STATUS OF GREAT INDIAN BUSTARD AND ASSOCIATED SPECIES IN THE STATE OF MAHARASHTRA

APRIL 2018

STATUS SURVEY REPORT 2018

STATUS OF GREAT INDIAN BUSTARD AND ASSOCIATED SPECIES IN THE STATE OF MAHARASHTRA

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Executive Summary

The Great Indian Bustard (hereafter GIB) are magnificent, large flying bird and was previously found throughout India and parts of Pakistan (Islam & Rahmani, 2002). In India, it was distributed throughout the grasslands of North India and the Deccan Landscape (Rahmani, 1989), but in last three decades there has been a drastic change in its former range. Only about 250 individuals survive today in the parts of India, with no breeding range outside the India. (Dutta et al., 2011). The largest population of 100-150 birds is found in the state of Rajasthan (Rahmani, 2006) followed by less than 35 individuals in the states Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh (BirdLife International, 2015). GIB is listed under Schedule 1 species as per Wildlife (Protection) Act 1972, and listed as Endangered or Appendix 1 species of CITES.

As a part of the project titled 'Tracking of Great Indian Bustard (*Ardeotis nigriceps*) and mapping its potential habitat across the Deccan Landscape, Maharashtra' funded by the Forest Department, Govt. of Maharashtra, three GIBs were fitted with GPS transmitters and their movement was tracked for one year. The tracking data has helped in identifying suitable areas for GIB conservation beyond the protected area system in Maharashtra. In order to ascertain status of GIB and its potential habitat in Maharashtra, a landscape level survey was conducted in September, 2017 in collaboration with Maharashtra Forest Department.

The GIB is nomadic in nature and uses large areas without distinguished boundaries, and therefore, requires robust sampling method to evaluate its status and distribution. Since the present status of GIB is not known beyond the designated bustard areas, a probability distribution map for GIB covering an area of 55,000 km^2 was developed through probability distribution modeling (Phillips et al., 2006) using locations of tagged GIB across the across the landscape to survey potential GIB habitat in Maharashtra.

This survey revealed the status of GIB, Blackbuck and Chinkara in potential GIB habitat which is mostly in human dominated landscape of Maharashtra. A systematic survey was conducted in 372 grids of 12 x12 km across the State. Vehicle based species and habitat survey were conducted from 25th - 30th September, 2017 by 31 teams (1 researcher, 1 - 2 volunteer and 2 - 3 forest officials). Grids were surveyed along road trails of 3.03 ± 1.74 km length (single continuous or multiple broken transects) in a slow moving (10 - 20 km/hr) vehicle. At every 1 km interval along the transect, habitat characteristics that potentially influence species distribution were recorded. To overcome the issue of low detection owing to very low population size and their ecology, a blind test using life-size GIB dummies was conducted to know the possibility of detection in sampling grids by the sampling team. The dummies were placed in the sampling grids were placed by a separate team. The sampling team was unaware of the location of the dummy GIB.

Questionnaire survey were conducted by opportunistically interviewing up to three residents per grid with a semi-structured questionnaire. Respondents were asked whether they knew or could identify the bird, and about reports or sightings of GIB in their vicinity. Information about the occurrence of associated species from these areas was also collected.

A total of 238 groups of Blackbuck were recorded across 2117 line transects covering a distance of 6436.6 km (mean length 3.03 ± 1.74 km)

in 372 grids. Density of Blackbuck in potential GIB habitat was found to be 0.74 ± 0.11 /km² and total population was found to be 37,690 ± 5626. 19 groups of Chinkara were recorded across 2117 line transects covering a distance of 6436.6 km (mean transect length 3.03 ± 1.74 km) in 372 grids. Density of Chinkara in potential GIB habitat was found to be 0.02 ± 0.01 /km² and total population was found to be 1481 ± 577. The data was left-truncated at 20 m, so that the model was not constrained by the limited number of Chinkara observed on or close to the transect.

During the survey, no GIB was sighted. However, out of 1401 respondents 72 confirmed GIB presence in their area within the last 4 days to 6 months. We used this information along with locations of tagged birds in Maharashtra to identify 87 out of 372 grids as conservation priority areas for GIB. These grids constituted 11 clusters spread across 12 forest divisions of Maharashtra covering an area of 12,528 km² dominated by kharif crops and open areas.

Out of the 30 GIB dummies placed, only 4 were detected by the respective sampling teams. The detection probability was found to be 13% which is within the range of previous studies (Rahmani, 1986). Power analysis on detection probability (13%) and occupancy (8.06%) of dummy life-sized GIB showed that 8 replicates required in 180 grids of detecting 53% change in occupancy. This would mean that, if the population of GIB ranges from 8 to 10, there is a chance of detecting one GIB with a minimum sampling effort of 8 temporal replicates for each transect considering that detection probability of dummy GIB and live GIB are the same. During the survey, no GIB was sighted, which implies that the number of GIB might be less than 8 in Maharashtra.

Eleven clusters in 12 forest divisions has been identified important for GIB conservation in the state of Maharashtra. Most of these areas are dominated by kharif crops (sorghum, peanut, groundnut, seed oils), preferred by GIB as foraging grounds. The following recommendations are made on the basis of the findings of the landscape level GIB survey for conservation of GIB in the state:

- The 11 identified clusters should be monitored for a duration of 1-2 years continuously at least 2-3 times a year.
- Department-owned areas within such grids should be managed as bustard habitats by removing invasive species.
- There is an urgent need for awareness in these identified clusters with option to promote traditional cropping patterns. Any changes in these areas will be critical for GIB conservation.
- Traditional cropping patterns need to be promoted by involving other line departments and need to have awareness and capacity building for the same.
- There is a need to put reflectors on power-lines in such areas.
- Dog population needs continuous monitoring and measures should be taken to control the growth of dog populations in such areas.
- GIB conservation in Maharashtra is only possible if traditional cropping and land sparing is promoted and incentivized.

Introduction

India is a globally important biodiversity region harboring four biodiversity hotspots (Myers et al., 2000). It also harbors nearly 1.2 billion people, experiencing rapid development and population expansion, creating various challenges for conservation of different taxa (Velho et al., 2012). Many anthropogenic factors affect species ecology leading to their extinction (Morrison et al., 2007). Large animals by virtue of their size and home range are relatively more susceptible to extinction as a consequence of fragmentation and degradation of habitat (Schaller 1967). The effect is more pronounced on species which share their habitat with humans. The Great Indian Bustard *Ardeotis nigriceps* (hereafter GIB) is one such species. GIB is a critically endangered (IUCN 2017) and Schedule 1 species as per the Wildlife (Protection) Act, 1972. GIB belongs to the family Otitidae of the Order Otidiformes and is considered among the largest flying birds in the world. GIB had its share of fame when it became a candidate for the National bird of India. The renowned Indian ornithologist Salim Ali strongly recommended for it, but it was over-ruled in favor of the Indian Peafowl (Ali, 1961). GIB is a large, charismatic bird once found throughout India and parts of Pakistan. Until the end of the 19th century, GIBs were seen in large flocks across the grasslands of India and Pakistan. Within India, they were distributed throughout the grasslands of North India and the Deccan Landscape (Rahmani, 1989), However, in the last three decades, there has been a drastic change in its former distribution range and even a flock of three individuals is a rare sight (Islam and Rahmani, 2002). The species' total population was estimated to be less than 300 individuals in 2008, and these were confined to only certain parts of India with no breeding range outside India (Dutta et al., 2011). The most recent estimate places the population at a range between 50-249 mature individuals (BirdLife International, 2015). The largest population of 100-150 birds is found in Rajasthan (Rahmani, 2006) and less than 35 individuals in the states Gujarat, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh (BirdLife International, 2015). Earlier studies conducted in Maharashtra during the 1980s revealed that there were 60 individuals, which then decreased to 36 adult individuals by 2006 (Anon, 2006). The current population is believed to be less than 8 – 10 birds.

The recent decline in GIB numbers has been recorded from all regions in the present distribution range, including Rajasthan and Gujarat (Dutta et al., 2011), having completely disappeared from the state of Haryana, Punjab, Orissa, Madhya Pradesh, Tamil Nadu and Uttar Pradesh (Anon, 2015). The current populations of Maharashtra, Karnataka and Andhra Pradesh are considered to be at the risk of local extinction. The sparse population status of GIB across its range necessitates baseline data collection data of its status, distribution and habitat parameters. This information is very essential for conservation planning and subsequently assessing the effectiveness of management actions.

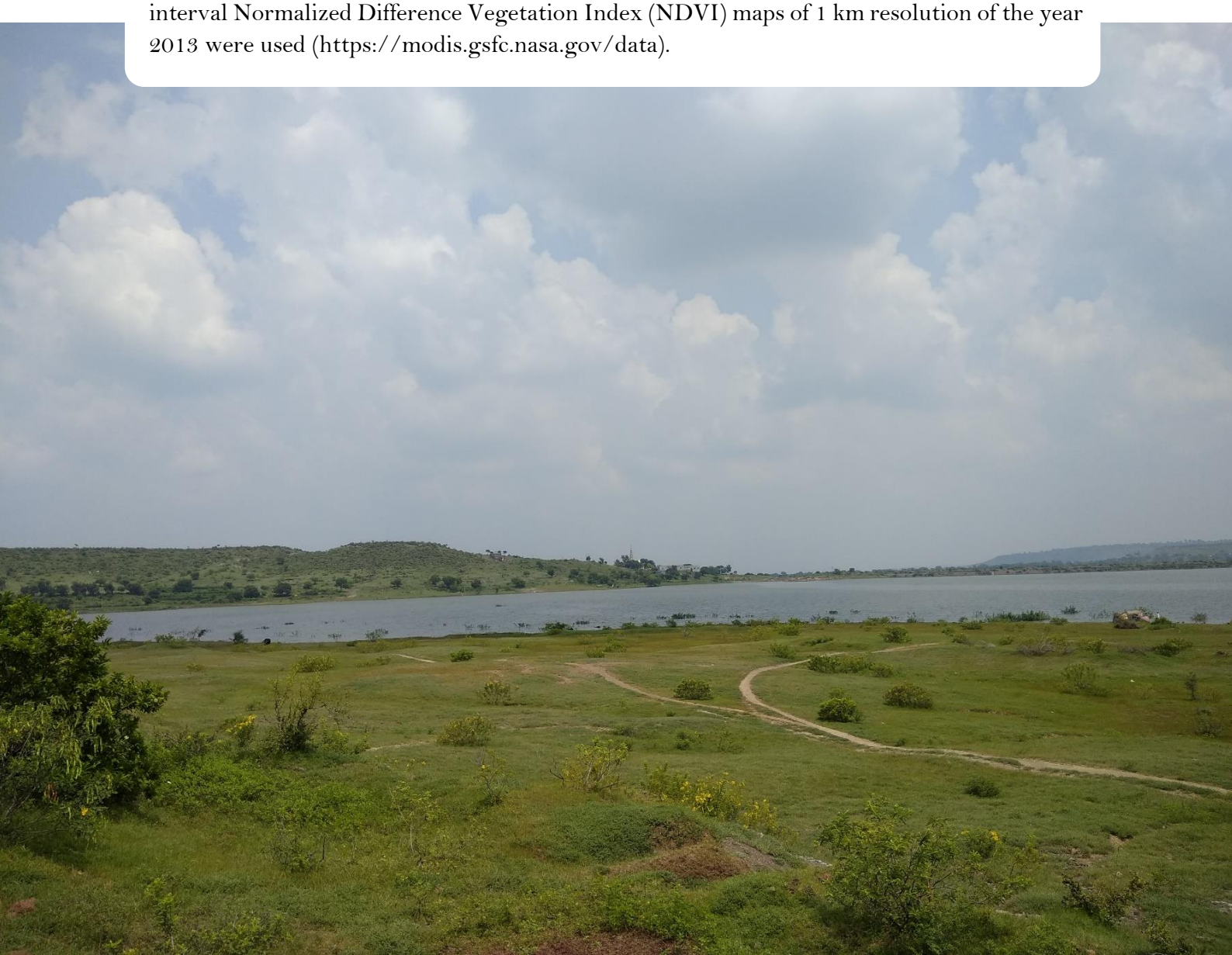
The GIB is nomadic in nature and uses large areas without distinguished boundaries, and therefore, requires robust sampling methods to evaluate its status and distribution. Since the present status of GIB is not known beyond the designated bustard areas, a probability distribution map for GIB covering an area of 55,000 km^2 was developed through probability distribution modeling (Phillips et al., 2006) using locations of tagged GIB across the across the landscape to survey potential GIB habitat in Maharashtra.

The identified potential habitat was divided into 372 grids of 12 x 12 km. 31 field survey teams consisting of researchers from Wildlife Institute of India, volunteers and forest officials of Maharashtra State Forest Department were trained through workshops prior to the survey. Each team collected data for 12 adjacent grids through 20 km vehicle transects in each grid, and recorded data on GIB, its habitat and associated grassland species viz., Blackbuck *(Antilope cervicapra)*, Chinkara (*Gazella bennettii)*, Indian Fox (*Vulpes bengalensis)* and Indian Wolf (*Canis lupus*).

Materials and Methods

Mapping potential GIB landscape in Maharashtra

To develop potential GIB distribution map for the state of Maharashtra, the GPS locations of three tagged birds were used. The birds were tagged as a part of project entitled 'Tracking of the Great Indian Bustard and mapping its potential habitat in Deccan landscape of Maharashtra'. The birds were captured using noose traps and fitted with 70-gram Solar Argos/GPS PTT (Microwave Telemetry Inc.). The instrument recorded GPS locations daily at 05:00, 07:00, 09:00, 11:00, 17:00, 19:00 and 21:00 hours and Argos locations on alternate days. We collected a total of 2923 locations from all the three birds. Using these locations, we predicted the probability distribution map of GIB using MaXent model (Phillips et al., 2006); http://www.cs.princeton.edu/wschapire/maxent/) (Figure: 1). For this, 16 days interval Normalized Difference Vegetation Index (NDVI) maps of 1 km resolution of the year 2013 were used (https://modis.gsfc.nasa.gov/data).



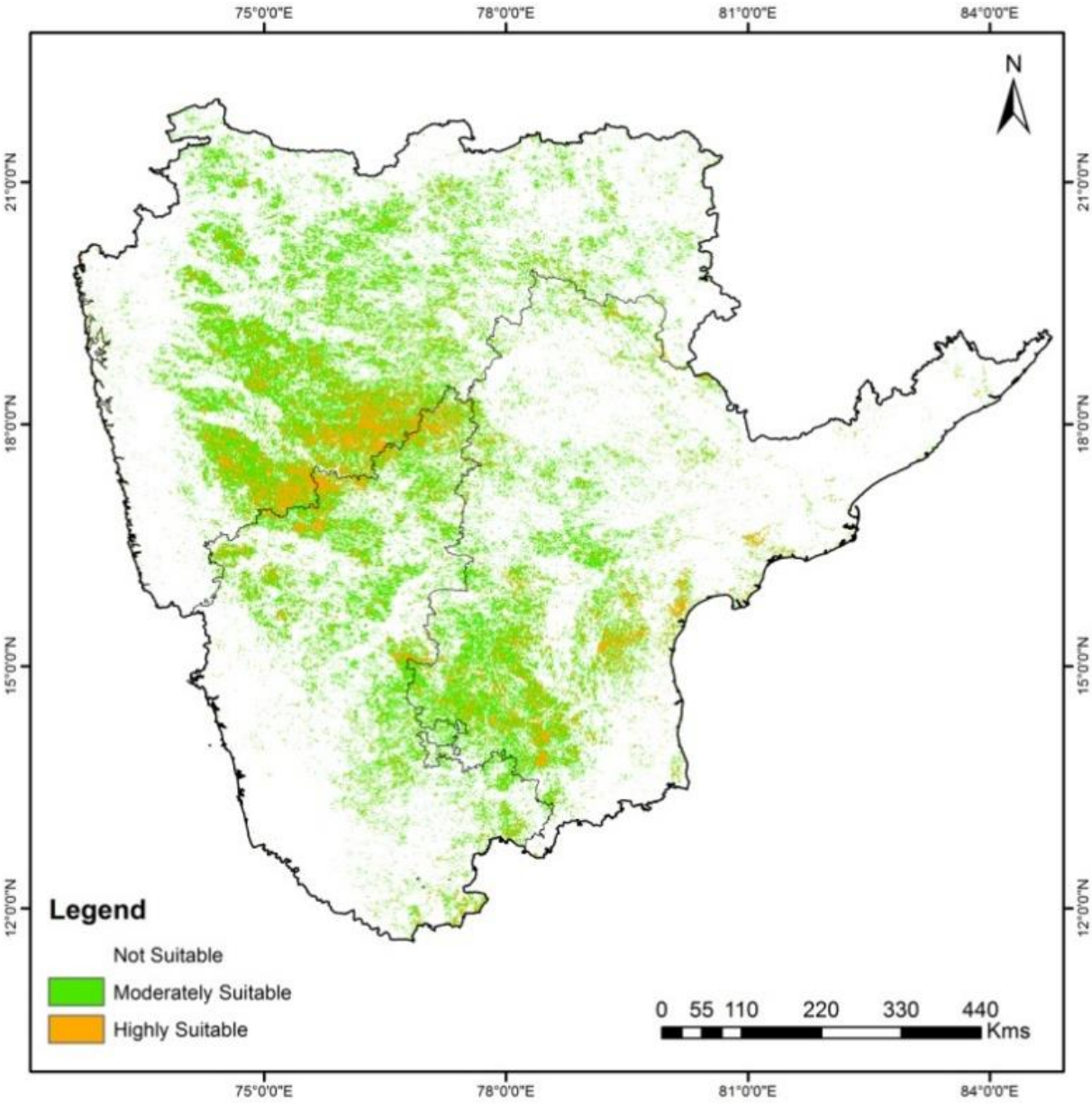


Figure 1: Probable GIB distribution in the states of Maharashtra, Andhra Pradesh and Karnataka

Survey Design

12 x12 km grids were overlaid on the probability distribution map (Figure 2) and 372 grids were selected for sampling. A workshop for trainers was conducted at Wildlife Institute of India on 21st September, 2017. Subsequently, each of these trainers conducted workshops at their respective field sites to train forest staff and volunteers. Each team was assigned 12 adjacent grids to cover in 6 days from 25th - 30th September 2017 (two grids per day). In each grid, multiple vehicle transects of minimum 2 km length totaling 20 km were traversed to collect data on GIB, its associated species and habitat parameters.

The objectives of the survey were:

- To identify areas used by GIB in the state of Maharashtra,
- To evaluate the status of GIB and associated species, and threats to their conservation in the state of Maharashtra,
- To develop management strategies to conserve critical grassland habitats in the state of Maharashtra.

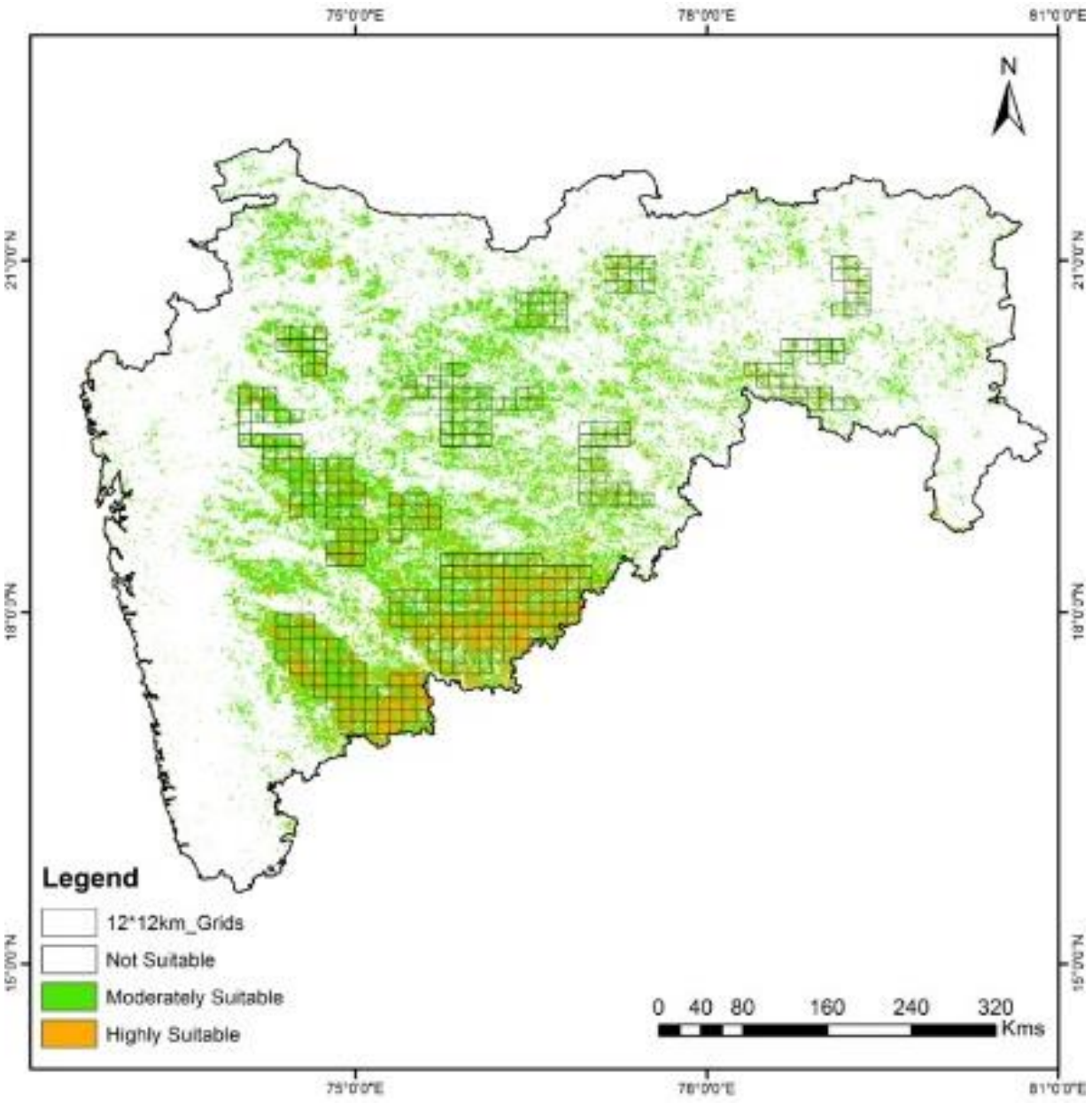


Figure 2: Probable GIB distribution map in Maharashtra with sampling grids

Sampling Design

Species and habitat status were assessed using systematically designed vehicle transects. 372 grids were overlaid on the potential GIB habitat (covering 55000 sq. km). Sampling was carried out from 25th - 30th September, 2017 with the help of 31 teams (1 researcher, 1-2 volunteers and 2-3 forest officials). Grids were surveyed along road trails of 3.03 ± 1.74 km length (single continuous or multiple broken transects) in a slow moving (10-20 km/hr) vehicle. Each team covered 12 grids in six consecutive days, one grid in the morning (0600-1000 h) and one in the evening (1600-1900 h), when animal activity is expected to be highest. Each team collected data on GIB presence and associated species (Blackbuck, Chinkara, feral dogs, Nilgai, Wild Pig, Indian Fox and Indian Wolf). The teams also recorded important habitat characteristics such as land cover, substrate and human disturbances at 1 km interval, on each transect. Secondary information on occurrence and perceived threats to GIB and associated species was also collected through a semi-structured questionnaire survey of the local people from different villages in each grid.

Data Collection

Data on GIB presence and its associated species was collected along transects. For each direct sighting of GIB and associated species, number of individuals, GPS coordinates, transect bearing, animal bearing and sighting distance were recorded using rangefinder and compass. Information on physical parameters such as terrain, soil substrate, land cover etc. were also recorded.

Habitat Characteristics

At every 1 km interval along the transects, habitat characteristics that potentially influence species distribution, such as land cover, terrain, soil substrate, and human disturbances were recorded. The dominant land-cover type (barren/agriculture/grassland/shrub land/woodland), terrain type (flat/sloping/undulating-moderate or very), and substrate type depending on soil characteristics (rock/gravel/sand/soil) were recorded within a radius of 100 m of the point. Vegetation structure was recorded as percentage of ground covered by grasses (tall, medium, short), herbs, shrubs (<2m) and tree within 20 m radius of the point. These covariates were recorded in broad class-intervals (0-10, 10-20, 20- 40, 40-60, 60-80, and 80-100 %) to reduce inconsistency of observation errors between teams. Vegetation composition was recorded as three dominant plants within 100 m radius of the point. Presence of human structures (settlement/ farm-hut/ metalled-road/ electric-lines/ wind-turbine/ water-source) was also recorded within 100 m radius of the point.

Questionnaire Survey

Questionnaire surveys were conducted by opportunistically interviewing up to three residents per grid with a semi-structured questionnaire. Respondents were asked whether they knew or could identify the bird, and about reports or sightings of GIB in their vicinity. Information about the occurrence of associated species from these areas was also collected.

Results

Density estimation of GIB associated species

Blackbuck (*Antilope cervicapra*)

A total of 238 groups of Blackbuck were recorded across 2117 line transects covering a distance of 6436.6 km (mean length 3.03 ± 1.74 km) in 372 grids. Density of Blackbuck in potential GIB habitat was found to be 0.74 ± 0.11 /km^2 and total population was found to be 37,690 ± 5626 (Table 2).

Table 2: Density estimate for Blackbuck in surveyed areas of Maharashtra, India

Parameter	Point Estimation	Standard Error	% Co-efficient of Variation	95% Confidence of Interval	
DS	0.14	0.01	12.24	0.11	0.17
E(S)	5.29	0.45	8.54	4.47	6.26
ESW	131.70	9.26	7.04	114.67	151.25
D	0.74	0.11	14.93	0.55	0.99
N	37690	5625.8	14.94	28168	50431

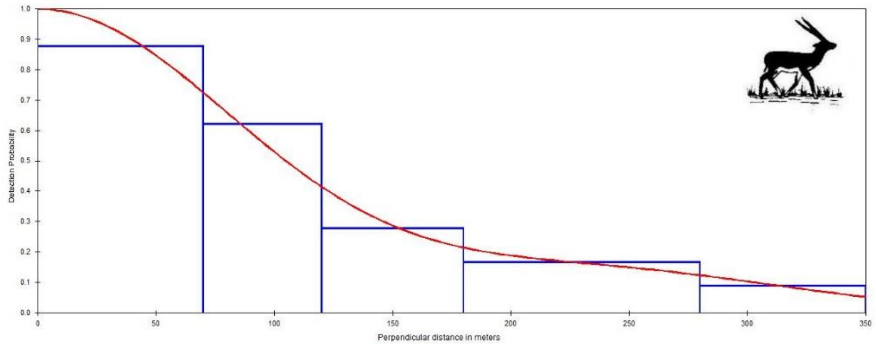
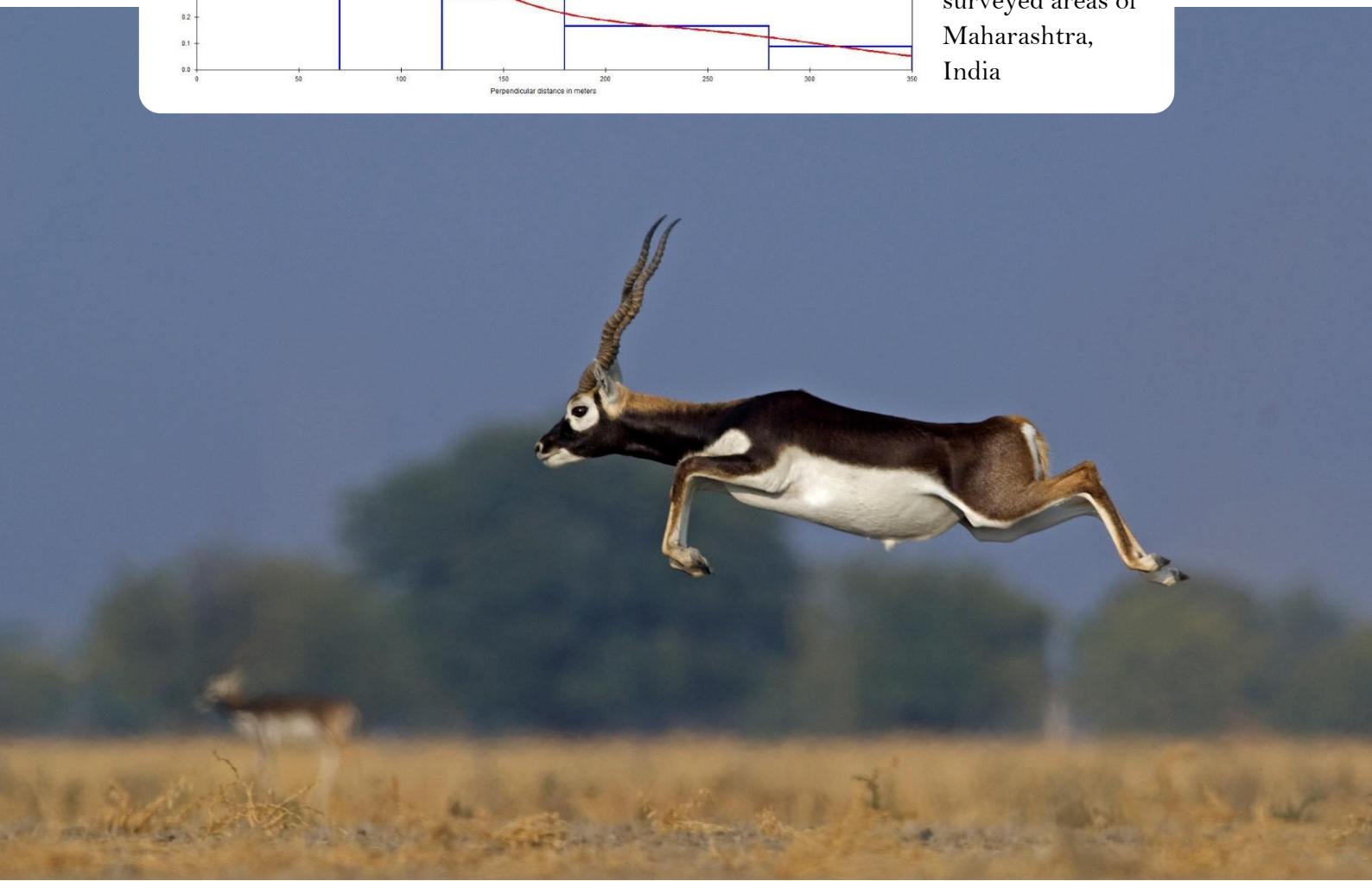


Figure 3: Detection probability plot for Blackbuck in surveyed areas of Maharashtra, India



Chinkara *(Gazella bennettii)*

A total of 19 groups of Chinkara were recorded across 2117 line transects covering a distance of 6436.6 km (mean transect length 3.03 ± 1.74 km) in 372 grids. Density of Chinkara in potential GIB habitat was found to be 0.02 ± 0.01 /km^2 and total population was found to be 1481 ± 577 (Table 3). The data was left-truncated at 20 m, so that the model was not constrained by the limited number of Chinkara observed on or close to the transect (Figure 4).

Table 3: Density estimate for Chinkara in surveyed areas of Maharashtra, India

Parameter	Point Estimation	Standard Error	% Co-efficient of Variation	95% Confidence of Interval	
DS	0.01	0.003	32.25	0.005	0.01
E(S)	2.68	0.58	21.91	1.70	4.24
ESW	135.88	29.26	21.53	86.87	212.53
D	0.02	0.01	38.99	0.01	0.05
N	1481	577.49	38.99	702.0	3128.0

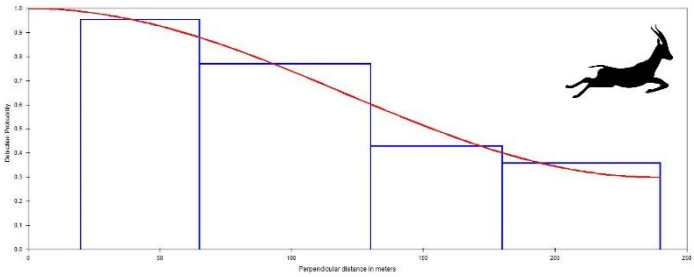
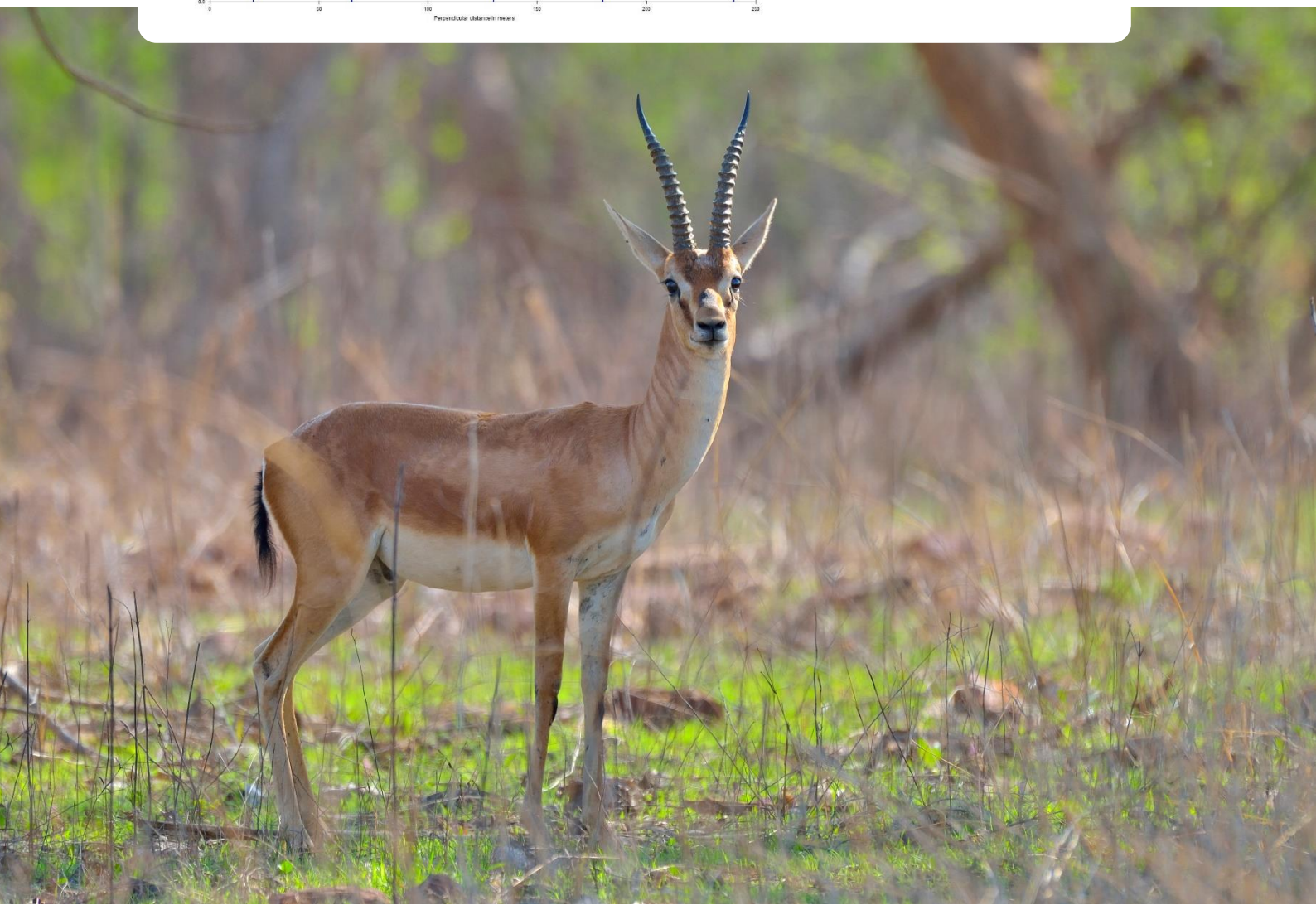


Figure 4: Detection probability plot for Chinkara in surveyed areas of Maharashtra, India



Distribution of associated species in potential GIB habitat

The state of Maharashtra harbors good populations of Blackbuck, Chinkara, Indian Fox and Indian Wolf that are distributed outside the protected area of the landscape as well. During the survey, Blackbuck were reported from most of the forest divisions except Chandarpur and Pandharkawada Forest Divisions (Figure 5). Chinkara were reported from Aurangabad, Ahmadnagar, Beed and Sangli Forest Divisions (Figure 6). Figure 7 shows, Blackbuck and Chinkara overlap and exclusive areas surveyed in the landscape.

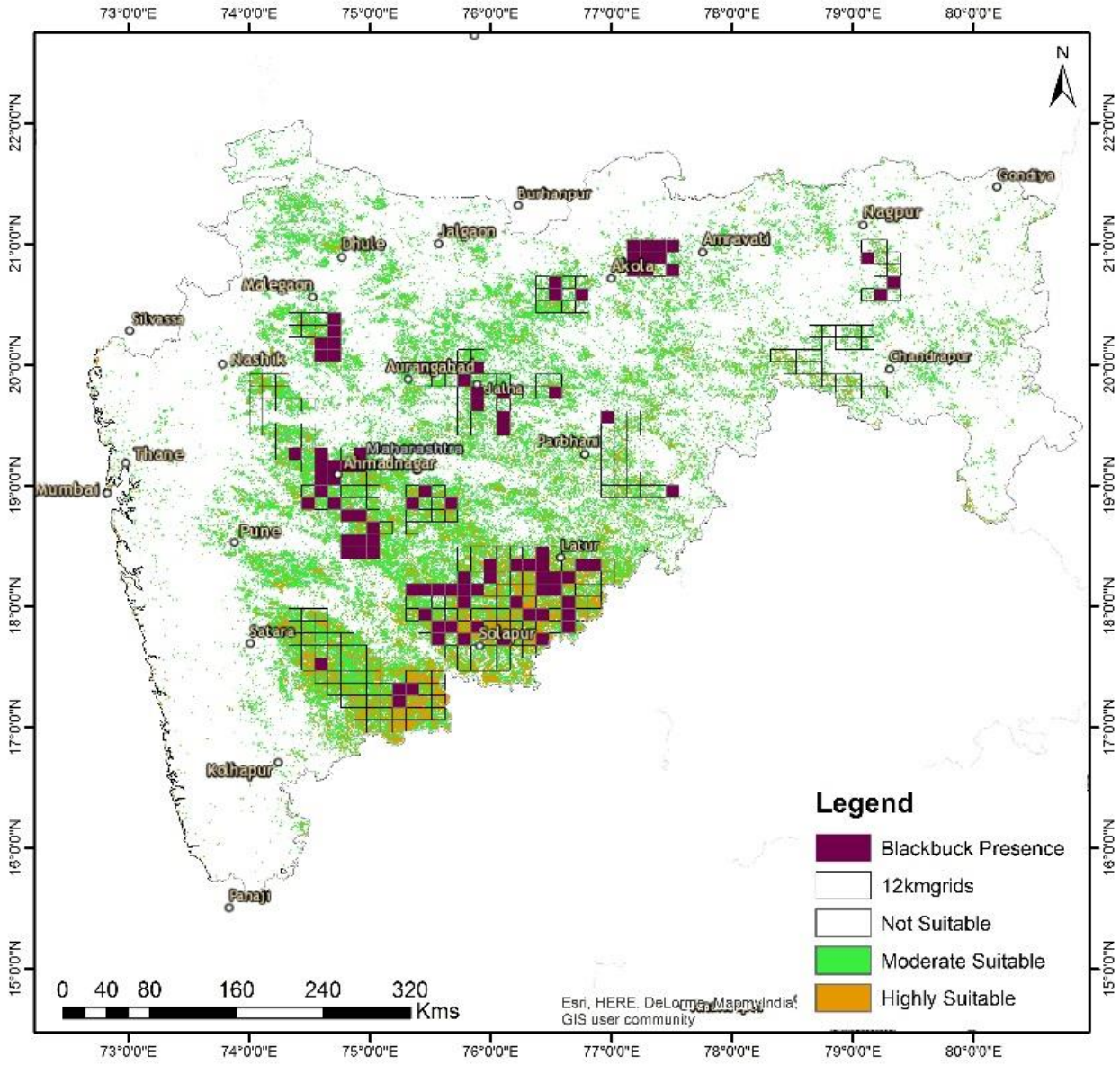


Figure 5: Map showing grids with Blackbuck presence across surveyed grids in Maharashtra, India

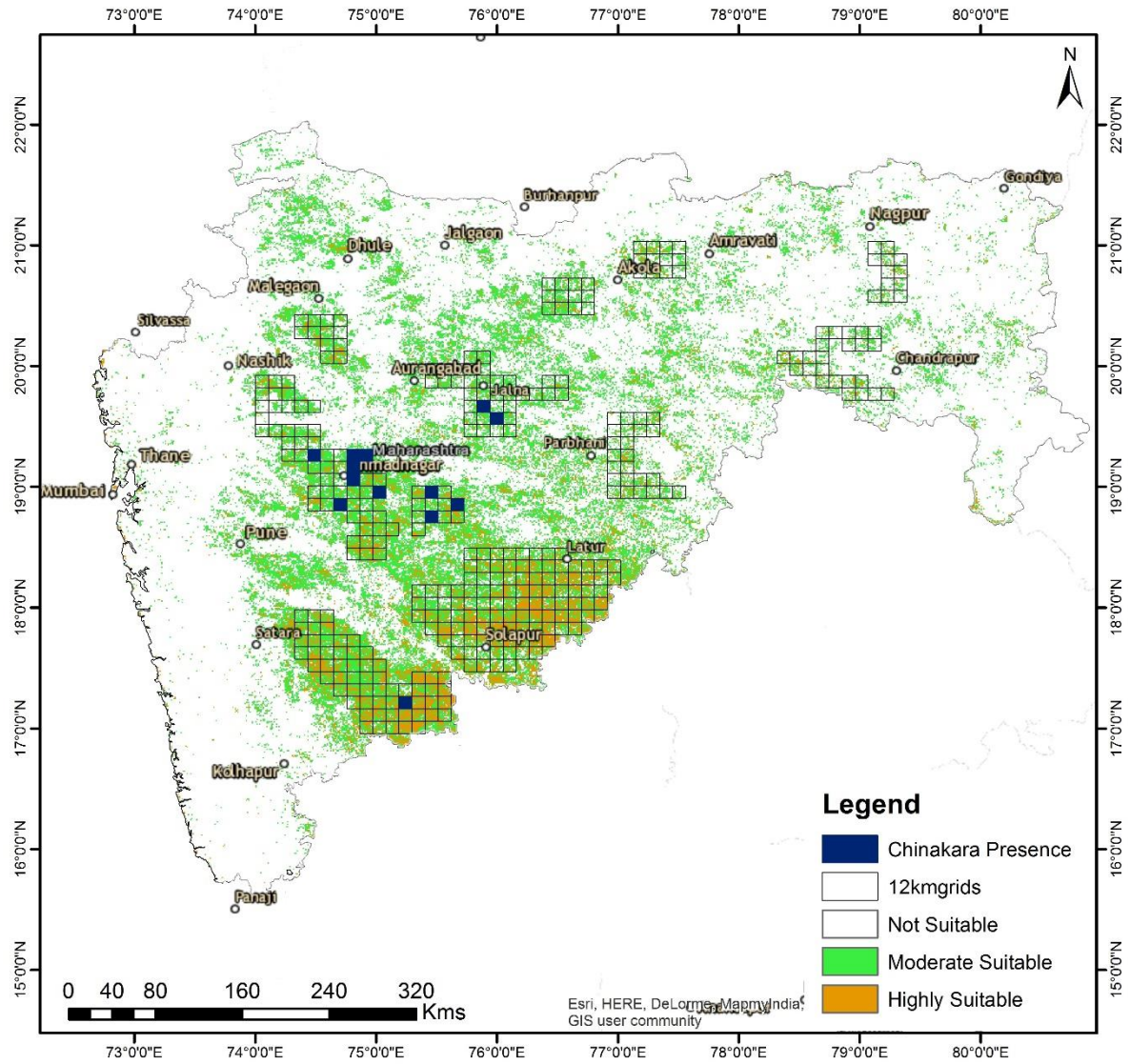


Figure 6: Map showing grids with Chinkara presence across surveyed grids Maharashtra, India

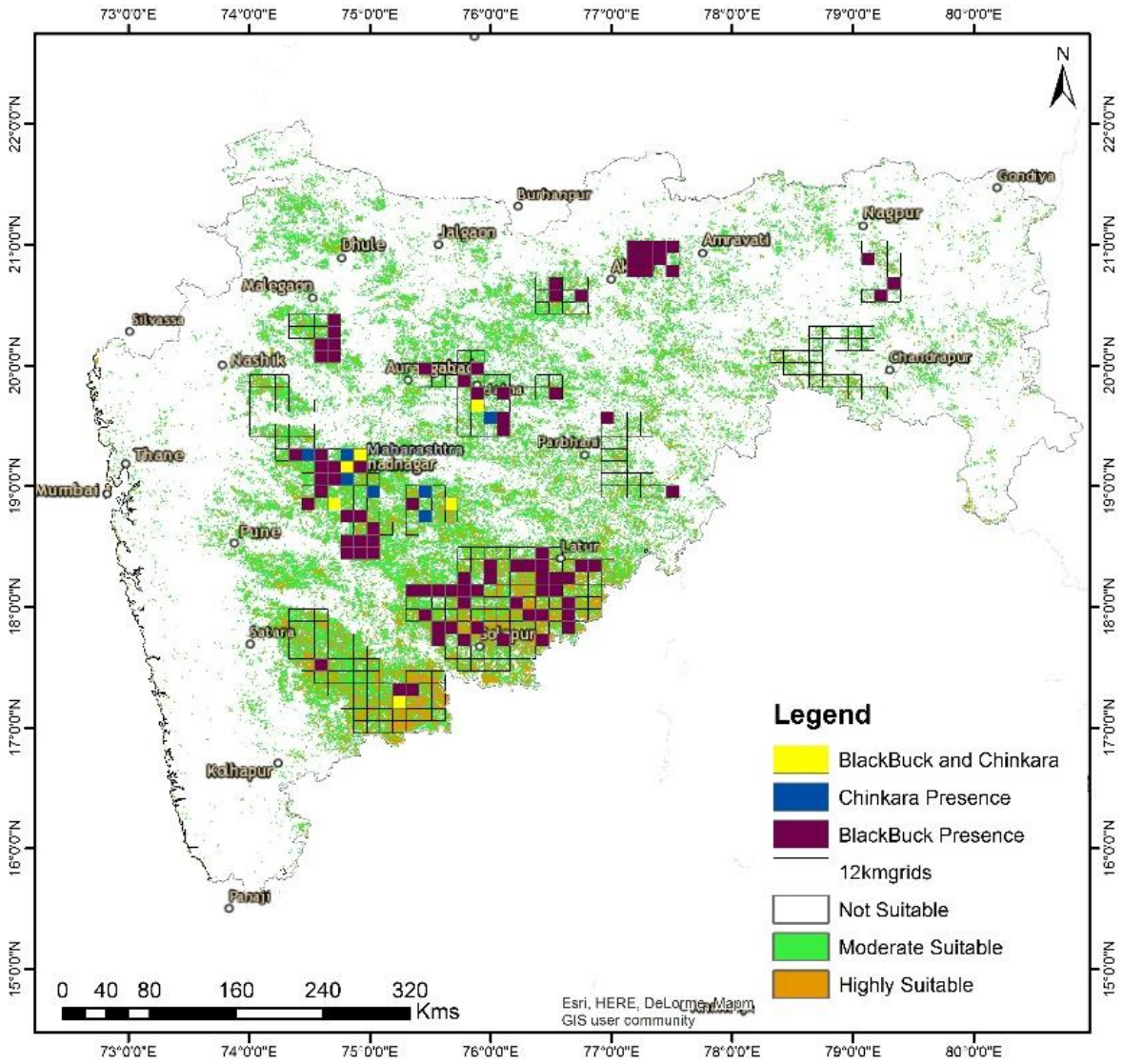


Figure 7: Map showing grids with Blackbuck and Chinkara presence and their overlaps across surveyed grids in Maharashtra, India

GIB occurrence during landscape survey

During the survey, no GIB was sighted. However, out of 1401 respondents 72 confirmed GIB presence in their area within last 4 days to 6 months. We used this information along with locations of tagged birds in Maharashtra to identify 87 out of 372 grids as conservation priority areas for GIB. These grids constituted 11 clusters spread across 12 forest divisions of Maharashtra covering an area of 12,528 km². The important GIB areas like Nannaj and Warora are part of these priority clusters. Figure 8 shows GIB priority areas across Maharashtra

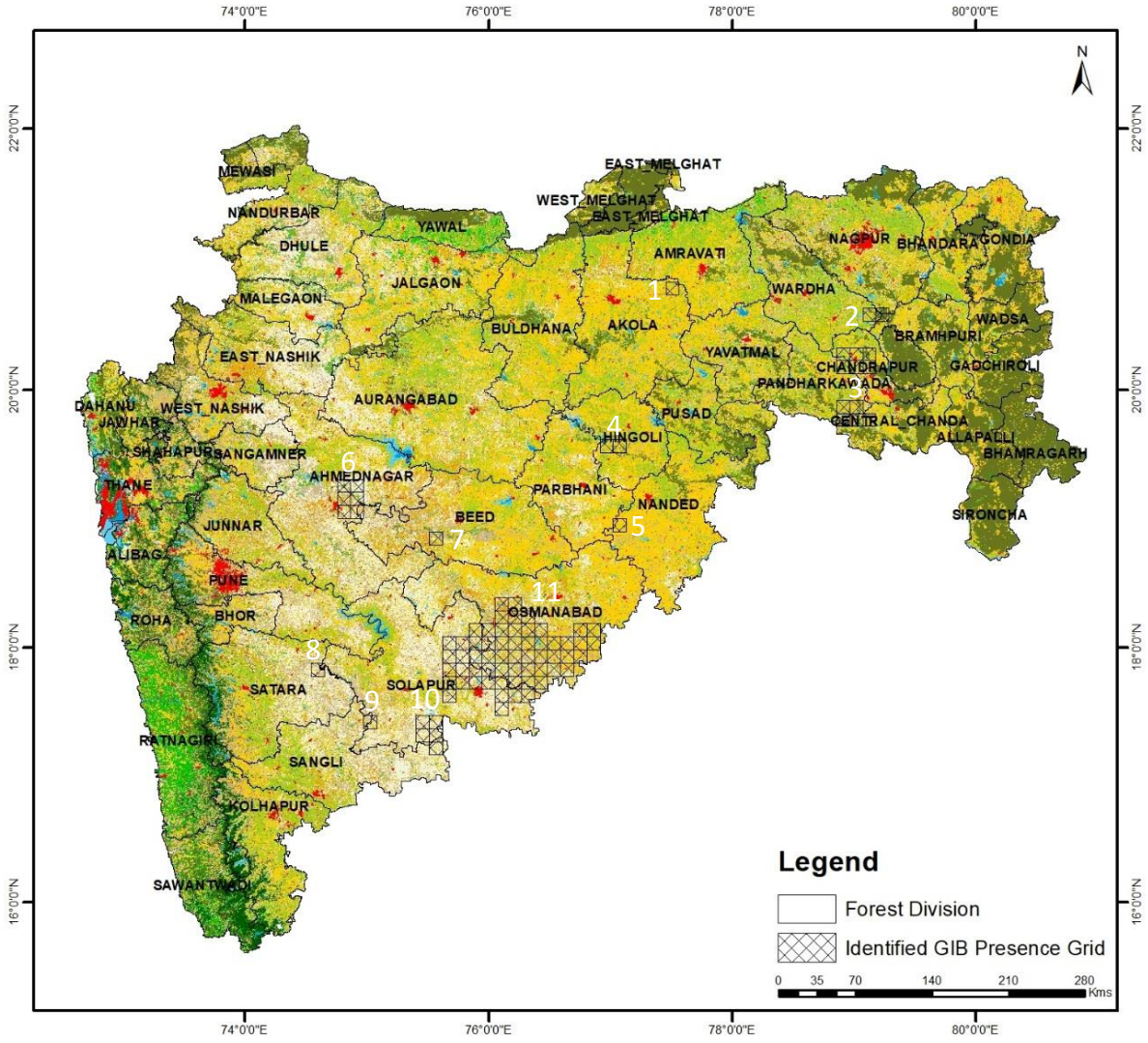


Figure 8: Map showing 11 clusters for priority conservation in Maharashtra, India

Cluster 1: Grid-A (Near Murtizapur of Akola Forest Division)

This cluster has one 12 x 12 km grid covering an area of 144 km² area. Grid A12 within this cluster falls near Murtizapur of Akola Forest Division. The overall land use is dominated by kharif crops followed by mixed crops. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 4 and corresponding map is given in Figure 9. GIB presence in this grid was confirmed to be within the last 1 month.

Table 4: Table showing areas under different land use categories

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	1.88	Deciduous Forest	1.42
Kharif Crop	85.27	Degraded Forest/ Forest	0.11
Rabi Crop	1.68	Wasteland	2.58
Zaid Crop	0.007	Waterbody Max	2.30
Double/Triple Crop	23.63	Waterbody Min	0.06
Current Fallow	6.52		

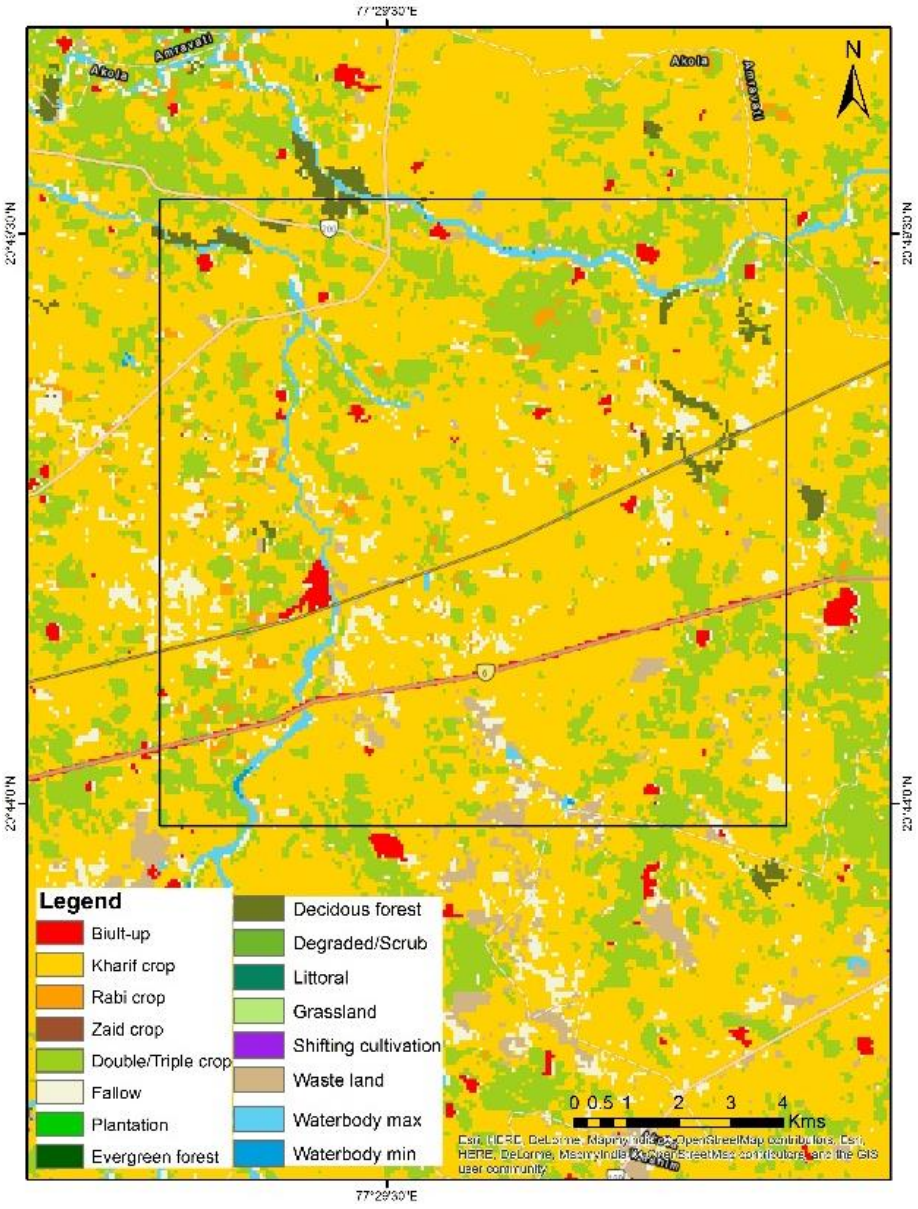


Figure 9: Potential GIB habitat grid identified during landscape survey in Akola Forest Division, Maharashtra, India

Cluster 2: Grid-C (Near Arvi and Pimpalgaon of Wardha Forest Division)

This cluster has one 12x12 km grid covering an area of 144 km² area. Grid C10 within this cluster falls near Arvi and Pimpalgaon of Wardha Forest Division. The overall land use is dominated by kharif crops and mixed crop. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 4 and corresponding map is given in Figure 10. GIB presence in this grid was confirmed to be within the last 6 months.

Table 5: Table showing areas under different land use categories

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	0.60	Deciduous Forest	13.85
Kharif Crop	42.07	Degraded Forest/ Forest	1.84
Rabi Crop	0.48	Wasteland	11.10
Double/Triple Crop	41.23	Waterbody Max	3.04
Current Fallow	8.81	Waterbody Min	0.01
Plantation	0.07		

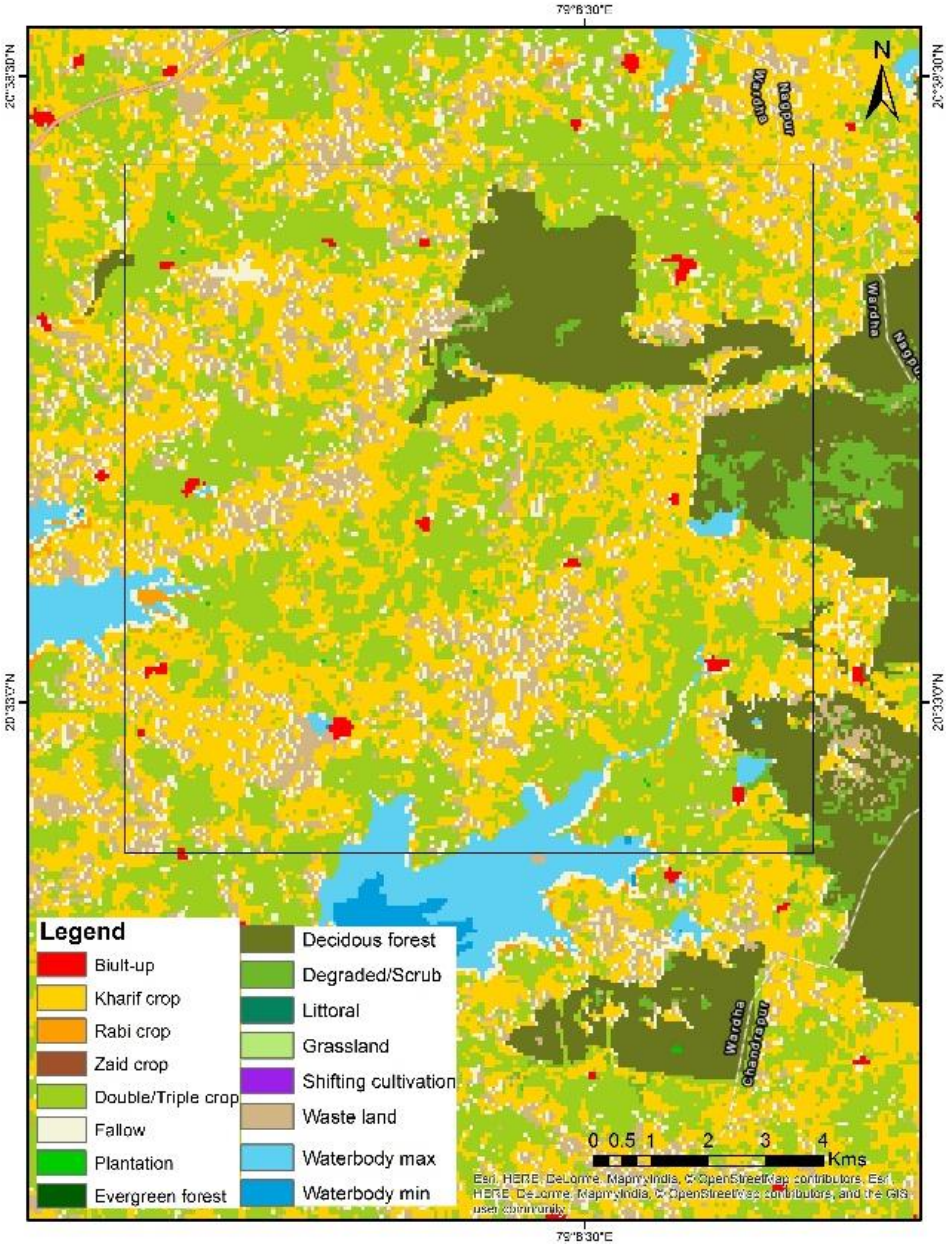


Figure 10: Potential GIB habitat grid identified during landscape survey in Wardha Forest Division, Maharashtra, India

Cluster 3: Grid-E (Near Warora and Wani of Chandrapur and Pandharkawada Forest Division)

This cluster has eight 12x12 km grid covering an area of 1152 km² area. Grids E1-3, E7-11 within this cluster falls near Warora and Wani of Chandrapur and Pandharkawada Forest Division. The overall land use is dominated by kharif crops followed by mixed crops. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 6 and corresponding map is given in Figure 11. GIB presence in this grid was confirmed to be within the last 1 month.

Table 6: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	33.94	Plantation	0.15
Kharif Crop	543.75	Deciduous Forest	90.58
Rabi Crop	3.93	Degraded Forest/ Forest	41.78
Zaid Crop	0.064	Wasteland	99.38
Double/Triple Crop	438.37	Waterbody Max	22.63
Current Fallow	71.45	Waterbody Min	3.62

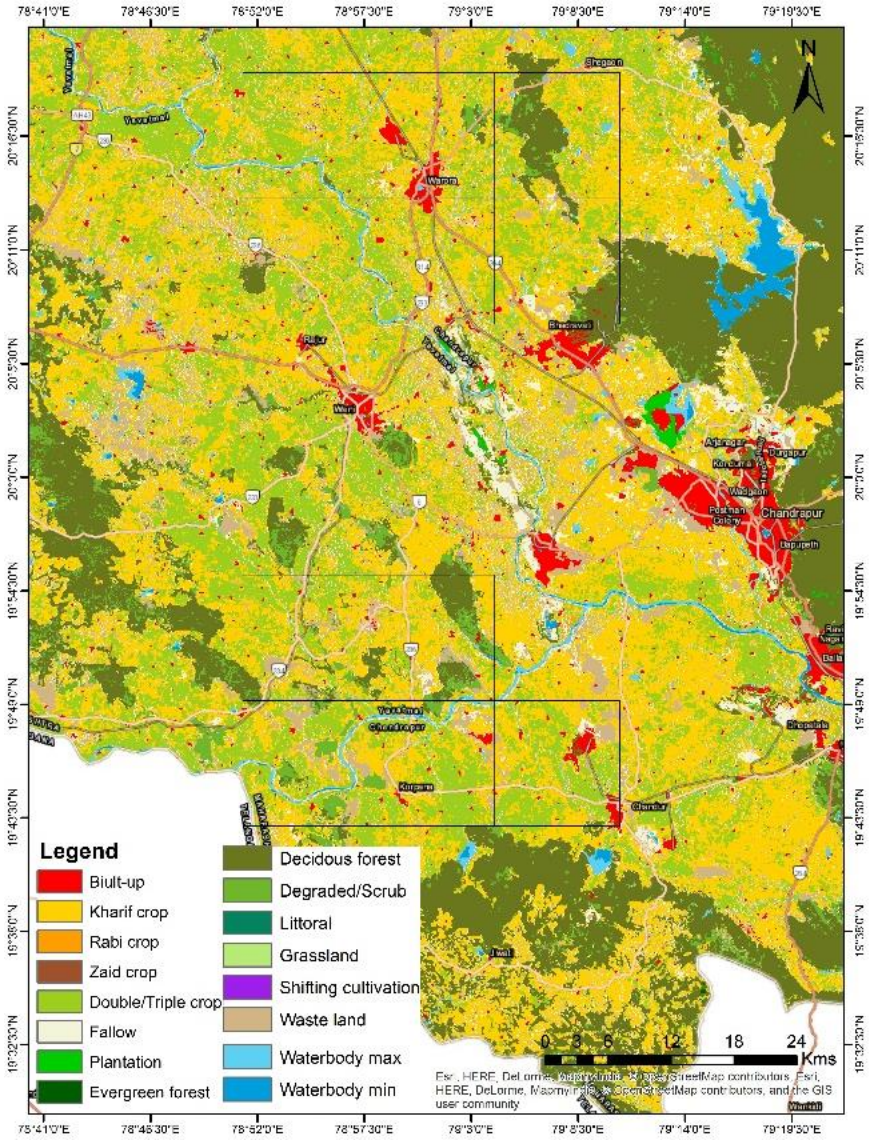


Figure 11: Potential GIB habitat grid identified during landscape survey in Chandrapur and Pandharkawada Forest Division, Maharashtra, India

Cluster 4: Grid-J (Hingoli Forest Division)

This cluster has two 12x12 km grid covering an area of 288 km² area. Grids J1 and J2 within this cluster falls near Hingoli of Hingoli Forest Division. The overall land use is dominated by kharif crops followed by wastelands and Deciduous forest. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 7 and corresponding map is given in Figure 12. GIB presence in this grid was confirmed to be within the last 1 month.

Table 7: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	2.79	Deciduous Forest	16.86
Kharif Crop	125.88	Degraded Forest/ Forest	4.66
Rabi Crop	0.08	Wasteland	22.26
Double/Triple Crop	55.66	Waterbody Max	5.16
Current Fallow	11.11	Waterbody Min	8.97
Plantation	0.76	Plantation	0.76

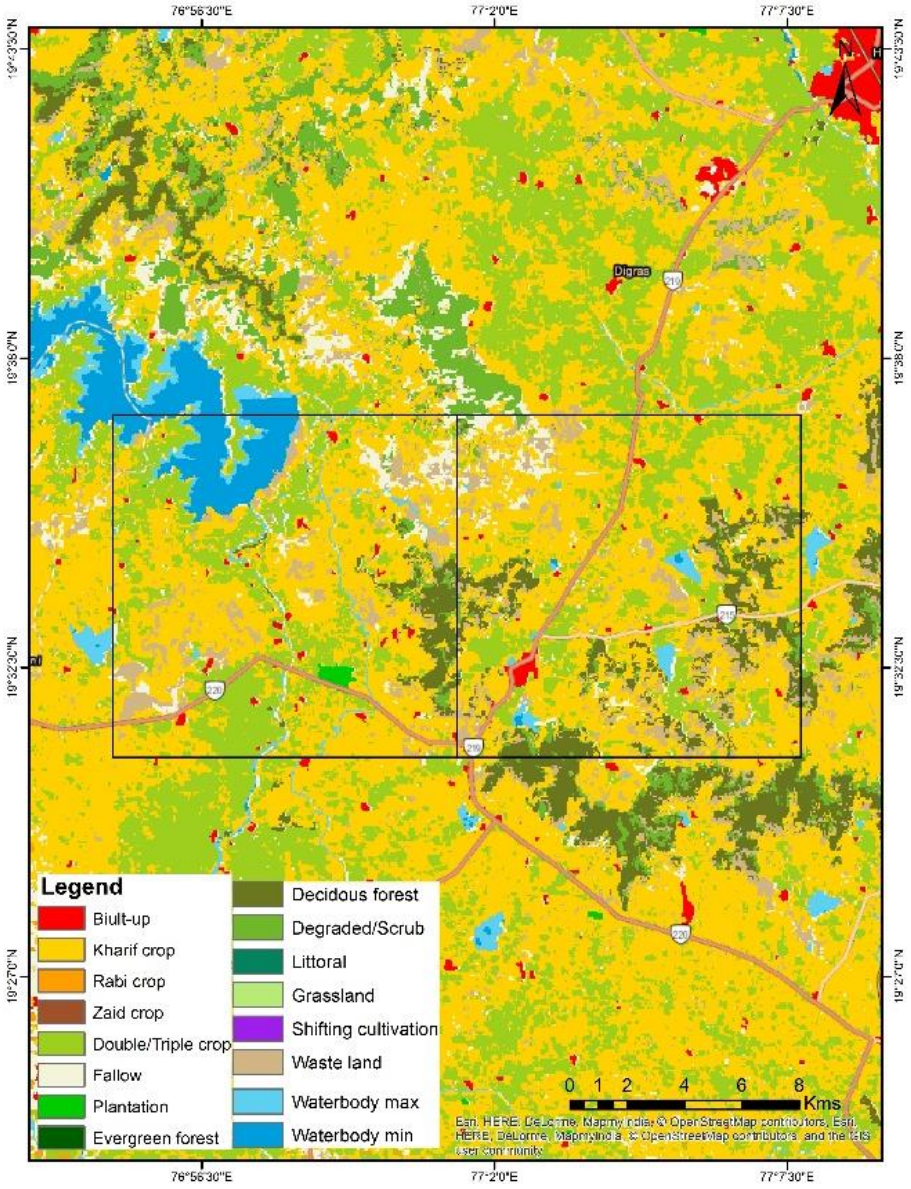


Figure 12: Potential GIB habitat grid identified during landscape survey in Hingoli Forest Division, Maharashtra, India

Cluster 5: Grid-K (Near Loha of Nanded Forest Division)

This cluster has one 12x12 km grid covering an area of 144 km² area. Grid K8 within this cluster falls near Loha of Nanded Forest Division. The overall land use is dominated by kharif crops followed by wastelands and deciduous forest. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 8 and corresponding map is given in Figure 13. GIB presence in this grid was confirmed to be within the last 1 month.

Table 8: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	2.78	Deciduous Forest	16.86
Kharif Crop	125.88	Degraded Forest/ Forest	4.66
Rabi Crop	0.08	Wasteland	22.26
Double/Triple Crop	55.66	Waterbody Max	5.16
Current Fallow	11.11	Waterbody Min	8.97
Plantation	0.76	Plantation	0.76

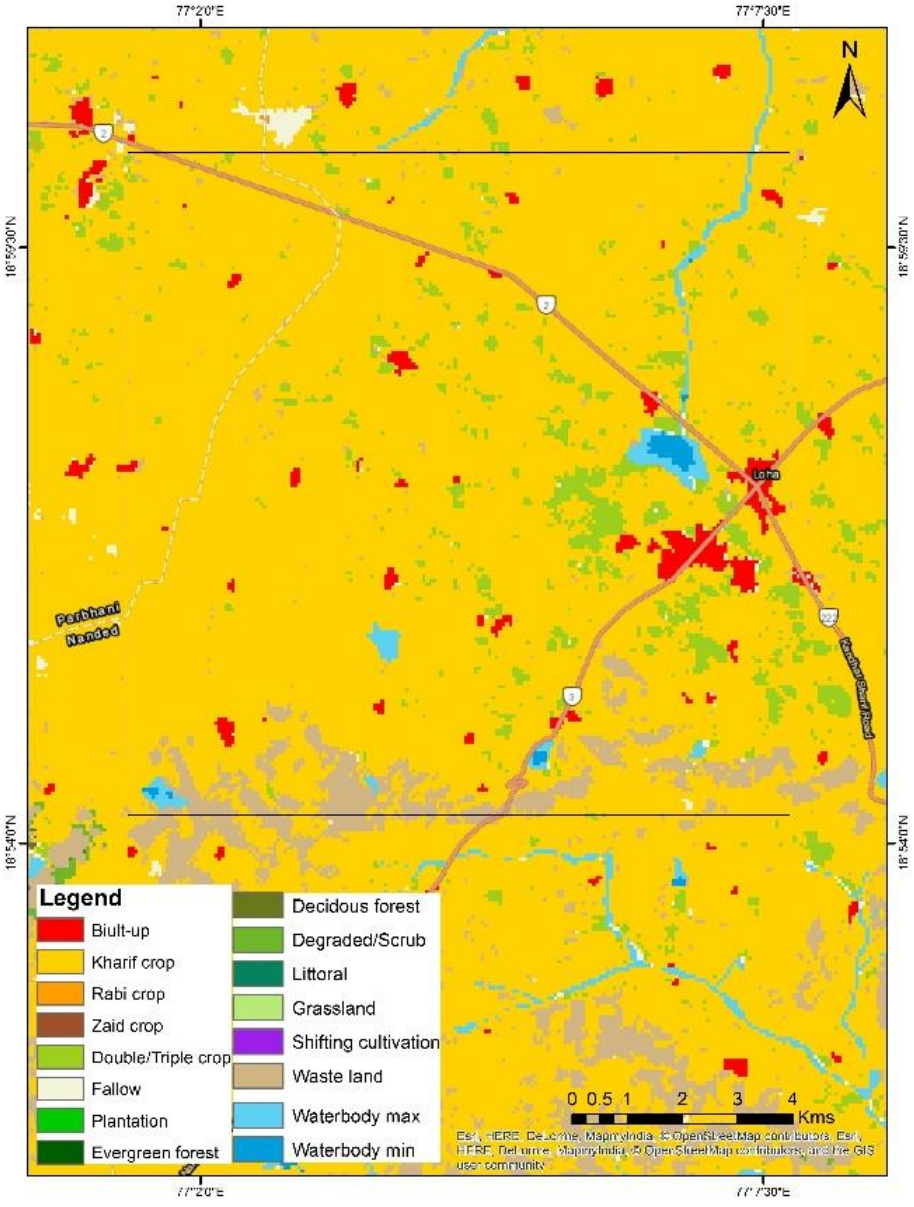


Figure 13: Potential GIB habitat grid identified during landscape survey in Nanded Forest Division, Maharashtra, India

Cluster 6: Grid-O (Ahmadnagar Forest Division)

This cluster has six 12x12 km grid covering an area of 864 km² area. Grids O1-6 within this cluster falls near Ahmadnagar of Ahmadnagar Forest Division. The overall land use is dominated by fallow lands followed by wasteland and major crops types are kharif crops and Rabi crops. The areas under each land use category is provided in Table 9 and corresponding map is given in Figure 14. GIB presence in this grid was confirmed to be within the last 1 month.

Table 9: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	17.30	Plantation	0.88
Kharif Crop	88.97	Deciduous Forest	22.05
Rabi Crop	72.55	Degraded Forest/ Forest	29.72
Zaid Crop	0.23	Wasteland	133.15
Double/Triple Crop	18.56	Waterbody Max	7.59
Current Fallow	393.99	Waterbody Min	0.06

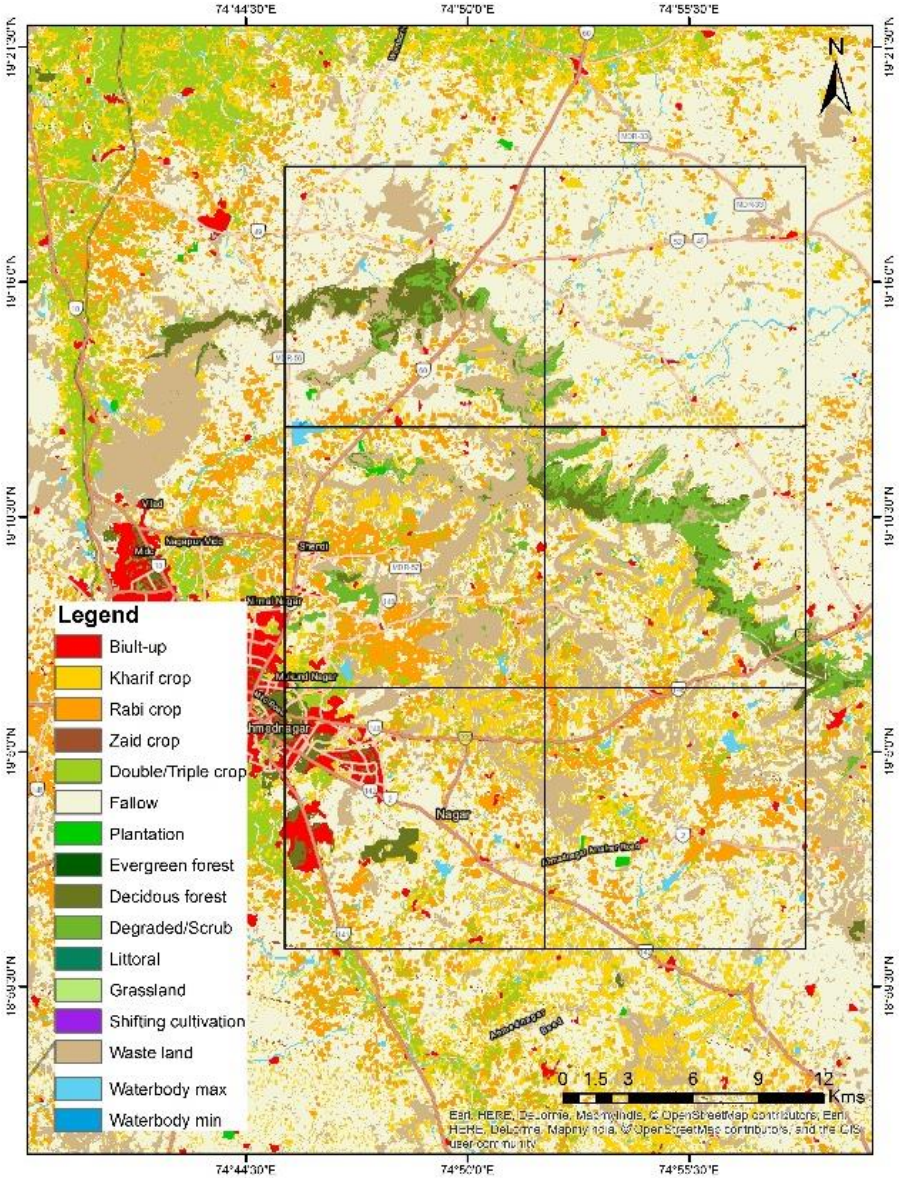


Figure 14: Potential GIB habitat grid identified during landscape survey in Ahmadnagar Forest Division, Maharashtra, India

Cluster 7: Grid-Q (Near Patola and Borkhed of Beed Forest Division)

This cluster has one 12x12 km grid covering an area of 144 km² area. Grid Q6 within this cluster falls near Patola and Borkhed of Beed Forest Division. The overall land use is dominated kharif crops followed by fallow lands. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 10 and corresponding map is given in Figure 15. GIB presence in this grid was confirmed to be within the last 2 months.

Table 10: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	0.90	Plantation	0.27
Kharif Crop	28.30	Deciduous Forest	2.13
Rabi Crop	22.75	Degraded Forest/ Forest	7.83
Zaid Crop	0.003	Wasteland	33.79
Double/Triple Crop	9.34	Waterbody Max	1.87
Current Fallow	23.39	Waterbody Min	0.18

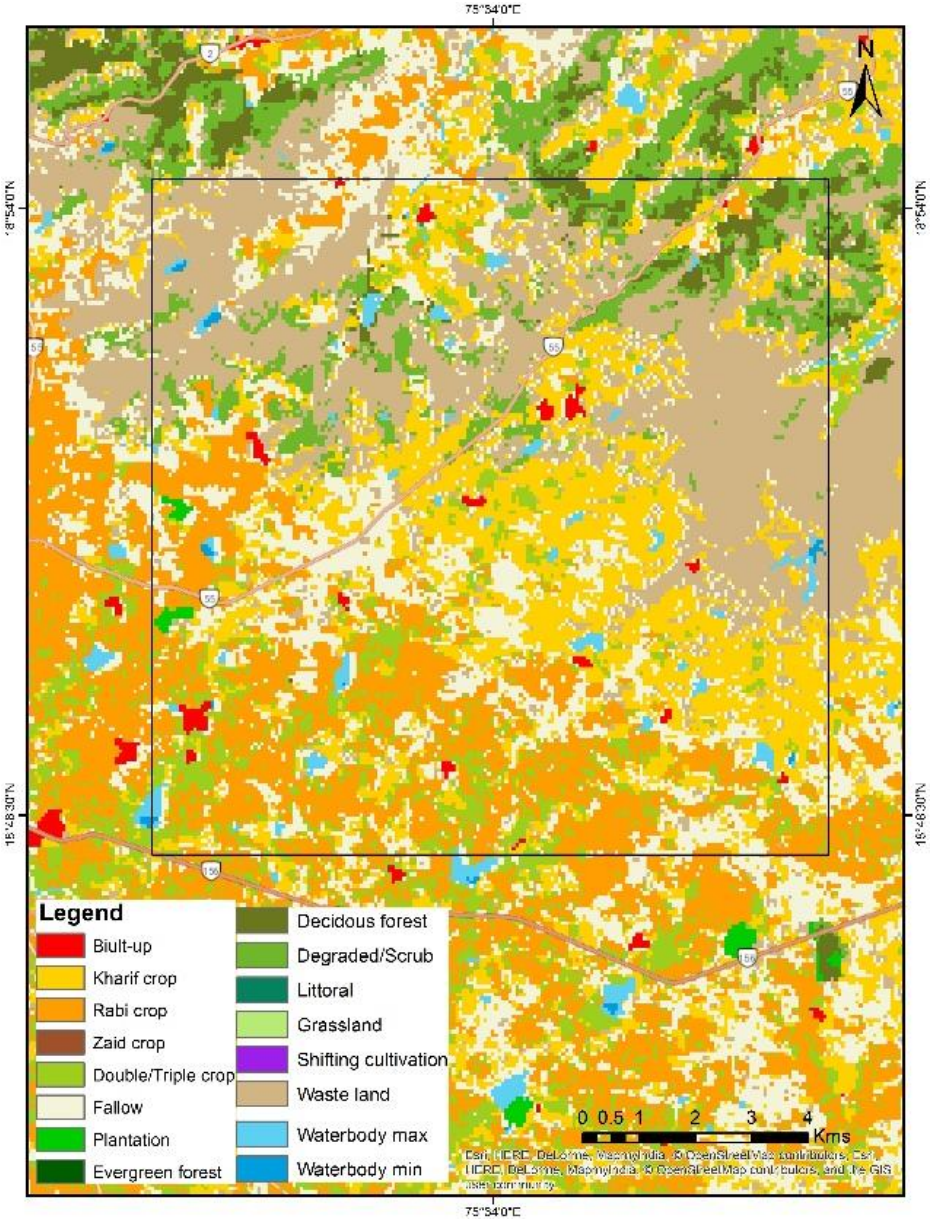


Figure 15: Potential GIB habitat grid identified during landscape survey in Beed Forest Division, Maharashtra, India

Cluster 8: Grid-R (Near Phaltan and Pimpari of Satara Forest Division)

This cluster has one 12x12 km grid covering an area of 144 km² area. Grid R6 within this cluster falls near Phaltan and Pimpari of Satara Forest Division. The overall land use is dominated fallow land followed by wasteland. The areas under each land use category is provided in Table 11 and corresponding map is given in Figure 16. GIB presence in this grid was confirmed to be within the last 1 month.

Table 11: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	1.22	Deciduous Forest	0.12
Kharif Crop	12.24	Degraded Forest/ Forest	1.84
Rabi Crop	3.74	Wasteland	44.69
Zaid Crop	0.02	Waterbody Max	1.59
Double/Triple Crop	1.54	Waterbody Min	0.03
Current Fallow	65.30	Current Fallow	65.30

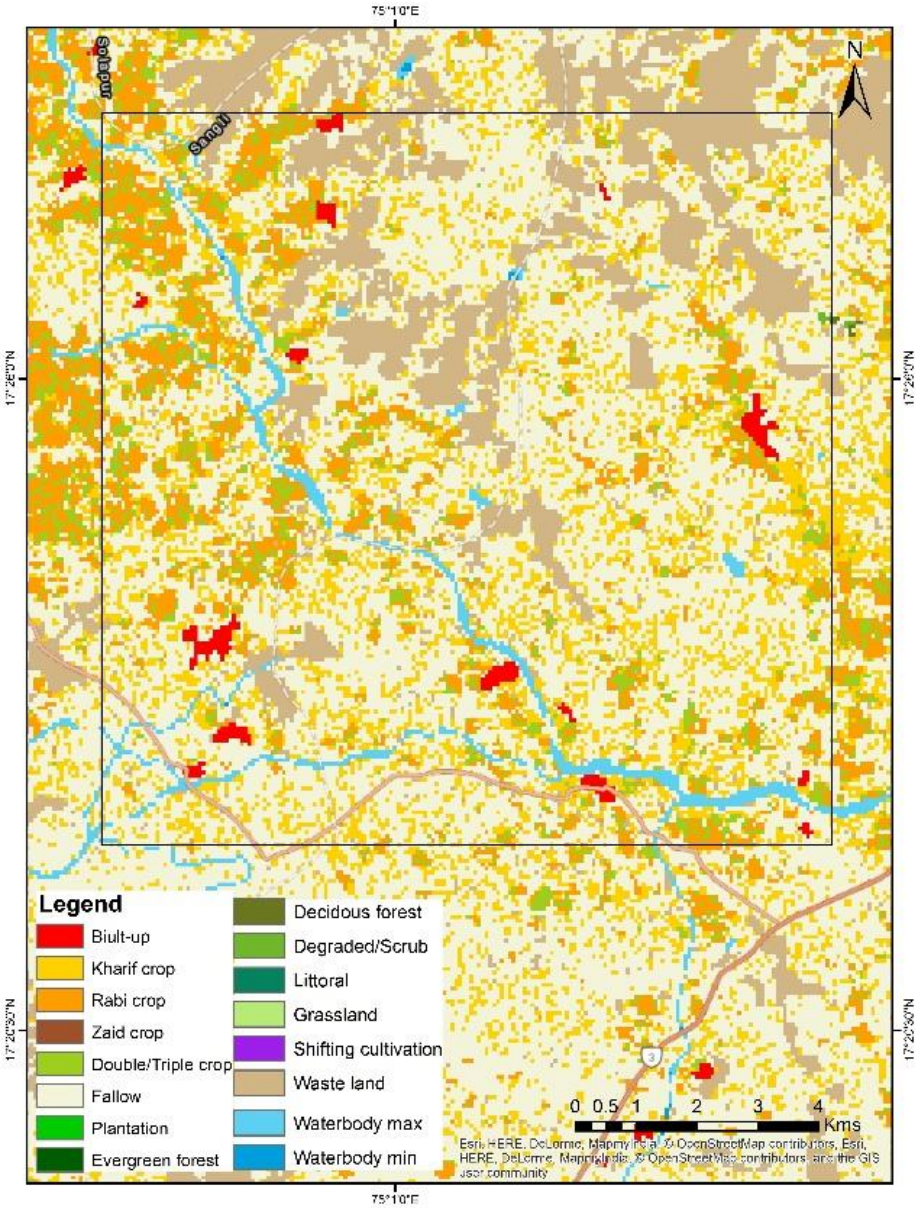


Figure 16: Potential GIB habitat grid identified during landscape survey in Satara Forest Division, Maharashtra, India

Cluster 9: Grid-T (Near Atpadi and Sangola of Sangli Forest Division)

This cluster has one 12x12 km grid covering area of 144 km² area. Grid T5 within this cluster falls near Atpadi and Sangola of Sangli Forest Division. The overall land use is dominated by fallow land followed by kharif crops. The agriculture practice in the area is traditional. The areas under each land use category is provided in Table 12 and corresponding map is given in Figure 17. GIB presence in this grid was confirmed to be within the last 2 months.

Table 12: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	1.39	Deciduous Forest	0.007
Kharif Crop	25.10	Degraded Forest/ Forest	0.02
Rabi Crop	12.68	Wasteland	16.17
Double/Triple Crop	5.66	Waterbody Max	3.50
Current Fallow	68.50	Waterbody Min	0.02

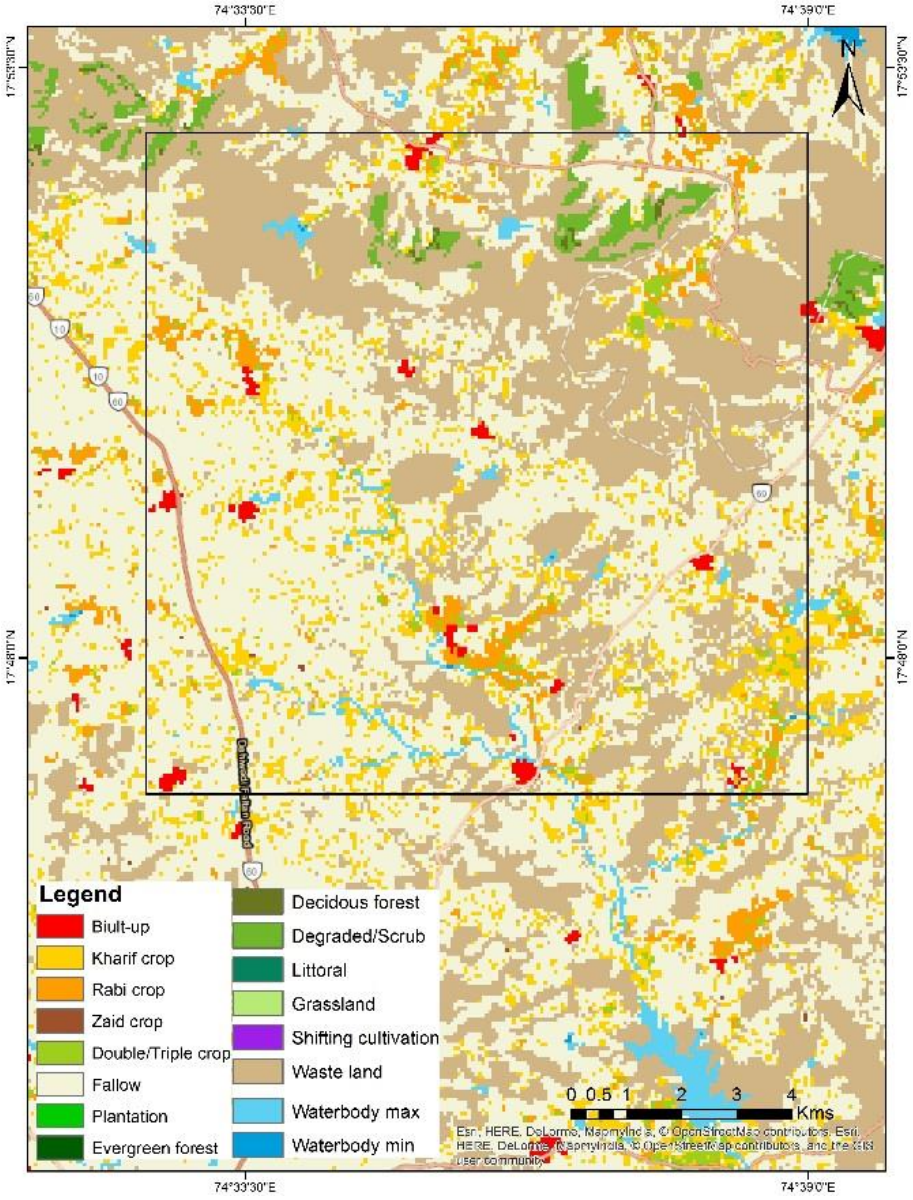


Figure 17: Potential GIB habitat grid identified during landscape survey in Sangli Forest Division, Maharashtra, India

Cluster 10: Grid-T (Near Mangalwedha and Nandeshwar of Solapur Forest Division)

This cluster has five 12x12 km grid covering an area of 720 km² area. Grids U2, U3, U5, U6 and U9 within this cluster falls near Mangalwedha and Nandeshwar of Solapur Forest Division. The overall land use is dominated by fallow lands followed by kharif crops and wastelands. The areas under each land use category is provided in Table 13 and corresponding map is given in Figure 18. GIB presence in this grid was confirmed to be within the last 6 months.

Table 13: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	3.52	Plantation	0.85
Kharif Crop	116.08	Deciduous Forest	0.43
Rabi Crop	9.54	Degraded Forest/ Forest	0.52
Zaid Crop	0.079	Wasteland	73.74
Double/Triple Crop	5.85	Waterbody Max	9.79
Current Fallow	409.62	Waterbody Min	0.49

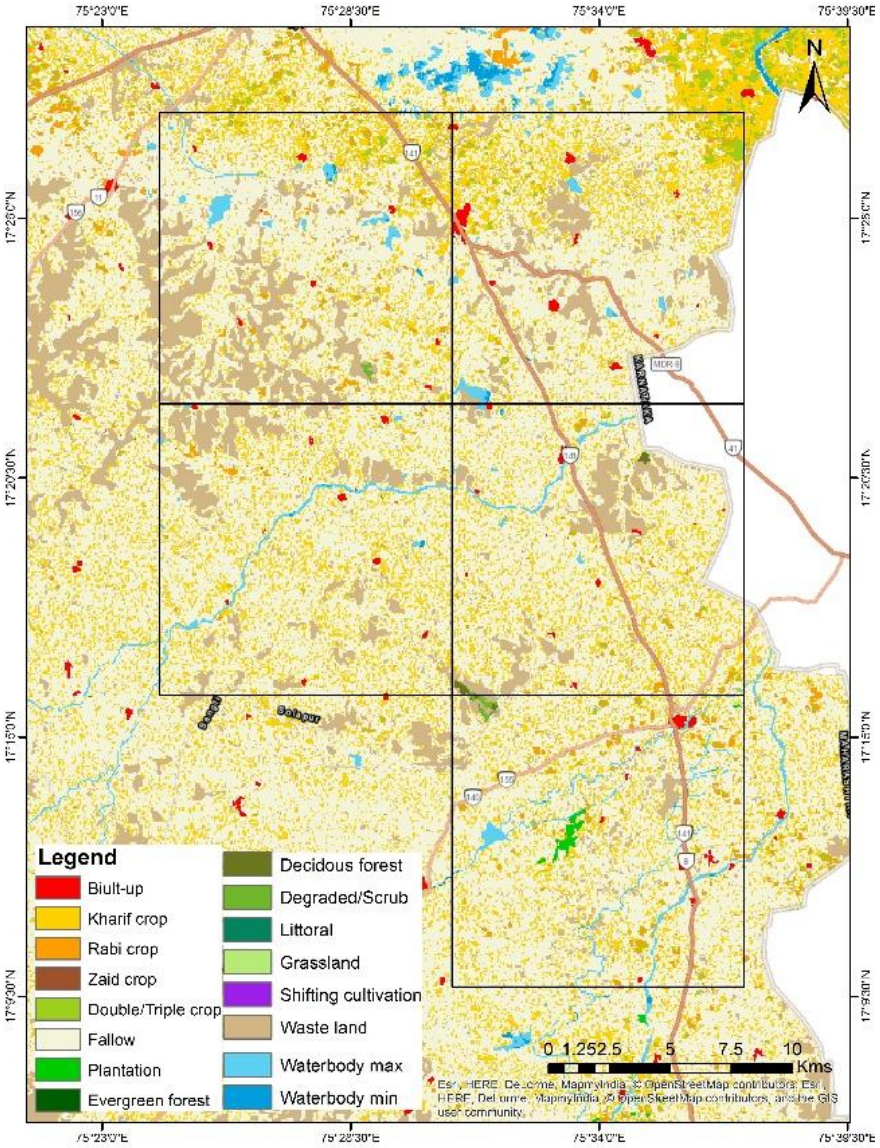


Figure 18: Potential GIB habitat grid identified during landscape survey in Solapur Forest Division, Maharashtra, India

Cluster 11: Grid- W, X, Y, Z, AA, AB, AC and AE (Near Solapur, Tuljapur, Osmanabad, Latur and Ausa of Solapur and Osmanabad Forest Division)

This cluster has fifty-nine 12x12 km grid covering area of 8496 km² area. Grids W8, W12, X5, X9, X10, Y10-12, Z1, Z2, Z4-12, AA1-12, AB1-12, AC3-12, AE1-5, and AE9 within this cluster falls near Solapur, Tuljapur, Osmanabad, Latur and Ausa of Solapur and Osmanabad Forest Division. The overall land use is dominated by kharif crops followed by mixed crops. The areas under each land use category is provided in Table 14 and corresponding map is given in Figure 19. GIB presence in this grid was confirmed to be within the last 4 days to 8 months.

Table 14: Table showing areas under different land use category

Landuse type	Area in sq. km	Landuse type	Area in sq. km
Built-up	155.84	Plantation	15.56
Kharif Crop	2538.0	Deciduous Forest	13.39
Rabi Crop	555.76	Degraded Forest/ Forest	9.12
Zaid Crop	0.67	Wasteland	927.81
Double/Triple Crop	496.28	Waterbody Max	200.90
Current Fallow	2703.65	Waterbody Min	40.75

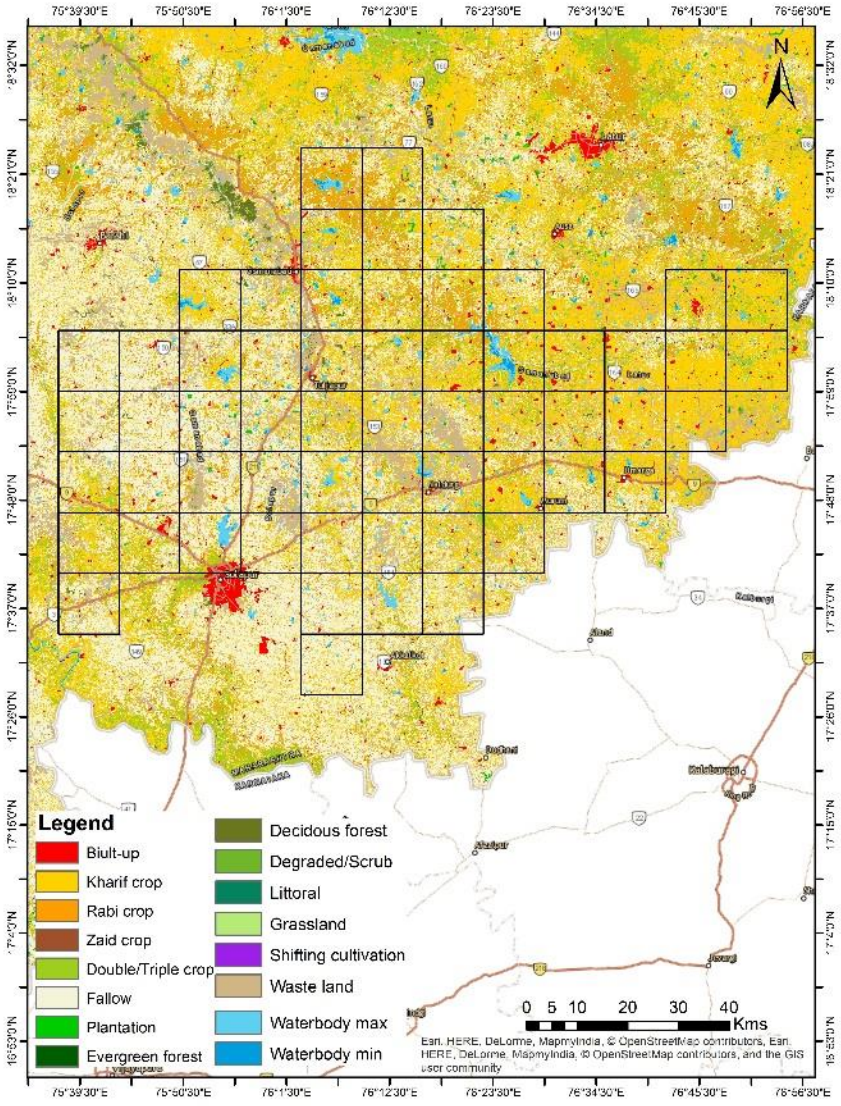


Figure 19: Potential GIB habitat grid identified during landscape survey in Solapur and Osmanabad Forest Division, Maharashtra, India

Questionnaire Survey

The questionnaire survey data (n=1401 respondents) revealed that 53.82% of respondents had no idea about the bird, 37.26% knew but had never seen a GIB. 2.28% of respondents had seen GIB in last 6 months (April – September, 17) (Figure 20). The 72 respondents who knew about or had seen GIB were asked about the perceived reasons of decline of GIB. 59.72% of respondents had no idea, 18.06% respondents believed that change in cropping pattern is the reason of decline, 8% believed electric lines are responsible for the decline and 4.17% believed development is the main reason (Figure 21).

Figure 20: Graph showing respondents' knowledge of GIB presence in their area

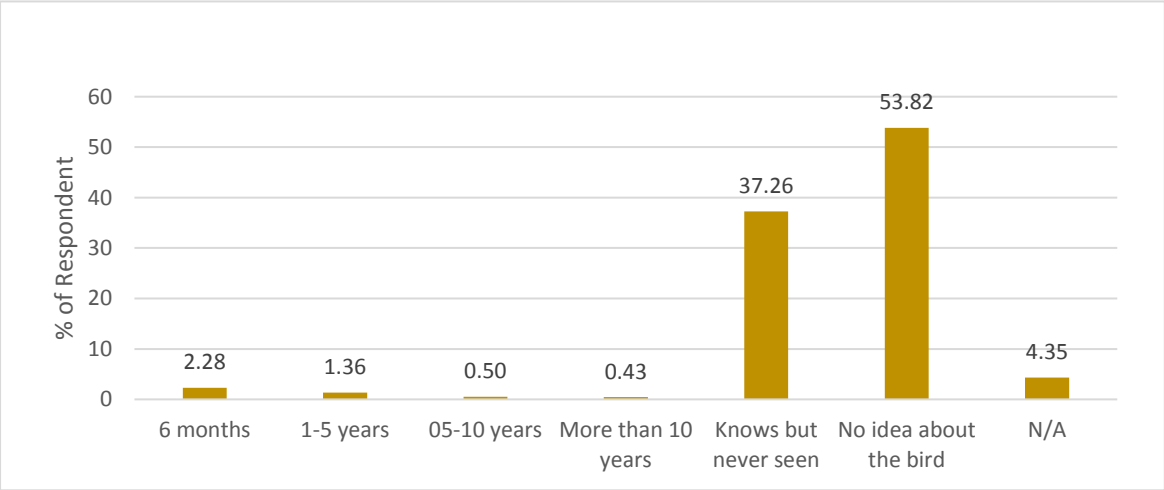
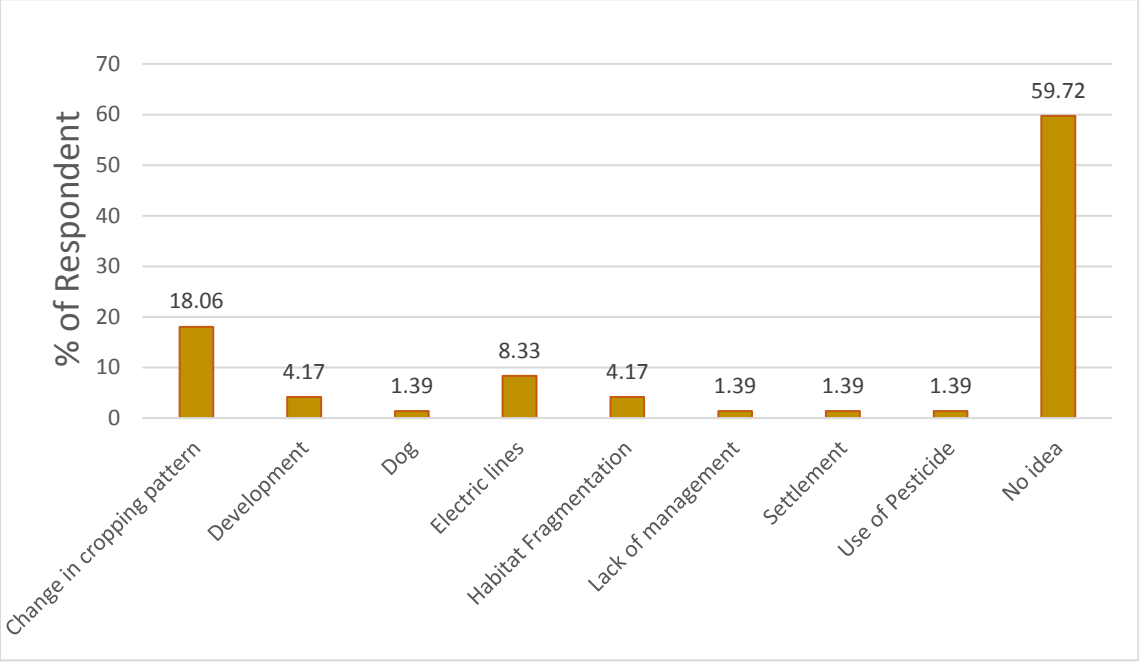


Figure 21: Graph showing perceived reasons of GIB decline in various part of Maharashtra according to questionnaire survey



Blind Test using life-size dummy

GIB prefers arid and semi-arid grasslands with scattered short scrub, bushes and low intensity cultivation in flat or gently undulating terrain. They congregate in traditional grassland patches (mostly identified) with low disturbance, to breed during mid-summer and monsoon. In non-breeding season, it makes local and possibly long distance nomadic movements in response to various factors, using areas rich in food resources and surrounded by natural grass-scrub habitat for easy navigation. It requires different microhabitat envelope for different activities, such as grasslands with relatively tall vegetation (25-100 cm), high insect resources and less grazing pressure, for nesting; short sparse vegetation (<25 cm) on slightly elevated grounds for display; sparse vegetation (<25 cm) with minimal scrub for roosting; and moderate (25-50 cm) vegetation shade for resting (Rahmani, 1989; Dutta, 2012). Because of their ecology and low population in Maharashtra probability to see one GIB is very low. To overcome this, a blind test using life-size GIB dummies was conducted (Figure 22) to know the possibility of detection in sampling grids by the sampling team. The dummies were placed in the sampling grids by a separate team. The sampling team was unaware of the location of dummy GIB. The placement of the dummies GIB across grids is shown in the Figure 23.

Placement of life-sized dummy GIB

The study extended over a large area and each team was assigned to cover an area of 1728 sq. km. One dummy GIB was placed for each team in one of the 12 grids without informing the teams about its location. A total of 30 dummy GIBs were placed across the area sampled in Maharashtra to evaluate the chance of detection of GIB (Figure 23). The detection probability of dummy GIB and live GIB were assumed to be same.

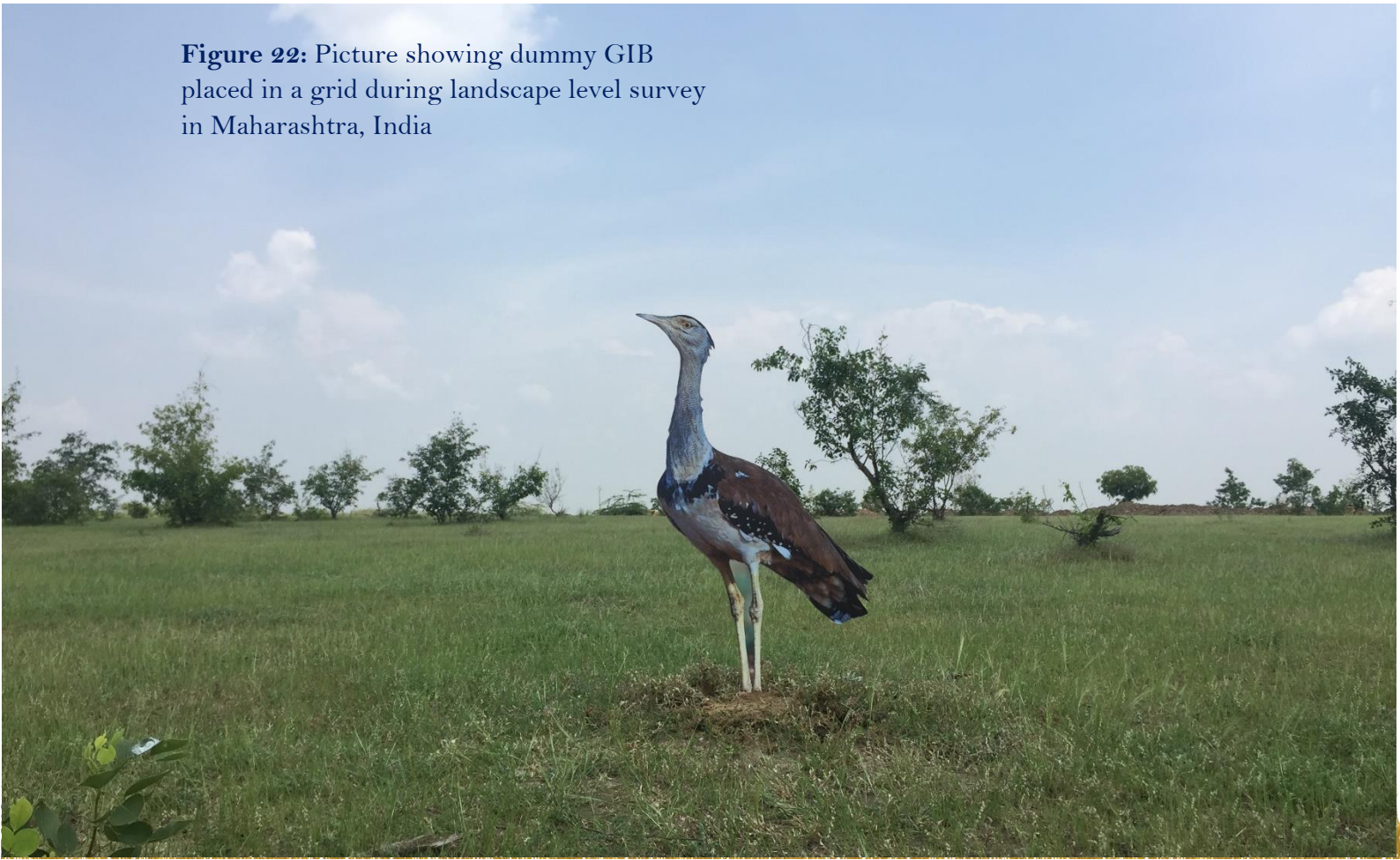


Figure 22: Picture showing dummy GIB placed in a grid during landscape level survey in Maharashtra, India

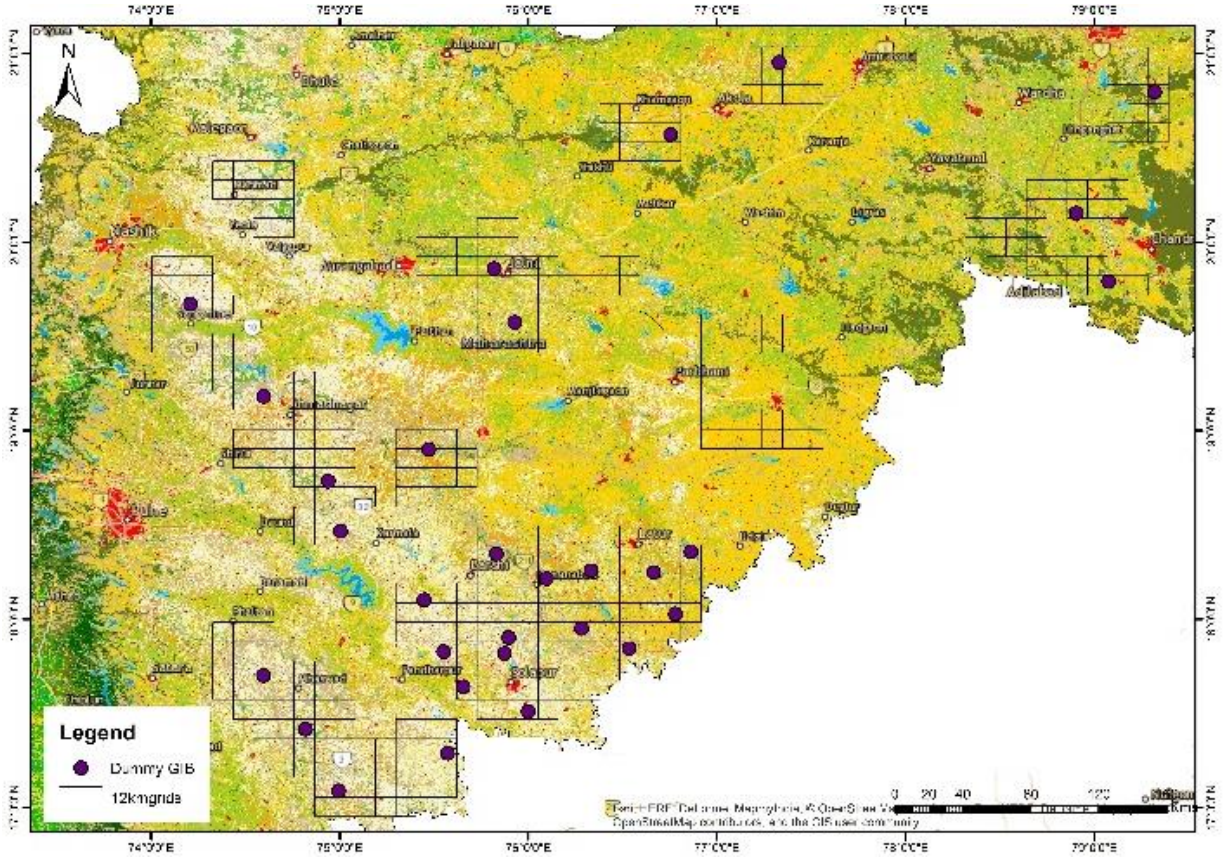


Figure 23: Map showing the locations of dummy GIBs placed in grids

Random points were generated across potential GIB distribution map for placement of dummy birds. The area was further scrutinized and dummies were placed at suitable areas where chances of GIB occurrence was assumed to be high. 30 life-size dummies were placed in grids so as to ensure that each team would have at least 1 dummy in their respective grids.

Outcomes and Conclusion

Out of the 30 dummies placed, only 4 were detected by the respective sampling teams. The detection probability was found to be 13% which is within the range of previous studies (Rahmani, 1986). This would mean that, if the population of GIB ranges from 8 to 10, there is a chance of detecting one GIB with a minimum sampling effort of 8 temporal replicate for each transect considering that detection probability of dummy GIB and live GIB are the same. During the survey, no GIB was sighted which implies that the number of GIB might be less than 8 in Maharashtra.

The number of sampling occasion required the determine species presence at occupied sites based on blind test (dummy life-size of GIB) varied accordingly to designed confidence level. Based on our estimate of occupancy (8.06%) and detectability (13%) of dummy GIBs. Power analysis showed, that there is 80% chance of detecting a 53% change in occupancy with sampling effort of 8 replicates in 200 grids (Barata et al., 2017). This can also be achieved by sampling 140 - 150 grids with 10 replicates (Figure: 24). This indicates need for intensive sampling for detecting any population change in Maharashtra.

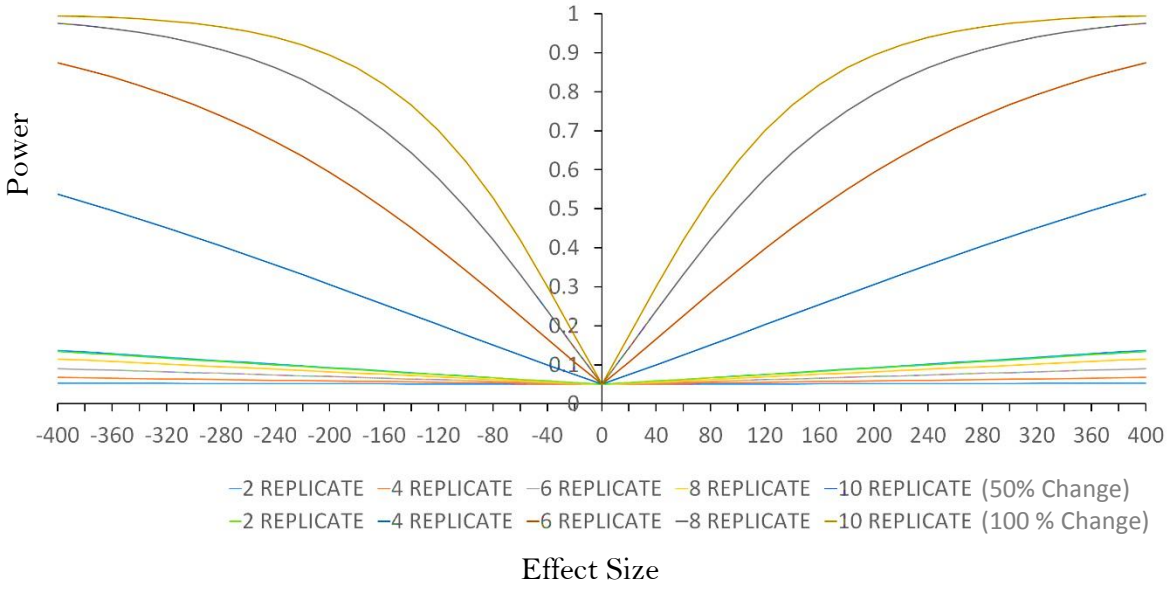


Figure 24: Statistical power as function of change in occupancy under different sampling designs (number of replicates and grids)

Discussion

India has experienced a significant loss in grassland habitats over the last few hundred years due to expansion of agriculture as well as human settlements (Tian et al., 2014). In addition, farmers have been shifting to cash crop production from traditional cultivation of pulses and oil seed (Nalawade et al., 2010; Seethalakshmi, 2010; Kadapatti, and Bagalkoti, 2014). This shift from the traditional agricultural pattern is mainly due to increase in demand and high economic value of cash crops. The rapid conversion of grasslands and shrub lands into agricultural lands, excessive use of insecticides and pesticides, over grazing and human disturbance are the major contributing factors in the decline of GIB populations.

GIBs were once distributed throughout the grasslands of northern India and the Deccan Landscape in around 11 states (Rahmani, 1989), but are now confined to only 7 states with less than 250 individuals (Dutta et al., 2010). The aim of this survey was to provide an overview of suitable areas for GIB in Maharashtra and identify potential areas for future planning. The GPS locations from tagged birds revealed habitats preferred by GIB in the state of Maharashtra. It was earlier considered that GIB only used grasslands (Simcox, 1913; Tyabji, 1952; Dangre, 1966; Rahmani, 1987; Thosar et al., 2007) but telemetry data has revealed that they spend most of their time in agricultural fields and fallow lands for foraging and congregate at grasslands for breeding. The tagged birds were seen to be utilizing an area of more than 14,000 km^2. These findings make it clear that conserving habitats outside the protected area system is critical for GIB conservation in the state of Maharashtra.

Maharashtra harbors a good population of Blackbuck outside the protected area; their density was found to be 0.74 ± 0.11 km^2, and total population was found to be 37690 ± 5625. The density of Chinkara was found to be very low (0.02 ± 0.01 km^2) and total population was found to be 1481 ± 577. This is probably our grids were in potential GIB habitat. Chinkara generally prefers arid areas, including sand deserts, flat plains and hills, dry scrub and open forests (Rahmani, 1990; Jaipal, 2015; IUCN, 2017).

Unfortunately, no GIBs were sighted during the survey, However, indirect information of their presence in known areas was collected through questionnaire survey and probable new areas were identified. The authenticity of this information was confirmed by showing pictures of Wooly Necked Stork *(Ciconia episcopus)* to respondents as this species is one of the closest species in the area with whom GIB is confused by the local people. Once people confirmed the presence of GIB, information about areas where GIB has been seen and approximate time of such sightings was collected. Using this information, 11 clusters (87 grids) were identified. Most of these grids fall outside protected grassland areas with crop fields dominated by kharif crops and open areas. These grids need proper monitoring for further validation.

The blind test experiment conducted by placing dummy GIBs has revealed low detection of these birds which can be further confounded by low population size, nomadic movement and use of large agricultural landscape for foraging without distinguished boundary. Out of the 30 dummies placed, only 4 had been detected by survey teams. Power analysis on detection probability (13%) and occupancy (8.06%) of dummy life-sized GIB showed that 8 replicates required in 180 grids of detecting 53% change in occupancy. Considering this, it would

require 8 temporal replicates for each transect across the landscape to detect one GIB if the population size is 8-10. This indicates that the probable population size of GIB is less than 8 birds in the state of Maharashtra. It is recommended to survey the 11 identified clusters in a more rigorous way in the coming year.

Conservation Implications

GIBs are large flying birds, which generally take low flights resulting in mortality due to collision with electric lines. Dogs are another major threat to them. The habitat selection of GIB changes throughout the year in response to food availability. The telemetry data has indicated that GIB prefers open grasslands and agricultural fields of sorghum, groundnuts, and pigeon pea. In this context, both the agricultural and land sparing practices are to be well managed for GIB conservation in Maharashtra. Awareness raising programs should be initiated and measures should be taken to protect traditional agricultural practices.

Management of Potential GIB Clusters in Maharashtra

There are 11 clusters in 12 different forest divisions which are important for GIB conservation in the state of Maharashtra. Most of these areas are dominated by kharif crops (sorghum, peanut, groundnut, seed oils), preferred by GIB as foraging grounds. The following recommendations are made on the basis of the findings of the landscape level GIB survey:

- The 11 identified clusters should be monitored for a duration of 1-2 years continuously at least 2-3 times a year.
- Department-owned areas within such grids should be managed as bustard habitats by removing invasive species.
- There is an urgent need for awareness in these identified clusters with option to promote traditional cropping patterns. Any changes in these areas will be critical for GIB conservation.
- Traditional cropping patterns need to be promoted by involving other line departments and need to have awareness and capacity building program for the same.
- There is a need to put reflectors on power-lines in such areas.
- Dog population needs continuous monitoring and measures should be taken to control the growth of dog populations in such areas.
- GIB conservation in Maharashtra is only possible if traditional cropping and land sparing is promoted and incentivized.

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