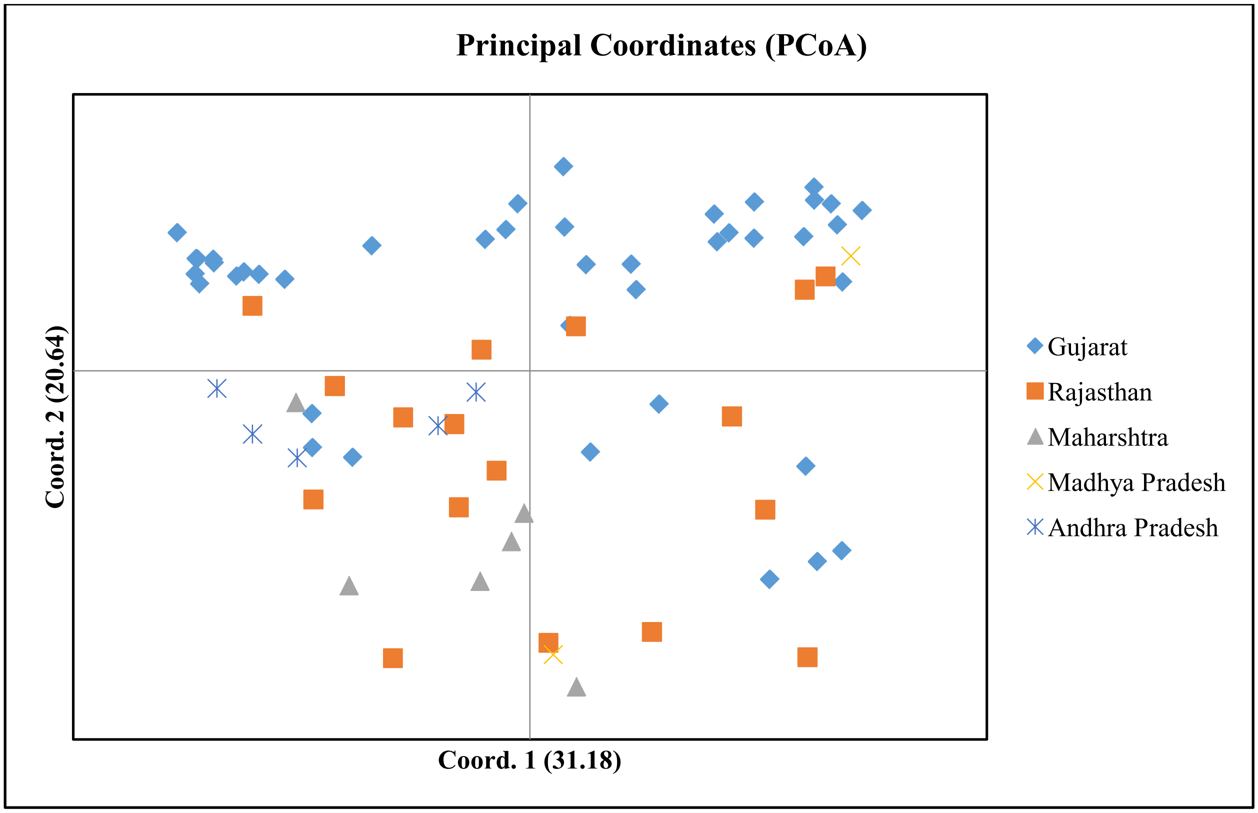
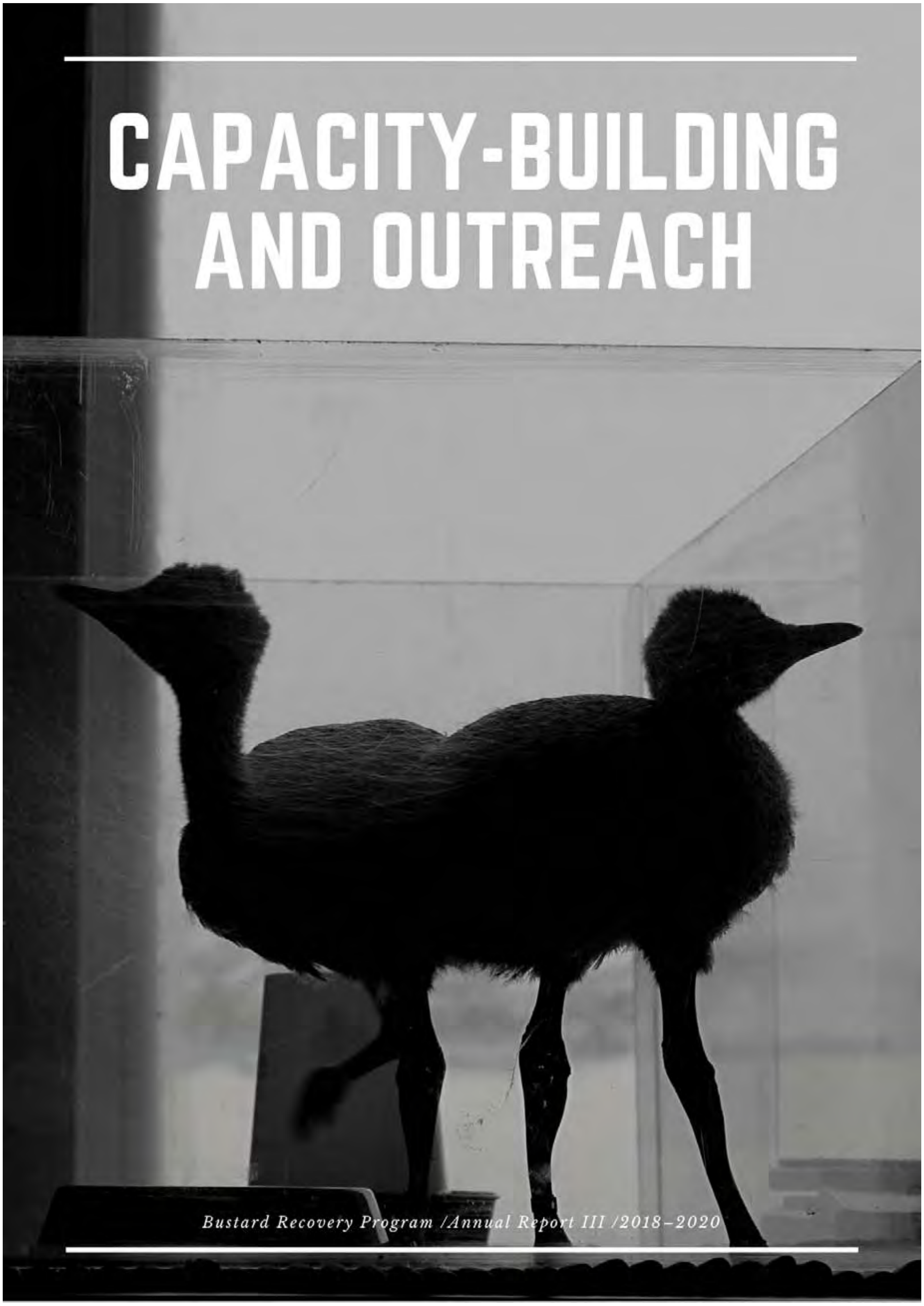


Figure 45.Principal coordinates analysis plot (PCoA) with percentage of variation explained by each axis computed by GenAlEx v 6.5

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.



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. Asad Rahmani 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 mediaon 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 duringAnnual 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.825/2019filed 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 17thFebruary, 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 20 th 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.

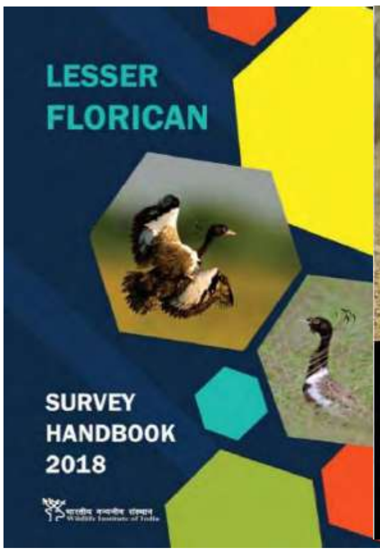
Second side event on behalf of MoEF&CC with partnership of TCF and WCS on 'The Final Flight: Conserving Eurasia's Iconic Bustard Species' This side event was Co-chaired by Dr. Borja Heredia, Dr, Mimi Kessler (IUCN Bustard Specialist Group) Dr. Asad Rahmani, Shri M.K. Vasu, IFS(Retd.),PCCF & HoFE Assam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

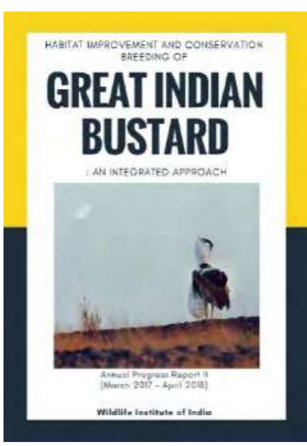
2.3.2. Awareness materials and publications

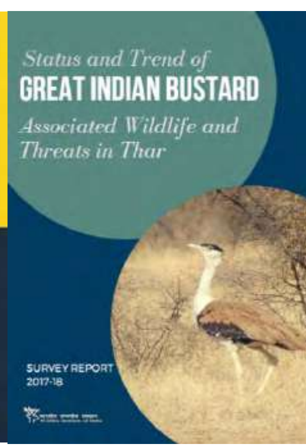
Sensitization Brochures

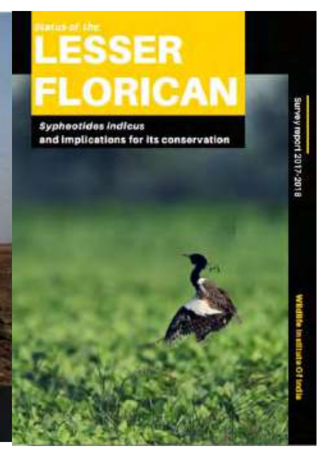
Survey handbook **Poster** **Notebook**



Reports







Bookmarks

T shirts

Carry bags

2.3.3. Social Engagement

A significant component of the on going 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 ($N_{village}$=20, N_{dhanis}=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, Tejsi, Jajeeya, Salkha, Kanoi, Jamra, Sipla, Neemba, Koriya, Dhuliya, Barna, Kuchhri and Ganga was conducted. With 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 peoples' 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 area 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 livestock against better veterinarian services. We would assess the scope of this intervention and identify sites where livestock could be translocated if such intervention succeeds.

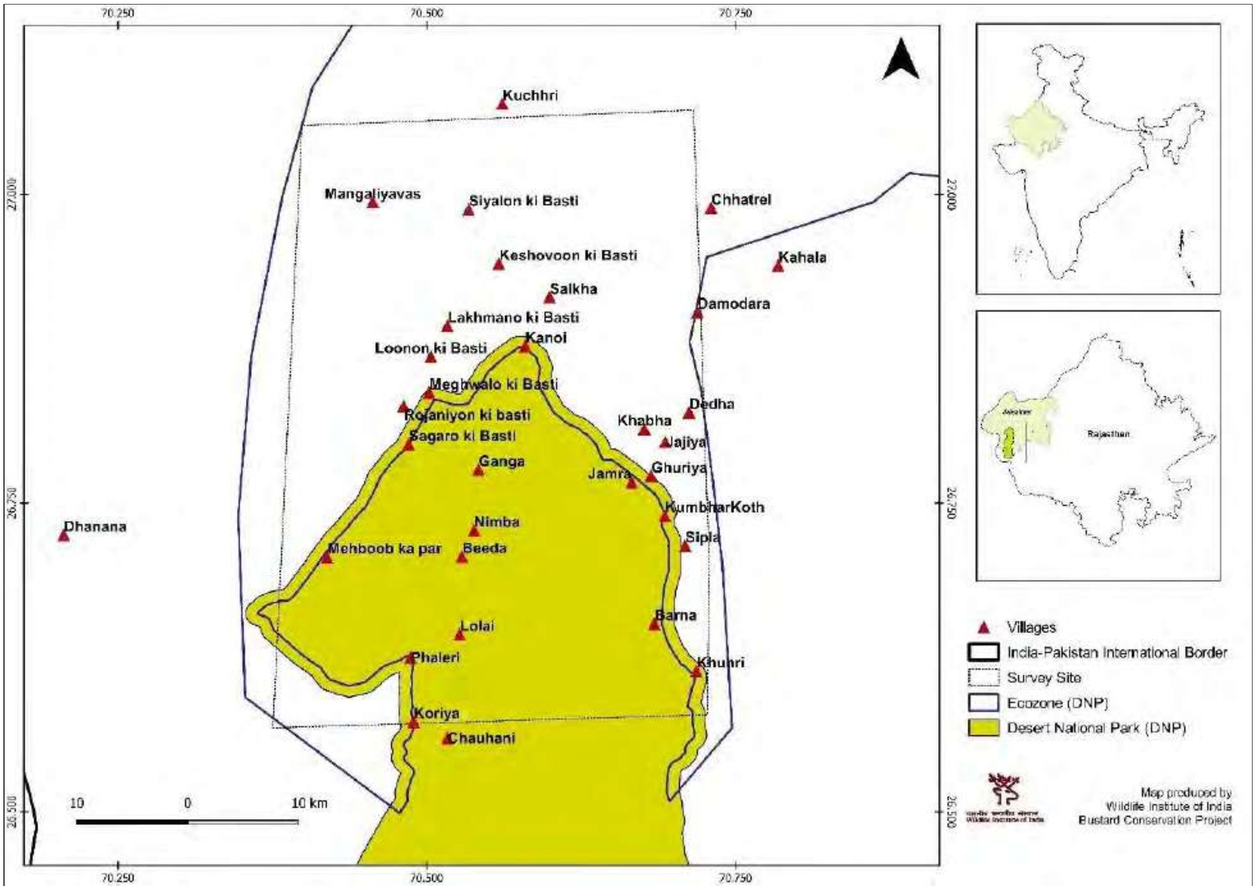


Figure 46. Map showing villages where household surveys were conducted in and around Desert National Park, Jaisalmer

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 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 an supplementary source of income. Sheep was the most abundant livestock reared by a household (Mean= 36.43 ± 2.89SE) followed by goat (Mean= 23.26 ± 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.

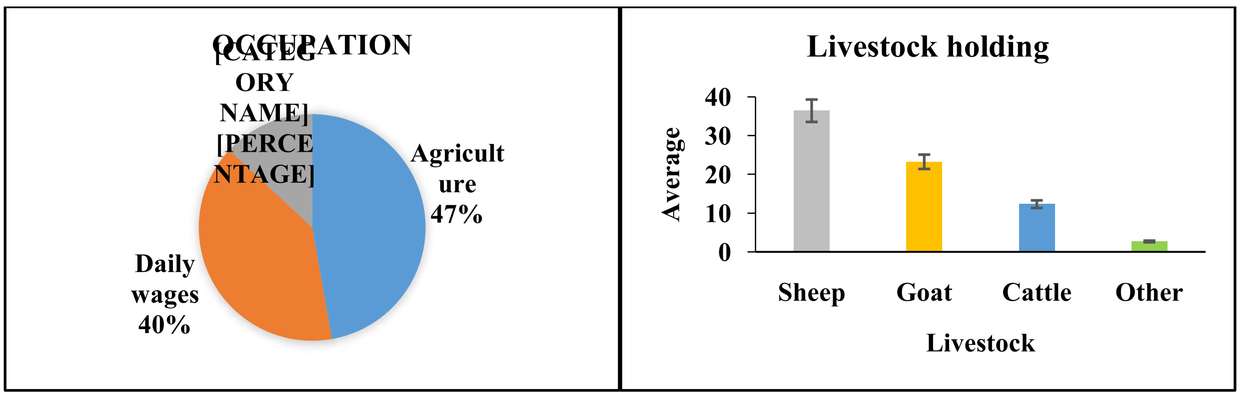


Figure 47. (a) Livelihood of villagers in and around Desert National Park, Jaisalmer **(b)** Livestock holding of villagers in and around Desert National Park, Jaisalmer (Error bars are standard errors)

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).

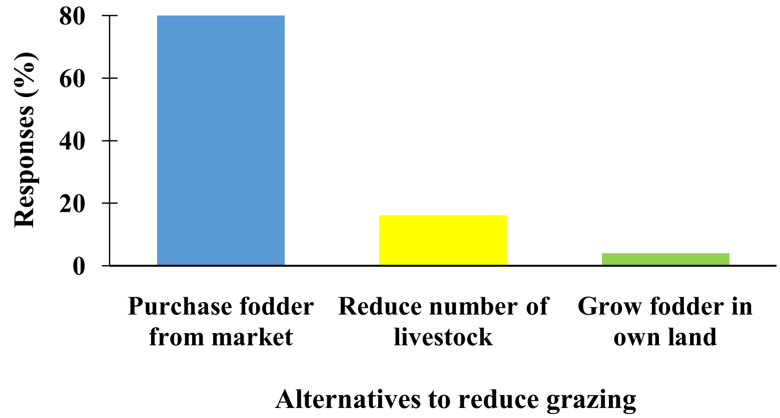


Figure 48. Alternatives suggested by respondents to reduce grazing pressure on village pasture land in and around Desert National Park, Jaisalmer (n=158)

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.

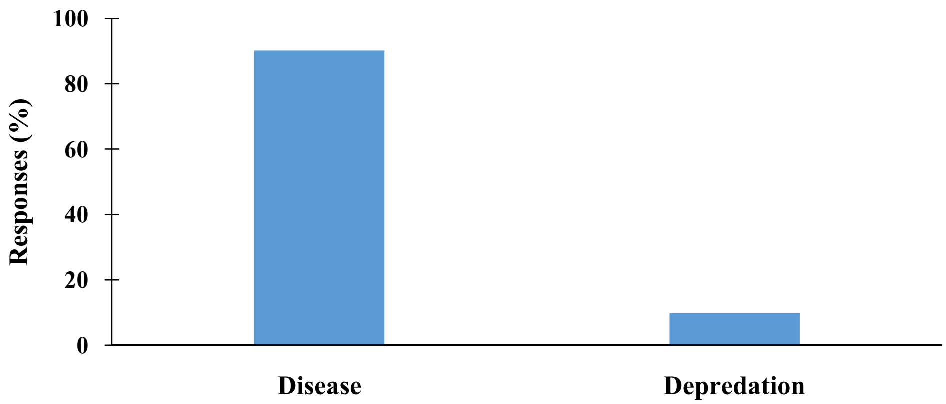
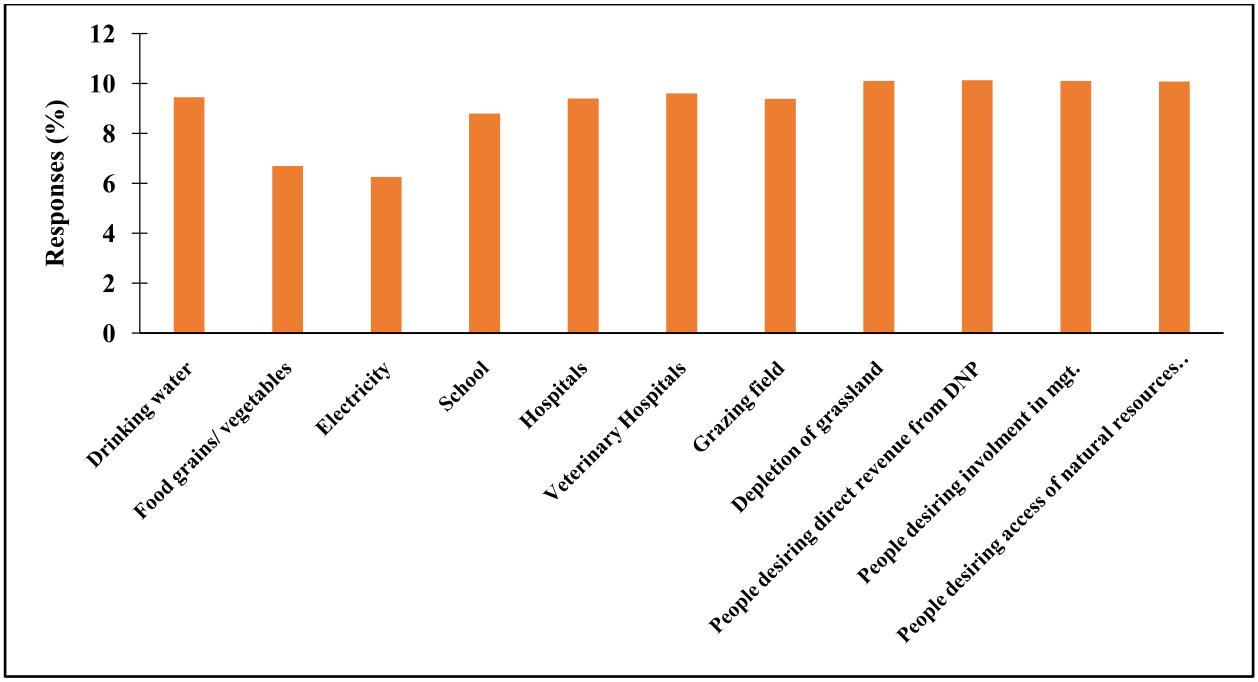


Figure 49. Causes of livestock mortality according to villagers in and around Desert National Park, Jaisalmer

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).



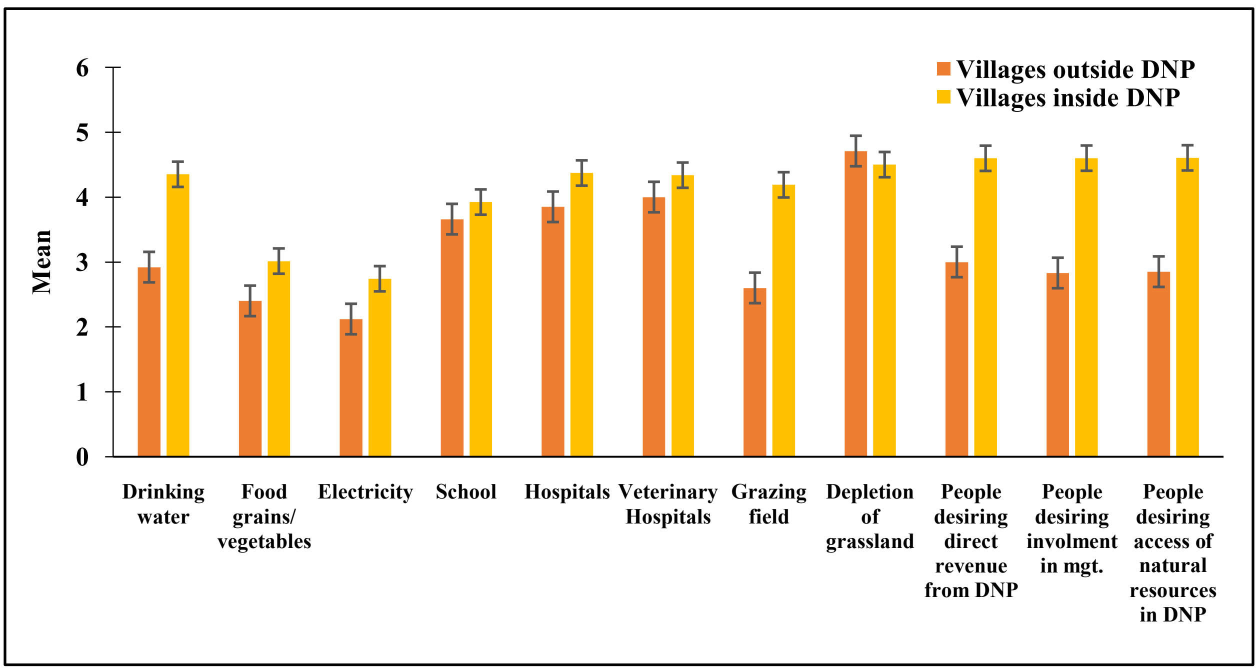


Figure 50. Problems perceived by villagers inside and outside Desert National Park, Jaisalmer (Error bars are standard errors)

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).

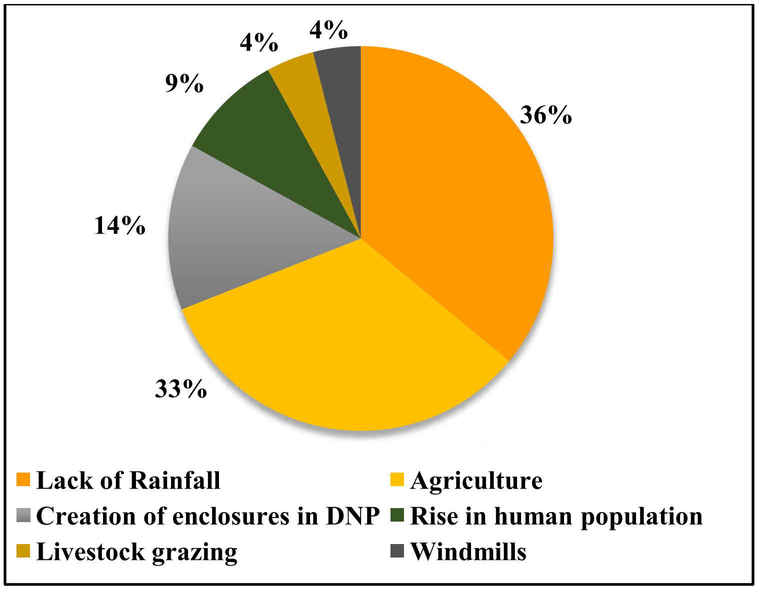


Figure 51. Reasons behind degradation of grasslands according to respondents in and around Desert National Park, Jaisalmer

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)

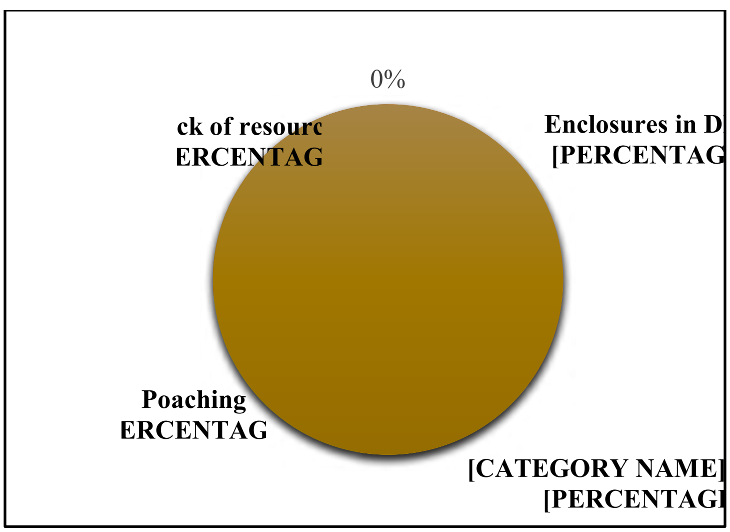
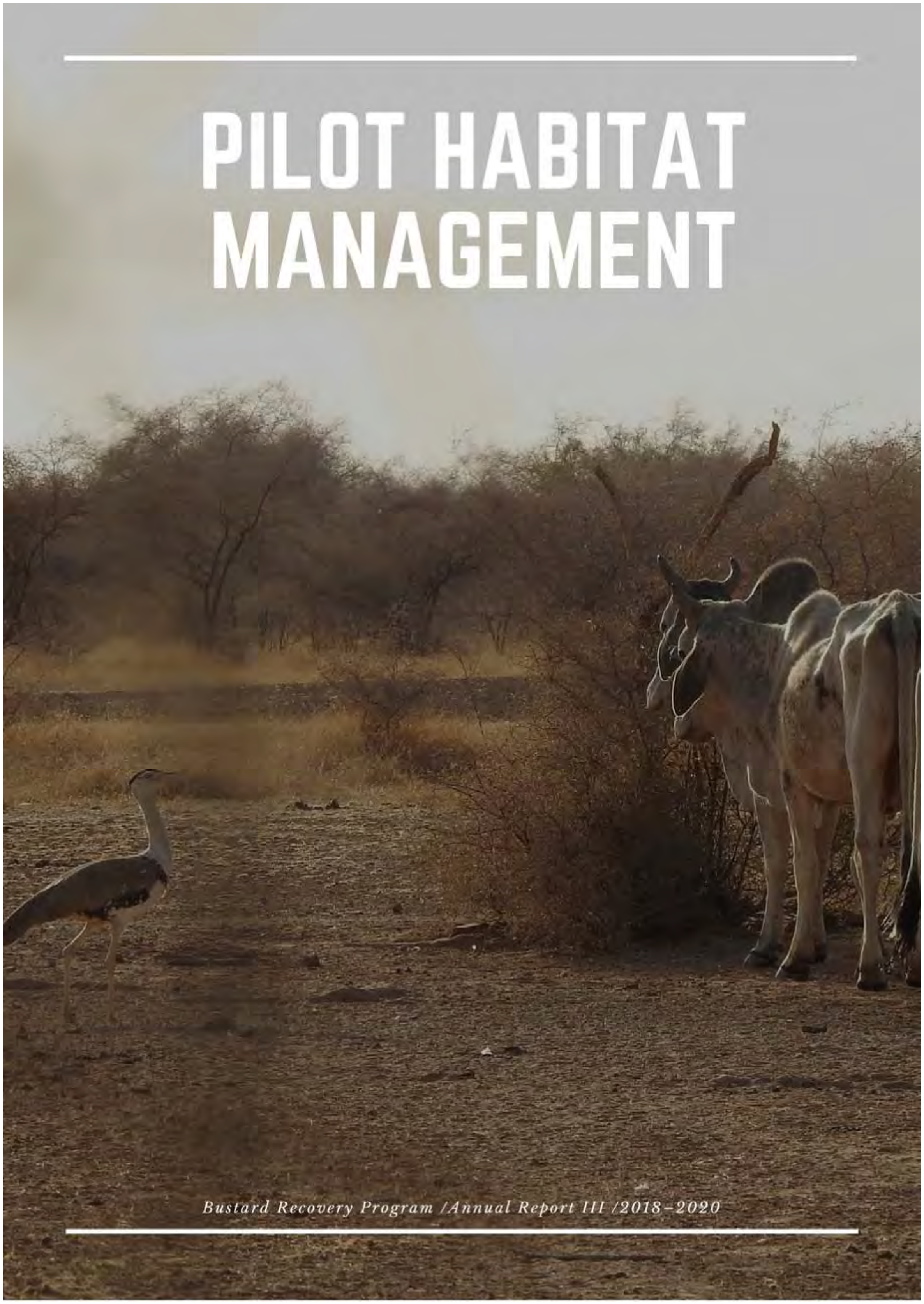


Figure 52. Reasons behind decline in the number of wild animals according to respondents in and around Desert National Park, Jaisalmer


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).

Table16. 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 km^2 (Table 18)

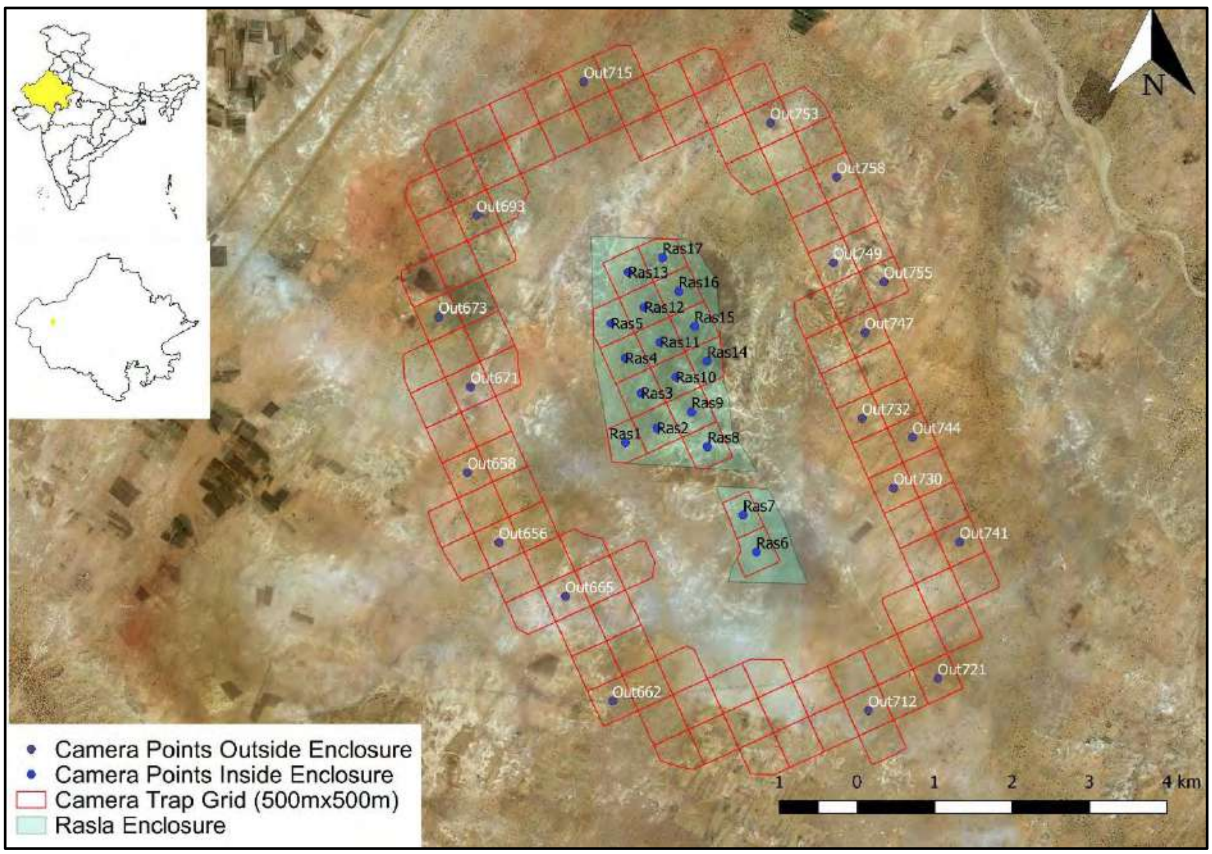


Figure 54. Sampling design of camera trap survey conducted inside and outside one of the Great Indian Bustard enclosures in Thar, Jaisalmer

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 ornata, 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

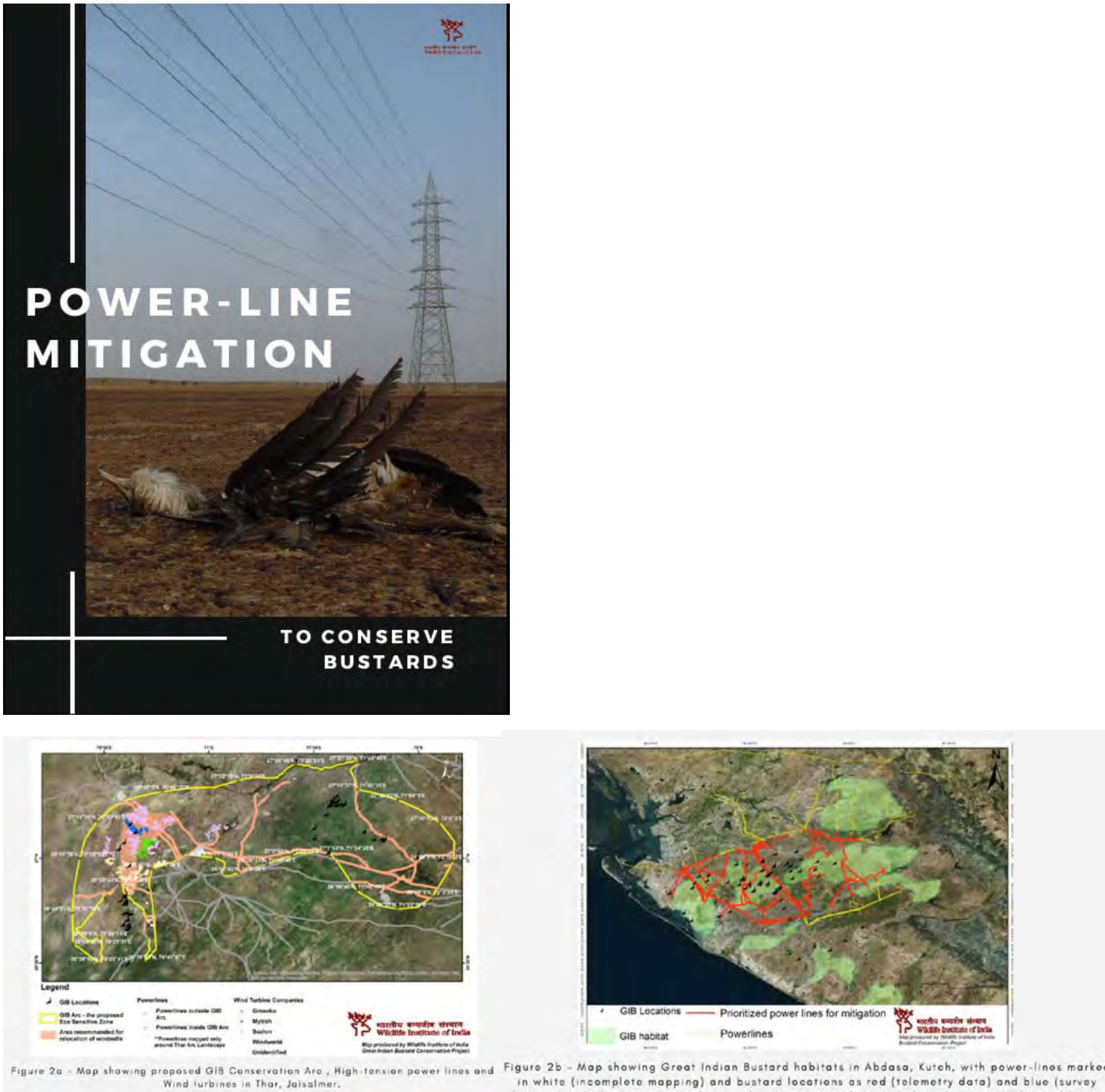
Category	Species	No of photo captures	Encounter Events	Photo-capture rate (No. of photo captures per 100 days)
Priority species	Great Indian Bustard	10	7	0.17
Active nest-predators	Pig	465	368	8.06
	Desert fox	448	440	7.77
	Dog	188	180	3.26
	Desert cat	149	148	2.58
	Indian fox	112	111	1.94
	Indian grey 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 ~13,100 km^2 and ~ 78,500 km^2 respectively (Figures55a &56) whereas in Gujarat, the priority and potential area spans ~ 500 km^2 and ~ 2100 km^2 respectively(Figures55b &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.

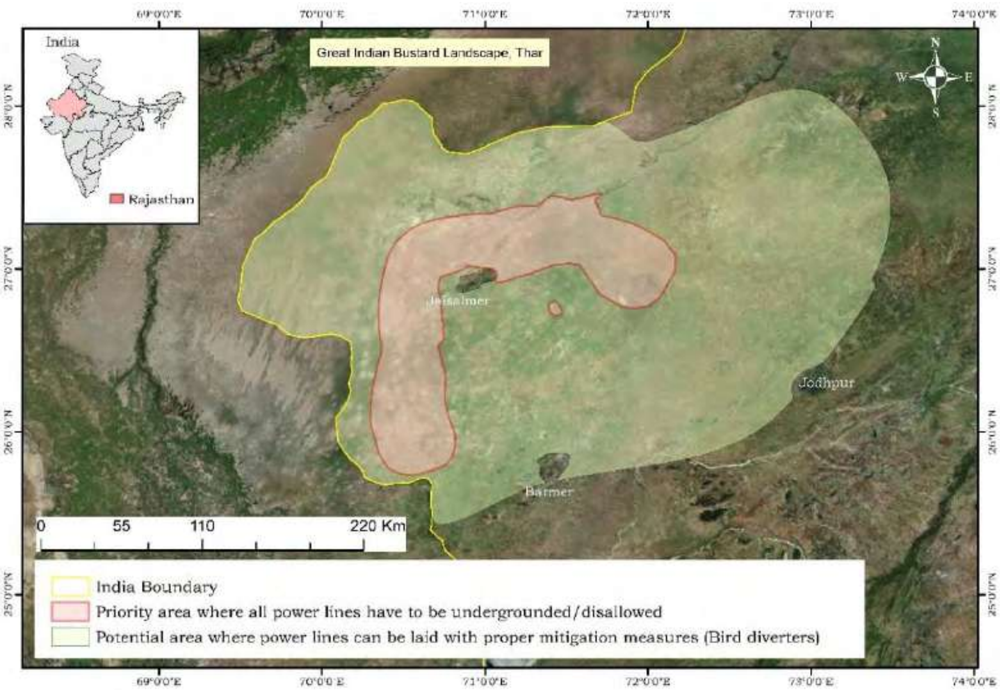


Figure 56. Great Indian Bustard landscape in Rajasthan delineating the priority and potential areas for power line mitigation

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

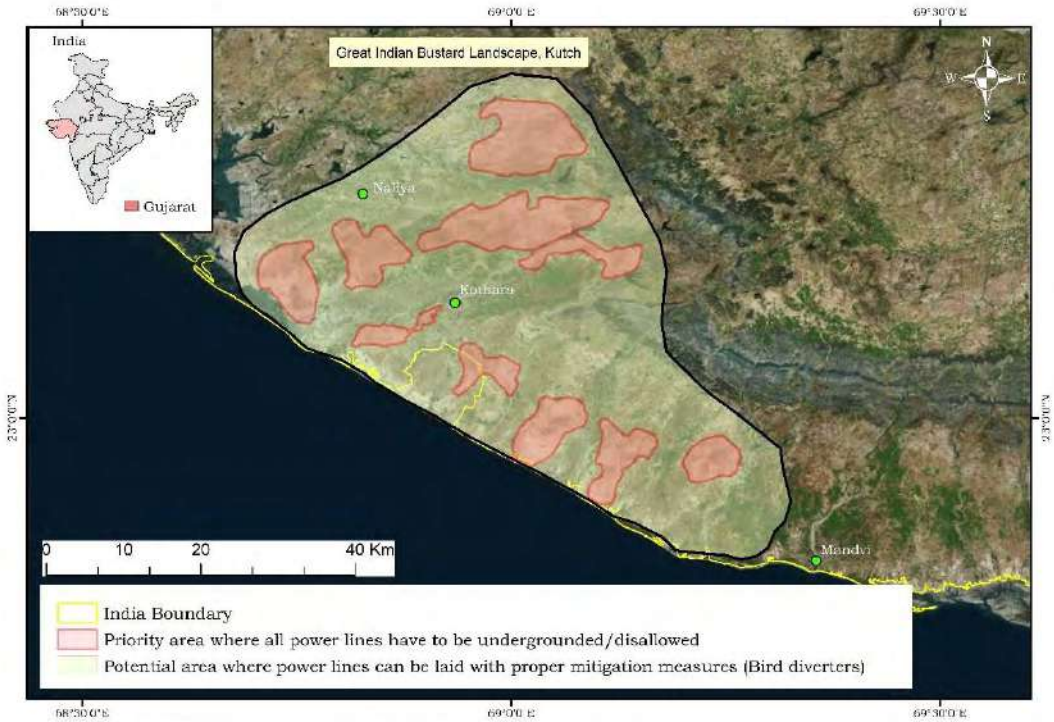


Figure 57. Great Indian Bustard landscape in Gujarat delineating the priority and potential areas for power line mitigation

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.

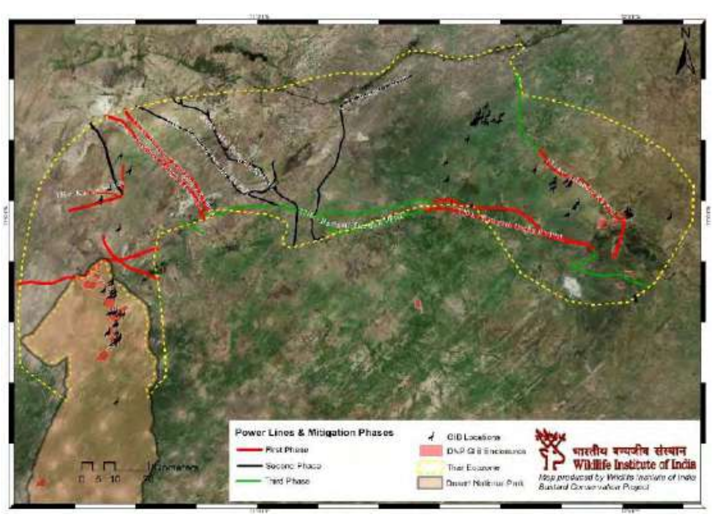


Figure 58. Map showing high tension (> 33 kV) power lines divided into three phases for undergrounding and bird diverter installation in Great Indian Bustard habitat, Rajasthan

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 Vidyuth 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 Arctis Advisers Private Ltd - Mr. Rahul Agrawal, Director, Mr. Abhishek Bansal, Director, and Sprng 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).

Figure59. 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).

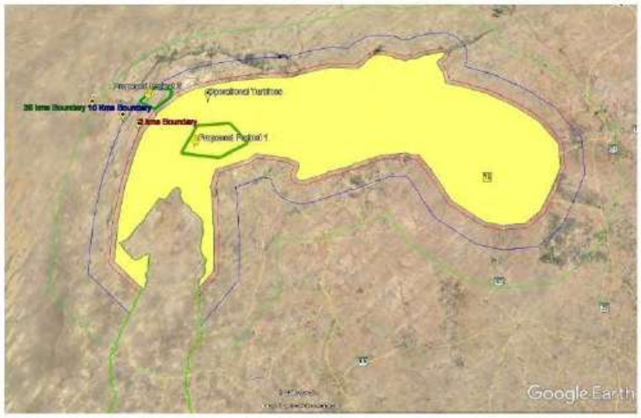


Figure60.Map showing the shelved power project proposed to be developed inside Great Indian Bustard habitat in Thar, Jaisalmer

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, RVPNL, Gujarat Energy Transmission Corporation, Essel Surya Urja 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 arc 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.

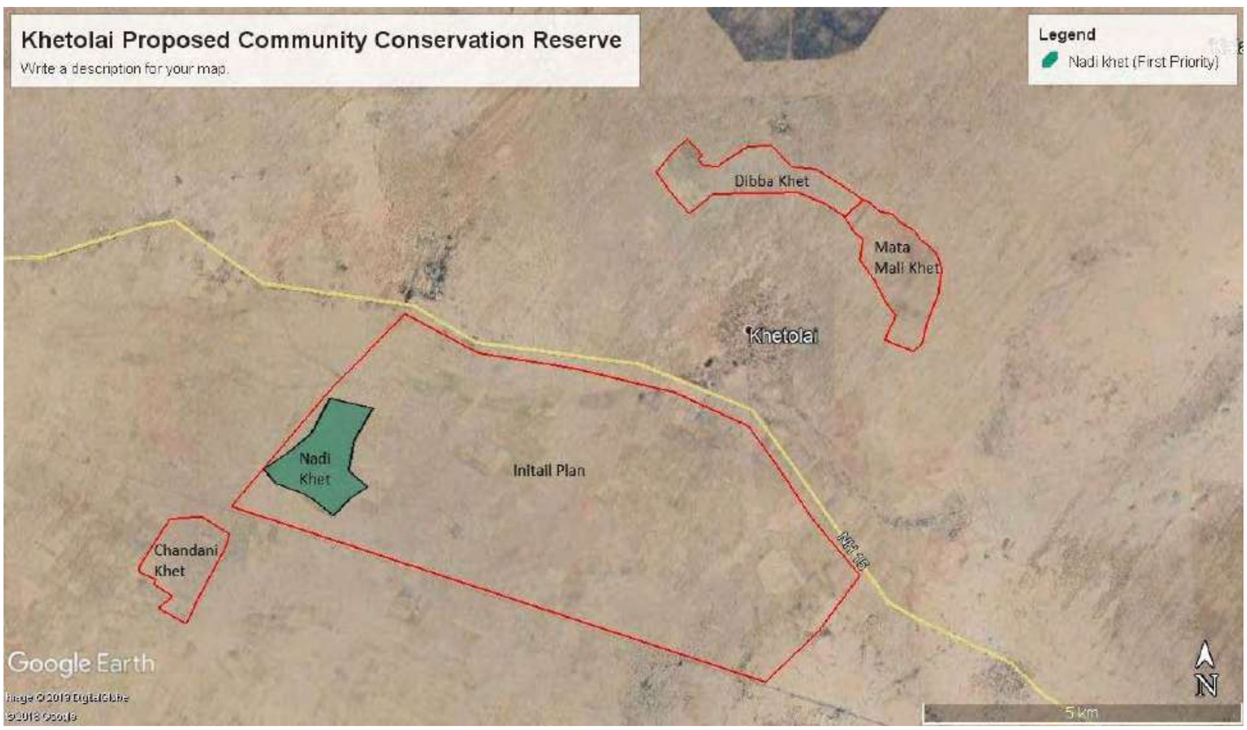


Figure61. Map of proposed Community Conservation Reserve in GIB habitat at Khetolai village in Jaisalmer

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

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

BUSTARD
RECOVERY PROGRAM

International Fund for Houbara Conservation

Rajasthan State Pollution Control Board

BNHS INDIA

The Corbett Foundation

HUMANE SOCIETY INTERNATIONAL

Rajasthan Forest Department