Research Article

Status, Distribution, and Diversity of Birds in Mining Environment of Kachchh, Gujarat

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Opencast mining is one of the major reasons for the destruction of natural habitats for many wildlife including birds. The Kachchh region belongs to the arid part of India and is one of the rich areas of mineral resources in the country. In the recent time and after the 2001 earthquake, mining and other developmental activities are increased, and as a result, the natural habitats of birds are disturbed and fragmented. So, this study was conducted to assess the impact of mining and associated activities on the diversity and distribution of birds. Birds were studied by surveying 180 transects along 9 zones around three selected major mines, and each zone is made in every 2 km radius from the mine. Based on the record, it was found that the density and diversity of birds are highest in zone 5 and lowest in zone 1 and zone 2, respectively. The result indicates that the diversity and abundance of birds were less in zones which are located close to the mines in comparison to the zones far from the mines. In conclusion, mining and its associated activities have some impacts on the diversity and distribution of birds in Kachchh region in India.

1. Introduction

Mining and its related activities are one of the major causes for the destruction of natural habitats for wildlife. As these activities increased in context of rapid use of natural resources to meet the demand of the market and the development of region and country, the pressure of threat to the wildlife is increasing day by day. In addition to mining, large parts of forests and wildlife habitats are being cleared for agriculture, industry, roads and railways network, and human habitation leading to degradation, fragmentation, and loss of habitat contributing to the overall loss of biological diversity. The loss of habitat and biological diversity by means of mining and its associated activities creates imbalance in ecological equilibrium.

Kachchh is one of the rich avifaunal diversity areas of India and also falls under one of the migratory route of the avifauna of this country. The list of birds of Kachchh district was made by some workers from time to time; notably among them were Lester [1], Ali [2], Ripley [3], Himmatsinhji [4], and Maharao [5]. The Kachchh district supports around 303

species of birds as recorded by Tiwari [6] and 370 bird species as reported by Sen [7] with some species including raptors, waterfowl, waders, and larks which are commonly found in this district. Similar to that, Kachchh is also a rich area of minerals including limestone, bentonite, and lignite. After the 2001 earthquake in Kachchh, many steps like industrialization and mining activities were increased for the development of this region. The consequence of the above activities results in the loss and fragmentation of habitat for wildlife. The major impacts on avifaunal diversity by means of the above development in postearthquake period are not being studied and assessed. In addition to that, so far no studies were made on the status, distribution, and diversity of birds in relation to the impact of mining and other developmental activities.

The bird species are widely distributed among various habitats in western Kachchh region. Various factors associated with different habitat types had a distinct impact on bird species. Likewise, various land use activities especially open-cast mining that is being done at a mass scale in the region also affect the bird populations considerably, so we tested the following research hypotheses.

Ho: There is an impact of mining on the distribution and diversity of bird species.

2. Materials and Methods

2.1. Study Area. The study was conducted in three major mining areas, namely, Pandhro, Mata-nu-madh, and Jadva. The mining activities are carried out for extraction of minerals including limestone, bentonite, and lignite. All the three mines are opencast mines results into that major loss of habitats by extraction of minerals and dumping of waste materials in open ground. These mines are situated in the westernmost part of Kachchh district, Gujarat, and are very close to the Narayan Sarovar Wildlife Sanctuary, which is the only habitat in Kachchh for Indian gazelle (*Gazella benetti*) and some other wildlife. This area falls in the arid zone of the country and is characterized by presence of an admixture of distinguishable habitats such as *Acacia* forest (AF), *Euphorbia salvadora* forest (ES), mixed thorn forest (MTF), *Prosopis* forest (PF), dense grassland (DG), and sparse grassland (SG). Some seasonal and perennial wetlands and agricultural fields were also interspersed in and around the mining areas. The habitats found in the study area were broadly divided into seven habitat types which are described below.

Acacia Forest (AF). In this habitat, *Acacia senegal* and *Acacia nilotica* were dominant species with negligible distribution of *P. juliflora*.

Mixed Thorn Forest. This habitat is a complex distribution of species like *Acacia nilotica*, *A. senegal*, *Euphorbia caducifolia*, *Grewia* spp. *Commiphora wightii*, and *Salvadora* spp. with some individuals of *P. juliflora*.

Euphorbia salvadora Forest. This habitat, dominated by *Euphorbia caducifolia*, *Salvadora persica*, and *Salvadora oleoides*.

Prosopis Forest. This habitat dominated by the *P. Juliflora* (an Invasive alien species) with few other species like *Grewia tenax*, *G. villosa*, and *Capparis deciduas* which were also found.

Grassland Forest. Some areas were flat to gentle undulate terrain covered by annual or perennial grasses, and absence of shrub or tree species which were categorized under grassland. Grassland has a main component of the member of Gramineae family. *Cymbopogon* spp. and *Dichanthium* spp. are the major grass species.

Agriculture Field. This habitat included agriculture field (fallow or current agriculture) in which annually single cropping system was existed. The agricultural fields were also invaded by *P. juliflora*, *Capparis deciduas*, or *Salvadora* spp.

Wetland. Wetland habitat included man-made and natural water bodies with the presence of water in the whole year or some parts of the year. Most of the wetlands of the study area were man-made due to low precipitation rate.

2.2. Sampling Method. Prior to field surveys, the study area was stratified into various distinguishable habitats such as *Acacia* forest (AF), *Euphorbia salvadora* forest (ES), mixed thorn forest (MTF), *Prosopis* forest (PF), dense grassland (DG), and sparse grassland (SG). The above habitats were evenly distributed in the whole study area. After stratification, the entire area was divided into 5×5 km grids using survey of India's georeferenced coordinate system. Those grid cells were further subdivided into 1×1 km smaller grids, and a total of 180 transects were laid down randomly within the grids (Figure 1). The length of each transect was 1.1 km and was laid down randomly to cover each kind of habitats. To understand the impact of mining on birds, the diversity and distribution pattern of bird was recorded by dividing the area into nine circular zones (zone 1 to zone 9) with an interval of 2 km from the centre of mine (Figure 1). Care was taken to have adequate sampling in each of the topographical features across lateral and vertical gradients like altitudinal range and terrain, and spatially within each habitat type.

Bird survey was done using direct count methods which include (1) point count method and (2) area search method. In point count method [8], birds were recorded in four circular plots with 25 m radius in every 300 m distance along transects. In area search method [9], survey was made in 3 m wide belt along transect in between the circular plot. The time taken for survey varied depending on the terrain and topography. Surveys were conducted in the morning hours (6.30 a.m. to 9.30 a.m.) and evening hours (3.30 p.m. to 6.30 p.m.) by a single observer. Samplings were made in seasonal basis for the period of three years (2008 to 2010) using same transect and time. Observations were carried out with the aid of 8×40 binoculars, and field characteristics were noted down on special ornithological data sheet which included species, number of individuals, activity, microhabitat, threats with other minor details. The birds were identified with the help of Ali and Ripley [10], Ali [11], and Grimmett et al. [12]. Birds sighted during our survey were categorized based on their migratory nature including resident breeder (RB), resident (R), and migrant (M) according to Ali [11] and also categorized into their trophic guilds like insectivore, nectarivore, omnivore, scavenger, frugivore, carnivore, piscivore, and granivore according to Willis [13], Robinson et al. [14], and Anjos [15].

2.3. Data Analysis. The data collected during the whole study period were analyzed in PAST statistical software [16] to calculate species diversity, density, richness, and species composition by using the following formulae.

$$(A) \text{ Shannon Wiener diversity index } (H') \quad H' = \sum P_i \times \ln(P_i), \text{ where}$$

H = index of species diversity,

P_i = proportion of total sample belonging to the i th species,

$\ln$ = natural log1.

$$(B) \text{ Density} = \text{no. of individuals/total area surveyed (in hectare)}.$$

FIGURE 1: Location of the study area and transects (spots) and various zones (in circles) made around the three selected mines (Pandhro, Mata-na-madh, and Jadva) of western Kachchh for bird study.

(C) Menhinick richness index = the ratio of the number of taxa to the square root of sample size.

(D) Buzas and Gibson's evenness: e^H/S .

The rarefaction analysis was carried by using Biodiversity Pro software, 1997, to cope up the problem in comparing diversity among various land cover or habitat categories evaluated during the present study.

2.4. Hypothesis Testing. The null hypotheses tested for significance of differences was the following.

Ha: There is no impact of mining on the distribution and diversity of bird species.

Analysis of variance (ANOVA) was used to test the hypotheses, and Tukey's HSD post hoc analysis was carried to identify specific variables that differ significantly. The variables used for testing the hypotheses included the number of species, density, Shannon diversity index, and Menhinick species richness index. These variables representing bird species diversity were evaluated from each mine zone from Z1 to Z9.

Further, cluster analysis was made to quantify the resemblance among bird communities inhabiting various mine zones. Cluster analysis was performed on bird species. Abundance data were obtained from transect survey using minimum variances technique, known as Ward's method, which has been recognized as the best way to classify the ecological communities and to identify community structure. The cluster analysis generated a dendrogram providing hierarchically nested groups or clusters representing distinct bird communities, which were represented by subclusters.

3. Results

On surveying the mining and surrounding peripheral areas of the study area including all kinds of habitat, 252 species of birds (see Table 2) were recorded in western Kachchh. Various zones from zone 1 to zone 9 made for this study were located in and around the mines as shown in Figure 1. Zone 1 and zone 2 are overlapping with mines and are very close to the mines while zone 9 is the farthest from the mines. These zones were described as Z1, Z2, Z3, Z4, Z5, Z6, Z7, Z8, and Z9. The total number of bird species, mean number of species/transects, and their density recorded in various zones are shown in Table 1. Among these zones, Z1 recorded the least number of species and Z5 recorded the highest number of species of birds, while mean number of species/transects recorded its minimum value in Z2 and its maximum in Z7. Among the zones, Larks were the most abundant group of birds in Z1, Z3, and Z9, common coot was the most abundant in Z2, Z5, and Z8, while lesser short-toed lark, common crane, and white pelican were the most abundant in Z4, Z6, and Z7, respectively. The density or mean number of individual/ha recorded its highest value in Z5 (322) and its lowest in Z1 (204) in comparison to the other zones.

The overall diversity of the birds was rich within each zone of mining areas (Figure 2) with the highest value in Z8 ($H' = 4.47$) and the lowest in Z1 ($H' = 4.10$) and Z4 ($H' = 4.10$), while diversity of bird species/transects recorded the highest value in Z9 ($H' = 3.40$) and the lowest in Z2 ($H' = 2.71$). The species richness in various zones and per transect within each zone was calculated (Figure 3), and found that the Menhinick species richness index/zone was recorded the highest value in Z1 (2.92) and the lowest in Z4 (1.18), whereas Menhinick species richness index/transect recorded the highest value in Z9 (2.65) and the lowest in Z2 (1.96). Similarly, the species

TABLE 1: Bird species diversity and density in various zones of mining areas.

Zone	Total number of species	No. of species/transects	Mean density/Ha
Z1	114	31.66	204
Z2	153	31.06	250
Z3	126	34.33	271
Z4	139	32.73	222
Z5	195	37.89	322
Z6	149	39.54	254
Z7	175	40.42	303
Z8	154	35	270
Z9	157	42.04	248

FIGURE 2: Species diversity of birds in various zones made around the mines in the study area.

evenness values of each zone and transect within were also calculated (Figure 3), and we found that the highest species evenness index was recorded in Z8 (0.57) and the lowest in Z5 (0.34), while species evenness index per transect was recorded more or less similar with the highest value in Z8 (0.78) and the lowest in Z2 (0.66).

On analysis of the data on various aspects of birds diversity in and around the mining areas based on various zones, it was found that diversity (Shannon diversity: $F = 2.984$, $df = 8$, and $P < 0.05$) and richness (Menhinick species richness: $F = 2.403$, $df = 8$, and $P < 0.05$) of birds in between zones differ significantly. Further, a Tukey HSD post hoc analysis results suggest that Z2 differs significantly from Z5 ($P = 0.018$), Z6 ($P = 0.003$), Z7 ($P = 0.015$), Z8 ($P = 0.046$), and Z9 ($P = 0.001$) in terms of mean diversity, and Z2 differs significantly from Z9 ($P = 0.012$) in terms of species richness. Rarefaction analysis was done for the expected number of species in each zone of the mining areas to standardize unequal sampling sizes (Figure 4). The expected number of species recorded its highest value in Z5 and its lowest in Z1. On cluster analysis of the data, abundance of birds revealed

FIGURE 3: Species richness and equitability of birds in various zones made around the mines in the study area.

FIGURE 4: Rarefaction curve for expected number of bird species in different zones of mining environment of Kachchh, Gujarat.

great similarities among sampling points belonging to the same kind of habitat. Six distinct groups, namely, Z1, Z3; Z4, Z6; Z9; Z8; Z2; Z7, Z5 were identified (Figure 5), and we found that Z4 and Z6 have maximum similarity in abundance and next to that were Z1 and Z3, while they have very less similarity of clusters with Z5.

TABLE 2: Checklist of birds recorded during the study.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
<i>Anseriformes</i>						
1	Anatidae	<i>Anas acuta</i>	Northern pintail	M	—	A
2		<i>Anas clypeata</i>	Northern shoveller	M	—	A
3		<i>Anas penelope</i>	Eurasian wigeon	M	—	A
4		<i>Anas platyrhynchos</i>	Mallard	RM	—	A
5		<i>Anas poecilorhyncha</i>	Spot-billed duck	RM	—	A
6		<i>Anas querquedula</i>	Garganey	M	—	A
7		<i>Anas strepera</i>	Gadwall	M	—	A
8		<i>Aythya ferina</i>	Common pochard	M	—	A
9		<i>Aythya fuligula</i>	Tufted pochard	M	—	A
10		<i>Sarkidiornis melanotos</i>	Comb duck	R	—	A
11	Dendrocygnidae	<i>Dendrocygna javanica</i>	Lesser whistling duck	R	—	A
<i>Apodiiformes</i>						
12	Apodidae	<i>Apus affinis</i>	House(little) swift	R	—	I
<i>Ciconiiformes</i>						
13	Accipitridae	<i>Accipiter badius</i>	Shikra	R	—	C
14		<i>Accipiter nisus</i>	Eurasian sparrow-hawk	R	—	C
15		<i>Aquila heliaca</i>	Imperial eagle	R	VU	C
16		<i>Aquila nipalensis</i>	Steppe eagle	M	—	C
17		<i>Aquila pomarina</i>	Lesser spotted eagle	M	—	C
18		<i>Aquila rapax</i>	Tawny eagle	R	—	C
19		<i>Butastur teesa</i>	White-eyed buzzard	R	—	C
20		<i>Buteo buteo</i>	Long-legged buzzard	R	—	C
21		<i>Circaetus gallicus</i>	Short-toad snake eagle	R	—	C
22		<i>Circus aeruginosus</i>	Eurasian marsh harrier	M	—	C
23		<i>Circus macrourus</i>	Pallid harrier	M	NT	C
24		<i>Circus melanoleucos</i>	Pied harrier	RM	—	C
25		<i>Circus pygargus</i>	Montagu's harrier	M	—	C
26		<i>Elanus caeruleus</i>	Black-shouldered kite	R	—	C
27		<i>Gyps bengalensis</i>	Indian white-backed vulture	R	CR	C
28		<i>Gyps indicus</i>	Long-billed vulture	R	CR	C
29		<i>Haliaeetus leucogaster</i>	White-bellied sea-eagle	R	—	C
30		<i>Haliaeetus leucoryphus</i>	Pallas's fish-eagle	RM	VU	C
31		<i>Haliastur Indus</i>	Brahminy kite	R	—	C
32		<i>Hieraaetus fasciatus</i>	Bonelli's eagle	M	—	C
33		<i>Hieraaetus pennatus</i>	Booted eagle	R	—	C
34		<i>Milvus migrans</i>	Black kite	R	—	C
35		<i>Pernis ptilorhynchus</i>	Oriental honey-buzzard	R	—	C
36		<i>Spilornis cheela</i>	Crested serpent eagle	R	—	C
37	Ardeidae	<i>Ardea alba</i>	Great egret	RM	—	A
38		<i>Ardea cinerea</i>	Grey heron	RM	—	A
39		<i>Ardea purpurea</i>	Purple heron	RM	—	A
40		<i>Ardeola grayii</i>	Indian pond heron	R	—	A
41		<i>Bubulcus ibis</i>	Cattle egret	R	—	I
42		<i>Butorides striatus</i>	Little green heron	RM	—	A
43		<i>Egretta garzetta</i>	Little egret	R	—	A
44		<i>Egretta gularis</i>	Western reef-egret	R	—	A
45		<i>Mesophoyx intermedia</i>	Intermediate egret	R	—	A
46	Burhinidae	<i>Burhinus oedicnemus</i>	Eurasian thick-knee	R	—	A

TABLE 2: Continued.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
47	Charadriidae	<i>Calidris alpine</i>	Dunlin	M	—	A
48		<i>Charadrius alexandrinus</i>	Kentish plover	RM	—	A
49		<i>Charadrius mongolus</i>	Lesser sand plover	RM	—	A
50		<i>Charadrius dubius</i>	Common ring plover	RM	—	A
51		<i>Esacus magirostris</i>	Greater sand-plover	R	—	A
52		<i>Himantopus himantopus</i>	Black-winged stilt	R	—	A
53		<i>Pluvialis squatarola</i>	Grey plover	M	—	A
54		<i>Rostratula benghalensis</i>	Painted snipe	R	—	A
55		<i>Tringa erythropus</i>	Spotted redshank	M	—	A
56		<i>Vanellus indicus</i>	Red-wattled lapwing	R	—	I
57		<i>Vanellus malabaricus</i>	Yellow-wattled lapwing	R	—	I
58		<i>Calidris minuta</i>	Little stint	M	—	A
59	Ciconiidae	<i>Ephippiorhynchus asiaticus</i>	Black necked stork	R	NT	P
60		<i>Mycteria leucocephala</i>	Painted stork	RM	NT	A
61	Falconidae	<i>Falco chicquera</i>	Red-necked falcon	R	—	C
62		<i>Falco jugger</i>	Lagger falcon	R	NT	C
63		<i>Falco naumanni</i>	Lesser kestrel	R	VU	C
64		<i>Falco subbuteo centralasiae</i>	Eurasian hobby	M	—	C
65		<i>Falco tinnunculus</i>	Common kestrel	RM	—	C
66	Glareolidae	<i>Cursorius coromandelicus</i>	Indian courser	R	—	I
67	Laridae	<i>Calidris alba</i>	Sanderling	RM	—	P
68		<i>Chlidonias leucopterus</i>	White winged black tern	RM	—	P
69		<i>Larus brunnicephalus</i>	Brown-headed gull	RM	—	P
70		<i>Larus cachinnans</i>	Yellow-legged gull	M	—	P
71		<i>Larus fuscus</i>	Lesser black backed gull	M	—	P
72		<i>Sterna acuticauda</i>	Black-bellied tern	M	NT	P
73		<i>Sterna aurantia</i>	River tern	R	—	A
74	Pelecanidae	<i>Sterna caspia</i>	Caspian tern	RM	—	P
75		<i>Pelecanus onocrotalus</i>	Great white-pelican	RM	—	P
76	Phalacrocoracidae	<i>Phalacrocorax carbo</i>	Great cormorant	R	—	A
77		<i>Phalacrocorax fuscicollis</i>	Indian cormorant	R	—	A
78		<i>Phalacrocorax niger</i>	Little cormorant	R	—	A
79	Phoenicopteridae	<i>Phoenicopeterus minor</i>	Lesser flamingo	RM	NT	A
80		<i>Phoenicopeterus ruber</i>	Greater flamingo	RM	—	A
81	Podicipedidae	<i>Podiceps cristatus</i>	Great crested grebe	RM	—	A
82		<i>Podiceps nigricollis</i>	Black-necked grebe	M	—	A
83		<i>Tachybaptus ruficollis</i>	Little grebe	R	—	A
84	Pteroclididae	<i>Pterocles alchata</i>	White-bellied sandgrouse	M	—	G
85		<i>Pterocles exustus</i>	Chestnut-bellied sandgrouse	R	—	G
86		<i>Pterocles indicus</i>	Painted sandgrouse	R	—	G
87	Scolopacidae	<i>Actitis hypoleucos</i>	Common sandpiper	R	—	A
88		<i>Limosa limosa</i>	Black-tailed godwit	M	NT	A
89		<i>Numenius phaeopus</i>	Whimbrel	M	—	A
90		<i>Tringa glareola</i>	Wood sandpiper	M	—	A
91		<i>Tringa nebularia</i>	Common greenshank	M	—	A
92		<i>Tringa ochropus</i>	Green sandpiper	M	—	A
93		<i>Tringa stagnatilis</i>	Marsh sandpiper	M	—	A
94	Threskiornithidae	<i>Platalea leucorodia</i>	Eurasian spoonbill	RM	—	A
95		<i>Plegadis falcinellus</i>	Glossy ibis	RM	—	I
96		<i>Pseudibis papillosa</i>	Black ibis	R	—	I
97		<i>Threskiornis melanocephalus</i>	Black-headed ibis	RM	NT	A

TABLE 2: Continued.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
<i>Columbiformes</i>						
98	Columbidae	<i>Columba livia</i>	Rock pigeon	R	—	G
99		<i>Streptopelia chinensis</i>	Spotted dove	R	—	G
100		<i>Streptopelia decaocto</i>	Eurasian collared dove	R	—	G
101		<i>Streptopelia orientalis</i>	Oriental turtle-dove	RM	—	G
102		<i>Streptopelia senegalensis</i>	Laughing dove	R	—	G
103		<i>Streptopelia tranquebarica</i>	Red-collared dove	R	—	G
<i>Coraciiformes</i>						
104	Alcedinidae	<i>Alcedo Hercules</i>	Common kingfisher	R	—	P
105	Cerylidae	<i>Ceryle rudis</i>	Lesser pied kingfisher	R	—	P
106	Coraciidae	<i>Coracias benghalensis</i>	Indian roller	R	—	I
107		<i>Coracias garrulus</i>	European roller	RM	NT	I
108	Dacelonidae	<i>Halcyon smyrnensis</i>	White-throated	R	—	P
109	Meropidae	<i>Merops leschenaulti</i>	Chestnut-headed bee-eater	R	—	I
110		<i>Merops orientalis</i>	Green bee-eater	R	—	I
111		<i>Merops persicus</i>	Blue-cheeked bee-eater	RM	—	I
112		<i>Merops philippinus</i>	Blue-tailed bee-eater	RM	—	I
<i>Cuculiformes</i>						
113	Centropodidae	<i>Centropus sinensis</i>	Greater coucal	R	—	O
114	Cuculidae	<i>Cuculus canorus</i>	Pied-crested cuckoo	R	—	I
115		<i>Eudynamys scolopacea</i>	Asian koel	R	—	F
116		<i>Phaenicophaeus leschenaultii</i>	Sirkeer cuckoo	R	—	O
<i>Galliformes</i>						
117	Phasianidae	<i>Coturnix coromandelica</i>	Rain quail	R	—	G
118		<i>Coturnix coturnix</i>	Common quail	R	—	G
119		<i>Francolinus francolinus</i>	Black francolin	R	—	G
120		<i>Francolinus pictus</i>	Painted francolin	R	—	G
121		<i>Francolinus pondicerianus</i>	Grey francolin	R	—	G
122		<i>Pavo cristatus</i>	Indian peafowl	R	—	G
123		<i>Perdica asiatica</i>	Jungle bush quail	R	—	G
<i>Gruiformes</i>						
124	Gruidae	<i>Grus grus</i>	Common crane	M	—	O
125		<i>Grus virgo</i>	Demoiselle crane	M	—	O
126	Otididae	<i>Ardeotis nigriceps</i>	Great indian bustard	R	EN	G
127	Rallidae	<i>Fulica atra</i>	Common coot	R	—	A
128		<i>Gallinula chloropus</i>	Common moorhen	R	—	A
<i>Passeriformes</i>						
129	Alaudidae	<i>Alauda arvensis</i>	Eurasian skylark	R	—	G
130		<i>Alauda gulgula</i>	Oriental skylark	R	—	G
131		<i>Ammomanes phoenicurus</i>	Rufous-tailed lark	R	—	G
132		<i>Calandrella brachydactyla</i>	Greater short-toed lark	M	—	G
133		<i>Calandrella rufescens</i>	Lesser short-toed lark	RM	—	G
134		<i>Eremopterix grisea</i>	Ashy-crowned sparrow-lark	R	—	G
135		<i>Galerida cristata</i>	Crested lark	R	—	G
136		<i>Galerida deva</i>	Sykes's crested lark	R	—	G
137		<i>Galerida malabarica</i>	Malabar lark	RM	—	G
138		<i>Mirafra affinis</i>	Jerdon's bushlark	RM	—	G
139		<i>Mirafra cantillans</i>	Singing bushlark	R	—	G
140		<i>Mirafra erythroptera</i>	Indian bushlark	R	—	G
141		<i>Mirafra erythroptera</i>	Red-winged bush-lark	R	—	G

TABLE 2: Continued.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
142	Certhiidae	<i>Salpornis spilonotus</i>	Spotted creeper	R	—	I
143	Cisticolidae	<i>Orthotomus sutorius</i>	Tailor bird	R	—	I
144		<i>Prinia buchanani</i>	Rufous-fronted prinia	R	—	I
145		<i>Prinia hodgsonii</i>	Grey-breasted prinia	R	—	I
146		<i>Prinia inornata</i>	Plain prinia	R	—	I
147		<i>Prinia socialis</i>	Ashy prinia	R	—	I
148		<i>Prinia sylvatica</i>	Jungle prinia	R	—	I
149	Corvidae	<i>Aegithina nigrolutea</i>	Marshall's iora	R	—	I
150		<i>Coracina macei</i>	Large cuckoo shrike	R	—	I
151		<i>Corvus splendens</i>	House crow	R	—	O
152		<i>Dendrocitta vagabunda</i>	Rufous treepie	R	—	I
153		<i>Dicrurus caerulescens</i>	White-bellied drongo	R	—	I
154		<i>Dicrurus macrocercus</i>	Black drongo	R	—	I
155		<i>Pericrocotus cinnamomeus</i>	Small minivet	R	—	I
156		<i>Rhipidura aureola</i>	White-browed fantail	R	—	I
157		<i>Tephrodornis gularis</i>	Large wood shrike	R	—	I
158		<i>Tephrodornis pondicerianus</i>	Common woodshrike	R	—	I
159	Fringillidae	<i>Emberiza buchanani</i>	Grey-necked bunting	M	—	G
160		<i>Emberiza cia</i>	Rock bunting	M	—	G
161		<i>Emberiza melanocephala</i>	Ortolan bunting	M	—	G
162		<i>Emberiza striolata</i>	House bunting	R	—	G
163		<i>Melophus lathami</i>	Crested bunting	R	—	G
164	Hirundinidae	<i>Hirundo concolor</i>	Dusky crag-martin	R	—	I
165		<i>Hirundo daurica</i>	Red-rump swallow	R	—	I
166		<i>Hirundo fluvicola</i>	Streak-throated swallow	R	—	I
167		<i>Hirundo rupestris</i>	Eurasian crag-martin	R	—	I
168		<i>Hirundo rustica</i>	Barn swallow	RM	—	I
169		<i>Hirundo smithii</i>	Wire-tailed swallow	R	—	I
170	Laniidae	<i>Lanius collurio</i>	Red-backed shrike	R	—	C
171		<i>Lanius cristatus</i>	Brown shrike	M	—	C
172		<i>Lanius isabellinus</i>	Rufous-tailed shrike	RM	—	C
173		<i>Lanius meridionalis</i>	Southern grey shrike	R	—	C
174		<i>Lanius schach</i>	Long-tailed shrike	R	—	C
175		<i>Lanius schach canipes</i>	Rufous-backed shrike	R	—	C
176		<i>Lanius vittatus</i>	Bay-backed shrike	R	—	C
177	Muscicapidae	<i>Cercomela fusca</i>	Brown rock chat	R	—	I
178		<i>Cercotrichas galactotes</i>	Rufous chat	M	—	I
179		<i>Copsychus saularis</i>	Oriental magpie robin	R	—	I
180		<i>Culicicapa ceylonensis</i>	Grey-headed flycatcher	R	—	I
181		<i>Ficedula parva</i>	Red-throated flycatcher	R	—	I
182		<i>Ficedula superciliaris</i>	Ultramarine flycatcher	R	—	I
183		<i>Muscicapa striata</i>	Spotted flycatcher	RM	—	I
184		<i>Oenanthe deserti</i>	Desert wheatear	RM	—	I
185		<i>Oenanthe isabellina</i>	Isabelline wheatear	RM	—	I
186		<i>Oenanthe picata</i>	Variable wheatear	M	—	I
187		<i>Phoenicurus erythronotus</i>	Rufous-backed redstart	RM	—	I
188		<i>Phoenicurus ochruros</i>	Black redstart	RM	—	I
189		<i>Saxicola caprata</i>	Pied bush chat	R	—	I
190		<i>Saxicola jerdoni</i>	Pied chat	R	—	I
191		<i>Saxicola macrorhyncha</i>	Stoliczka's bushchat	RM	VU	I

TABLE 2: Continued.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
192		<i>Saxicola torquata</i>	Common stonechat	RM	—	I
193		<i>Saxicoloides fulicata</i>	Indian robin	R	—	I
194		<i>Turdus naumanni</i>	Dusky thrush	RM	—	I
195		<i>Turdus obscurus</i>	Eyebrowed thrush	RM	—	I
196		<i>Zoothera citrina</i>	Orange-headed thrush	R	—	I
197	Nectariniidae	<i>Aethopyga siparaja</i>	Crimson sunbird	R	—	N
198		<i>Dicaeum agile</i>	Thick-billed flowerpecker	R	—	N
199		<i>Nectarinia asiatica</i>	Purple sunbird	R	—	N
200		<i>Nectarinia zeylonica</i>	Purple-rumped sunbird	R	—	N
201	Paridae	<i>Parus major</i>	Great tit	R	—	I
202		<i>Parus nuchalis</i>	Pied tit	R	VU	I
203	Passeridae	<i>Anthus campestris</i>	Tawny pipit	RM	—	G
204		<i>Anthus godlewski</i>	Blyth's pipit	RM	—	G
205		<i>Anthus rufulus</i>	Paddyfield pipit	R	—	G
206		<i>Anthus similis jerdoni</i>	Brown rock pipit	M	—	G
207		<i>Anthus trivialis</i>	Tree pipit	RM	—	G
208		<i>Dendronanthus indicus</i>	Forest wagtail	RM	—	I
209		<i>Lonchura malabarica</i>	Indian silverbill	R	—	G
210		<i>Lonchura striata</i>	White-rumped munia	R	—	G
211		<i>Motacilla alba</i>	White wagtail	RM	—	I
212		<i>Motacilla cinerea</i>	Grey wagtail	RM	—	I
213		<i>Motacilla citreola</i>	Citrine wagtail	RM	—	I
214		<i>Motacilla flava</i>	Yellow wagtail	RM	—	I
215		<i>Passer domesticus</i>	House sparrow	R	—	G
216		<i>Petronia xanthocollis</i>	Chestnut-shouldered petronia	R	—	G
217		<i>Ploceus philippinus</i>	Baya weaver	R	—	G
218	Pycnonotidae	<i>Pycnonotus cafer</i>	Red-vented bulbul	R	—	I
219		<i>Pycnonotus leucotis</i>	White-eared bulbul	R	—	I
220	Sturnidae	<i>Acridotheres ginginianus</i>	Bank myna	R	—	O
221		<i>Acridotheres tristis</i>	Common myna	R	—	I
222		<i>Sturnus pagodarum</i>	Brahminy starling	R	—	O
223		<i>Sturnus roseus</i>	Rosy starling	M	—	G
224	Sylviidae	<i>Acrocephalus aedon</i>	Thick-billed warbler	M	—	I
225		<i>Acrocephalus dumetorum</i>	Blyth's reed-warbler	RM	—	I
226		<i>Acrocephalus stentoreus</i>	Indian great reed-warbler	RM	—	I
227		<i>Chaetornis striatus</i>	Bristled grass-warbler	M	VU	I
228		<i>Chrysomma sinense</i>	Yellow-eyed babbler	R	—	I
229		<i>Cisticola juncidis</i>	Streak fantail warbler	R	—	I
230		<i>Hippolais caligata</i>	Booted warbler	RM	—	I
231		<i>Locustella naevia</i>	Grasshopper warbler	R	—	I
232		<i>Phylloscopus inornatus</i>	Desert warbler	R	—	F
233		<i>Phylloscopus magnirostris</i>	Large-billed leaf-warbler	M	—	I
234		<i>Phylloscopus neglectus</i>	Plain-leaf warbler	R	—	F
235		<i>Phylloscopus trochiloides</i>	Greenish leaf-warbler	M	—	I
236		<i>Sylvia communis</i>	Greater whitethroat	R	—	I
237		<i>Sylvia curruca</i>	Lesser whitethroat	M	—	I
238		<i>Sylvia hortensis</i>	Orphean warbler	M	—	I
239		<i>Turdoides caudatus</i>	Common babbler	R	—	G
240		<i>Turdoides malcolmi</i>	Large grey babbler	R	—	G
241		<i>Turdoides striatus</i>	Jungle babbler	R	—	G
242	Zosteropidae	<i>Zosterops palpebrosus</i>	Oriental white-eye	RM	—	F

TABLE 2: Continued.

Sl. no.	Order/family	Species scientific name	Common name	MS	IUCN 2010	Feeding habit
<i>Piciformes</i>						
243	Picidae	<i>Dendrocopos mahrattensis</i>	Yellow-fronted pied woodpecker	R	—	I
244		<i>Jynx torquilla</i>	Eurasian wryneck	R	—	I
<i>Psittaciformes</i>						
245	Psittacidae	<i>Psittacula cyanocephala</i>	Plum-headed parakeet	R	—	F
246		<i>Psittacula krameri</i>	Rose-ringed parakeet	R	—	F
<i>Strigiformes</i>						
247	Strigidae	<i>Bubo bubo</i>	Eurasian eagle owl	R	—	C
248		<i>Otus bakkamoena</i>	Collared scops-owl	R	—	I
249	Caprimulgidae	<i>Caprimulgus asiaticus</i>	Indian nightjar	R	—	I
250		<i>Caprimulgus europaeus</i>	Eurasian nightjar	M	—	I
251	Strigidae	<i>Athene brama</i>	Spotted owlet	R	—	C
<i>Upupiformes</i>						
252	Upupidae	<i>Upupa epops</i>	Common hoopoe	RM	—	I

FIGURE 5: Clusters of zones based on abundance of bird species in mining areas of Kachchh, Gujarat.

4. Discussion

Ecosystem disturbance is one of the major phenomena in recent times which alters the relationship of organisms and their habitat in time and space. The extraction of mineral resources through mining activities in wildlife areas is one of the major factors for ecosystem disturbances and habitat fragmentation results impact on the survival of precious wildlife. Large-scale denudation of forest cover, scarcity of water, pollution of air, water, and soil, and degradation of agricultural lands are some of the conspicuous environmental implications of mining in western Kachchh. The result of the study reveals that the whole mining areas and its surrounding areas are rich in terms of avifaunal diversity and abundance. It's also found that the species diversity, richness, and abundance were less in the zones which are close to the mines within 4 km radius to mines. Interestingly, the species diversity was found lowest in zone 2 in comparison to zone 1 which is probably due to the frequency of mining activities which were more in zone 2 in comparison to zone 1. The mining activity is completed in zone 1 and as a result some aquatic water bodies were developed in this zone which attracts aquatic birds to it. Salovarov and Kuznetsova [17] also found similar type of results

in coal mining areas of Angara region, Russia. At the present time, mining activities are more frequent in zone 2 as a result of bird species diversity, and abundance recorded less in comparison to the other zones. The species diversity, abundance, and richness were found highest in zones beyond zone 5 to zone 9 which were located in between 8 km to 18 km from the mines. The expected number of species in zone 5 was found to be the highest and zone 2 was the lowest. Some of the species of birds may adapt to the human habitation and mining environment as it provides easy food and habitat. Smith et al. [18] found that mining has no impact on birds, but it helps in supporting some breeding birds. The species of birds which naturally survive in certain kind of habitat in this area will get more threat from the mining activities as the mining in this areas is opencast type.

5. Conclusion

These results indicate that mining and its associated activities have some impacts on the diversity and distribution of birds in Kachchh region of Gujarat. The enhancement of mining and other developmental activities after the earthquake and in recent times has worsened the situation which will further increase the rate of habitat destruction and their avifaunal diversity. Apart from the above, western Kachchh is the gateway of large number of migratory birds to India which will also be affected if the rate of mining activities and industrial development will go on like today.

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