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Cover: Mixed media illustration of a Blue bird and Sunbird. © Lakshmi Niranjana.



INTRODUCTION

Bengal Florican, *Houbaropsis bengalensis* (Gmelin, 1789), is a 'Critically Endangered' grassland bird (IUCN 2022) belonging to the family Otididae. In India, it is protected under Schedule I of the Wildlife Protection Act, 1972. The population of Bengal Florican is 350–400 in India, <100 in Nepal (Collar et al. 2017; Baral et al. 2020) and <500 individuals in Cambodia (BirdLife International 2022). In India, the population of Bengal Florican is restricted to the sub-Himalayan region of the Indo-Gangetic floodplains and the Brahmaputra floodplains (Rahmani et al. 2017). They are extremely habitat specialists and are restricted to grasslands (Prasai et al. 2021). Bengal Floricans were once distributed from Uttar Pradesh, Bihar, and West Bengal to the foothills of Assam and Arunachal Pradesh in India. However, at present, it is confined to a few protected areas in India including Manas National Park (MNP), Kaziranga National Park, Orang National Park, Dibru-Saikhowa National Park, Burachapori Wildlife Sanctuary in Assam, D'Ering Wildlife Sanctuary in Arunachal Pradesh, and Dudhwa National Park in Uttar Pradesh. The species is confined to only these few protected areas and appears nowhere outside these areas (BirdLife International 2022).

In 1989–90, the Bombay Natural History Society (BNHS) conducted a survey in India and found that Manas National Park had the highest Bengal Florican population. Around 80 birds were estimated during the study, which is perhaps the largest known population of Bengal Florican in any single locality. However, the population of Bengal Floricans declined from 1990–2000 because of the socio-political unrest created during Bodo agitation in the areas adjoining Manas. However, according to reports, the population has shown an increasing trend from 2003–2012 (Brahma et al. 2009). The population of Bengal Florican was estimated to be around 50 individuals in Manas National Park (Brahma et al. 2009). Since 1989–1990, approximately 40% of the Bengal Florican population has been lost, and grass height was the main factor. It is assumed that these birds are site-selective in establishing their territory, and prefer wet alluvial grassland for breeding, which is reduced by 47% and succeeding towards savanna grassland (Brahma 2013). The global population of the species has been rapidly declining, and the IUCN Red List for Threatened Species has upgraded Bengal Florican from 'Endangered' to 'Critically Endangered' (BirdLife International 2010).

The highest number of Bengal Floricans was reported from Kokilabari Agriculture Farm (KAF) (Brahma et al.

2009). The KAF is 9 km², which is a large grassland site. The KAF is under extensive agricultural practice and leased to local communities for paddy cultivation. Paddy cultivation began in June and harvested in December. It has been reported that the Bengal Florican population was established during 2000–2001, the period when the farm was not under cultivation. One reason for the selection of these sites by Bengal Floricans is the lack of waterlogging (Brahma et al. 2009).

The aim of this study is to address the lack of information on the populations and habitats of the Bengal florican in Manas National Park through a systematic approach, thereby contributing to the development of long-term conservation strategies. This research serves as a stepping stone for further research and education aimed at preserving the Bengal florican and its habitat.

METHODS

Study site

Manas National Park

Manas National Park (MNP) is a World Heritage Site, a Tiger Reserve, a Biosphere Reserve, and an Elephant Reserve located in the state of Assam (Das et al. 2022). MNP ((26.583–26.833 °N, 90.750–91.250 °E) is the core area of Manas Tiger Reserve with an area of 500 km², located in Baksa and Chirang districts of the Bodoland Territorial Council, Assam (Figure 1). Apart from Bengal Floricans the grasslands are home to a wide variety of wildlife including grassland specialist like Pygmy Hog *Porcula salvania*, Hispid Hare *Caprolagus hispidus*, Hog Deer *Axis porcinus* and other mega herbivorous like Indian Rhino *Rhinoceros unicornis*, Brahma et al. 2009 Wild Water Buffalo *Bubalus arnee*, Eastern Swamp Deer *Rucervus duvaucelii ranjitsinhi*, Gaur *Bos gaurus*, and Asian Elephant *Elephas maximus*. It is a regional priority site for the conservation of charismatic species, including 55 mammals, 50 reptiles, and more than 450 bird species (Sarma et al. 2008; Das et al. 2022). A total of 462 plant species have been reported from within the national park, but the region is rich in plant life with about 622 plant species reported from the larger Manas Biosphere region. This includes 429 dicotyledons, 162 monocotyledons, 30 pteridophytes, and one gymnosperm (Hajra & Baishya 2002). It lies at an altitude of 57–280 m. The temperature ranges from 6–37 °C. The rainfall lies between 3,000 mm to 4,000 mm per year. The rainfall reaches its peak in July and

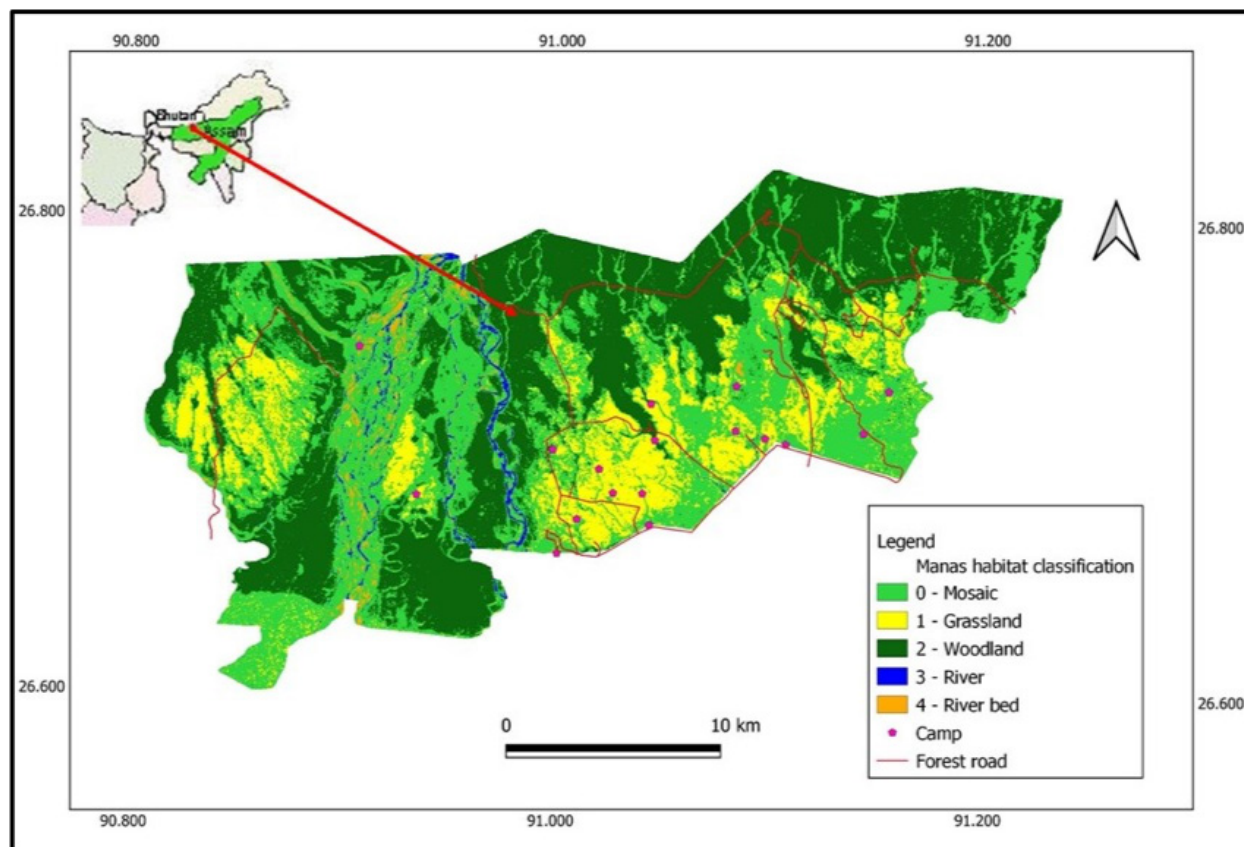


Figure 1. Map of Manas National Park in Assam.

August. The vegetation of the park is moist deciduous forest, early successional woodland grassland, and dry-wet alluvial grassland (Sarma et al. 2008; Banerjee et al. 2021). Due to resource extraction by local communities and livestock grazing, MNP experiences biotic pressure. Local people may start fires to encourage the growth of fresh grass, but processes are mostly initiated by park managers to control woody plant encroachment into grassland areas. However, the dynamics of fires after ignition are not controlled by forest managers, and the spatial patterns and extent of fires are determined by habitat factors (Banerjee et al. 2021).

Methods for population assessment

The survey was conducted based on habitat maps and past records of the complete population census of Bengal Florican. The surveys were carried out in the three ranges, namely, Bansbari, Bhuyanpara, and Panbari of Manas National Park during the peak breeding season of the Bengal Florican from 20 February–22 April 2021. Birds were observed using vehicles, walking on foot, or from elevated forest towers. Sightings and GPS locations were recorded. Field surveys were carried

out during the early morning (0600–0930 h) and late evening (1500–1800 h). On certain days, the survey was conducted until noon. The number of Bengal Floricans spotted, the number of males and females sighted, the time of sightings, along with the location of the species were recorded. Since, the species is territorial in nature during the breeding season, the display site of a male, was considered as an individual male territory and each displaying male was recorded as an individual male and the females are difficult to locate (Images 1 & 2). The breeding territories were identified and marked using handheld GPS (Garmin etrex 30x) and GIS-based map of identified Bengal Florican territories was prepared using QGIS (QGIS Development Team 2020).

The methodologies employed in this survey were consistent with those used in the studies by Brahma (2013) and Narayan (1992). Similar techniques and area coverage were utilized to ensure comparability between the current and previous surveys. No higher conservation technologies were employed during this survey, maintaining the same level of effort and methodological approach as in the earlier studies.

Method for land cover change

Satellite images from 2000 and 2020 were analyzed to detect the change in land cover using remote sensing and geographic information system tools. The open-source satellite images were obtained from Landsat 7 and Landsat 8 through <https://earthexplorer.usgs.gov>. Landsat 7 and Landsat 8 images were used for classification at 30 x 30 m resolution and I, II, III, IV, V, VII and II, III, IV, V, VI, VII bands were used respectively. Open-source QGIS software (QGIS Development Team 2020) was used to classify the image objects. Using supervised classification, Bengal Florican record sites were classified and land cover changes were analyzed and the classified habitat into three classes: grassland, woodland, and grassland woodland mosaic.

Method for vegetation survey

First, a grid map of Florican locations was prepared using GIS. The standardized grid size was 1 x 1 km. The total area of grassland was divided into 10; 1 x 1 km blocks. Within each 1 x 1 km grid area, 10 quadrats of x 1 m were placed centrally. To fulfill the objectives, quadrat sampling method (Stohlgren et al. 1995) was used for the quantitative study of the vegetation of Bengal Florican.

Method for disturbance study

To study the disturbance drivers of the Bengal florican and their habitats, the same 1 x 1 km grids were used for data collection. Cattle grazing, the presence of invasive alien plant species, problematic native species, and other human-induced disturbances were recorded.

RESULT

Distribution and population status

Houbaropsis bengalensis were recorded from Bansbari, Bhuyanpara, and Panbari grasslands. (Figure 3, Table 1). 50 males and 17 females were observed in Kuribeel, Rupahi, Sidajhar, Kokilabari, Bhumuk, Abiwidora, Agrang, and Murabari (Table 1). Eighteen males were sighted displaying: nine in Kokilabari, four in Rupahi, three in Agrang, and two in Kuribeel. The highest number of individuals were sighted in Kokilabari located in the Bhuyanpara range of the National Park, followed by Rupahi and Kuribeel. Seven males were observed during flight, looking at their flight direction. Females are difficult to spot, and direct observations estimate the total count of Bengal Floricans to be 74 (Table 2). No floricans could be sighted in areas such as Kasindaha, Mahout Camp Fields, Palsiguri, Uchila-

Bongali Hathdhowa, Bura Buri Jhar, Dighlatari, and Pohu Field, where floricans had been previously reported (Narayan 1992; Brahma 2013).

Table 3 list the names of grassland blocks located in Manas National Park where Bengal Floricans have been reported in the past and in the current study. The map was generated using QGIS to study and compare Bengal Florican locations in grasslands over the last few decades. The results of past surveys carried out in 1989 (Narayan 1992), 2011 (Brahma 2013), and 2021 were used to compare the data with those of the current study (Figures 2 & 3).

Land cover change

The results indicated habitat changes in vegetation within the recorded site. In the year 2000; 11.7 km² area of grassland represent 79%, 3.03 km² area of grassland woodland mosaic represent 21%, and 0.036 km² area of woodland are represent 0.24 % (Table 4, Figures 4 & 6). In the year 2020; 7.3 km² area of grassland represent 49.6%, 0.75 km² area of woodland represent 5.1%, and 6.67 km² area of grassland woodland mosaic represent 45.3% (Table 5, Figures 5 & 6). From 2000–2020; 4.7 km² of grassland area was converted to mosaic representing 32%, 0.49 km² of grassland area was converted to woodland representing 3.4%, 0.0009 km² of the mosaic area was converted to a waterbody representing 0.01%,

Table 1. Bengal Florican sightings along with GPS locations.

	Locations	Area	Number of males sighted	Number of territories established (Female)
1	N26.74857, E91.17289	Kokilabari	20	7
2	N26.68549, E91.02865	Kuribeel	5	2
3	N26.68469, E91.04027	Bhumuk	2	0
4	N26.71303, E91.08633	Rupahi	7	4
5	N26.72930, E91.08080	Abiwidora	3	3
6	N26.71128, E91.15022	Agrang	7	0
7	N26.68044, E90.91007	Murabari	2	1
8	N26.69722, E90.92653	Sidhajhar	4	0

Table 2. Total count of Bengal Florican population.

	Bengal Florican	Population
1	Male	50
2	Female	17
3	Additional male sighted in flight	7
	Total	74

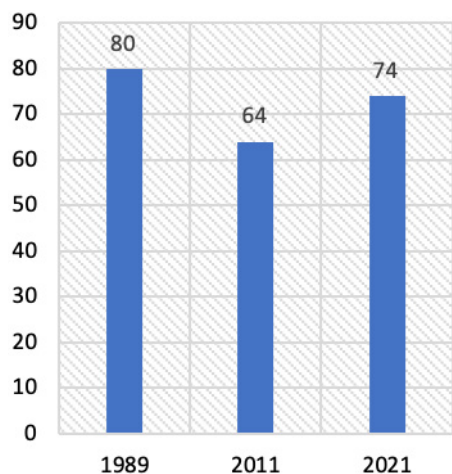


Figure 2. Bengal Florican recorded in 1989, 2011, and 2021.

Table 4. Classification of L7 Satellite imageries of 2000.

Class ID	Class name	Pixel sum	Area [km ²]	Percentage [%]
0	Mosaic	3368	3.031	20.57
1	Grassland	12960	11.664	79.17
2	Woodland	40	0.036	0.244

0.81 km² of the mosaic area was converted to grassland representing 5.5%, 0.24 km² mosaic area converted to woodland representing 1.63%, and 0.02 km² woodland area converted to mosaic representing 0.13% (Table 6).

Vegetation survey

The grasslands were burned in the month of February and a fresh flush of grasses emerged soon after establishing a suitable habitat for the Bengal Floricans to breed. The following plant species were observed during the survey (Table 7). And most of the Bengal Florican habitats where they are recorded in the grassland have short grass *Imperata cylindrica* and moderately tall and dense grasses like *Saccharum spontaneum* and *Saccharum narenga*.

Threats

The grasslands of the park are subjected to a number of natural and anthropogenic disturbances. The conversion of grasslands into woodlands is a serious threat to grassland species. *Bombax ceiba* (Simul), a tree species was found growing extensively in the grasslands. Cattle grazing is one such disturbance that has been observed in the National Park. The grazing of livestock by communities living in the fringes of the National

Table 3. Male Bengal Florican sightings over the last four decades (Narayan 1992; Brahma 2013).

	Grassland Block	1989	2011	2021
1	Kasindaha	7	NA	NA
2	Mahout Camp Fields	4	NA	NA
3	Palsiguri	3	NA	NA
4	Kuribeeel	6	5	5
5	Uchila-Bongali Hathdhowa	1	NA	NA
6	Bura Buri Jhar	1	NA	NA
7	Lafasari	NA	4	NA
8	Kapur-pura/ Sidhajhar	8	5	4
9	Pohu Field	NA	2	NA
10	Dighlatari	NA	4	NA
11	Agrang	NA	4	7
12	Kokilabari	NA	8	20
13	Murabari	NA	NA	2
14	Abiwidora	NA	NA	3
15	Rupahi	NA	NA	7
16	Bhumuk	NA	NA	2
Total		30	32	50

Table 5. Classification of L8 Satellite imageries of 2020.

Class ID	Class name	Pixel sum	Area [km ²]	Percentage [%]
0	Mosaic	7421	6.6789	45.33
1	Water	1	0.0009	0.0061
2	Grassland	8110	7.299	49.54
3	Woodland	836	0.7524	5.10

Park is one of the major causes of habitat degradation. *Premna herbacea*, a medicinal herb that grows profusely in the grasslands of Manas is a major non-timber forest products (NTFPs). Local communities depend on these products for their livelihoods. The presence of humans in these grasslands inhabited by Bengal Floricans is another cause of disturbance to the species. The presence of invasive alien plants is another major disturbance to the habitat. *Chromolaena odorata* a shrub was found growing extensively in the grasslands of the national park occupied by Bengal Floricans.

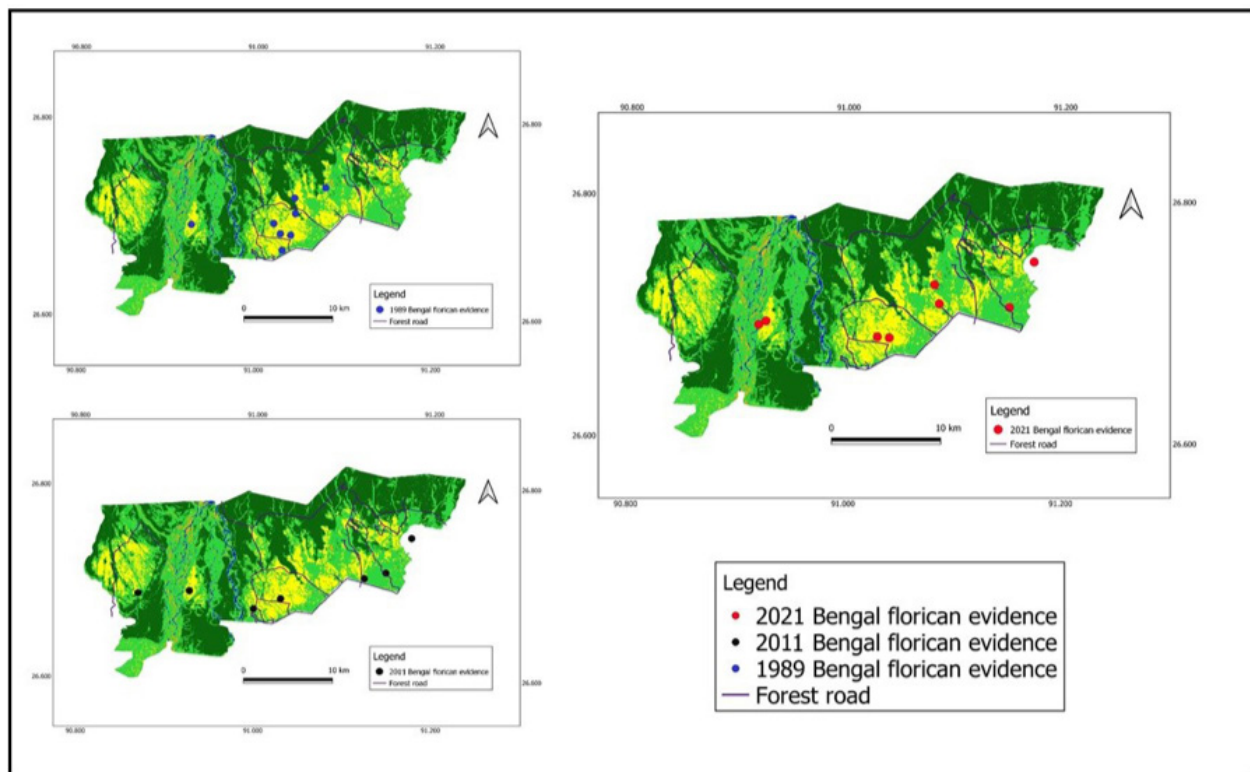


Figure 3. The distribution of Bengal Florican in the surveys carried out in 1989, 2011, and in the current study 2021.

Table 6. Land cover change between 2000 and 2020.

Cross class code	Reference class (L7)	New class (L8)	Pixel sum	Area [km ²]	Percentage of change (%)
6	Mosaic	Mosaic	2202	1.98	13.45
10	Mosaic	Water	1	0.0009	0.01
14	Mosaic	Grassland	898	0.8082	5.49
18	Mosaic	Woodland	267	0.2403	1.63
7	Grassland	Mosaic	5197	4.6773	31.78
15	Grassland	Grassland	7212	6.4908	44.10
19	Grassland	Woodland	551	0.4959	3.37
8	Woodland	Mosaic	22	0.0198	0.13
20	Woodland	Woodland	18	0.0162	0.11

DISCUSSION

Our survey estimated 74 Bengal Floricans in Manas, which compared to 2011 represents an increase (Figure 3). The Florican number 74 is higher than the result of the last survey conducted in 2011 (Brahma 2013), but lower than the result of a previous survey conducted in 1989 (Narayan 1992). Interestingly, at least 20 male floricans and seven female floricans were recorded at the Kokilabari Agriculture Farm (KAF). The highest

number of floricans was recorded in KAF. Thus, there is a long term need to conserve such sites such as the KAF for long term conservation of the species.

The survey for Bengal Floricans in Manas National Park provides important evidence for the presence of Bengal Floricans at the study site. It also indicates an increasing trend since the last survey carried out in 2011 which is encouraging (Brahma 2013). This survey also provided new information from previously surveyed areas such as Murabari, Abiwidora, and Bhumuk grassland areas,

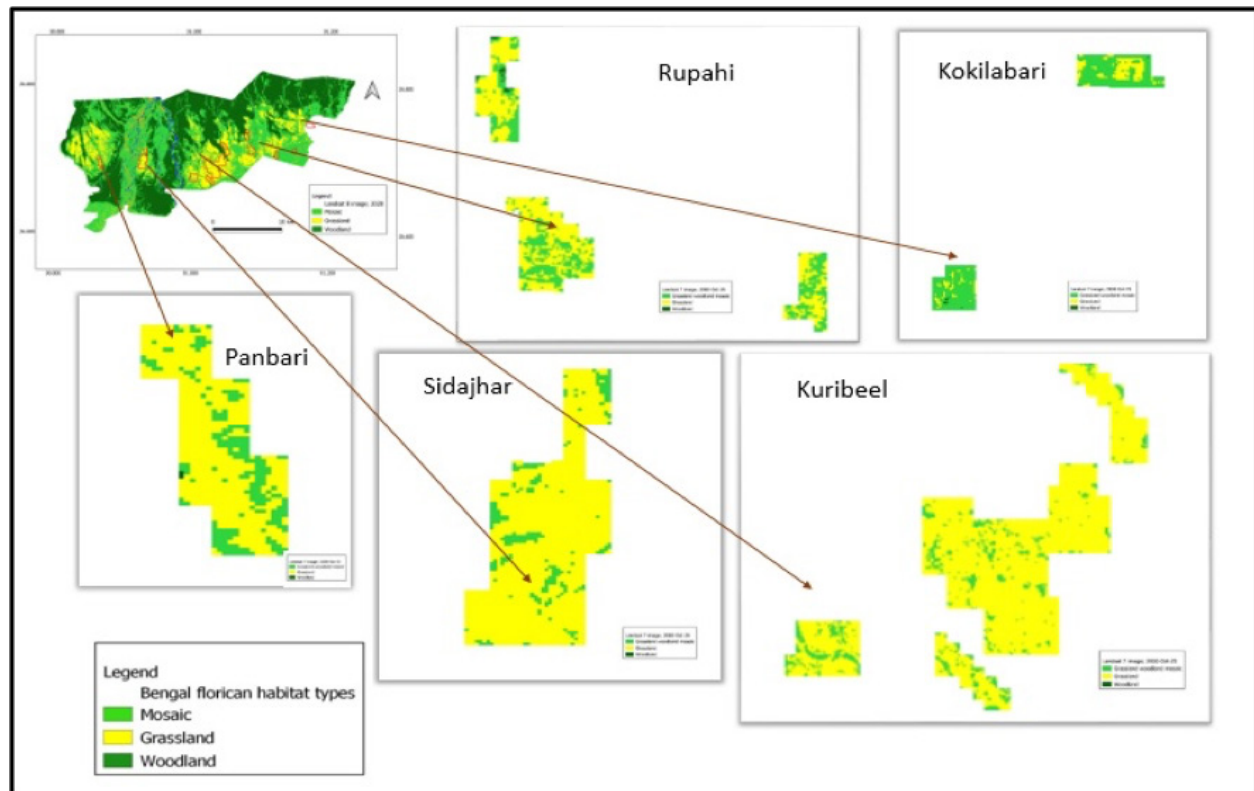


Figure 4. Land use map of Bengal Florican habitat as in 2000.

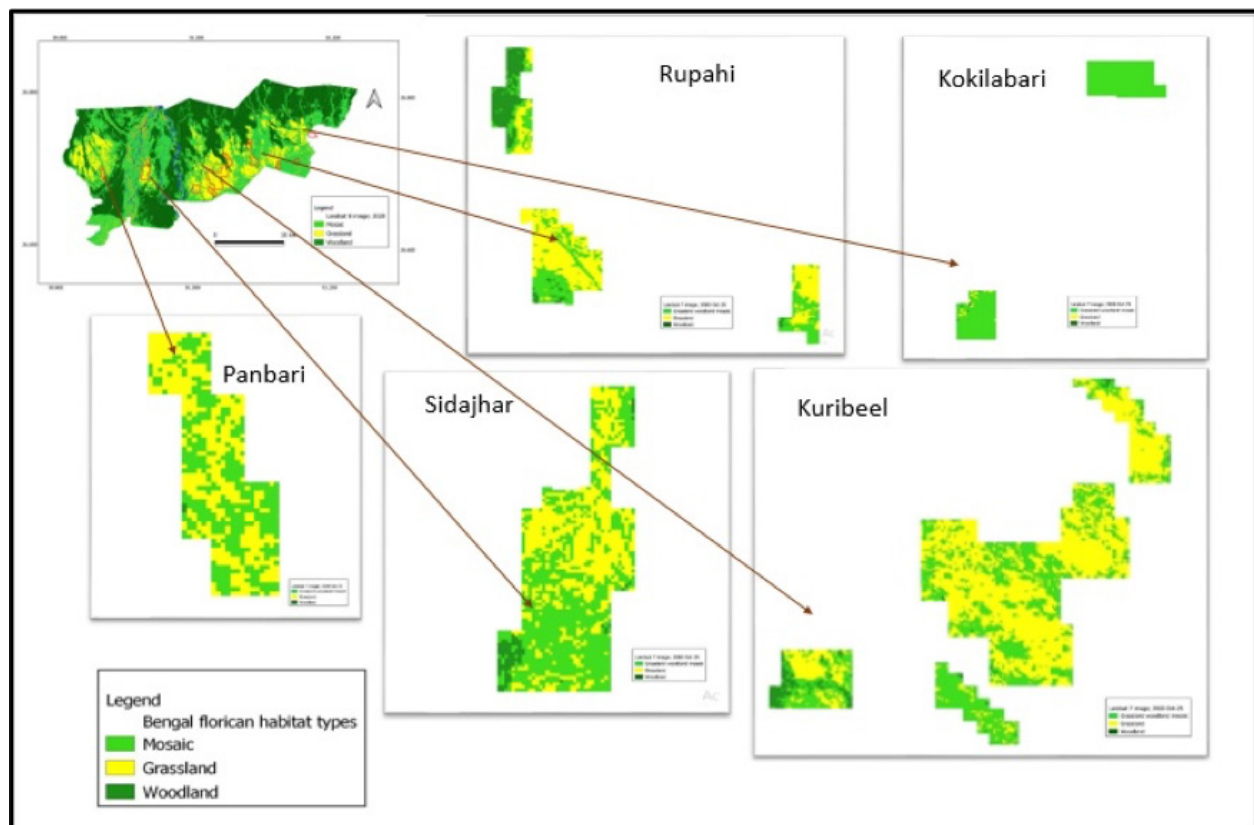


Figure 5. Land use map of Bengal Florican habitat as in 2020.

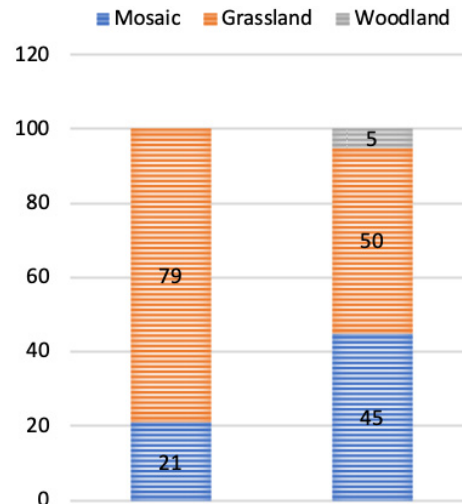
Table 7. List of plants observed in the habitats occupied by Bengal Florican.

	Scientific name	Local name	Family
1	<i>Saccharum narenga</i>	Barenga	Poaceae
2	<i>Saccharum spontaneum</i>	Kohua	Poaceae
3	<i>Leea asiatica</i>	Athu bhanga	Vitaceae
4	<i>Cymbopogon flexuosus</i>	Gondho birina	Poaceae
5	<i>Imperata cylindrica</i>	Ulu kher	Poaceae
6	<i>Phragmites karka</i>	Khagori	Poaceae
7	<i>Premna herbacea</i>	Mati kaldhab	Lamiaceae
8	<i>Commelina</i> sp.	Konaximolu	Commelinaceae
9	<i>Bombax ceiba</i>	Simul	Bombacaceae
10	<i>Croton bonplandianus</i>	Bon tulsi	Euphorbiaceae
11	<i>Scleria terrestris</i>	Har kata	Cyperaceae
12	<i>Cyperus</i> sp.	NA	Cyperaceae
13	<i>Grewia sapida</i>	Mati phehura	Tiliaceae
14	<i>Senecio madagascariensis</i>	NA	Asteraceae
15	<i>Plectranthus ternifolius</i>	NA	Lamiaceae

where Floricans have been recorded. The survey also clearly indicated the success of the method wherein the collaboration between forest frontline staff, invited experts and local guides was instrumental in obtaining a quick result.

The Bengal florican population in Manas has faced severe problems due to habitat loss and degradation, with grassland habitats decreasing alarmingly. Key factors contributing to this conservation challenge include the indiscriminate conversion of grasslands, domestic cattle grazing, unauthorized burning, opportunistic hunting, and egg collection. Invasive species such as *Chromolaena* and *Mikania* further exacerbate the problem by outcompeting native flora crucial for Bengal florican survival. Despite these challenges, our data shows a paradoxical increase in the Bengal florican population. This can be attributed to the concentrated conservation efforts by stakeholders, particularly within the KAF areas, which host sizable populations contributing to the overall increase in the park. However, the persistence of habitat issues necessitates robust management interventions to ensure sustainable population growth.

In Assam, most grasslands are confined to protected areas and a few in the Brahmaputra floodplains. Thus, conserving these grasslands is imperative to protect grassland-obligate avifauna (Brahma 2013). Scientific studies are essential to manage these remaining grasslands effectively. Our study involved mapping the habitat and assessing the current Bengal Florican

**Figure 6. Percentage of land cover change in 2000 and 2020.**

population in Manas. While it is encouraging that the BF population is increasing in Manas, the concurrent decrease in grassland habitat is concerning. While an increase in vegetation cover is often beneficial for forests, in Manas, the increase in specific land cover types such as woodland and woody plant infested mosaic forest poses a serious threat to the unique grassland habitat (Das et al. 2022). Burning of grasslands conducted in January aimed to regenerate grasses and control invasive species. However, this practice is insufficient to reduce the encroachment of alien invasive plants and problematic native plants (Das et al. 2019). Therefore, appropriate habitat management actions must be undertaken to restore and conserve grassland habitats.

RECOMMENDATIONS

- Maintenance of mosaic grassland: Which include both tall and short grasslands.
- Implement comprehensive habitat restoration programs to remove invasive species and native woody species.
 - Strategic implementation of prescribed burning.
 - Enforce stricter regulations against unauthorized land conversion, grazing, and burning.
 - Promote conservation friendly agricultural practices adjacent to grassland areas, especially in KAF.
 - Engage local communities in conservation efforts through education and incentivizing sustainable practices.
- Conduct long-term scientific studies to monitor the impact of management practices in BF population.



Image 1. Male Bengal Florican in flight.



Image 2. Male Bengal Florican in the grassland.

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Articles

Spatial assemblage of shorebirds (Aves: Charadriiformes) in an altered wetland of the southern coast of Sri Lanka

– V.N. Mendis, E.J.A.P. Buddhi Priyankara, E.G.D.P. Jayasekara & W.A.D. Mahaulpatha, Pp. 25495–25506

Current conservation status of Bengal Florican *Houbaropsis bengalensis* in Manas National Park, Assam, India

– Miranda Thakur, Jonmani Kalita, Namita Brahma, Koushik Rajbongshi, Kangkanjyoti Bhattacharyya, Amal Chandra Sarmah, Alolika Sinha, Deba Kumar Dutta, Dhritiman Das & Bibhuti Prasad Lahkar, Pp. 25507–25515

Assemblages of frugivorous butterflies in two urban parks in Quezon City, Philippines

– Micael Gabriel A. Itliong, Nikki Heherson A. Dagamac & Jade Aster T. Badon, Pp. 25516–25527

Assessment of the status of *Spodoptera* species (Lepidoptera: Noctuidae: Armyworm) in India through DNA barcoding technique

– Dinesh Nalage, P.S. Kudnar, Tejswini Sontakke, Ishwar Chittapure, Yashdeep Gowda, Shantanu Kharbal & Yashashri Alamwar, Pp. 25528–25535

Taxonomy and distribution of some orthopteran species (Orthoptera: Gryllidae, Trigonidiidae, Acrididae) from northwestern Morocco

– Hanae El Harche, Samiha Kaioua & Dalale Mansouri, Pp. 25536–25544

Impact of root harvest on *Decalepis hamiltonii* Wight & Arn. population across habitats in Savandurga Reserve Forest, Karnataka, India

– M. Sathya Sangeetha, Kaliamoorthy Ravikumar & H.C. Chetan, Pp. 25545–25570

Communications

Rare encounters: Jungle Cat *Felis chaus* Schreber, 1777 (Mammalia: Carnivora: Felidae) in the lower reaches of the Jordan River, Jordan

– Ehab Eid & Mohammad Farid Alayyan, Pp. 25571–25576

Diversity of bird species in Ebpanan Marsh, Maguindanao del Norte, Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Philippines

– Gindol Rey A. Limbaro, Benito Anthony A. Pingoy & Peter Jan D. de Vera, Pp. 25577–25583

Heleocoris stephanus (Heteroptera: Naucoridae: Laccocorinae), a new species of creeping water bug from Kallada River, Kerala, India

– Dani Benchamin, R. Sreejai & M.S. Arya, Pp. 25584–25589

Incidence and risk factors associated with parasitic infections in captive wild mammals and birds in Indian zoos

– Nikita Das, P.D. Pawar, P.P. Mhase, V.G. Nimbalkar, R.V. Jadhav, V.S. Dhayagude, Gavin Furtado & L.D. Singla, Pp. 25590–25597

Bryophyte diversity of Berinag (Pithoragarh District) in Kumaun Himalaya, Uttarakhand, India

– D. Dhami & P. Chaturvedi, Pp. 25598–25603

Short Communications

The opportunistic feeding behaviour of *Schistura notostigma* (Teleostei: Nemacheilidae) in tropical mountain streams in Sri Lanka

– J. Bandara, M.P. Gunawardena & R.T.P. Jayasuriya, Pp. 25604–25608

First record of *Pieris napi* L. (Lepidoptera: Pieridae) from Kashmir Valley, India

– Firdousa Rasool & Altaf Hussain Mir, Pp. 25609–25612

Reassessment of *Strobilanthes recurva* (Acanthaceae), an endangered plant from Manipur, India

– Rajkumari Jashmi Devi & Biseshwori Thongam, Pp. 25613–25616

New distribution record of Slender Wild Basil *Clinopodium gracile* (Benth.) Kuntze (Lamiaceae: Nepetoideae: Mentheae) for the flora of Himachal Pradesh, India

– Rimjhim Chandra & Mamita Kalita, Pp. 25617–25622

Notes

Rusty-spotted Cat *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) (Mammalia: Carnivora: Felidae) in the semi-natural subterranean habitat in Karnataka, India

– Shirish Manchi, Goldin Quadros, Dipika Bajpai, Shomita Mukherjee, Suma Haleholi, Mahesh Marennavar, Sangmesh Neeralagi, Prakash Ganiger, Suresh Lamani & Nikhil Kulkarni, Pp. 25623–25626

First record of Scaly-breasted Munia *Lonchura punctulata* (Linnaeus, 1758) (Aves: Passeriformes: Estrildidae) from Kashmir, India

– Shazia Shafayat, Fayaz Ahmad Ahanger, Tariq Ahmad, Bilal A. Bhat & Zakir Hussain Najar, Pp. 25627–25629

First record of *Proszynskia diatrete* (Simon, 1902) (Araneae: Salticidae) from Gujarat, India

– Manisha P. Patel & Dhruv A. Prajapati, Pp. 25630–25631

Medicago monantha (Fabaceae) and *Euphorbia jodhpurensis* (Euphorbiaceae) as new additions to the flora of Maharashtra State, India

– Praveen V. Kale & Rajendra D. Shinde, Pp. 25632–25636

Book Review

All eyes on the island: A book review of The Great Nicobar Betrayal

– Lakshmi Ravinder Nair, Pp. 25637–25638

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