Status of the

LESSER FLORICAN

Sypheotides indicus and implications for its conservation

Survey report 2017-2018

Wildlife Institute Of India

ABBREVIATIONS

BNHS	***Bombay Natural History Society;***
BBNP	***Blackbuck National Park;***
FD	***Forest Department;***
GIB	***Great Indian Bustard;***
LF	***Lesser Florican;***
MDS University	***Maharshi Dayanand Saraswati University, Ajmer;***
MoEFCC	***Ministry of Environment, Forest and Climate Change;***
NP	***National Park;***
PA	***Protected Area;***
RF	***Reserve Forest;***
TCF	***The Corbett Foundation:***
WII	***Wildlife Institute of India, Dehradun;***
WLS	***Wildlife Sanctuary***

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

BNHS INDIA CONSERVING NATURE SINCE 1883

The Corbett Foundation

सत्यमेव जयते
Rajasthan Forest Department

FOREST DEPARTMENT GOVT. OF GUJARAT

Ministry of Environment, Forest and Climate Change
Government of India

STATUS OF THE LESSER FLORICAN

SYPHEOTIDES INDICUS AND IMPLICATIONS FOR ITS CONSERVATION

SURVEY REPORT 2017 - 2018

Implementing agency
Wildlife Institute of India (Endangered Species Recovery Program), Dehradun
Bombay Natural History Society, Mumbai
The Corbett Foundation, Kutch

Partner agency
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Gujarat State Forest Department
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SUMMARY

1. Lesser Florican *(Sypheotides indicus)* is an endangered agro-grassland bird whose ecology and status are poorly known that impedes conservation efforts. To fill this gap, a national status survey was designed by the Endangered Species Recovery Program of Wildlife Institute of India and was jointly implemented with Bombay Natural History Society, The Corbett Foundation and State Forest Departments across the species' breeding range. This report documents the methodology of this exercise, and presents its findings on lesser florican's distribution, abundance, habitat relationships, threats and their implications for conservation.

2. We delineated lesser florican' breeding range using informed digitization with the aid of MaxEnt distribution model, and inputs from local experts. We assessed the species' status based on displaying males, using spatially representative sampling and analytical design that accounted for imperfect detection. Our assessment used hurdle modeling approach, where we: a) first estimated the species' occupancy in 36 sq km cells using vehicle observation points (stop-overs), and b) estimated the species' abundance at detected sites (subset of occupied sites) using line transect distance sampling. c) quantified habitat characteristics (land cover, vegetation structure and anthropogenic pressures) systematically along occupancy and distance surveys. d) explored and developed statistical relationships between habitat covariates and occupancy/abundance. e) mapped the species' distribution, local densities and threats, to generate conservation priority map. We drew inferences 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; Maharashtra: Akola-Washim).

3. The status survey was conducted during the breeding season (July–September, 2017) with a team of 121 observers, who were trained on the standard data collection protocol through state-level workshops at Bhavnagar, Ujjain, Ajmer and Akola. Lesser florican occupancy was assessed at 428 sites (36 sq km) spread across ~20,000 sq km range, using 5564 stop-overs, and density was assessed in 32 sites (where the species was detected) using 479 km transect-walks that yielded 70 sightings (64 males, 6 females).

4. Lesser florican occupied 13+3SE % sites or 1908 sq km area, at ecological density of 0.25+0.06SE territorial males per sq km. The population size was estimated to be **340 (162–597 95%CI) territorial males**, with a conservative estimate of **264 individuals** that indicates ~80% population decline in last 3–4 generations (since 2000). Regional assessments indicated that the population was largely restricted to: Velavadar (Bhavnagar, Gujarat) having 96–115 territorial males and Shokaliya-Bhinai (Ajmer, Rajasthan) having 110–136 territorial males. The species' response to habitat exhibited regional plasticity, with occupancy favoured by grassland cover in Gujarat, and by agricultural cover in Ajmer. However, density in occupied site was an increasing function of grassland cover, indicating that males congregated in large contiguous grasslands. Birds were dispersed over a large agricultural expanse at low density in Ajmer (~800 sq km) and clustered at high density in a small grassland reserve in Bhavnagar (~100 sq km). This inverse density-occupancy relationship perhaps resulted from their flexible social/spatial organization, implying that, a contiguous grassland would achieve the same conservation outcome as a much larger agricultural area would. Finally, we prioritized sites and quantified threat levels across landscapes and regions, to guide convervation investments.

5. Our methodology for estimating lesser florican numbers assumes that expected abundance at occupied sites where species was not detected (but present) 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 on the 'minimum population size' of 264 individuals as a conservative estimate of the population.

6. We also developed conservation recommendations for each landscape to guide species' recovery actions, based on prior knowledge (Dutta *et al*. 2013) and our collective observations. Highlighting that lesser florican population might have dwindled by ~80% over last 3–4 generations, we call for immediate scaling up of efforts for the species' conservation. The priority sites for conservation actions are Shokaliya and Saurashtra landscapes followed by Kutch and Kekri landscapes, followed by Ratlam, Shahpura and Akola landscapes. Our key recommendations for priority sites are to: a) provide protection to priority lesser florican sites by creating conservation areas and implementing strict patrolling by Forest Department and local communities; b) regulating intensive landuses such as infrastructural, industrial and salt pan developments, and mitigation of 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) consolidation 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; and h) advocacy and outreach programs to generate support among multiple stakeholders for lesser florican conservation. i) Finally, given the potential decline of the species, gaps in our 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 a captive population for insurance and possible reintroduction in future. Given the current numbers, there is still a window of opportunity for recovery of the lesser florican.

7. This status assessment protocol and its inferences, including the spatial prioritization needs to be refined over next two years, and should thereafter be implemented periodically to monitor the pulse of the endangered lesser florican and its dwindling habitats. In the imminent future, we plan to refine our status assessment protocol and conduct consultative meetings at regional levels to prepare site-wise conservation plans.

List I: Participants of the lesser florican status survey 2017

SN	Wildlife Institute of India	Bombay Natural History Society	The Corbett Foundation
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6	Tanerav Singh	Vikas Pisal	Bertrand Horne
7	Shailesh Gupta	Aniruddha Rathod	Tanveer Ahmed
8	Akshay Jain	Vasudeo Sharma	Zarreen Syed
9	Akshay Shinde	Abhay Sakharkar	Shaizah Tajdar
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27	Sweta Iyer		Mr. Rakesh Padariya
28	Shyam Paradi		Mr. Sunny Bhabhor
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List II: Forest staff involved in the lesser florican status survey 2017

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Rajendra Rathore	Mr. A. P. Patel (RFO)	Mr. S.P. Rathore (Forest Guard, Petlawad)	Nandkihor More (Forest Guard)
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List III: Collaborators in the lesser florican status survey 2017

SN	Name and designation	Institution / individual	Site
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5	Mr. Mukesh Bhatt	Individual	
6	Mr. Viral Joshi	Individual	
7	Mr. Shatrughna Jebaliya	Individual	
8	Mr. Nirav Bhatt	Individual	
9	Mr. Yogendra Shah	Individual	
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11	Dr. P. P. Dodia: Associate Professor, Zoology Department	Sir. P. P. Institute of Science, M. K. Bhavnagar University	
12	Mr. Uday Vora (Retd. Chief Conservator of Forest)	Gujarat Forest Department	
13	Mr. Ajay Desai	Prakriti Mitra Mandal, Dadhod	
14	Mr. Ashok Mashru	Individual	
15	Mr. Ajay Gadikar	Individual	Madhya Pradesh
16	Mr. Govind Pande	Forest Department, Akola	Maharashtra
17	Mr. Kaustubh Pandharipande (President)	SAMVEDANA	

List IV: Officers who helped in lesser florican status survey 2017 logistics

SN	Rajasthan	Gujarat	MP	Maharashtra
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2	Shri Ajay Chittora (DCF, Ajmer)	Shri A. P. Singh (CCF, Junagadh)	Shri Pankaj Shrivastav (APCCF, Indore)	Shri P.J. Lonkar (DCF, Akola-Washim)
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6		Shri J. L. Jhala (DCF, Bariya)	Shri Kshitij Kumar (DCF, Ratlam)	
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9		Shri Mohan Ram (DCF, Bhavnagar)		
10		Shri T. Karuppasamy (DCF, Dhari)		
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12		Shri Sunil Berwal (ACF, Dhari)		
13		Shri R. M. Parmar (ACF, Bariaya)		
14		Shri Mahesh Trivedi, (ACF, Velvadar NP)		

SPECTACULAR DISPLAY BY A FLORICAN. THE JUMPING DISPLAY BY THE MALE FLORICANS IS TO ATTRACT FEMALES FOR COURTSHIP

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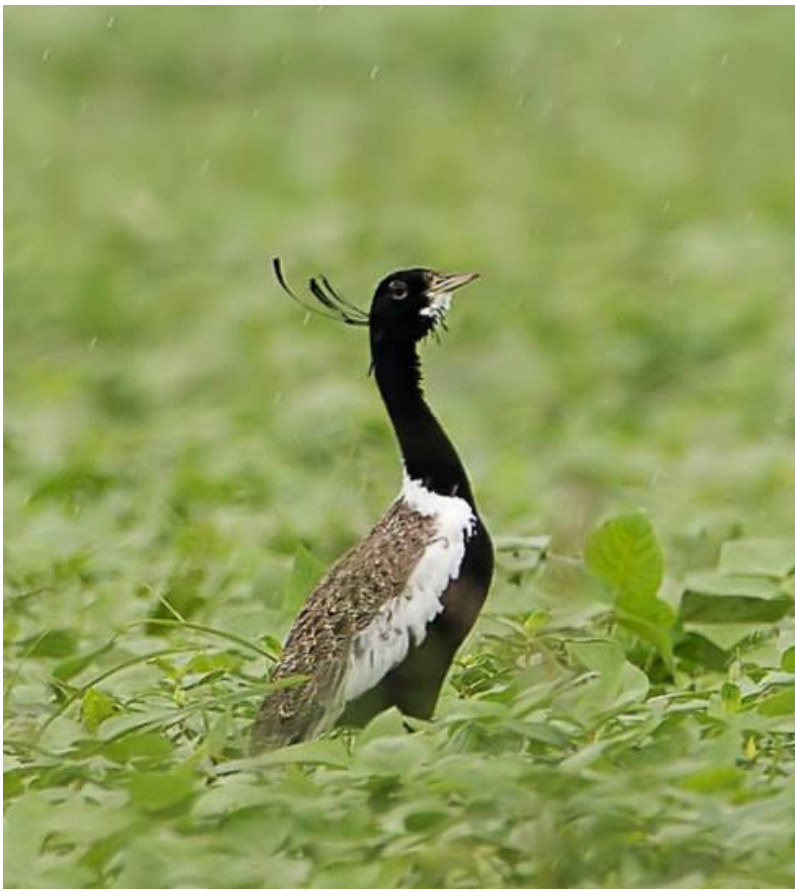
INTRODUCTION

1.2 Need for status survey

Endangered species conservation entails regular and objective assessment of their distribution, abundance current threats to identify priority habitats, develop conservation strategies, and routinely assess management effectiveness. However, the last population assessment of the lesser florican was conducted in 2006 by late Ravi Sankaran, following which a distribution survey was carried out by the Wildlife Institute of India in 2010 (Bhardwaj *et al.* 2011). Since then, there is paucity of information on the species' status and conservation contexts that impedes current recovery efforts. Additionally, the species' biology and ecology are poorly understood, especially in the non-breeding season due to their elusive nature. To fill these information gaps, a status assessment exercise across the breeding range following a standardized protocol is needed that can be replicated across years.

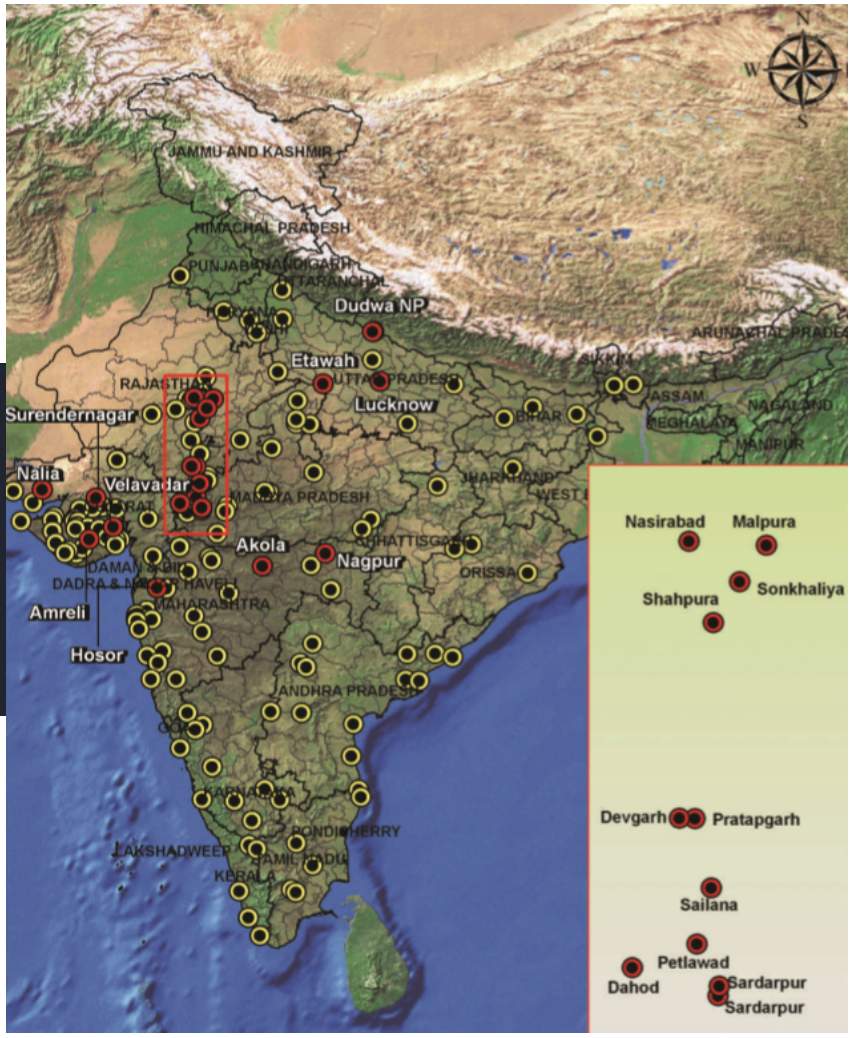
1.1 About lesser florican (*Sypheotides indicus*)

Lesser florican (*Sypheotides indicus*) is the smallest bird of the bustard family (*Otididae*). It is one of the four bustard species of India, all of which are threatened (IUCN), and is endemic to this country. Though lesser florican has been given the highest degree of protection under Schedule-I of the Wildlife (Protection) Act 1972, its numbers have declined, necessitating its declaration as an Endangered species in the IUCN Red list. Subsequently, it has been included as a priority species in the Species Recovery plan by the Ministry of Environment, Forest and Climate Change, Government of India (Dutta *et al*. 2013).



1.3 Distribution of Lesser Florican in India

Lesser florican is virtually endemic to India (Ali 1981, BirdLife International 2001) and is distributed in the lowland open plains (Goriup and Vardhan 1982). Historically, it occurred from Gujarat and Rajasthan in west to West Bengal and Orissa in east, and from Saharanpur as well as Mainpuri districts (Gopi Sundar 2006) of Uttar Pradesh in north to Thiruvananthapuram (Kerala) in south (Ganguli Lachungpa and Rahmani 1990; Baker 1922-1930; BirdLife International 2001; Sankaran 1993). It also occurred in Terai region of Nepal, Pakistan and vagrantly in Bangladesh and Myanmar. The main breeding areas were probably in the districts of Nashik, Ahmednagar and Solapur of Maharashtra, eastern Haryana and the Kathiawar Peninsula of Gujarat (Anon. 1908, Goriup and Karpowicz 1985).



Past (Yellow) and Present (Red) distribution of lesser florican in India Source: Threatened Birds of India

The current breeding distribution is restricted to:
1) Rajasthan, in the districts of Ajmer (Shokaliya Community Reserve), Bhilwara, Tonk, Pali and Pratapgarh (Bharadwaj *et al*. 2011);
2) Gujarat, in the districts of Dahod, Bhavnagar (Blackbuck NP, Velavadar) (Gadhvi and Shah 2008), Amreli, Surendranagar and Kutch (Lala-Naliya WLS) (Fulljames 1837; Bharadwaj *et al*. 2011);
3) Madhya Pradesh, in the districts of Ratlam (Sailana WLS) (Ganguli-Lachungpa 1985), Dhar (Sardarpur WLS), Jhabua and Sheopur (Kuno WLS);
4) Maharashtra, in the districts of Yavatmal, Akola (Kasambe and Gahale 2010), Washim (Pandhripande pers. comm.), Chandrapur (Narwade *et al*. 2015) and Nashik (Raha and Prakash 2001); and
5) Andhra Pradesh, in the district of Kurnool (Rollapadu WLS) (Ganguli-Lachungpa and Lachungpa 1986).
Post-breeding, birds migrate to peninsular- (Dharmakumarsinhji 1950) and north- India (Sankaran pers. comm.). Note that, the sites mentioned in parantheses are Protected Areas in each landscape, where lesser florican occurs.

1.4 GENERAL ECOLOGY

HABITAT USE

Lesser florican breeds in rain-fed grasslands (>2 ha in area) with ample ground cover (>55% grass and herb cover), moderately tall grasses (~50 cm) like *Sehima*, *Chrysopogon*, *Dicanthium* and *Cymbopogon* spp., and scattered shrubs (<50/ha density) like *Zizyphus* and *Acacia* spp. (BirdLife International 2009; Sankaran 2000). Use of croplands for breeding is not common, but has been recorded in soybean (*Glycine max*), groundnut (*Arachis hypogea*), and less frequently in sorghum (*Sorghum vulgare*), maize (*Zea mays*), sugarcane (*Saccharum*), rice (Oryza sativa), mustard (*Brassica campestris*), and wheat (*Triticum vulgare*) crops (Sankaran 2000), as well as grasslands within forest plantations. Hilly terrain, wetland, dense forest, and deserts are avoided. Moderately high grassland biomass, an indicator of low grazing pressure, and remoteness from human settlements (>2.6 km away) are additional important predictors of their occurrence (Dutta and Jhala 2014; Sankaran 1997b). Dutta and Jhala (unpublished data) found that breeding male territories have more heterogeneous ground vegetation structure than the general habitat, possibly to accommodate diverse life-history needs (food, concealment and advertisement). Sankaran (1997a) reported that in intensively grazed grasslands, species tends to be found more frequently in croplands, and in years of good rainfall when grasslands are covered with tall (>1.5m) grass, males shift to shorter vegetation, such as soybean fields. During nonbreeding season, the species sometimes uses lightly wooded areas, grasslands and Zizyphus dominated scrubland (Sankaran 2000).

BEHAVIOUR

Individuals are relatively solitary and extremely elusive, except during the breeding season. Birds conceal themselves in ground vegetation by lying low, and are flushed when the source of disturbance is within few meters. Their flight is similar to other bustards, characterized by rhythmic strokes of broad wings, neck outstretched and legs tucked under body, although their wing-beats are faster than other bustards.

FOOD

The species is omnivorous, feeding on insects such as grasshoppers, beetles (families *Cantharidae, Chrysomelidae, Buprestidae* and *Scarabidae*), ants and caterpillars, amphibians, and plant parts like seeds, herbs, fruits and plant shoots (Ali *et al.* 1986; Baker 1922–1930; BirdLife International 2001; Sankaran and Rahmani 1986b). Birds forage in relatively open areas in early morning and evening, and retire into thicker cover during mid-day. They commonly feed in short grasses and low crops; typically by walking 5–10 m before pausing and scanning for prey as well as threats, thereafter either dashing at or snapping up or creep-stalking prey items in the manner of an egret (Ali *et al*. 1986). On reaching their breeding grounds in lean condition, birds feed throughout the day; however, with the advancement of season, males are observed to feed and display alternatively. Availability of insects is considered as an important factor in the reproductive success of female lesser floricans.

BREEDING

Breeding behaviour of lesser florican has been extensively studied in the past (Dharmakumarsinhji 1950; Dharmakumarsinhji 1953; Goriup and Karpowicz 1985; Sankaran 1997c; Sankaran and Manakadan 1990; Sankaran and Rahmani 1986a). The species exhibits an exploded lek mating system, where males establish territories of 2–3 ha, spaced at 200–500 m from each other (Sankaran 1994). Sankaran (1994) reported an average 4.7 territories per sq km, while a more recent study (Dutta and Jhala 2012) estimated an average 1.5 males per sq km in grasslands of Kutch. Breeding coincides with the timing and intensity of south-west monsoon, beginning from May through September. During this time, birds immigrate to breeding grounds, where males acquire breeding plumage and establish territories within first few weeks (Sankaran 1994). They perform an aerial display from specific spots within their territories (Sankaran and Rahmani 1986a), where they leap up to two meters in air, rapidly beating their wings and paddling their legs, thereafter falling swiftly back to the ground with their wings and legs tucked in. They also emit a frog-like rattle from the friction of their primaries that can be heard from 300–400 m distance. Males perform this display after every 50 seconds on an average (Ridley *et al.* 1985, Dutta and Jhala unpublished data) and up to 500–600 times a day. Display rates are generally higher during the latter part of breeding season, early morning and cloudy/rainy weather. It serves the dual function of territorial and sexual advertisements. Females visit male arenas exclusively for mating, and nest outside or at the periphery of their territories (Sankaran 1994), raising the offsprings alone.

Image 1
Lesser florican displaying male (left) and elusive female (right)
© Mukesh Bhatt

Females prefer tall grass cover for nesting, and lay 4–5 eggs (49 x 41 mm size and olive-brown, mottled, streaked and blotched pattern) on bare ground (Gadhvi 2003; Sankaran 1994). She incubates these eggs for 21 days sitting cautiously still to avoid detection. They remain highly vulnerable to predators and poachers during this time. The newly hatched precocious chicks stay with their mother for roughly over 15–30 days. Females and chicks stay in breeding grounds for at least a month longer than males. Breeding in cultivation is not frequent, but does occur in short crops like soybean and groundnut, and less frequently in the taller ones like cotton, sorghum, maize and sugarcane (Sankaran 2000). Grasslands in southern India are possibly used for breeding only when conditions are unfavorable in the usual breeding range (Sankaran and Manakadan 1990). At the end of the breeding season around October/November, birds have been reported to return to the southeastern and northern regions (Dharmakumarsinhji 1950, Sankaran 1997b).

RANGING PATTERNS

The species is a local migrant in India, and their ranging patterns are poorly known. Life-history information is scanty, but one ringing recovery showed that their life span could exceed four years (Dharmakumarsinhji 1943). Their local movements are considered partial and opportunistic, with birds tending to concentrate in regions that have received good rainfall in the current year, and sporadically elsewhere. Dutta and Jhala (2012) reported much lower breeding bird density in drought year (~0.6 males/sq km) than years with average rainfall (~1.5 males/ sq km) in grasslands of Kutch. However, it is yet to be concluded whether this pattern is due to lower display rate (primary detection cue) or abandonment of the area in droughts. Dharmakumarsinhji (1950) observed males returning to the same breeding sites every year for >20–30 years, and speculated that breeding site fidelity is strong. However, ringing records (involving 18 of 489 birds) revealed moderate levels of site fidelity, as only 10 of these birds were recaptured in the ringing site while the remaining were found >50 km away (Dharmakumarsinhji 1950).

1.5 Threats and conservation issues

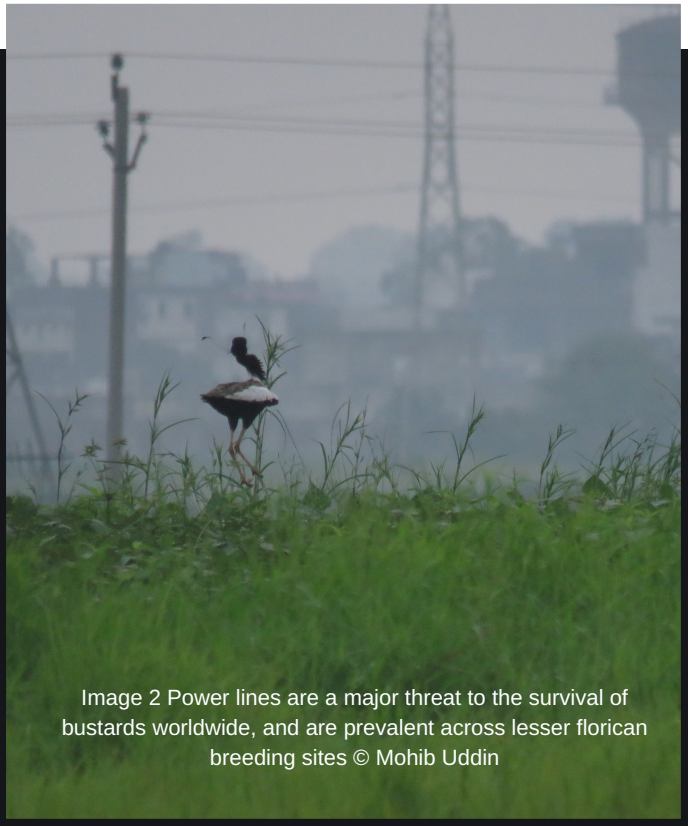


Image 2 Power lines are a major threat to the survival of bustards worldwide, and are prevalent across lesser florican breeding sites © Mohib Uddin

Major threats to the species include habitat loss and mismanagement due to the lack of a holistic grassland conservation policy and scientific management . Paucity of ecological information, particularly for non-breeding habitats, also impedes their conservation. A detailed list of threats and conservation issues is as follows:

1. Poaching, trapping, and egg collection.
2. Pesticide usage in breeding grounds that can potentially deplete insect biomass and increase environmental toxicity.
3. Land use changes involving agricultural intensification, changes in cropping patterns, diversion of grasslands for infrastructure (wind-turbines and power-lines), industries/housing, and salt pans particularly in Bhal region of Gujarat.
4. Mismanagement of agro-grasslands through untimely grass harvest, excessive livestock grazing, plantation of harvest of shrub/tree species.
5. Mining projects in prime breeding areas, especially the open caste mines.
6. Free ranging dogs in prime breeding habitats, and possibly nest or chick predation caused by them.
7. Renewable energy projects such as installation of wind turbines in open habitats and expansion of power-lines have resulted in loss of habitat and (possibly) bird mortality due to collision or electrocution.
8. Excessive livestock grazing in breeding grounds during monsoon is a major threat as the species avoids grazed areas because of disturbances and the depletion of cover.
9. Poorly planned plantations of shrub/tree species such as Prosopis juliflora by the Forest Departments has made several historically used sites suboptimal for the species.
10. Erratic and changing precipitation patterns induced by climate change in the lesser florican range can potentially affect breeding success and population recovery.
11. Prevalent disturbance from unethical photography results in stress to the breeding birds.
12. Lack of awareness regarding importance of grasslands and lesser florican among locals in the species range.
13. Finally, paucity of ecological and conservation information, including inadequate knowledge of current distribution, abundance, demography, ranging patterns and non-breeding habitat use impedes effective conservation strategies.

METHODS

2.1 BACKGROUND

Lesser florican population have been assessed in the past by Sankaran (Sankaran, 1990; Sankaran et al., 1992; Sankaran, 1996b; Sankaran, 2000). This approach entailed visits to a sample of agro-grassland sites during the breeding season (July – September), counting all male floricans displaying in the site by intensive/combing foot search, doubling this count assuming equal sex ratio, and extrapolating the estimate to include unsampled sites. This protocol was used to monitor lesser florican population status for five cycles between 1982 and 2006 (Collar, 1982; Sankaran, 1990; Sankaran *et al.*, 1992; Sankaran, 1996; Sankaran, 2000). Since then, there has been discontinuity in monitoring lesser florican population, and the habitat/conservation contexts have also changed drastically across the species' breeding range.

A few concerns regarding this traditional approach of counting lesser florican are that, the protocol is not exactly replicable and is not robust to non-detection of birds in surveys. The problem of non-replicability is related to sampling objectivity: unless sampling efforts are standardized across space and time, or detections are corrected for variable efforts, abundance estimates cannot be compared meaningfully. Since sampling efforts per site (number and experience of observers, intensity of search, spatial representation etc.) are not explicit in the earlier survey reports, it is difficult to replicate this method and yield meaningfully comparable results. The problem of non-detection can negatively bias abundance estimates, and make comparisons across space and time difficult if detectability varies simultaneously. The count statistic in lesser florican surveys is based on displaying males, and factors affecting the detection of display, such as display rate (which is a function of environmental conditions – local rainfall/resources, weather and time of day), habitat characteristics, and observer experience can strongly vary across space and time. Hence, there is a need to correct for missing individuals in the survey. In our current study, we attempted to develop a monitoring protocol that, notwithstanding the need of further refinements, addresses these issues.

2.2 DELINEATION OF SAMPLING FRAME

To assess the range-wide status of lesser florican, we first defined our area of interest or the sampling frame. This is particularly difficult for bustards, especially lesser florican, because of their behavioural plasticity and use of contrasting habitats in different landscapes. We delineated the sampling frame by expert/knowledge based digitization of potential lesser florican breeding sites from very high-resolution satellite imagery. Researchers at the Wildlife Institute of India with multiple years' experience of working in varied lesser florican landscapes manually digitized agro-grass-scrub habitats that can be potentially occupied by the species in Google Earth, based on prior knowledge of breeding sites, habitat use (Sankaran, 2000; Bhardwaj *et al.* 2011), and ground conditions (fig 1).

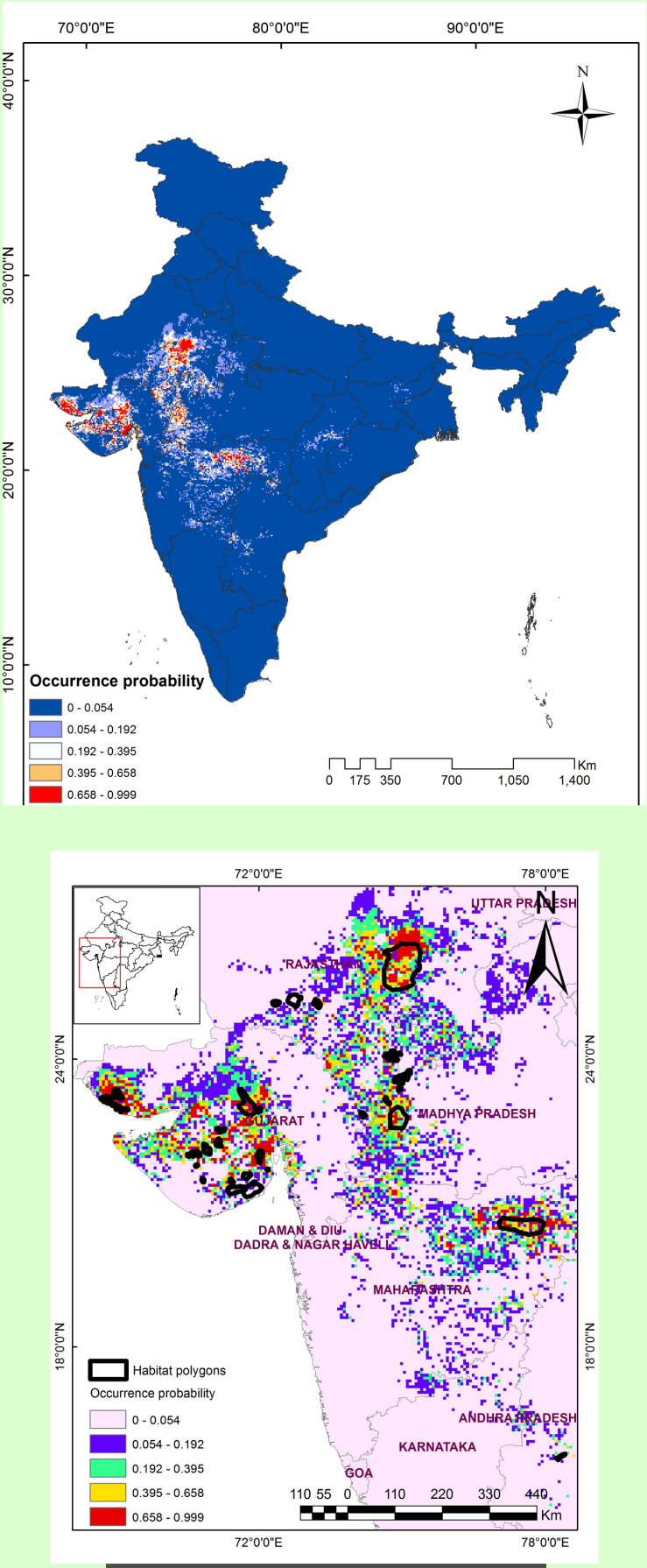


Figure 1
Habitat suitability map showing occurrence probability of lesser florican across its breeding range based on Maxent modeling (top) along with digitzed habitat polygons (bottom)

To verify if our digitization has covered the potential distribution range of lesser florican, we developed a MaxEnt habitat suitability model (Ferrier *et al*., 2006) based on recent occurrences (post 1980s) and environmental variables such as a) monthly maximum normalized difference vegetation index (NDVI) of 10 day composite from January through December 2013 (source: SPOT Vegetation NDVI accessed from spotImage/http://probav.vgt.vito.be/en/product-tools) at 1 sq km grain-size, b) elevation, c) slope, and d) compound topographic index (source: Hydro-1K dataset accessed from USGS 2001) and e) 19 bioclimatic variables (Hijmans *et al*., 2005, Stockwell & Nobel 1992, Stockwell & Peterson 2002). We used default settings for parameters such as prevalence, regularization multiplier, and density of background sampling, for creating multiple replicate models. We used MaxEnt based niche models since their outputs are known to be more accurate than comparable techniques (Ferrier *et al*., 2006); however, it can overpredict the distribution. The output is shown in figure 1. Areas that were predicted to be potentially suitable by MaxEnt were reviewed by researchers based on recent occurrence information and local habitat characters, and the digitization was refined when required. Finally, we circulated this map to local subject experts that included NGO partners, birdwatchers and State Forest Departments in each landscape (see contributors in list I–III), who refined the habitat polygons further. To be on the safer side, we added a buffer of 1 km to these habitat polygons.Thus, we delineated the potential breeding distribution map of lesser florican, hereafter referred to as the 'breeding range'. Given the historically widespread distribution of lesser florican and its occasional vagrant movements (fig 2), some unknown and sporadic breeding sites may be left out from this mapping. However, we believe that this excluded area will not exceed 10% of the species' breeding range.

We classified the breeding range into following regions and landscapes based on ecogeographical criteria: Ajmer region (Shokaliya and Kekri landscapes), rest of Rajasthan (Shahpura, Jalore and Pratapgarh), Gujarat (Kutch and Saurashtra), Madhya Pradesh (Ratlam-Sardarpur), Maharashtra (Akola-Washim) (fig 2), and Kurnool (Rollapadu) .

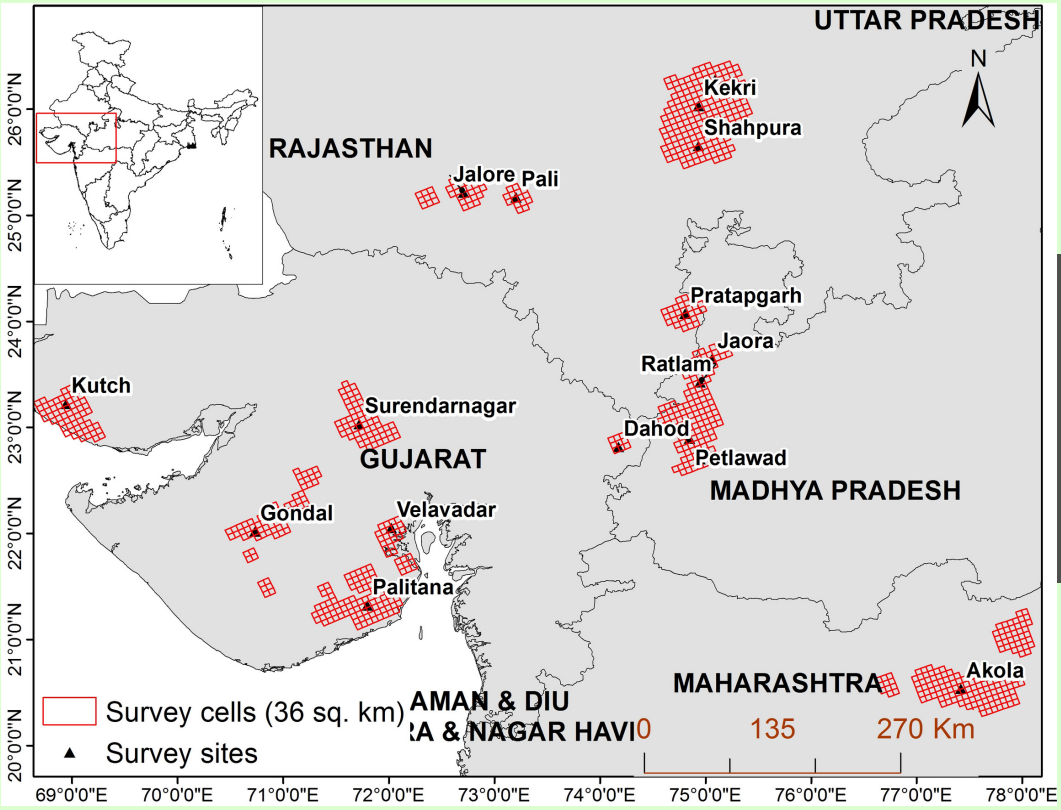


Figure 2 Lesser florican breeding range classified into survey regions, landscapes and sites

2.3 SAMPLING APPROACH

Our sampling approach was analogous to hurdle modelling (Hu *et al*. 2011), wherein we decomposed the lesser florican abundance into two components: proportion of sites occupied and abundance in occupied sites. We assessed these measures using two metrics: occupancy (probability of a sampled site being occupied) and density (mean abundance per sq km in occupied site). These metrics are independently useful in monitoring two important ecological aspects: breeding distribution and ecological density (clustering) of lesser florican. Additionally, population abundance can be inferred from the product of these two metrics, which we introduce below and critically discuss later.
Our sampling units, hereafter 'sites', were 6 x 6 sq km cells, overlaid on the breeding range. Sites with >33% habitat area were retained and ~75% sites were sampled, with equiproportional representation from all regions (fig 2). We preferred grid-cells to habitat-patches for sampling, because the transition between habitats and non-habitats is not clear-cut here (unlike forested systems) that complicates statistical extrapolation of population metrics. Conversely, fixed cells facilitate multiple-year comparisons of population status at sites. We selected this site dimension because it is sufficiently large to contain exploded lek(s) (Sankaran, 1997b; Dutta & Jhala, 2014). These studies have shown that lesser florican occurs in agro-grass patches generally >1 sq km in area and males occupy ~5 ha territories but can shift territories within breeding season in response to grazing and habitat changes.

We sampled sites in two phases: Occupancy surveys (Mackenzie *et al*., 2002) in the first phase and Line Transect surveys (Ralph *et al*., 1993) in the second phase.

2.3.1 OCCUPANCY SURVEYS

We assessed site occupancy using spatially replicated surveys following Mackenzie et al. (2002). We sampled 75% of sites in each landscape. We sampled a site along a route, digitzed prior to the survey in Google Earth, passing through optimal lesser florican habitats that covered at least three 4-sq km cells (hereafter 'sub-units') nested in the site (30% coverage). A team of two trained observers surveyed these routes on two or four wheel vehicles, recording lesser florican detections in one or two ~10 min stopovers per sub-unit that were at least 1 km apart, to ensure adequate dispersion of surveys (fig 3). To maximize detections, we laid stopovers in relatively optimal habitats (for e.g., dense scrubs with low use- or detection- probability were avoided), and also recorded lesser florican(s) that were detected in the kilometre following a stopover, although such detections were negligible (<5% relative frequency). Surveys were conducted during 06:30–10:30 and 17:00–19:00 hours because males display most frequently in early morning and late evening hours, leaping in the air and producing a 'rattle' once per minute that is usually audible up to 500 m (Sankaran, 1996; Dutta & Jhala, 2012). Hence, if a lesser florican is present within 500 m of a stopover, we are likely to detect it within 10 minutes. Based on a pilot analysis of detection history from 20 sites in Shokaliya-Kekri landscape in program GENPRES, we sampled each site with at least five stopovers, to achieve the desired precision (<20% CV) in our global occupancy estimate. Since time of day, wind-speed and weather conditions could potentially influence the production and reception of the sexual signal, inducing heterogeneity in detection probability, we also recorded these covariates at each stopover. Since we were interested in identifying factors influencing the probability of occurrence, we recorded the land-cover, ground vegetation cover and height in 100 m radius, and anthropogenic disturbances in 200 m radius of stopover points.

2.3.2 LINE TRANSECT SURVEYS

If a site was occupied (at least one detection), we assessed lesser florican density in it, using intensive and spatially representative line transect distance sampling. Line transects of approximately 2-km length were placed along the diagonal of 4- sq km cells/sites (fig 3). Two trained observers walked each transect once during 06:30–10:30 and 17:00–19:00 hours, the peak activity period, to count displaying lesser floricans. Observers used binoculars to detect birds and recorded the sighting distance and angle of each detection, using laser range finder and compass, respectively. Since we were also interested in abundance-habitat relationships, we quantified habitat variables that could potentially influence lesser florican numbers, at every 250 m along the transect. We recorded terrain and land-cover in 100-m radius, vegetation structure and composition in 50-m radius, and anthropogenic disturbances in 200-m radius plots. We preferred: a) line transect to point counts since the latter is more prone to biases due to animal movements and observer disturbance, and b) foot transect to vehicle transect since lesser florican's sexual signals can get masked by the noise of the vehicle, reducing detection.

We realized sites, sub-units, occupancy routes, and transects on ground using Google Map applications in smart phones or handheld GPS units (see Annexure 4). We recorded data in standard data sheets (see annexures 1 and 2) and entered field data on daily basis in online spreadsheets that were subsequently collated, processed and analysed.

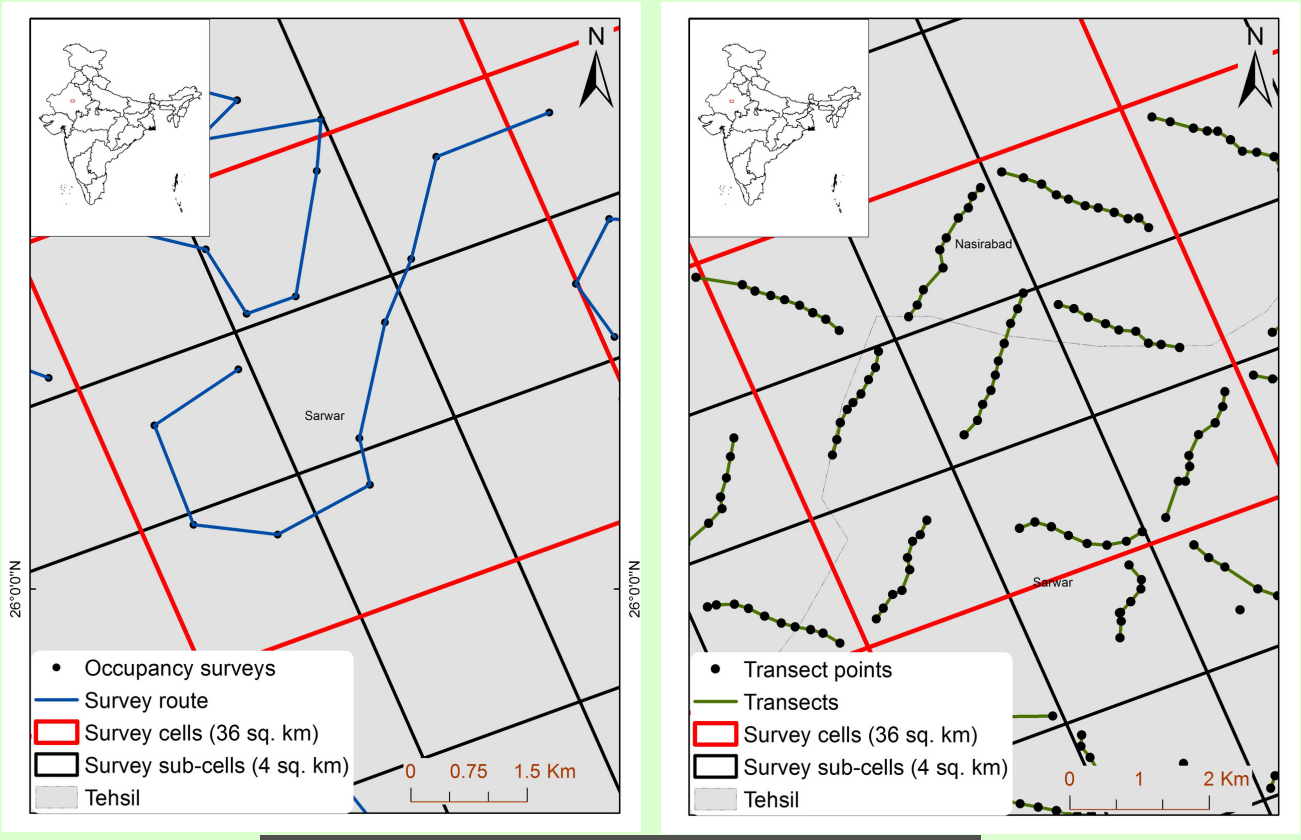


Figure 3
Graphical representation of point-count based occupancy and line transect based distance sampling for status assessment of lesser florican across the breeding range in 2017

2.4 INSTITUTIONAL COLLABORATION

Lesser florican population assessment is feasible within a small window of 45–75 days as displaying males can be spotted only during July-September. Hence, large human and financial resources were needed to conduct the range-wide survey. To mobilize such resources, it was decided to conduct joint surveys through collaborative efforts of Wildlife Institute of India (WII), Bombay Natural History Society (BNHS) and The Corbett Foundation (TCF) along with range State Forest Departments and local NGOs/institutions. We identified agencies working in each landscape and having overlapping goals, and approached them for collaboration. State Forest Department also provided logistic support for the exercise. Such collaboration facilitated sharing of knowledge and coordination between potential partner agencies to prepare site-specific lesser florican conservation plans in line with the National Species Recovery Plan (Dutta et al. 2013). We hope that this collaborative exercise will also help leverage funding for the implementation of site level recovery projects.

COLLABORATION AND TRAINING

To train surveyors on the standardized population assessment approach and data collection protocol, we organized two-days training workshops, one at each survey State:

1. **Gujarat** – Department of Marine Science, Department of Zoology, Sir P.P. Institute of Science, M.K. Bhavnagar University and Blackbuck National Park, Velavadar in Bhavnagar on 16-17 July 2017

2. **Madhya Pradesh** – Office of the Chief Conservator of Forests, Ujjain and Sailana Wildlife Sanctuary in Ratlam on 24 July 2017

3. **Rajasthan** – Department of Environment, MDS University, Ajmer and Shokaliya Conservation Reserve, Nasirabad on 2-3 August 2017

4. **Maharashtra** – Ampi Theatre, Vankuti, Akola on 17 September 2017

We also organized a post survey workshop at Wildlife Institute of India, Dehradun on 12-13 October 2017, where representatives of partner agencies and core survey teams participated to discuss and collate learnings from varied landscapes. This workshop resulted in refinement of breeding range maps, better understanding of logistic requirements, and development of conservation problems and solutions at the landscape-level.

2.5 DATA ANALYSIS

2.5.1 OCCUPANCY ESTIMATION

To assess occupancy, we analysed detection history (1/0) from spatial surveys (observation points) at 36 sq km cells, to estimate the proportion of sites occupied by lesser florican after correcting for imperfect detection. We first modeled the species' detection probability in a survey, by comparing a) a model with constant detection probability, against models where b) detection probability was assumed to vary with local abundance (Royle et al. 2004), or c) regions, capturing regional variations in lesser florican density and habitat characteristics, d) wind speed and e) weather, capturing weather effects on reception of signal. Since, we were evaluating factors that influenced detection in this step, we fitted the above models by retaining the same state model, where occupancy was a function of region. We compared these models using Information Theoretic approach (Burnham & Anderson, 2002), and selected the least AICc model to characterize the detection process (Akaike, 1974) and examine factors influencing the species' occupancy (see Section 2.5.2 and 2.5.4).

We estimated range-level occupancy, we assumed occupancy to be constant across sites. We extrapolated the estimate to unsampled sites, to assess the number of sites occupied and area of occupancy. To examine spatial variation in occupancy, we modelled occupancy on regions: Ajmer, rest of Rajasthan, and Gujarat. These regions represented different habitat characteristics and conservation contexts that could influence occupancy. We removed Maharashtra and Madhya Pradesh from this analysis since there was no detection in these regions. We built and compared occupancy models using the package unmarked in program R (Mackenzie *et al.*, 2002) (see Annexure 3 for R script).

2.5.2 DENSITY ESTIMATION

To assess lesser florican density in occupied sites, we used conventional distance sampling (Strindberg & Buckland, 2004) that models detectability as a function of perpendicular distance of sightings. After diagnosing the distance data for evasive bird movements (close to the line) and peaking of observations (at further distances), we fitted half–normal and hazard–rate detection functions to it. We selected the best detection model using AICc (Akaike, 1974) and goodness–of–fit tests, to estimate detection probability. Using this estimate, we corrected counts along spatially replicated transects to obtain site-level densities. We estimated the mean global density in occupied sites by averaging site-level densities.

2.5.3 POPULATION SIZE

Finally, we estimated range-level (hereafter 'global') abundance from the product of number of sites occupied by lesser florican and the mean abundance at a site. We generated bootstrapped geometric mean and 95% confidence intervals of global abundance by sampling site occupancy and density from normal distributions specified by respective mean and SE estimates in program R (see annexure 3 for R script). This formulation assumes that expected abundance at occupied sites where species was not detected (but present) 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 on a conservative estimate of global abundance based only on sites where the species was detected, representing a 'minimum population size'.

2.5.4 HABITAT RELATIONSHIPS

To generate baseline information on habitat characteristics in lesser florican breeding range, we summarised habitat variables at sites sampled for occupancy and sub-units sampled for density. Using this data, we assessed regional- and landscape- scale habitat differences, by comparing mean and 95% confidence intervals of habitat variables. We assessed lesser florican-habitat relationships in a hurdle modelling framework (Hu *et al.* 2011). First, we identified habitat selection of lesser florican by modelling occupancy at sites on grassland cover, sward biomass (ground-vegetation height * cover) and disturbances, as additive and interactive effects of regions. Then, we identified factors influencing site abundance by modelling density at sub-units on grassland-prevalence, terrain flatness, sward- cover and structural heterogeneity, crop- cover and structural heterogeneity, and anthropogenic disturbances, as additive or interactive effects of regions.

We postulated that habitat selection would differ by region (interactive effect) because the species exhibited prominent behavioral plasticity in their habitat responses across regions, probably because of the vast differences in their conservation and habitat contexts. We built occupancy and density models using generalized linear models of binomial and Poisson families, respectively, and compared models using Information Theoretic approach in program R (see annexure 3 for R script). Unless mentioned otherwise, we used only male lesser florican detections in the above statistical analyses, because female detections were too few for meaningful inferences.

2.5.5 CONSERVATION PRIORITIZATION AND THREAT ASSESSMENT

We mapped lesser florican detections, habitat variables, predicted occupancy and density across sites using program ArcGIS version 10.2.2 (ESRI 2014). We generated a conservation priority map, where the importance of a site for lesser florican conservation (W) was assessed from the region's contribution to the global population (wr) and the expected/predicted abundance of lesser florican in that site (ns), as: W = wr*Ns. This ranking valued contiguous large sub-populations over small-fragmented populations for species conservation.

We carried out comparative assessment of anthropogenic threats to lesser florican across landscapes. To quantify threats, we used proxy variables that were collected from occupancy surveys and were quantified as the proportion of observation points in a landscape with a particular threat. We averaged this value across sites in a landscape, to estimate the mean occurrence probability of the threat. This metric was scaled to the maxium occurrence probability for that threat across landscapes, to generate a relative threat index for each landscape. A composite threat index was generated by weighted average of various threat indices, wherein certain threats (e.g., industrial/infrastructural development and excessive livestock grazing) were given higher weightage than others (e.g., agricultural activities and road networks), based on prior conservation understanding. Although, relativizing threat prevalence enabled comparison across threats and developing the composite index, it was not useful in comparing the status of a threat across time. Hence, we also reported the actual mean occurrence probability of each threat across landscapes. Finally, landscapes were ranked using the composite threat index, to make informed decisions on where/how to invest conservation funds given the priority and threats. Details of the threats, proxies and weightages are presented on page 35.

Datasheets for occupancy (Annexure 1) and line transect surveys (Annexure 2) are provided.

P. juliflora prolification is a major cause of shrinking habitat of floricans.

Results & Findings

3.1 EFFORT

We conducted the exercise with 121 surveyors (see list I–III). Breeding range of lesser florican encompassed 576 sites (36-sq km cells). We assessed the species' occupancy in 506 sites (18,206 sq km area), out of which, 428 sites (75% of available sites) were adequately sampled (see criteria in methods), each with 13Mean (5SD) (range 5-32) spatial surveys or 'stop-overs'. We detected lesser florican in 31 sites. Subsequently, we assessed lesser florican density in these sites by sampling each site with 7Mean (2SD 0(range 3-9) spatially replicated transects of length 2.3Mean (0.6SD)(range 0.5–3.8) km. Cumulatively, we walked 218 transects covering 478.8 km, and detected 70 lesser floricans, out of which, 64 observations were of males – with 45 observations based on visual cues and 19 observations based only on auditory cues. Only six observations were of females, which were discarded from the analysis (Table 1).

Habitat variables were quantified during occupancy and line transect surveys, and were used to describe site characteristics across breeding range (Table 2) and sites occupied by lesser florican (Table 3).

Table 1
Sampling efforts at regional and landscape levels for assessing lesser florican occupancy and density across the breeding range in 2017

Area		Occupancy sampling				Density (distance) sampling			
Region	Landscape	Sites	Stop-overs (surveys)	Detected stop-overs	Detected sites	Sites	Transects	Efforts (km)	Male sightings
Ajmer	Kekri	37	444	4	2	3	19	39	15
	Shokaliya	51	711	21	17	17	112	244	15
Rajasthan rest	Jalore	20	254	1	1	1	5	9	0
	Pratapgarh	15	140	1	1	1	5	11	2
	Shahpura	48	555	3	3	4	30	72	0
Gujarat	Kutch	30	407	5	4	4	29	78	1
	Saurashtra	105	1450	14	3	2		35	31
Maharashtra	Akola-Washim	50	649	0	0				
Madhya Pradesh	Ratlam-Sardarpur	72	790	0	0				
Total		428	5400	49	31	32	218	488	64

Table 2:
Mean (SE) of habitat variables at sites sampled for lesser florican occupancy across the breeding range based on occupancy survey habitat quantification in 2017

Region	Units	Ajmer		Rajasthan (rest)			Gujarat		Madhya Pradesh	Maha-rashtra
Landscape		Kek	Sho	Jal	Prt	Sha	Kut	Sau	Rat	Ako
Agriculture	% cover	64 (2.2)	70.1 (2.2)	46.5 (4.3)	71 (5.6)	55.7 (3)	32.2 (2.9)	58.1 (2.1)	53.2 (2.4)	64.5 (2.8)
Grassland		19.4 (2)	12.1 (2)	27.1 (3)	23.6 (5.8)	21.5 (3.1)	45.1 (2.7)	24.6 (2)	38.7 (2.2)	14.2 (2)
Scrub/wood		16.7 (1.6)	17.7 (1.4)	26.4 (4.1)	5.4 (1.7)	22.8 (2.1)	22.6 (1.5)	17.4 (1)	8.1 (1)	21.3 (2.4)
Ground veg height	cm	45.4 (1.6)	41 (1.3)	35.3 (1.8)	36.9 (1.7)	38.5 (1.5)	35.2 (1.5)	43.7 (1)	28.6 (1.2)	55.9 (1.4)
Ground veg cover	% cover	57.1 (1.9)	67.4 (1.3)	58.6 (2.4)	50.3 (2.9)	68 (1.1)	66.2 (1.4)	68.2 (0.8)	66.9 (1.1)	59.1 (2.5)
Active disturbance	index (intensity)	0.46 (0.02)	0.45 (0.02)	0.37 (0.04)	0.62 (0.05)	0.47 (0.02)	0.34 (0.03)	0.44 (0.01)	0.45 (0.02)	0.42 (0.02)
Passive disturbance		0.25 (0.02)	0.23 (0.02)	0.18 (0.03)	0.53 (0.04)	0.25 (0.02)	0.26 (0.02)	0.33 (0.01)	0.31 (0.02)	0.29 (0.02)

Landscapes include Kekri (Kek), Shokaliya (Sho), Jalore (Jal)Pratapgarh (Prt), Shahpura (Sha), Kutch (Kut), Saurashtra (Sau), Ratlam-Sardarpur (Rat) and Akola-Washim (Ako)

Table 3:
Mean (SE) of habitat variables at sites occupied by lesser florican across the breeding range based on distance survey habitat quantification in 2017

Habitat variables		Units	Ajmer	Gujarat	Rajasthan (rest)
Land cover	Agriculture	% cover	73.2 (2.1)	34.1 (4.5)	66.6 (4.9)
	Grassland		14 (1.5)	43.5 (4.3)	16.8 (4)
	Scrub/wood		12.8 (1.3)	22.4 (2.7)	16.5 (3.1)
Natural vegetation	Ground veg cover	% cover	30.6 (1.5)	81.1 (4.8)	36.9 (3.1)
	Ground veg height	cm	33.2 (0.5)	34.8 (1.4)	31.7 (1.7)
	Woody cover	% cover	8.5 (0.6)	16.9 (2.9)	11.5 (1.3)
Cropping characteristics	Crop cover	% cover	58.4 (1.8)	25.9 (3)	50.8 (4.6)
	Crop height	cm	67.6 (2.1)	42.5 (3.1)	60.1 (3.8)
	Crop richness	number/plot	1.17 (0.03)	0.54 (0.07)	0.95 (0.09)
	Sorghum	occurrence (%)	50.6 (2.1)	17.9 (3.8)	21 (3.3)
	Sesame		4.1 (0.8)	8.1 (2.3)	13.6 (3.2)
	Blackgram		15.4 (2.2)	0 (0)	34.3 (6.3)
	Greengram		31.5 (2.8)	5.9 (1.9)	16 (4.6)
Disturbances	Active disturbance	index (intensity)	0.7 (0.04)	0.7 (0.09)	0.74 (0.1)
	Passive disturbance		0.57 (0.05)	0.74 (0.1)	0.59 (0.11)

3.2 OCCUPANCY

We detected male lesser florican in only 6.3% of sampled sites (naïve occupancy) at the range-level. However, the probability to detect a lesser florican during a survey, if it was present in the site, was <<1. Further, comparison of alternate models showed that region and weather conditions influenced detection probability (model 2 in Table 4a). Detectability of the species was higher in Gujarat than Ajmer and rest of Rajasthan (fig 4), and this trend reflected regional variations in lesser florican density (see section 3.4). Using the best detection model and assuming constant occupancy (model 18 in Table 4a), we estimated range-level occupancy at 13 (2.6SE) % of sites, equivalent to 1908 sq km occupied area. This estimate is representative of Ajmer, rest of Rajasthan, and Gujarat regions only (n = 306 sampled sites out of total 380 sites), as Maharashtra and Madhya Pradesh were excluded from the analysis since lesser florican was not detected there, and these regions were assumed to be entirely unoccupied. Assuming occupancy to vary across regions (model 17 in table 4a), we estimated the occupancy probability to be higher in Ajmer ($\hat{\psi}$ = 40.6 (SE 12.1) % sites) than Gujarat ($\hat{\psi}$ = 4.9 + SE 1.9 % sites), but could not precisely estimate occupancy for rest of Rajasthan (20.6 (38.2) % sites) due to very few observations (fig 4).

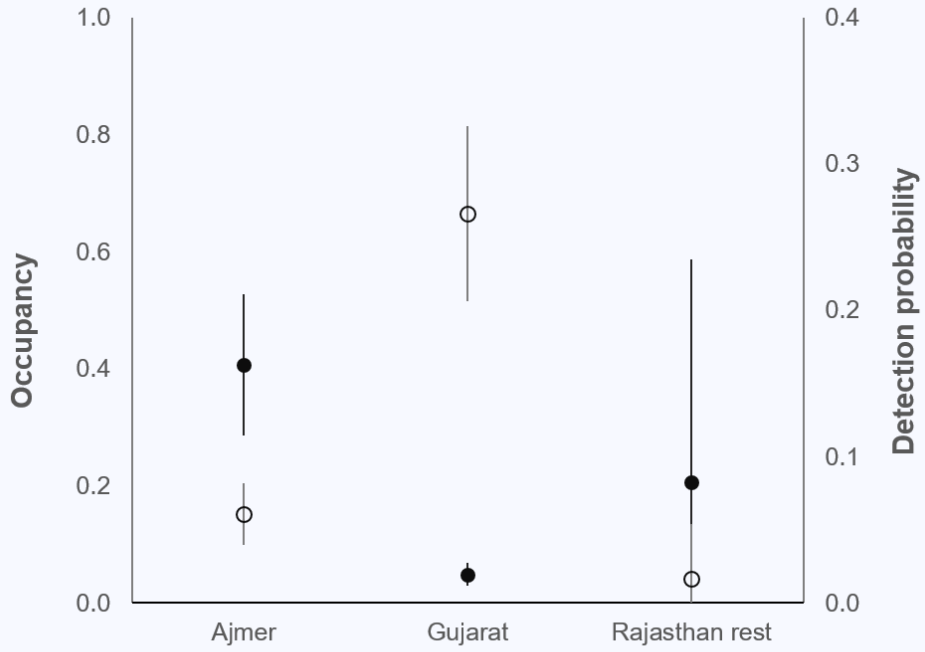


Figure 4
Regional occupancy probability (open circles) and species' detection probability (closed circles) of lesser florican across regions in the breeding range in 2017. Error bars are 1 SE.

3.3 OCCUPANCY-HABITAT RELATIONSHIPS

Habitat quantification in potential breeding sites showed that agricultural cover was maximum in Ajmer (Shokaliya > Kekri) and Maharashtra (Akola-Washim) regions, followed by rest of Rajasthan (Pratapgarh > Shahpura > Jalore), Madhya Pradesh (Ratlam-Sardarpur), and Gujarat (Saurashtra > Kutch), while grassland cover followed an inverse trend (Gujarat ≈ Madhya Pradesh > rest of Rajasthan > Maharashtra ≈ Ajmer). Despite grassland availability, ground vegetation height was considerably low in Madhya Pradesh followed by Kutch and rest of Rajasthan, while being highest in Akola-Washim followed by Saurashtra and Ajmer. Active (human presence) and passive (human artifacts) disturbances were particularly intense in Pratapgarh landscape. Mean and 1 SE of these habitat variables are reported in Table 3, as baseline information for future monitoring. However, as these variables were quantified at spatial locations which were optimal for lesser florican use/detection, this habitat characterization may not be truly representative; but can be used as a relative measure for spatial and temporal comparisons.

Comparison of alternate hypotheses on factors influencing lesser florican distribution found maximum support for regional effects of grassland cover (model 9 in Table 4a), wherein occupancy probability increased with grassland cover in Gujarat but decreased with grassland cover in Ajmer (fig 5). Occupancy probability also increased with grassland cover in rest of Rajasthan, but the relationship was not precise due to inadequate observations (Table 5a). We generated spatially explicit occupancy probability of lesser florican from this model (fig 6).

Lesser Florican in agricultural field. Though the floricans prefer open pure grasslands as their breeding habitat, still they visit neighboring crop fields for foraging.

Table 4:
Ranking of candidate models explaining lesser florican (a) occupancy and detection probability across the breeding range and (b) density (mean abundance 10 per sq km) across occupied sites in 2017

No.	Model	W_i	ΔAICc	AICc	Deviance	K
1	ψ (.) p(.)	-	-	446.76	442.72	2
Candidate models for detection probability with occupancy modeled on region						
2	ψ (Rgn) p(Rgn + Wthr)	0.73	0.00	411.71	397.34	5
3	ψ (Rgn) p(Rgn + Wind + Wthr)	0.27	2.01	413.72	397.24	6
4	ψ (Rgn) p(Rgn)	0.00	10.86	422.57	410.29	4
5	ψ (Rgn) p(Wthr)	0.00	14.68	426.40	416.20	4
6	ψ (Rgn) p(Wind + Wthr)	0.00	15.59	427.30	415.02	5
7	λ (Rgn) p(.) Royle-Nichols	0.00	24.10	435.81	427.68	3
8	ψ (Rgn) p(.)	0.00	48.94	460.65	452.52	3
Candidate models for occupancy with detection probability modeled on region and weather						
9	ψ (Rgn*Grsl) p(Rgn + Wthr)	0.44	0.00	394.56	373.82	10
10	ψ (Rgn*Grsl + Vhet) p(Rgn + Wthr)	0.16	2.06	396.62	373.73	11
11	ψ (Rgn*Grsl + Pdtb) p(Rgn + Wthr)	0.16	2.08	396.65	373.75	11
12	ψ (Rgn*Grsl + Vhgt*Vcov) p(Rgn + Wthr)	0.08	3.39	397.96	370.71	13
13	ψ (Rgn*Grsl + Pdtb + Adtb) p(Rgn + Wthr)	0.08	3.45	398.01	372.95	12
14	ψ (Rgn*Grsl + Pdtb + Vhet) p(Rgn + Wthr)	0.05	4.17	398.74	373.67	12
15	ψ (Rgn*Grsl + Pdtb + Vhgt*Vcov) p(Rgn + Wthr)	0.03	5.57	400.13	370.69	14
16	ψ (Rgn*Grsl + Pdtb + Adtb + Vhet + Vhgt*Vcov) p(Rgn + Wthr)	0.00	9.03	403.59	369.71	16
17	ψ (Rgn) p(Rgn + Wthr)	0.00	17.15	411.71	397.34	7
18	ψ (.) p(Rgn + Wthr)	0.00	35.15	429.72	419.52	5
19	ψ (Grsl) p(Rgn + Wthr)	0.00	37.13	431.70	419.42	6

SN	Model	W_i	ΔQAICc	QAICc	Deviance	K
1	Grassland + Woody cover	0.44	0.00	46.55	157.68	3
2	Grassland + Woody cover + Active disturbance + Passive disturbance	0.34	0.55	47.10	134.61	5
3	Grassland	0.22	1.38	47.93	174.83	2
4	Active disturb	0.00	15.12	61.67	233.36	2
5	Woody cover	0.00	15.34	61.89	234.30	2
6	*Null*	0.00	15.91	62.47	247.24	1
7	Grassland + Woody cover + Active disturb	0.00	16.74	63.29	229.01	3
8	Active disturb + Passive disturb	0.00	18.27	64.82	246.79	2

Model covariates include: Region (Rgn), Grassland cover (Grsl), Ground vegetation height heterogeneity (Vhet), Ground vegetation height (Vhgt), Ground vegetation cover (Vcov), Prevalence of passive disturbances (Pdstb), Prevalence of active disturbances (Adtb) as site covariates; and Weather (Wthr) and Wind speed (Wind) as survey covariates

Table 5:
Effect of habitat variables on lesser florican (a) occupancy (logit-transformed occurrence probability) and (b) density (logtransformed number 10-km-2) across breeding range in 2017

(a)

Parameter	Effect size	SE	z-stat
Intercept	1.31	1.09	1.20
Gujarat	-7.27	1.88	-3.86
Rajasthan (rest)	-4.35	1.66	-2.62
Grassland cover	-14.85	6.66	-2.23
Gujarat * Grassland	22.07	7.25	3.04
Rajasthan (rest) * Grassland	19.24	7.20	2.67

(b)

Parameter	Effect size	SE	z-stat
Intercept	1.06	0.97	1.09
Grassland cover (proportion)	3.88	1.01	3.86
Woody cover (proportion)	-14.69	10.23	-1.44

3.4 DENSITY

We detected 64 males in 28 out of 218 transects across 32 occupied sites. Although the total area of a site was 36 sq km, the habitat area in a site where transects were actually laid was 29 sq km on average. Half normal detection function fitted the distance data best ($\chi 2=0.26$, df=3, p=0.97), and yielded estimates of effective half-strip width (ESW = 277, SE 27, 95% CI 227–338 m) and detection probability (p = 0.53, 0.43–0.65). Correcting for imperfect detection, lesser florican density in occupied sites was estimated to be 0.25 (0.06SE) (95% CI 0.15–0.42) males per sq km. At regional level, density tended to be higher in Gujarat (0.50 + 0.18SE, 0.24–1.02 per sq km) than Ajmer (0.18 + 0.07, 0.09–0.37 per sq km) and rest of Rajasthan (0.04 + 0.04, 0.01–0.20 per sq km) (fig 6 and 7).

3.5 DENSITY-HABITAT RELATIONSHIPS

Lesser florican density (n = 32 sites) was modelled as mean abundance 10 per sq km on habitat variables, which were collected from sampling plots on transects and averaged for the site. More intensive and representative habitat quantification at sites where lesser florican density was assessed, corroborated that agricultural attributes (coverage, height and crop richness in a plot) were higher in Ajmer and rest of Rajasthan compared to Gujarat, while grassland cover followed an inverse trend. Ground vegetation cover, but not height, was markedly higher in Gujarat than Ajmer and rest of Rajasthan. Passive disturbance intensity was relatively higher in Gujarat than other regions. Mean and 1 SE of these habitat variables are reported in Table 3, and represent an unbiased characterization of the occupied sites; hence, will allow more robust spatial and temporal comparison of habitat in occupied sites.

Habitat variables were strongly cross-correlated (|r|>0.4) that could complicate the interpretation of parameters in density models. Hence, we removed less important variables based on prior ecological understanding to ensure satisfactory variance inflation factors (<2 units) of parameter estimates (see Annexure 3 for R script), and >6 observations per parameter in the full model. Based on histograms of response along with residual diagnosis and dispersion parameters ($\hat{c}$) of the full model, we concluded that lesser florican density followed a zero-inflated Poisson distribution that was best modelled as a quasi-Possion distribution using generalized linear models.

Comparison of alternate hypothesis explaining density-habitat relationships found maximum support for models (1-3 in Table 4b) including grassland cover with/without woody cover and disturbance variables. We selected the least QAICc model (Wi = 0.44) for inference that showed a strong positive effect of grassland cover on lesser florican density (Table 5b), where density was particularly high in contiguous/extensive grassland sites (fig 5). Spatially explicit density was generated from the least AICc model for sites where lesser florican occupancy was detected (fig 6).

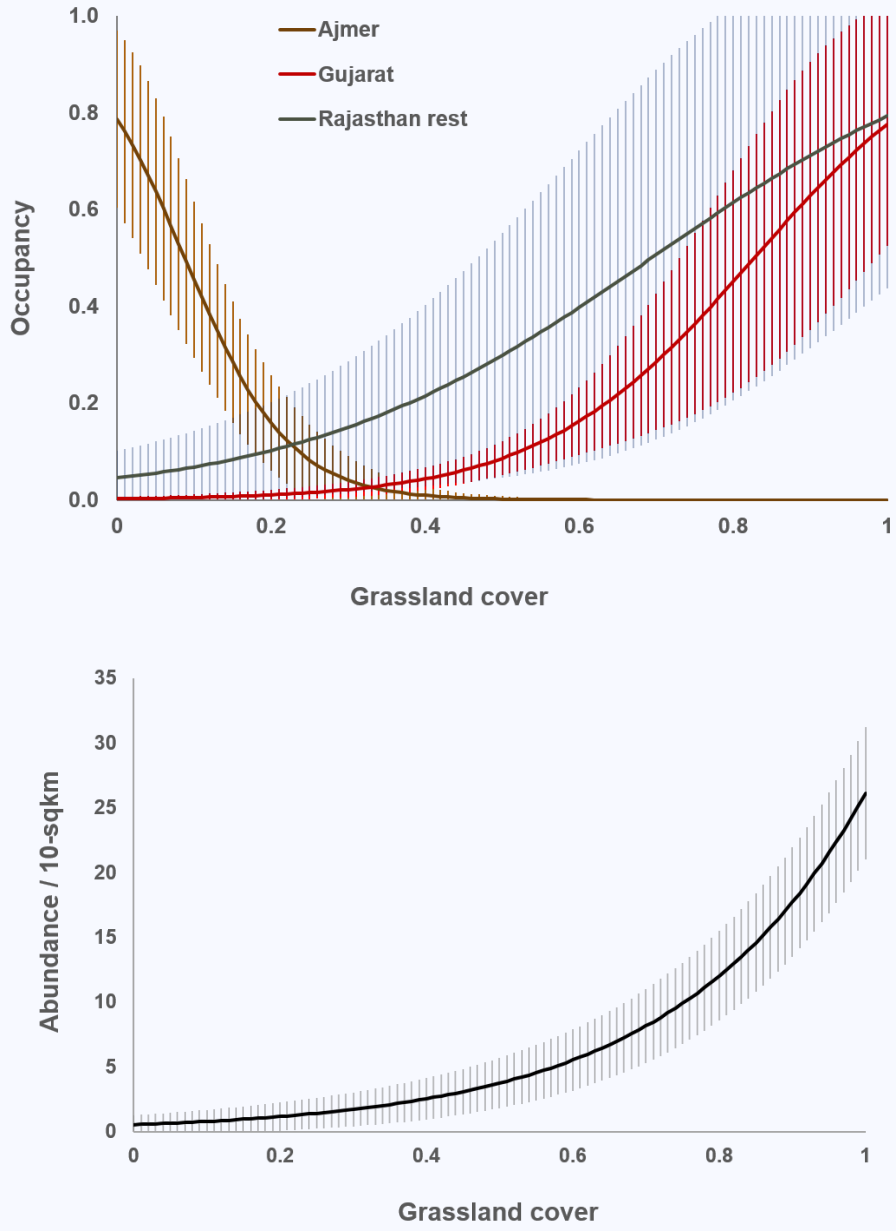
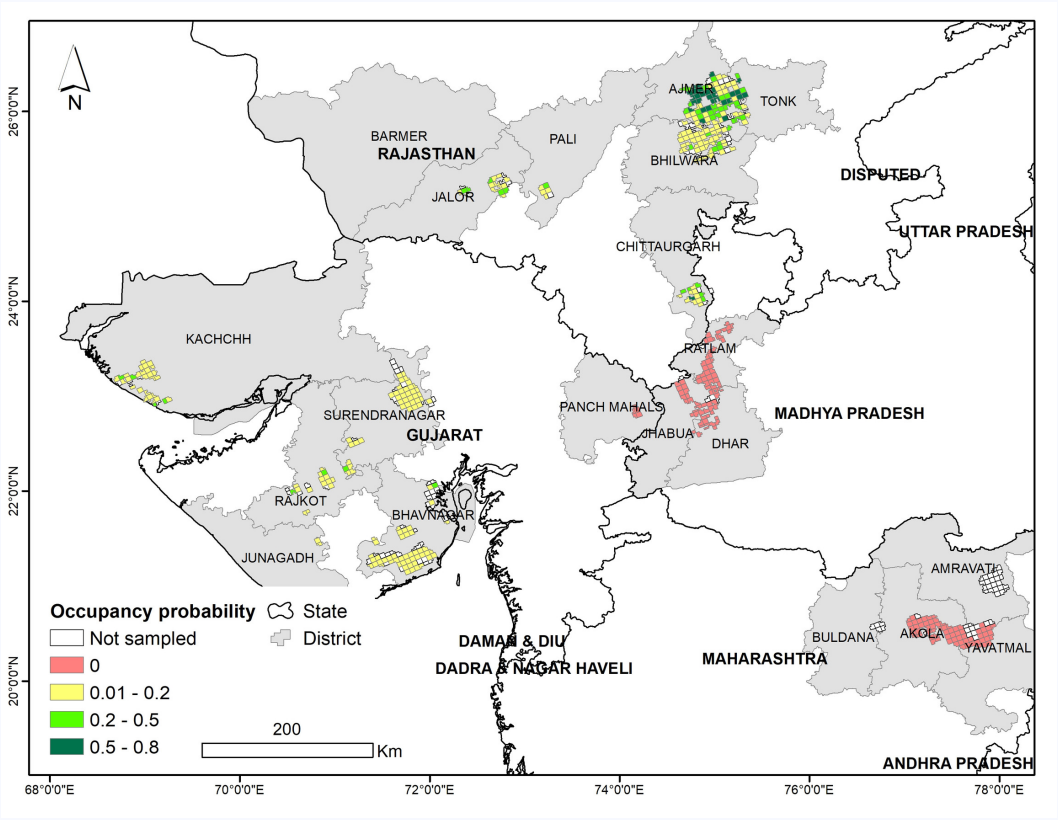


Figure 5
Relationships between occupancy probability and proportional grassland cover across regions (top), and mean abundance 10 per sq km vs. proportional grassland cover across sites occupied by lesser florican in the breeding range in 2017. Error bars are 1 SE.



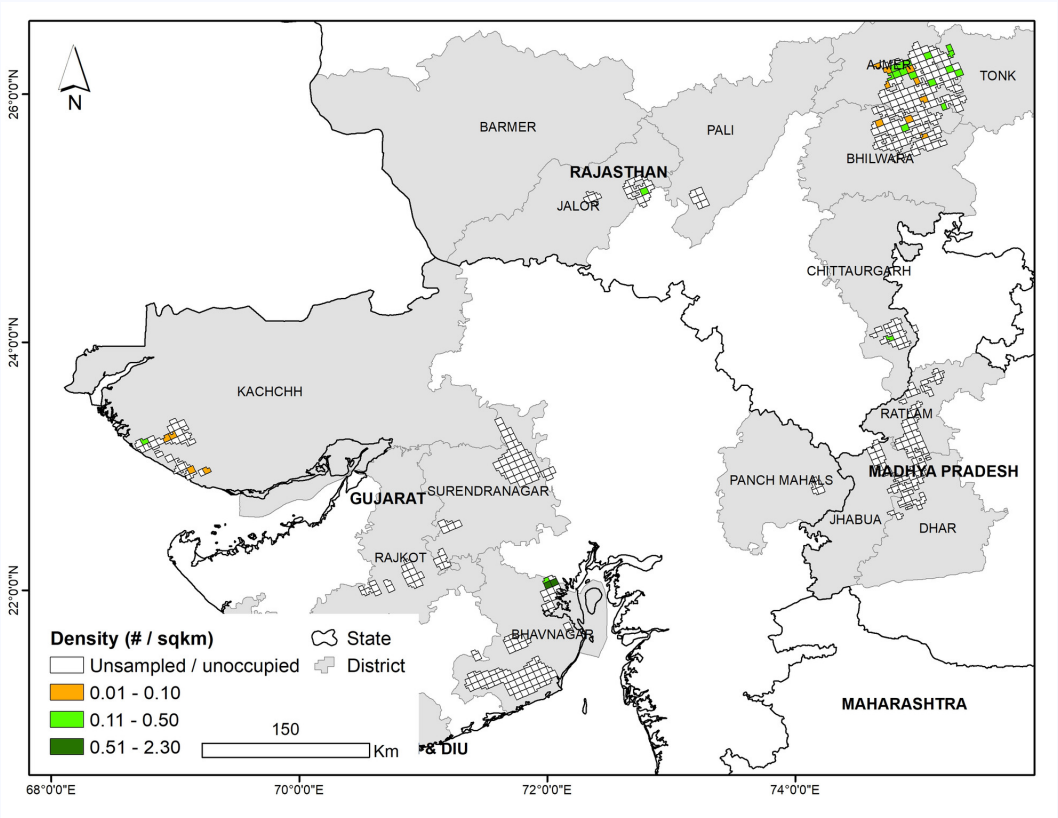


Figure 6

Model-predicted lesser florican occupancy probability (top) and mean number per sq km (bottom) in sites (36 sq km cells) across breeding range in 2017.

3.6 POPULATION ABUNDANCE

Based on the proportion of sites occupied (0.13 (0.03SE) and mean abundance at an occupied site 7.25 (1.74SE), we estimated the geometric mean number of breeding male lesser florican to be 340 (95% CI 162–597) individuals. This estimate includes the potential breeding habitat in sites (mean area 29 sq km) across Rajasthan (Ajmer and Rest of Rajasthan) and Gujarat states, while that of Madhya Pradesh and Maharashtra were ignored as lesser florican was not detected, and only a few males if at all, were likely to occur there. Abundance of male lesser florican across sites where their occupancy was detected (i.e., naïve occupancy of 6.5% sites, without any extrapolation to undetected but possibly occupied sites) was estimated to be 264 (66SE), (95% CI 157–442) individuals. We propose this figure as a conservative estimate of the global population of the male breeding pool. Due to logistic constraints, we could not conduct surveys in Rollapadu WLS, where 6 males were reported in 2017 (Prudhviraj and Vaibhav Mupadi, pers. comm.).

As expected, detection probability in occupancy surveys (fig 4) surrogated the density gradient reasonably well (fig 7), when compared across regions.We observed an inverse occupancy-density relationship across breeding regions that suggested regional differences in the species' social/spatial organization (fig 7). Male lesser florican arenas were dispersed across a larger area at very low density in Ajmer region; while their arenas were concentrated in a few sites at relatively high density in Gujarat (Saurashtra) region. Thus, Ajmer and Saurashtra represented two extremes of the species' exploded lek mating system, from very loose congregation in agriculturally dominated landscape to very tight congregation in grassland dominated landscape. The process(es) behind this pattern needs to be examined because of their strong implications in the species' sociobiology and conservation, as grasslands are being converted to agriculture across India.

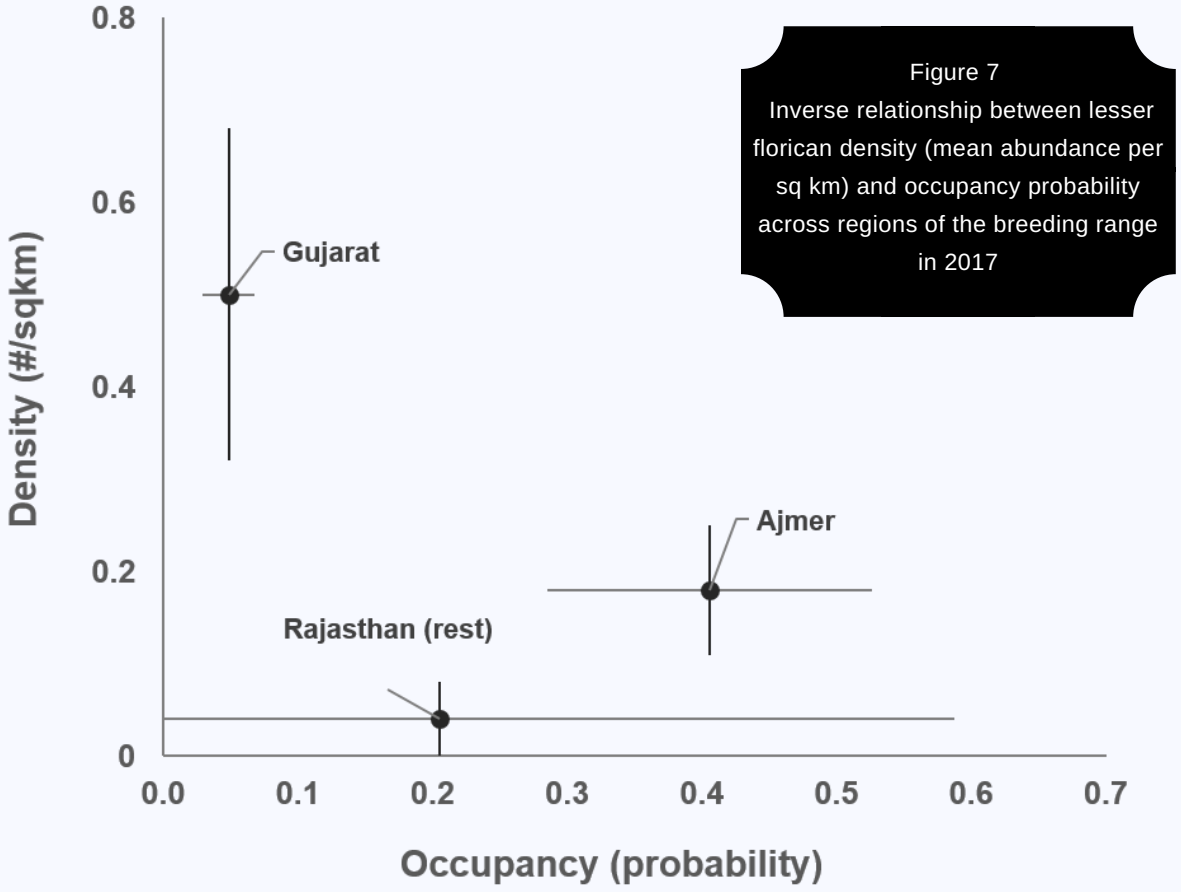


Figure 7
Inverse relationship between lesser florican density (mean abundance per sq km) and occupancy probability across regions of the breeding range in 2017

3.7 CONSERVATION MAPPING

Conservation priority rank, computed from expected lesser florican abundance at sites weighted by relative contribution of the regional population to the global pool, indicated that the priority conservation areas are clustered in two areas. The Blackbuck National Park, Velavadar and its adjoining area in Bhavnagar district, Gujarat held about 96 (model-predicted)–115 (empirically estimated) male lesser floricans in two sites. Here males congregate in the well-managed grasslands, and occasionally use surrounding agricultural areas particularly during late breeding season that are also used by nesting females (Indra Gadhvi pers. obs). Another 110 (model-predicted)–136 (empirically estimated) male lesser floricans were found in Ajmer extending from Bhinai in west through Shokaliya Conservation Reserve, Nasirabad and adjoining areas to Malpura, Tonk in the east. As mentioned above, males are spread out at low density across estimated 22 sites comprising of agricultural fields here; with one site near Bhinai (26.0443 N, 74.6975 E) having relatively flat, unobtrusive, low-impact agriculture holding substantially high density (1.8 males per sq km). Although our conservation prioritization is intended to guide managers to allocate conservation efforts, we caution readers that this exercise is a preliminary representation, and needs to be refined using data from at least two-three breeding cycles since this species is known to shift breeding grounds in response to local rainfall patterns (fig 8).

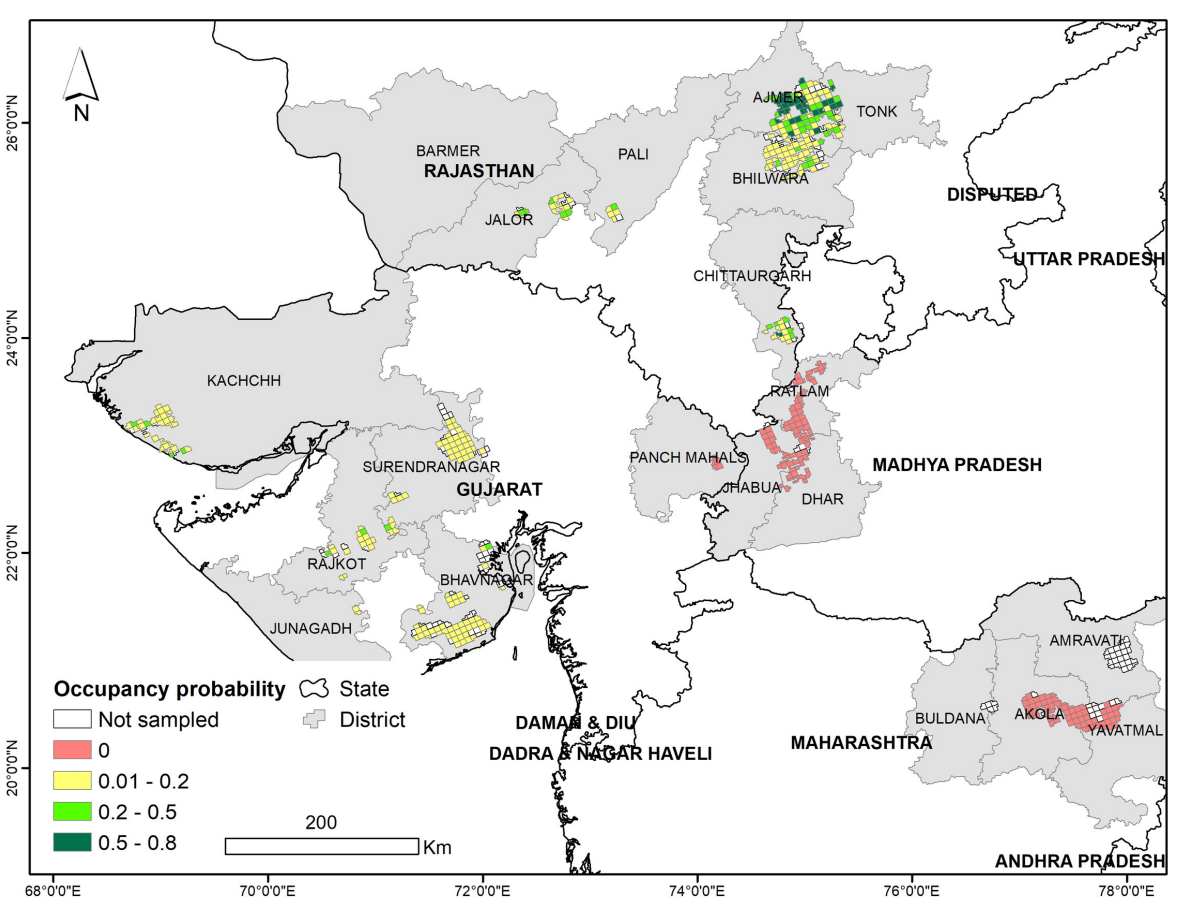


Figure 8
Importance of sites (36 sq km cells) for lesser florican conservation across breeding range in 2017. Note that, this map is preliminary and needs to be refined using data from at least three breeding cycles since lesser florican is known to change their spatial distribution in response to local rainfall patterns.

3.8 THREATS

Our comparative threat assessment with the focus on lesser florican indicated that Ratlam-Sardarpur (region Madhya Pradesh) > Shokaliya–Kekri (Ajmer) > Akola-Washim (Maharashtra) were the most threatened landscapes, whereas Jalore and Shahpura (region rest of Rajasthan) were relatively less threatened. Agticultural activities were highest in Shokaliya–Kekri, urbanization and infrastructural development was highest in Ratlam-Sardarpur, industrialization was maximum in Akola-Washim and Shokaliya, livestock grazing was highest in Ratlam-Sardarpur, and free-ranging dogs were highest in Kutch (Table 6 and 7).

Interfering Wings!

Though the windmills have no direct affect on the florican population, but the noise of the moving wings suppresses the sound of the jumping males.

Table 6:
Comparative threat assessment across landscapes, based on proportions of occupancy observation points with a particular threat across sites (values in top row), scaled to the maximum value across landscapes (values in bottom row and parantheses) in the lesser florican breeding range in 2017

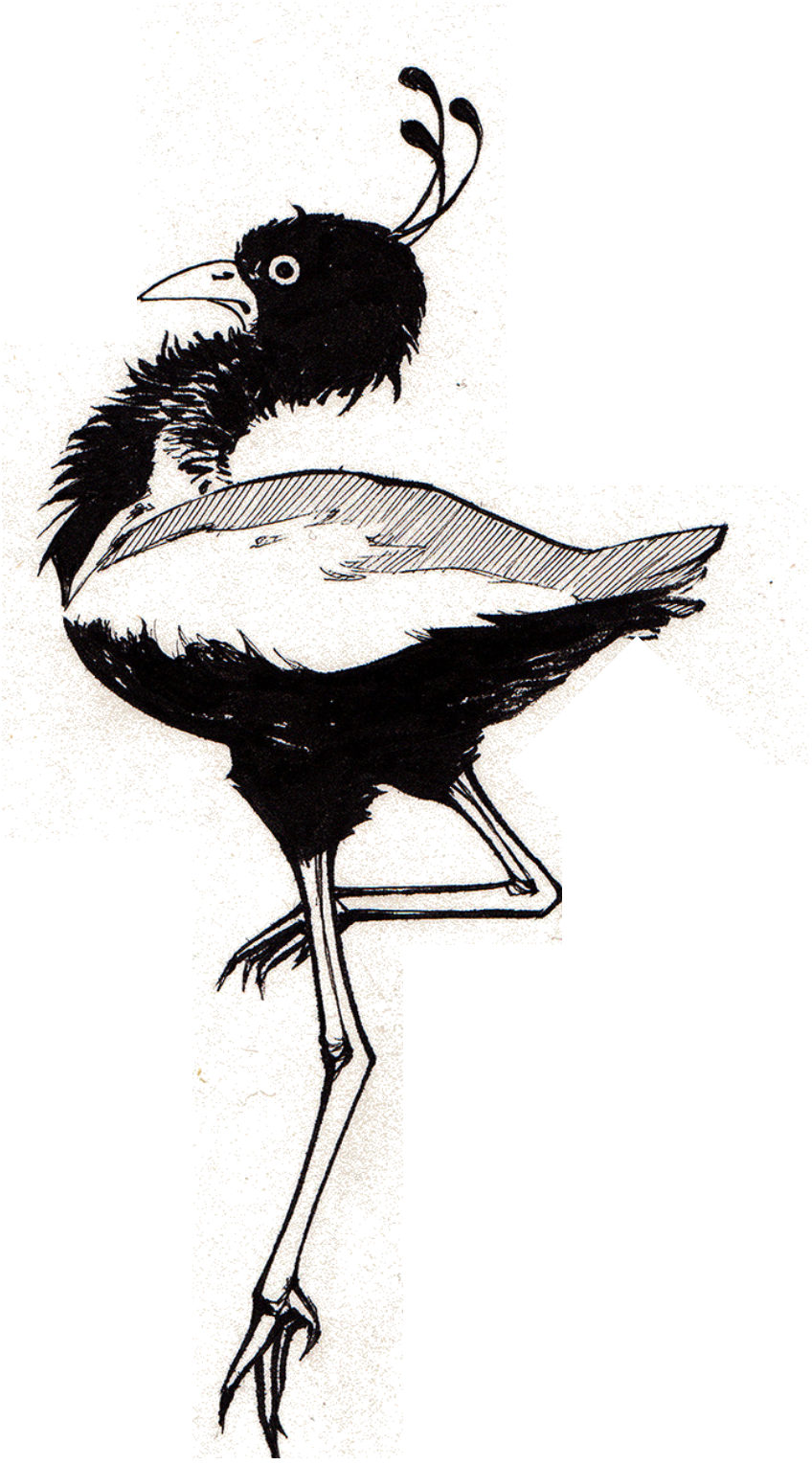
			Landscape								
Threats	**Proxy**	**Weight**	**Sho**	**Kek**	**Sha**	**Jal**	**Rat**	**Kut**	**Sau**	**Ako**	**Mean**
Agricultural activities	Agriculture	0.5	0.66 (1)	0.63 (0.95)	0.56 (0.85)	0.44 (0.66)	0.58 (0.87)	0.33 (0.5)	0.59 (0.88)	0.65 (0.98)	0.56
	Human	0.5	0.76 (0.95)	0.81 (1)	0.77 (0.96)	0.68 (0.84)	0.81 (1)	0.62 (0.77)	0.8 (0.99)	0.61 (0.75)	0.73
Urbanization	Settlement	1.0	0.16 (0.42)	0.21 (0.55)	0.18 (0.48)	0.18 (0.49)	0.38 (1)	0.23 (0.61)	0.17 (0.44)	0.25 (0.67)	0.22
Infrastructure development	Powerlines	0.8	0.42 (0.59)	0.44 (0.61)	0.43 (0.61)	0.5 (0.7)	0.65 (0.91)	0.63 (0.88)	0.72 (1)	0.47 (0.66)	0.53
	Road	0.5	0.31 (0.65)	0.38 (0.79)	0.4 (0.84)	0.33 (0.69)	0.48 (1)	0.28 (0.58)	0.45 (0.94)	0.41 (0.85)	0.38
	Industries	1.0	0.05 (0.9)	0.02 (0.39)	0.01 (0.2)	0.03 (0.45)	0.01 (0.22)	0.01 (0.1)	0.03 (0.55)	0.06 (1)	0.03
Overgrazing	Livestock	1.0	0.39 (0.88)	0.42 (0.95)	0.4 (0.9)	0.32 (0.73)	0.44 (1)	0.25 (0.57)	0.34 (0.77)	0.41 (0.92)	0.37
Nest predation	Dog	1.0	0.15 (0.54)	0.09 (0.33)	0.14 (0.51)	0.16 (0.59)	0.16 (0.57)	0.28 (1)	0.15 (0.53)	0.2 (0.72)	0.17
Cumulative threat index			**0.72**	**0.65**	**0.62**	**0.62**	**0.78**	**0.62**	**0.72**	**0.82**	
Threat rank *			**3**	**5**	**7**	**8**	**2**	**6**	**4**	**1**	
Conservation importance **			**1**	**2**	**3**	**4**	**3**	**2**	**1**	**4**	

Landscapes include Kekri (Kek), Shokaliya (Sho), Pratapgarh (Prt), Shahpura (Sha), Kutch (Kut), Saurashtra (Sau), Ratlam-Sardarpur (Rat) and Akola-Washim (Ako)

* Landscapes are ranked in descending order of threats; lower ranks indicating higher threat levels

** Landscapes are ranked in descending order of conservation importance; lower ranks indicating higher conservation value

A SPECIES ON ITS PATH TO EXTINCTION?



DISCUSSION AND RECOMMENDATIONS

This report presents the protocol developed as part of the Endangered Species Recovery Program of WII, to assess the population status of lesser florican across its breeding range, along with the outcomes of its first implementation through collaborative efforts of WII, BNHS, TCF, State Forest Departments and other local institutions/indiviudals. We estimated a global population of 340 (95% CI 162–597) male territories distributed across ~2000 sq km area. However, this estimate would be unbiased only if density in sites where the species was detected was representative of sites where the species occurred but was not detected. Since this assumption can be violated, we emphasize on the use of the conservative 'minimum population size' estimate of 240 individuals. Meanwhile, we are attempting to refine our analytical approach to generate more robust estimate on the lines of the two-phase adaptive sampling proposed by Conroy et al. (2006). It is extremely difficult to assess female numbers, and earlier studies have typically assumed equal sex ratio. However, we avoid making such assumptions and have reported only the male territory numbers. Notably, this estimate is considerably lower than the last estimate of 3530 individuals or 1765 territories in 1999 (Sankaran 2000). This difference would imply a probable population decline of 81% over three-four generations. However, this conclusion can be premature as a few annual status assessments are required to confirm their current status. But, to be cautious, conservation managers should take cognizance of the probable decline and scale up efforts for the species' conservation.

Our surveys also showed that the lesser florican population is largely concentrated in two areas: Shokaliya and Velavadar. Although these areas hold similar numbers, birds are densely clustered in a few (at least two) sites in Velavadar – a contiguous grassland area, as opposed to being widely dispersed over many (estimated to be 22) sites in Shokaliya – an uniformly agricultural area. One possible explanation to such ecologically contrasting spatial organizations, is the likely difference in resource dispersion between the two habitats, although this hypothesis is yet to be tested. The conservation implication of this finding is that, although lesser florican may breed in agricultural landscape, it would require hundreds of square kilometers of agricultural area to achieve the same population outcome as a ten square kilometer contiguous grassland patch.

We provide some broad recommendations to conserve lesser florican in the current contexts, while detailed landscape wise recommendations are provided later (Annexure 6).

4.1. Key recommendations

1. Protection to lesser florican conservation sites :

All priority conservation sites, mapped by us (figure 8) and to be refined in future status assessments that are outside Protected Areas, must be consolidated under some form of flexible yet legal protection status such as community reserve or conservation reserve (Borrini-Feyerabend et al. 2004), so that detrimental land-uses can be disallowed and lesser florican-friendly subsistence land-uses can be promoted in these areas. However, local people should retain land-ownership in these areas, to avoid public antagonism towards lesser florican conservation.

2. Land-use regulation in lesser florican conservation sites :

Our surveys show intense anthropogenic disturbances in lesser florican conservation sites in the form of infrastructural (settlements, power-lines and roads), industrial (mining and wind energy), agricultural (intensive inorganic agriculture) and salt pan developments, particularly in Bhal region of Gujarat. Although lesser florican is more tolerant to human presence than the great Indian bustard and other bustards, their conservation is incompatible with intense disturbances. Therefore, the following land-uses should be disallowed in priority conservation sites: mining, wind energy production, expansion of power lines [while existing power lines should be mitigated by undergrounding or marking overhead cables with bird diverters following Jans and Ferrer (1998)], and plantation of shrub/tree species by Forest Department.

The following land-uses should be regulated/modified in priority conservation sites: use of pesticides in agriculture and free-ranging lilvestock grazing during the four monsoon months June–September.

3. Scientific grassland management and restoration :

Although lesser florican can breed and survive in agricultural landscapes, our findings show that they prefer and occur at much higher densities in grasslands that are large, contiguous and with adequate herbaceous biomass. Very few protected grasslands are currently managed in this form with the only exception of Blackbuck National Park, Velavadar. Therefore, PA managers should target consolidating relatively large (>10–20 km2) grasslands and manage them as contiguous habitats that are freed from livestock grazing during four monsoon months (June–September). These grasslands should not be planted with shrub/tree species such as Prosopis and Glyricidia, while existing plantations should be removed and planted with native grasses, to restore grassland habitats.

4. Promotion of florican-friendly agricultural practices :

Since a large proportion of lesser floricans are breeding in cropfields, there is need to promote florican-friendly agricultural practices. A long-term sustainable agricultural scheme should be launched through partnerships between conservation agencies and local farmers that reduces pesticide usage (to boost insect resources and reduce environmental toxicity) and compensates for the foregone production cost by marketing these organic conservation products at higher prices. This scheme should be integrated into ongoing bustard recovery programs.

5. Strengthening of local people's participation in conservation :

Lesser florican inhabits human-use landscapes with negligible control of Forest Department; the federal conservation agency in India. Although the response of local people to lesser florican conservation varies from antagonism to mild support across sites, the majority lacks awareness and is neutral to the species. Hence, there is significant scope of launching outreach programs that raises local awareness on the need, requirement and benefits of lesser florican conservation, and recruits local nature enthusiasts to form a network of 'florican friends' who can provide active protection to the species and inculcate conservation values in their localities.

6. Nest/chick predator control :

Although there is no hard evidence of nest/chick predation by free-ranging dogs, wild pig and other nest/chick predators, given the recent human-induced population increase of these species, there is an urgent need of controlling these populations through a mix of strategies including active removal and sterilization of these nest predators, and regulation of garbage disposal in priority conservation sites.

7. Conservation research and monitoring :

Current conservation plans for lesser florican are entirely based on their breeding ecology and distribution, while their non-breeding ecology and distribution remain completely unknown. These information are vital for effective conservation planning, as threats during non-breeding season can play vital role(s) behind their ongoing decline. For instance, note the occasional rescues of female lesser floricans from human-dominated areas during non-breeding season (appendix III). Therefore, biotelemetry research to understand the species' non-breeding ecology and ranging patterns, is urgently needed. Additionally, their status needs to be assessed regularly (annually for the first three years to refine/streamline the monitoring protocol and once every three years since then) following the protocol demonstrated in this report.

8. Conservation breeding as an insurance policy :

For continued persistence of the species, a national level conservation breeding programme should be commenced immediately, and implemented with adequate and long-term financial, physical and technological resources

9. Advocacy and policy intervention :

Finally, there is an urgent need of strong multi-agency advocacy to influence policy-makers that lesser florican conservation sites are conservable ecosystems and not unproductive 'wastelands', to ensure that policy safeguards to implement the conservation actions recommended above are in place.

4.2. Future plan of work

1. To refine our status assessment protocol and generate robust inference on the current numbers and distribution, breeding range surveys need to be conducted following similar collaborative and standardized approach in successive two years (July-September of 2018 and 2019).

2. Consultative meetings at the regional levels need to be organized to prepare site-wise conservation plans, strengthen the networks of local people, and consolidate collaborations between national conservation agencies, local conservation groups, and State Forest Departments for joint implementation of recovery actions.

Sr. No.	Conservation action	Task	Priority/ Process	Regions/ Sites	Requirement	Estimated fund requirement (per programme per site in INR)	Justification
1	Reduce nest/ chick predation	Removal of free-ranging dogs from lesser florican breeding sites Sustained sterilization of dogs from villages buffering lesser florican breeding sites Garbage management in villages around lesser florican breeding sites	High/ Continuous	All priority lesser florican conservation sites	Awareness among local communities about issues/threats of free-ranging dogs Collaboration with concerned agencies for removal and sterilization programs Linking this programme with Swachh Bharat abhiyan	~ Rs. 10 lakh for community awareness per village ~ Rs. 20 lakh for dog sterilization programme to be carried out at each site (4-5 villages) for 2-3 months per year for 1000 dogs ~ Rs. 10 lakh for garbage management per village	To improve recruitment rate of lesser florican population
2	Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	High/ Continuous	1. Shokaliya 2. Velavdar 3. Kutch	1. Radio tracking of ~10 birds in Rajasthan and Gujarat to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	1. Rs. 4 lakh for marking 1 km of power lines with bird diverters 2. Cost of undergrounding 1 km poweline is Rs. 35 lakh for high tension line and Rs. 20 lakh for low tension line	Tol help reduce mortality of birds
3	Develop Conservation Breeding Program	Develop a national conservation breeding center (CBC) with State Forest Depts., MoEFCC and scientific organization (WII / BNHS) as partners and international bustard breeders as collaborators	High/ Long-term (20 years)	1. Sorsan 2. Velavdar / Kutch	1. Signing of Memorandum of Understanding between partners 2. Permission to collect eggs and tag birds 3. Development of conservation breeding center 4. Execution of program following scientific protocol	Rs. 40 crores for construction and running CBC for 20 years	To secure an insurance population against imminent extinction risk
4	Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	High/ Continuous	Agricultural areas in priority conservation sites of 1. Shokaliya 2. Kutch 3. Akola	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	1. Rs. 1 lakh for farmer training program per site 2. Rs. 2 lakhs for certification of land of one farmer who wish to get associated with the scheme	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years

Sr. No.	Conservation action	Task	Priority/ Process	Regions/ Sites	Requirement	Estimated fund requirement (per programme per site in INR)	Justification
5	Grazing regulation in unprotected grasslands	Stop/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	High/ Continuous	Grasslands > 5 km^2 area, particularly in 1. Kutch, 2. Dahod 3. Saurashtra, 4. Pratapgarh 5. Ratlam	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. 3. Incentivized stall-feeding of livestock during monsoon	Rs. 1 lakh per site for engaging two local people to enforce grazing restriction during 2-3 monsoon months. Cost of incentive needs to be computed based on livestock holding in a site	To help in increasing herbaceous biomass, which is critical for lesser florican breeding, and provide fodder for livestock in the lean period (winter through summer)
6	Research and monitoring	**1. Satellite telemetry** Satellite tracking of lesser florican to understand their movement patterns, critical nesting and non-breeding habitat requirements, and basic biology that are all poorly known. Also understand the impact of land-use change on lesser florican ecology 2. **Monitoring** Distribution and population status assessment following the protocol demonstrated here.	1. High/ immediate 2. High/ (During 2018, 2019 thereafter once every three years)	1. Shokaliya 2. Velavadar 3. Kutch 4. Pratapgarh All lesser florican landscapes	1. Necessary permissions from government agencies to procure tags and capture and tag birds 2. Effects of agricultural intensification, new renewable energy projects, and habitat fragmentation due to industrialization on lesser florican need to be assessed through long-term research using land-cover change trend analysis. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerened agencies	Rs. 3 lakhs per PTT x 5 PTTs / site + Rs. 2 lakh for field expenses required for installing PTT per site Rs. 10 lakhs for field monitoring, image processing and other expenses per year per site	To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions
7	Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	High/ Continuous	All lesser florican conservation sites, particularly 1. Shokaliya 2. Velavadar 3. Kutch	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	1. Rs. 1 lakh per workshop 2. Rs. 25,000 for each follow up event	To generate public support for lesser florican conservation
8	Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	High/ once in every two years prior to monsoon (May–June)	1. Shokaliya 2. Sailana 3. Abdasa 4. Bhal including Velvadar	Collaborative implementation by Forest departments and concerned agencies	Rs. 1000-1500/- per acre for uprooting a plant using mechanization method such as excavators(JCB/Pokland)/ bulldozers	Tocreate more optimal habitats for lesser florican

Sr. No.	Conservation action	Task	Priority/ Process	Regions/ Sites	Requirement	Estimated fund requirement (per programme per site in INR)	Justification
9	Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**PA rationalization** Rationalization of boundaries of the Wildlife Sanctuaries (WLS) and defining the Eco-Sensitive Zone (ESZ)	High/ priority	1. Sailana WLS 2. Sardarpur WLS	There is need to take decision on revenue land inside Sanctuary areas and demarcation of the core areas	Chain link fence cost Rs. 7 lakh / km and gates as per requirements With additional cost for predator proof concrete foundation	To avoid public antagonism due to restrictions on land-use and livelihoods in areas adjoining Protected Areas (PAs) that can be detrimental to lesser florican conservation
		Relief from crop-raiding Compensation policy to be designed to address the issue of crop raiding by large herbivores like Nilgai	Medium/ Priority	Sailana Sardarpur Velavadar NP Akola	, Crop-raiding by nilgai and wild pigs, in/around PAs demarcated for lesser florican causes antagonism towards lesser florican conservation.	Rs 20,000 per farmer per Ha for damage of more than 50% of the crop	
		Protection to marginal conservation areas Focusing on existing and unprotected lesser florican breeding sites	High	All non-protected lesser florican sites	1. Regulation of intensive land-uses (mining, salt pans, infrastructure, intensive farming) 2. Incentivizing local people for implementing lesser florican-friendly land-uses 3. Land ownership should remain with the people.	Rs. 20 lakhs per year per site	To balance livelihood concerns and lesser florican conservation Capacity building and involvement of local people in lesser florican conservation
		Preventing disturbances to breeding birds Preventing human disturbances, hunting and livestock grazing by patrolling in PAs	High/ Continuous	All known breeding sites of lesser florican	1. Identifying and engaging poachers or other interested local people as protectors and forest watchers to create a parallel protection force for four months 2. Adequate training and logistic/fund support for the training 3. Deploy local villagers as 'Florican friends' during June-September (lesser florican breeding season)	Rs. 10 lakhs per site Rs. 5000 per person per year per site x 40 sites	
10	Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	High/ Continuous	All lesser florican breeding sites, particularly 1. Shokaliya 2. Velavadar 3. Kutch 4. Pratapgarh	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people 2. Identify and train local people interested in this alternate livelihood and develop required facilities 3. Implement in collaboration with Forest Department to ensure that tourism is not detrimental to conservation	Rs. 50,000 for training programme for nature guides	To help improve local revenue and awareness about lesser florican
11	Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	High/ priority	1. Shokaliya 2. Kutch	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	1. Rs. 50,000 for workshop for CCA community 2. Rs. 30 lacs as incentives for the people involved in conservation	To help develop a pilot habitat model apart from a conservation area governed by local people

REGION CHAPTERS

We have segregated the breeding range of lesser florican into regions and landscapes that have similar ecogeographical and conservation settings. Here, we provide information on these regions and landscapes, such as their geo-political location (http://districts.nic.in/), bio-geographic zone (Rodgers et al. 2000), vegetation type (Champion and Seth 1968), climate, topography, major land cover/ use, human population density (Census of India 2011), livestock population density (Livestock Census 2014), major livelihoods, major crops, and protected/ conservation- areas. We also report occupancy and density maps along with conservation recommendations for each landscape that will be particularly useful for site specific conservation management.

5.1 REGION: AJMER

SHOKALIYA, KEKRI (DISTRICTS AJMER AND TONK)

Attribute	Ajmer	Tonk
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern tropical dry deciduous forests (5B)	Northern tropical dry deciduous forests (5B)
Annual rainfall (2012-16)	Min.- 462 mm (2015), Max.- 612 mm (2012), Average- 562mm	Min.- 607 mm (2015), Max.- 793 mm (2013), Average: 722 mm
Elevation (range)	316-870 m above mean sea level	316-870 m above mean sea level
Temperature (2011)	Min.- 3.3°C, Max.- 46.6° C	Min.- 3.3°C, Max.- 46.6°C
Topography	Mostly plains with some undulating areas	Mostly plains with some undulating areas
Major land cover/ use	Mainly crop fields and highly degraded scrub forests	Mainly crop fields and highly degraded scrub forests
Tehsils surveyed	Nasirabad, Kishangarh, Sarwar, Kekri and Bhinay	Malpura, Toda Raisingh, Devli (Tonk District)
Human population density (2011)	305/ km^2	198/ km^2
Livestock population density (2012)	232/ km^2	168/ km^2
Major livelihoods	Farming, animal husbandry and mining (minerals- feldspar, quartz, mica, limestone, marble and masonry stone)	Farming, animal husbandry and mining (minerals- feldspar, quartz, granite, silica, masonry stone and limestone.)
Major crops	Sorghum, wheat, maize, groundnut, pearl millet, bengal gram and green gram	Sorghum, wheat, maize, groundnut, pearl millet, bengal gram and green gram
Protected/ Conservation- Areas/ Important sites for conservation	Shokaliya closed area (17 km^2) – Established in 1980, with few patches of grasslands protected as reserve forests. More than 80 Great Indian Bustards (GIB) used to breed in crop fields in this landscape during 1980s' (Rahmani and Manakadan 1988), while lesser florican were reported to visit this area regularly during monsoon (Sankaran *et al.* 1992)	Grasslands (Bheed/Bir/Charagah) in Malpura Tehsil, Bisalpur Conservation Reserve- 48 km^2. Lesser floricans have been reported from Kurad and Lamba Harisingh villages in Malpura Tehsil (Bhardwaj et al. 2011)

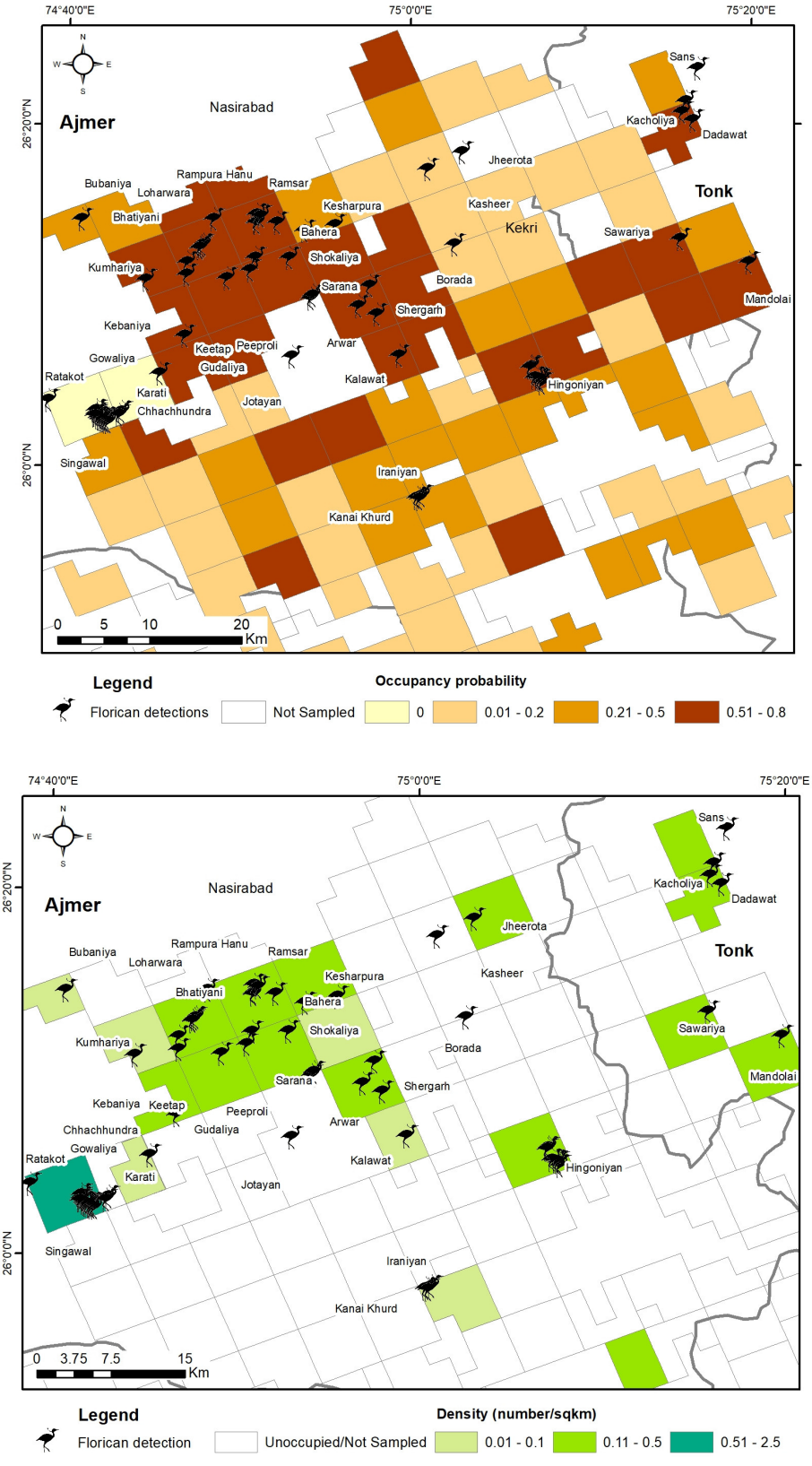


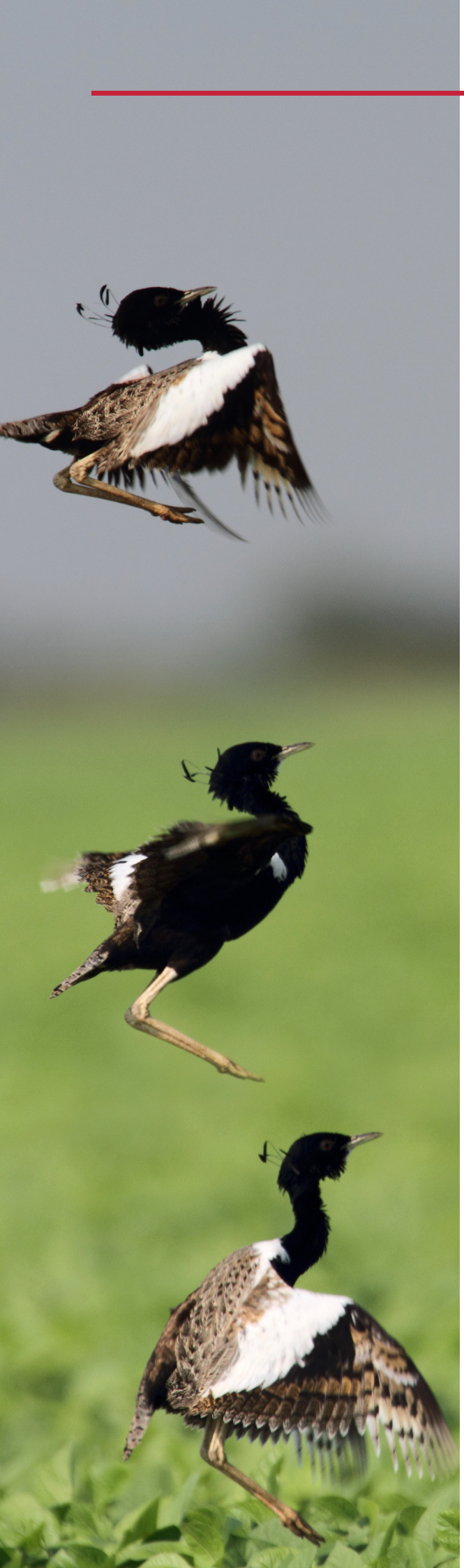
Figure 9: Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Ajmer region

CONSERVATION RECOMMENDATIONS:

URGENT REQUIREMENT OF COMMUNITY CONSERVATION AREA

A strategy needs to be devised and implemented to deal with mining and protection of lesser floricans as well their habitat in Shokaliya landscape (Narwade et al. 2017). During the survey, mining activities were seen across this landscape, for major minerals such as feldspar, quartz, mica stone quarries, etc. as well as minor minerals such as marble and masonry stone, etc. A number of abandoned, non-functional and operational mines have resulted in disturbances and fragmentation of the area. We compiled location data of mines that were encountered during surveys, and additional information on the proposed mines were received through the Office of the Deputy Conservator of Forests (DCF), Ajmer as well as the reports of District Level Environment Impact Assessment Authority (DEIAA) and District Level Expert Appraisal Committee (DEAC). The existing and upcoming mining projects in Shokaliya landscape were mapped and overlaid on the lesser florican distribution maps for prioritizing projects that need to be mitigated (Table 7 and fig 10).

xcept few Reserve Forests, there are no lesser florican Protected Areas in Shokaliya landscape. Therefore, we tried to identify potential areas that could be managed as lesser florican conservation areas (Fig 10). Restoration of all Reserve Forest patches to grasslands should be a long-term strategy in Nasirabad, Bhinay, Sarwar, Malpura, Kishangarh, Toda Raisingh and Kekri tehsils.
Management of lesser florican conservation areas should be based on the following prescription.



E1. Protection of lesser florican sites – All lesser florican distribution sites outside Protected Areas can be declared as Lesser florican community reserves, with small core areas of 100 Ha and larger buffer area or Eco-Sensitive Zone (ESZ) of few square kilometres.

2. Special criteria to be adopted for lesser florican community reserves-

a. Ownership of the land will remain with the people except areas under control of the Forest Department

b. Small core areas should be given full protection, especially during breeding season of lesser floricans

c. Sustainable/ traditional agriculture practices should be promoted in buffer areas

d. Regulation in buffer zone for habitat alteration, mining, industrialization and establishment of non-renewable energy projects and installation of power lines

3. Promotion of lesser florican friendly agricultural practices - Since, majority of the lesser floricans are found breeding in crop fields, there is need to promote lesser florican friendly agricultural practices. Lesser florican recovery programme should have a component of sustainable agriculture scheme. Farmers, who get associated with the lesser florican friendly agricultural practices, can get training and certificate from concerned agencies for availing better market price for their crop yield.

4. Habitat restoration – Because of mismanagement, almost all grasslands under Reserve Forests have become unsuitable habitat for lesser floricans, and need to be immediately restored by removing the plantations of invasive Prosopis juliflora.

5. Rotational grazing – To avoid overgrazing by livestock, some of the plots can be managed by rotational grazing

Table 7: List of mines in Shokaliya landscape

DEAC DEIAA mines					
S. No.	Mine Lease No.	Village	Tehsil	Latitude	Longitude
1	6|99	Shokaliya	Sarvar	26°14'42"	74°50'20"
2	24|09	Derathu	Nasirabad	26°17'15"	74°46'00"
3	9|92	Bhudwasa	Nasirabad	26°10'55"	74°44'00"
4	10|09	Rambadi	Nasirabad	26°20'10"	74°53'28"
5	41|06	Chat	Nasirabad	26°14'40"	74°44'40"
6	25|95	Loharwada	Nasirabad	26°14'31"	74°46'30"
7	211|05	Ramsar	Nasirabad	26°14'10"	74°50'55"
8	48|05	Ramsar	Nasirabad	26°14'1"	74°50'35"
9	1|96	Ramsar	Nasirabad	26°14'3"	74°50'30"
10	41|09	Loharwada	Nasirabad	26°15'52"	74°47'27"
11	88|09	Sanod	Nasirabad	26°17'30"	74°48'04"
12	22|96 R	Shokaliya	Sarwar	26°12'15"	74°50'32"
13	86|11	Bhatiyani	Nasirabad	26°13'35"	74°44'40"
14	73|01	Sarana	Sarwar	26°16'15"	74°54'15"
15	139|08	Ramsar	Nasirabad	26°15'23"	74°52'10"
16	109|11	Mavasiya	Nasirabad	26°16'47"	74°55'45"
17	9|99	Derathu	Nasirabad	26°15'55"	74°45'8"
18	156|07	Ramsar	Nasirabad	26°18'40"	74°52'20"
19	9|01	Sarana	Sarwar	26°10'35"	74°53'20"
SEIAA mines					
20	3|05	Sarana	Sarwar	26°8'30"	74°50'30"
21	24|99	Piproli	Sarwar	26°11'50"	74°50'00"
22	445|05	Sanod	Nasirabad	26°17'8"	74°48'27"
23	6|92	Saneed	Nasirabad	26°18'35"	74°48'50"
24	184|07	Chat	Nasirabad	26°14'20"	74°44'50"
25	5|96	Sanod	Nasirabad	26°17'40"	74°48'30"
26	1|96	Ramsar	Nasirabad	26°14'35"	74°50'30"
27	47|2000	Sanod	Nasirabad	26°17'27"	74°49'00"
28	352|08	Rampura	Nasirabad	26°13'45"	74°47'45"
29	347|08	Rampura	Nasirabad	26°13'45"	74°47'45"
DEIAA mines					
30	75|02	Bhagwantpura	Sarwar	26°13'7"	74°55'47"
31	48|07	Bavdi	Sarwar	26°12'25"	74°56'15"
32	321|04	Kesarpura	Sarwar	26°9'42"	74°50'46"
33	549|05	Kesarpura	Sarwar	26°9'50"	74°51'4"
34	443|05	Lakshmipura	Nasirabad	26°15'05"	74°53'15"
35	85|11	Kesarpura	Nasirabad	26°14'45"	74°52'20"
Other mines					
36	31|97	Bavdi	Sarwar	26°12'15"	74°55'45"
37	16|93	Piproli	Sarwar	26°11'50"	74°50'20"
38	44|2000	Arwad	Sarwar	26°10'20"	74°55'10"
39	4|04	Kebaniya	Sarwar	26°11'00"	74°45'56"
40	316|05	Sanod	Nasirabad	26°16'42"	74°47'50"
41	2|91	Loharwada	Nasirabad	26°16'15"	74°47'50"
42	539|05	Ramsar	Nasirabad	26°15'00"	74°51'52"
43	52|08	Ramsar	Nasirabad	26°14'57"	74°51'42"
44	23|03	Bhatiyani	Nasirabad	26°12'45"	74°44'50"
45	245|06	Hanuliya	Nasirabad	26°11'55"	74°49'40"
46	309|08	Ramsar	Nasirabad	26°19'5"	74°53'30"
47	468|05	Derathu	Nasirabad	26°17'25"	74°46'55"
48	348|05	Rampura	Nasirabad	26°13'45"	74°47'45"
49	515|05	Bhudasa	Nasirabad	26°11'15"	74°43'12"
50	379|05	Bhudasa	Nasirabad	26°10'55"	74°43'20"
51	11|09	Rambadi	Nasirabad	26°20'00"	74°53'20"

Table 8: Areas proposed as lesser florican conservation reserve in Shokaliya landscape

S. No.	Villages falling under block	Area (in Ha)
1.	Sawaipura, Ratakot, Mathaniya	2090
2.	Gwaliya, Gopalpura	210
3.	Gopalpura	79
4.	Ratanpura	151
5.	Kebaniya	102
6.	Bhatiyani	219
7.	Loharwara	198
8.	Rampura Hanu, Jaswantpura, Hanwantiya	134
9.	Shokaliya, Kesharpura	136
10.	Kumaria Khdea, Kotdi	477
11.	Ganeshpura, Arwar, Sarana	400
	Total area	**4196**

Shokaliya and Kekri landscapes: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Reduce nest/ chick predation	1. Removal of free-ranging dogs from lesser florican breeding sites 2. Sustained sterilization of dogs in villages around lesser florican breeding sites 3. Garbage management in villages around lesser florican breeding sites	1. Awareness among local communities about issues/threats of free-ranging dogs 2. Collaboration with concerned agencies for removal and sterilization programs 3. Linking this programme with Swachh Bharat abhiyan	Priority sites (map)	High / continuous	FD, HSI - WII	To improve recruitment rate of lesser florican population
Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	1. Satellite tracking of ~10 birds to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	Priority sites (map)	High / first 5 years	FD, BNHS, WII	To help reduce mortality of birds
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers.	Priority sites (map)	Medium / continuous	FD, BNHS	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years. More sites could be added with additional information from successive surveys.
Grazing regulation in unprotected grasslands	Reduce/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	Restore grazing lands by removing invasive *Prosopis* and planting native grasses Develop community fodder farms or allow grazing in one-third of grazing lands while sparing the rest for lesser florican. Incentivize stall-feeding of livestock during monsoon	Priority sites (map)	Medium/ continuous	FD,BNHS, local people	To help increase herbaceous biomass in breeding sites, which is critical for lesser florican breeding. Provide fodder for livestock in the lean period (winter through summer)
Research and monitoring	**1. Satellite telemetry:** Satellite tracking of lesser florican to understand their movement patterns, critical nesting and non-breeding habitat requirements, and basic biology that are all poorly known. Also understand the impact of land-use change on lesser florican ecology 2. **Monitoring:** Distribution and population status assessment following the protocol demonstrated here	1. Necessary permissions from government agencies to procure tags and capture and tag birds. 2. Effects of agricultural intensification, new renewable energy projects, and habitat fragmentation due to industrialization on lesser florican need to be assessed through long-term research using land-cover change trend analysis. 3. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerned agencies	All sites	High / first 5 years	WII,BNHS, FD	To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	Priority sites (map)	Medium / once every three years	WII,BNHS, FD	To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	Veedis and grazing lands in all sites	High / first 5 years	FD, local people	To create more optimal habitats for lesser florican
Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**Protection to marginal conservation areas** Focusing on existing and unprotected Lesser Florican breeding sites **Minimizing disturbances to breeding birds** Reducing human disturbances, hunting and livestock grazing by patrolling in protected breeding sites	1. Regulation of intensive land-uses (mining, salt pans, infrastructure, intensive farming) 2. Incentivizing local people for implementing lesser florican-friendly land-uses 3. Land ownership should remain with the people. 1. Identifying and engaging poachers or other interested local people as protectors and forest watchers to create a parallel protection force for four months 2. Adequate training and logistic/fund support for patrolling staff 3. Deploy local villagers as 'Florican friends' during June-September (lesser florican breeding season)	Priority conservation sites (map)	Medium / continuous	FD, BNHS, local people	To balance livelihood concerns and lesser florican conservation. More sites could be added with additional information from successive surveys. Capacity building and involvement of local people in lesser florican conservation.
Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people 2. Identify and train local people interested in this alternate livelihood and develop required facilities 3. Implement in collaboration with Forest Department to ensure that tourism is not detrimental to conservation	Shokaliya	Medium / continuous	BNHS, FD, local people	To help improve local revenue and awareness about lesser florican
Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	Shokaliya, Sarana, Malpura, Kumhariya, Ratakot, Bhinai	Medium / continuous	FD, BNHS, local people	To help develop a pilot habitat model apart from a conservation area governed by local people

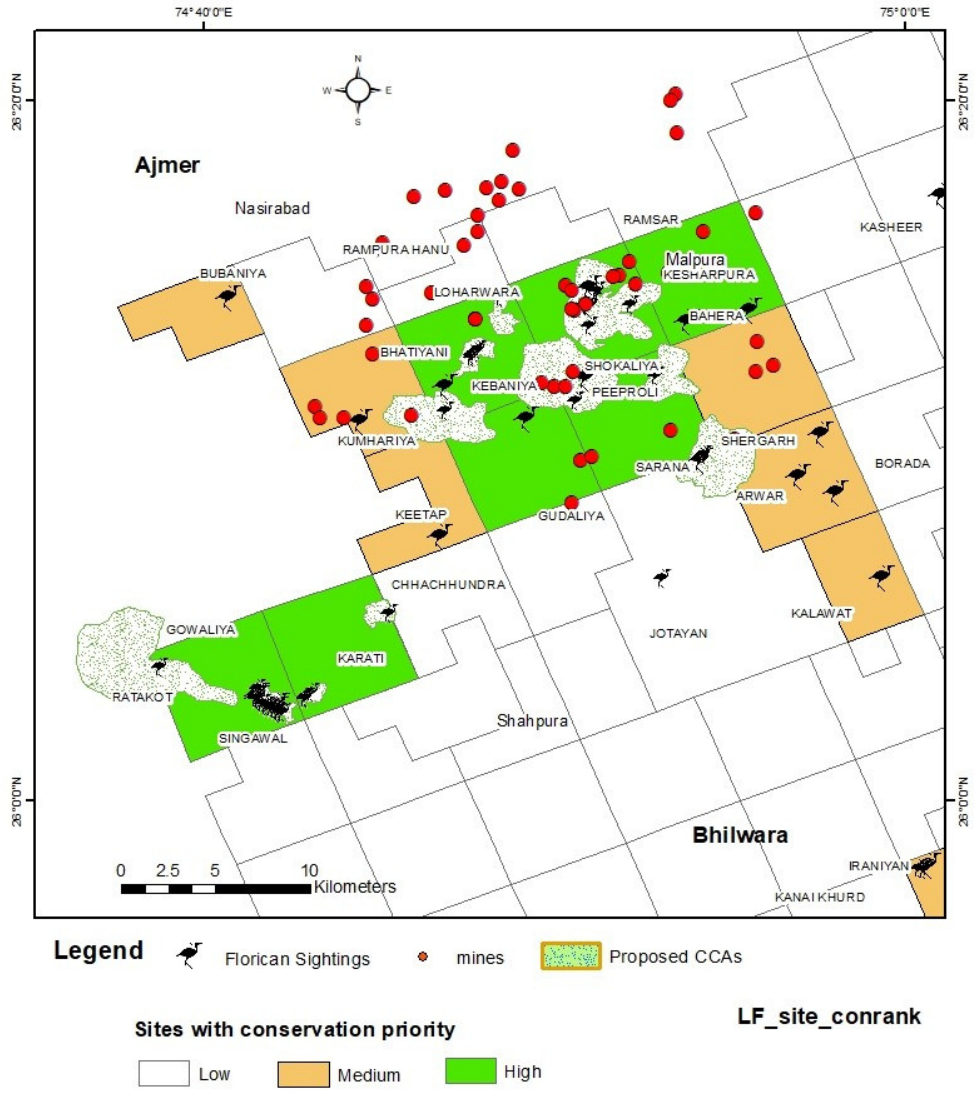


Figure 10: Locations of mines overlaid on priority conservation sites and lesser florican detections, and the proposed Community Conservation Areas (CCAs) in Shokaliya landscape of Ajmer region

5.2 REGION: REST OF RAJASTHAN

5.2.1 SHAHPURA

Attribute	Details
District	Bhilwara
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern tropical dry deciduous forests (5B)
Annual rainfall (2012-16)	Min.- 548 mm (2015), Max.- 934 mm (2016), Average- 712 mm
Elevation (range)	305-822m above mean sea level
Temperature (2011)	Min- 2.3°C, Max- 45.8°C
Topography	Mostly open plains and some undulating areas
Major land cover/ use	Mainly crop fields and highly degraded scrub forests
Tehsils surveyed	Shahpura, Gulabpur, Jahazpur, Banera, Kotri (Bhilwara District)
Human population density (2011)	230/ km^2
Livestock population density (2012)	234/ km^2
Major livelihoods	Farming, animal husbandry and mining (minerals- feldspar, soapstone, Iron ore, mica, masonry stone, marble, granite)
Major crops	Sorghum, wheat, maize, groundnut, pearl millet, bengal gram, green gram and black gram
Protected/ Conservation-Areas/ Important sites for conservation	Grassland (Charagah/bheed/bir) near Bhatera village. Lesser floricans have been reported from Loolas/Kalsas, Shopura, Arni Ghoda, Khamora, and Mataji ka Kheda villages (Sankaran, 1999, Bhardwaj et al. 2011)

Shahpura landscape: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	1. Satellite tracking of ~10 birds to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	All breeding sites	High / first 5 years	FD, BNHS, WII	To help reduce mortality of birds
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	Lachhman-pura, Amli Kaloosingh, Muhala, Bhatera villages	Medium / continuous	FD, BNHS	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years. More sites could be added with additional information from successive surveys.
Grazing regulation in unprotected grasslands	Reduce/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. c. Incentivized stall-feeding of livestock during monsoon	Lachhman-pura, Amli Kaloosingh, Muhala, Bhatera villages	Medium/ continuous	FD,BNHS, local people	To help increase herbaceous biomass in breeding sites, which is critical for lesser florican breeding. Provide fodder for livestock in the lean period (winter through summer)
Research and monitoring	**1. Satellite telemetry:** Satellite tracking of lesser florican to understand their movement patterns, critical nesting and non-breeding habitat requirements, and basic biology that are all poorly known. Also understand the impact of land-use change on lesser florican ecology 2. **Monitoring:** Distribution and population status assessment following the protocol demonstrated here	1. Necessary permissions from government agencies to procure tags and capture and tag birds. 2. Effects of agricultural intensification, new renewable energy projects, and habitat fragmentation due to industrialization on lesser florican need to be assessed through long-term research using land-cover change trend analysis. 3. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerned agencies	All sites	High / first 5 years	WII,BNHS, FD	To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	Lachhman-pura, Amli Kaloosingh, Muhala, Bhatera villages	Medium / once every three years	WII,BNHS, FD	To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	Veedis/beeds/birs/charagah in all sites	High / first 5 years	FD, local people	To create more optimal habitats for lesser florican
Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	Lachhman-pura, Amli Kaloosingh, Muhala, Bhatera villages	Medium / continuous	FD, BNHS, local people	To help develop a pilot habitat model apart from a conservation area governed by local people

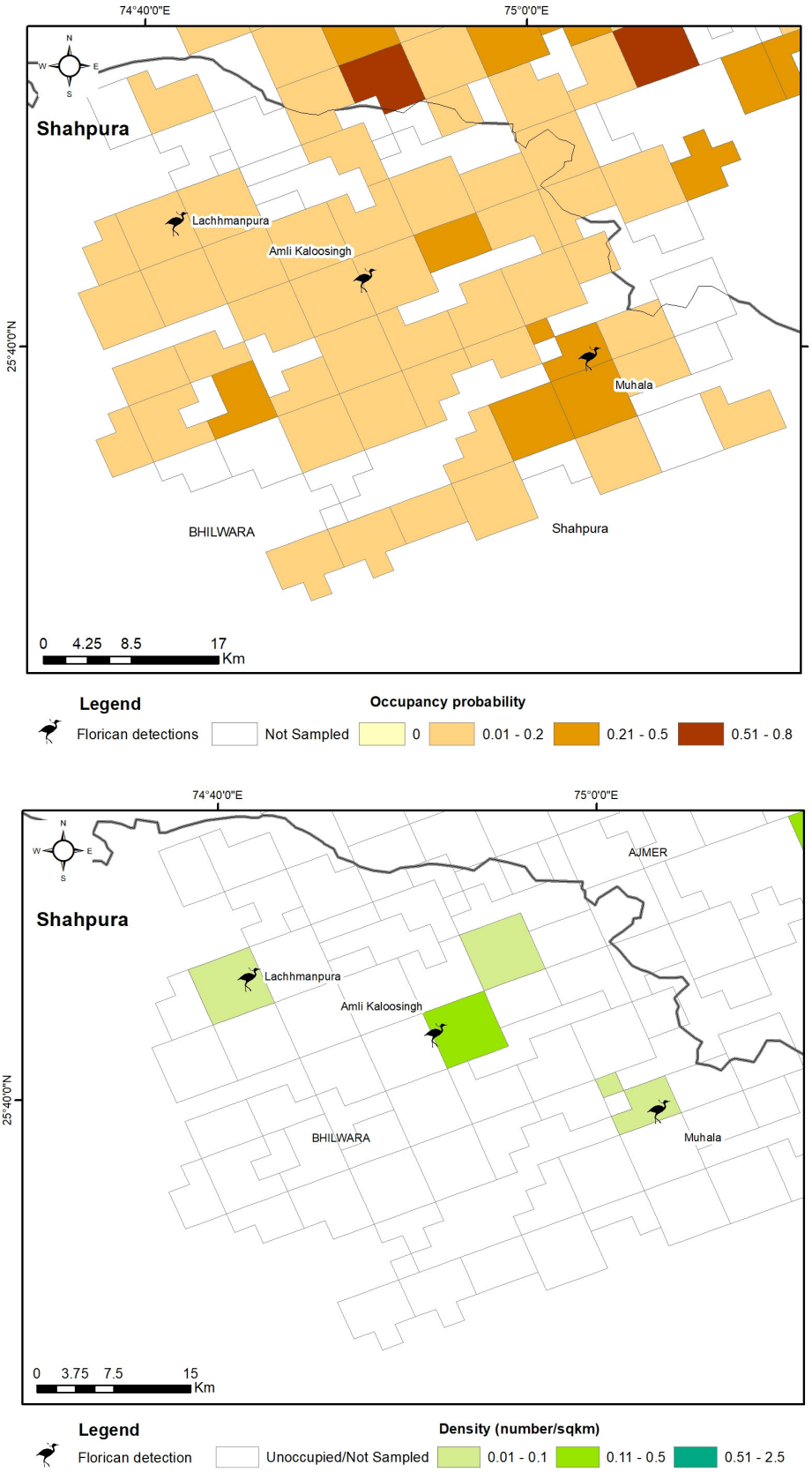


Figure 11: Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Shahpura landscape

5.2.2 JALORE

Attribute	Jalore	Sirohi	Pali
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern tropical dry deciduous forests (5B)	Northern tropical dry deciduous forests (5B)	Northern tropical dry deciduous forests (5B)
Annual rainfall (2012-16)	Min.- 283 mm (2012), Max.- 690 mm (2015), Average- 484 mm	Min.- 723 mm (2014), Max.- 1134 mm (2015), Average- 912 mm	Min.- 506 mm (2012), Max.- 882 mm (2016), Average- 607 mm
Elevation (range)	180-991m above mean sea level	184- 1722m above mean sea level	180-991m above mean sea level
Temperature (2011)	Min.- 5.6°C, Max.- 47.2 °C	Min.- -5.4°C, Max.- 47 °C	Min.- 1.8°C, Max.- 45.4 °C
Topography	Mostly open plains and some undulating areas	Open plains, undulating areas and hills	Undulating plains and scattered hills
Major land cover/ use	Mainly crop fields and highly degraded scrub forests	Mainly crop fields, dry deciduous and highly degraded scrub forests, pastures	Mainly crop fields, pastures, dry deciduous and highly degraded scrub forests
Tehsils surveyed	Jalore, Bhinmal, Ahor	Shivganj	Bali
Human population density (2011)	172/ km^2	202/ km^2	164/ km^2
Livestock population density (2012)	153/ km^2	175/ km^2	186/ km^2
Major livelihoods	Farming, animal husbandry and mining (minerals- fluorite, gypsum, masonry stone and granite)	Farming, animal husbandry and mining (minerals- limestone, marble, calcite, masonry stone, and granite)	Farming, animal husbandry, manufacturing and mining (minerals- - limestone, quartz, feldspar, masonry stone and granite)
Major crops	Sorghum, wheat, maize, groundnut, pearl millet, Bengal gram and green gram	Sorghum, wheat, maize, castor, pearl millet, sesame and green gram	Sorghum, wheat, maize, groundnut, pearl millet, green gram and sesame
Protected/ Conservation- Areas/ Important sites for conservation	Sundha Mata Conservation Reserve-117 km^2	Mount Abu Wildlife Sanctuary- 326 km^2	Lesser floricans were reported in 1996 from Boya, Birolia and Omkali villages (Vyas and Sharma 2013). Jawai Bandh Conservation Reserve- 19 km^2, Tadgarh Raoli Wildlife Sanctuary- 495 km^2, Kumbalgarh Wildlife Sanctuary - 608 km^2, Phulwari KI Nal Wildlife Sanctuary - 692 km^2

5.2.3 PRATAPGARH (DISTRICT PRATAPGARH)

Attribute	Detail
District	Pratapgarh
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern tropical dry deciduous forests (5B)
Annual rainfall (2012-16)	Min.- 712 mm (2015), Max.- 1319 mm (2016), Average-1022mm
Elevation (range)	180-991m above mean sea level
Temperature (2011)	Min.- 2.3°C, Max.- 45.8 °C
Topography	Mostly undulating with some open plains
Major land cover/ use	Mainly crop fields and highly degraded scrub forests
Tehsils surveyed	Pratapgarh
Human population density (2011)	195/ km^2
Livestock population density (2012)	172/ km^2
Major livelihoods	Farming, animal husbandry and mining (minerals-soapstone, red ochre, masonry stone, marble)
Major crops	Wheat, maize, soya bean, groundnut, red lentil, black gram
Protected/ Conservation- Areas/ Important sites for conservation	Lesser floricans were reported in 2008 from Ratniyakhedi, Kariabad, Siddhpura, Bajrangarh and Mowdikhera villages (Bhardwaj 2010). While, in the same landscape Sankaran (2000) counted 28 males in year 1999. Sita Mata Wildlife Sanctuary- 422 km^2

Pratapgarh and Jalore landscape: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Reduce nest/ chick predation	1. Removal of free-ranging dogs from lesser florican breeding sites 2. Sustained sterilization of dogs from villages buffering lesser florican breeding sites 3. Garbage management in villages around lesser florican breeding sites	1. Awareness among local communities about issues/threats of free-ranging dogs 2. Collaboration with concerned agencies for removal and sterilization programs 3. Linking this programme with Swachh Bharat abhiyan	Naulakha beed, Police line, Chiklad, Ratniya kheri (Pratapgarh)	High / continuous	FD, HSI, WII	To improve recruitment rate of lesser florican population
Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	1. Satellite tracking to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	Naulakha beed	High / continuous	FD, WII	Tol help reduce mortality of birds
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	Bajrang garh, Peeplikhera (Pratapgarh)	Medium / continuous	FD, BNHS	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years
Grazing regulation in unprotected grasslands	Stop/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. 3. Incentivized stall-feeding of livestock during monsoon	Naulakha beed	High / continuous	FD, BNHS	Tol help in increasing herbaceous biomass, which is critical for lesser florican breeding, and provide fodder for livestock in the lean period (winter through summer)
Research and monitoring	**Monitoring:** Distribution and population status assessment following the protocol demonstrated here	3. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerened agencies	Naulakha beed	High / continuous	FD, WII, BNHS	To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	Pratapgarh, Pali and Jalore	Medium / continuous	FD, WII	To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	Jalore, Pali	High / continuous	FD, Local people	Tocreate more optimal habitats for lesser florican
Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**Protection to marginal conservation areas** Focusing on existing and unprotected Lesser Florican breeding sites	1. Regulation of intensive land-uses (mining, salt pans, infrastructure, intensive farming) 2. Incentivizing local people for implementing Lesser Florican-friendly land-uses 3. Land ownership should remain with the people.	Naulakha beed of Pratapgarh	High / continuous	FD, Local people	To balance livelihood concerns and Lesser Florican conservation. Capacity building and involvement of local people in Lesser Florican conservation
Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people 2. Identify and train local people interested in this alternate livelihood and develop required facilities 3. Implement in collaboration with Forest Department to ensure that tourism is not detrimental to conservation	Pratapgarh	Medium / continuous	FD, BNHS	To help improve local revenue and awareness about lesser florican
Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	Pratapgarh	High / continuous	FD, WII	To help develop a pilot habitat model apart from a conservation area governed by local people

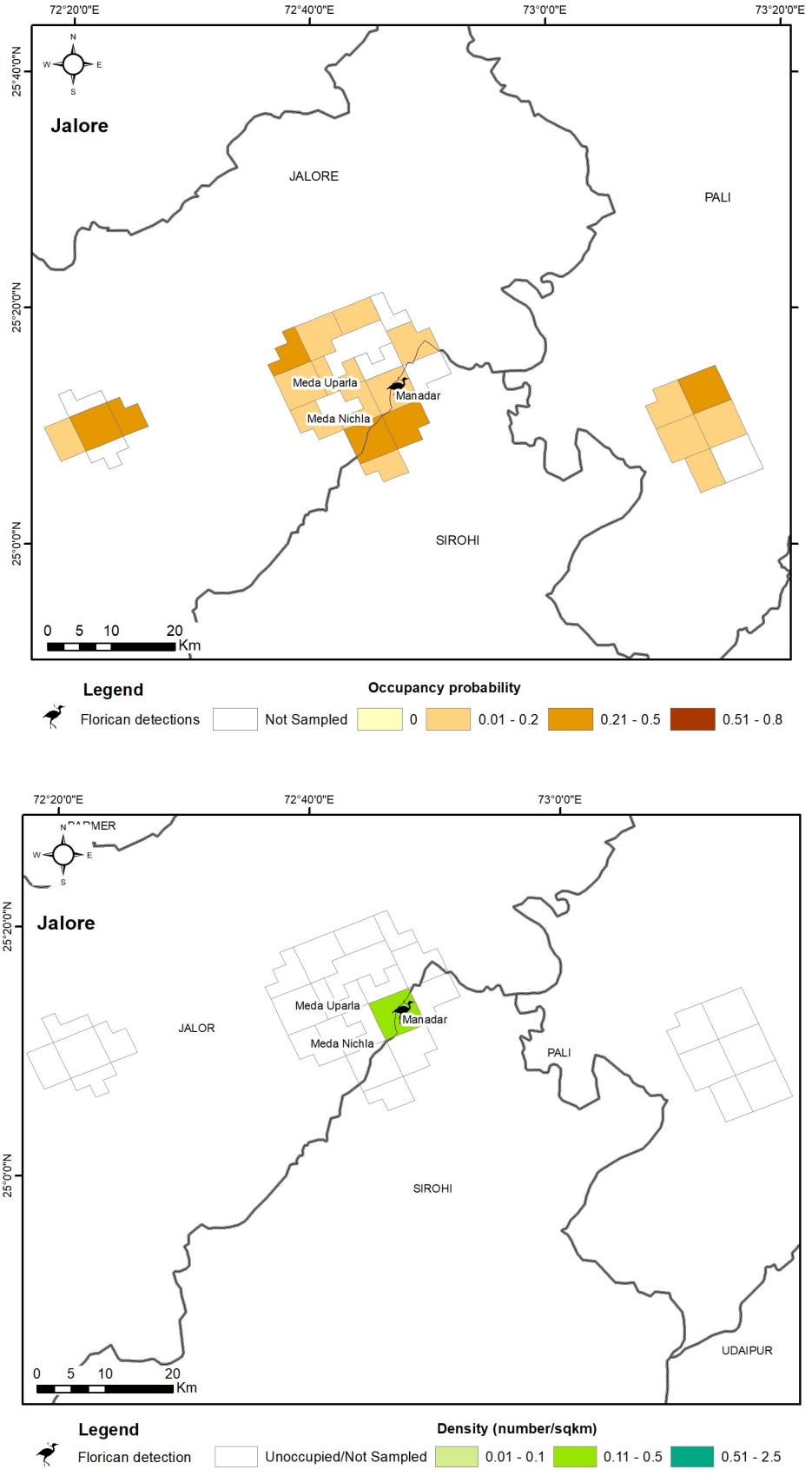


Figure 12: Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Jalore landscape

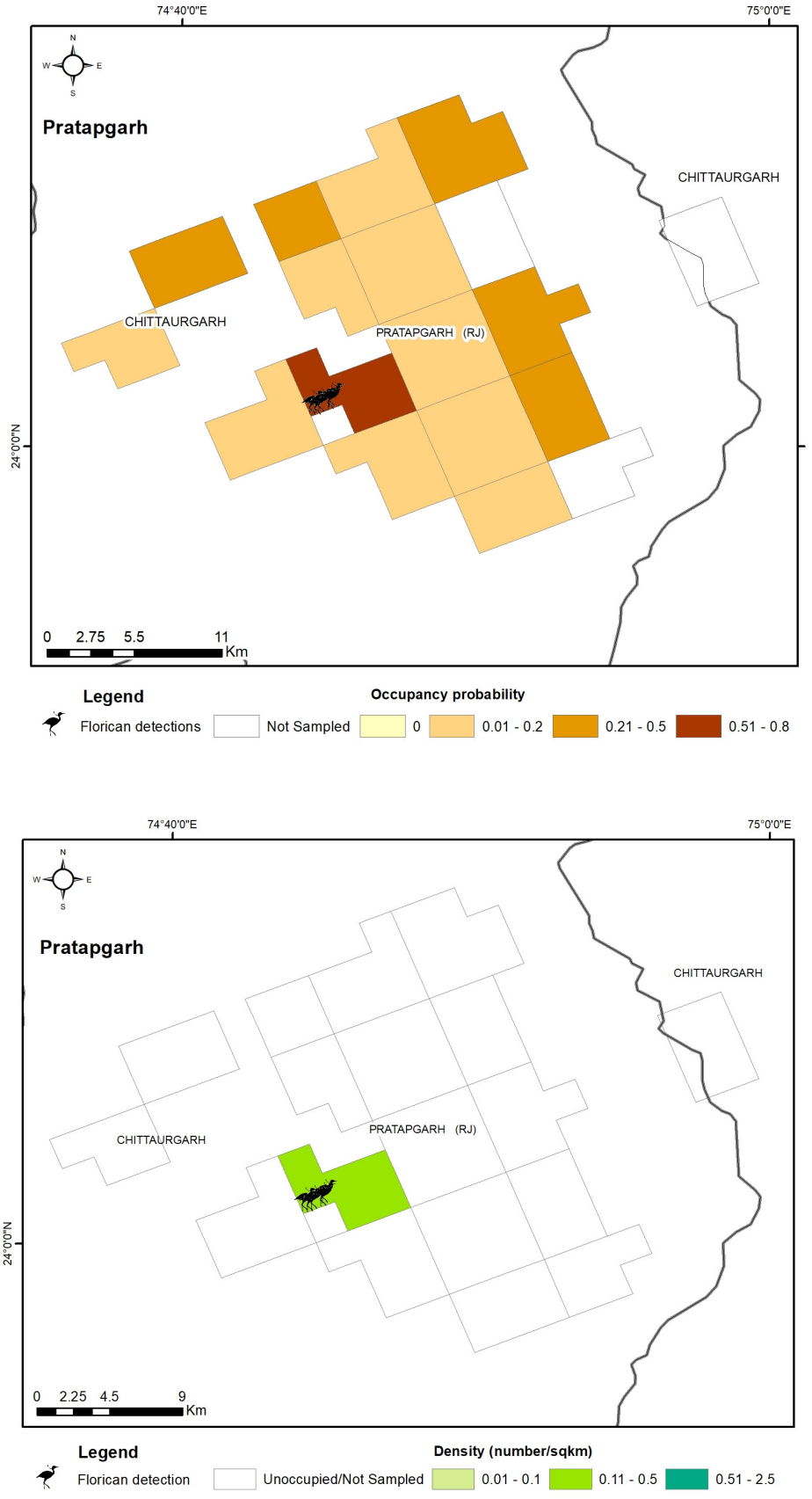


Figure 13 Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Pratapgarh landscape

5.3 REGION: GUJARAT

5.3.1 SAURASHTRA (DISTRICTS BHAVNAGAR, AMRELI, SURENDRANAGAR, JUNAGADH, RAJKOT)

Attribute	Bhavnagar	Amreli
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern Tropical Thorn Forest (6B)	Northern Tropical Thorn Forest (6B)
Annual rainfall (2012-16)	Min.- 382 mm (2012), Max.- 933 mm (2013), Average- 602 mm	Min.- 348 mm (2012), Max.- 901 mm (2013), Average- 651 mm
Elevation (range)	1-501m above mean sea level	5-649m above mean sea level
Temperature (2011)	Min.- 9.7°C, Max- 43.6 °C	Min.- 7.2°C, Max. -42.8 °C
Topography	Open plains and some undulating areas	Open plains, undulating areas and hills
Major land cover/ use	Mainly crop fields and highly degraded scrub forests	Mainly crop fields and highly degraded scrub forests
Tehsils surveyed	Bhavnagar, Ghogha, Vallabhipur, Talaja, Mahuva, Sihor, Palitana, Gariyadhar	Savar Kundla, Lilia, Kunkavav Vadia
Human population density (2011)	287/ km^2	205/ km^2
Livestock population density (2012)	119/ km^2	147/ km^2
Major livelihoods	Farming, animal husbandry, fisheries, manufacturing and mining (minerals- dolomite, lignite, masonry stone, moulding sand, salt)	Farming, animal husbandry, fisheries, manufacturing and mining (minerals- limestone, natural clay, marl)
Major crops	Cotton, wheat, maize, sesame, pearl millet, groundnut, sorghum, sugarcane	Cotton, wheat, pearl millet, groundnut, sugarcane, maize
Protected/ Conservation- Areas/ Important sites for conservation	Blackbuck National Park, Velavadar- 34 km^2, Grass/grazing lands (*Vidi*s). In early 1990s, lesser floricans were recorded in almost all tehsils of Bhavnagar. Around 50-60 lesser florican males used to be seen till year 2000. In recent years, they are sighted only in and around Blackbuck National Park during monsoon.	Paniya Wildlife Sanctuary-39 km^2, Mithiyala Wildlife Sanctuary-18 km^2, Krakanch grassland- Lilia tehsil and Grass/grazing lands (*Vidi*s). Two male floricans have been reported from small grasslands patches of around 50 Ha area each near Manikpura and Nana Liliya villages.

Attribute	Surendranagar	Junagadh	Rajkot
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana,	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Northern Tropical Thorn Forest (6B)	Northern Tropical Thorn Forest (6B), Northern tropical dry deciduous forests (5B)	Northern Tropical Thorn Forest (6B)
Annual rainfall (2012-16)	Min.- 331 mm (2012), Max.- 672 mm (2013), Average- 453 mm	Min.- 430 mm (2012), Max.- 1192 mm (2013), Average- 810 mm	Min.- 341 mm (2012), Max.- 1028 mm (2013), Average- 609 mm
Elevation (range)	7-366 m above mean sea level	5-1174 m above mean sea level	1-314 m above mean sea level
Temperature (2011)	Min.- 11°C, Max.- 46 °C	Min.- 12°C, Max.- 39 °C	Min.- 7.5°C, Max.- 44.5 °C
Topography	Mostly open plains and some undulating areas	Open plains, undulating areas and hills	Open plains, undulating areas and hills
Major land cover/ use	Mainly crop fields, pastures and degraded scrub forests	Mainly crop fields, pastures and mixed deciduous forests	Mainly crop fields, pastures and scrub forests
Tehsils surveyed	Dhrangadra, Dasada, Wadhwan, Chotila, Lakthar	Visavadar, Bhesan	Rajkot, Jasdan, Kotda Sangani, Gondal, Wankaner, Jam Kandorna, Jetpur
Human population density (2011)	168/ km^2	311/ km^2	340/ km^2
Livestock population density (2012)	117/ km^2	139/ km^2	123/ km^2
Major livelihoods	Farming, animal husbandry, manufacturing and mining (minerals- silica sand, fireclay)	Farming, animal husbandry, fisheries, manufacturing and mining (minerals- limestone, natural clay)	Farming, animal husbandry, manufacturing and mining (minerals- fireclay, silica sand, limestone)
Major crops	Cotton, wheat, pearl millet, groundnut, sugarcane, sorghum	Cotton, wheat, pearl millet, groundnut, sugarcane, sorghum, mango	Cotton, wheat, pearl millet, groundnut, sugarcane, sorghum, mango
Protected/ Conservation-Areas/ Important sites for conservation	Wild ass Wildlife Sanctuary- 4953 km^2, Nalsarovar Wildlife Sanctuary-120 km^2, Vidis. Lesser floricans have been recorded from the fringe areas of LRK, *vidis* of Rajpara and Mandav, Anantpur areas which are privately managed.	Gir National Park-258 km^2, Gir Wildlife Sanctuary- 1153 km^2, Girnar Wildlife Sanctuary-178 km^2, Grasslands in Visavadar, Grass/grazing lands (*Vidis*)	Wild ass Wildlife Sanctuary- 4,953 km^2, Rampura Vidi Wildlife Sanctuary- 15 km^2, Grass/grazing lands (*Vidis*)

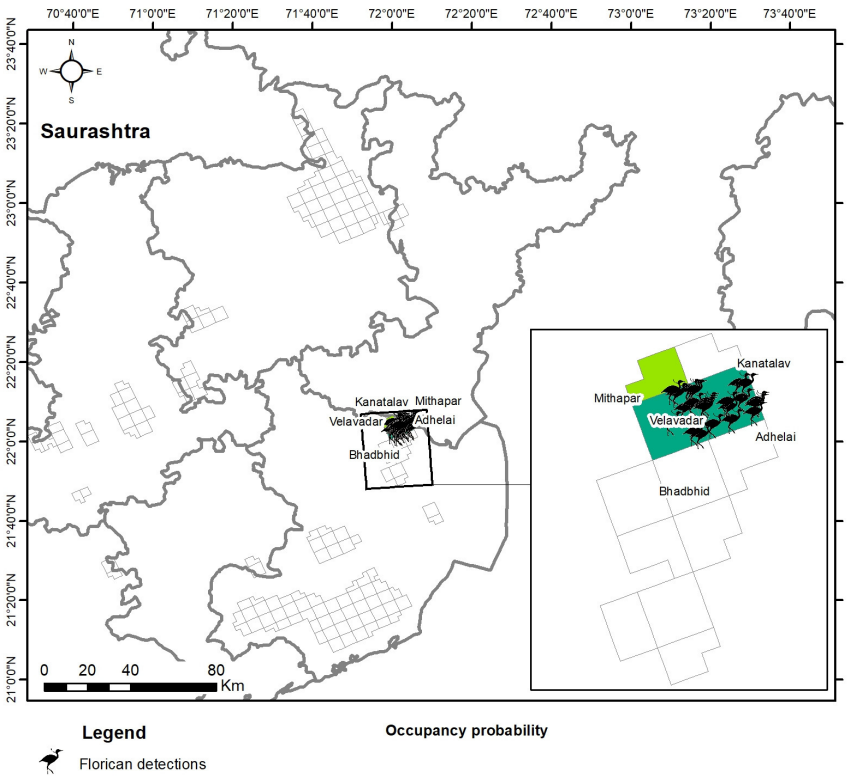
5.3.2 KUTCH (DISTRICT KUTCH)

Attribute	Details
District	Kutch
Bio geographic zone	Desert (3B)- Katchchh
Vegetation	Northern Tropical Thorn Forest (6B)-Desert Thorn Forest (6B/C1)
Annual rainfall (2012-16)	Min.- 253 mm (2012), Max.- 652 mm (2013), Average- 395 mm
Elevation (range)	3-458 m above mean sea level
Temperature (2011)	Min.- 7.5°C, Max.- -45.6 °C
Topography	Mostly open plains
Major land cover/ use	Mainly crop fields, pastures and degraded scrub forests
Tehsils surveyed	Naliya, Mandvi
Human population density (2011)	46/ km^2
Livestock population density (2012)	42/ km^2
Major livelihoods	Farming, animal husbandry, fisheries, manufacturing and mining (minerals- lignite, clay, salt, limestone, laterite, bauxite)
Major crops	Cotton, wheat, pearl millet, groundnut, sorghum, green gram, fruits
Protected/ Conservation-Areas/ Important sites for conservation	Kutch bustard Sanctuary- 2 km^2, Kutch Desert Wildlife Sanctuary- 7506 km^2, Narayan Sarovar Wildlife Sanctuary- 442 km^2, Chharidhand Conservation Reserve-227 km^2, Banni grasslands. Lesser floricans are mainly seen in Kutch bustard Sanctuary, Naliya grasslands, Bhanada, Kunathiya, Vinga ber, Parjau, Nani Duphi, Bhachunda, Khirsara and adjoining areas of Abdasa. They are also seen in Dedhiya, Godhra, Layja and adjoining areas of Mandvi tehsil. These areas are also inhabited by GIB.

Saurashtra and Kutch landscapes: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Reduce nest/ chick predation	1. Removal of free-ranging dogs from lesser florican breeding sites 2. Sustained sterilization of dogs from villages buffering lesser florican breeding sites 3. Garbage management in villages around lesser florican breeding sites	1. Awareness among local communities about issues/threats of free-ranging dogs 2. Collaboration with concerned agencies for removal and sterilization programs 3. Linking this programme with Swachh Bharat abhiyan	Great Indian Bustard (GIB) Core Area (100 sqkm) in Kutch, Blackbuck National Park (BBNP) and villages of Bhal	High Priority, should be done in 2 years	FD, TCF, DNCS, WII, concerned Govt. Dept.	To improve recruitment rate of lesser florican population
Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	1. Satellite tracking to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	Kutch, BBNP Velavadar Bhal area	High and continuous for 5 years	FD, WII, TCF, DNCS, FD, GETCO, Suzlon, concerned Govt. Dept	ToI help reduce mortality of birds
Develop Conservation Breeding Program	Develop a national conservation breeding center (CBC) with State Forest Depts., MoEFCC and scientific organization (WII / BNHS) as partners and international bustard breeders as collaborators	1. Signing of Memorandum of Understanding between partners 2. Permission to collect eggs and tag birds 3. Development of conservation breeding center 4. Execution of program following scientific protocol	Mandvi in Kutch and BBNP in Bhavnagar	High/ should be done within 1 year	WII, FD, TCF, DNCS	To secure an insurance population against imminent extinction risk
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	GIB Core area with ~40 villages in Abdasa, and BBNP & its surrounding vilages in 20 km radius, in Bhavnagar	High/ continuous	TCF, FD, WII, DNCS,Local NGOs	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years
Grazing regulation in unprotected grasslands	Stop/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. 3. Incentivized stall-feeding of livestock during monsoon	GIB Core area with ~40 villages in Abdasa, and BBNP & its surrounding vilages in 20 km radius, in Bhavnagar	Medium/ should be done in 3 years	FD,TCF, DNCS, Local NGOs, Panchayat, BMCs	ToI help in increasing herbaceous biomass, which is critical for lesser florican breeding, and provide fodder for livestock in the lean period (winter through summer)
Research and monitoring	**Satellite telemetry:** Satellite tracking of lesser florican to understand their movement patterns, critical nesting and non-breeding habitat requirements, and basic biology that are all poorly known. Also understand the impact of land-use change on lesser florican ecology **Monitoring:** Distribution and population status assessment following the protocol demonstrated here	1. Necessary permissions from government agencies to procure tags and capture and tag birds 2. Effects of agricultural intensification, new renewable energy projects, and habitat fragmentation due to industrialization on lesser florican need to be assessed through long-term research using land-cover change trend analysis. 3. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerened agencies	Kutch & BBNP Velavadar	High/ Continuous	WII, FD, DNCS, TCF	To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	GIB Core area with ~40 villages in Abdasa, and BBNP & its surrounding vilages in 20 km radius, in Bhavnagar	High/ continuous	TCF, DNCS, WII, FD, Local NGOs	To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	GIB Core Area (100 sqkm) in Kutch, Blackbuck National Park (BBNP) and villages of Bhal	High/ continuous for 5 years	FD	Tocreate more optimal habitats for lesser florican
Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**Acquisition of Revenue lands for conservation** **Protection to marginal conservation areas** Focusing on existing and unprotected Lesser Florican breeding sites **Preventing disturbances to breeding birds** Preventing human disturbances, hunting and livestock grazing by patrolling in PAs	1. Identification and transfer of Revenue Dept. lands that are important for lesser florican to Forest Department, to prevent encroachment. 2. Regulation of intensive land-uses (mining, salt pans, infrastructure, intensive farming) 3. Incentivizing local people for implementing lesser florican-friendly land-uses in their private lands protection force for four months 4. Adequate training and logistic/fund support for the training 5. Identify and deploy local villagers as 'Florican friends' during June-September (lesser florican breeding season)	GIB Core area with about 40 villages in Abdasa Kutch, and in Bhavnagar BBNP & its surrounding vilages within 20 km radius	High and continuous, should be done in a year	FD, TCF, WII, DNCS and concerned Govt. Dept.	To balance livelihood concerns and lesser florican conservation. Capacity building and involvement of local people in Lesser Florican conservation
Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people 2. Identify and train local people interested in this alternate livelihood and develop required facilities 3. Implement in collaboration with Forest Department to ensure that tourism is not detrimental to conservation	Great Indian Bustard (GIB) Core Area (100 sqkm) in Kutch, Blackbuck National Park (BBNP) and villages of Bhal	Medium/continuous	TCF, FD, DNCS, Local NGOs	To help improve local revenue and awareness about lesser florican
Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	GIB Core area with about 40 villages in Abdasa Kutch, and in Bhavnagar BBNP & its surrounding vilages within 20 km radius	High	TCF, FD, WII, DNCS, Local NGOs	To help develop a pilot habitat model apart from a conservation area governed by local people



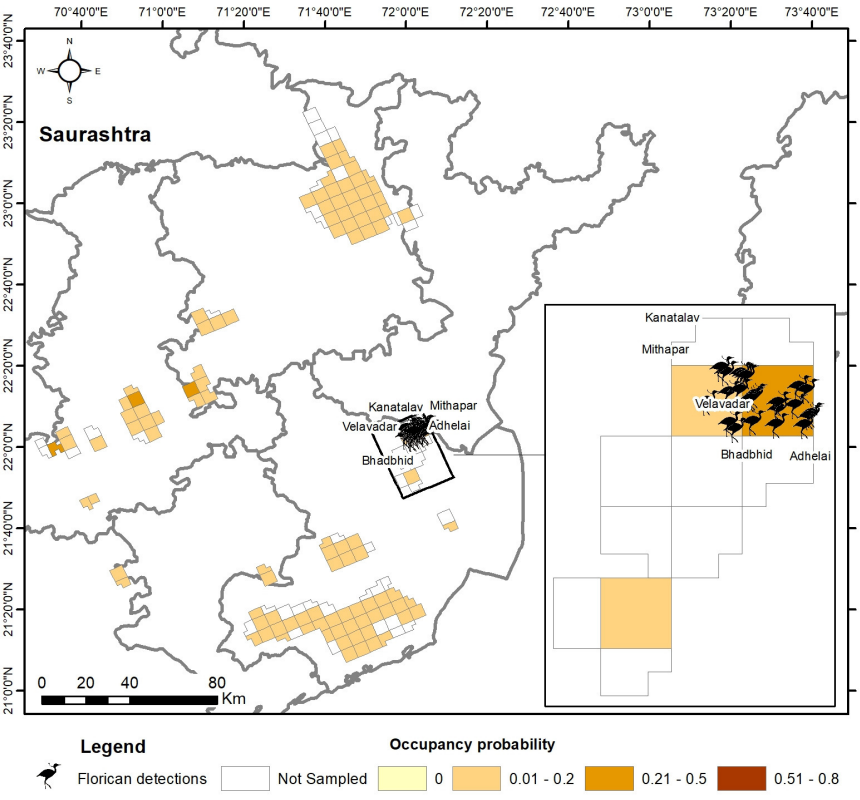


Figure 14 Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Saurashtra landscape

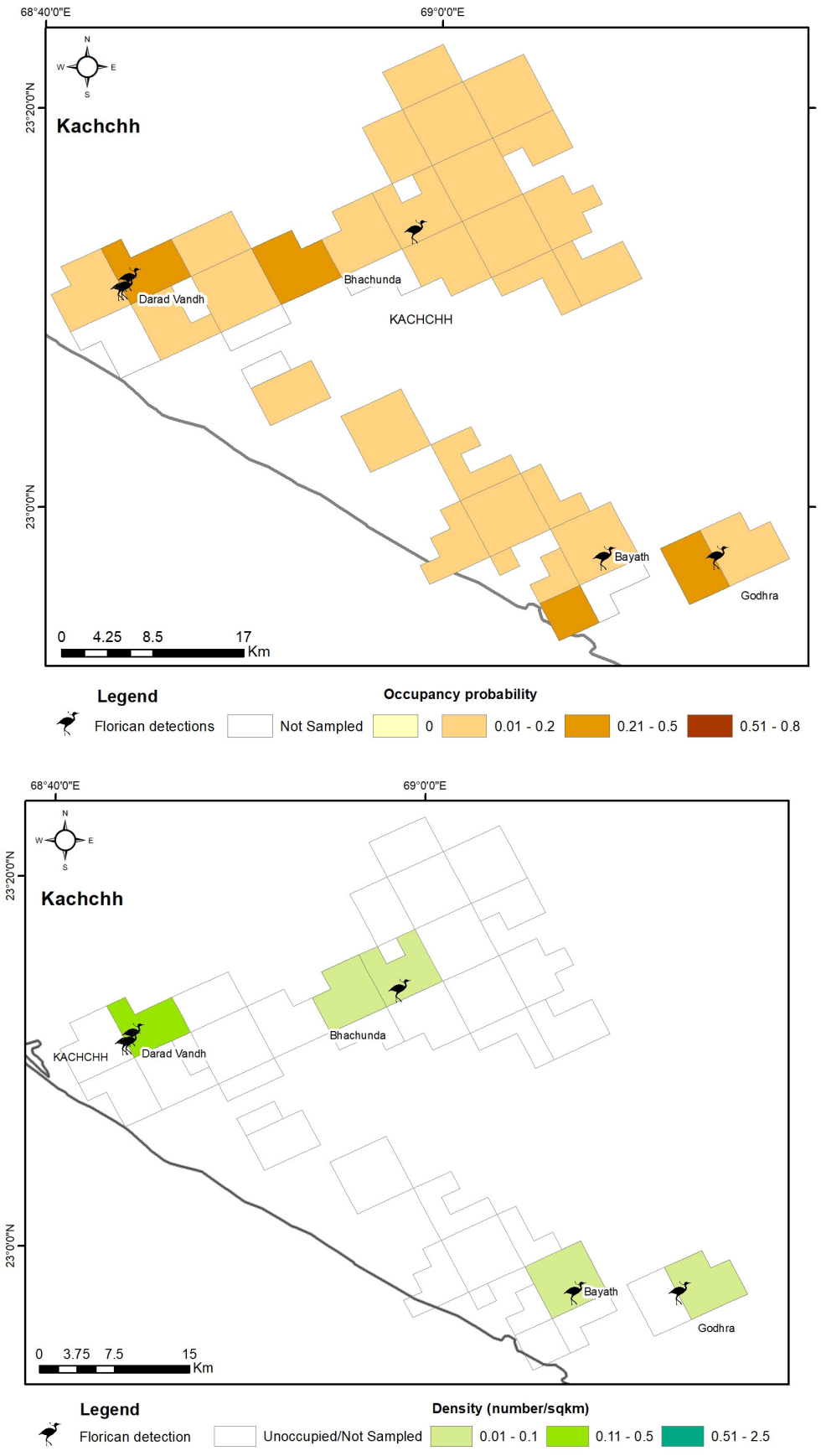


Figure 15: Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Kutch landscape

5.4 REGION: MADHYA PRADESH AND MAHARASHTRA

Attribute	Ratlam (Madhya Pradesh)	Dhar (Madhya Pradesh)
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Southern tropical dry deciduous forests (5A)	Southern tropical dry deciduous forests (5A)
Annual rainfall (2012-16)	Min.- 614 mm (2014), Max.- 1354 mm (2016), Average- 1115 mm	Min.- 736 mm (2014), Max.- 1297 mm (2013), Average- 955 mm
Elevation (range)	305-640 m above mean sea level	150-751 m above mean sea level
Temperature (2011)	Min.-7.9°C, Max.- 42.4 °C	Min.-10°C, Max. -45.0 °C
Topography	Mostly open plains with some hilly areas	Mostly open plains with some hilly areas
Major land cover/ use	Mainly crop fields, forests and pastures	Mainly crop fields and forests
Tehsils surveyed	Sailana, Ratlam, Jaora	Sardarpur, Kukshi, Badnawar
Human population density (2011)	299/ km^2	268/ km^2
Livestock population density (2012)	144/ km^2	155/ km^2
Major livelihoods	Farming, animal husbandry, and manufacturing	Farming, animal husbandry, and manufacturing
Major crops	Wheat, maize, cotton, soya bean, opium	Wheat, soya bean, maize, cotton
Protected/ Conservation- Areas/ Important sites for conservation	Sailana Wildlife Sanctuary- 12.96 km^2, Jaora grasslands. Shikarwadi compartment comprises 354 ha area (grassland in 200 ha and remaining crop fields and grazing lands). Amba compartment is almost 1000 ha area. The area is known for the cyclic dry phases leading to fluctuation in of population of lesser floricans (Sankaran and Rahmani 1990, Sankaran 1991). In 2015, the lesser florican count was 20 birds which dropped to four in year 2016 and two in 2017.	Lesser florican Wildlife Sanctuary, Sardarpur - 348 km^2 with 628 hectares of grassland. In newly developed grassland area of Panpura plot (50 ha), a male lesser florican was sighted displaying during 2015 and 2016.

Attribute	Jhabua (Madhya Pradesh)	Dahod (Gujarat)
Bio geographic zone	Semi-arid (4B) Gujarat-Rajputana	Semi-arid (4B) Gujarat-Rajputana
Vegetation	Southern tropical dry deciduous forests (5A)	Southern tropical dry deciduous forests (5A)
Annual rainfall (2012-16)	Min.- 776 mm (2015), Max.- 1293 mm (2013), Average- 991 mm	Min.- 439 mm (2015), Max.- 802 mm (2013), Average- 663 mm
Elevation (range)	150-751 m above mean sea level	174-400 m above mean sea level
Temperature (2011)	Min.- 11.3°C, Max.- 39.5 °C	Min.- 4.1°C, Max.-43.0 °C
Topography	Mostly open plains with some hilly areas	Mostly open plains with some hills
Major land cover/ use	Mainly crop fields and forests	Mainly crop fields, forests and pastures
Tehsils surveyed	Jhabua, Petlawad, Thandla, Jobat	Dahod, Jhalod, Limkheda
Human density (2011)	285/ km^2	584/ km^2
Livestock density (2012)	217/ km^2	478/ km^2
Major livelihoods	Farming, animal husbandry and fisheries	Farming, animal husbandry and manufacturing
Major crops	Wheat, soya bean, maize, cotton, black gram	Paddy, wheat, groundnut, green gram, maize, soya bean, ginger
Protected/ Conservation- Areas/ Important sites for conservation	Petlawad Reserve Forest. Lesser florican presence has been reported from Ratamba forest patch since year 2011. This forest patch comprises 525 hectares of grassland, and the entire area is fenced to protect the birds from disturbance (Gadikar 2015). Lesser floricans are also sighted in Tarkhedi beat in Bani, Morjheria and Samarkundia villages.	Rampara Vidi (grassland) includes three protected grasslands of 1987.81 ha total area (a) Kali Talai (858.68 ha) b) Muvalia (750.43 ha), Razam (378.40 ha). Forest Department protect these grassland from late June to December, Ratanmahal WLS, Grass/grazing lands (*Vidi*s).

Ratlam-Sardarpur landscape: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Reduce nest/ chick predation	1. Removal of free-ranging dogs from lesser florican breeding sites 2. Sustained sterilization of dogs in villages around lesser florican breeding sites 3. Garbage management in villages around lesser florican breeding sites	1. Awareness among local communities about issues/threats of free-ranging dogs 2. Collaboration with concerned agencies for removal and sterilization programs 3. Linking this programme with Swachh Bharat abhiyan	Sailana, Sardarpur, Petlawad	High / continuous	FD, HSI - WII	To improve recruitment rate of lesser florican population
Reduce mortality factors for adult birds	1. Identify and characterize fatal threats (e.g. wind turbines and power lines) in breeding habitats 2. Develop effective mitigation measures to reduce these threats	1. Satellite tracking of ~2 birds to understand mortality factors 2. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 3. Undergrounding power lines in critical areas	Sailana	High / continuous	FD, WII	Securing rapidly declining population of Lesser Florican
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	Sailana, Sardarpur, Petlawad	Medium / continuous	FD, BNHS, Samvedana, BAIF Foundation	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years
Grazing regulation in unprotected grasslands	Stop/ partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. 3. Incentivized stall-feeding of livestock during monsoon	Sardarpur, Sailana	High / continuous	FD, BNHS, Samvedana, BAIF Foundation	To reduce egg trampling by cattle
Research and monitoring	**1. Satellite telemetry:** Satellite tracking of lesser florican to understand their movement patterns, critical nesting and non-breeding habitat requirements, and basic biology that are all poorly known. Also understand the impact of land-use change on lesser florican ecology 2. **Monitoring:** Distribution and population status assessment following the protocol demonstrated here	1. Necessary permissions from government agencies to procure tags and capture and tag birds. 2. Effects of agricultural intensification, new renewable energy projects, and habitat fragmentation due to industrialization on lesser florican need to be assessed through long-term research using land-cover change trend analysis. 3. Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerened agencies	Sailana, Sardarpur, Petlawad			To help develop effective conservation plans, refine population monitoring exercise, fill information gaps on non-breeding ecology and distribution, and prioritize conservation actions

Conservation action	Task	Requirement	Sites	Priority / process	Implementing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders	Sailana, Sardarpur, Petlawad	Medium / once every alternate year		To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	Sailana, Sardarpur, Petlawad	High / first 5 years	FD, local people	Tocreate more optimal habitats for lesser florican
Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**PA rationalization** Rationalization of boundaries of the Wildlife Sanctuaries (WLS) and defining the Eco-Sensitive Zone (ESZ) **Relief from crop-raiding** Compensation policy to be designed to address the issue of crop raiding by large herbivores like Nilgai **Protection to marginal conservation areas** Focusing on existing and unprotected Lesser Florican breeding sites **Preventing disturbances to breeding birds** Preventing human disturbances, hunting and livestock grazing by patrolling in PAs	There is need to take decision on revenue land inside Sanctuary areas and demarcation of the core areas Crop-raiding by nilgai and wild pigs, in/around PAs demarcated for lesser florican causes antagonism towards lesser florican conservation 1. Regulation of intensive land-uses (mining, infrastructure, intensive farming) 2. Incentivizing local people for implementing lesser florican-friendly land-uses 3. Land ownership should remain with the people. 1. Identifying and engaging poachers or other interested local people as protectors and forest watchers to create a parallel protection force for four months 2. Adequate training and logistic/fund support for the training 3. Deploy local villagers as 'Florican friends' during June-September (lesser florican breeding season)	Sailana WLS, Sardarpur WLS Shisa, Masa, Borgaon-Manju villages and adjoining areas Petlawad	Medium / continuous	FD, BNHS, local people	To balance livelihood concerns and Lesser Florican conservation. Capacity building and involvement of local people in Lesser Florican conservation To secure safe breeding habitat for birds
Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people	Sailana, Petlawad	Medium / continuous	BNHS, FD, local people	To help improve local revenue and awareness about lesser florican

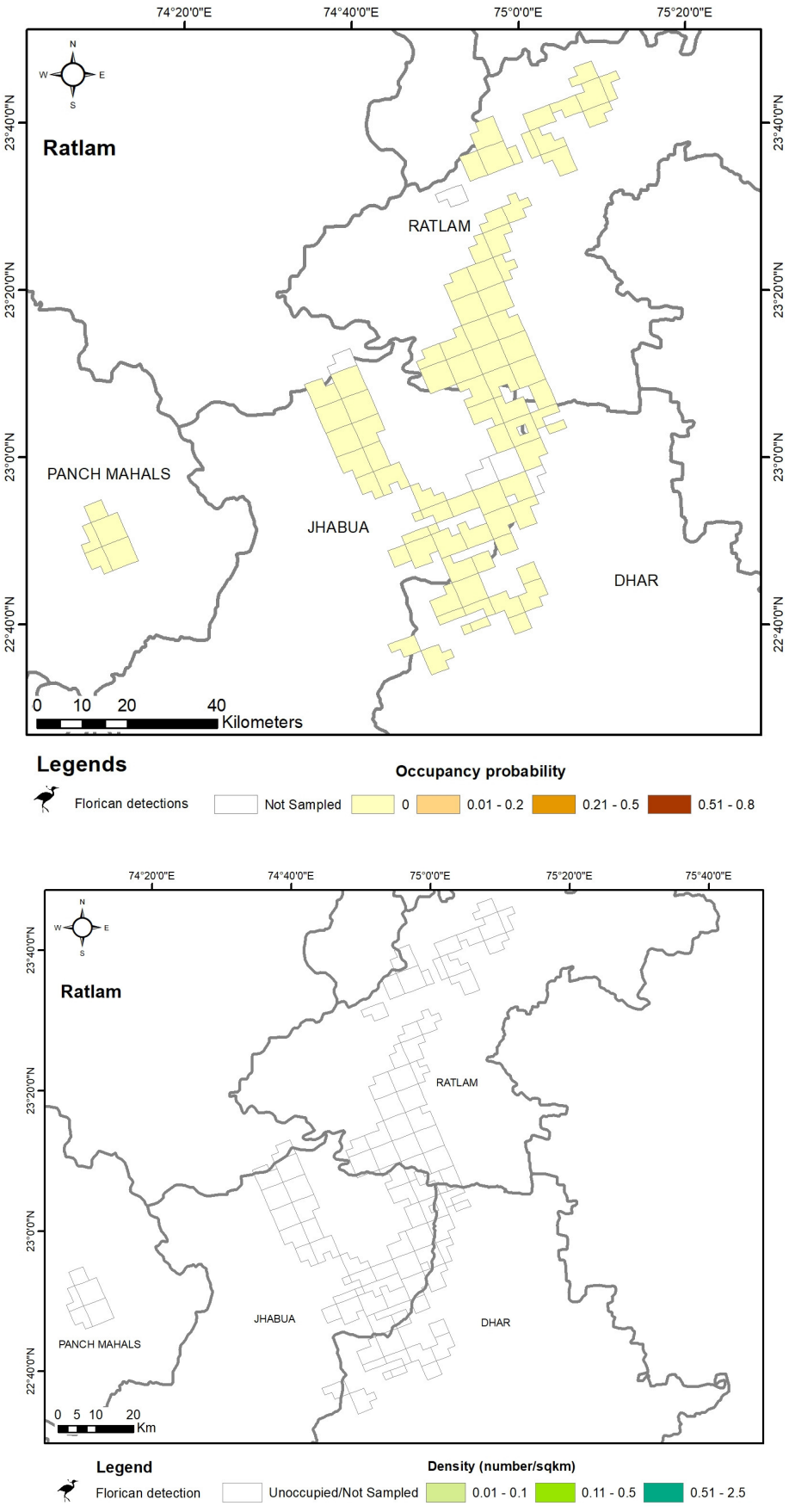


Figure 16: Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Madhya Pradesh region

5.4.2 AKOLA-WASHIM (DISTRICTS AKOLA, WASHIM, YAVATMAL)

Attribute	Akola	Washim	Yavatmal
Bio geographic zone	Deccan Peninsula (6D) Central Plateau	Deccan Peninsula (6D) Central Plateau	Deccan Peninsula (6D) Central Plateau
Vegetation	Southern Tropical Dry deciduous forests (5A)	Southern Tropical Dry deciduous forests (5A)	Southern Tropical Dry deciduous forests (5A)
Annual rainfall (2012-16)	Min.- 798 mm (2014), Max- 1335 mm (2013), Average- 929 mm	Min- 702 (2014), Max- 1330mm (2013), Average- 920 mm	Min.- 763 (2014), Max.- 1317mm (2013), Average- 953 mm
Elevation (range)	250-940 m above mean sea level	261-549 m above mean sea level	261-549 m above mean sea level
Temperature (2011)	Min.- 8.0°C, Max.- 48.0 °C	Min.- 8.0°C, Max.- 47.0 °C	Min.- 8.0°C, Max.- 47.0 °C
Topography	Mostly plains with some undulating areas	Mostly plains with some undulating areas	Mostly plains with some undulating areas
Major land cover/ use	Mainly crop fields, degraded forests and pastures	Mainly crop fields, degraded forests and pastures	Mainly crop fields, forests and pastures
Tehsils surveyed	Akola, Barshi Takali, Murtizapur	Washim, Karanja Lad	Darwha, Ner
Human population density (2011)	320/ km^2	244/ km^2	204/ km^2
Livestock population density (2012)	82/ km^2	94/ km^2	84/ km^2
Major livelihoods	Farming, animal husbandry, and manufacturing (cotton industry)	farming, animal husbandry, and manufacturing (cotton industry)	Farming, animal husbandry, mining (minerals- coal, limestone) and manufacturing (cotton industry)
Major crops	Cotton, wheat, sorghum, sugarcane, green gram, pigeon pea	Soya bean, cotton, wheat, green gram, pigeon pea, sorghum	Soya bean, cotton, wheat, green gram, pigeon pea, sorghum
Protected/ Conservation- Areas/ Important sites for conservation	Lesser florican has been reported from Borgao Manju (Kasambe & Gahale 2010). Grasslands near Shisa, Masa villages, Akola telsil and near Vadala village Barshi Takali tehsil. During 2016, 4-5 males were reported from this area. Katepurna Wildlife Sanctuary- 73 km^2, Narnala Wildlife Sanctuary- 12 km^2	Karanja Reserve Forest, Karanja Sohol Blackbuck Sanctuary- 18 km^2.	Lesser florican has been recorded from Darwha, in Yavatmal District (Kasambe & Gahale 2010) Reserve Forests in Ner and Darwha Tehsils, Tipeshwar Wildlife Sanctuary- 148 km^2, Painganga Wildlife Sanctuary- 324 km^2.

Akola-Washim landscape: conservation recommendations

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Reduce nest/ chick predation	1. Removal of free-ranging dogs from lesser florican breeding sites 2. Sustained sterilization of dogs in villages around lesser florican breeding sites 3. Garbage management in villages around lesser florican breeding sites	1. Awareness among local communities about issues/threats of free-ranging dogs 2. Collaboration with concerned agencies for removal and sterilization programs 3. Linking this programme with Swachh Bharat abhiyan	Shisa, Masa, Borgaon-Manju villages and adjoining areas	High / continuous	FD, HSI - WII	To improve recruitment rate of lesser florican population
Reduce mortality factors for adult birds	Develop effective mitigation measures to reduce these threats	1. Mapping of potential threats (e.g. power lines and wind turbines) and identifying mitigation areas 2. Undergrounding power lines in critical areas	Shisa, Masa, Borgaon-Manju villages and adjoining areas		FD, BNHS	Securing rapidly declining population of lesser florican
Promote lesser florican friendly farming	Promotion of lesser florican-friendly agricultural practices, including sparing of grasslands between crop fields, mixed cropping of different heights, and replacement of pesticides and chemicals with bio-remedies	1.Collaboration/ engagement with farmers and agriculture department 2. Create awareness about health benefits of organic farming and provide alternate bioremedies 3. Marketing lesser florican-friendly crops at higher prices as an incentive to farmers	Florican distribution sites inTehsils Akola, Barshi Takali and Murtizapur and GIB Sanctuary, Solapur	Medium / continuous	FD, BNHS, Samvedana, BAIF Foundation	To balance livelihood concerns and lesser florican conservation. To ensure sustenance of program, land will be monitored for three years
Grazing regulation in unprotected grasslands	Stop / partition livestock grazing in non PA, private/village owned lesser florican breeding grasslands during June–September (breeding season) by encouraging herders to stall feed livestock through dialogue or legal restrictions	1. Engagement with grassland owners (individuals or village panchayats) to develop joint management plans that may include: a. Developing community fodder farms b. Allowing grazing in one-third of a grassland while sparing the rest for lesser florican. 2. Incentivized stall-feeding of livestock during monsoon	Florican distribution sites inTehsils Akola, Barshi Takali and Murtizapur and GIB Sanctuary, Solapur	High / continuous	FD, BNHS, Samvedana, BAIF Foundation	To reduce egg trampling by cattle
Research and monitoring	**Monitoring:** Distribution and population status assessment following the protocol demonstrated here	Necessary permissions and logistical support from government agencies to conduct surveys and collaborative efforts from all concerened agencies	Florican distribution sites inTehsils Akola, Barshi Takali and Murtizapur and GIB Sanctuary, Solapur			

Conservation action	Task	Requirement	Sites	Priority / process	Implement-ing agencies	Remarks
Create positive publicity for lesser florican conservation	Outreach programme for Forest Department staff, local communities and other stakeholders (Revenue, Agricultural & Veterinary Depts.) on the need and requirements for lesser florican conservation	1. Identification of stakeholders 2. Develop & disseminate outreach materials on ecological/conservation values of lesser florican and their habitats in vernacular languages 3. Conduct multiple stakeholder sensitization workshops 4. Arrange nature education programme	Florican distribution sites inTehsils Akola, Barshi Takali and Murtizapur and GIB Sanctuary, Solapur	Medium / once every alternate year		To generate public support for lesser florican conservation
Habitat restoration	**Invasive weed management** Removal of *Prosopis juliflora* and other invasive plants from breeding sites	Collaborative implementation by Forest departments and concerned agencies	Newly developed florican grassland by Akola Division	High / first 5 years	FD, local people	To create more optimal habitats for lesser florican
Reduce public antagonism by integrating lesser florican conservation with local livelihood issues	**Relief from crop-raiding** Compensation policy to be designed to address the issue of crop raiding by large herbivores like Nilgai **Protection to marginal conservation areas** Focusing on existing and unprotected Lesser Florican breeding sites **Preventing disturbances to breeding birds** Preventing human disturbances, hunting and livestock grazing by patrolling in PAs	Crop-raiding by nilgai and wild pigs, in/around PAs demarcated for lesser florican causes antagonism towards lesser florican conservation 1. Regulation of intensive land-uses (mining, infrastructure, intensive farming) 2. Incentivizing local people for implementing lesser florican-friendly land-uses 3. Land ownership should remain with the people. 1. Identifying and engaging poachers or other interested local people as protectors and forest watchers to create a parallel protection force for four months 2. Adequate training and logistic/fund support for the training 3. Deploy local villagers as 'Florican friends' during June-September (lesser florican breeding season)	Florican distribution sites inTehsils Akola, Barshi Takali and Murtizapur Shisa, Masa, Borgaon-Manju villages and adjoining areas	Medium / continuous	FD, BNHS, local people, Samvedana	To balance livelihood concerns and Lesser Florican conservation. Capacity building and involvement of local people in Lesser Florican conservation, to secure safe breeding habitat for birds
Promote regulated lesser florican tourism	Regulated, ethical tourism can be promoted to generate alternate income for local livelihoods and increase the conservation support for lesser florican	1. Develop guidelines of eco-tourism that does not disturb breeding birds and generate income for local people 2. Identify and train local people interested in this alternate livelihood and develop required facilities 3. Implement in collaboration with Forest Department to ensure that tourism is not detrimental to conservation	Shisa, Masa, Borgaon-Manju villages and adjoining areas	Medium / continuous	BNHS, FD, Samvedana, local people	To help improve local revenue and awareness about lesser florican
Developing Community Conservation Areas (CCAs)	Developing an organizational structure for Community Conservation Areas	1. High intensity of engagement, first 2 years 2. Handholding for institutionalization of the programme	Shisa, Masa, Borgaon-Manju villages and adjoining areas	High / continuous	BNHS, FD, local people	To help developp a pilot habitat model apart from a conservation area governed by local people

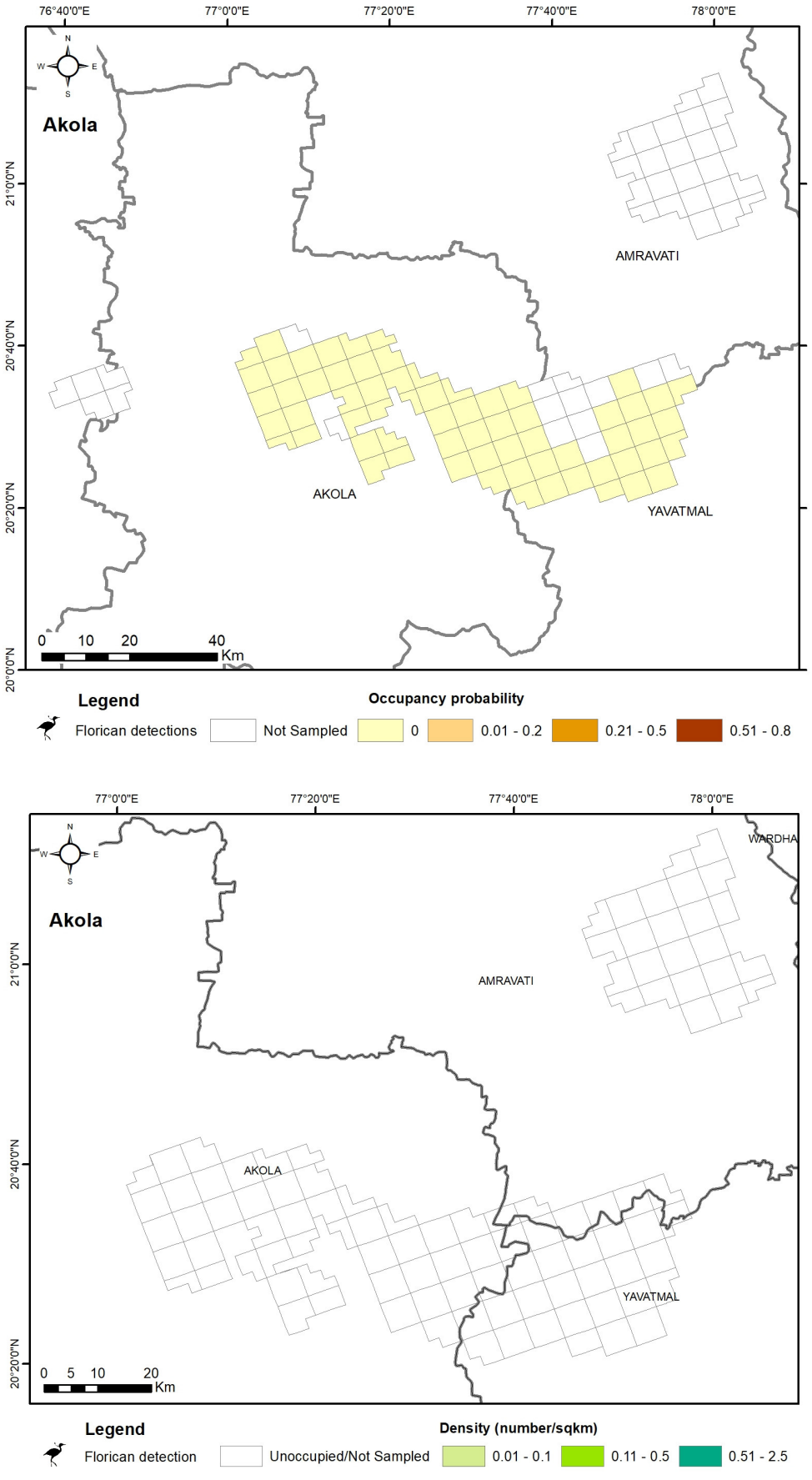


Figure 17 Predicted occupancy probability (top) and density (bottom) along with detections of lesser florican in sites (36 sq km cells) across Maharashtra region

APPENDICES

APPENDIX I - MAPS OF PROTECTED AREAS WHERE LESSER FLORICAN OCCUR

Gujarat

Image 3: Blackbuck National Park, Velavdar, Bhavnagar, Gujarat

Image 4: Kutch bustard Sanctuary, Lala, Kutch, Gujarat

Madhya Pradesh

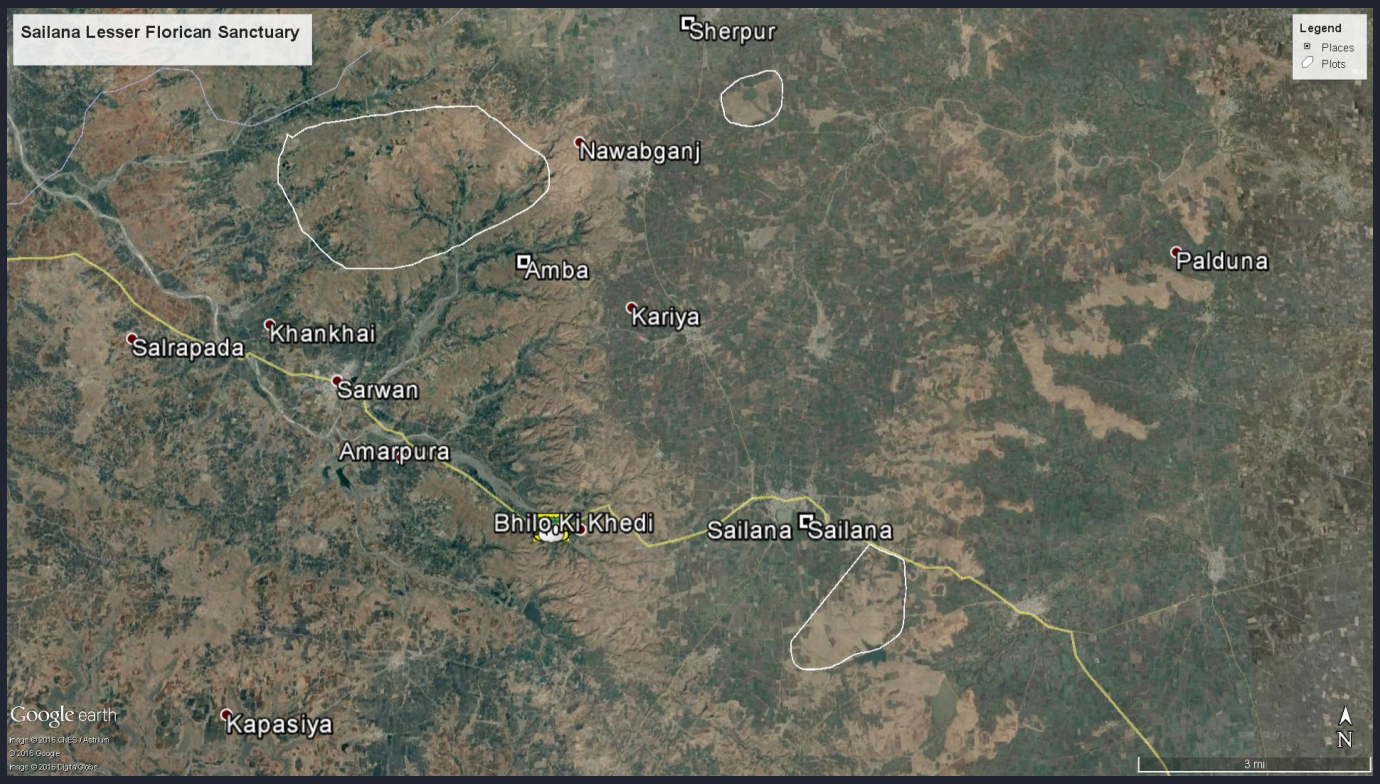


Image 5: Important breeding sites of lesser florican in Sailana WLS, Ratlam, Madhya Pradesh

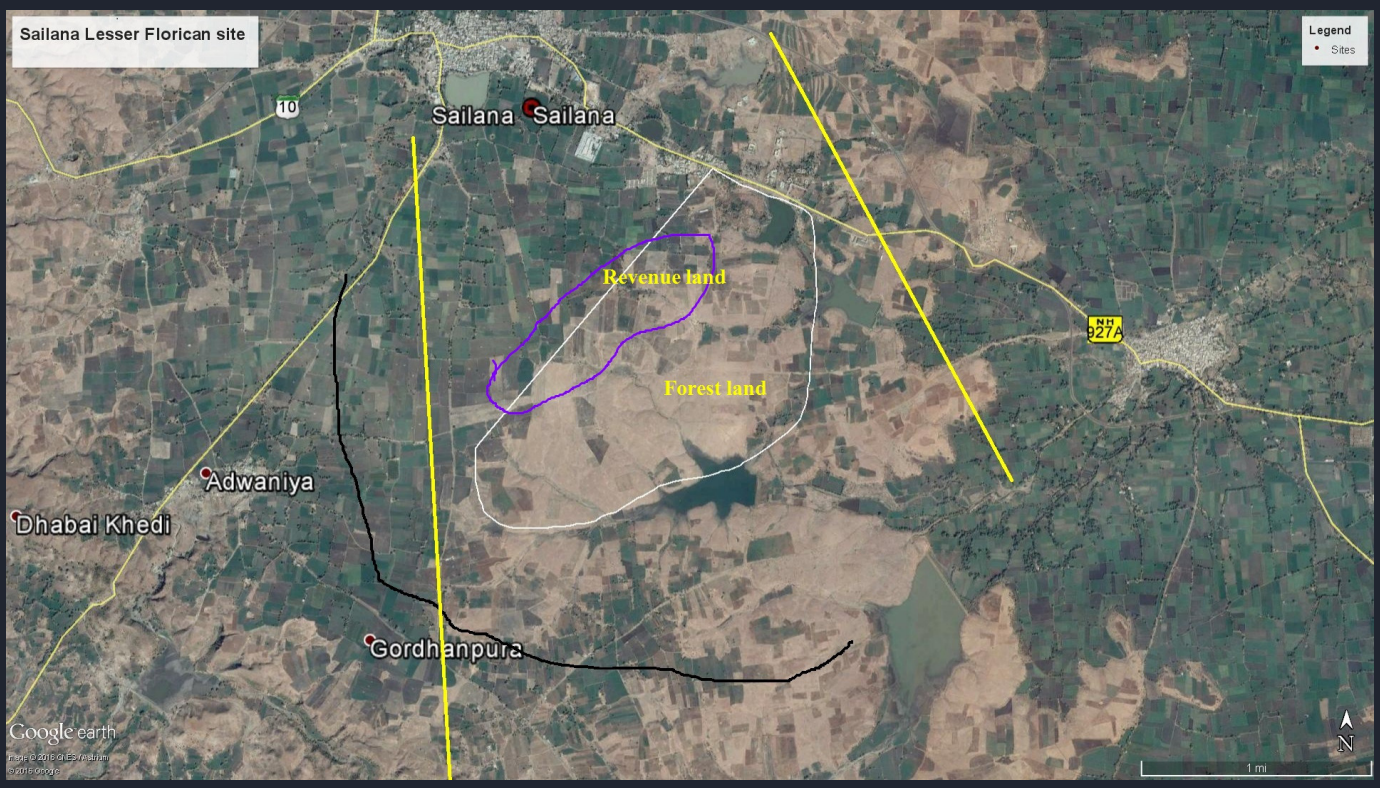


Image 6: Shikarwadi core area (black: wind turbines, yellow: high tension power lines) in Sailana WLS, , Ratlam, Madhya Pradesh

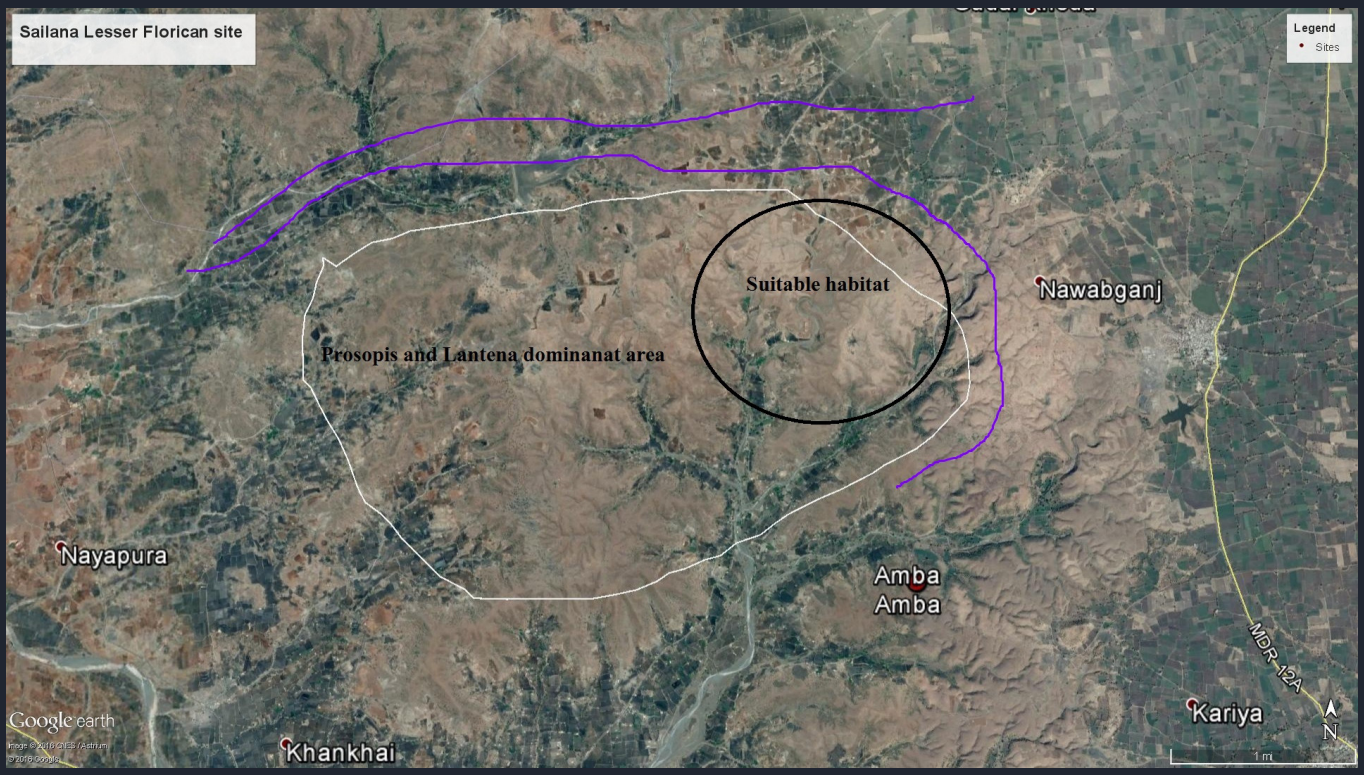


Image 7: Amba lesser florican site (black boundary: suitable habitat, purple lines: wind turbine areas) in Ratlam, Madhya Pradesh

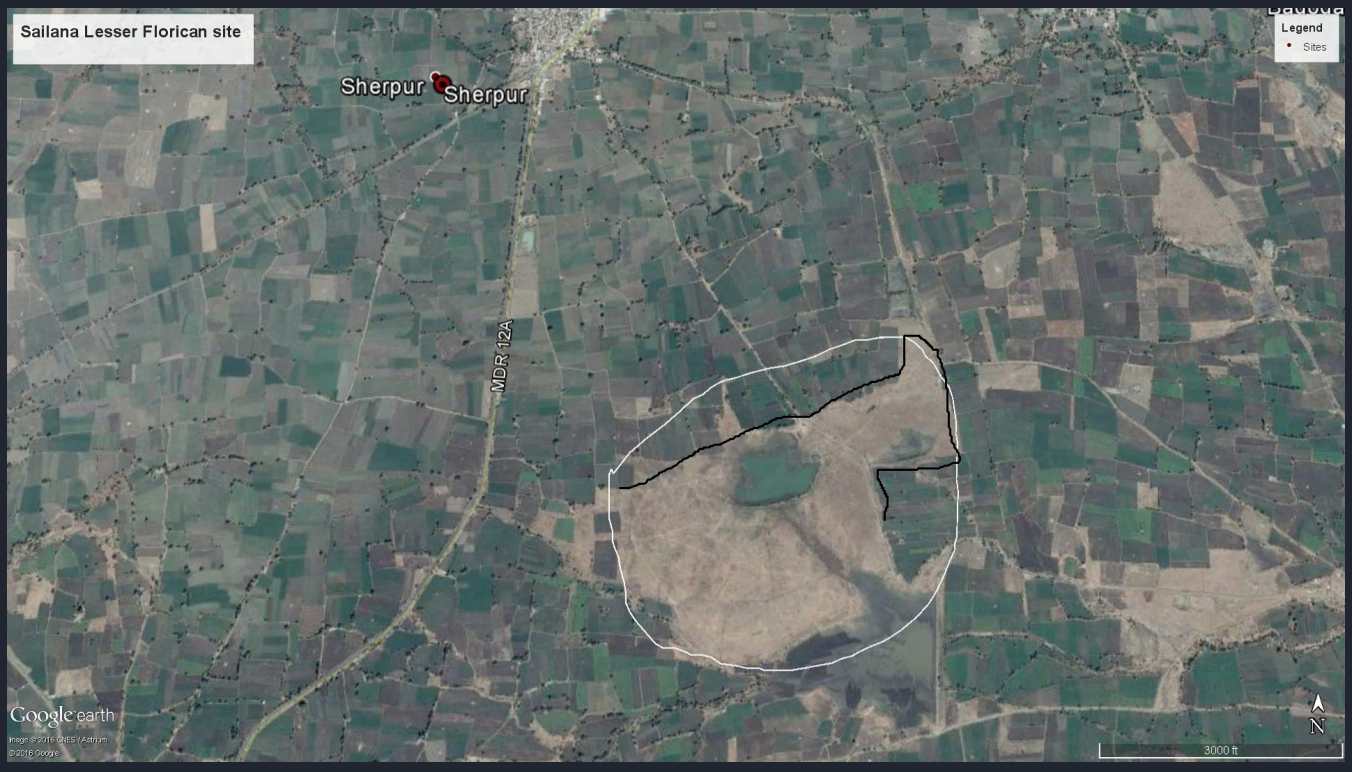


Image 8: Sherpur lesser florican site with conservation exclosure of <100 ha in Ratlam, Madhya Pradesh

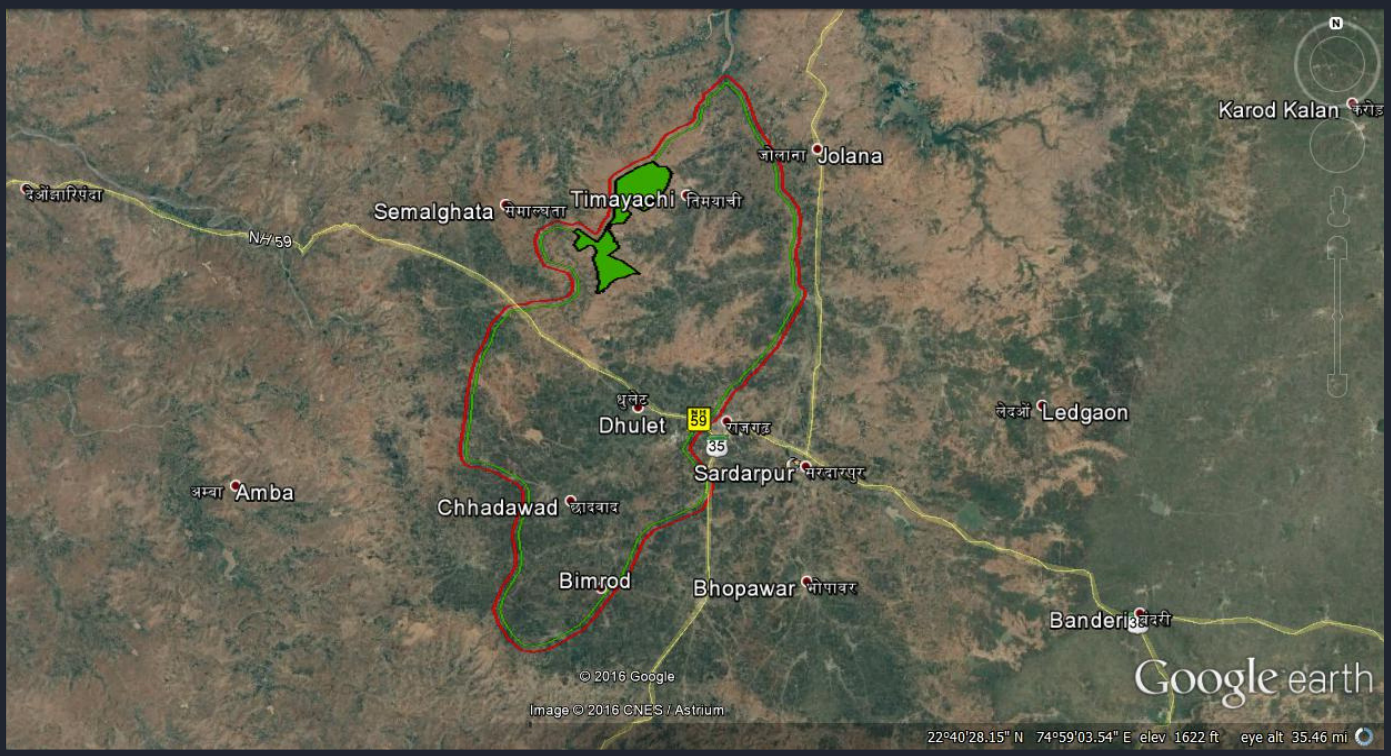


Image 9: Sardarpur WLS spread across 350 km2 area (polygons showing core areas) in Sardarpur, Madhya Pradesh

APPENDIX II FIELD AND HABITAT PHOTOS

Image 10: Typical lesser florican habitat with mosaic of grassland and agriculture in Sailana, Ratlam, Madhya Pradesh in 2017 © Sujit Narwade

Image 11: Habitat degradation due to invasive Lantana and Prosopis in lesser florican site of Amba, , Ratlam, Madhya Pradesh in 2017 © Sujit Narwade

Image 12: Installation of wind turbines near lesser florican breeding sites are a source of disturbance due to power-lines and noise © Sujit Narwade

Image 13: Lesser florican breeding habitat in Sardarpur WLS, Sardarpur, Madhya Pradesh © Sujit Narwade

Image 14: Kutch Bustard Sanctuary, Gujarat surrounded by wind turbines © Balasaheb Lambture

Image 15 : View of Rampura grassland area during monsoon in Dahod, Gujarat © Ameya Karulkar

Image 16: Habitat of lesser florican and great Indian bustard in Naliya grassland, Kutch, Gujarat © Ameya Karulkar

Image 17: Pesticide spraying in agricultural fields in Shokaliya landscape, Ajmer, Rajasthan © Sujit Narwade

Image 18: Farmers working in mixed crop field in lesser florican breeding site in Shahpura landscape, Bhilwara, Rajasthan © Biswajit Chakdar

Image 19: Interaction with local farmers at florican site of Pratapgarh, Rajasthan © Mohib Uddin

Image 20: Lesser florican breeding site near Bhatera village, Shahpura landscape, Bhilwara, Rajasthan © Biswajit Chakdar

Image 21: Breeding habitat of lesser florican in Shokaliya landscape, Ajmer, Rajasthan © Sujit Narwade

Image 22: Lesser florican breeding site in Pratapgarh, Rajasthan © Mohib Uddin

Image 23: Remaining grassland patches of Jalore, Rajasthan © Mohib Uddin

Appendix III - Note on lesser floricans rescued and released in year 2017

A total of five lesser floricans were rescued and released during September to December 2017, in various parts of the India.

1. Maharashtra (2 birds) - One female lesser florican with wing injury was found (18.2971°N 74.7464°E) near grasslands of Bhigwan village, Tehsil Indapur, District Pune on 19 September 2017(S. Jared, pers. comm). It was kept at his home for two days, treated with turmeric, and released on 22 September 2017. One juvenile lesser florican was rescued by a group of birdwatchers (Mr. Sandeep Valvi and Mr. Akshay Akki) from an open ground at Police headquarters, Solapur city (17.6659°N 75.9192°E) on 25 November 2017. According to the sources (M. Shete, pers. comm.) the bird was feeding on insects under light lamps in the evening and a police officer on duty noticed bird and followed it. The disturbed bird ran and was trapped in an auditorium from where it was rescued and handed over to the Office of Range Forest Officer, Great Indian Bustard Sanctuary, Nannaj, Solapur. The bird was perfectly fine and kept in custody of Forest Department for deployment of satellite transmitter. Forest Department staff released the bird on 30 November 2017, in grasslands of Nannaj (Source, Office of the Range Forest Officer, GIB Sanctuary).

2. Karnataka – One female lesser florican was rescued by local birdwatchers near Hubli city on 17 November 2017 and released in city outskirts on 18 November 2017.

3. Gujarat – One bird was rescued near Vadodara, ringed by BNHS and Gujarat Forest Department team and released in Rampura grassland, Dahod on 2 November 2017.

4. Rajasthan – One abandoned chick of lesser florican was rescued by a villager in Kacholia, Malpura tehsil, District Ajmer (26.3545°N, 75.2698°E) on 11 October 2017 which was released at the same place the next day.
The sighting of birds mostly from areas outside its known range and during non breeding season highlights the immediate need of radio telemetry studies for conservation of non-breeding habitats of this species.

Appendix IV- Photos of training workshop, field surveys and interactions during lesser florican status assessment, 2017

Image 24: Training workshop conducted at MK University, Bhavnagar, Gujarat © Balasaheb Lambture

Image 25: Training workshop conducted at Ujjain, Madhya Pradesh © Balasaheb Lambture

Image 26: Training workshop conducted at MDS University, Ajmer, Rajasthan © Forest Division, Ajmer

Image 27: Training workshop conducted at Akola, Maharashtra © BNHS photo library

Image 28: Post survey workshop organised at WII, Dehradun © WII photo library

Image 29: Regional universities and NGOs were involved in the lesser florican survey © Parul Sen

Image 30: Stakeholder meeting conducted at Sailana, Madhya Pradesh © Range Forest Officer, Sailana

Image 31: Survey team and Forest Department staff during lesser florican survey © Vikas Pisal

Image 32: Survey team conducting line transect sampling to assess lesser florican status © Sutirtha Dutta

Image 33: Interactions of survey team with local people during field surveys © BNHS photo library

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  Rainfall data - http://www.imd.gov.in/pages/services_hydromet.php
  District data - http://districts.nic.in/

ANNEXURES

Annexure 1: Datasheet for site-occupancy assessment of lesser florican using occupancy surveys

Site..... Visit..... Date..... Observers..... Track ID.....(GPS) Tr-len .....(km)

Point SN 1-km	Cell ID	Latitude dd-mm-ss	Longitude dd-mm-ss	Time (hh:mm) start – end	Weather	Wind speed	Land-cover 100m radius	Ground veg 100m radius		Active disturbance 200m	Passive disturbance 200 m	Florican count			Activity	Secondary data (farmers/herders)	
								Height (0-3)	Cover (0-3)			M	F	Total		Seen Likh this season here?	When was Likh last seen here?
1					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
2					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
3					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
4					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
5					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
6					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
7					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
8					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
9					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
10					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
11					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
12					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
13					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
14					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
15					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		

Abbreviations Weather: S (Sunny) / B (Bright) / C (Cloudy) / R (Rainy); Wind speed: N (None) / M (Mild) / S (Strong); Land-cover: G (Grassland), A (Agriculture), S (Scrubland), W (Woodland); Active disturbance: H (Human), D (Dog), L (Livestock), O (Others); Passive disturbance: S (Settlement), E (Electric lines), R (Road), I (Industrial uses); Sex: M (Male) / F (Female); Activity: D (Display) / F (Foraging) / A (Aerial/flight)

Annexure 2: Datasheet for population and habitat assessments of lesser florican using line transect surveys

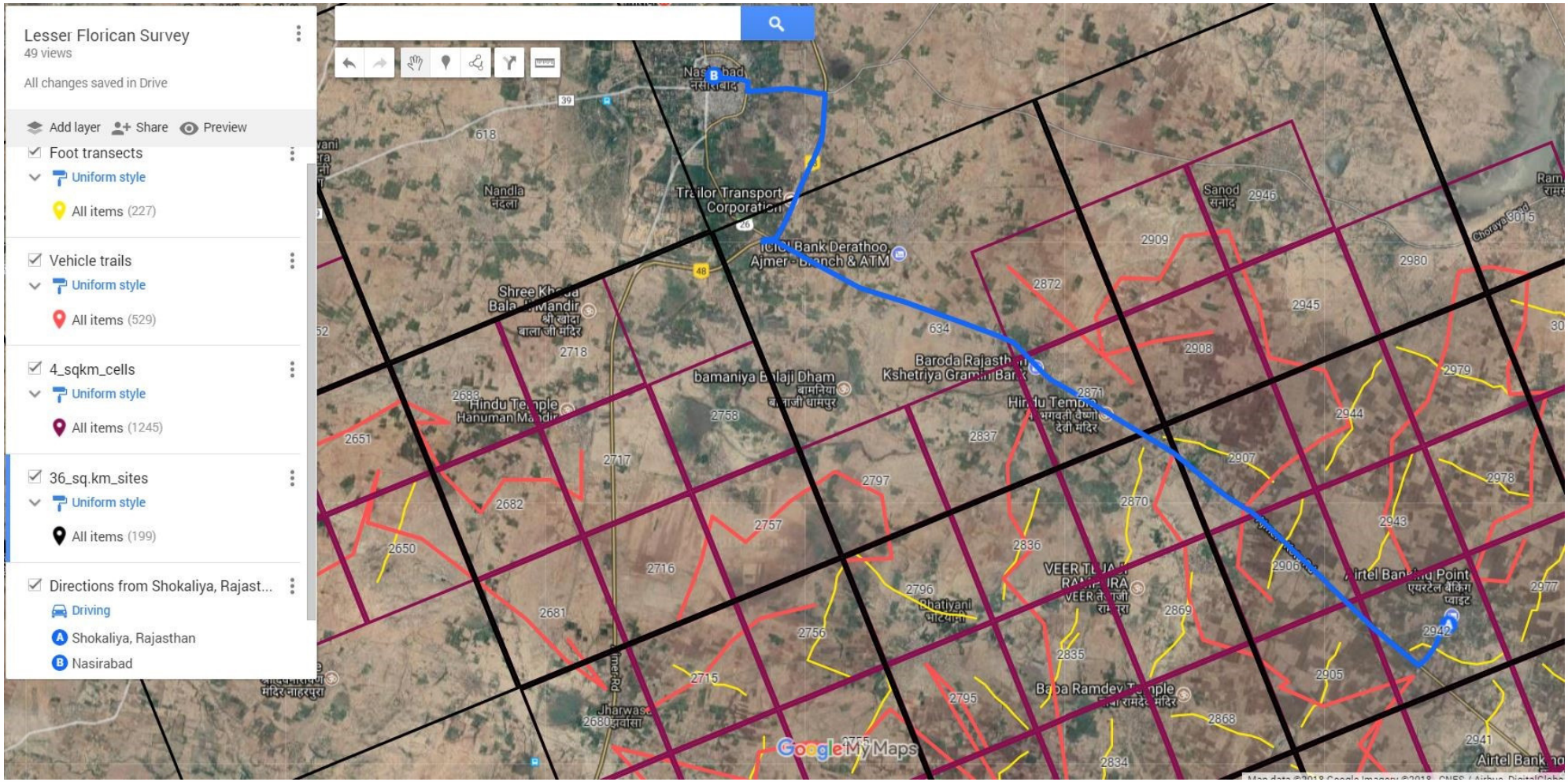
Site..... Visit..... Date..... Observers..... Track ID.....(GPS) Tr-len .....(km)

Point SN 1-km	Cell ID	Latitude dd-mm-ss	Longitude dd-mm-ss	Time (hh:mm) start – end	Weather	Wind speed	Land-cover 100m radius	Ground veg 100m radius		Active disturbance 200m	Passive disturbance 200 m	Florican count			Activity	Secondary data (farmers/herders)	
								Height (0-3)	Cover (0-3)			M	F	Total		Seen Likh this season here?	When was Likh last seen here?
1					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
2					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
3					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
4					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
5					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
6					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
7					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
8					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
9					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
10					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
11					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
12					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
13					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
14					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		
15					S/B/C/R	N/M/S	G/A/S/W			H/D/L/O	S/E/R/I				D/F/A		

Abbreviations Weather: S (Sunny) / B (Bright) / C (Cloudy) / R (Rainy); Wind speed: N (None) / M (Mild) / S (Strong); Land-cover: G (Grassland), A (Agriculture), S (Scrubland), W (Woodland); Active disturbance: H (Human), D (Dog), L (Livestock), O (Others); Passive disturbance: S (Settlement), E (Electric lines), R (Road), I (Industrial uses); Sex: M (Male) / F (Female); Activity: D (Display) / F (Foraging) / A (Aerial/flight)

ANENXURE 3: SCRIPT FOR ANALYZING LESSER FLORICAN SURVEY DATA IN PROGRAM R

```
library(unmarked)
library(MuMIn)
data <- read.csv("LF_occ_2017_all.csv")
names(data)
data$Lndscp <- as.factor(data$Lndscp)
data$Rgn <- as.factor(data$Rgn)
summary(data)
# checking for multicollinearity
habdat <- data[,63:71]
cor <- cor(habdat)
corr <- ifelse(cor>0.4, round(cor,2),0)
corr
# Pull out occupancy matrix - all sites
y.all <- data[,2:57]
x.all <- data[,58:71]
# Make unmarked frame - all sites
umf.all <- unmarkedFrameOccu(y=y.all,
  siteCovs=data.frame(x.all))
head(umf.all)
# Pull out occupancy matrix - sites in occupied landscapes
drgnr <- read.csv("LF_occ_2017_rgnr.csv")
names(drgnr)
drgnr$Lndscp <- as.factor(drgnr$Lndscp)
drgnr$Rgn <- as.factor(drgnr$Rgn)
summary(drgnr)
y.rgnr <- drgnr[,2:57]
x.rgnr <- drgnr[,58:71]
# Make unmarked frame - sites in occupied landscapes
umf.rgnr <- unmarkedFrameOccu(y=y.rgnr,
  siteCovs=data.frame(x.rgnr))
head(umf.rgnr)
# Pull out occupancy matrix - sites in occupied regions
drgnl <- read.csv("LF_occ_2017_rgnl.csv")
names(drgnl)
drgnl$Lndscp <- as.factor(drgnl$Lndscp)
drgnl$Rgn <- as.factor(drgnl$Rgn)
summary(drgnl)
y.rgnl <- drgnl[,2:57]
x.rgnl <- drgnl[,58:71]
# Make unmarked frame - sites in occupied landscapes
umf.rgnl <- unmarkedFrameOccu(y=y.rgnl,
  siteCovs=data.frame(x.rgnl))
head(umf.rgnl)
# Run occupancy models
## all data  to estimate range-level occupancy
occ_null = occu(~1 ~1, data=umf.all)
occ_RN = occuRN(~1 ~1, K=72, data=umf.all)
# Compare basic models
list(AIC(occ_null, occ_RN))
backTransform(occ_null, type="state")
## occupied region data  to estimate range and region level occupancies
# modeling detection probability with occupancy modeled on regions
occ_null. = occu(~1 ~1, data=umf.rgnl)
occ_null.rgnl = occu(~1 ~Rgn, data=umf.rgnl)
occ_RN.rgnl = occuRN(~1 ~Rgn, K=72, data=umf.rgnl)
occ_drgn.rgnl = occu(~Rgn ~Rgn, data=umf.rgnl)
occ_dcova.rgnl = occu(~Wthr+Wndspd ~Rgn, data=umf.rgnl)
occ_dcovb.rgnl = occu(~Wthr ~Rgn, data=umf.rgnl)
occ_drgncova.rgnl = occu(~Rgn+Wthr+Wndspd ~Rgn, data=umf.rgnl)
occ_drgncovb.rgnl = occu(~Rgn+Wthr ~Rgn, data=umf.rgnl)
# model selection and inference
occrngl_sel = model.sel(occ_null.,occ_null.rgnl, occ_RN.rgnl,occ_drgn.rgnl,
occ_dcova.rgnl,occ_dcovb.rgnl,occ_drgncova.rgnl, occ_drgncovb.rgnl)
write.csv(occrngl_sel,"detection_models.csv")
occrngl_sel
```

```
summary(occ_drgncovb.rgnl)
# estimate regional occupancies
Rgn = c("Ajm","Guj","Rajr")
Wthr = mean(drgnl$Wthr)
newdat1 = data.frame(Rgn,Wthr)
occrgn_prd = predict(occ_drgncovb.rgnl , newdata=newdat1, type="state",
se.fit=TRUE)
detrgn_prd = predict(occ_drgncovb.rgnl , newdata=newdat1, type="det",
se.fit=TRUE)
occ_est_rgn = data.frame(newdat1,occrgn_prd, detrgn_prd)
occ_est_rgn
write.csv(occ_est_rgn,"regional_occupancy.csv")
# modeling occupancy on habitat covariates with best detection model
occu1 = occu(~Rgn+Wthr ~ 1, data=umf.rgnl) # to estimate range-level
occupancy
occu2 = occu(~Rgn+Wthr ~ Rgn, data=umf.rgnl)
occu3 = occu(~Rgn+Wthr ~ Grsl, data=umf.rgnl)
occu4 = occu(~Rgn+Wthr ~ Rgn*Grsl, data=umf.rgnl)
occu5 = occu(~Rgn+Wthr ~ Rgn*Grsl+Psv_dstb, data=umf.rgnl)
occu6 = occu(~Rgn+Wthr ~ Rgn*Grsl+Psv_dstb+Act_dstb, data=umf.rgnl)
occu7 = occu(~Rgn+Wthr ~ Rgn*Grsl+Grndvg_het, data=umf.rgnl)
occu8 = occu(~Rgn+Wthr ~ Rgn*Grsl+Grndvg_ht*Grndvg_cov, data=umf.rgnl)
occu9 = occu(~Rgn+Wthr ~ Rgn*Grsl+Grndvg_het+Psv_dstb, data=umf.rgnl)
occu10 = occu(~Rgn+Wthr ~ Rgn*Grsl+Grndvg_ht*Grndvg_cov+Psv_dstb,
data=umf.rgnl)
occu11 = occu(~Rgn+Wthr ~
Rgn*Grsl+Grndvg_het+Grndvg_ht*Grndvg_cov+Psv_dstb+Act_dstb,
data=umf.rgnl)
occmodsel = model.sel(occ_null.,
occu1,occu2,occu3,occu4,occu5,occu6,occu7,occu8,occu9,occu10,occu11)
occmodsel
write.csv(occmodsel,"occupancy_models.csv")
summary(occu4)
# Generate response curves
Wthr = rep(mean(drgnl$Wthr),303)
Grsl = rep(seq(0,1,0.01),3)
Rgn = rep(c("Ajm","Guj","Rajr"), each=101)
newdat2 = data.frame(Rgn,Grsl,Wthr)
newdat2
occmod_pred = predict(occu4, newdata=newdat2, type="state", se.fit=TRUE)
occmod_est = data.frame(newdat2,occmod_pred)
occmod_est
write.csv(occmod_est,"occupancy_prediction.csv")
# Density estimated in Distance sampling
# Calculate geometric mean & 95% CI of population abundance
# run for range-level
psi = 0.13
psi.se = 0.026
sites=380
D = 0.25
Ns = 0.25*29
N.se = Ns*0.24
# start iterations
iter=10000
N = as.data.frame(matrix(0,ncol=4,nrow=iter))
colnames(N) = c("occ","Ns", "Abun", "lnAbun")
for(n in 1:iter){
N[n,1] = rnorm(1, psi, psi.se)*sites
N[n,2] = rnorm(1, Ns, N.se)
N[n,3] = N[n,1]*N[n,2]
N[n,4] = log(N[n,3]+1)}
arith = mean(N$Abun)
geo = mean(N$lnAbun)
# Computing lf male abundance estimates
mean = exp(geo)-1
tlc = quantile(N$lnAbun, probs = 0.025)
tuc = quantile(N$lnAbun, probs = 0.975)
lc = exp(tlc)-1
uc = exp(tuc)-1
est = c(mean, lc, uc)
```

ANNEXURE 4: GOOGLE MAP APPLICATION IN ANDROID DEVICE USED FOR NAVIGATION DURING LESSER FLORICAN STATUS SURVEY 2017