International Journal of Ecology and Environmental Sciences 48: 673-686, 2022
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2022.6673

Sarus Crane: Life in Human-Dominated Landscape

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ABSTRACT
The Sarus Crane *Grus antigone* is one of culturally important birds of India, living in human-dominated landscapes mainly due to the tolerance of the general public. It is dependent on seasonally occurring small shallow wetlands called *jheels* for foraging and breeding. These jheels are under tremendous biotic pressures mainly due to expansion of agriculture and urbanization. Climate change and unpredictable monsoons are putting additional pressures on the Sarus habitat. New threats in the form of free-ranging dogs, expansion of fisheries/water-chestnut cultivation, plastic pollution, and over-head transmission wires have emerged which may impact the Sarus populations. The paper discusses the life of Sarus Crane in human-dominated landscape of central Uttar Pradesh, India.

Key words: Sarus crane, *Grus antigone antigone*, ecology, status, human-dominated landscape, Uttar Pradesh

INDTRODUCTION

In India, the Sarus Crane *Grus antigone* (henceforth Sarus) is mainly found in north, northwest and central India, and as we go south, its population decreases. It is found in Punjab, Haryana, Uttar Pradesh, western Bihar, Jharkhand, Rajasthan, Gujarat, Madhya Pradesh, Chhattisgarh and northern Maharashtra. There are occasional records from Himachal Pradesh, Andhra Pradesh, Telangana, and Odisha. The largest numbers of Sarus are found in Gujarat, Rajasthan and Uttar Pradesh. Uttar Pradesh can be called the Sarus Capital of India. Incidentally, Uttar Pradesh is one of the most densely populated states in India, with human density of 828 persons per km^2. Outside India, it is still found in the terai of Nepal, but extinct in Pakistan and Bangladesh due to hunting. A subspecies of Sarus *Grus antigone sharpii* is found in Myanmar, Cambodia and Vietnam (extinct?), and Australia.

Sarus is the largest bird of India, and the tallest flying bird of the world. Like most crane species, Sarus is also dependent on marshes and *jheels* for foraging, resting and nesting, but being adaptable, it frequently uses flooded agricultural fields for foraging and nesting. These fields are surrogate marshes for Sarus. It is not found in large deep wetlands. It is also not found in forested protected areas even though they may have a few marshes (e.g. Dudhwa, Kishanpur) due to the danger of predation by tiger or leopard (Rahmani et al. 2019). It is a bird of floodplain shallow seasonal marshes, either developed due to flooding of large rivers or/and created by monsoonal deposition in depressions. Most of these marshes are now more or less taken over by human being for agricultural or industrial purpose, therefore, in some areas Sarus has no choice but to live in crop fields.

Sarus cannot live in sugarcane areas as sugarcane is dense and tall. Nonetheless, it is frequently seen in newly-grown sugarcane below the height of Sarus, but not in tall sugarcane. It is, however, frequently found in paddy and wheat fields, particularly when they are irrigated. It is also found in harvested paddy/ wheat fields to feed on fallen grains, and in wet grasslands, particularly found on the edges of drying up shallow jheels and lakes (Sundar and Choudhury 2003, Sundar and Subramanya 2010, Rahmani et al. 2019).

Sarus is an omnivorous bird and forages in shallow wetlands, inundated crop fields, fallow fields and margins of small rivers. Their diet consists of fallen grains, tubers, roots, aquatic insects,

grasshoppers, tadpoles, small fish, eggs of birds, as well as several species of aquatic plants. They have been seen to feed on larger vertebrates such as water snake, fish and baby turtles but this is very rare. Many times, they catch a large fish or a frog, and peck at it desultory, and may eat a few pieces if the prey breaks down, and leave it. Among the aquatic vegetation, they eat tubers, corns, and grass shoots. Tubers of aquatic and semi-aquatic plants appears to be their main diet, and Sarus can be seen probing in the soil for a long time till they extract the tuber. They probe in to the depth that their large beak can reach. Sometimes they even submerge their head for a brief period to reach a particular tuber. They eat seeds and grains such as exposed groundnut, and fallen rice and wheat grains. The agricultural crops, however, do not constitute a major diet of the Sarus and hence they are tolerated by the farmers in the agricultural landscape (Choudhury and Rahmani 2014).

In several wetlands, Important Bird and Biodiversity Areas (IBAs), and other Protected Areas (PAs) of Uttar Pradesh a sizable population of Sarus survive. The PAs supporting Sarus in Uttar Pradesh are National Chambal Sanctuary, Sur Sarovar Bird Sanctuary, Nawabganj Bird Sanctuary, Parwati-Aranga Bird Sanctuary, Patna Bird Sanctuary, Saman Bird Sanctuary, Sandi Bird Sanctuary, and Bakhira Bird Sanctuary (Rahmani et al. 2016). Though the state has 15 wetland-based bird sanctuaries, there is no specific Sarus Conservation Reserve or Sanctuary in the state. However, 90% of the Sarus population in the state of Uttar Pradesh inhabit outside the protected area network of the state. The state forest department's Sarus habitat survey reveals out of around 1,550 Sarus Crane habitation sites, 25% are privately owned, and the others are either

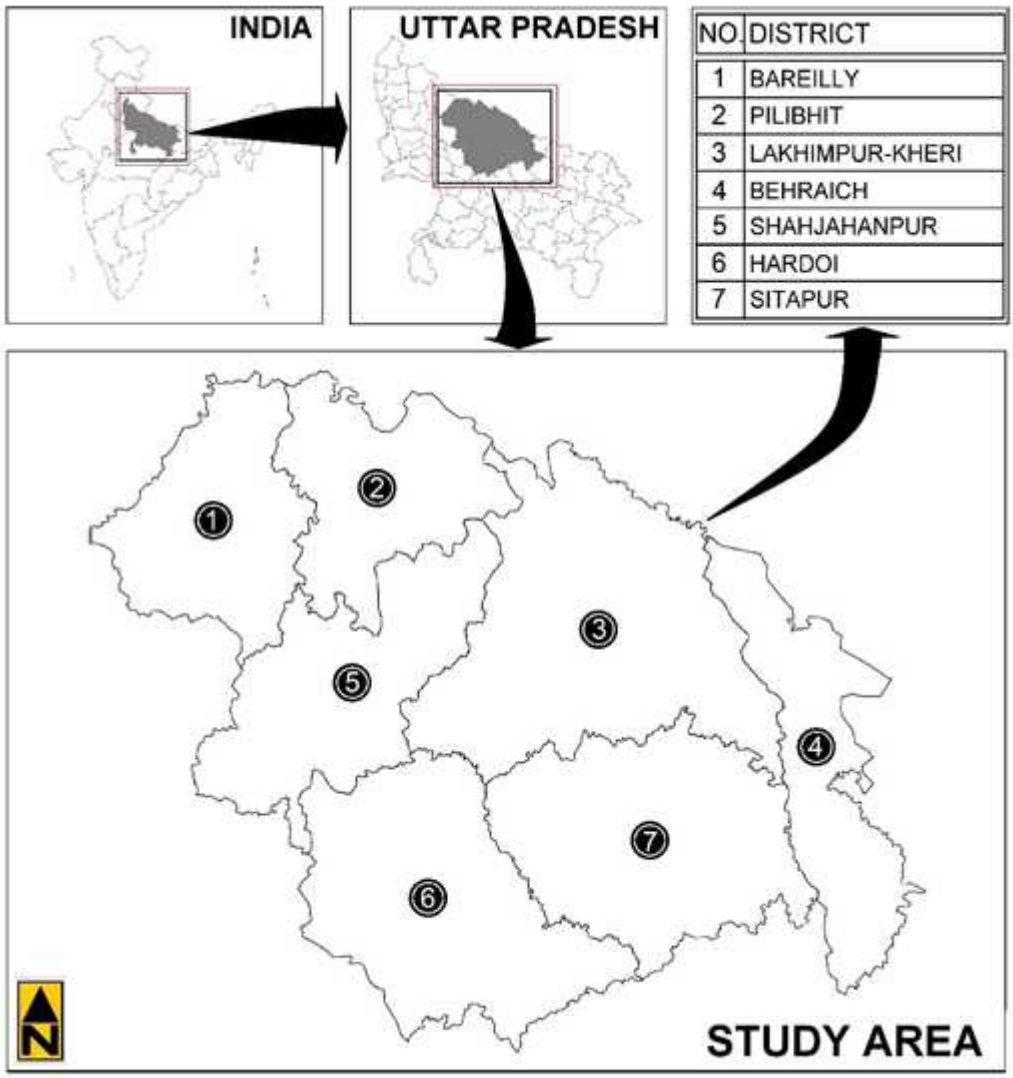

Figure 1. Study area

government or community owned. In this paper, we discuss the survival of Sarus crane in human-dominated landscape of central Uttar Pradesh and the problems it faces.

STUDY AREA

Most of the study was conducted from July 2017 to June 2019 in seven districts: Lakhimpur Kheri, Pilibhit, Shahjahanpur, Hardoi, Sitapur and Barielly, with few visits to Bahraich district (Fig. 1). The climate of the study area can be described as humid subtropical, with dry winter and hot summer. The temperature varies from 0^{O}C in winter to 45^{O}C in summer. The monsoon starts from mid-June and last for three months. The total average annual rainfall is 1,000 mm, 85% falling during monsoon. In several areas cyclical droughts and floods occur due to unpredictable rains. This unpredictability is likely to increase with climate change. Human population density is very high, much above the national density of 520 people/km^2. For example, Sitapur has 780 people/km^2, Pilibhit 559 people/km^2, and Hardoi 690 people/km^2. Most of the natural forests is left in the terai belt of Pilibhit, Lakhimpur-Kheri and Bahraich districts.

Wetlands of the Gangetic plains

Uttar Pradesh has a network of rivers, most draining in the Ganga River. Besides Ganga, the major rivers are Yamuna, Ghagra, Gandak, Chambal, Ramganga, Gomati, Rapti, Betwa, Sind, Ken and many others. There are many minor rivers, all ultimately draining in the Ganga or its major tributaries. There are thousands of wetlands dotted all over the state, many occurring in the flood plains of major rivers and many formed during monsoon in depressions.

According to the National Wetland Atlas, Government of India, there are 745,370 fresh-water wetlands in India that were mapped by Space Application Centre, Ahmedabad (Anonymous 2011). Out of which, 630,869 wetlands are less than 5 ha (84.64%), 44,007 wetlands are between 5 and 10 ha (5.90%) and 53,710 wetlands are 10-50 ha (7.21%). We can say that almost 98% of the wetlands are less than 50 ha. These are the wetlands, if present in north and central India are important for Sarus. Other figures are also interesting (Table 1). Despite the fact that wetlands from 100 to 500 ha form only 0.83% of the total number of wetlands, area-wise they constitute 12.14%. We have given below some statistics of the wetlands, reservoirs, rivers in India.

According to SAC data, there are nearly 14,000 wetlands in Uttar Pradesh that are below 5 hectares, and more than 10,000 wetlands are between 5 and 50 ha. They constitute nearly 50% of the all the wetlands mapped by SAC. There are the wetlands that are useful for Sarus breeding and foraging (Table 2).

Reservoirs number nearly 1600 of different sizes (Table 3) but such reservoirs are not suitable for Sarus for breeding purpose, except for foraging and loafing. There is another category of wetlands which excludes rivers and reservoir, according to SAC that number more than 25,000 (Table 4). Coming to the study districts, in Table 5, basic statistics of different types of wetlands and their respective area covered are given. These statistics apart, what is important for

Table 1. Number of natural wetlands in India in National Wetland Atlas, Government of India based on the information of Space Application Centre, Ahmedabad. (Reference: Anonymous 2011)

Size of wetland	No. of wetlands	% of number	Area of wetlands (in ha)	% of area
Less than 5 ha	6,30,869	84.64%	7,91,750.94	7.91%
5-10 ha	44,007	5.90%	3,10,443.91	3.10%
10-50 ha	53,710	7.21%	11,68,652.30	11.68%
50-100 ha	9,051	1.21%	6,24,226.30	6.24%
100-500 ha	6,167	0.83%	12,14,839.89	12.14%
500-1000 ha	736	0.10%	5,11,537.86	5.11%
1,000-10,000 ha	754	0.01%	18,68,069.04	18.67%
>10,000 ha	76	0.01%	35,13,954.78	35.13%
Total	**7,45,370**	**100%**	**1,00,03,475**	**100%**

Table 2. Number and area of wetlands (excluding rivers) in Uttar Pradesh, according to SAC data (Reference: Anonymous (2011)

Size of wetland (ha)	No. of wetlands	% of number	Area (ha)	% of area
Less than 5 ha	13,973	51.41%	124,203.3	20%
5- 10 ha	4,569	16.81%	32,435.39	5%
10 - 50 ha	6,635	24.41%	14,9971.1	24%
50 - 100 ha	1,240	4.56%	85,527.86	13%
100 - 500 ha	703	2.59%	12,9449.8	20%
500 - 1000 ha	32	0.12%	21,328.87	3%
1000 - 10000 ha	27	0.10%	47,765.63	8%
> 10,000 ha	2	0.01%	44,533.67	7%
Total	**27,181**		**63,5215.7 ha**	

Table 3. Number and area of reservoirs in Uttar Pradesh (Reference: Anonymous 2011)

Size of reservoir (ha)	Number	Area (ha)
Less than 5 ha	1016	2460.19
5- 10 ha	280	1922.22
10 - 50 ha	203	4470.24
50 - 100 ha	35	2463.89
100 - 500 ha	42	9260.82
500 - 1000 ha	12	8196.95
1000 - 10000 ha	18	32333.11
> 10,000 ha	2	44533.67

Table 4. Total number of wetlands (excluding rivers and reservoirs) and their areas in Uttar Pradesh (Reference: Anonymous 2011)

Size of reservoir (ha)	Number	% of total numbers	Area (ha)
Less than 5 ha	12,957	50.67%	12,1743.1
5- 10 ha	4,289	16.77%	30,513.17
10 - 50 ha	6,432	25.15%	14,5500.9
50 - 100 ha	1,205	4.71%	83,063.97
100 - 500 ha	661	2.58%	1,20189
500 - 1000 ha	20	0.08%	1,3131.92
1000 - 10000 ha	9	0.04%	1,5432.52
> 10,000 ha	0	0.00%	
Total	**25,573**		**529,574.6**

Sarus is a small shallow undisturbed *jheel* of 5-10 ha where it can nest and raise its chicks. The normal pattern of rainfall for 3-4 months is also important. Neither these *jheels* (also called *jhabbar*, *jhabiria, jhabru* or *pokhar*) are safe from human overuse nor we expect that normal rainfall pattern will remain due to climate change. It will be an understatement to say that most wetlands are under severe stress and some may not even survive the next few years, leaving Sarus with sub-marginal habitats such as paddy fields to nest where it faces constant disturbance and pesticides (Sundar 2009; Rahmani et al. 2019).

METHODOLOGY

Intensive surveys were conducted in Pilibhit, Sitapur, Bareilly, Shahjahanpur, Hardoi and Lakhimpur-Kheri districts from July 2017 to June 2019. We used all types of modes to reach wetlands, many times walking for kilometres. Visits were made in all the seasons. We also consulted local people to locate Sarus/wetlands. Sarus Crane was seen in a total of 1020 sites (some sites were repeated).

We tried to cover all the six districts but due to logistic reasons, some districts could not be covered properly (e.g. Bahraich, and Bareilly), but the remaining districts were repeatedly surveyed in all seasons. Some sites were visited only once, but many sites (large wetlands) were visited twice or thrice. Most of the data were collected within 200 m of the Sarus without anyway disturbing the birds. Data on the following parameters were collected: size of the wetland, presence/absence of Sarus, number of Sarus, distance from the nearest human structure, distance of Sarus from the road, types of the road, distance from over-head wire, distance from dogs, number of dogs, breeding status, and observer distance from Sarus.

Preparation of maps

We took wetland data (shape format) from Space Application Centre, Ahmedabad. Further, we also

extracted wetland data on Google Earth. We verified wetlands on Google Earth images by maximum zooming and removed flooded crop field data and marked only active wetland because some of the wetlands from SAC data do not exist anymore on ground. We have prepared Google Earth map of filtered wetland data of SAC.

Another information that we wanted is the map of distribution of high-tension wires fixed to pylons and electricity wires. The data appears to be 'restricted' and not openly available. We request the U.P. Forest Department to get this data, if possible, which will help in overlaying with the distribution of Sarus and high-tension wires. High tension and electricity wires are becoming a major reason for the death of Sarus, and this problem will increase as the Sarus are increasingly disturbed and forced to fly by people (unintentionally or intentionally) or by free-ranging stray dogs. Finally, the maps of high-tension wires were prepared with the help of Google images (pylon locations), and ground trothing was done. We could not prepare electricity supply maps to villages, houses, and crop fields (for generators) as the wire network was too dense. It was very difficult to get the wire network from government offices (at village, tehsil and district levels).

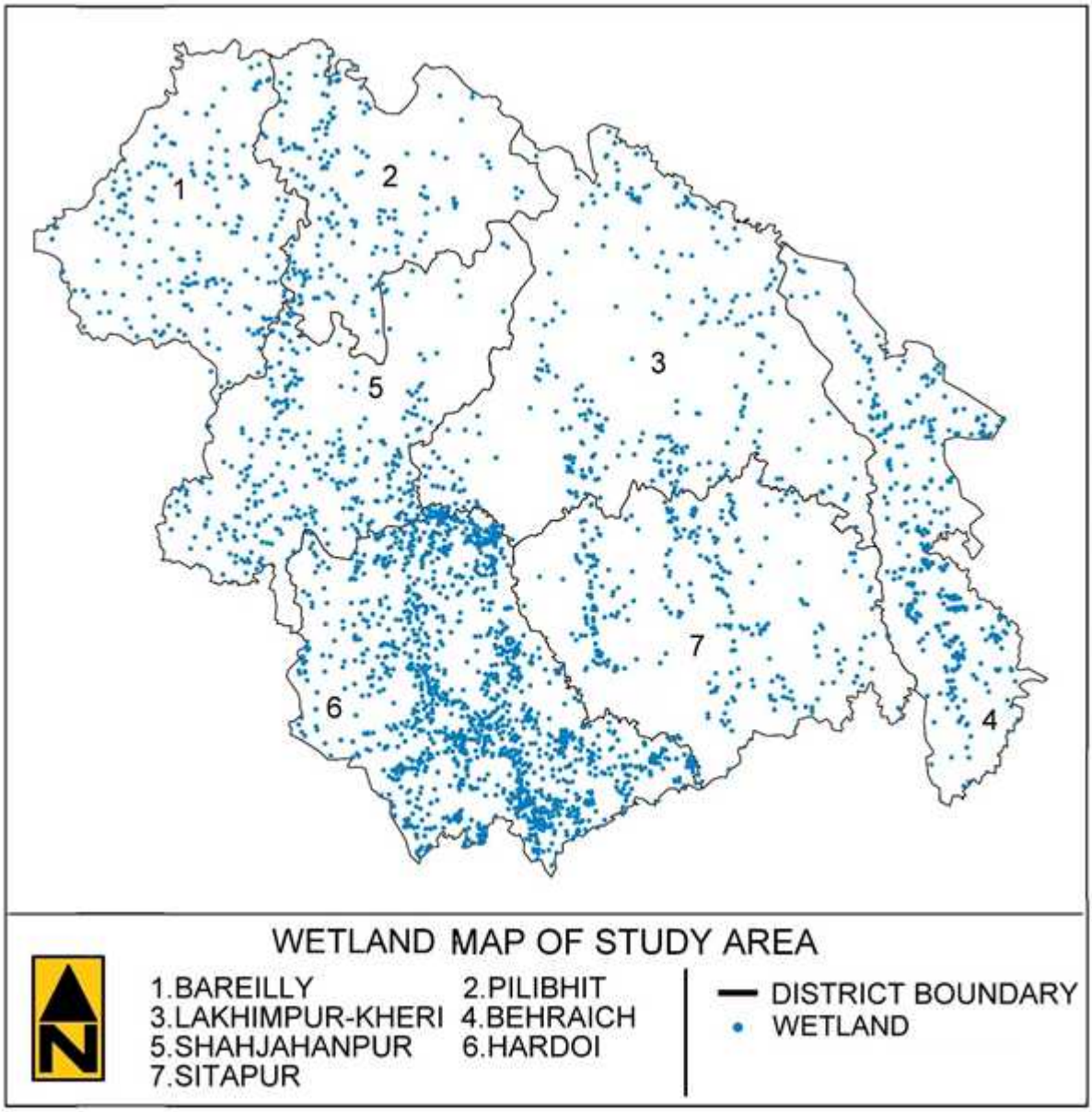

Figure 2. Wetland locations (>5 acres) in the study area

Sarus and locations of wetlands

According to the sources in the Forest Department, Uttar Pradesh has nearly 125,000 wetlands. We worked on the wetlands data developed by the Space Application Centre, Ahmedabad. We procured the data but found that there were many wetlands reported by SAC that do not exist anymore. Therefore, we did ground-truthing and also confirmed some wetlands from Google maps. Based on our survey work and desk work, we were able to prepare a map of wetlands of the seven districts that were our study area (Rahmani et al. 2019). A total of 2,916 wetlands were identified, varying in size from >5 acres to 100 acres (Fig. 2). District wise data are as follows: Bareilly (179), Bahraich (346), Hardoi (1394), Lakhimpur-Kheri (269), Pilibhit (165), Shahjahanpur (284), and Sitapur (279). On our wetland map, we overlay our records of Sarus sightings (Fig. 3).

Largest number of wetlands are found in Hardoi and Bahraich district, respectively (Fig. 2). However, largest number of Sarus sightings were not necessary where largest number of wetlands are present because in the study area, most sightings of Sarus were in the crop fields. It should be noted that due to logistic

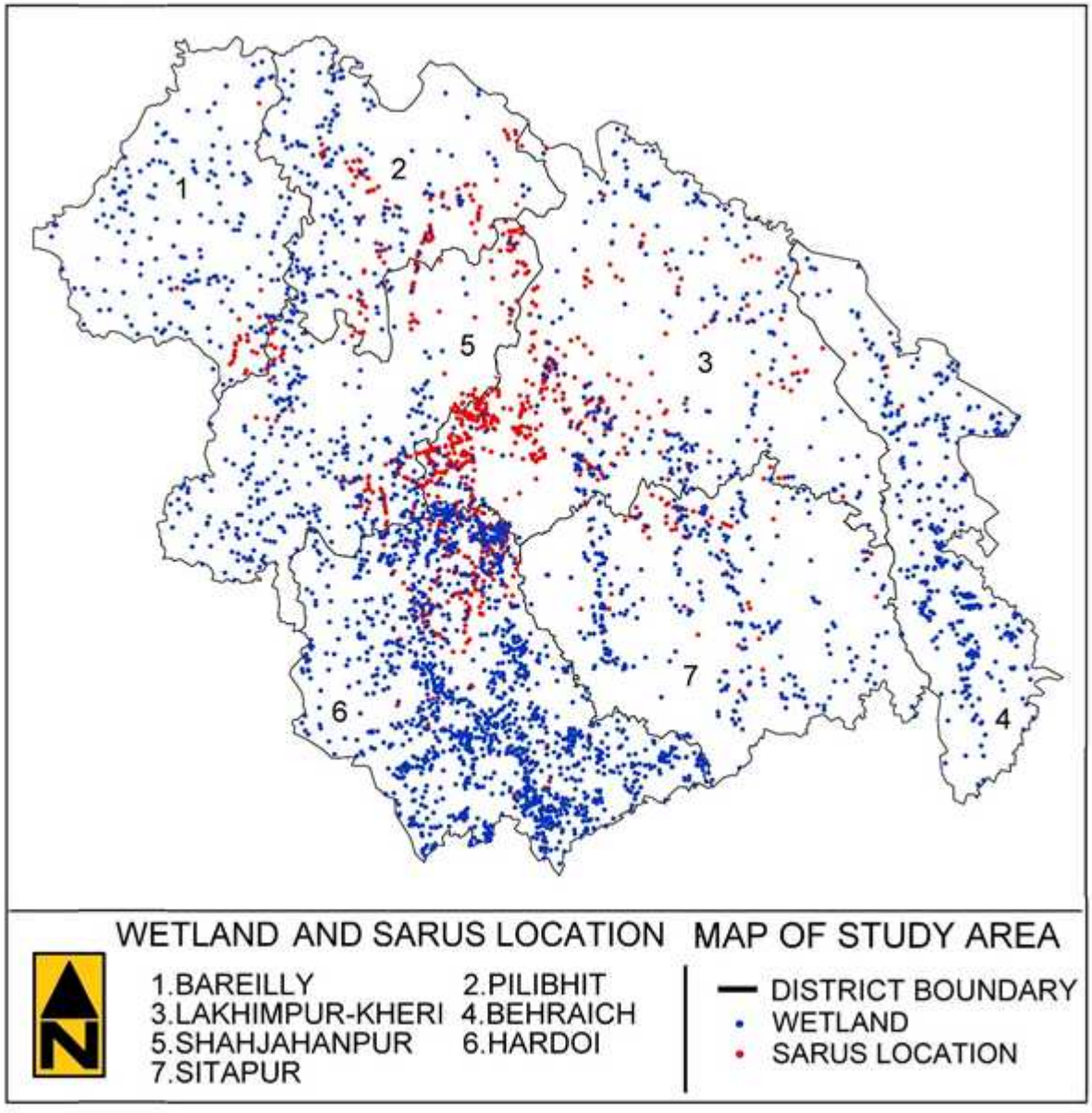

Figure 3. Distribution of wetlands and sightings of Sarus (July 2017 to June 2019)

reasons, we could not survey southern part of Hardoi and Bahraich districts as thoroughly as we had surveyed other districts. Not many Sarus were located on large wetlands mainly because such wetlands are intensively used by human beings either to grow paddy, water chestnut or fish.

RESULTS AND DISCUSSION

Distance of observers from Sarus: For collecting data on habitat use and Sarus numbers, during our surveys we also noted the distance of Sarus (on first sighting) from us (Fig. 4). Most of our observations (85%) of Sarus were within 150 m. As Sarus is a large bird, it cannot be missed if it is in an area. We also scanned the area through binoculars and sometimes we found them 300 to 500 m away. Occasionally, we went closer to gather other information about Sarus. However, for analysis purpose, only the first sighting data were taken.

Group size of Sarus: It is well-known that adult Sarus lives in pairs, particularly in the breeding season. After the breeding is over, it moves with chicks/juveniles or adults join other Sarus in small or large groups. These groups are generally loose aggregation of pairs/families and not very cohesive. We collected data on group size of Sarus and found that almost 70% of sightings (n = 693) were of pairs (Fig. 5). Most of the sightings of three or four birds were parents with juveniles. Sometimes solitary Sarus was seen but it was quite rare (*c.* 5%). We had 10% sightings or 100 sightings of four Sarus. Either these could be two pairs temporarily coming together or a pair with two fully grown juveniles. We had 39 sightings in total of 6-10 individuals and 11 sightings of more than 10 Sarus cranes. These congregations were mainly seen in winter or in the hot months when Sarus congregate in larger wetlands. These large congregations were seen during day time. For roost congregation, the data are given data separately.

Size of the wetlands: When we saw Sarus in a wetland, we tried to get the data on the size of the wetland from the villagers or estimated it ourselves. Out of the 380 sightings of Sarus in wetlands, 80% sightings were in wetlands smaller than 50 acres. Most sightings were in smaller wetlands of less than 5-10 acres, locally known as *jhabar*. Slightly more than 10 percent sightings were in wetlands of size

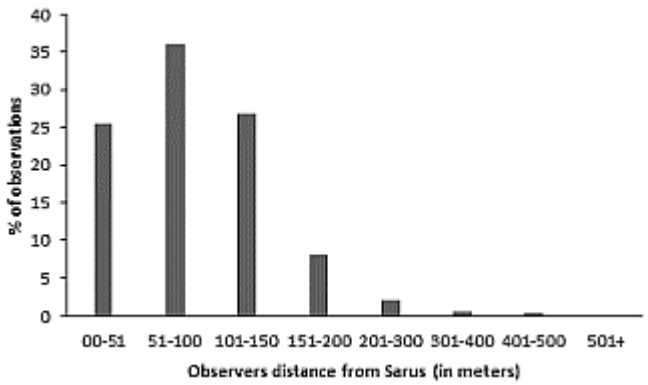

Figure 4. Distance of observer from the Sarus (n=991)

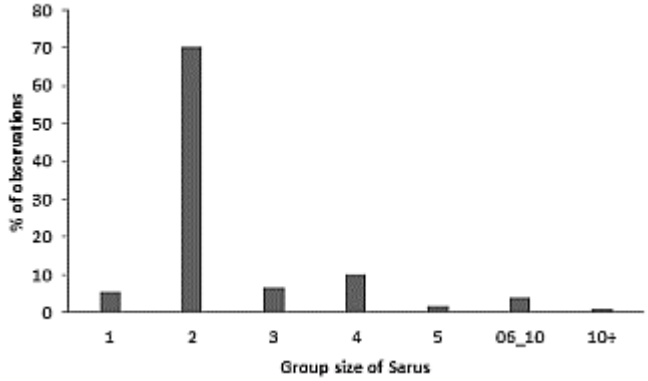

Figure 5. Group size of Sarus (n=985)

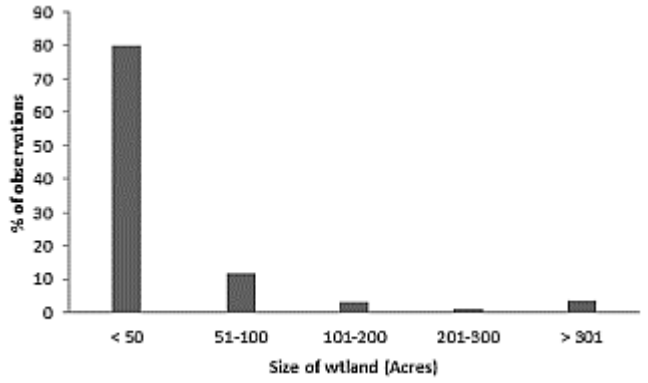

Figure 6. Size of wetlands where Sarus were found (n= 380).

from 51 acres to 100 acres (Fig. 6). Very few sightings were in wetlands of more than 100 acres, either they were deep or too disturbed due to fishing activities.

Type of wet areas used by Sarus: We also studied the type of wetlands (including flooded fields) used by Sarus. Whenever we saw a Sarus, we noted the type of habitat (flooded crop field, fallow field, wetland, village pond, river) where it was seen first time by us. We found that most sightings (60%) were in the flooded crop fields. This included paddy, young

wheat and young sugarcane. Next were in the village ponds called *jhabar*. In the larger wetlands of more than 50 acres (including surrounding crop fields), we had few sightings (Fig. 7).

Type of crop fields: We also considered the type of crop fields and found that maximum sightings of Sarus (40%) were in either freshly flooded wheat fields or harvested wheat fields (Fig. 8). Next was in the paddy fields. Such sightings were mostly in flooded fields. Interestingly, we also found many Sarus in young sugarcane fields with standing water. Once sugarcane become taller than Sarus and dense, birds no more use the habitat. Similarly, in the ripe wheat and paddy fields, just before harvesting, very few Sarus were found. In wetlands that are under *singhara* cultivation, Sarus were mostly absent mainly due to disturbance by people. Same was the case of totally dry fallow fields (particularly in summer). Fisheries ponds despite having water had very few Sarus, perhaps due to the depth of the water and frequent disturbance by pond owners on the presumption that Sarus feeds on fish.

All the districts are under intensive cultivation, with paddy, wheat and sugarcane as major crops. Sarus has very few natural wetlands left so it mainly forages in these fields, particularly when they are flooded for irrigation. It should be noted that in the whole terai, flood irrigation is done where 5 to 15 cm of water is left standing for many days. Such crop fields act as pseudo-wetlands for Sarus, which may be the reason that nearly 966 sightings were in such crop fields. Sarus is also seen in fallow fields, particularly wheat and paddy to pick up the fallen grains. We also had few sightings (2%) in mustard fields, but no sighting in fish ponds as mentioned above.

Broad habitat types: As Sarus lives in a matrix of crop fields, fallow fields, and wetlands in a large landscape, we broadly divided its habitat in to Standing Crops, Wetland, Fallow, Ripe or Mature Crop field, Young Sugarcane and Miscellaneous. We found that maximum sightings were in the standing crop fields (of wheat, paddy), next were in wetlands (*jhabars*, *jheels*, ponds), then Ripe Crop fields, Fallow fields, and likewise (Fig. 9).

Sarus and people: We took data on people's attitude towards Sarus. Our analyses show that most of the people have positive attitude towards Sarus. One way of judgement of tolerance of Sarus was how close

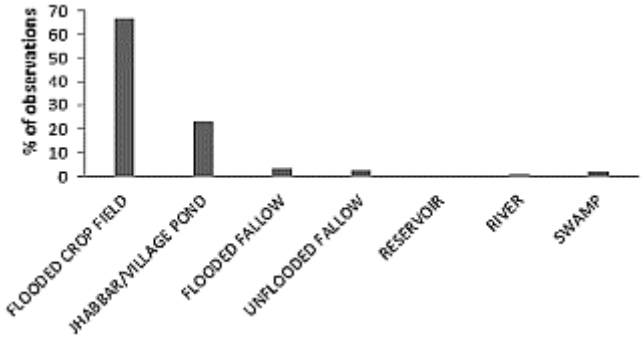

Figure 7. Type of wet areas where Sarus was found (n= 1013)

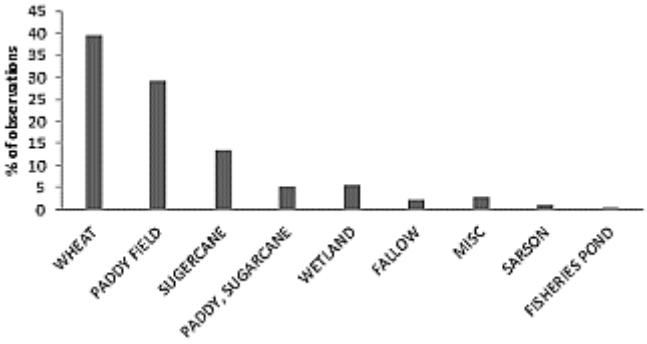

Figure 8. Type of crop fields where Sarus was found (n=966)

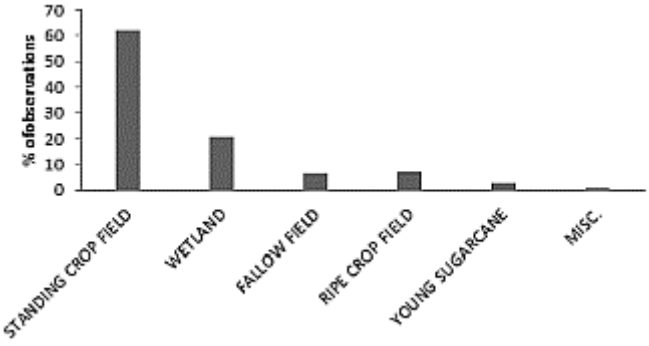

Figure 9. Major habitat types used by Sarus in the study area (n=987)

Sarus is found near people. Out of the 809 sightings of Sarus with people nearby, we found that more than fifty percent of the sightings of Sarus were within 100 m of people, either working in the crop fields or tending cattle or walking in the field (Fig. 10). As Sarus lives in densely populated landscape, people were never out of view wherever Sarus was located. Throughout the day, Sarus encounters human beings.

Distance of Sarus from road: Uttar Pradesh has a vast network of roads. We found that in the study

area, almost all villages are now connected with roads. The type and quality of road can vary but road is present. Sarus is so used to people and traffic that almost 90% of our sightings were less than 200 m from the road (Fig. 11). But there is a bias in this interpretation as the probability of sightings of Sarus from a moving survey vehicle decreases as the distance increases. We also walked for many kilometres in *katcha* roads or bridle paths. We can say that most of our Sarus sightings were within 200 m from the roads. Our data further proves the adaptability of Sarus to live in human-dominated landscape, and within the complex network of the road system.

Sarus sightings from different road types: During our survey, we divided the road type in to six categories: National Highway, District Highway, Village Road, Canal Road, Kachha Path, and Foot Path or bridle path. We did not come across Sarus from the high-speed National Highways (a total of nearly 2,000 km National Highway was covered during multiple surveys). Maximum sightings were from Village Road, next was from District Road (Fig. 12). Minimum number of Sarus were seen from canal roads. This is due to two main factors: we could generally see only on one side from the canal road, and secondly and perhaps more importantly, near the canals mostly sugarcane is grown which is not a suitable habitat for Sarus. This was particularly so in Sitapur, Lakhimpur and Hardoi districts where vast areas are under sugarcane cultivation. For kilometres beside the canal, only sugarcane is grown due to network of channels and easy availability of water.

Closeness of Sarus to human structure: We also collected data to find out how close Sarus is found near human-made structure (house, school, brick kiln, etc). As soon as we located a Sarus, we estimated how close/far it is from human-made structure. We did not count data beyond 500 m. As expected, nearly 70% of our sightings were within 200 m from a human-made structure (Fig. 13). Some birds were seen as close as 10 m from a house or a school. Most of the shallow wetlands are under extensive encroachment, so even a building is under construction, Sarus would be seen as long as some water was present. Perhaps such sites were their traditional nesting and foraging areas which will disappear soon. Many large birds use their traditional natal areas even when the habitat has been modified.

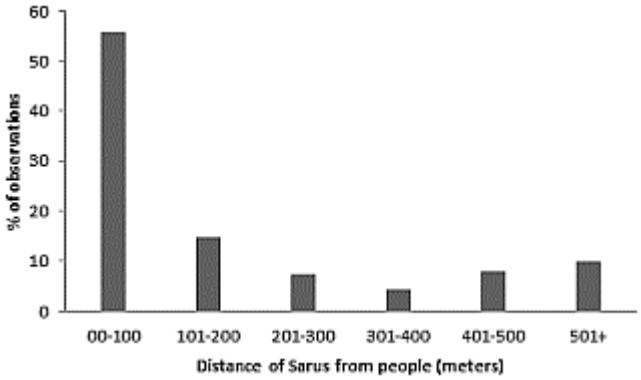

Figure 10. Proximity of people to Sarus (n=809)

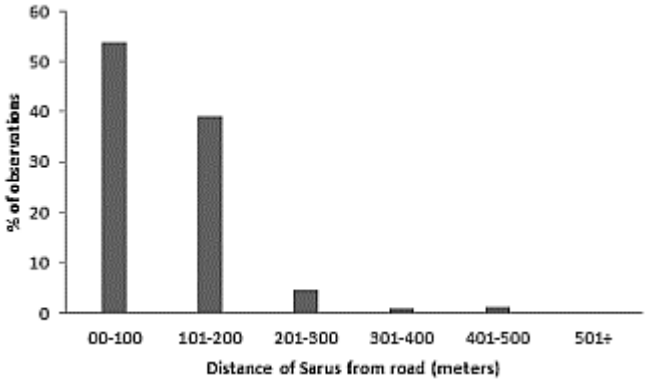

Figure 11. Distance of Sarus from the nearest road (n= 957)

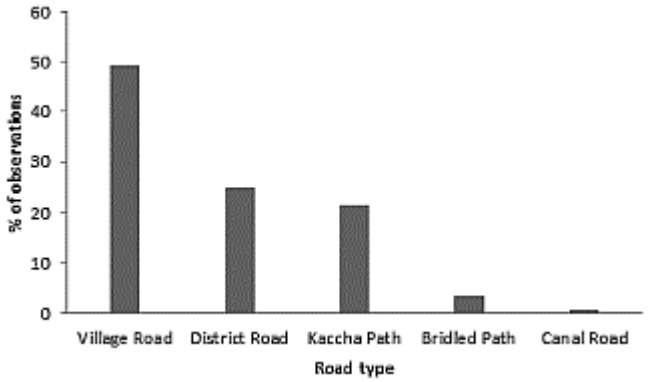

Figure 12. Sarus sightings from different road types (n=981)

Conservation issues

Sarus Crane lives in human-dominated landscape and earlier may have even benefitted from ruralisation of the countryside. However, increasing human population, change in the crop pattern, and rapid industrialization are putting subtle stresses to Sarus populations that are sometimes not easy to understand and quantify. Beside habitat modification, new threats are emerging such as powerlines, free-ranging stray dogs and pesticides (Rahmani et al. 2019).

Habitat destruction and modification: Wetlands

There are numerous studies in India regarding the status and number of wetlands in India (Gopal 2003, Gopal et al. 2008, Gopal and Chauhan 2011). Based on the studies conducted by Space Application Centre, Ahmedabad, there are more than 745,000 natural wetlands in India. Wetlands of less than 5 ha are 630,869, constituting nearly 85% of total wetlands, and wetlands from 5-10 ha are 44,00, constituting 6%, and 10-50 ha wetlands are 53,710 constituting 7.21% (Table 1). In short, nearly 97% of natural wetlands are less than 50 ha. These are the wetlands that are suitable for the Sarus crane. We also have a large number of reservoirs (Table 2) but as we have shown earlier, reservoirs are generally deep and not suitable for Sarus. Similar is the case of "other" type of larger and small wetlands that are mostly found on the coast or in urban areas where Sarus is not found (Table 3).

Almost all the wetlands that we visited, we saw human presence either in the form of rice or water chestnut (*singhara*) cultivation and fishing. Out of the 200 natural wetlands that we visited, almost 100% had human intervention in some form or the other. Drainage and cultivation were seen in nearly 80% of the wetlands. Almost 90% of the wetlands had invasive weed, water hyacinth (*Eichhornia crassipes*), either fully covering the wetland or partially. Only very small wetlands of less than 5 acres, amongst crop fields were free of this pernicious weed. Sometimes villagers had removed the weed for cultivation of pisciculture – either way the wetland become unsuitable for Sarus.

Stealing of eggs

We also found that out that stealing of eggs is a big problem in certain areas such as in parts of Shahjahanpur and Hardoi. In 2017, out of 16 nests monitored, eggs disappeared from five nests, and in another six the fate was not known – some may have been preyed upon even. Some farmers removed the eggs to prevent disturbance in the agricultural field (Kaur and Choudhary 2003) (Fig. 14).

Free-ranging Dogs: New apex predator of the countryside

Domestic dogs include feral and free-ranging stray animals and pet dogs. As such pet dogs are not such a big problem for wildlife but free-ranging stray dogs have become a great menace to wildlife (Gompher 2014), particularly in the Indian countryside. Besides

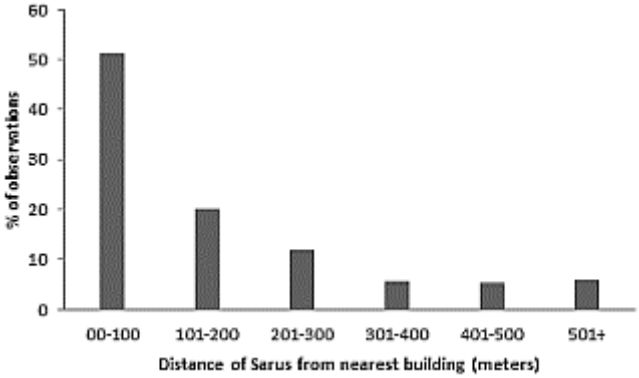

Figure 13. Distance of Sarus from the nearest human structure or building (n=535)

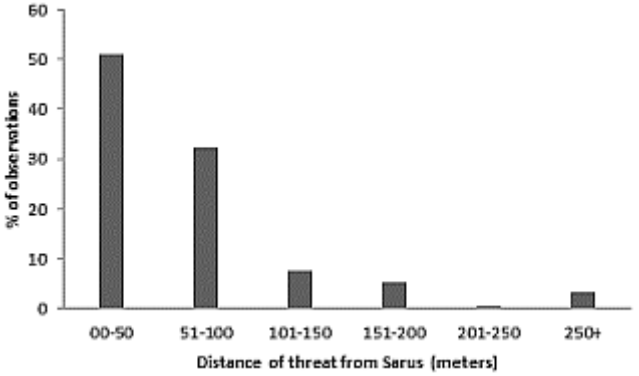

Figure 14. Location of Sarus from threats (high tension power line, distribution power line, mobile tower and dogs) (n= 294)

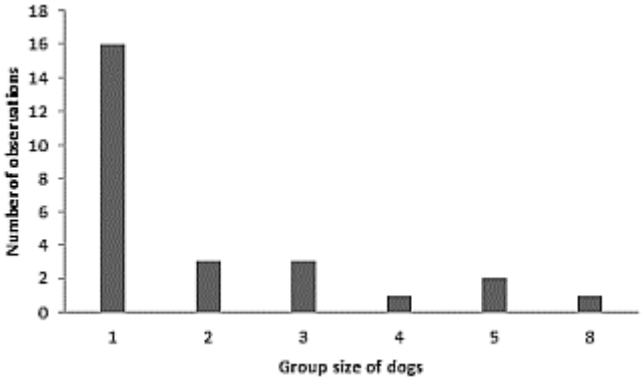

Figure 15. Group size of dogs near Sarus (n=26)

cats and rodents, dogs are the third most damaging mammalian invasive predators in the world. According to some estimates, there could be one billion dogs in the world today: about 75 percent are free breeding. World-wide, free-ranging domestic dogs are reported to cause potential risk to nearly 200 vertebrate species listed in the Red Data List of IUCN (Doherty et al. 2017). During this study, we kept records of all sightings of free-ranging dogs near Sarus Crane. While we found many such dogs during

our surveys in all the districts, on 26 occasions we found dogs disturbing the Sarus or very close to Sarus with chicks/juveniles. Most sightings were of a single dog, but up to eight dogs disturbing Sarus were also noted (Fig. 15).

As the menace of free-ranging dog is a complex issue, we need an in-depth study to find the impact of dogs on the survival of Sarus Crane. In future, both human and dog populations are likely to increase geographically and numerically, it is imperative to understand the effects of domestic dogs on the Sarus Crane. We recommend sterilization of 80 to 90% of the free-ranging stray dogs in the countryside, particularly in Sarus areas and around PAs.

Threat of Powerlines to Sarus

While habitat destruction and unsustainable harvests are the two major problems across the board for all wildlife species, for many species, powerlines (both transmission 220 kV and distribution 15 kV–45 kV lines) and other such infrastructures are now the major killers. This is particularly true for large flying birds such as bustards, storks, eagles, and cranes. Cranes and bustards have a visionary block in front of their head due to placement of their eyes on the sides. These large birds are particularly prone to collision due to their low manoeuvrability during flight and/or poor forward-facing visual vision. While flying fast, by the time they see a high-tension wire, it is too late. Either they are injured or electrocuted or both. The large bodies touch two wires resulting in electrocution.

There is an increasing scientific literature on the impact of powerlines on large flying birds. For example, in Spain it has been proved that collision from powerlines is the major problem for the Great Bustard *Otis tarda* (Alonso et al. 1994, Janss 2000, Martin and Shaw 2010, Martin 2011). A study on the Whooping Cranes *Grus americana* found that when the juveniles migrate from Canada to Texas in the USA, many juveniles die after collision as they are unfamiliar with the landscape (Stehn and Wassenich 2008). In a detailed study on the impact of powerlines on birds, especially Great Indian Bustard, Mohibuddin et al. (2021), found that about 87,966 (SE 25,701) bird mortalities occur per year

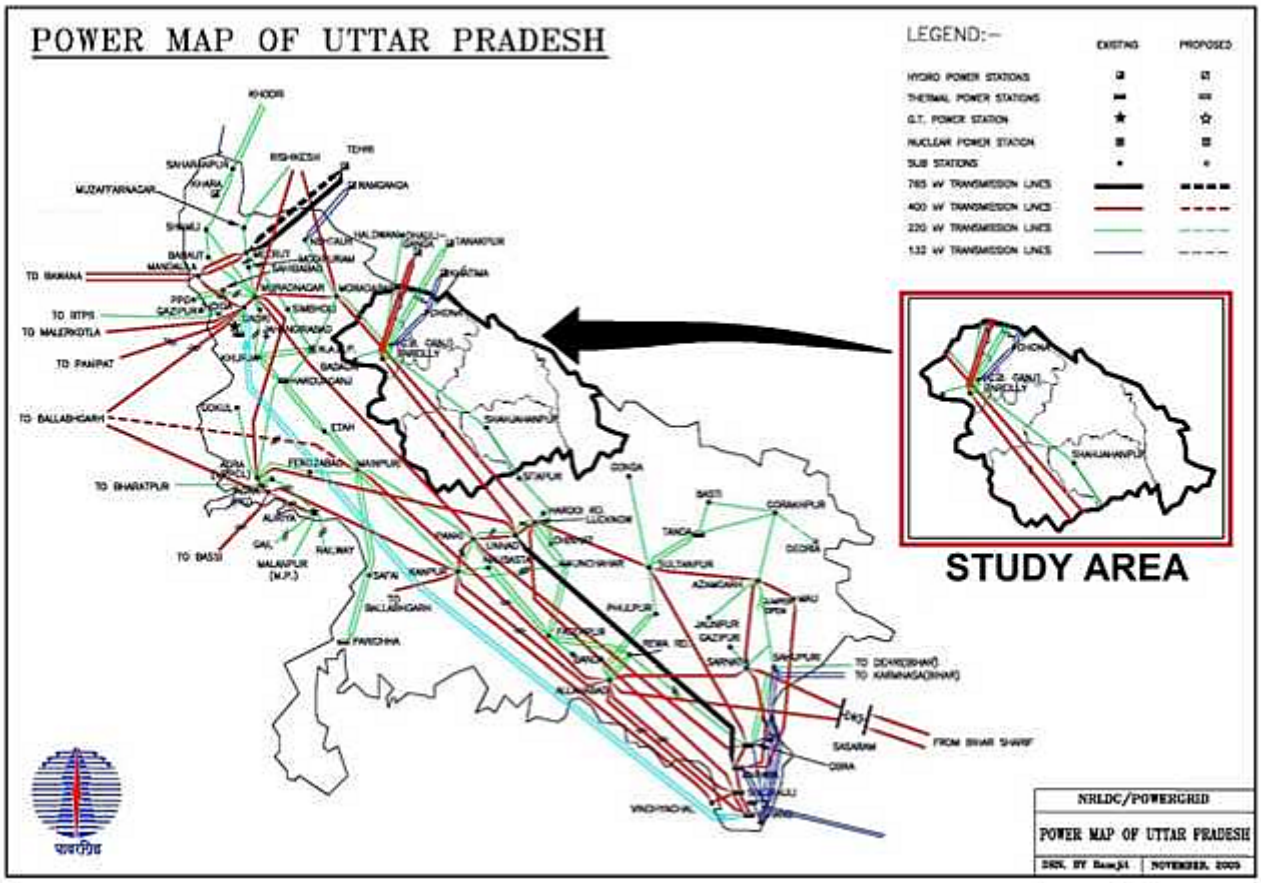

Figure 16. Major power grid of Uttar Pradesh and the study area.

in the study area in GIB habitats of Thar landscape in Jaisalmer.

Sundar and Choudhury (2005) were the first to highlight the threat of overhead wires to the Sarus Crane. In a study based in Mainpuri and Etawah districts, they found that 1% Sarus die every year after hitting the wires. They found that the non-breeding Sarus cranes were most susceptible to wires and, within territories, mortalities were higher for pre-dispersed young.

Uttar Pradesh has a huge and complex network of electric, telephone and high-tension wires in almost all the areas where we found Sarus (Fig. 16). In many wetlands/crop fields, these wires go right across them. At every sighting of Sarus, we collected data on presence/absence of wires. We noted the two major types of wires: electricity powerlines and high-tension wires (called pylon in short). We found that in 20% of sightings of the Sarus, they were within 100 m of powerlines, and 10% sightings near or under high-tension wires. We found dead Sarus in three incidents. We came to know another eight specific cases that had happened earlier but we could not find the carcasses as they had decomposed/eaten by predators. While speaking to local people, many of them told us that they have seen or know cases of Sarus getting killed by powerline wires. When we asked local people about the major threats to Sarus, most of them told us pesticide poisoning and powerlines.

Sarus and danger of plastic pollution

Plastic has become a major threat to many birds, particularly sea birds which mistakenly feed on pieces of free-floating plastic thinking it as a food item. Plastic pollution in the ocean is a global concern; concentrations reach 580,000 pieces per km^2 and production is increasing exponentially (Wilcox et al. 2015). Researchers from the Ugyen Wangchuck Institute of Conservation and Environmental Research (UWICER), the Royal Society for Protection of Nature (RSPN), and the Bumdeling Wildlife Sanctuary (BWS) collected 1,000 samples of faeces in Bumdeling, one of the major wintering grounds for the Black-necked Crane *Grus nigricollis* in Bhutan. They found plastic pieces in 5 percent of faeces analysed so far. In one faeces, 6.5 gm of plastic pieces were found. This is a country that has officially banned one-time use plastic carry bags and where environment is still considered 'pristine'. Bumdeling is a small village of less than 3,000 people so unlikely to have much plastic waste. Despite this, cranes are picking up plastic pieces thinking them to be food items. On the contrary, plastic in rural Uttar Pradesh is littered every where. Although we could not conduct any research on the food habits of Sarus Crane (it was not our mandate under the Project), we recommend that a detailed study on the food habits of Sarus Crane and the impact of discarded plastic in the Sarus habitat should be studied.

Pesticides

We found heavy use to pesticides in all the districts, particularly at the start of paddy growing season. Pesticide poisoning as a hazard for Sarus crane has been documented (Muralidharan 1992, Kaur and Nair 2008), mainly unintentional but sometime intentional. A notorious case of Sarus poisoning occurred outside Keoladeo National Park, Bharatpur, Rajasthan on 23 November 2000, when 15 Sarus cranes and three Common Cranes *Grus grus* were found dead in a field adjacent to the Park, where wheat seed had been sown the previous day (Muralidharan 2004). During our study, in two years, we were thrice told by villagers that some Sarus died after foraging in crop fields where pesticides have been used. Details of pesticides used in the study area were given by Rahmani et al. (2019).

Cultivation of Water Chestnut (singhara)

Breeding of Sarus coincides with cultivation of *singhara*. We found that many *jhabars* have been converted for *singhara* cultivation and Sarus were either chased away or abandoned the *jhabar*. Some *jhabars* were deepened and bunded, making them unsuitable for Sarus. Singhara is finally harvested by mid-November, after that the plant dies.

Change in cropping pattern and change in people's attitude

As Sarus inhabits agrarian landscapes, three issues, namely cropping pattern, pesticide use and behavioural attitude towards farming as an occupation, have significant bearing on the suitability of the habitat for this species. The current cropping pattern appears suitable for Sarus in some regions of Uttar Pradesh. However, cropping pattern is subject to change due to various factors such as market forces, India's export/import policy, farmers distress, new agriculture research, and population pressures further subdividing already small holdings. Even

genetic research can change the cropping pattern, indirectly impacting the Sarus crane. For example, new researches are showing that sugarcane can be genetically enhanced to increase the amount of oil content in its leaves and stems which can be used for biofuel production. If growing sugarcane becomes much more lucrative in future (sugar, *ghur*, bagasse and biofuel from one crop), many farmers presently growing paddy and wheat may change to sugarcane, hugely impacting Sarus Crane.

Pesticide is another issue that can change the Sarus status. Genetically modified crops and introduction of new chemicals may not appear to have any links with Sarus survival but we should be aware of such indirect links. For example, when diclofenac sodium chemical was introduced for veterinary use in the early 1990s in India, no one thought that it will have impact on vultures. It led to catastrophic decline in the vulture numbers from which they have still not recovered although diclofenac was officially banned in 2006 by the Government of India. Very little work on the impact of pesticides on Sarus crane and other farmland birds has been done in India. Lack of data gives us a complacency that everything is fine.

FUTURE OF SARUS CRANE IN UTTAR PRADESH

At present, local people have positive inclination towards Sarus but this attitude can change quickly as the new generation of farmers grow. They have a lesser connect to their landscape and the species therein. We are witnessing increasing farmers' distress and increasing aspirations of new generation to make money. In such a situation any activity that even slightly decreases their crop productivity (e.g. Sarus breeding in paddy fields) will not be looked positively. Sarus protection cannot be endured at the cost of loss of crop yield. These are changing perceptions and attitudes in the fast-changing countryside of Uttar Pradesh.

Predation by free-ranging stray dogs are becoming an immense conservation problem for landscape species such as cranes. Old methods to eliminate the problem animals is now socially unacceptable and legally banned, so new solutions have to be found before this menace further aggravates as far as Sarus is concerned. More disturbance by dogs to Sarus may lead to higher mortality due to electrocution death as the bird is forced to fly more. Devices are available that can minimize bird collision with powerlines. We also need research on the flight patterns of Sarus cranes to find out which types of powerlines are most destructive to these large, low-flying birds. Presently not much is known on these aspects in Uttar Pradesh.

Monitoring Sarus is not easy as it lives in a highly complex rural landscape so standard line transect method may not be very suitable. Randomly selected block count using ground staff/researchers and drones may give better results. However, this has to be statistically robust to interpret the data for the whole area/region.

With increase in human population, urbanization, and agriculture expansion and modification in its natural habitat, the present Sarus numbers should not give us complacency that this-long living and slow-breeding bird can thrive in the coming decades in Uttar Pradesh. It is imperative that policy-changes need to be brought up to protect smaller wetlands from further degradation.

ACKNOWLEDGEMENTS

We want to thank the Sarus Protection Society for funding the project. Special thanks to various Chief Wildlife Wardens and Principal Chief Conservator of Forests (Wildlife) before and during the tenure of this project. Notable names are Dr. Rupak De, Mr. S. K. Upadhyaya, Mr Pawan Kumar, and Mr. Sunil Pandey. Our sincere thanks to Mr. Mukesh Kumar, Mr. V.K. Singh, Mr. Sanjay Srivatava, Mr R. K. Singh, Mr. Mohd Ahsan, Mr. Abu Arshad, Mr. R.K. Gupta, Mr. Raja Mohan, Mr. Aadarsh Kumar, Mr. Rajeev Kumar, Mr. Praveen Khare, and other officers of the Forest Department. Our sincere gratitude to Dr. Ramesh Pandey, Field Director, and Dr. Mahavir Kaujlaji, Deputy Director, Dudhwa Tiger Reserve and all their staff. Our personal thanks to the late, Dr. V. P. Singh (Lahimpur-Kheri), Mr. Qamar Qureshi (WII-Dehradun), Mr. Neeraj Srivastava, Mr. Sanjay Kumar, and Dr. Shalendra Singh (Turtle Survival Alliance). Thanks to Dr. Kamal Dalakoti of Wetlands International South Asia (WISA) for preparing maps of the wetlands of different districts. Our gratitude to Dr. Ritesh Kumar, Director, WISA and Dr. Siddharth Kaul, President of WISA. Personal thanks to Mr. B.C. Choudhury, Dr. Samir Sinha and Dr. Arshad Ahmad of Wildlife Trust of India (WTI)

for discussion from time to time. We also had discussion with Dr. S. Muralidharan of SACON and his students working on the Sarus project. We also want to thank the photographers for providing their images of Sarus and related subjects. Their names are acknowledged beside the images. Besides these regular volunteers, we took help of the staff of WWF (Kabeer Ahmad, Mudit Gupta) and local wildlifer in Barielly (Sachin Guar), Pilibhet (Akhtar Mia) and Mr. 'Sonu' Leeladhar for helping us in the field.

Authors' contributions: All authors contributed equally

Conflict of interest: Authors declare no conflict of interest

REFERENCES

Alonso J.C., Alonso J.A. and Muñoz-Pulido, R. 1994. Mitigation of bird collisions with transmission lines through ground wire marking. Biological Conservation, 67, 129-134.

Anonymous. 2011. National Wetland Atlas, SAC/EPSA/ABHG/NWIA/ATLAS/34/2011, Space Applications Centre (ISRO), Ahmedabad, India, 310 pages.

Choudhury, B.C. and Rahmani, A.R. 2014. Sarus Crane: A Pictorial Lifehistory. Bombay Natural History Society, U.P Forest Department and Sarus Protection Society, Mumbai and Lucknow. 132 pages.

Doherty, T.S., Dickman, C.R., Glen, A.S., Newsome, T.M., Nimmo, G., Ritchie, G.E., Vanak, A.T. and Wirsing, A.J. 2017. The global impacts of domestic dogs on threatened vertebrates. Biological Conservation, 210 A, 56-59.

Gopal, B. and Chauhan, M. 2001. South Asian wetlands and their biodiversity: the role of monsoons. pp. 257-275, In: Gopal, B., Junk, W.J. and Davis, J.A. (Eds.) Biodiversity in Wetlands: Assessment, Function and Conservation. Volume 2. Backhuyas Publishers, Leiden, The Netherlands

Gompper, M.E. (Ed.) 2014. Free-ranging dogs and wildlife conservation. Oxford University Press, UK. 336 pages.

Gopal, B. 2003. Perspectives on wetland science, application and policy. Hydrobiologia, 490, 1–10.

Gopal, B., Junk, W.J., Finlayson, C.M. and Breen, C.M. 2008. Present state and future of tropical wetlands. pp 142–154. In: Polunin, N.V.C. (Ed.) Aquatic Ecosystems. Cambridge University Press, Cambridge, (U.K. Foundation for Environmental Conservation), 412 pages.

Janss, G.F.E. 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biological Conservation, 95, 353–359.

Kaur, J. and Choudhary, B.C. (2003) Stealing of Sarus crane eggs. Current Science, 85 (11), 1515-1516.

Kaur, J. and Nair, A. 2008. Community involvement in conservation of Sarus crane breeding habitat in three districts of semi-arid tract of Rajasthan, India. Report submitted to Rufford Small Grants Foundation, U.K., 29 pages.

Martin, G.R. and Shaw, J.M. 2010. Bird collisions with power lines: failing to see the way ahead? Biological Conservation, 143, 2695–2702.

Martin, G.R. 2011. Understanding bird collisions with man-made objects: a sensory ecology approach. Ibis, 153, 239–254.

Mohib-Uddin, Dutta, S., Kolipakam, V., Sharma, H., Usmani, F. and Jhala, Y. 2021. High bird mortality due to power lines invokes urgent environmental mitigation in a tropical desert. Biological Conservation, 261, 109262. https://doi.org/10.1016/j.biocon.2021.10962.

Muralidharan, S. 1992. Poisoning of Sarus. Hornbill, 1, 2-7.

Murlidharan, S. 2004. Mortality of globally threatened Sarus cranes *Grus antigone* from monocrotophos poisoning in India. Science of the Total Environment, 326 (1-3), 55-61.

Rahmani, A.R., Islam, M.Z. and Kasambe, R.M. 2016. Important Bird and Biodiversity Areas in India: Priority Sites for Conservation (Revised and updated). Bombay Natural History Society, Indian Bird Conservation Network, Royal Society for the Protection of Birds and BirdLife International (U.K.), xii+ 1992 pages.

Rahmani, A.R., Kumar, B., Ahmad, S., Mehta, P. and Rahman, F. 2019. Sarus Crane in North Uttar Pradesh: Status survey of Sarus and mapping of its wetland habitats. Bombay Natural History Society, Mumbai, 109 pages.

Stehn, T.V. and Wassenich, T. 2008. Whooping crane collisions with power lines: an issue paper. pp. 25-36, In: Folk, M.J. and Nesbitt, S.A. (Eds.). Proceedings of the Tenth North American Crane Workshop, Feb. 7-10, 2006, Zacatecas City, Zacatecas, Mexico: North American Crane Working Group.

Sundar, K.S.G. 2009. Are rice paddies suboptimal breeding habitat for sarus cranes in Uttar Pradesh, India? The Condor, 111(4), 611-623.

Sundar, K.S.G. and Choudhury, B.C. 2005. Mortality of Sarus Cranes (*Grus antigone*) due to electricity wires in Uttar Pradesh, India. Environmental Conservation, 32(3), 260-269.

Sundar, K.S.G. and Subramanya, S. 2010. Bird use of rice fields in the Indian Subcontinent. Waterbirds, 33 (sp1), 44-70.

Sundar, K.S.G. and Choudhury, B.C. 2003. The Indian sarus crane *Grus a. antigone*: a literature review. Journal of Ecological Society, 16, 16–41.

Wilcox, C., Sebille, E.V. and Hardesty, B.D. 2015 Threat of plastic pollution to seabirds is global, pervasive, and increasing. PNAS, 112 (38), 11899-11904.

Received:4th January 2022
Accepted:30th August 2022