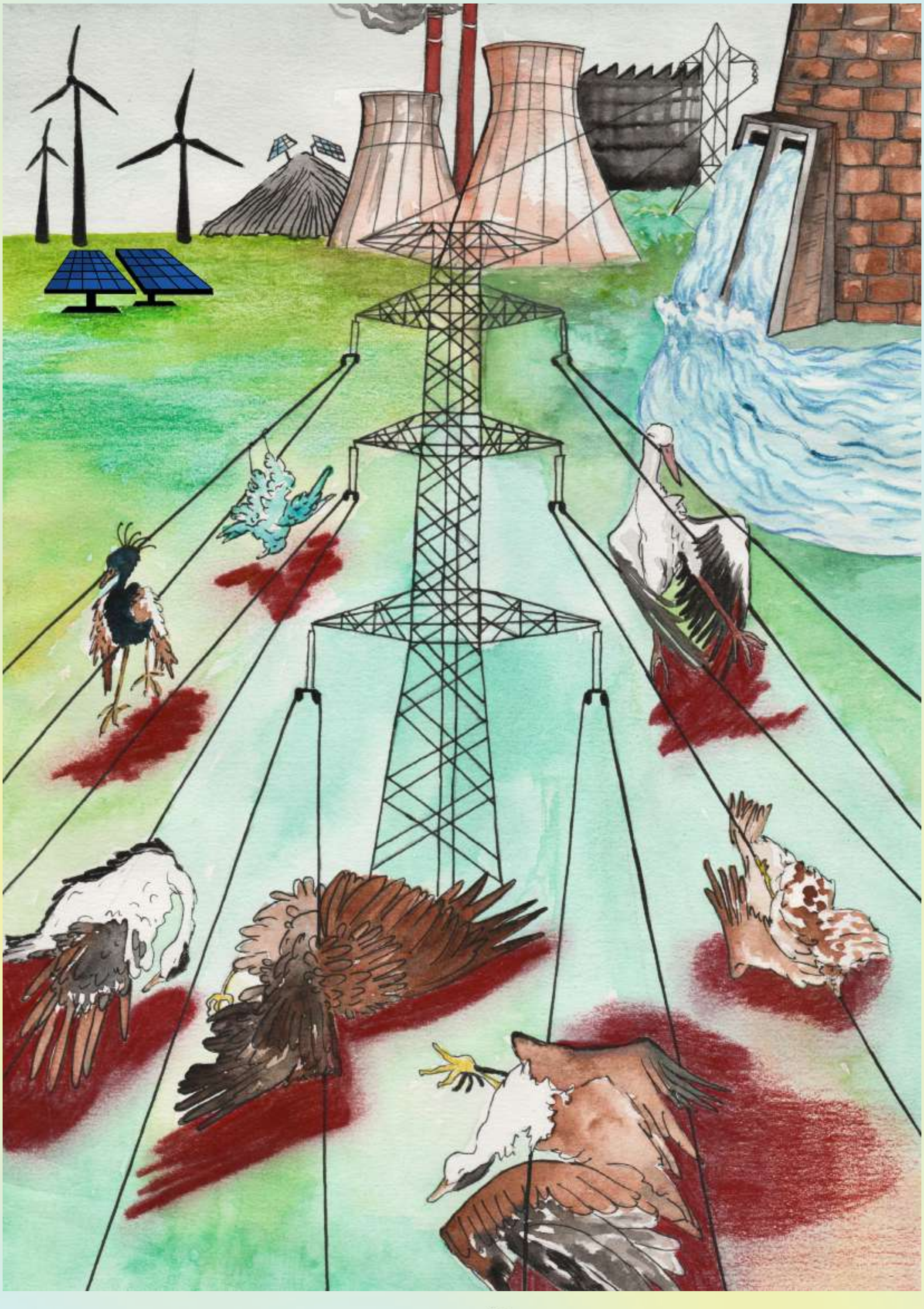
BUCEROS

EIACP Resource Partner on AVIAN ECOLOGY Vol. 28, No. 2 & 3, Aug. 2023–Mar. 2024



AVIAN FATALITIES: ENERGY INFRASTRUCTURE IMPACTS AND SOLUTIONS

ABOUT EIACP

EIACP (Environmental Information, Awareness, Capacity Building and Livelihood Programme) is a network of subject-specific centres located in various institutions throughout India. The focal point of the 60 EIACP centres in India is at the Ministry of Environment, Forest and Climate Change, New Delhi, which further serves as the Regional Service Centre (RSC) for INFOTERRA, the global information network of the United Nations Environment Programme (UNEP) to cater to environment information needs in the South Asian sub-region. The primary objective of all EIACP centres is to collect, collate, store and disseminate environment-related information to various user groups, including researchers, policy planners, and decision makers.

The EIACP Resource Partner (formerly known as ENVIS) on Avian Ecology at the Bombay Natural History Society was set up in June 1996 to serve as a source of information on Avian Ecology.

Objectives of the EIACP Centre at BNHS

- To establish and maintain database on Avian Ecology
- Publish and distribute BUCEROS and other informative products.
- To upload database on website by using internet and provide knowledge to the users.
- Spread information on birds through doubt clearance service and organise workshops.
- To conduct various certificate courses under Green Skill Development Programme (GSDP).
- Conduct capacity building programmes approved by the Ministry of Environment, Forest and Climate Change (MoEF&CC).
- Organize mass awareness campaigns and activities on Mission LiFE as per the direction of MoEF&CC.

BNHS India
CONSERVING NATURE SINCE 1883

BUCEROS
EIACP Newsletter
Avian Ecology

Vol. 28, No. 2 & 3
August 2023 – March 2024

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CONTENTS

Editorial

India is well-known for its rich floral and faunal biodiversity, despite its high population. The nation's ecological richness can be attributed to its mosaic of indigenous communities, each with distinctive cultures, traditions, and profound connections to nature. These communities safeguard invaluable knowledge and practices, handed down through generations, providing profound insights that help to preserve this biodiversity.

India is home to over 1,350 avian species. The country's diverse habitats, like marine, rivers, wetlands, grasslands, mountain forests, sacred groves (*devrai*), private forests, mangroves, agricultural areas, and coastal habitats, nurture this vast and diverse birdlife. BNHS has been engaged in the research, conservation and education of India's biodiversity and their habitats, since 1883. It also collaborates with the central and state Governments in the Central Asian Flyway project to study species migration, habitats, and conservation issues.

BNHS has studied terrestrial and marine bird species and is working with the government to address habitat and species-specific threats. However, there are insufficient studies on the impacts of green infrastructure projects on birds. Seabirds are vulnerable to human activities, and many species have experienced population declines. Urgent research is needed to ascertain the scale of threats they face. Wader populations are declining worldwide, and conserving this species requires international cooperation. To address the widespread decline in shorebird populations, India's National Action Plan for conserving migratory birds and their habitats along the Central Asian Flyways (2018–2023) has been created.

Global studies consistently indicate that birds are generally perceived as being less affected by Highways compared to other wildlife. The prevailing notion is that birds can mitigate the risk of road impacts by swiftly taking off and /or flying at higher altitudes than traffic. This is largely attributed to the perception that birds do not pose a direct threat to motorists during wildlife-vehicle collisions. This perception has led to slower implementation of innovative measures to reduce road impacts on birds compared to other animal groups.

Activities like foraging, roosting and nesting near roads make the species more prone to vehicle collisions. e.g., vultures feed on road-killed carcasses and cannot take off quickly to avoid collisions. Collision frequency depends on the proximity of water sources and human habitation. Birds in open areas are more prone to collision than birds in forests. For many species, vehicle-induced mortality increases during breeding and migration season, and mortality may increase during winters. The impact of roadside lighting varies among different bird species. Effective road planning should prioritize the preservation of natural habitats, minimizing the overall impact. Identifying and protecting essential features like waterbodies and watercourses can minimise the cumulative impact of Wildlife Vehicle Collision (WVC) on birds.

The issue of bird collisions with man-made structures, such as power lines, poses a significant threat to bird populations globally. While these structures are necessary for human development, they can have a devastating impact on bird populations. One of the most vulnerable species is the Great Indian Bustard, facing extinction with fewer than 100 individuals in the wild. Due to its poor frontal vision, the Great Indian Bustard is at a heightened risk of colliding with power lines, further increasing the threat of collisions.

This problem is compounded by high human activity and infrastructure development in its inhabiting areas. To mitigate this threat, it is essential to consider the impact of heavy energy infrastructure on wildlife sensitive areas, including critical breeding habitats and movement corridors. BNHS has suggested installing underground cables for power lines beyond 33 kV to prevent further threat to the Great Indian Bustard. This would significantly reduce the risk of bird collisions with power lines and promote coexistence with avian species. While India's renewable energy projects are essential for the country's development, policy decisions must prioritize the safety of avian species.

The BNHS has urged government agencies such as The National Committee on Transmission (NCT) and state electricity distribution and transmission line agencies to make India's power line infrastructure bird-safe by implementing simple yet effective design changes that minimize the risk of electrocution. In a recent meeting with Rajasthan Rajya Vidyut Prasaran Nigam Ltd (RRVPNL), BNHS requested to underground a stretch of 18.2 km of 220 kV line at Dholiya to Chacha village and 17.7 km of 132 kV of line from Odhaniya to Dholiya village in Pokhran area of Jaisalmer to save one of the essential and viable populations of GIB. Effective mitigation measures that preserve bird habitats and movement corridors can also help conserve avian species. Citizen participation is another crucial aspect of bird conservation efforts. By acting as vigilant custodians of vulnerable bird species, citizens can help create a safer environment for avian species, emphasizing the urgency of implementing underground power lines in high-priority areas.

This special issue of BUCEROS provides relevant information regarding bird collisions with power lines at the global, national, and site levels, such as the Thar Desert. While this issue is going to press, the honorable Supreme Court ordered to free the grassland habitats to set up solar plants and transmission lines as they cannot hold the development in the entire landscape for Great Indian Bustard. In this pretext bringing out this special issue becomes more important. The issue highlights some success stories that could be replicated across India, emphasizing the need for thoughtful policies that promote coexistence with avian species while promoting sustainable development. The issue also particularly emphasizes on the importance of monitoring and evaluating the effectiveness of mitigation measures and the need for continuous improvements in bird conservation efforts.

BNHS has been studying the impacts of airports set up in grasslands, coastal habitats, infrastructure projects like roads and flyovers in coastal areas, and several infrastructure projects proposed in different ecosystems. The projects must consider ground nesters and ground-dwelling birds, owls, scavengers, and frugivores susceptible to specific threats. Road impact for bird species is species-specific. Standard mitigations like underpasses, overpasses, and fencing do not work except for a few ground-dwelling birds. The same is true for the herpetofauna. However, the outcome of the studies conducted in India, especially by BNHS, has hardly been given serious attention by the infrastructure agencies or judiciary. These studies also show that the MoEF&CC guidelines require serious reconsideration for avian species and alteration. Some proactive state governments can also frame their guidelines for infrastructure agencies. Hence, the efforts of the EIACP division of BNHS to bring out a special issue of BUCEROS on the impacts of power lines on birds have the utmost importance. I appreciate the efforts and hope this issue will benefit all the concerned agencies, including the forest department and financial institutions. ■

KISHOR RITHE, Director, BNHS

Bird mortality and power lines globally and mitigation measures– A literature review

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INTRODUCTION

Global linear infrastructure, spanning over 100 million kilometres and comprising roads, railways, waterways, and power lines, constitutes a significant threat, degrading 75% of the terrestrial environment (Georgiadis 2020). The surge in global industrialization and enhanced electricity accessibility has led to widespread electrification, with the rise of wind farms, solar power plants, and other renewable energy sectors contributing to the expansion of the power grid for efficient electricity transmission (Garrido *et al*. 2022 in Martin *et al*. 2022). In 2022, worldwide electricity consumption reached about 25,500 trillion watt-hours, compared to 7,323 trillion watt-hours in 1980 (Statista n.d.). Over the span of 1980 to 2022, the utilization of electricity tripled.

This proliferation of power lines and associated transmission solutions necessitates a proactive approach to prevent unacceptable ecological costs linked to their development and operation (Martin *et al*. 2022). Power lines cause bird mortalities due to collision and electrocution. In the United States, collisions of birds with power lines range from 8 to 57 million annually, coupled with 0.9 to 11.6 million birds killed by electrocution, highlighting the urgency of the issue (Loss *et al*. 2014; 2015). Similar concerns arise in Canada with annual bird

RACHID EL KHAMLICHI

A sight of Griffon Vultures *Gyps fulvus* drying feathers on a pylon, serves as a visual representation of their specific susceptibility to electrocution

Collisions predominantly occur on transmission pylons with ground wires at the top, which are usually less visible than conductors

fatalities ranging from 2.5 to 25.6 million (Rioux *et al*. 2013; Martin *et al*. 2022). In Europe, fatalities in birds also reach millions each year (Prinsen *et al*. 2011; Garrido *et al*. 2022 in Martin *et al*. 2022).

The impact of power line mortalities extends beyond individual birds to population-level consequences, affecting species such as cranes, bustards, and diurnal raptors (Jenkins *et al*. 2010, 2011; Loss *et al*. 2015; Martins *et al*. 2023). Power lines also induce habitat conversion, fragmentation, and create barrier effects, altering migratory patterns of birds (Pruett *et al*. 2009; Raab *et al*. 2011; Palacín *et al*. 2017; Biasotto and Kindel 2018; Martins *et al*. 2023). For instance, Sage Grouse *Centrocercus urophasianus* avoid nesting within 1.1 km of transmission lines, with negative impacts on nest and brood success observed up to distances of 2.4 km and 1.3 km, respectively (Kohl *et al*. 2019). Arctic-breeding geese also experience limitations in usable feeding areas due to power lines in staging and wintering habitats, leading to avoidance (Haas *et al*. 2003). The disturbances stemming from power lines, including noise, magnetic and electrical fields, increased predation risks, and the formation of barriers, effectively result in habitat loss (Prinsen *et al*. 2011).

Collisions mainly occur when birds fly into overhead wires (Demerdzhiev 2014; Bateman *et al*. 2023), and can happen universally at all above-ground power lines. The likelihood is higher on high-voltage lines, mainly due to the almost invisible ground wire, when compared to low or medium voltage lines (Prinsen *et al*. 2011).

Collision is influenced by factors like exposure frequency, environmental conditions (habitat and time of day), and species traits (size, visual ability, etc.) (Bevanger 1994; Bevanger 1998; Jenkins *et al*. 2010; Loss *et al*. 2014). Large, heavy, less maneuverable birds, with short, round wings, and species with rapid flight, are at the highest risk of collision (Bevanger 1998; Jenkins *et al*. 2010; Raab *et al*. 2011; Sporer *et al*. 2013). Species that regularly breed, rest, or forage near power lines face very high risk of collision

JUSTO MARTÍN

Collisions peak during twilight with less visible power lines, concurrent with the increased movement of birds during these hours

(APLIC 1994; Bevanger and Broseth 2004; Prinsen *et al.* 2011; APLIC 2012; Sporer *et al*. 2013; Dwyer *et al*. 2022 in Martin *et al*. 2022). Most collisions occur during twilight and at night when visibility is reduced (APLIC 1994; Haas *et al*. 2003; Dwyer *et al*. 2022 in Martin *et al*. 2022).

Birds get electrocuted on poles/wires when they create a circuit by touching two live parts or a live part and a grounded one (Loss *et al*. 2014). Grounded parts include a non-insulated pole or pole equipment like transformers (Kagan 2016). Distribution lines (lower voltage lines) pose electrocution risk as large birds can easily contact two electrical conductors like cables, poles, transformers, while higher-voltage structures or transmission towers ensure safer distances, comparatively reducing this risk for birds (APLIC 2006). Gregarious birds face multiple simultaneous electrocutions (Nicholson *et al*. 2022 in Martin *et al*. 2022). The electrocution of birds not only raises conservation concerns but also results in financial losses attributed to power disruptions and repair expenses (Shobrak 2012).

Here we summarise the impacts of power lines on birds in the form of collision and electrocution and possible mitigation measures practised around the world.

METHODOLOGY

Literature pertinent to the electrocution, collision of birds with power lines, and mitigation measures was reviewed from various sources. Various search engines like Google™, Google Scholar™, and scientific journal websites in the biological sciences were explored. Additionally, the Connected Papers platform (www.connectedpapers.com) was employed for a more targeted exploration of academic papers on the subject. In some cases, information was obtained directly from relevant authorities working in similar field via email. For detailed information not accessible in the open literature, organizational websites were also referred to.

DISCUSSION

Global Scenario

Bird mortalities due to power lines have been reported globally spanning Europe, North America, Asia, Africa, and South America. Research papers referred in this review indicate affected countries, including Spain, Italy, Bulgaria, Poland, Slovakia, the Czech Republic, Austria, Hungary, Azerbaijan, Kazakhstan, Russia, Nepal, Saudi Arabia, Mongolia, South Africa, Sudan, Morocco, U.S., Canada, Argentina, New Zealand and Norway.

Impact of collision on population of large species like Bustards, Cranes, Storks and other species

Large bird species, such as bustards, cranes, and storks, frequently experience collisions in notable numbers. Janss & Ferrer (1998) and Janss (2000) reported mortalities, including 26 and 10 Little Bustards *Tetrax tetrax* from 1991 to 1995 (west-central Spain) and 1991 to 1993 (central-west Spain), respectively. Additionally, Janss & Ferrer (2000) and Raab *et al*. (2012) documented the deaths of 23 and 32 Great Bustards *Otis tarda* from 1992 to 1995 in southwestern Spain and from 2002 to 2011 in Eastern Austria and Western Hungary, respectively.

Jenkins *et al*. (2011) reported 109 Ludwig's Bustard *Neotis ludwigii* mortalities from May 2008 to August 2009 in Southwest Africa. Furthermore, Janss (2000) and Janss & Ferrer (2000) detailed mortalities, including 8 and 25 Common Crane *Grus grus* from 1991 to 1993 in central-west Spain and 1992 to 1995 in southwest Spain, respectively. Murphy *et al*. (2016) and Dwyer *et al*. (2019a) reported deaths of 17 and 49 Sandhill Cranes *Grus Canadensis* at Nebraska, USA in 2009 and 2018, respectively. Additionally, Janss and Ferrer (1998), Garrido and Fernandez-Cruz (2003), Shobrak (2012), and Demerdzhiev (2014) documented mortalities, including 6, 101, 254, and 20 White Storks *Ciconia ciconia* from 1991–1995 in west-central Spain; December 1999 to November 2000 in Madrid, Central Spain; 2008 to 2011 in Saudi Arabia; and in some time segments from 2004 to 2012 in Bulgaria, respectively. Moreover, Demerdzhiev *et al*. (2009) reported 4 Black Stork *Ciconia nigra* mortalities from September to December 2004 in southern Bulgaria.

Waterfowl were also found to be affected by collision incidents, with reports from Faanes (1987) indicating 166 waterbird mortalities in North Dakota during seasonal intervals between July 1980 to May 1982. Janss and Ferrer (1998) documented 4 Mallard *Anas platyrhynchos* mortalities in west-central Spain from 1991 to 1995, while Costantini *et al*. (2017) reported 4 Mallard mortalities in Italy from April 2009 to April 2010.


JUSTO MARTÍN

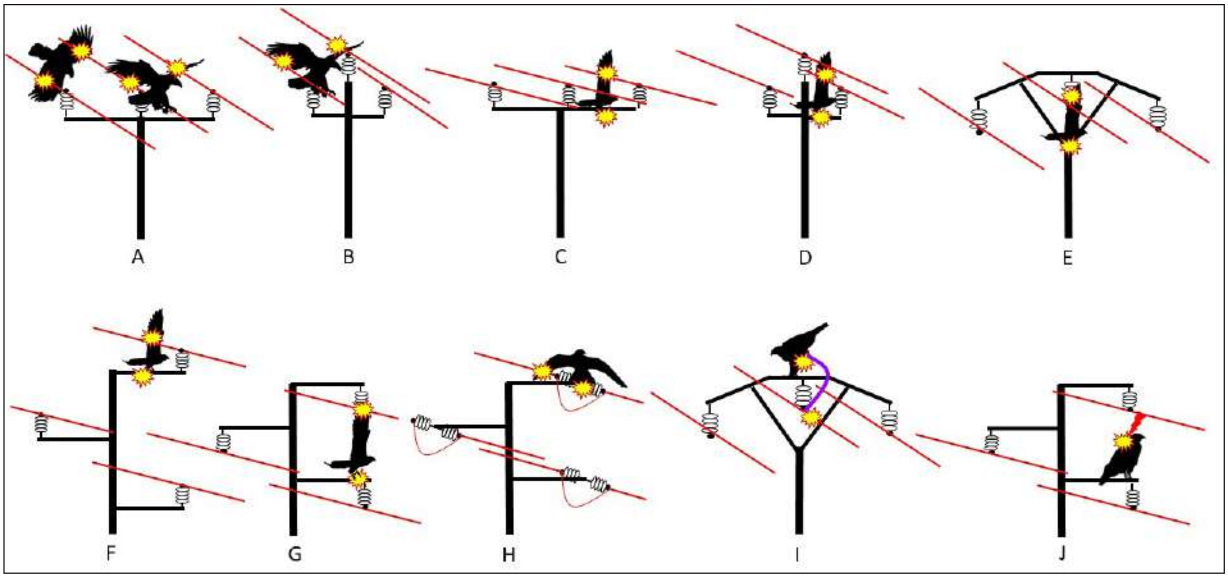
Navigational challenges are greater for the large, heavy bustard species, as collisions become a notable concern given their poor frontal vision, high wing loading and poor maneuverability. In image: Great Bustard *Otis tarda*

Additionally, Galis *et al*. (2019) reported 189 Mute Swan *Cygnus olor* mortalities in southern Slovakia for some time segments during 2014 to 2016. Furthermore, Sporer *et al*. (2013) detailed incidents involving 83 American Coots *Fulica americana* and 27 Double-crested Cormorants *Phalacrocorax auritus* in North Dakota, USA from 2006 to 2008. Morover, Martin *et al*. (2022) documented deaths of Mallards and Northern Shovelers *Spatula clypeata* in Canada in 2016-17.

Greater Flamingos *Phoenicopterus roseus* were also recorded as collision victims in Southwest Spain from 1991 to 1995 by Janss and Ferrer (1998) (n=6).

Impact of electrocution on population of large birds like Birds of Prey and Storks

Raptors experience some impact of collisions, but their primary vulnerability lies in electrocution. In our review, we found studies reporting frequent mortalities of raptor species such as Eurasian Buzzard *Buteo buteo* by Janss (2000) (n=167) from 1990–92 in south-west Spain, (Demerdzhiev *et al*. 2009) (n=12) from September–December 2004 in southern Bulgaria, (Demerdzhiev 2014) (n=26) in some time segments from 2004–2012 in Bulgaria, (Galis *et al*. 2019) (n=1023) from 2014–16 in Southern Slovakia, and (Škorpíková *et al*. 2019) (n=452) from 2015–16 in Czech Republic. Similarly, Bonelli's Eagle *Aquila fasciata* mortalities are reported by Janss (2000) (n=17) from 1990–92 in south-west Spain, Manosa and Real (2001) (n=6) from 1990–97 in Catalonia, northeastern Spain, and Irizi *et al*. (2021) (n=19) from 2016–19 in Guelmim-Oued Noun, Morocco. Long-legged Buzzard *Buteo rufinus* mortalities are reported by Lasch *et al*. (2010) (n=35) from May to August 2006 in Central Kazakhstan, Irizi *et al*. (2021) (n=32) from 2016–2019 in Guelmim-Oued Noun, Morocco, and Pestov *et al*. (2020) (n=2) during summer 2017 and autumn 2019 in Western Kazakhstan. Mortalities of 17 Egyptian Vultures *Neophron percnopterus* in East



Source: Martin Martin *et al*. 2019

Various scenarios depict potential contact points leading to electrocution events: Electrocution occurs when birds contact conductors (A, B) or a conductor and grounded metal (C-H) simultaneously. Rarely, it results from defecation (I) or electric arc formation (J). In ungrounded cross arms, electrocution happens only with contact between two phases (A, B)

Africa (Angelov *et al*. 2013), 7 Black Vultures *Coragyps atratus* in Argentina (Galmes *et al*. 2017), and 1 White-rumped Vulture *Gyps bengalensis* in Nepal (Hamal *et al*. 2023) were documented. Our review found 59 Eurasian Eagle-owls *Bubo bubo* faced mortality in Bergamo, Italian Alps (1960–1999) (Rubolini *et al*. 2001). In Tucson, Arizona (March–September 2003, February–August 2004), 33 Great Horned Owls *Bubo virginianus* died (Dwyer and Mannan 2007), and in Alberta, Canada (June–August 2003), 6 Great Horned Owls and Red-tailed Hawks *Buteo jamaicensis* were reported dead (Kemper *et al*. 2013).

Storks, including 36 White Storks in south-west Spain (1990 to 1992), 51 White Storks in central Spain (December 1999 to November 2000), 3 Black Storks in southern Bulgaria (Sep. to Dec. 2004), and 50 White storks in Bulgaria (Sep. 2004 to Dec. 2004, Feb. 2008 to Jan. 2010, Sep. 2012 to Nov. 2012) were reported as electrocution victims (Janss 2000; Garrido and Fernandez-Cruz 2003; Demerdzhiev *et al*. 2009; and Demerdzhiev 2014 respectively).

At the end of this article, an annexure includes data on collision and electrocution mortalities from 37 studies, highlighting the most impacted species in each study alongside any species of conservation significance and other relevant factors.

Comparison between mortalities due to transmission lines and distribution lines

In our review of 37 research papers, Rubolini *et al*. (2001), Demerdzhiev *et al*. (2009), Demerdzhiev (2014), Galis *et al*. (2019), and Hamal *et al*. (2023) reported that birds can die due to collision and electrocution on the same distribution line, but comparison showed that the number of mortalities are more due to electrocutions as compared to collisions on same distribution lines. Birds prone to such mortalities are Common Starling *Sturnus vulgaris*, Black Stork, White Stork, Eurasian Buzzard, Eurasian Magpie *Pica pica*, Common Myna *Acridotheres tristis*, House Crow *Corvus splendens,* and Rock Dove *Columba livia*. Bevanger and Broseth (2004) found that in a subalpine habitat, a 22 kV distribution line caused more mortalities of Willow Ptarmigan *Lagopus lagopus* by collision as compared to 66 kV and 300 kV power lines.

Bird groups most commonly affected by collision with high-tension transmission lines are bustards, cranes, ducks, swans, pheasants, lapwings, doves, pigeons, larks, and sparrows (Alonso *et al*. 1994; Janss and Ferrer 1998; Janss 2000; Janss and Ferrer 2000; Manosa and Real 2001; Jenkins *et al*. 2011; Raab *et al*. 2012; Murphy *et al*. 2016, Costantini *et al*. 2017; Galis *et al*. 2019; Dwyer *et al*. 2019; Ferrer *et al*. 2020; Martin *et al*. 2022). Manosa and Real (2001) reported Bonelli's Eagles experiencing mortality due to collision and electrocution on transmission lines.

Habitat – Comparative account of various habitats with reasoning

A variety of habitats significantly impact bird mortalities associated with power lines. Factors such as habitat preferences, food availability, nesting and perching sites, and migration patterns impact mortality risk. Our literature review encompasses diverse habitats, including open landscapes, cultivated areas with scrub and cereal crops, mountainous regions, urban environments, wetlands, subalpine habitats, river channels, and more. Understanding the specific bird species in an area is crucial for targeted conservation efforts to mitigate power line-related threats. In open areas, where large and medium-sized birds like raptors often use power lines and associated structures as perching sites, they are particularly vulnerable to electrocution.

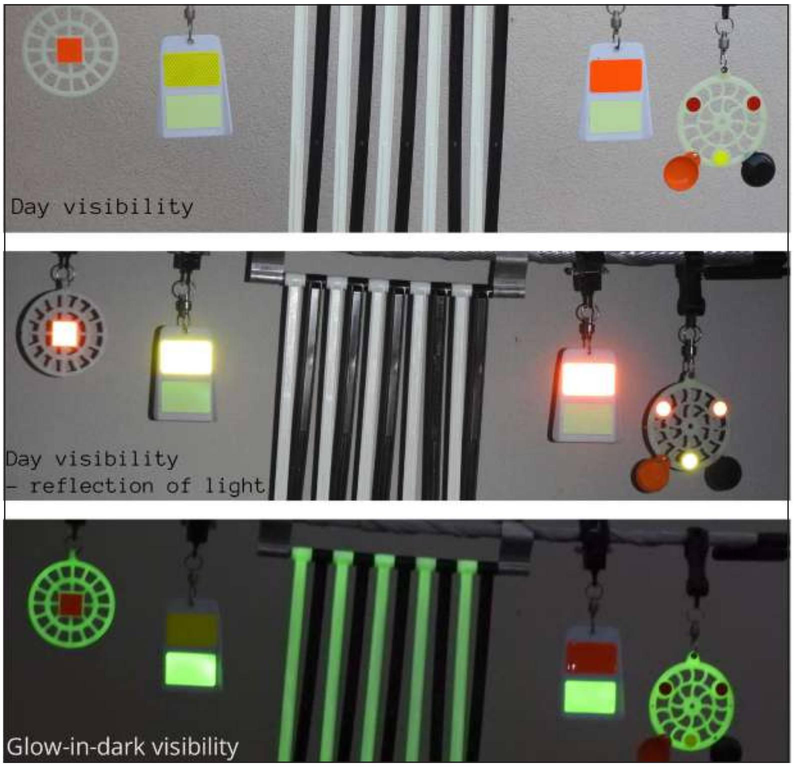
In our review, several studies focussed on bird mortalities associated with power lines in grasslands, agricultural zones, cultivated landscapes, and steppe ecosystems (Janss and Ferrer 1998; Demerdzhiev *et al*. 2009; Shobrak 2012; Voronova 2012; Raab *et al*. 2012; Kemper *et al*. 2013; Galis *et al*. 2019; Škorpíková *et al.* 2019; Ferrer *et al*. 2020; Dixon 2020; Pestov *et al*. 2020; Irizi *et al*. 2021; Martin *et al*. 2022 etc.). This implies a higher occurrence of bird mortalities in these ecosystems, emphasizing the need for precise mitigation strategies.

Effectiveness of bird diverters in reducing bird collisions

Various types of line marking devices or bird diverters have been tested to enhance visibility of power lines to birds. These devices are also useful for other sky users like parachutists, paragliders, microlights, helicopters, and so on (Derouaux *et al*. 2012). Line markers include various types such as aerial marker spheres, spirals like bird flight diverter and swan flight diverter, suspended devices (fixed or rotating, reflective, hanging plastic plates) like Firefly bird diverters, BirdMark bird diverters, RIBE line marking devices etc. As per Barrientos *et al*. (2011) and Bernardino *et al*. (2019), the effectiveness varies significantly, ranging from under 10% to over 90%, with an average around 50%, but, the efficacy is dependent on the bird species. Active markers with moving elements are more effective than passive ones (Bernardino *et al*. 2018; Ferrer *et al*. 2020; Martin *et al*. 2022). Investigating avian perception of power line cables and markers is a critical scientific research area. Further insights into interspecific variations in visual acuity, colour, and UV perception could enhance the understanding of collision risks, aiding the development of more effective markers (Bernardino *et al*. 2018).

Here, we present few case studies evaluating the efficacy of various bird markers.

1) Static wire marking as a strategy to reduce collisions – Alonso *et*



Courtesy: RAPTOR PROTECTION OF SLOVAKIA, dravce.sk

Various Line markers during day and night (Birdmark Afterglow, FireFly Bird diverter, RIBE® bird flight diverter, CROCFAST® BIRD DIVERTER)

Courtesy: RAPTOR PROTECTION OF SLOVAKIA, dravce.sk

UV-stabilized FireFly Bird Flight Diverters are highly reflective during the day, and continue to glow for up to 10 to 12 hours post sunset

Courtesy: RAPTOR PROTECTION OF SLOVAKIA, dravce.sk

Double black and white aviation marker balls employed for 220 kV power lines, with one marker placed every 30–35 meters along the earth wire and conductor

JAMES DWYER, EDM International, Inc.

Drones provide a cost-effective and safe alternative for attaching line markers without risking human safety, revolutionizing traditional methods

al. (1994) found 61% reduction in daily bird crossings in Spain after placing red-coloured spirals along a transmission line. The diversity and number of dead birds found in marked areas decreased from 45 birds of 19 species before marking to 18 birds of 13 species after marking. In contrast, unmarked sectors saw no significant change in the number of dead birds.

2) Conductor-marking and static wire marking – Janss and Ferrer (1998) found decrease in collisions along a transmission line and two distribution lines in Spain by comparing mortality below marked spans to unmarked spans along the same power line. Under 4.6 km of unmarked line, 60 mortalities were recorded, whereas under 3.8 km of marked line, only 26 mortalities occurred. White spirals reduced collisions by 81% through static wire marking. Black crossed bands were effective through conductor marking, but not for Great Bustard. The third marker, consisting of thin black stripes did not reduce mortality through conductor marking.
3) Sporer *et al*. (2013) found that BirdMark Flappers, Swan Flight Diverters, and Firefly Flappers were ineffective on power lines over open water, resulting in only a 28.9% reduction in mortalities from 10.3 to 5.8 carcasses per span per year in North Dakota, USA. Line marking was most beneficial for birds with long, slender wings, like shorebirds

Courtesy: RAPTOR PROTECTION OF SLOVAKIA, dravce.sk

Avian marker spheres are of international orange, gloss white, gloss yellow, and other colours, of which yellow is effective, reflecting light at dawn and dusk, and contrasting with backgrounds better than international orange

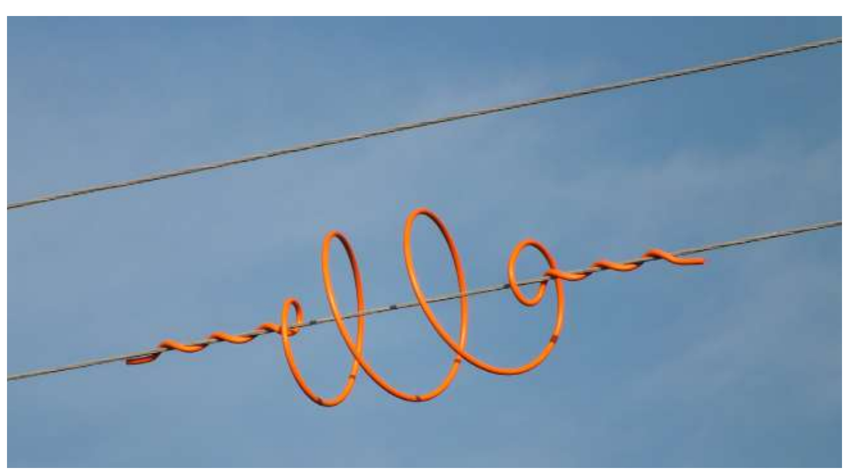
and gulls, while those with medium-aspect-ratio (high-speed) wings derived the least benefit. Durability issues were noted for some markers. The study reported 40 bird carcasses below marked spans over open water, 197 bird carcasses below unmarked spans over open water, and 39 bird carcasses below unmarked spans over lake shores. Power line collisions were most common for American Coots and Double-crested Cormorants. This highlights the complex and varied effectiveness of different marking strategies in reducing bird mortalities linked to power lines.

4) In a study by Murphy *et al*. (2016) in the USA, it was observed that the FireFly HW Bird Flapper and spiral vibration dampers were unsuccessful in averting collisions of Sandhill Cranes, particularly at night. The majority of collisions (64.8%) occurred with the shield wire on a 69 kV transmission line.

5) Galis and Sevcik (2019) reported a 93.5% reduction in bird fatalities (93 vs. 6) on 77 km of marked power lines (including phase conductors and earth wire) in Slovakia from June 2016 to June 2019. This was in comparison to the pre-installation period (December 2014 to February 2016), which recorded 93 carcasses of various bird species, including Mute Swans, Mallards, Great White Egrets *Ardea alba*, passerines, White Storks, Common Pheasants *Phasianus colchicus*, Northern Lapwings *Vanellus vanellus*, and Common Pochards *Aythya ferina*. After installation, only 6 carcasses involving Mute Swans and Great White Egrets were observed. The study highlighted the positive impact of bird flight diverters (FireFly Bird Diverter, RIBE Bird Flight Diverter, and Swan Flight Diverter) in enhancing power line visibility, resulting in fewer bird observations within 5 meters of power lines and indicating increased bird reaction distances.

6) Ferrer *et al*. (2020) found that by marking the ground wire across a 400 kV transmission line in Southern Spain, the flapper flight diverter resulted in a 70.2% lower avian mortality rate (CI: 50-90%), followed by the orange spiral (43.7%, CI: 15.8-71.6%), and the yellow spiral (40.4%, CI: 2.8-78%), compared to control spans. Flappers showed the greatest reduction in mortality compared to non-marked spans.

7) Shaw *et al*. (2021) found that implementing yellow and black bird flappers, and white and black large, helical, static bird flight diverters on a 72 km stretch of a 400 kV transmission line in South Africa's semi-arid Nama Karoo significantly reduced collisions for Blue Cranes *Anthropoides paradiseus* by 92% and all large birds by 51% over eight years (2008–2016).



Courtesy: RAPTOR PROTECTION OF SLOVAKIA, dravce.sk

Swan Flight Diverter

However, Ludwig's Bustard and other bustard species did not show a similar reduction. Among the 10 most frequently found carcasses, 5 were bustard species, including Northern Black Bustard *Afrotis afraoides* and Kori Bustards *Ardeotis kori*. High collision rates of Ludwig's Bustards (0.68 birds km–1 yr–1) raised concerns about population-level effects for this range-restricted and endangered species. These "poor fliers," characterized by large bodies and high wing loadings, need to fly at high speeds to stay airborne, but they have limited maneuverability in avoiding obstacles (Bevanger 1998; Raab *et al*. 2011; Silva *et al*. 2022). The study emphasizes the urgency of exploring alternative strategies to mitigate bustard collision mortality. A total of 31 bird species as collision victims were recorded after marking.

We conclude that line marking devices have demonstrated effectiveness in mitigating bird collisions with power lines, although the effectiveness may vary depending on factors such as bird species, the type of marker used, and the specific marking techniques employed.

Devices which aid in monitoring collisions

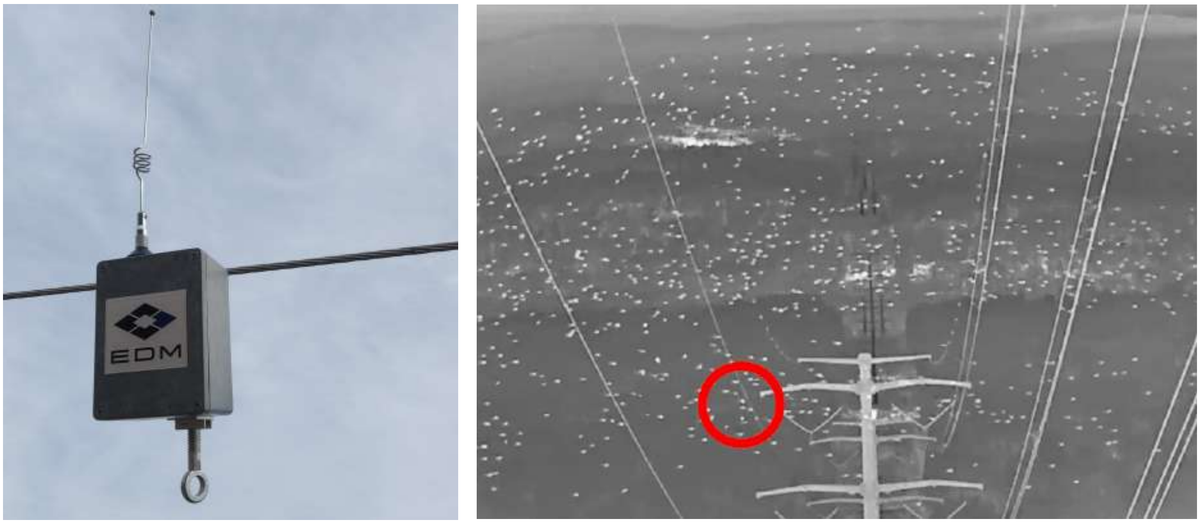
In this section, we discuss devices specifically engineered to monitor bird collisions with power lines. A notable example is the Accelerometer-based Bird Strike Indicator (BSI). BSIs detect vibrations from bird strikes, sending recorded signal data to a base station. BSIs have demonstrated successful utilization in multiple projects, as evidenced by published results from Harness *et al*. (2003) and Pandey *et al*. (2007). BSIs outperform visual observation, detecting crane collisions (Murphey *et al*. 2009; Murphy *et al*. 2016) and assess bird flight diverter efficacy (Luzenski *et al*. 2016). BSIs are an alternative to directly observe bird collisions and can be particularly useful in low-light or no-light conditions (APLIC 2012).

Additionally, the Electric Power Research Institute (EPRI) in the USA is developing an Animal Activity Monitor (AAM) equipped with smart vision thermal cameras. Installed on transmission towers, these cameras track and report collisions, utilizing an algorithm to distinguish bird activity from other background movements, such as clouds and wire motion caused by wind (Dwyer *et al*. 2022 in Martin *et al*. 2022).

Emerging technologies and feasibility in execution to reduce mortalities

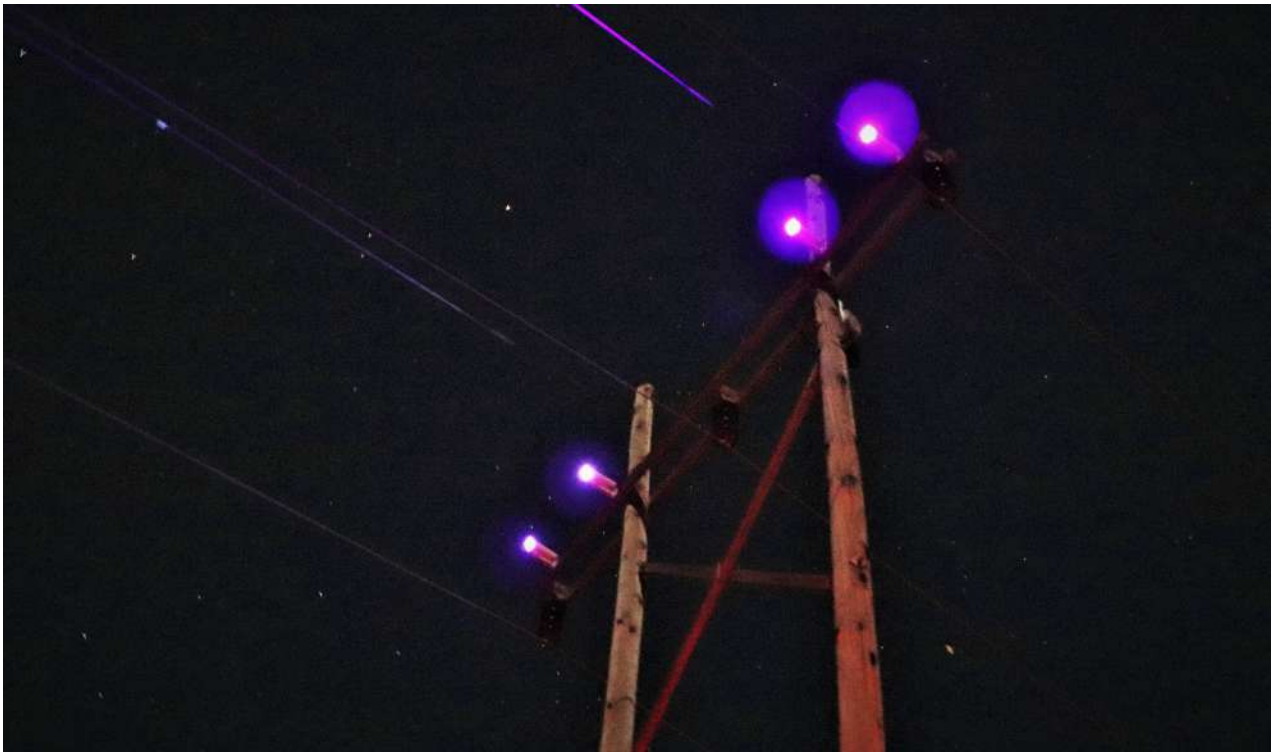
As efforts to mitigate bird collisions with power lines continue, innovative approaches and advanced technologies have emerged as crucial components. Some noteworthy examples are outlined below:

RICHARD HARNESS, EDM International, Inc.



RICHARD HARNESS, EDM International, Inc.

(Left): Utilizing advanced Bird Strike Indicators (BSI) is crucial for monitoring and mitigating potential collisions, providing valuable insights into bird behaviour around critical areas to enhance avian safety in proximity to power lines (Right): Smart vision cameras installed on a transmission pole capture passerines crossing a transmission line, offering direct monitoring for collision mortality on power lines


JAMES DWYER, EDM International, Inc.

Avian Collision Avoidance System (ACAS) employs near-ultraviolet light, invisible to the human eye but visible to birds, on power lines to prevent Sandhill Crane *Grus canadensis* collisions in Nebraska, USA

1) In a groundbreaking study, Dwyer *et al*. (2019a) achieved an outstanding 98% reduction in Sandhill Crane collisions with power lines in early spring by implementing the Avian Collision Avoidance System (ACAS). This solar-powered device emits near-ultraviolet light (UV-A; 380–395 nm; visible to birds but not humans) along wires (258-m power line span crossing the Platte river), reducing hazardous flights by 82%. Notably, prior attempts using two types of line markers, FireFly and Bird Flight Diverter, proved ineffective in preventing Sandhill Crane collisions at the Nebraska Rowe Sanctuary, USA. The practicality of implementing the Avian Collision Avoidance System (ACAS) for widespread use may be constrained due to higher costs in comparison to traditional non-lighted line markers like FireFly. ACAS could find utility in specific collision hotspots, but the overall expense, installation complexity, and maintenance might favour the continued use of traditional markers, particularly in areas with infrequent collisions, balancing budget and conservation priorities. The expenses associated with illuminated systems may reduce as the products reach commercial maturity.

   The study acknowledges the effectiveness of ACAS in specific contexts, and its broader applicability to diverse bird species and varied line configurations needs further exploration (Dwyer *et al.* 2019b).

2) On the island of Kaua‘i in Hawaii, USA, innovative experiments have been conducted to safeguard endangered and endemic seabird species, including the Newell’s Shearwater *Puffinus newelli*, Hawaiian Petrel *Pterodroma sandwichensis*, and Band-rumped Storm-Petrel *Hydrobates castro*. These initiatives involve the creation of a ‘laser fence’ using lasers projected between poles. This cutting-edge technology utilizes narrowly focused green beams, ensuring visibility to birds in complete darkness while posing no hazard to aircraft or passersby, as the beams are parallel to the ground and the installation is

not in designated airspace. This approach presents a rapid and cost-effective solution to reduce line strikes by endangered seabirds. Additionally, bird diverters with LED reflectors and glow-in-the-dark features are being strategically deployed along specific spans of power lines.

These concerted efforts, led by the Kaua‘i Island Utility Cooperative (KIUC) in collaboration with the Kaua‘i Endangered Seabird Recovery Project (KESRP), include KIUC's minimization of powerline bird strikes by reconfiguring lines to reduce vertical layers, removing static wires, and deploying bird diverters (reflective and LED), with strike reductions ranging from 42% to over 90% (LaserPointerSafety 2015; Kaua‘i Endangered Seabird Recovery Project n.d.; Pers. Comm. Beth Amaro – Kaua‘i Island Utility Cooperative).

3) The solar-powered Overhead Warning Light (OWL) line marker emits small flashes of light perpendicular to its installation line (Preformed Line Products 2017; Dwyer *et al*. 2019a).

Green laser lights installed on power lines indicated reduction in seabird collisions on Kaua‘i Island, Hawaii, USA

Mitigation Measures

Collision Mitigation –

In the global effort to mitigate bird collisions with power lines, complete elimination is possible only by burying wires underground, as highlighted by Janss & Ferrer (1998) and Rubolini *et al*. (2005). Various measures have been explored for bird collision prevention, including both preventive actions applied beforehand and corrective or mitigating measures addressing issues either partially or fully, whether temporarily or permanently; the selection of these measures necessitates consideration of technical, economic, and species-specific factors, as emphasized in studies such as APLIC (2012) and Bernardino *et al*. (2018). In addition to utilizing line markers, alternative measures can be implemented to mitigate bird collisions as given below.

1) Line Configuration

Extensive research has shown that the horizontal configuration of high-tension power lines is preferable over predominantly vertical alignment, effectively minimizing the collision-prone vertical plane for birds. This insight is drawn from studies conducted by Bevanger (1994), Jenkins *et al*. (2010), Prinsen *et al*. (2011), and Bernardino *et al*. (2018).

2) Line Routing

In areas with multiple line intersections, combining or closely situating power lines has been recommended. This condensed network enhances visibility, requiring birds to undertake a single ascent and descent to navigate the series of lines. Relevant studies supporting this strategy include APLIC (2012) and Prinsen *et al*. (2011).

Topography

Optimizing power line routing by aligning it parallel to natural landscape features, such as rivers or mountain valleys, has been proposed as an effective strategy. This approach minimizes collision risks by following concentrated bird flight routes, as indicated by studies conducted by Faanes (1987), Drewitt and Langston (2008), and APLIC (2012). Avoiding perpendicular placement to crucial flight routes further reduces the potential for collisions, as highlighted in APLIC (1994).

3) Installing large-diameter ground wires

Studies have identified that birds are more prone to collisions with the ground wire, a thin single wire positioned above the conductors (APLIC 1994; Sporer *et al*. 2013; Bernardino *et al*. 2018, Martin *et al*. 2022). The reduced detectability of the ground wire increases collision risk compared to phase conductors (Pandey *et al*. 2007; Murphy *et al*. 2009; Martin and Shaw 2010, Prinsen *et al*. 2011; Rioux *et al*. 2013). Integrating substantial ground wires with a diameter exceeding 20 mm, such as Optical Ground Wire (OPGW) featuring an optical fiber inner core, enhances visibility and differentiation from the conductors, as proposed by Bernardino *et al*. (2018). However, the effectiveness of this initiative remains unstudied to date—an interesting avenue for future research, as suggested by Dwyer *et al*. (2022) in Martin *et al*. (2022).

4) Bundling of Wires

Research indicates that bundling wires enhances visibility, reducing collision risk, with added effectiveness achieved by using spacers to prevent wire contact. This technical intervention is specifically essential for high-tension power lines (150 kV or higher), as emphasized by Prinsen *et al*. (2011).

5) Insulated and Twisted Conductors

Insulated and twisted conductors serve as a permanent solution to reduce electrocution while minimizing collision risks with a single, highly visible element. However, the implementation of twisted conductors is limited to voltages below 30 kV, and its application can be costly, especially for existing lines. For voltages exceeding 132 kV, employing distinct insulated conductors is feasible, as discussed by Ferrer *et al*. (2022a) in Martin *et al*. (2022).

Electrocution Mitigation –

Mitigating the risks of electrocution is considered a more practical approach compared to collision mitigation, as noted by Prinsen *et al*. (2012). Given the

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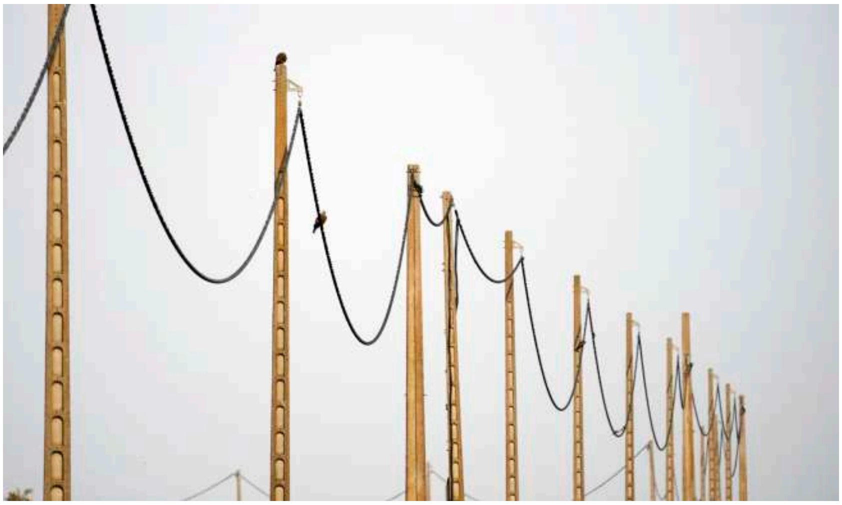
Visibility of wires is enhanced by bundling of a high-voltage transmission line at 380 kV featuring spacers (indicated by an arrow) designed to maintain separation between individual energized phase conductors within each bundle



Twisted, insulated conductors reduce collisions by increasing visibility in distribution lines

(Top): Disconnected insulation sheath results from suboptimal fitting, highlighting the importance of precise installation for effective bird protection (Bottom): The insulation inadequately shields the entire live metal component, potentially compromising safety

significant expenses associated with modifying pylons and power lines, it is crucial to prioritize careful planning and ensure a safe configuration right from the outset, as emphasized by Ferrer *et al*. (2022a) in Martin *et al*. (2022).

Various measures as described below can be commonly employed in electrocution mitigation (APLIC 2006; Prinsen *et al*. 2011; Prinsen *et al*. 2012; Martin *et al*. 2022). These include 1) positioning power lines (conductors) below the cross-arms, 2) preferably selecting suspended insulators and vertical disconnectors, and covering upright insulators and horizontal disconnectors. The latest generation of insulating caps is applied on upright insulators, 3) Additionally, energized and grounded parts are insulated using suitable material, and insulating chains of at least 70 cm (0.70 m) in length are utilized, 4) Cross-arm insulation is implemented on both sides of the cross-arm for at least 70 cm, 5) Further measures involve perch-specific insulation, targeting all other energized parts within 70 cm of a potential perch, 6) Bird-friendly devices, such as perching and nesting devices, are installed to enhance safety, 7) Spacing guidelines are crucial, necessitating adequate spacing, a minimum of 1.4 m (140 cm) between power lines, and a gap greater than 0.6 m (60 cm) between potential perch sites and energized parts. In regions with large perching raptors like Africa, maintaining greater distances (>2.7 m between power lines and >1.8 m between perches and energized parts) is recommended,

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(Top): Bird-friendly crossbar design with alternating suspended insulators, ensures safety distances to minimize electrocution risk. (Bottom): Enhanced bird safety from electrocution is achieved by retrofitting pylons with advanced insulation

Courtesy: MOHAMED BIN ZAYED RAPTOR CONSERVATION FUND AND THE MONGOLIAN BIRD CONSERVATION CENTRE

The insulation of crossarms is pivotal for safety enhancements in certain setups

8) To ensure safe cross-arm configurations on supports, the implementation of total or partial cross-arm replacement is considered a lasting solution, particularly when supports pose known dangers.

Some good examples of mitigating electrocution risks –

In preventing bird electrocutions, several commendable examples highlight the effectiveness of strategic interventions:

1) TasNetworks' Avian Protection Initiative: In the late 1990s, Tasmanian power distribution network provider TasNetworks achieved a remarkable reduction of over 80% in electrocutions of Grey Goshawks *Accipiter novaehollandiae* and Wedge-tailed Eagles *Aquila audax* by altering pole-top configurations near nests (Hess *et al*. 1996).
2) Andalusia's Power Line Safety Project: In Andalusia since 1992, a collaboration between the main electricity company and the regional government led to the safeguarding of 20,000 dangerous pylons along 5,000 km of power lines, implementing straightforward solutions and adjusting line configurations based on scientific advice. Actions included building new pylons with suspended insulators, avoiding those with exposed jumpers above the insulators, and routing new power lines away from breeding grounds. Retroactive mitigation measures involved replacing exposed insulators with suspended ones and installing protective systems on pylons to prevent bird collisions. These efforts resulted in a notable 62% decrease in mortality rates despite the ongoing expansion of overhead power lines. Consequently, the population of Spanish Imperial Eagles *Aquila adalberti* in Andalusia surged from 22 breeding pairs in the early 1970s to 122 pairs by 2020. (CMS 2020; Ferrer *et al*. 2022b in Martin *et al*. 2022).
3) Mohamed Bin Zayed Raptor Conservation Fund's Global Impact: The Mohamed Bin Zayed Raptor Conservation Fund has played a pivotal role in preventing the electrocution of approximately 18,000 raptors in Mongolia annually, including about 4,000 Saker Falcons *Falco cherrug*, through extensive measures such as insulating 27,000 poles since 2019–the world's largest single-line electrocution mitigation effort. The Fund's impactful conservation extends to Bulgaria, addressing genetic barriers and establishing a self-sustaining breeding population for Saker Falcons (Gulf Today 2023).

Need of Environmental Impact Assessment (EIA) studies focussed on birds

During the planning phase of power lines, Environmental Impact Assessment (EIA) studies are essential, emphasizing year-long ornithological investigations. These surveys should characterize local and

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Effective anti-electrocution measures (Top Left): A White Stork *Ciconia ciconia* perching on a raised structure atop a pylon and an anti-perching deterrent; (Top Right): Raised structure for nesting purposes with a White Stork *Ciconia ciconia* nest; (Bottom): Utilization of anti-perching deterrents combined with a nearby artificial nest alternative

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(Top): Various anti-perching deterrents discourage birds from perching on hazardous surfaces or structures – Sturdy metal plates; (Bottom): Fixed metal anti-bird spikes with an umbrella configuration

regional bird movements, including local commuting flights between breeding, feeding, and resting areas, and seasonal migration. Day, twilight, and night flight patterns must be studied. This comprehensive data is vital for informed decision-making and effective collision risk mitigation (Haas *et al*. 2003; Prinsen *et al*. 2011).

Additional measures include sensitivity mapping, the installation of double circuit lines over existing ones (APLIC 2012), integrating with transportation routes, avoidance of sensitive wildlife areas, and incorporation of restoration measures in environmental impact studies (e.g. nest boxes for small and medium-sized birds, improvements in the vegetation, etc.). Furthermore, maintenance near nests during nesting and breeding seasons of prioritized species should be minimized (Martin *et al*. 2022a in Martin *et al*. 2022). Redundant power lines and cables should be removed, and non-functional devices, such as poles retrofitted with detached insulating sheaths, should be promptly replaced (Martin *et al*. 2022a in Martin *et al*. 2022).

Citizen Science Initiatives

There are various citizen science initiatives being taken worldwide to protect birds from harm caused by energy infrastructure.

(1) In Europe, initiatives like the 'Vogelfundportal' – an online portal enabling users to report bird fatalities near power lines – involve collaboration between Renewables Grid Initiative (RGI), NABU/BirdLife Germany, and German grid operators (Martin *et al*. 2022b in Martin *et al*. 2022).

(2) IUCN-Med in collaboration with Fundación Amigos del Águila Imperial, Lince Ibérico y Espacios Naturales Privados, provides the free mobile app e-faunalert (https://efaunalert.org/) to collect global data on wildlife-threatening power lines, available in multiple languages (Martin *et al*. 2022b in Martin *et al*. 2022).

AVISTEP: Safeguarding Birds and Biodiversity in Renewable Energy Expansion

To safeguard birds and biodiversity from potential harm caused by the expansion of renewable energy infrastructure in Asia, BirdLife International and the Asian Development Bank (ADB) collaborated to develop AVISTEP: The Avian Sensitivity Tool for Energy Planning (avistep.birdlife.org). This tool enables the identification of areas where renewable energy projects could impact birds and biodiversity, allowing planners to make informed decisions and select the most suitable locations for facilities. Although AVISTEP aims for global coverage, its current focus includes surveying the following Asian countries: India, Nepal, Thailand, and Vietnam. The tool encompasses various energy infrastructure types, such as onshore wind, offshore wind, photovoltaic (PV) solar, overhead transmission lines (high voltage), and overhead distribution lines (low-medium voltage) (Asian Development Bank 2022).

Recommendations in the Indian context

Indian biologists have not extensively studied avian interactions with power lines, but recent studies suggest a significant impact on bird populations. With the increasing number of power lines associated with renewable energy projects, the risk to bird species from electrocutions and collisions is expected to rise (Uddin *et al*. 2021; Narwade *et al*. 2021; Juvvadi 2022 in Martin *et al*. 2022). In India, the National Committee on Transmission (NCT) has approved ten new transmission projects worth Rs. 6,600 crore, including two major projects in Gujarat and the eastern region of India, with the aim of achieving 500 GW of renewable energy by 2030 (mint 2023). Policy decisions are crucial for making India's power line infrastructure bird-safe. Proposed measures include small design changes, such as using suspended insulators, to minimize the risk of electrocution (Juvvadi 2022 in Martin *et al*. 2022). A separate article can be referred in the same document.

Bird-friendly measures to tackle energy infrastructure across the world

Countries across the globe are implementing various bird-friendly measures to mitigate the impact of power lines on avian species, which are outlined in Table 1. These initiatives include undergrounding power lines, enacting legislation for bird-safe construction, incorporating mitigation measures, and collaborating with conservation authorities and NGOs. The efforts range from guidelines and working groups, strict environmental impact assessment procedures, demonstrating a global commitment to reducing bird mortality associated with power infrastructure. Below, we summarize the bird-friendly measures adopted by various countries (Compiled from Prinsen *et al*. 2011).

(***continued on next page***)

Table 1: Bird-friendly measures adopted by various countries

Sr. No.	Countries	Bird-friendly Measures
1	Austria	High percentage of medium voltage lines already undergrounded. Governmental working groups and guidelines on bird-friendly practices.
2	Bosnia and Herzegovina	Nature protection legislation mandates mitigation measures on power lines. Close consultation with the Ministry of Energy for bird-safe construction.
3	Bulgaria	EIA procedures for potential undergrounding in sensitive areas. Voluntary measures by electricity companies to reduce bird mortality. Active participation in LIFE projects targeting bird protection. Ongoing monitoring by NGOs, such as BirdLife Bulgaria.
4	Canada	EIA procedures at federal and provincial levels for power lines. Mitigation measures applied by electricity companies.
5	Czech Republic	Enacted in 2009, legislation mandates mitigation measures on all power lines by 2024. New power lines must incorporate mitigation measures from inception under the 1992 Nature Conservation and Landscape Act.
6	Denmark	Decision made to underground power lines, starting with lower voltage and later progressing to higher voltage lines, as per the available technical solutions.
7	Germany	Federal law mandates nationwide mitigation since 2002. New constructions must integrate measures, and existing ones should enhance bird safety. German NGO NABU's 'Birds and power lines' group, active for 30+ years, influenced new guidelines in 2011 from electricity companies (VDE) to reduce outages.
8	Hungary	BirdLife Hungary monitors and researches power line impacts, supported by the EU/LIFE program for species like Saker Falcon *Falco cherrug* and Red-footed Falcon *Falco vespertinus*. Electricity companies contribute financially for research and conservation, presenting strategies to prevent negative impacts of power lines. Hungary received LIFE grants for protection of Great Bustard and Eastern Imperial Eagle *Aquila heliac*a.
9	Israel	The distribution company (IEC) in Israel has implemented measures such as insulating pylons, particularly near IBAs, rubbish dumps, and nature reserves.
10	Montenegro	The Nature Conservation Act of 2009 in Montenegro mandates construction of electricity poles in a way to prevent bird electrocution and collision, including monitoring of bird populations, with a strict EIA procedure for new power lines considering bird conservation aspects.
11	Namibia	Namibia mandates EIA procedures for new power lines, requiring bird-friendly construction to reduce bird electrocutions and power outages. Guidance and training given to technicians for effective mitigation measures by companies.
12	Portugal	Extensive collaboration and proactive measures, with legislation and financial support systems reinforcing environmental conservation efforts by electricity companies.
13	Serbia	Special emphasis is placed on protecting bird migration routes, ensuring power lines avoid such paths. In 2005, Serbian electricity company EPS committed to modifying existing power line poles and designing new ones, particularly for medium and low voltage lines.

Sr. No.	Countries	Bird-friendly Measures
14	Slovakia	Legislation such as the Nature and Landscape Protection Act mandates measures to prevent bird fatalities, fostering collaboration between electricity companies and conservation authorities.
15	South Africa	A collaborative effort between the primary electricity supplier and the 'Endangered WildLife Trust' aims to minimize bird risks and implement mitigation measures, addressing both conservation and outage concerns.
16	Spain	The Nature and Landscape Protection Act specifies legal obligations, aligned with EU Directives, Bern, and Bonn conventions, for power line construction and mitigation in sensitive areas, encompassing protected areas, important bird areas, and regions with threatened species. Spain has received LIFE grant for protection of endangered birds of prey and both Little and Great Bustard.
17	Switzerland	Strict EIA procedures govern the construction of higher voltage lines, with provisions for compensatory measures in protected areas and for red-listed species. Legislation mandates bird-safe constructions for pylons in new power lines, with a shift towards underground cables and guidelines available for implementing technical measures.
18	United Kingdom	Legal obligations aligned with EU Directives ensure bird collision and electrocution mitigation, involving measures like replacing wires with insulated ones, markers, and avoiding dangerous pylons. National Policy Statements prioritize safety, with considerations for underground placement of wires.

Note: Source – Prinsen *et al*. (2011)

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(***For Annexure, see alongside***)

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
1	North Dakota, U.S.	Two spring and two fall migration periods between July 1980 to May 1982	Waterfowl	166	–	Diverse habitats: grazed prairie, cropland, emergent vegetation, wetlands, riparian, wheat fields	400 kV, 230 kV, and 12 kV	Faanes 1987
			Gulls	143				
			Cranes	62				
2	Southwest Spain	December 1989 to April 1990, December 1990 to April 1991	Common Woodpigeon *Columba palumbus*	18	–	Typical mediterranean scrubland area – Cereal cultivation alternate with Holm Oak Wood and Cork Oak	380 kV	Alonso *et al.* 1994
			Northern Lapwing *Vanellus vanellus*	14				
			Common Crane *Grus grus*	7				
			Great Bustard *Otis tarda*	5				
			Little Bustard *Tetrax tetrax*	5				
3	West-central Spain, south-west Spain	1991 to 1995	Great Bustard *Otis tarda*	23	–	Cultivated area with partial scrubland, grassland, and cereal crops; extended cultivated area for cattle-grazing and for cereal cultivation; river delta	380 kV, 132 kV, and 13 kV	Janss and Ferrer 1998
			Little Bustard *Tetrax tetrax*	26				
			Common Crane *Grus grus*	13				
4	South-west Spain	September 1990 to November 1992	Eurasian Buzzard *Buteo buteo*	–	167	Cultivated areas with dispersed oak trees; marshes, Mediterranean scrubland, cork oak forest, and pine plantations; mountainous with rocky cliffs, Mediterranean scrubland and forests, and oak savannah; oak trees and used for extensive agriculture (cattle grazing, grain plantation) forming a steppe-like habitat.	Not mentioned	Janss 2000
			Common Raven *Corvus corax*		117			
	Central-west Spain	December 1991 to January 1992, August 1992 to March 1993, July 1993 to October 1993	Great Bustard *Otis tarda*	16	–	Section A: Cultivated area with scrub, oak savannah and cereal cultivation. Section B: Mediterranean Holm Oak wood. Section C: Cultivated area used for cattle grazing and for cereal cultivation forming a steppe-like habitat.		
			Little Bustard *Tetrax tetrax*	10				
			Common Crane *Grus grus*	8				

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines (*contd.*)

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
5	Spain	1992 to 1995	Common Crane *Grus grus*	25	–	Cereal cultivation with dispersed oak trees, scrub, Mediterranean forest	400 kV	Janss and Ferrer 2000
			Great Bustard *Otis tarda*	23		Extensive cultivated, steppe-like habitat for cattle grazing and cereal cultivation	132 kV	
6	Bergamo, Italian Alps	1960 to 1999	Eurasian Eagle-owl *Bubo bubo*	10	59	Italian Alps	15–30 kV	Rubolini *et al.* 2001
7	Catalonia, northeastern Spain	1990 to 1997	Bonelli's Eagle *Aquila fasciata*	2	6	Littoral and Pre-littoral Mountain ranges	110 and 400 kV	Manosa and Real 2001
8	Madrid, Central Spain	December 1999 to November 2000	White Stork *Ciconia ciconia*	101	51	Intensified dry and irrigation farming, grazing lands for cattle, gravel extraction, and human rubbish dumps	Distribution lines and transmission lines	Garrido and Fernandez-Cruz 2003
9	Southern Norway	April 1989 to June 1995	Willow Grouse *Lagopus lagopus*	318	–	Subalpine habitats dominated by northern boreal birch woodland mixed with small mires	300 kV, 66 kV, and 22 kV	Bevanger and Broseth 2004
10	Tucson, Arizona, USA	March to September 2003, February to August 2004	Harris's Hawk *Parabuteo unicinctus*	–	75	Urban and suburban area surrounding the city of Tucson	4 kV and 8 kV	Dwyer and Mannan 2007
			Great Horned Owl *Bubo virginianus*		33			
11	Southern Bulgaria	September to December 2004	Common Starling *Sturnus vulgaris*	5	11	Cultivated fields and pastures with scattered bushes, groups of oak trees, and small coppices	20 kV	Demerdzhiev *et al.* 2009
			Black Stork *Ciconia nigra*	4	3			
			White Stork *Ciconia ciconia*	1	14			
			Eurasian Buzzard *Buteo buteo*	2	12			
12	Wairau Plain, Marlborough, New Zealand	Not mentioned	New Zealand Falcon *Falco novaeseelandiae*	–	10	Not mentioned	Not mentioned	Fox and Wynn 2010
13	Central Kazakhstan	May to August 2006	Long-legged Buzzard *Buteo rufinus*	–	35	Urban environment; steppe habitats and salt lakes; fields and fallow lands	10–35 kV	Lasch *et al.* 2010
			Lesser Kestrel *Falco naumanni*		61			

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines (*contd.*)

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
14	Karoo, South Africa	May 2008 to August 2009	Ludwig's Bustard *Neotis ludwigii*	109	–	–	400 kV	Jenkins *et al.* 2011
15	Saudi Arabia	2008 to 2011	White Stork *Ciconia ciconia*	254		Site 1: Open sandy areas with cultivated trees on the roadside/scattered ground cover. Site 2: Open with sand and sandy gravels and crosses several wadis and rocky areas	380-400 kV, 110-170 kV	Shobrak 2012
			Common Quail *Coturnix coturnix*	170				
16	Central Kazakhstan	7 to 11 May 2011, 21 to 30 May 2011, 20 June to 04 July 2011, 20 Aug. to 04 Sep. 2011, 6 to 16 Sep. 2011	Small passerines	11	–	Steppe ecosystem	6–10 kV, 35 kV, 110 kV	Voronova 2012
			Little Bustard *Tetrax tetrax*	5				
			Rook *Corvus frugilegus*	–	303			
			Eagle sp *Aquila* sp.		273			
			Steppe Eagle *Aquila nipalensis*		36			
17	Eastern Austria and Western Hungary	1 June 2002 to 31 May 2011	Great Bustard *Otis tarda*	32	–	Flat or gently undulating agricultural areas dominated by cereal fields and some fallow fields	380 kV, 220 kV, and 110 kV	Raab *et al.* 2012
18	Alberta, Canada	June to August 2003	Great Horned Owl *Bubo virginianus*	–	6	Agricultural areas with a mosaic of cereal crops and small livestock operations	7.2 kV, 14.4 kV, and 24.9 kV	Kemper *et al.* 2013
			Red-tailed Hawk *Buteo jamaicensis*					
19	North Dakota, USA	2006 to 2008	American Coot *Fulica americana*	83	–	Open Water/Causeway bisecting lakes	115 kV and 41.6 kV	Sporer *et al.* 2013
			Double-crested Cormorant *Phalacrocorax auritus*	27				
20	Sudan, East Africa	30 September 2010 and 1 October 2010	Egyptian Vulture *Neophron percnopterus*	–	17	Not mentioned	Distribution line	Angelov *et al.* 2013
21	Bulgaria	Sep. 2004 to Dec. 2004, Feb. 2008 to Jan. 2010, Sep. 2012 to Nov. 2012	White Stork *Ciconia ciconia*	20	50	Arable lands, Grasslands, Vineyards, Forests	20 kV	Demerdzhiev 2014
			Eurasian Buzzard *Buteo buteo*	7	26			
			Common Starling *Sturnus vulgaris*	7	21			

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines (*contd.*)

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
22	Leszno, Western Poland	2005 to 2012	White Stork *Ciconia ciconia*	24		Agricultural area of arable fields interspersed with meadows, pastures, human settlements, and small forests.	Not mentioned	Tobolka 2014
23	US Fish and Wildlife Service's National Forensics Laboratory (NFWFL)	2000 to 2015	Bald Eagle *Haliaeetus leucocephalus*	–	230	–	Distribution lines	Kagan 2016
			Golden Eagle *Aquila chrysaetos*		103			
			Red-tailed Hawk *Buteo jamaicensis*		32			
			Great Horned Owl *Bubo virginianus*		15			
			Osprey *Pandion haliaetus*		16			
			Red-shouldered Hawk *Buteo lineatus*		6			
			Swainson's Hawk *Buteo swainsoni*		4			
			Harris's Hawk *Parabuteo unicinctus*		3			
			Peregrine Falcon *Falco peregrinus*		3			
			California Condor *Gymnogyps californianus*		1			
			Cooper's Hawk *Accipiter cooperii*		2			
			Rough-legged Buzzard *Buteo lagopus*		1			
			Snowy Owl *Bubo scandiacus*		1			
24	Platte River, Nebraska, USA	4 March to 13 April 2009	Sandhill Crane *Grus canadensis*	17	–	River channel braided with sandbars and islands, and bordered by grassy meadows and croplands.	69 kV	Murphy *et al.* 2016
25	Italy	April 2009 to April 2010	Common Pheasant *Phasianus colchicus*	8	–	Open/agricultural, wetland, and woodland habitats	132 kV and 380 kV	Costantini *et al.* 2017
			Mallard *Anas platyrhynchos*	4				

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines (*contd.*)

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
26	La Pampa, Central Argentina	November 2011 to December 2012	Burrowing Parrot *Cyanoliseus patagonus*	–	12	Arid and semiarid biomes (xerophytic deciduous forests characterised by trees of the genus *Prosopis*; high shrub steppe, mostly characterised by *Larrea* sp. communities with isolated *Prosopis* sp. trees).	13.2 kV	Galmes *et al.* 2017
			Black Vulture *Coragyps atratus*		7			
			Crowned Solitary Eagle *Buteogallus coronatus*		4			
27	Southern part of Slovakia	December 2014 to March 2015, April 2015 to February 2016	Mute Swan *Cygnus olor*	189	–	Lowland agricultural landscapes	110 kV	Galis *et al.* 2019
			Common Pheasant *Phasianus colchicus*	120				
			Eurasian Buzzard *Buteo buteo*	3	1025		22 kV	
			Eurasian Magpie *Pica pica*	5	601			
			Eastern Imperial Eagle *Aquila heliaca*	–	6			
			Saker Falcon *Falco cherrug*		7			
28	Czech Republic	July 2015 to April 2016	Passeriformes like Common Blackbird *Turdus merula*, Fieldfare *Turdus pilaris*, Song Thrush *Turdus philomelos*	33	–	Open lowland landscapes	22 kV and 35 kV	Skorpikova *et al* 2019
			Other Passeriformes	45				
			Eurasian Buzzard *Buteo buteo*	–	452			
			Eurasian Magpie *Pica pica*		201			
29	Central Platte River, Rowe Sanctuary, Nebraska, USA	18 February to 19 April 2018	Sandhill Crane *Grus canadensis*	49	–	River	69 kV	Dwyer *et al.* 2019
30	Andalusia, Southern Spain	October 2004 to October 2006, March 2008 to March 2009, March 2009 to January 2012, March 2009 to February 2012	Columbidae	23	–	Line 1: Pseudo-steppe area occupied by dry cereal crops, leguminous crops, and fallow lands; Line 2: man-made steppes, occupied by dry cereal crops, with some spotted areas of olive trees and bushes; Line 3: Dry cereal crops with areas of olive trees and bushes	400 kV	Ferrer *et al.* 2020
			Alaudidae	20				

Annexure: Avian mortalities reported in various study areas due to collisions and electrocutions at power lines (*contd.*)

S. No.	Study Area	Study Duration	Affected bird species/groups	No. of Collision Mortalities	No. of Electrocution Mortalities	Habitat	Capacity of power line	Reference
31	Mongolia	2013 to 2015 and 2018	Saker Falcon *Falco cherrug*	–	1721	Open undulating steppe landscape	15 kV	Dixon 2020
32	Nakhchivan Autonomous Republic	2016–2017	European Bee-eater *Merops apiaster*	–	36	Less open, open space (loos), forest landscape, residential areas, and less grove areas	Distribution lines	Mammadov and Matsyura 2020
			Common Starling *Sturnus vulgaris*		35			
33	Western Kazakhstan	Summer 2017 and Autumn 2019	Steppe Eagle *Aquila nipalensis*	–	11	Not mentioned	6 – 20 kV	Pestov *et al.* 2020
			Long-legged Buzzard *Buteo rufinus*		2			
34	Orenburg, Russia/ Kazakhstan	2010 to 2020	Eastern Imperial Eagle *Aquila heliaca*	–	17	Mainly steppe ecosystem with minor forest-steppe ecosystem	6 – 10 kV	Barbazyuk 2021
			Red-footed Falcon *Falco vespertinus*		17			
35	Guelmim-Oued Noun, Morocco, Africa	April 2016 to December 2019	Long-legged Buzzard *Buteo rufinus*	–	32	Open steppe and undulating landscapes with sparse human activity	22 kV	Irizi *et al.* 2021
			Bonelli's Eagle *Aquila fasciata*		19			
			Spanish Imperial Eagle *Aquila adalberti*		2			
36	Southeastern Alberta, Canada	5 May to 24 June 2016 and 31 March to 5 May 2017	Western Meadowlark *Sturnella neglecta*	–	–	Intact, non-cultivated grassland habitat with constructed wetlands	500 kV	Martin *et al.* 2022
			Sharp-tailed Grouse *Tympanuchus phasianellus*					
			Mallard *Anas platyrhynchos*					
			Northern Shoveler *Spatula clypeata*					
37	Nepal	November 2021 to May 2022	House Swift *Apus nipalensis*	5	–	Agricultural lands, forests, settlements, and river basins	11 kV and 33 kV	Hamal *et al.* 2023
			Common Myna *Acridotheres tristis*	6	1			
			House Crow *Corvus splendens*	2	11			
			Rock Dove *Columba livia*	1	5			
			White-rumped Vulture *Gyps bengalensis*	–	1			

Note: The table presents the two or more most impacted species from each study, selected from all species reported, alongside any species of conservation significance, regardless of their lower mortality figures.

Bird mortalities due to electrocutions and collisions with energy infrastructures in India — A review

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Energy infrastructure and its impacts on birds

The detrimental effects of power lines and associated structures on the habitat and biodiversity are well known. As the demand for electricity generation grows with the need to reduce dependency on fossil fuels, a steep rise in the "green energy" sector is seen. A rise in wind farms, solar power plants and other renewable energy sectors also contributes to the global power grid for transmission of the harnessed electricity and thus, an increase in the power line network along with other associated transmission solutions (Rafique *et al*. 2018). Substantial research on the impact of linear structures like power lines and renewable energy infrastructure (eg; wind turbines) on ecosystems and biodiversity has long since been discussed.

Negative effects of such structures are especially pronounced in volant organisms such as birds and bats (Schuster *et al*. 2015). As reviewed by Biasotto and Kindel (2018), in addition to habitat conversion and fragmentation, direct impact of overhead power lines is of creating a barrier effect, thus leading to collision and electrocution risks for millions of birds (Loss *et al*. 2015). Though transmission lines and associated towers act as a resource for a foraging/nesting perch, instances of electrocution due to perching, lead to additional mortalities (Biasotto and Kindel 2018). Power line mortalities are known to have population-level impacts (Loss *et al*. 2015) and cause even changes in migratory patterns (Palacín *et al*. 2017). Redlisted species are many a times documented as casualties (Biasotto and Kindel 2018).

As evidenced by a number of studies, the rotation of the wind turbines pose mortality risks to volant organisms such as birds and bats (Laranjeiro *et al*. 2018, Perold *et al*. 2020). Birds, based on their size, flight dynamics, and other factors get hit by the rotating blades of the wind turbines leading to mortality. However, except a few studies, the impact of wind turbines on birds seem minimal in comparison to power line mortalities (Kikuchi 2008, Loss *et al*. 2014).

Global reviews on the impact of power lines on birds and subsequent mortalities are biased towards North America and Europe (Bernardino *et al*. 2018, Richardson *et al*. 2017). The same is the case for wind energy-biodiversity studies where studies are concentrated around North America and Europe (Fernández-Bellon 2020). In their review, Bernardino *et al*. (2018) show that the least percentage of studies conducted on bird collisions with power lines is in South America (4.5%) followed by Asia (6.1%). With China being the world's leading producer of electricity and India, the third only after the United States of America, the lacunae present in the knowledge of power line impacts on birds and environmental impact studies geographically, is clearly seen.

Status in India

Globally, India stands third highest in electricity production (PIB 2020). With respect to renewable energy, India has the fourth highest rank in wind installed capacity (total installed capacity - 35.6 GW)


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Powerlines in the prime bird habitats at Kutch, Gujarat

and stands the fifth highest in solar power deployment (30 GW). Overall electricity generation in the country, including generation from grid connected renewable source, has been increased from 1,110.458 BU during 2015 to 1,390.457 BU by 2020, with a total installed capacity of 3,79,130 MW. Power Grid Corporation of India Limited (POWERGRID), which transmits about 50% of the total power generated in India on its transmission network operates more than 1,51,507 Ckt. kms network of transmission lines, 3,55,029 MVA transformation capacity and 239 no. of substations that constitute most of India's interstate and inter-regional electric power transmission system and carries electric power across India.

Though almost 3,03,014 sq. km of its area is covered by a power grid network, there is still a lacuna of research on the effect of these overhead transmission and supply lines on birds in India. A handful of studies have been published in peer-reviewed sources. Other than a journal issue with compilation of reports of avian and bat collision and electrocution (Narwade *et al*. 2013), other studies focus on single-species mortality like Flamingos (Tere and Parasharya 2011) or Sarus Crane *Grus antigone* (Kaur *et al.* 2008, Sundar and Choudhury 2005) with the exception of two. Other than these publications, the other reports of bird collision and electrocution mortality in India are only in the form of "grey literature".

Review of existing information

In this review, we address the issue of lack of a systematic review of bird mortalities in India due to renewable energy and electricity generation. Though previous studies have focused on specific species and locations, a comprehensive survey is still lacking. With this review article, we aim to consolidate current knowledge by providing a qualitative overview of major effects on birds, and the factors that probably influence these effects.

Mesh of powerlines in bird habitats, Coimbatore, Tamil Nadu

Review Methodology

An extensive search of literature was done to amass information on bird collisions and electrocutions with power lines and wind turbines in India. Published peer-reviewed literature was searched using the internet search engine Google™, Google Scholar™ (www.scholar.google.com) and scientific journal websites related to Biological sciences along with individual reports of mortalities at collision hotspots such as wind farms or due to power transmission lines. This collection of studies was supplemented largely by the information available as "grey" reports in the form of news articles reporting casualties, study reports by websites of organisations (Sálim Ali Centre of Ornithology and Natural History, Wildlife Institute of India, and Bombay Natural History Society) working on birds. For detailed reports not available in open literature, information was gathered on request from the author and institutes. Searches were also done to extract online regional newspaper accounts of mortalities in Tamil, Hindi, Marathi, and Malayalam languages Some information was also collected from social media Facebook™ pages birdwatcher groups.

The relevant literature was reviewed for information including journal details, collision/electrocution dates, species, and causes. Studies with relevant details were analyzed, ranging from 1945 to 2021.

Review Results:

Data Summary

A total of 1,203 mortalities belonging to at least 82 definitive species, were recorded. Of the total number of mortalities documented, 93% were accounted for by literature pertaining to collisions/electrocutions with power lines, while 7% mortalities a result of wind turbine collisions.

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A wind turbine near a wetland in Kutch, Gujarat

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A windfarm near Kalakad Mundanthurai Tiger Reserve, Tamil Nadu

State-wise records of bird mortality

The compiled records, from 1945 to early 2021, span across 13 states with the highest number of mortality records from Rajasthan (42.5%), followed by Gujarat (19 %), Haryana (17%) and Maharashtra (5%). Seven states have less than 20 records (Fig. 1). Power line collisions/electrocution mortality has been recorded in 12 states, with the highest % mortality recorded in Rajasthan (45%), followed by Haryana (18.4%) as most of the records are mortalities due to collision with power lines rather than wind turbines.

It has to be noted that by nature of the studies – species, location and hazard specific, bird mortality (for eg: The high number of mortalities reported in Haryana is skewed due to a single observation of 206 mortalities of Indian Peafowl *Pavo cristatus* attributed to collision with power lines. Mortalities due to collision with wind turbines have been recorded in five states with the highest mortality represented in Gujarat (55.3%) followed by West Bengal (17.6%) and Maharashtra (15.3%).

Seasonal Pattern

Of the 1,203 mortality records, the month of collision/ electrocution could be extracted only for 557 records. Based on these records, the highest percentage mortality (56.8%), due to collision/electrocution, has been recorded during winter (December to February), followed by the monsoon season (June to

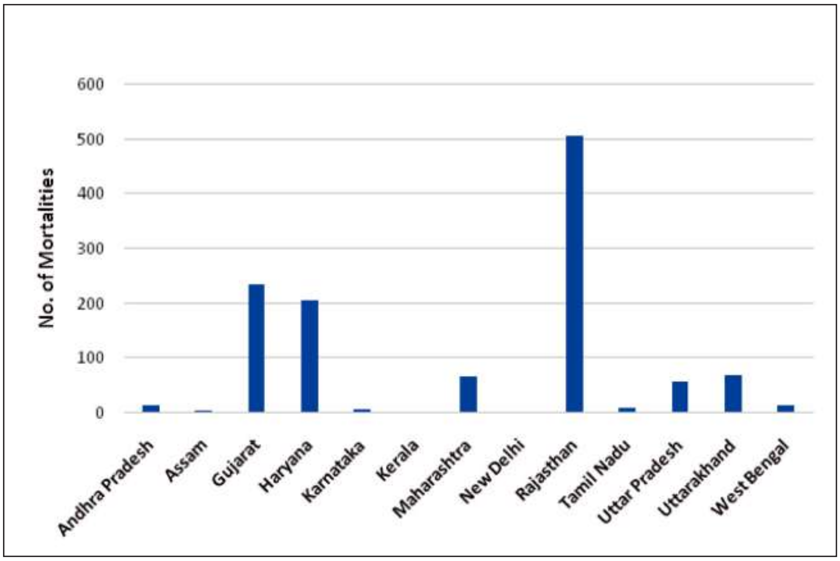

Fig.1 State-wise bird mortalities

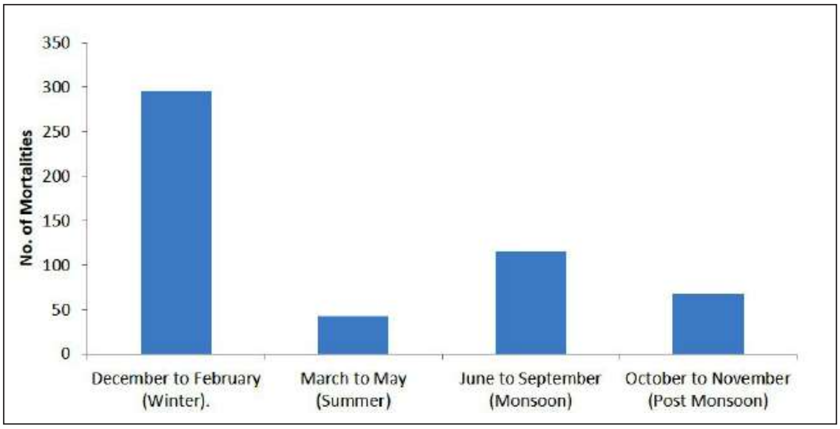

Fig. 2: Seasonal pattern of bird mortalities occurrence

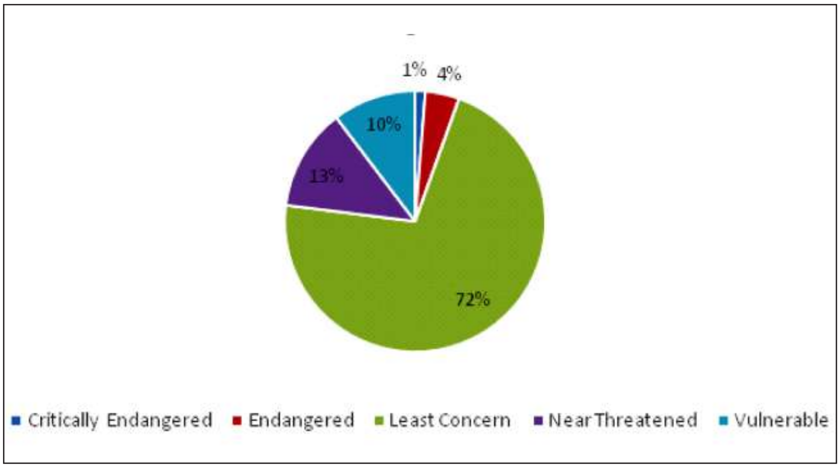

Fig. 3: IUCN Redlist categories of species reported in mortalities

September), where 22.3% records have been compiled (Fig. 2). During the summer months (March to May), 8.1% instances of bird mortality have been recorded.

Conservation Status of Species involved in Mortalities

Of the mortalities identified to the species level, worryingly, 28% of mortalities were of species categorised as globally Near-Threatened and Threatened, as per the IUCN Red list (Fig. 3).

Regarding fatalities caused by power transmission lines, it has been observed that out of the 1118 documented cases of collision/ electrocution mortalities, 135 individuals remain unidentified. The families Phasianidae, represented one species - Indian Peafowl, and Phoenicopteridae, represented two species - Greater Flamingo *Phoenicopterus roseus* and Lesser Flamingo *Phoeniconaias minor*, have reported the highest number of mortalities at 22.2% and 21.6%, respectively. Following them is Accipitridae at 16%, with 11 species represented, of which the Himalayan Griffon *Gyps himalayensis* has the highest mortality rate with 50 individuals recorded, followed by the Steppe Eagle *Aquila nipalensis* with 26 individuals. Strigidae, represented by five species of owls, has a mortality rate of 1.5%, with the Rock Eagle-owl *Bubo bengalensis* having the highest mortality rate of six individuals. It is worth noting that the available records do not allow for a clear differentiation of the source of mortalities, whether due to transmission lines or distribution lines.

Concerning wind turbine mortality, 85 cases of fatalities due to collisions with wind turbines have been reported, with 69 individuals identified up to species level. Columbidae, represented by two species – Rock Dove *Columba livia* (7 individuals) and Eurasian Collared-dove *Streptopelia decaocto* (10 individuals), accounts for the highest percentage of mortality at 22.7%, followed by Accipitridae at 20%, represented by five species, with the highest mortality rate being four individuals of Black Kite *Milvus migrans* (Table 1).

Table 1: Bird mortalities due to power lines and wind turbines in India

S. No	Family / Common Name	Scientific Name	Power Line related Mortalities	Wind Turbine related Mortalities	Total Mortalities
	Accipitridae				
1	Black Kite	*Milvus migrans*		4	4
2	Bonelli's Eagle	*Aquila fasciata*		1	1
3	Changeable Hawk-eagle	*Nisaetus cirrhatus*		1	1
4	Cinereous Vulture	*Aegypius monachus*	5		5
5	Crested Serpent-eagle	*Spilornis cheela*	1		1
6	Egyptian Vulture	*Neophron percnopterus*	25		25
7	Griffon Vulture	*Gyps fulvus*	13		13
8	Himalayan Griffon	*Gyps himalayensis*	50	2	52
9	Long-legged Buzzard	*Buteo rufinus*	3		3
10	Oriental Honey-buzzard	*Pernis ptilorhynchus*		1	1
11	Short-toed Snake-eagle	*Circaetus gallicus*	1		1
12	Steppe Eagle	*Aquila nipalensis*	26		26
13	Tawny Eagle	*Aquila rapax*	10		10
14	White-rumped Vulture	*Gyps bengalensis*	1		1
15	White-eyed Buzzard	*Butastur teesa*	9		9
	Unidentified Raptor		8	6	14
	Unknown Vulture		6		6

Table 1: Bird Mortalities due to Power lines and Wind Turbines in India (*contd.*)

S. No	Family / Common Name	Scientific Name	Power Line related Mortalities	Wind Turbine related Mortalities	Total Mortalities
	Acrocephalidae				
16	Clamorous Reed-warbler	*Acrocephalus stentoreus*	1		1
	Alaudidae				
17	Bimaculated Lark	*Melanocorypha bimaculata*	4		4
18	Greater Short-toed Lark	*Calandrella brachydactyla*	12		12
	Unknown Lark		14		14
	Alcidinidae				
19	White-breasted Kingfisher	*Halcyon smyrnensis*		1	1
	Anatidae				
20	American Black Duck (misidentification)	*Anas rubripes*		1	1
21	Bar-headed Goose	*Anser indicus*		1	1
22	Common Teal	*Anas crecca*	5		5
23	Gadwall	*Mareca strepera*	1		1
24	Lesser Whistling-duck	*Dendrocygna javanica*		1	1
25	Mallard	*Anas platyrhynchos*	2		2
26	Northern Pintail	*Anas acuta*	1		1
27	Northern Shoveler	*Spatula clypeata*	2		2
28	Red-crested Pochard	*Netta rufina*		1	1
29	Ruddy Shelduck	*Tadorna ferruginea*		1	1
	Anhingidae				
30	Oriental Darter	*Anhinga melanogaster*	1		1
	Apodidae				
31	Little Swift	*Apus affinis*		1	1
	Ardeidae				
32	Black-crowned Night-heron	*Nycticorax nycticorax*		1	1
33	Cattle Egret	*Bubulcus ibis*		5	5
34	Great White Egret	*Ardea alba*		1	1
35	Indian Pond-heron	*Ardeola grayii*		1	1
	Unknown Egret		4		4
	Unknown Heron		1		1
	Bucerotidae				
36	Great Hornbill	*Buceros bicornis*	1		1
	Caprimulgidae				
	Unknown Nightjar		1		1
	Charadriidae				
	Lapwing sp		1		1
37	Red-wattled Lapwing	*Vanellus indicus*	2	1	3
	Ciconiidae				
38	Greater Adjutant	*Leptoptilos dubius*	4		4
39	Painted Stork	*Mycteria leucocephala*	3	1	4

Table 1: Bird Mortalities due to Power lines and Wind Turbines in India (*contd.*)

S. No	Family / Common Name	Scientific Name	Power Line related Mortalities	Wind Turbine related Mortalities	Total Mortalities
	Columbidae				
40	Rock Dove	*Columba livia*	16	7	23
41	Eurasian Collared-dove	*Streptopedia decaocto*	25	10	35
	Coraciidae				
42	Indian Roller	*Coracias benghalensis*	51		51
	Corvidae				
43	House Crow	*Corvus splendens*	71	5	76
	Cuculidae				
44	Western Koel	*Eudynamys scolopaceus*		1	1
	Dicruridae				
45	Black Drongo	*Dicrurus macrocercus*		1	1
	Emberizidae				
46	Grey-necked Bunting	*Emberiza buchanani*	1		1
	Estrildidae				
47	Indian Silverbill	*Euodice malabarica*	1		1
	Falconidae				
48	Common Kestrel	*Falco tinnunculus*	8	4	12
49	Laggar Falcon	*Falco jugger*	2		2
50	Lesser Kestrel	*Falco naumanni*	1		1
	Glareolidae				
51	Cream-coloured Courser	*Cursorius cursor*	7		7
	Gruidae				
52	Common Crane	*Grus grus*	1		1
53	Demoiselle Crane	*Anthropoides virgo*	11		11
54	Sarus Crane	*Grus antigone*	72		72
	Hirundinidae				
55	Dusky Crag Martin	*Ptyonoprogne concolor*		2	2
56	Red-rumped Swallow	*Cecropis daurica*		5	5
	Laniidae				
57	Great Grey Shrike	*Lanius excubitor*	2		2
	Meropidae				
58	Blue-tailed Bee-eater	*Merops philippinus*	2		2
	Motacillidae				
59	Tawny Pipit	*Anthus campestris*	1		1
	Otididae				
60	Great Indian Bustard	*Ardeotis nigriceps*	11		11
	Pandionidae				
61	Osprey	*Pandion haliaetus*	1		1
	Pelecanidae				
62	Dalmatian Pelican	*Pelecanus crispus*	2	2	4
63	Spot-billed Pelican	*Pelecanus phillippensis*	1		1

Table 1: Bird Mortalities due to Power lines and Wind Turbines in India (*contd.*)

S. No	Family / Common Name	Scientific Name	Power Line related Mortalities	Wind Turbine related Mortalities	Total Mortalities
	Phasianidae				
64	Indian Peafowl	*Pavo cristatus*	219		219
	Phoenicopteridae				
	Flamingo sp		64		64
65	Greater Flamingo	*Phoenicopterus roseus*	98		98
66	Lesser Flamingo	*Phoeniconaias minor*	51		51
	Pittidae				
67	Indian Pitta	*Pitta brachyura*		2	2
	Ploceidae				
68	Baya Weaver	*Ploceus philippinus*	1		1
	Psittaculidae				
69	Rose-ringed Parakeet	*Psittacula krameri*	3		3
	Pteroclidae				
	Unknown Sandgrouse		4		4
	Rallidae				
70	Slaty-legged Crake	*Rallina eurizonoides*	1		1
	Scolopacidae				
71	Common Sandpiper	*Actitis hypoleucos*		1	1
72	Common Snipe	*Gallinago gallinago*		1	1
	Strigidae				
73	Eastern Grass-owl	*Tyto longimembris*	2		2
74	Indian Scops Owl	*Otus bakkamoena*		1	1
75	Mottled Wood-owl	*Strix ocellata*	1		1
	Owl		1		1
76	Rock Eagle-owl	*Bubo bengalensis*	6		6
77	Spotted Owlet	*Athena brama*	5		5
	Sturnidae				
78	Common Myna	*Acridotheres tristis*	10		10
79	Rosy Starling	*Pastor roseus*	1		1
	Sylviidae				
80	Lesser Whitethroat	*Curruca curruca*	2		2
	Threskiornithidae				
81	Eurasian Spoonbill	*Platalea leucorodia*	2		2
	Tytonidae				
82	Barn Owl	*Tyto alba*	7	1	8
	Unidentified families				
	Unidentified sp.		135	10	145
	Total		1118	85	1203

Consequences on conservation of birds

In India, most of the bird collisions with wind turbines occur during October–March, when several species of migratory birds use Indian habitats as stopover sites and wintering grounds. The estimated mortality rates ranged from about 0.5 to 2 birds/turbine/year in different studies within India. However the estimations may be on the lower side, as there are several factors like scavenger removal, searcher efficiency etc. (Smallwood 2007). More studies on different habitats like Banni grasslands, desert areas of Rajasthan, foothills of Western Ghats in Tamil Nadu need to be conducted in order to assess the magnitude of bird collision risks. The collision risk of globally threatened species like Steppe Eagle, Great Indian Bustard *Ardeotis nigriceps* etc., needs to be studied in detail, as several key habitats of these species are threatened by development of renewable energy infrastructures.

Displacement of birds due to the wind farms has been reported in Karnataka, Maharashtra, and Gujarat (Pande *et al.* 2013, Thaker *et al*. 2020, Kumara *et al*. 2022, Kumar *et al*. 2022). Studies reported low species richness, diversity in turbine area, compared to adjacent control area (Thaker *et al*. 2020, Kumara *et al*. 2022, Kumar *et al*. 2022) . Several passerine species were low in abundance in turbine area (Kumar *et al*. 2022). Similar effects on raptors were also observed, which is reported to cause a serious ecological imbalance in the particular areas (Kumar *et al*. 2017, Thaker *et al*. 2020). For instance, Thaker *et al*. (2020) found that wind farms in Karnataka reduced the abundance and activity of raptors which increased the density of lizards.

The long term impacts of the wind farm on certain groups like raptors, are of greater concern because they produce few offspring and have a long life expectancy. The study by Carrete *et al.* (2009) clearly explains that wind farms are a serious threat to long-lived raptors, as they decrease survival rates of this species and increase the chances of population decline. The establishment of wind turbines in the habitats of Great Indian Bustard, Lesser Florican *Sypheotides indicus* etc., will be a death blow to these species, as they face several other threat*s* and are on the verge of extinction.

Though bird collisions/ electrocutions are reported across India, reports of mortalities are high in states like Rajasthan, Haryana, Gujarat and Uttarakhand. Unlike other states, there are focussed studies on this issue from Rajasthan (Harness *et al*. 2013, Jhala *et al*. 2020, Narwade *et al*. 2021, Uddin *et al*. 2021). The major concern of studies from Rajasthan is that the affected species include critically endangered Great Indian Bustard. At least 10 individuals of Great Indian Bustard have been killed by the power lines since 2017 (Jhala *et al*. 2020, Narwade *et al*. 2021, Uddin *et al*. 2021). Presence of a large network of power lines in the prime habitats of Great Indian Bustard like Jaisalmer District is posing a severe threat to the survival of the species. Immediate actions should be taken to avoid further collisions of Great Indian Bustard with power lines (Narwade *et al*. 2021, Uddin *et al*. 2021). Another major concern from the Rajasthan studies is that several raptor species were affected by collision/electrocution including globally threatened species like the Egyptian Vulture *Neophron percnopterus*, Tawny Eagle *Aquila rapax*, and Steppe Eagle (Harness *et al*. 2013, Narwade *et al*. 2021). Any plan of renewable energy infrastructure development in the area should be avoided to minimise further risks.

In Haryana, most of the collisions were of Indian Peafowl (TOI 2019) whereas in Gujarat, collisions of species like Greater and Lesser Flamingos and Sarus Crane have been reported (Tere and Parasharya 2011, Mahendiran *et al*. 2020). In the last two decades, collisions of 70 individuals of Sarus Cranes were reported, however the unreported collisions may be very high (Dhruve and Kasambe 2011, Mahendiran *et al*. 2020, Sundar and Choudhury 2005).

Possible mitigation measures

Different types of bird diverters are effective in reducing the collision rate, however underground cables are suggested in the prime habitats of key species like Great Indian Bustard (Ferrer *et al*. 2020, Narwade *et al*. 2021, Uddin *et al*. 2021). Use of sensitivity maps (https://avistep.birdlife.org/) for new installations of power lines is highly suggested to avoid conflicts even before installations.

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Cattle Egret *Bubulcus ibis*

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Pallid Scops-owl *Otus brucei*

A.M.S. ALI

Painted Stork *Mycteria leucocephala*

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Unidentified Raptor

A.M.S. ALI

A dead Rock Dove *Columba livia*

A.M.S. ALI

An injured Rock Dove *Columba livia* (Note the Injuries on eye and under wings)

A.M.S. ALI

A Red-naped Ibis *Pseudibis papillosa* nest with chicks in Transmission Pylon, Kutch, Gujarat

A.M.S. ALI

Steppe Eagle *Aquila nipalensis* perching on a powerline post at Kutch, Gujarat

Conservation actions taken to mitigate this problem require more specific studies on this issue in key habitats of India. Strategic bird sensitivity map will play a crucial role in selecting safer locations for installation of new wind turbines and managing the existing wind farms. BirdLife International in collaboration with BNHS developed a bird sensitivity tool for renewable energy development in India (https://avistep.birdlife.org/). These tools will help in identifying low bird sensitive areas for new wind farm installation thereby reducing the conflict to a large extent. Yet, site specific bird monitoring studies should be conducted before installation of turbine to minimize the impacts.

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LIFE Danube Free Sky: Safer power lines for birds along the Danube river

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Introduction

One of the biggest threats for the wild bird species is electrocution and collisions with power lines causing thousands of avoidable deaths and injuries. These threats are targeted by the LIFE Danube Free Sky project (www.danubefreesky.eu) representing a unique example of wide transnational cooperation along with one of the most important migration corridors, stop-over sites, and wintering places for many bird species in Europe - the Danube River.

The LIFE Danube Free Sky project is co-funded by the LIFE Programme of the European Union and the Ministry of Environment of the Slovak Republic. During the period of project implementation (2020–2026), 15 project partners (8 energy companies, 1 railway company, 3 national parks, and 3 non-governmental bird conservation organizations) from 7 countries collaborate and apply the most effective solutions in order to prevent existential threats to birds. The project is implemented along the Danube River in 25 Special Protection Areas and their adjacent areas located in Austria, Slovakia, Hungary, Croatia, Bulgaria, Romania, and in 9 Important Bird Areas in Serbia. The main goal of the project is to contribute to the aim of the EU Biodiversity Strategy to halt the loss of biodiversity and ecosystem services along the Danube River. This will be achieved by reducing bird mortality on power lines (caused by either electrocution or collision) for 12 target species: *Anser erythropus, Aquila heliaca, Botaurus stellaris, Branta ruficollis, Clanga clanga, Clanga pomarina, Coracias garrulus, Crex crex, Falco cherrug, Falco vespertinus, Otis tarda*, and *Pelecanus crispus.* The most important areas for populations of target species are included in the project area. Thus, the project ensures implementation of measures and prevention of target species proximity with power lines in the most valuable and critical parts of the migration route along the Danube River. The focus is given to hotspots to achieve maximal efficiency of invested personal and financial resources while ensuring safety for target species. Transnational cooperation will help achieve adequate results and share knowledge between experts on this issue to prevent mistakes and adopt best practice methods and standards. The project is coordinated by a team of experts from Raptor Protection of Slovakia.

Monitoring of power lines and mortality risk evaluation

In order to take effective mitigation measures for the prevention of electrocution and collisions, it is necessary to identify the real mortality rate in the area and define the riskiest pole designs and sections of power lines. Over 80 trained field assistants carried out a field survey that covered almost 1,580 km of 8 types of the above ground power lines (10 kV, 20 kV, 22 kV, 35 kV, 110 kV, 220 kV, 400 kV, and electric railway lines) and 12,535 poles according to the International Monitoring Scheme prepared under the project. For each electricity pole/pylon, special technical data were collected together with other abiotic and biotic factors about the surrounding landscape structure and habitat important for birds. This survey provided important input data for the following assessment and classification processes.

During the field surveys, 2,098 bird carcasses and bird remains

MAREK GÁLIS

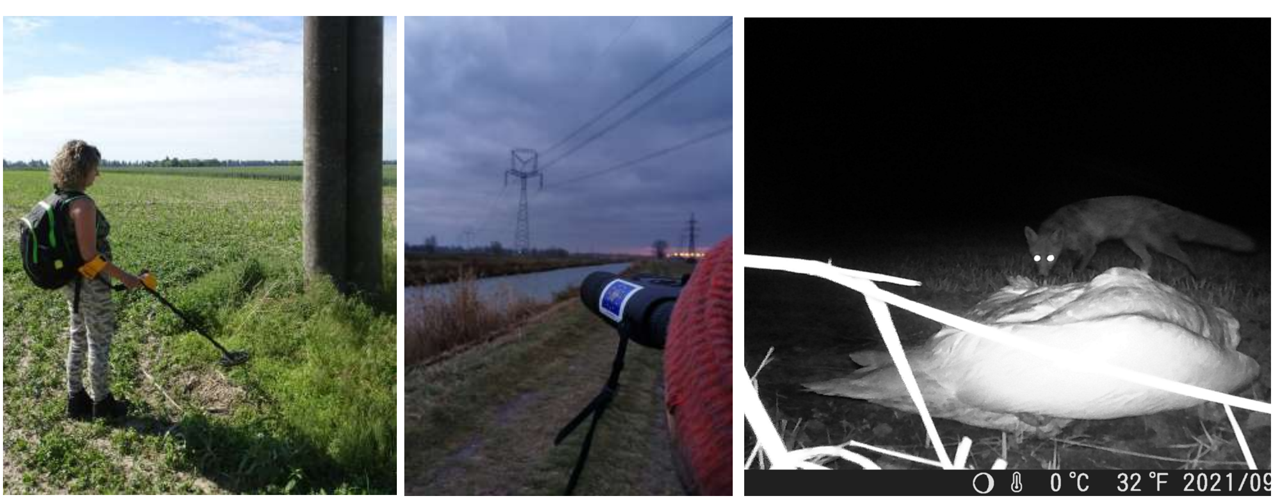
Image 1: Mute swans were the most common victims of collisions with power lines under the field survey of the LIFE Danube Free Sky project

representing 103 bird species were identified under the power lines. For 1,833 individuals belonging to 93 species, it was possible to determine the exact cause of death. Electrocutions accounted for 55% (1009 individuals), belonging to 35 bird species; collisions accounted for 45% (824 ind.), involving 78 bird species. The Eurasian Magpie *Pica pica* was the most detected and was associated with 27% (n=193) of all electrocutions. The second highest mortality was observed for the Eurasian Buzzard *Buteo buteo* with 22% (157 ind.). The Mute Swan *Cygnus olor* was the most common bird detected with 20% (155 ind.) of all identified collisions **(**Image 1**)**. The second highest mortality was observed for the Mallard *Anas platyrhynchos* with 9.1% (71 ind.).

Carcass removal near the powerlines by scavengers often biases the real mortality rate. Therefore, photo traps, video cameras, binoculars with nocturnal vision systems, and metal detectors were also used as additional forms of data collection to increase the detection efficiency and identify the scavenging rate to the maximum **(**Image 2**)**.

In Austria, specially trained dogs have been used to increase the effectiveness of detection around railway lines (Image 3). Another dog unit was also used in the field survey of transmission power lines in Hungary.

Preventing birds from collisions and electrocution is important to compensate for other threats that the endangered species need to face. The positive fact is that only parts of potentially dangerous lines are responsible for the majority of bird mortality. Based on the results of field survey, the highest-risk sections were prioritised for the implementation of mitigation measures. Taking into account the economic cost of marking, it is more likely to use



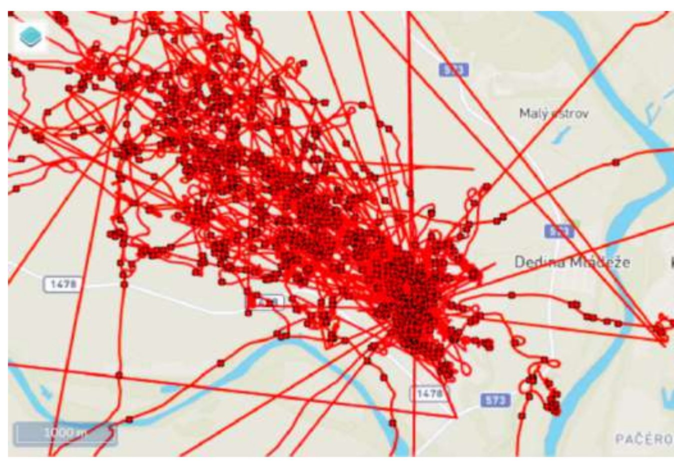
RAPTOR PROTECTION OF SLOVAKIA

Image 2: Metal detectors, cameras, and photo traps were also used during the monitoring

EVA HORKOVÁ

Image 3: Specially trained dog for tracking bird carcasses

JOZEF CHAVKO



RAPTOR PROTECTION OF SLOVAKIA

Image 4: Data from the satellite transmitters help us to identify the locations of the young individuals and possible threats

attachment of flight diverters to these hot-spots rather than to the whole sections of the power line. In the case of electrocution risk, it is necessary to proceed according to priorities, with the aim of focusing on the riskiest sections first, and then gradually on the whole surrounding area. These approaches adopted in the framework of the LIFE Danube Free Sky project ensure the treatment of the most dangerous poles/line sections while saving money for the distribution and transmission system operators.

One of the applied ways to identify risky poles in relation especially to juveniles is the installation of satellite transmitters (Image 4). Thanks to this data, it is then possible to identify which of the dangerous poles/lines are located in the home range of breeding pairs and priority habitats and accordingly take effective measures.

Preventing collisions of birds with power lines

Collisions of birds with power lines represent a significant mortality

RAPTOR PROTECTION OF SLOVAKIA

Image 5: Collision of swan into power lines often causes outages

factor for several waterbird species. They are related to a very important fact – power lines are unnatural obstacles in the landscape, and a flying individual is not always able to register such an obstacle in front of him in time. While interactions with electric power lines are one of the main threats to certain species, these interactions (collisions of heavy birds such as bustards, cranes, or swans) are also a problem for electricity companies and can be costly, causing power outages and damage to equipment (Image 5).

Even if collisions themselves cannot be completely eliminated, they can still be reduced by means of proper mitigation measures. Line marking is one of the best and quickest solutions to increase the visibility of power lines. Based on the results from the field surveys, under the LIFE Danube Free Sky project almost 270 km of power lines were identified as a top-priority for increasing the visibility via installation of several types of bird flight diverters. For example, the latest types of RIBE flight diverters (black and white lamellas) with glow-in-the-dark illumination, a FireFly Bird Diverter and a LED diverter capable of glowing thanks to the induction of voltage from the wires have been installed on power lines along the Danube river (Image 6).

Using a special drone to install the diverters reduces conflicts between the farmers and the power energy companies. There is no need to pay compensation for destroyed crop. At the same time, there is no need to shut down the line during the installation of the diverters (Image 7).

By implementing the mitigation measures, we will increase the visibility on 263.5 km of top-priority power lines in the most valuable and critical areas of the entire migration route along the Danube River. These long-term solutions will also prevent power outages and increase the reliability of electricity distribution to customers.

Some devices can be attached manually from the ground (e.g. during the construction of the line), others are snap on automatically via a claw, and some need to be manually attached in place from a hanging basket. Related to this is the speed of installation. For example, a FireFly diverter can be installed from the ground using a telescopic stick in 1 day in a quantity of 50 pieces, which means about 500–600 meters

MAREK GÁLIS

Image 6: RIBE lamella, FireFly and LED Diverter used to protect birds from collisions

of secure power line. In the case of installation using rollerblading, from a bucket truck, it is necessary that the power line is switched off. Installation of bird diverters is also possible by drone, while the power line is on. Installation requires a specially equipped drone, pilot, and navigator. It is possible to attach 200-250 pieces per day, installation of 1 diverter takes approximately 1.5 minutes. In terms of time efficiency, this method is four times more efficient compared to the installation from the ground using a telescopic stick.

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Image 7: Installation of the flight diverters on power lines with drone

Anti-electrocution measures

According to current knowledge and experience, it is possible to reduce the risk of electrocution significantly, within acceptable costs for electric utility companies. The adoption of permanent measures on power lines with dangerous poles may involve the total or partial modification of the line/cross-arm. Replacing of bare conductors of overhead power lines with covered conductors is a long-lasting solution and it doesn't cause difficulties with maintenance in comparison with insulation equipment installation (Image 8). Almost 4,000 poles were identified within the LIFE Danube Free Sky project as critical for implementing measures to avoid the high risk of electrocution.

Covering the conductors and other live elements with insulating materials helps reduce the mortality risk and is also an effective solution. This solution is very common, universal and is used in many countries and by many grid operators. On metal cross-arms, another possible type of insulation consists of placing rigid plastic covers on the parts where birds perch, so that they avoid contact with the ground connection of the pole (Image 9).

A transnational approach is necessary to achieve adequate results and share knowledge between experts on this issue to prevent

RAPTOR PROTECTION OF SLOVAKIA

Image 8: Changing the construction of the dangerous pole to more bird-friendly pole

EDG WEST

MAREK GÁLIS

Image 9: Measures against bird electrocution – covering conductors with insulation materials and installation of rigid plastic covers for safe perching of birds

mistakes and adopt best practice methods and standards. As part of the project, a special Facebook group of experts "Birds and power lines" (https://www.facebook.com/groups/birdspowerlines) has been created. The group is a space for discussion, its purpose is to exchange experiences, knowledge, best or new (innovative) practices on the issue of birds and power lines.

Raptor Protection of Slovakia (RPS)

Since 1974 our mission has been to improve conditions for birds of prey and owls in wild nature all over Slovakia with a special emphasis on endangered species. We study the breeding biology, threats, habitats and carry out actions to create and/or conserve safe nesting conditions, suitable foraging habitats, and roosting sites for birds of prey, owls as well as other bird species. One of the topics we focus on since the beginning is the birds vs. power lines interaction. Web: www.dravce.sk; e-mail: dravce@dravce.sk

Acknowledgements

This article was prepared under the project LIFE Danube Free Sky – Transnational conservation of birds along the Danube river (LIFE19 NAT/SK/001023). Project has received funding from the LIFE Programme of the European Union and the Ministry of Environment of the Slovak Republic. The content of this document reflects only the author's view; the European Commission, CINEA Agency, nor the granting authority is responsible for any use that may be made of the information it contains. ■

Energy infrastructure, especially powerlines in grasslands, poses a challenge for conserving Bustard and Florican

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About Great Indian Bustard (GIB) and Lesser Florican (LF)

Great Indian Bustard

The Great Indian Bustard *Ardeotis nigriceps* is Critically Endangered (IUCN 2023), listed as Schedule I species under the Wildlife (Protection) Act, 1972, Government of India, Appendix I of CMS (CMS COP 13), and Appendix I of CITES. It is also included under the National Wildlife Action Plan of the Government of India and Species Recovery Plan (SRP) – Under Integrated Development of Wildlife Habitats by the Ministry of Environment, Forest, and Climate Change (MoEF&CC).

The Great Indian Bustard, also known as GIB, is a large bird that was fairly distributed across India, from Punjab to Tamil Nadu and from the Indus Valley to the Chhota Nagpur Plateau. Sadly, this grassland obligate species is now considered “extinction-prone” due to its slow life-history traits and challenges for survival in areas dominated by humans. Like other bustards, the GIB demonstrates a classical lek mating system, where males occupy certain

NEELKANTH BORA

A Great Indian Bustard *Ardeotis nigriceps* got killed after colliding with a powerline at Deg Rai Mata Oran, Rasla, Jaisalmer in October 2022

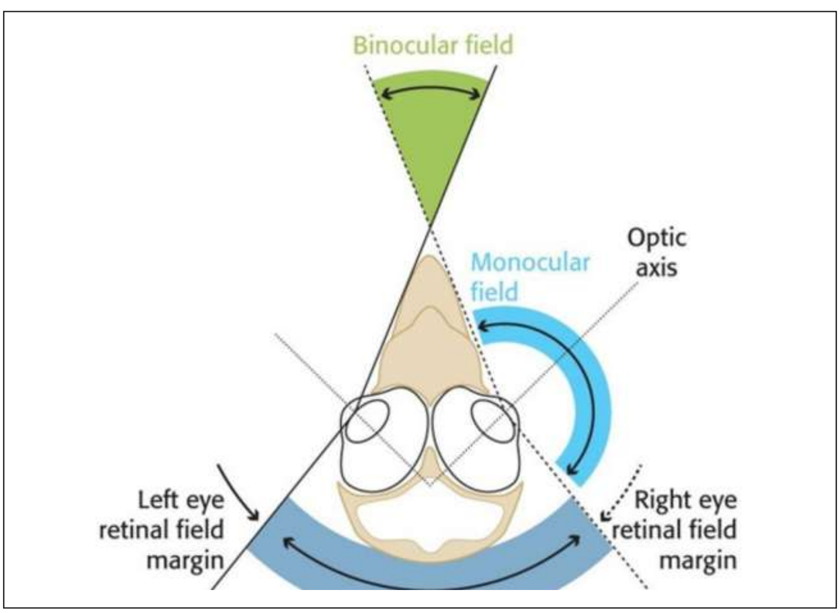
SUJIT NARWADE

The dynamic changes in land use, particularly concerning energy infrastructure, present significant challenges for GIB

grassland areas to attract nearby females through displays. During mating season, four to five males usually compete for the attention of females. Females have the freedom to choose their preferred partner. Interestingly, this behaviour has a strong site fidelity linked to it.

Unfortunately, the bustards faces further challenges due to poor frontal vision and difficulty in estimating depth perception (Martin 2022) (Fig. 1 & 2). Their substantial size and weight during flight make it difficult for them to navigate through power lines when they are spotted at the last moment (Dutta 2018). Over the past few decades, increasing human and livestock populations have created immense pressure on the bird's grassland habitat, leaving only small, fragmented, and degraded patches for the bustard (and other grassland fauna) to survive. Only two viable populations remain in India, and a small population exists around the international boundary with Pakistan. Major threats to the GIB's survival include vanishing habitats, infrastructural developments like road construction, electricity poles, renewable energy projects, mining, industrialization, collision with high-tension transmission lines (HTTL), and poaching. These threats are especially significant in non-protected areas.

The Great Indian Bustard has unfortunately experienced episodes of local extinction in areas such as Karera, Madhya Pradesh, and parts of Maharashtra. Despite our collective



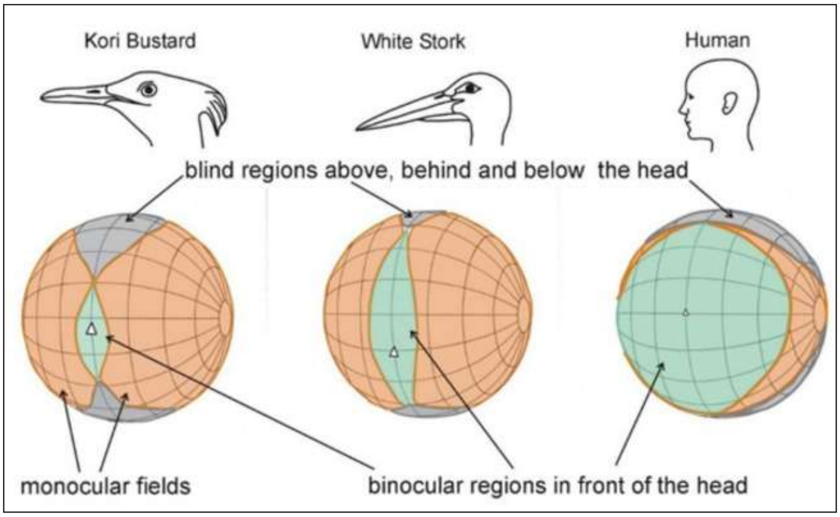
Source: MARTIN 2022 AND ILLUSTRATED BY NIGEL HAWTIN

Fig. 1: Birds have laterally projecting eyes that provide a complete visual perspective, creating a binocular field in front of their heads. Varying degrees of binocular overlap and blind spots exist due to eye position and field of view width differences among bird species. Birds have two areas of high spatial resolution in their lateral fields of view

efforts, the species has disappeared throughout its range over the past few decades (Narwade *et al.* 2015). It would be a tragic and shameful loss if this species vanishes, due to our negligence. The Bombay Natural History Society (BNHS) has been actively involved in conservation strategies for the GIB since 1980s. This includes a decade-long study on the GIB in the 1980s, sponsored by the US Fish & Wildlife Service, and various research and conservation projects related to the species. For more details, please visit https://www.bnhs.org/public/pdf_documents/GIB-On-the-brink-of-Extinction.pdf.

GIB faces significant threat from power line collisions (Silva *et al*. 2022). The rapid expansion of overhead power cabling in northwest India and the allocation of land for renewable energy projects have adversely impacted crucial habitats of GIB over the past decade (Collar *et al*. 2017). Power lines in Rajasthan contribute to a concerning 16% annual mortality rate in GIB, posing a potential extinction threat within two decades (Uddin *et al*. 2021; Silva *et al*. 2022).

Recent collisions contribute significantly to the species decline due to expansion of electricity network (BirdLife International 2018; Uddin *et al*. 2021), emphasizing the effectiveness of burying power lines as a solution (Collar *et al.* 2017; Narwade *et al*. 2021; Juvvadi 2022 in Martin *et al*. 2022; Silva *et al*. 2022). However, challenges persist, as the neglect of an order to bury power lines in GIB habitat highlights obstacles in effective conservation efforts (Collar *et al*. 2017).



Source: MARTIN 2022

Fig. 2: Some larger birds of prey and bustards have blind spots above their heads when they tilt down to view the ground, making it difficult for them to see in the direction they are flying. Birds also have areas of highest visual acuity on either side of their head, rather than directly in front of them

Bustards, with their broad lateral vision for enhanced predator detection, face numerous challenges (Martin and Shaw 2010). A comprehensive examination by Silva *et al*. (2022) up to January 2021 identified 2,774 instances of collisions with power lines across 14 of 26 bustard species worldwide. Both transmission and distribution lines contribute to the mortalities of bustards (Jenkins *et al*. 2011). In India total seventeen incidences of mortalities in bustards and floricans due to power lines have been reported (Table 1, Fig. 5). Cost-effective undergrounding of distribution cables is a prevalent practice in Europe (Haas *et al*. 2003; Raab *et al.* 2012; Silva *et al*. 2022).

The efficacy of bird flight diverters (BFDs) in mitigating collisions, particularly for bustards, remains inconclusive (Collar *et al*. 2017; Marques *et al*. 2020; Shaw *et al*. 2021). Dynamic BFDs, especially larger, reflective, self-illuminating ones, and laser lights are suggested to mitigate collisions (Silva *et al.* 2022). Also, improving

BNHS ARCHIVAL/CHANDRAPRAKASH PRAJAPAT

A Lesser Florican *Sypheotides indicus* narrowly escaped from the high-tension transmission lines. GIB and LF have more risks of collision during active time of early morning and late evening

NEELKANTH BORA

Some birds may not be able to navigate through obstacles without getting hurt. Regrettably, a female Lesser Florican *Sypheotides indicus* collided with a high-tension transmission line in the Ajmer region of Rajasthan, leading to an injury and eventual demise

OMKAR JOSHI

Source: DOWNLOADED FROM FACEBOOK, (UNKNOWN)

(Left): There have been a few reports of leg injuries among LF in the Deccan Plateau, possibly resulting from collisions with structures. (Right): LF injured by powerline

BHAGWAT MASKE

DEVESH GADHAVI

(Left): Unfortunately, a GIB satellite was lost due to collision with a powerline in Solapur, Maharashtra
(Right): The unfortunate demise of GIB occurred as a result of colliding with a powerline in Kutch, Gujarat

BFDs based on the sensory ecology of bustards is emphasized (Silva *et al.* 2022). Boycott *et al*. (2021) recommend exploration of visual deterrents aligned with bustard line of sight, such as ground-mounted lights, and acoustic deterrents. In light of uncertainties surrounding BFD effectiveness, compensation measures including habitat management and site protection are deemed essential (Collar *et al*. 2017). Routing power lines away from crucial bustard habitats (Marques *et al*. 2020; Silva *et al.* 2022) and migratory routes and stopover sites (Raab *et al*. 2011; Palacín *et al.* 2017) is crucial.

Recommendations include running cables low, decreasing inter-pylon distances in transmission lines, and utilizing thicker cables with bundled conductors for enhanced visibility. Utilizing microgeneration technologies in rural areas is a suggested measure (Silva *et al*. 2022). Conservationists are urged to inform authorities of bustard distribution to proactively prevent power line proposals and engage with energy companies for effective compensation (Collar *et al*. 2017; Silva *et al*. 2022).

Lesser Florican

Lesser Florican (LF) has been listed as Critically Endangered by IUCN (IUCN 3.1), included under Schedule I of the Wildlife (Protection) Act, 1972, Government of India, and in Appendix I of CITES. It is also listed under the National Wildlife Action Plan of the Government of India and Species Recovery Plan (SRP) – Under Integrated Development of Wildlife Habitats by the Ministry of Environment, Forest, and Climate Change (MoEF&CC).

Threats to the Lesser Florican (LF)

Habitat loss, degradation, and fragmentation due to the expansion of the renewable energy sector (impact mainly due to collision with high-tension transmission lines); mining, intensive agriculture, cattle overgrazing, free-ranging dogs, invasion by exotic plants, and other landscape-level threats loom. LF is endemic to India (at present, no known records outside the country) and presently reported breeding in seven states (Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, and Telangana). It inhabits semi-arid regions, mainly dominated by xerophytes, thorny trees, patchy grasslands, and human-dominated agricultural fields. The current global population of LF is 250–300 males, with a declining trend (Dutta *et al.* 2018). It was earlier believed that LF are long-distance migrantsand their foraging grounds might be in the Western Ghats and Gangetic Plains (Sankaran 2000; Dutta *et al.* 2023, Ram *et al.* 2022). They need to cross *c*.1,000 to 1,500 km through the network of powerlines.

There is no protected area for Lesser Florican in Rajasthan except for a few reserve forest patches. BNHS conducted a detailed study in 2019–2020 to understand the distribution of LF in the Ajmer landscape, where the birds return to breed every monsoon. LFs have strong site fidelity towards their breeding sites, whereas, during the non-breeding season, they were seen up to *c*.1,000 km away from breeding sites.

A study in 2019–2020 found LF in 73 locations across 266.21 sq. km. They prefer crops like Jowar, Moong, and Urad. Threats to breeding birds include chemical use and overgrazing (Narwade *et al.* 2020). Rainfall patterns affect distribution, and conservation efforts include traditional farming practices and a sensitization programme. BNHS recommends developing community conservation areas in the Ajmer-Kekri landscape of Rajasthan.

BNHS Bustard program in a nutshell

Research conducted by the BNHS team in Thar Desert of Rajasthan since 2019, has been focussed on conserving the Great Indian Bustard (GIB) in non-protected areas around Pokhran. This has been achieved by developing village-level action plans, particularly engaging the Bishnoi community. The project has also trained local youth in GIB monitoring techniques and increased awareness of wildlife conservation among villagers through a network of trained 'Godawan Mitra' (GIB friends). BNHS is currently working on a pilot basis to restore 1,500 hectares of habitat in the Khetolai area and surrounding villages to sensitize towards GIB conservation, particularly in the Pokhran Field Firing Range (PFFR) area, which is home to a significant global population of GIB.

Under the Central Asian Flyway (CAF) programme, BNHS has conducted sensitivity mapping of the Thar landscape for the renewable

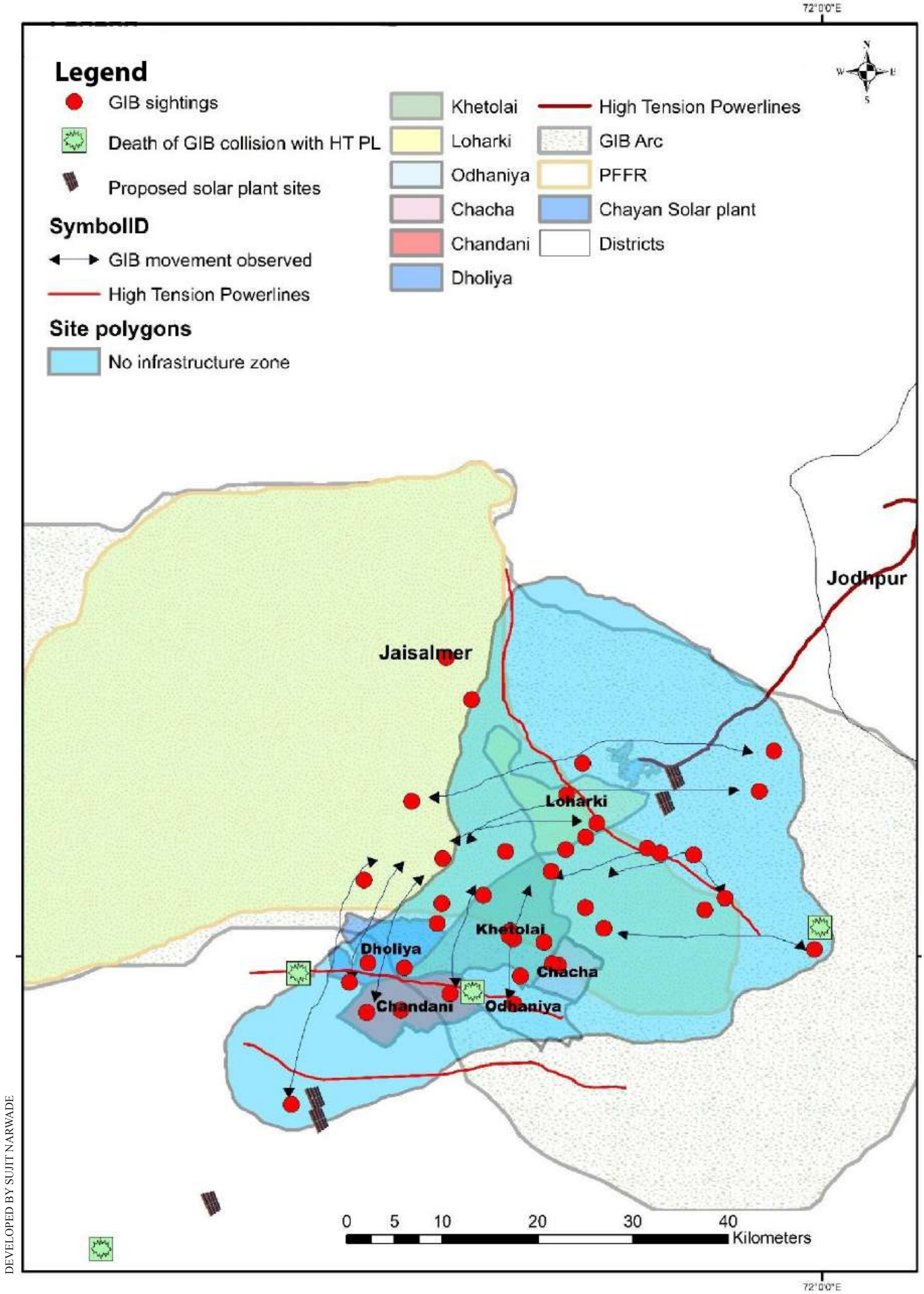


Fig. 3: Team on ground through multiple observers and taking notes of flight timing, direction, etc. has witnessed a GIB crossing the powerlines frequently in Pokhran area of Jaisalmer

energy sector, identifying areas sensitive to GIB and other birds that rely on grasslands (Narwade *et al*. 2021) and raptor sighting records across Jaisalmer and surrounding areas (Bora *et al*. 2023). Other landscape-level threats have also been identified and mapped (Fig. 3). To minimize such risks, BNHS recommends avoiding infrastructure development in highly sensitive areas, conducting detailed surveys before making any developmental decisions in medium-sensitive areas, and adopting proper mitigation measures such as undergrounding cables and erecting bird diverters in less sensitive areas. Additionally, Orans have been identified as important habitats that bustards use as corridors.

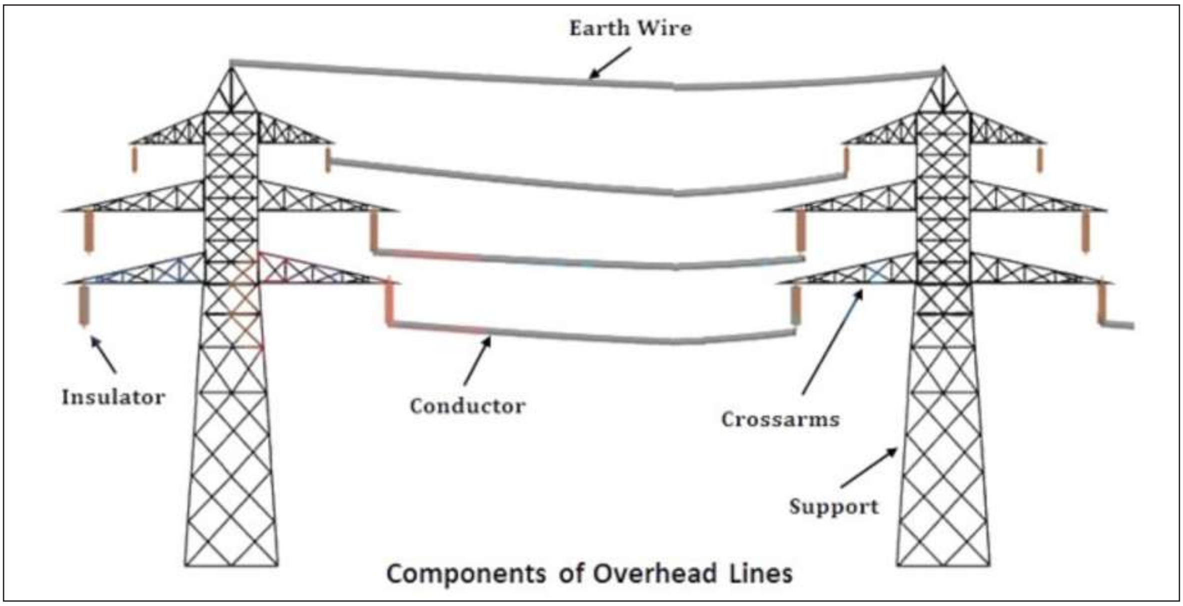
Orans of Rajasthan

Orans or Sacred groves are natural forest patches worshipped and conserved by the local or indigenous people. It is a widespread

KAMLESH BISHNOI

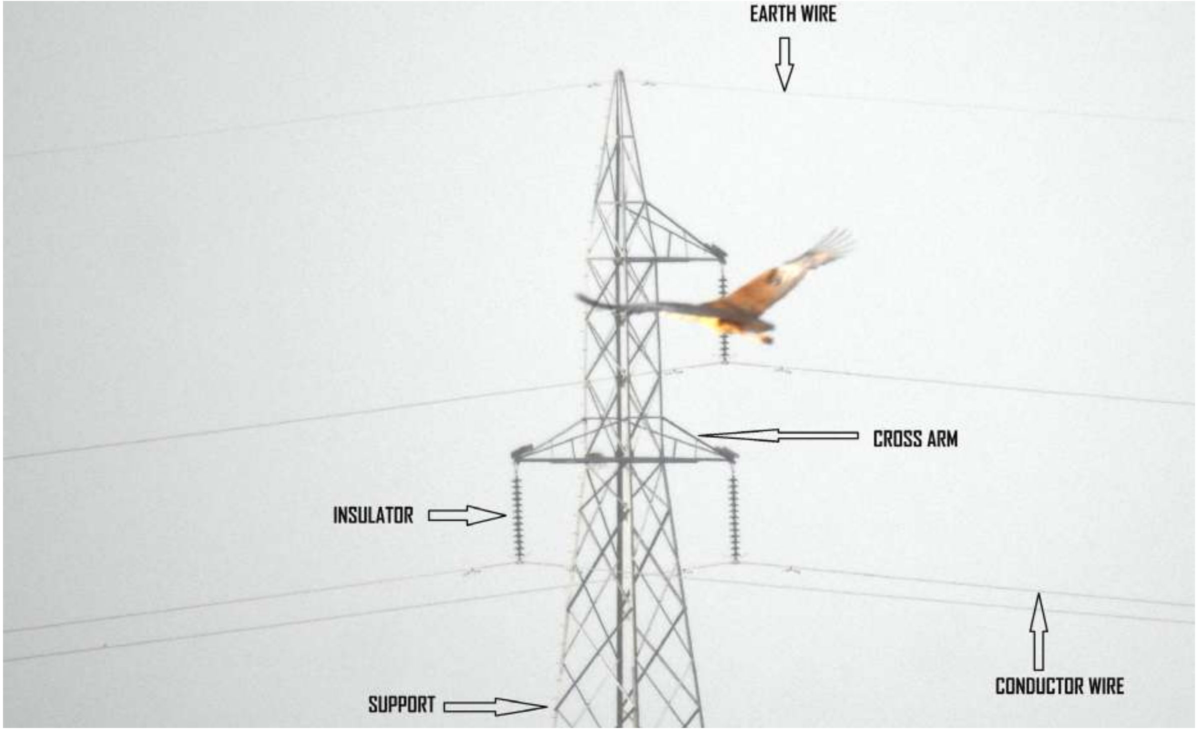
RAHUL PATIL

(Top): The flight of the GIB coinciding with the powerlines of various capacities as depicted in the above pictures
(Bottom): GIB collision with powerline at Gangewadi



Source: www.electricaldeck.com

Fig. 4: A schematic representation of transmission lines with different components



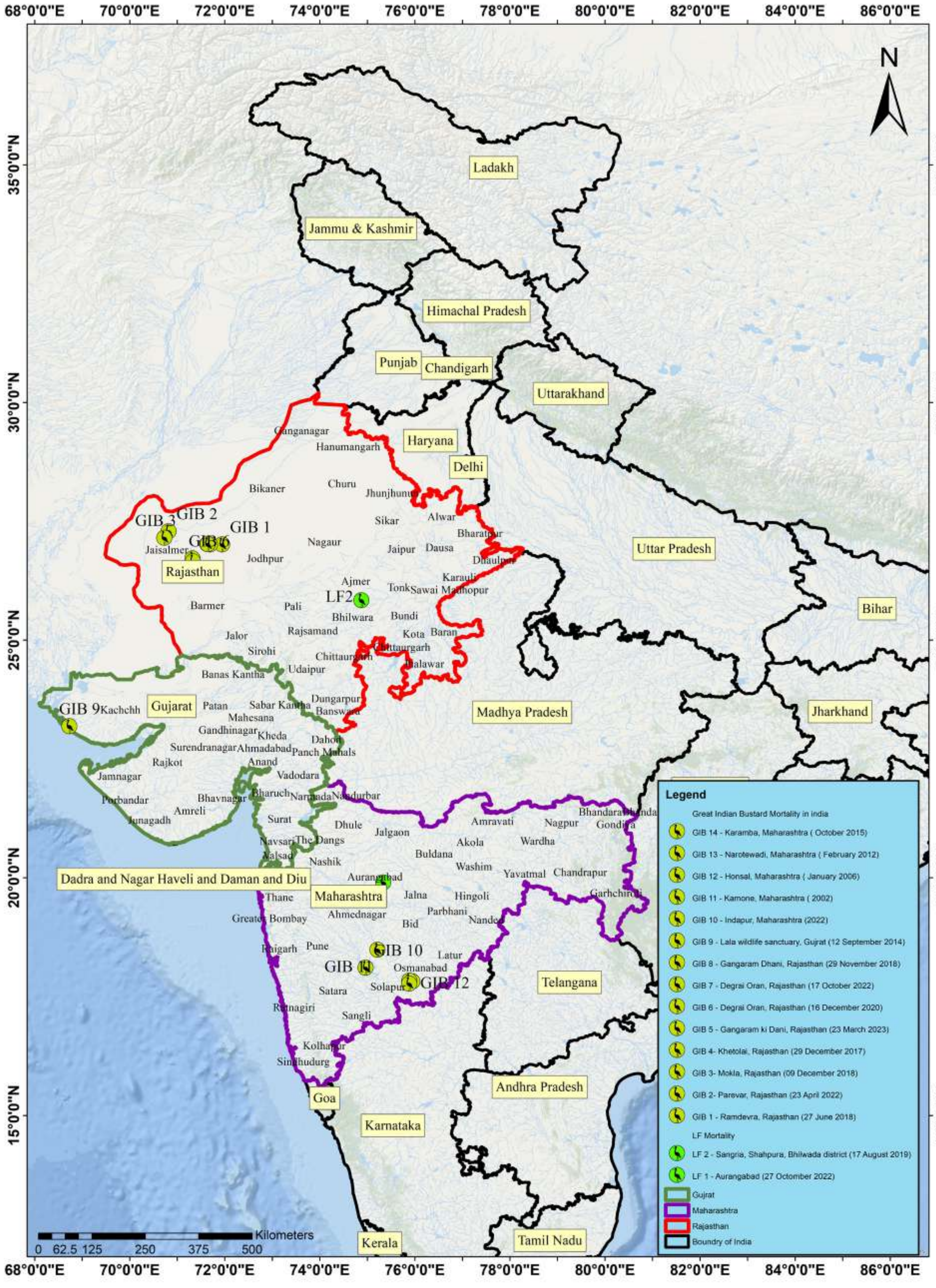
KAMLESH KUMAR

A pictorial representation depicting various components of a HTTL

Table 1: GIB and LF mortality in India

SN	Lat	Long	Species	Place & Date	Source
1	18.487305	75.210079	GIB	Kamone, Maharashtra **(2002)**	MFD
2	17.821729	75.947433		Honsal, Maharashtra **(January 2006)**	MFD
3	17.838097	75.882017		Narotewadi, Maharashtra **(February 2012)**	MFD
4	23.190534	68.72798		Lala wildlife sanctuary, Gujrat **(12 September 2014)**	GFD
5	17.770132	75.878638		Karamba, Maharashtra **(October 2015)**	MFD
6	27.01404	71.68745		Khetolai, Rajasthan **(29 December 2017)**	Radheshyam Pemani
7	27.013874	71.941532		Ramdevra, Rajasthan **(27 June 2018)**	RJFD
8	27.020523	71.636356		Gangaram Dhani, Rajasthan **(29 November 2018)**	Radheshyam Pemani
9	27.153093	70.724893		Mokla, Rajasthan **(09 December 2018)**	RJFD
10	26.721834	71.316992		Degrai Oran, Rajasthan **(16 December 2020)**	Sumer Singh Bhati
11	27.293116	70.81598		Parevar, Rajasthan **(23 April 2022)**	RJFD
12	26.657557	71.327464		Degrai Oran, Rajasthan **(17 October 2022)**	Sumer Singh Bhati
13	18.106612	74.960954		Indapur, Maharashtra **(2022)**	Local people
14	27.020241	71.631156		Gangaram ki Dani, Rajasthan **(23 March 2023)**	Radheshyam Pemani
15	29.75254	74.373561	LF	Sangria, Shahpura, Bhilwada district, Rajasthan **(17 August 2019)**	RJFD
16	19.902325	75.331841		Aurangabad, Maharashtra **(27 October 2022)**	Locals and Mr Kishor Pathak
17	19.56901	79.56576		Nimgaon, Gadchiroli	MFD

(MFD: Maharashtra Forest Department; GFD: Gujarat Forest Department; RJFD: Rajasthan Forest Department)



DEVELOPED BY RUSHIKESH PAWAR

Fig. 5: GIB and LF Incidences of mortality due to collision with electric wires occurred in various parts of India

Table 2: BNHS recommendations to major argument on draft regulation - "Electric lines of 33 kV and below voltage level passing through the Great Indian Bustard area shall be the underground cable"

No.	Regulation/Clause no of the Draft Regulations	Comments on the Draft Regulation/Proposed	Draft Justification for the Comments
1	Lines over 33 kV pose a serious risk of bird mortality	The draft regulations mandate underground cables for lines at 33 kV or below.	Electric lines with higher voltage levels pose a serious threat to the survival of endangered bird species, including the GIB. Between September 2020 and February 2024, a total of 59 incidents resulting in 75 bird mortalities (including two GIB cases) were documented by the BNHS team at Deg Rai Mata Oran, as listed in this article. Exempting powerlines with voltages exceeding 33 kV from the requirement to be underground contradicts the proposed regulations aimed at safeguarding the GIB from extinction.
2	Experience in laying underground lines up to 400 kV	Over 200 km of high voltage underground transmission lines up to 400 kV have been laid across the country, mostly in urban spaces.	As per our knowledge, underground cables are capable of handling voltages of up to 400 kV. Therefore, it is recommended that the mandate to bury electric lines be extended to this maximum possible voltage, especially in the areas that GIB currently utilizes extensively (refer to the maps and tables provided in this article).
3	Underground lines only up to 33 kV and excluding high-tension transmission lines may not be useful in mitigating the impact on bird mortality.	Generally, the 33 kV system connects generators to the pooling stations near the generators.	After the electricity is gathered at the pooling stations, it is transmitted at higher voltages ranging from 66 kV to 765 kV. However, it is noted that a considerable number of transmission lines operating over 33 kV were not covered by the proposed regulations concerning undergrounding. To address this issue, the authority should consider the option of sensitizing the developers to utilize sharing lines instead of erecting new ones every time.
4	Mitigation measures for the lines already commissioned or under construction and reliance on low efficacy Bird Flight Diverters (BFDs)	As per the studies in European countries, BFDs are less effective for lines in the priority habitat of the bustards.	We recommend expanding the scope of laying underground cables to electric lines over 33 kV. The draft regulations do not provide for any mitigation measures for the lines already commissioned or under construction, especially areas intensively used by GIB (details provided in this article).
5	Power to relax.	Regulation 7 of the draft regulations. The Authority order and for reasons to be recorded in writing, relax any of the provisions of these regulations regarding the matters referred to the Authority on a case-to-case basis."	We suggest that the authority should specify the objective criteria for relaxing regulations. These criteria should be used to determine which provisions of the regulations may be relaxed. Additionally, the authority should consider the concerns raised by conservationists and members of the local community who are committed to protecting the habitat and existence of endangered birds in the region.

Table 3: To save the GIB, following HTTL must be undergrounded immediately despite their capacities

SN	Name of Powerline	Distance in km
1	Eka to Pabupadiya	5.39
2	Ramdevra to Eka (Pokhran)	10.5
3	Ramdevra to Loharki (Pokhran)	13
4	Powerline Askandra (Pokhran)	3.38
5	Ajasar to Loharki 01 (Pokhran)	11
6	Ajasar to Loharki 02 (Pokhran)	6.59
7	Chacha to Khetolai (Pokhran)	10.9
8	Khetolai to Dholiya (Pokhran)	18
9	Odhaniya to Dholiya (Pokhran)	17.7
10	Dholiya to Lathi (Pokhran)	4. 36
11	Line Suzlon 220 kv (near DNP)	24.7
12	HT Powerline Kanoi (near DNP)	24.6
13	Powerline through Alaji Oran, (near DNP)	32.6
Total length		**182.72**

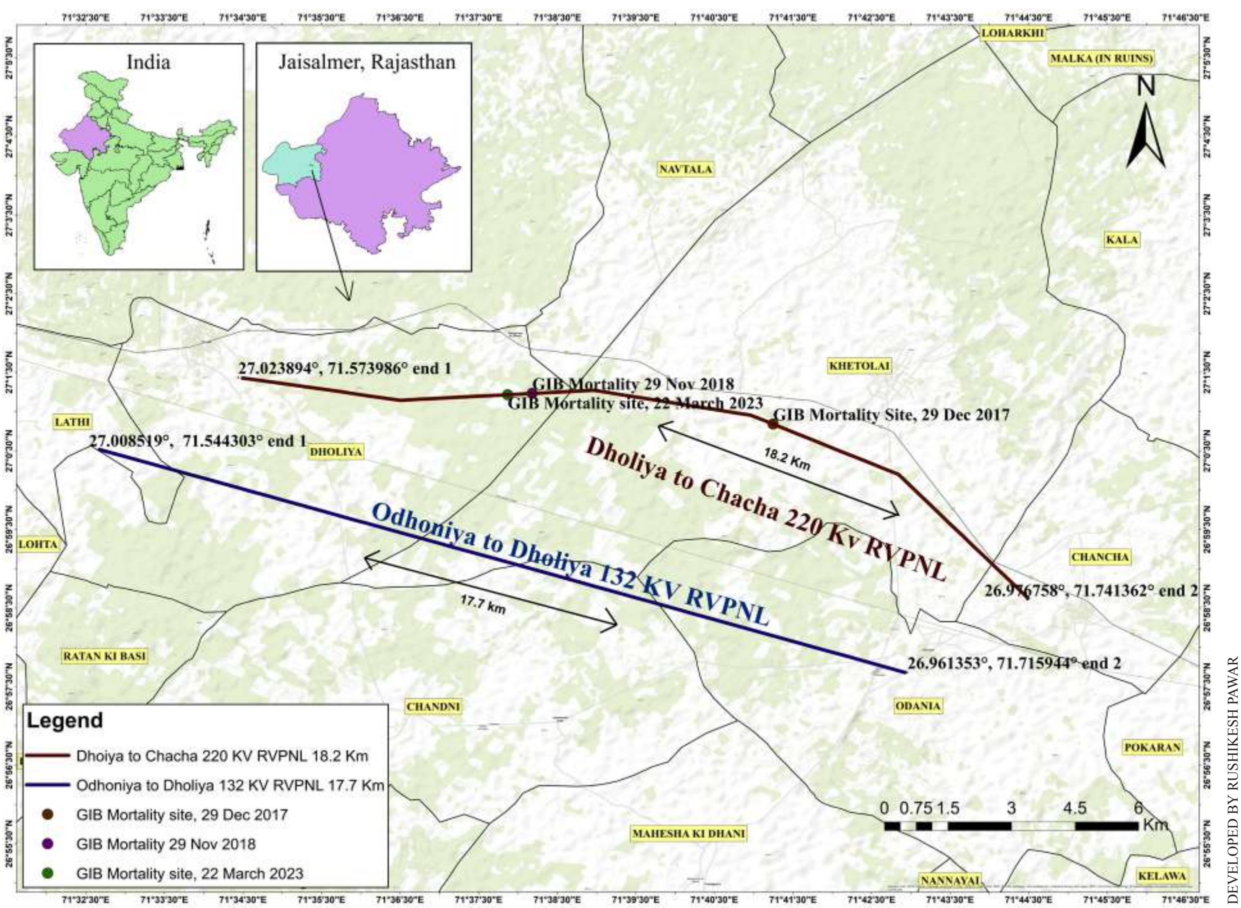


Fig. 6: Top priority lines to be undergrounded to save the GIB population in the Pokhran area

phenomenon in old-world cultures. The historical account of Oran dates to the ancient Greek and Indian cultures. They have better vegetation in comparison to unprotected surrounding areas. Since ancient times, ethics such as protecting trees and prohibiting hunting in such areas by the locals have played a crucial role in conservation (Gadgil and Vartak 1994; Robbins 1998).

The Oran falls under the "Culturable Waste Land" category (Mukhopadhyay 2008). In Rajasthan, the Oran constitutes around 9% of the desert area, whereas a single Oran can possess an area of a few meters to several hundred hectares (Mukhopadhyay 2008). Some of the important Orans of Jaisalmer are Bhadariya Rai Mata Oran and Deg Rai Mata Oran; Kundla Oran falls in the Barmer district. Historical accounts are full of tales of divine retribution for destroying an Oran leading to detrimental effects to the wrong doers, such as blinding and paralysis (Gadgil and Vartak 1994). The Oran acts as grazing land for livestock and an ideal habitat for various indigenous floral and faunal species. The local people have faith in the local deity, abide by the natural laws, and therefore the Oran is free from encroachment and over-exploitation (Dagla *et al*. 2007). Orans are unique examples of gene pool conservation of plant species. However, traditional biodiversity conservation methods have yet to appeal to many people and therefore, there is an urgent need to systematically survey, demarcate and conduct research in Orans (Singh and Bahl 2006). Jodha (1985) makes a case for protecting Orans from encroachment and land diversion.

Case study - Deg Rai Mata Oran

Deg Rai Mata Oran is in Fategarh tehsil, Jaisalmer district, surrounding Deg Rai Mata temple. It is almost 50 km away to the east of Jaisalmer city. History shows that the fifteenth-century ruler of the Bhati dynasty, Rawal Bersi Singh went to Pushkar as a pilgrim around 600 years ago. During his return journey, he stopped by Deg Rai Mata temple. He later donated around 22,000 hectares land in the temple's name. Rawal Bersi Singh also provided a '*Tamrapatra*' (inscription on a copper plate) as proof of the donation. The popular belief is that people around the Oran have protected this land since then, and this community effort made it a refuge for wildlife. After independence, the Oran was not recognized in the land settlement process. But in 2004, approximately 5,817 hectares of land was registered in the name of Deg Rai Mata Temple Trust. The rest of the historical Oran land is still not recognized. In June 2020, villagers submitted a memorandum to the District Collector to register the remaining land in the name of Deg Rai Mata Temple Trust.

People from the Rajput, Muslim, Raika, Meghwal, Jogi and Gowari communities reside in the above-mentioned villages. Most of the villagers here make their livelihood by herding camels, cows, goats, and sheep. A few of them depend on rainfed agriculture in the monsoon. According to the local estimation, the villagers in and around Oran have about 5,000 camels, 3,000 cows, 25,000 sheep, and 15,000 goats, which depend on the Oran for grazing. The following four villages are present in and around Deg Rai Mata Oran (Table 4).

About 18 perennial and temporary waterbodies are present in this Oran along with a few waterlogging areas during monsoon. Among them, ten are present in Sanwata village, four in Rasla village, two in Achla and Bhopa villages each.

Satellite enclosure of DNP near Deg Rai Mata Oran

One of the six satellite enclosures outside the Desert National Park (DNP) boundary was established near Deg Rai Mata Oran during 1988–1990. It is named Rasla Satellite enclosure. There are two separate enclosures, one 500 hectares, and

Table 4: Demographic information of the villages from the Deg Rai Mata Oran area

Sr. No.	Name of the Village	Geographical area (hectare)	Total population (2011 census)	Male	Female	Houses
1	Sanwata	6269.25	702	364	338	111
2	Rasla	6235.68	1,047	542	505	182
3	Achla	1215.31	462	250	212	65
4	Bhopa	2171.67	259	137	122	39

another 110 hectares. One male and one female Great Indian Bustard were observed inside the enclosure in 2016 (Durgaram, Forest Guard, pers. comm.). Asad Rahmani (pers. comm. 2020) has seen GIB many times during his surveys from the 1980s to the 2000s. A healthy population of Chinkara is present in and around the Rasla satellite conservation area. Macqueen's Bustard *Chlamydotis macqueenii* is found during winter. Another IUCN Red List species, White-browed Bushchat *Saxicola macrorhynchus* is also sighted here.

Birds of Deg Rai Mata Oran

A total of 66 avifauna species were observed during the survey around Deg Rai Mata Oran. The following IUCN Red Listed (Threatened and Near Threatened) species were found in the area.

1. **Critically Endangered**: Great Indian Bustard *Ardeotis nigriceps* and Indian Vulture *Gyps indicus*
2. **Endangered**: Egyptian Vulture *Neophron percnopterus*
3. **Vulnerable**: Common Pochard *Aythya ferina*, Asian Houbara *Chlamydotis macqueenii*, and Tawny Eagle *Aquila rapax*
4. **Near Threatened**: Black-headed Ibis *Threskiornis melanocephalus*, Cinerous Vulture *Aegypius monachus*, Dalmatian Pelican *Pelecanus crispus*, Laggar Falcon *Falco jugger*, and Pallid Harrier *Circus macrourus*

Mammals and Reptiles of Deg Rai Mata Oran

Mammalian species such as Indian Desert Fox *Vulpes vulpes pusilla*, Chinkara *Gazella bennettii,* and Nilgai *Boselaphus tragocamelus* were observed during the study. Active burrows of Desert Jird *Meriones hurrianae*, Indian Long-eared Hedgehog *Hemiechinus collaris* as well as Hardwicke's Spiny-tailed Lizard *Saara hardwickii* were observed.

Oran, upcoming power grid and associated powerlines

The Power Grid Corporation of India Ltd (PGCIL) is in the process of constructing a grid in the Oran, covering an area of 75 hectares. Over the past year, 10 powerlines spanning 115 km were installed in the Oran, with a total of 339 pylons (refer to Fig. 09) erected by December 23, 2020 to support these lines. To gather information on powerline-related bird mortality, a network of shepherds known to our local resource person Mr Sumer Singh Bhati, was utilized. Upon receiving secondary information, the site was visited immediately and photos of dead or injured birds were taken for identification purposes, with coordinates recorded for distribution data. The locations of observed species, electric pylons, and bird mortality data were saved and mapped using ArcMap 10.6.1 software. Additionally, information on the local wildlife, landscape, and community was gathered through conversations with community leaders, shepherds, and shopkeepers in the area.

Documentation of bird mortality at Deg Rai Mata Oran

The sacred grove of Deg Rai Mata Oran is in the Fatehgarh tehsil of Jaisalmer district, about 50 km

NEELKANTH BORA

A GIB was found dead 3 km away from a previous mortality site. Urgent action is needed to protect the species, as they require more habitat, especially in winter. Reported by Sumer Singh Bhati

SHEKAR DATTATRI

Sujit Narwade discussing with Sumer Singh Bhati about the death of a Cinereous Vulture *Aegypius monachus* due to colliding with a blade of a wind turbine

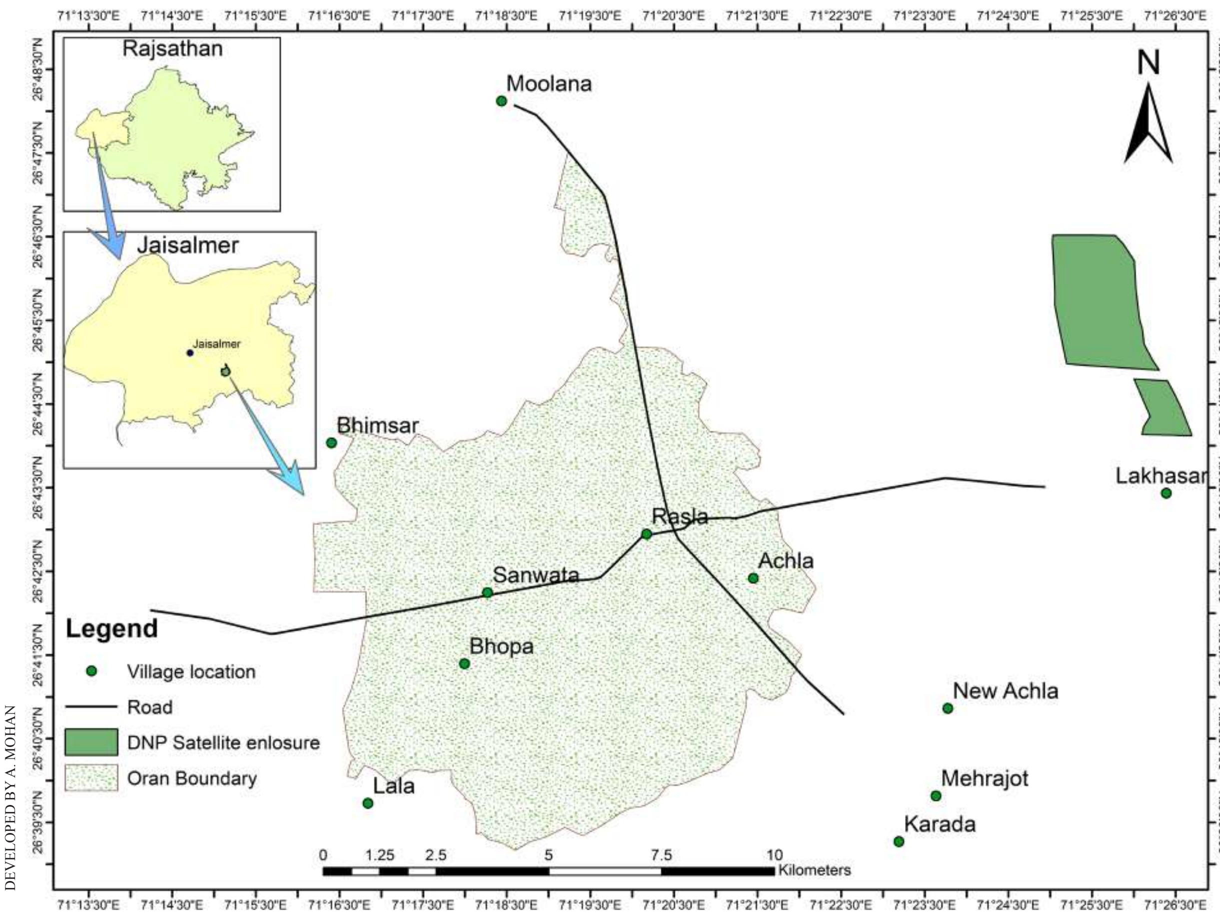
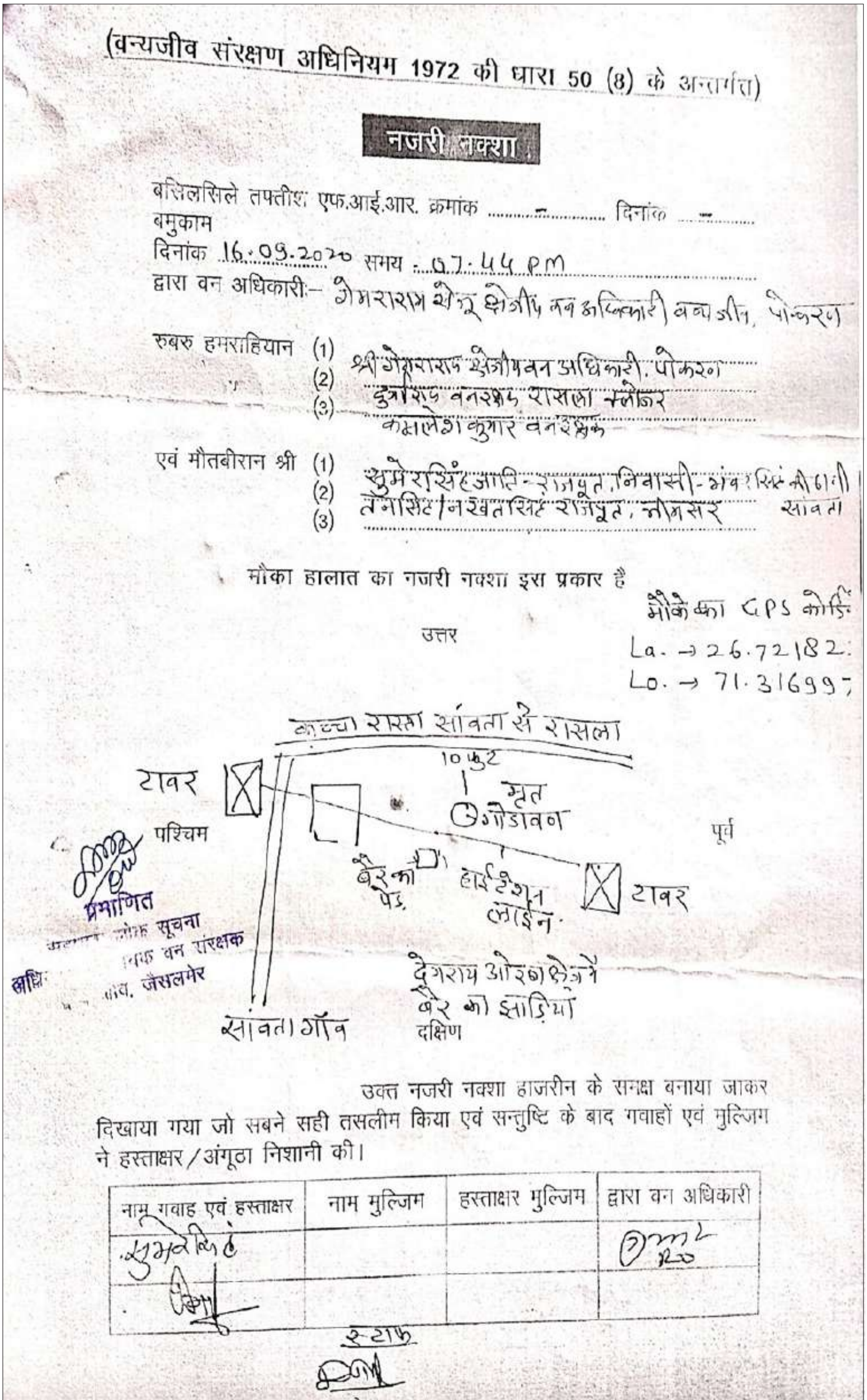


Fig. 7: The location of Deg Rai Mata Oran in Jaisalmer district and villages in and around the Oran (polygon generated by moving on the boundaries of Deg Rai Mata Oran was used to prepare the map)

east of Jaisalmer city. This area has become a centre for new renewable energy projects, power substation grids, and high-tension transmission lines. Since 2019, the BNHS team has been visiting Rasla-Sanwata near Devikot due to its historical presence of GIB and an enclosure developed by the Department of Forest, Desert National Park. On September 16, 2020, Mr Sumer Singh Bhati from Sanwata village reported the death of a GIB due to collision with a newly installed high-tension transmission line near the sacred grove. After a detailed discussion, it was discovered that a Grid Substation is being developed at the edges of Oran by Power Grid Corporation of India Ltd. As a result, HTTL from nearby energy developers would converge at this point. Continual field surveys were deemed necessary to estimate the impact these upcoming lines were causing to the avifauna.

'Critically Endangered' Great Indian Bustard *Ardeotis nigriceps* was killed due to a powerline collision inside Deg Rai Mata Oran in September 2020



(वन्यजीव संरक्षण अधिनियम 1972 की धारा 50 (8) के अन्तर्गत)

नजरी नक्शा

बसिलसिले तफ्तीश एफ.आई.आर. क्रमांक ....–........ दिनांक ...–....
बमुकाम
दिनांक 16.09.2020 समय : 07:44 PM
द्वारा वन अधिकारी– गेमराराम क्षेत्रीय वन अधिकारी वन्यजीव, पोकरण

रुबरु हमराहियान (1) श्री गेमराराम क्षेत्रीय वन अधिकारी, पोकरण
(2) दुर्गसिंह वनरक्षक रासला म्लोजर
(3) कमलेश कुमार वनरक्षक

एवं मौतबीरान श्री (1) सुमेरसिंह जाति- राजपूत निवासी- भंवरसिंह की ढाणी
(2) तनसिंह / नखतसिंह राजपूत, नोमसर सांवता
(3)

मौका हालात का नजरी नक्शा इस प्रकार है

उक्त नजरी नक्शा हाजरीन के समक्ष बनाया जाकर दिखाया गया जो सबने सही तसलीम किया एवं सन्तुष्टि के बाद गवाहों एवं मुल्जिम ने हस्ताक्षर / अंगूठा निशानी की।

नाम गवाह एवं हस्ताक्षर	नाम मुल्जिम	हस्ताक्षर मुल्जिम	द्वारा वन अधिकारी
सुमेरसिंह			[signature]
[signature]			

स्टाफ

It is rare for bird mortality to be officially recorded through a "Mauka panchnama" in India as given here. The post-mortem report clearly indicates that the cause of death was collision with the powerlines

Post mortem examination form

PME of PME

Date: 17 Sep 2020 Time: 11:45 Location of PME: Govt veter. Poly. Jaisalmer

Species: GIB (F) Sex: Female GPS location of carcass:

Date of death: ~~Time found:~~ → Appx. More than 72 hrs prior to PM. examination

Distance from powerline/wind turbine:

Measurements:

1. Tarsal length — 17 CM
2. Tarsal circumference —
3. Wing length —
4. Head length —— 15cm
5. Beak length — 8CM
6. Length of Primary feathers — 38 cm
7. Length of humerus —— 18cm
8. Length of radius ulna — 21cm
9. Length of femur —— 21.5cm
10. Length of Outer, middle and inner toe —

External injuries: ① 9 X 11 cm chest muscle maggoted wound.
② 7 x 5 cm maggoted wound on upper pectoral region
③ 11 x 10 cm maggoted wound on left shoulder region

Pectoral muscle condition:

Lung: Putrified

Liver: Putrified

Kidney: Putrified

Heart: Putrified

Gut: Putrified

Ovaries/ Testes: Putrified

Mouth: beak: NAD.

Oesophagus: Putrified

Trachea: putrified

Brain: Not opened

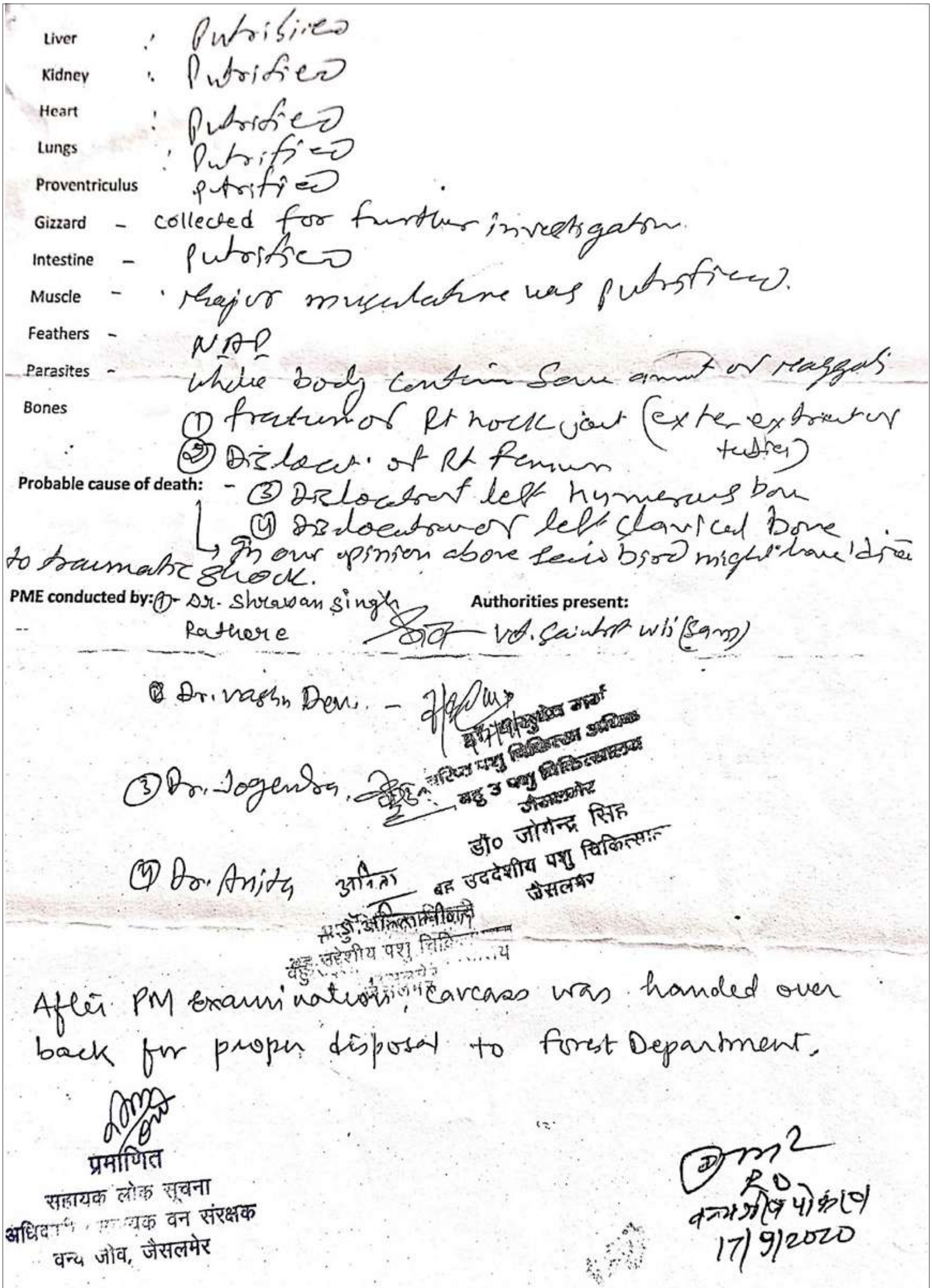
Bones: mentioned in detail on next page.

Samples collected: - Hemlata Joshi

प्रमाणित
लोक सूचना
वन संरक्षक
जैसलमेर

P.T.O.

The post-mortem report clearly indicates that the cause of death was a collision with the powerlines



Liver : Putrified
Kidney : Putrified
Heart : Putrified
Lungs : Putrified
Proventriculus : putrified
Gizzard – collected for further investigation.
Intestine – putrified
Muscle – Major musculature was putrified.
Feathers – NAD
Parasites – whole body contain some amount of maggots
Bones ① fracture of Rt hock joint (exter extensor tubercle)
② Dislocat. of Rt femur
Probable cause of death: – ③ Dislocation left humerus bone
④ Dislocation of left clavical bone
In our opinion above said bird might have died to traumatic shock.

PME conducted by: ① Dr. Shrawan Singh Rathore

Authorities present: VO. Sainta W/s (Sam)

② Dr. Vaibhav Devi.

③ Dr. Jogendra.

डॉ० जोगेन्द्र सिंह
बहु उद्देशीय पशु चिकित्सालय
जैसलमेर

④ Dr. Anita अनिता

After PM examination, carcass was handed over back for proper disposal to Forest Department.

प्रमाणित
सहायक लोक सूचना
अधिकारी, ... वन संरक्षक
वन्य जीव, जैसलमेर

RO
17/9/2020

Obtaining a post-mortem examination of deceased birds can be challenging due to a lack of knowledge

On October 17, 2022, another GIB collided with HTTL and died due to electrocution in Deg Rai Mata Oran, approximately three kilometres from the previous incident. Mr Singh was tasked with searching for any injured birds or incidents of mortality near the powerlines and wind turbines. As of February 07, 2024, 59 incidences were recorded, involving 14 different species. Tables 5 & 6 provide a detailed list of these incidents. The number of powerlines passing through the Oran has increased sharply, turning what was once a habitat most suitable for bustards and many other migratory species, such as raptors and Demoiselle Cranes *Anthropoides virgo*, into a death trap for these creatures (Fig. 8).

A report was presented in the Hon'ble Supreme Court of India, which has put a stay on any further activity by developers within the Oran land. However, the existing infrastructure is causing significant damage to both the residential and migratory avifauna.

Table 5: List of birds killed due to electrocution/collision with powerlines

Sr. No.	Name of Bird	Scientific Name	IUCN category	No. of Individuals	Date of Mortality
1.	Great Indian Bustard	*Ardeotis nigriceps*	CR	1	16-09-2020
2.	Common Crane	*Grus grus*	LC	1	09-01-2021
3.	Tawny Eagle	*Aquila rapax*	VU	1	22-01-2021
4.	Tawny Eagle	*Aquila rapax*	VU	1	23-01-2021
5.	Griffon Vulture	*Gyps fulvus*	LC	1	25-01-2021
6.	Long-legged Buzzard	*Buteo rufinus*	LC	1	02-02-2021
7.	Egyptian Vulture	*Neophron percnopterus*	EN	2	05-02-2021
8.	Tawny Eagle	*Aquila rapax*	VU	1	07-02-2021
9.	Griffon Vulture	*Anthropoides fulvus*	LC	3	10-02-2021
10.	Cinereous Vulture	*Aegypius monachus*	NT	1	19-02-2021
11.	Demoiselle Crane	*Anthropoides virgo*	LC	1	Undated
12.	Tawny Eagle	*Aquila rapax*	VU	1	24-02-2021
13.	Tawny Eagle	*Aquila rapax*	VU	2	25-02-2021
14.	Griffon Vulture	*Gyps fulvus*	LC	1	27-02-2021
15.	Demoiselle Crane	*Anthropoides virgo*	LC	2	04-10-2021
16.	Demoiselle Crane	*Anthropoides virgo*	LC	6	04-10-2021
17.	Common Teal	*Anas crecca*	LC	1	17-10-2021
18.	Tawny Eagle	*Aquila rapax*	VU	1	18-10-2021
19.	Demoiselle Crane	*Anthropoides virgo*	LC	2	19-10-2021
20.	Eurasian Collared-dove	*Streptopelia decaocto*	LC	1	23-10-2021
21.	Demoiselle Crane	*Anthropoides virgo*	LC	4	24-10-2021
22.	Tawny Eagle	*Aquila rapax*	LC	2	26-10-2021
23.	Demoiselle Crane	*Anthropoides virgo*	LC	1	28-10-2021
24.	Steppe Eagle	*Aquila nipalensis*	EN	1	30-10-2021
25.	Demoiselle Crane	*Anthropoides virgo*	LC	1	31-10-2021
26.	Indian Peafowl	*Pavo cristatus*	LC	1	01-11-2021
27.	Demoiselle Crane	*Anthropoides virgo*	LC	2	03-11-2021
28.	Rock Eagle-owl	*Bubo bengalensis*	LC	1	06-11-2021

Table 5: List of birds killed due to electrocution/collision with powerlines (*contd.*)

Sr. No.	Name of Bird	Scientific Name	IUCN category	No. of Individuals	Date of Mortality
29.	Rock Eagle-owl	*Bubo bengalensis*	LC	1	17-12-2021
30.	Great Indian Bustard	*Ardeotis nigriceps*	CR	1	17-10-2022
31.	Steppe Eagle	*Aquila nipalensis*	EN	1	22-12-2022
32.	Eagle sp.	*Aquila Spp.*		1	22-12-2022
33.	Griffon Vulture	*Gyps fulvus*	LC	1	29-12-2022
34.	Egyptian Vulture	*Neophron percnopterus*	EN	1	29-12-2022
35.	Steppe Eagle	*Aquila nipalensis*	EN	1	30-12-2022
36.	Egyptian Vulture	*Neophron percnopterus*	EN	1	01-01-2023
37.	Cinereous Vulture	*Aegypius monachus*	NT	1	03-01-2023
38.	Cinereous Vulture	*Aegypius monachus*	NT	1	03-01-2023
39.	Griffon Vulture	*Gyps fulvus*	LC	1	04-01-2023
40.	Griffon Vulture	*Gyps fulvus*	LC	1	08-01-2023
41.	Cinereous Vulture	*Aegypius monachus*	NT	1	13-01-2023
42.	Griffon Vulture	*Gyps fulvus*	LC	1	16-01-2023
43.	Griffon Vulture	*Gyps fulvus*	LC	1	16-01-2023
44.	Demoiselle Crane	*Anthropoides virgo*	LC	1	18-01-2023
45.	Griffon Vulture	*Gyps fulvus*	LC	1	21-01-2023
46.	Demoiselle Crane	*Anthropoides virgo*	LC	1	02-02-2023
47.	Egyptian Vulture	*Neophron percnopterus*	EN	1	03-02-2023
48.	Demoiselle Crane	*Anthropoides virgo*	LC	1	06-02-2023
49.	Griffon Vulture	*Gyps fulvus*	LC	1	16-02-2023
50.	Common Crane	*Grus grus*	LC	1	16-02-2023
51.	Cinereous Vulture	*Aegypius monachus*	NT	1	19-02-2023
52.	Steppe Eagle	*Aquila nipalensis*	EN	1	06-11-2023
53.	Demoiselle Crane	*Anthropoides virgo*	LC	1	08-11-2023
54.	Steppe Eagle	*Aquila nipalensis*	EN	1	20-11-2023
55.	Indian Peafowl	*Pavo cristatus*	LC	1	01-12-2023
56.	Cinereous Vulture	*Aegypius monachus*	NT	1	14-12-2023
57.	Steppe Eagle	*Aquila nipalensis*	EN	1	18-12-2023
58.	Short-toed Snake Eagle	*Circaetus gallicus*	LC	1	19-12-2023
59.	Himalayan Griffon	*Gyps himayensis*	NT	1	07-02-2024

(CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern)

Table 6: Bird species with more probability of getting killed by powerlines based on mortality and observation data

S.No.	Species Name	Number of Individuals	Number of Incidences
1	Cinereous Vulture	6	6
2	Common Crane	2	2
3	Common Teal	1	1
4	Demoiselle Crane	23	12
5	Eagle sp.	1	1
6	Egyptian Vulture	5	4
7	Eurasian Collared-dove	1	1
8	Great Indian Bustard	2	2
9	Griffon Vulture	12	10
10	Indian Peafowl	2	2
11	Long-legged Buzzard	1	1
12	Rock Eagle-owl	2	2
13	Steppe Eagle	6	6
14	Tawny Eagle	9	7
15	Short-toed Snake Eagle	1	1
16	Himalayan Griffon	1	1

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Most effective long-term solution to reduce bird mortality rates while installing bird diverters in areas inhabited by bustards/floricans is to underground the cables

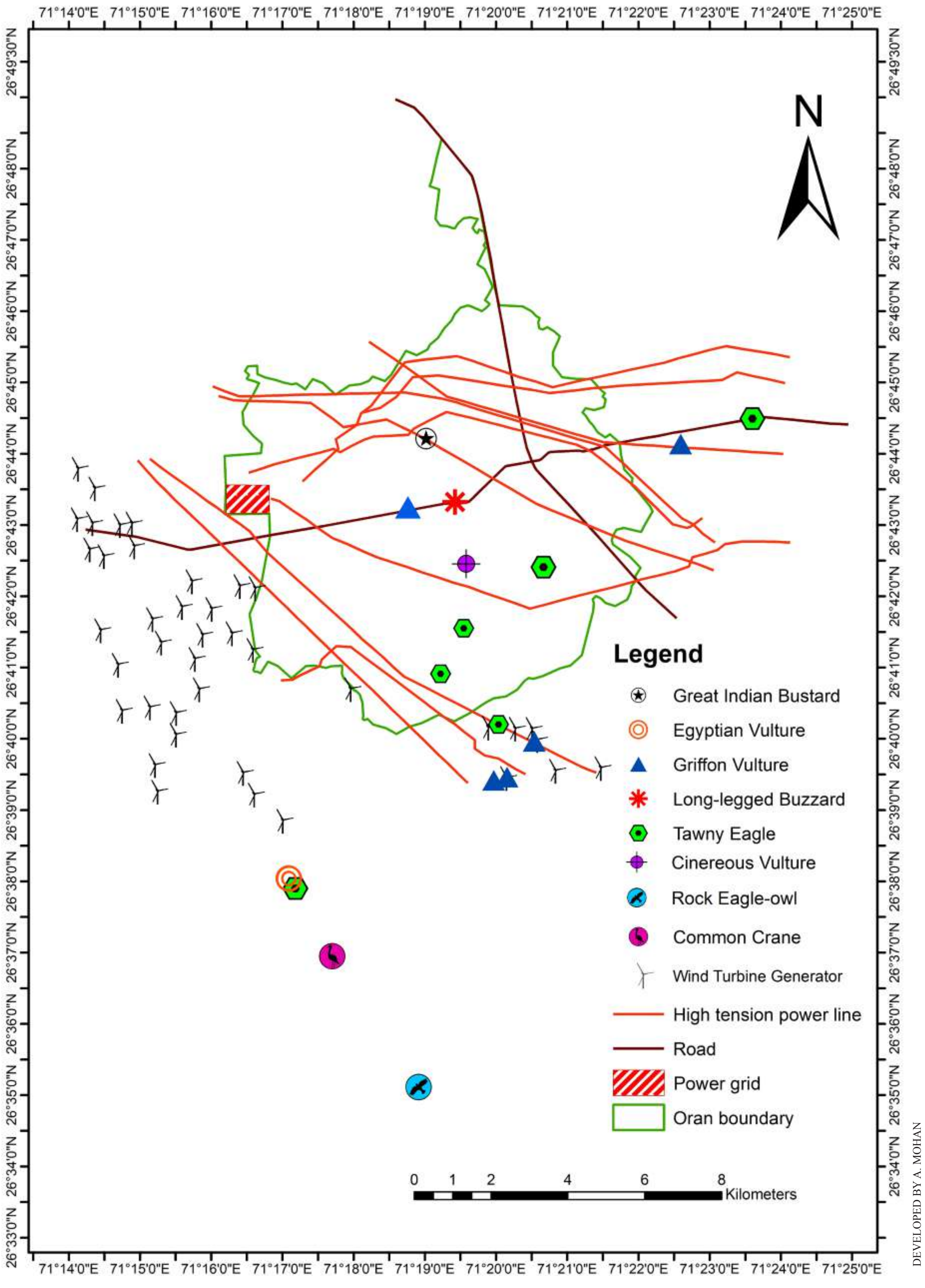


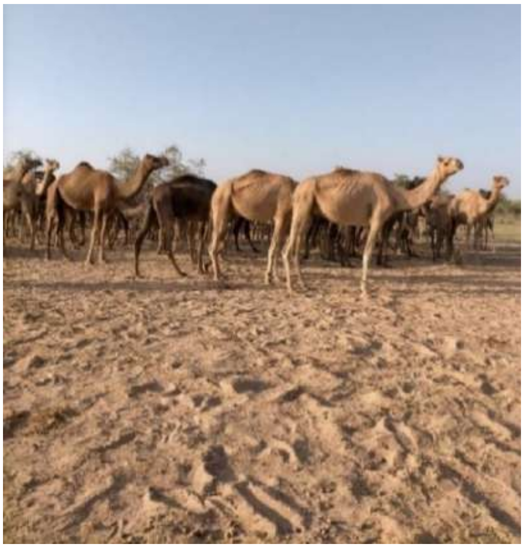
Fig. 8: Locations where birds have died from powerline collisions along Deg Rai Mata Oran boundaries

NEELKANTH BORA

Team inspecting remnants of feathers and body parts of a Demoiselle Crane *Anthropoides virgo* at Deg Rai Mata Oran area

ASHLEY CHIU

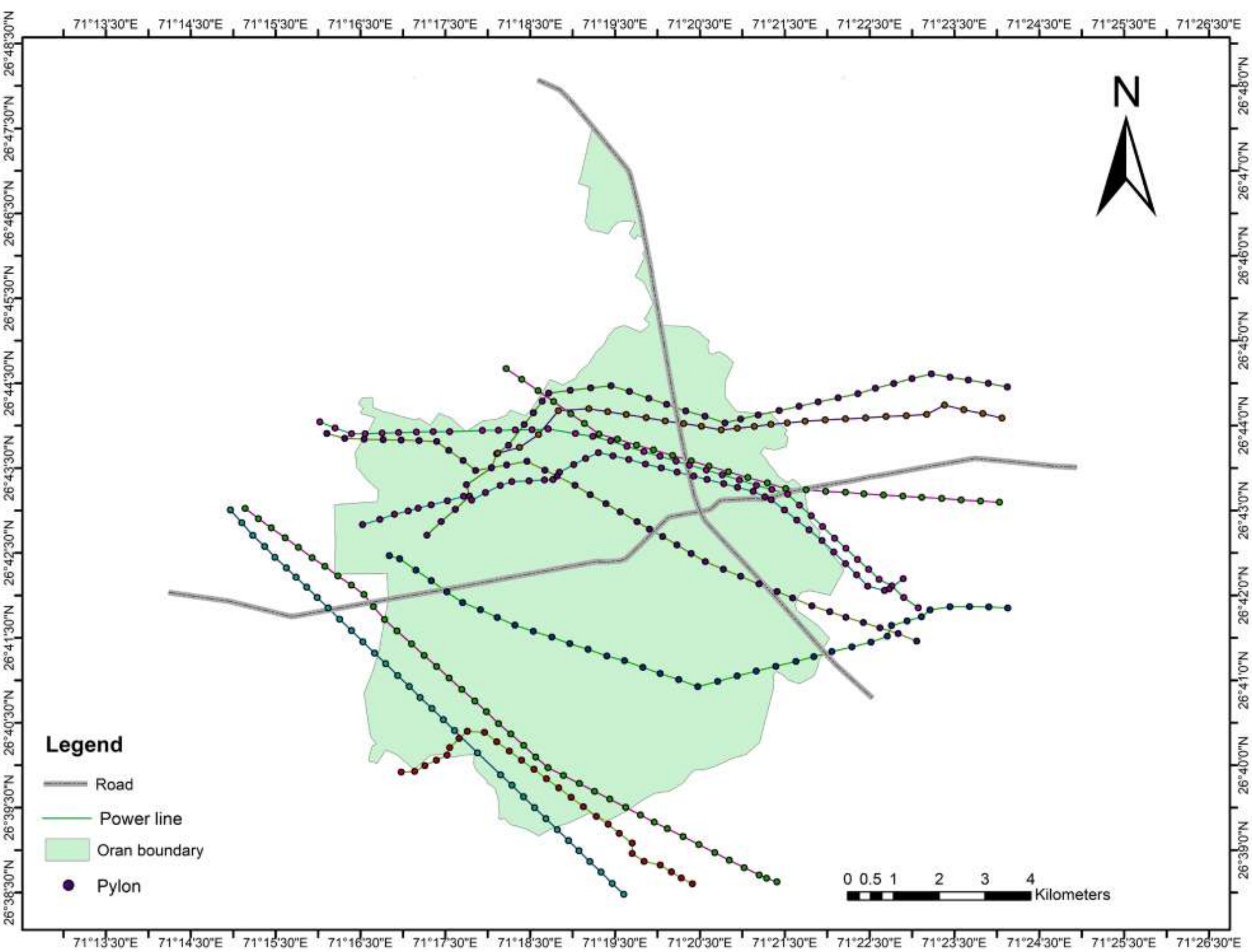
Birds are not safe while flying in the Deg Rai Mata Oran landscape



UNMESH MITRA

UNMESH MITRA

(Left): In Oran, a group of camels can be seen peacefully grazing. (Right): A group of herders takes a break under the shade of a Khejri tree (*Prosopis cineraria*)



DEVELOPED BY A. MOHAN

Fig. 9: A surge in pylons and powerlines has created a mesh that is becoming a death trap for the birds (Shapefiles of polygon prepared by moving on the boundaries of Deg Rai Mata Oran to a location map)

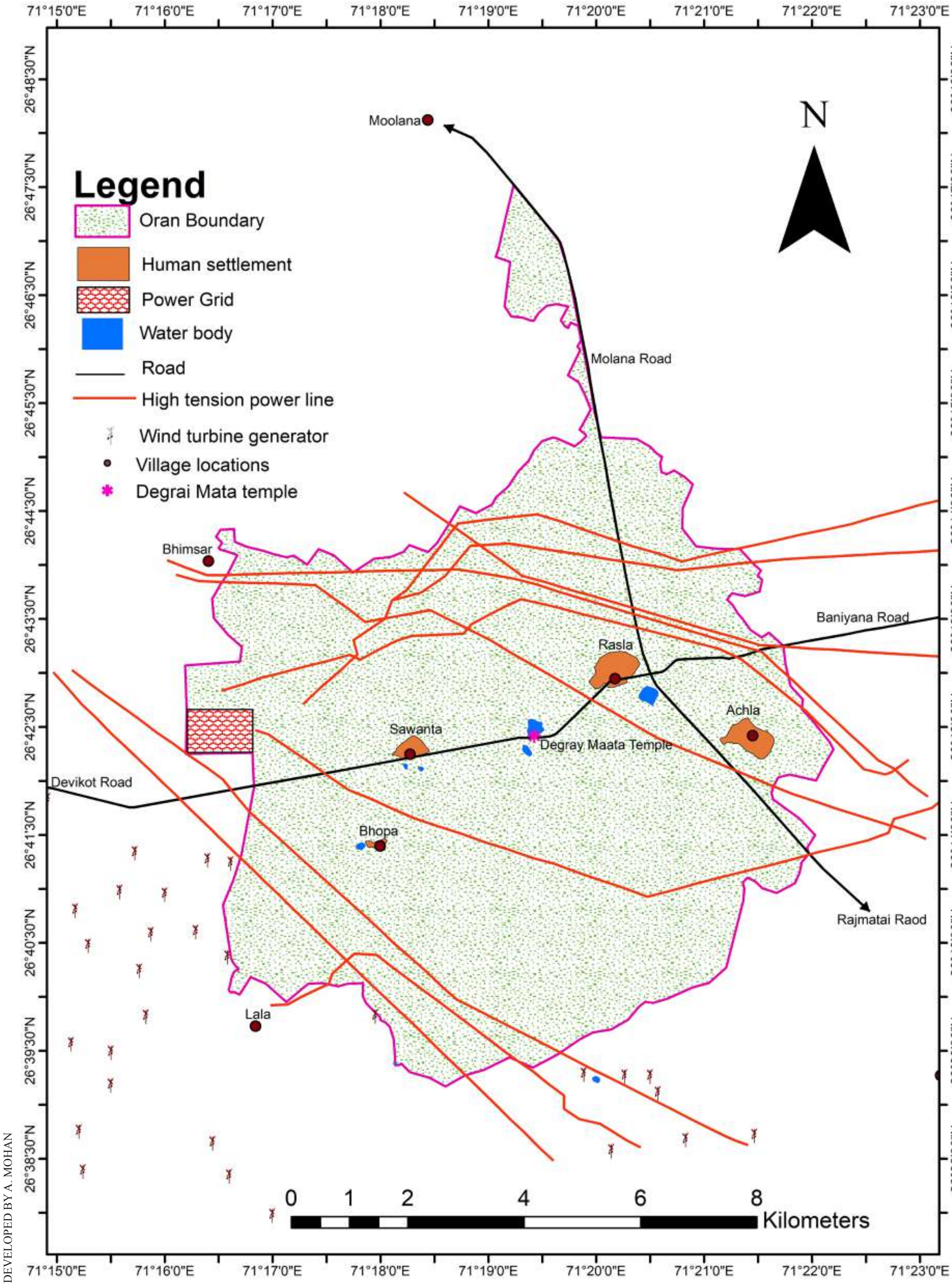


Fig. 10: Showing huge pressure on Deg Rai Mata Oran from the upcoming development and energy-related, heavy infrastructure (Shapefiles of villages, overlaid on polygon prepared by moving on the boundaries of Deg Rai Mata Oran, using saved tracks of powerlines crossing the areas, location of upcoming powergrid and wind turbines to prepare location map)

UNMESH MITRA

Egyptian Vultures roosting on pylons are prone to get electrocuted

UNMESH MITRA

'Endangered' Egyptian Vulture *Neophron percnopterus* became a victim of electrocution (beak burnt due to electrocution) in February 2021

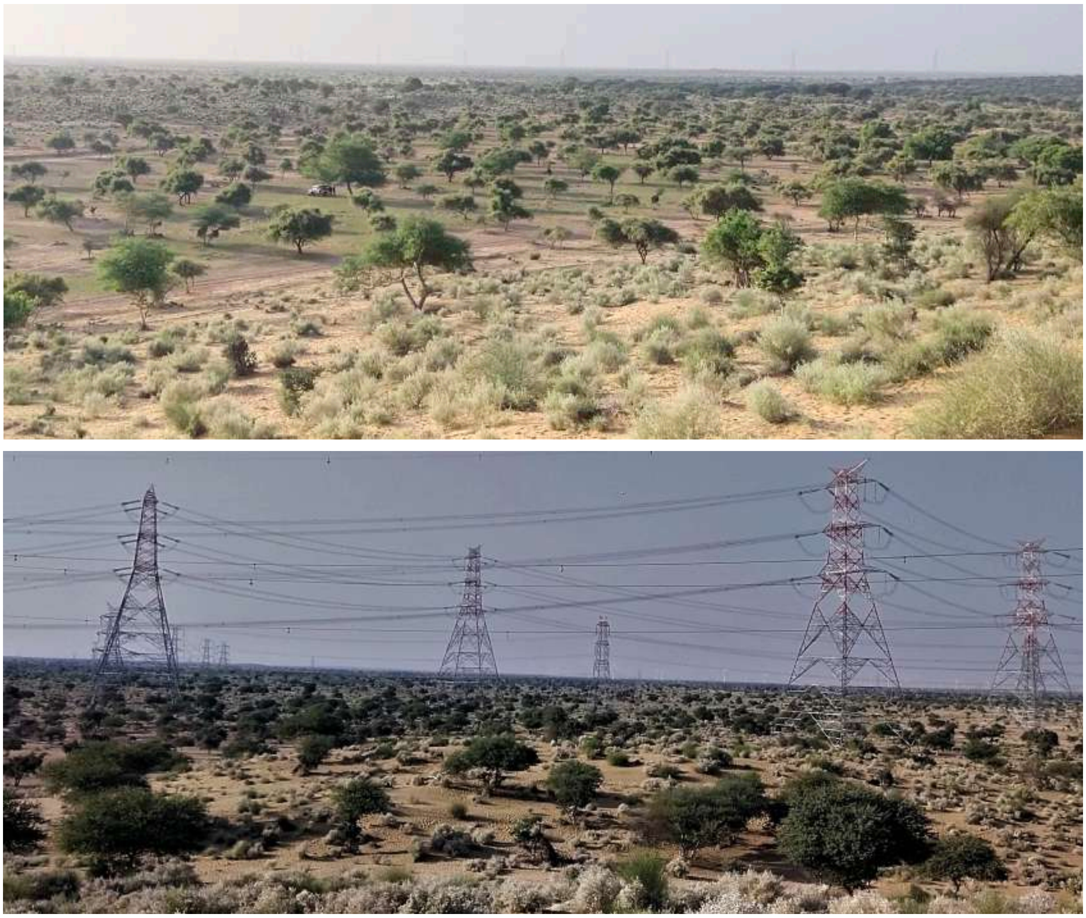
SUMER SINGH BHATI

The locals, particularly those who raise and care for livestock, are offering crucial insights into the bird's mortality rate

SUJIT NARWADE

SUJIT NARWADE

Steppe Eagle *Aquila nipalensis* was rescued, treated and released on November 5th, 2021 by Sumer Singh Bhati



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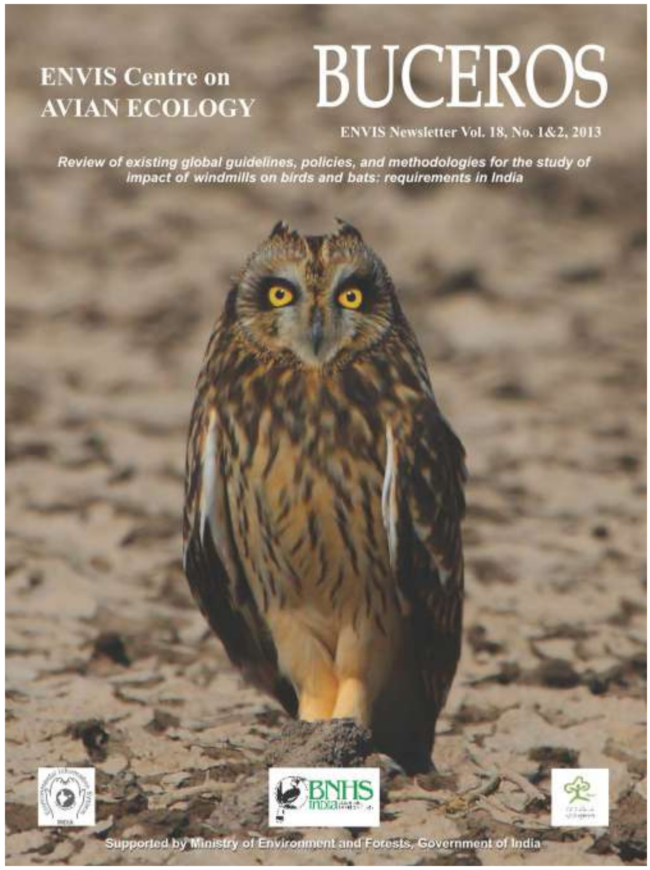
Deg Rai Mata Oran has transformed by adding many high-tension transmission lines, changing the look of the sky and surroundings in just two years. Above photo - September 2020, below - October 2022



In 2013, BNHS-EIACP highlighted the issue of the impact of wind and new renewable energy projects on birds

SUJIT NARWADE

New high voltage powerlines are coming up despite stay order by National Green Tribunal

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Compilation of case studies on undergrounding of the wires

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The burial of medium voltage distribution lines has seen limited application, primarily in select European countries such as France, Monaco, Italy, Spain, and Portugal (Prinsen *et al*. 2011). A noteworthy success story is seen in the Netherlands, where the sustained use of underground cables for low voltage utility and medium voltage distribution lines proved to be highly effective. This approach is now being adopted in Belgium, the United Kingdom, Norway, Denmark, and Germany (Prinsen *et al*. 2011; Prinsen *et al*. 2012; Skorpikova *et al*. 2019). This resulted in a reduction in electrocution-related issues, thus benefitting bird populations in these regions (Prinsen *et al*. 2011; Raptor Protection of Slovakia 2021) and in Holland (Haas *et al*. 2003) and the USA (Hamal *et al*. 2023). In Italy, a third of the high- and medium-voltage power lines in the Po Delta Regional Park have been buried, particularly in critical bird areas (Bernardino *et al*. 2018). As per a special note published by Conservation Action Trust (CAT), 765 kV cables are not manufactured locally in India, so underground transmission lines cost upto 4 to 6 times more than overhead transmission. Still, studies show that they can reduce outages by three to four times, improving the reliability of electricity supply to consumers (CAT 2024).

Few prominent examples

Global efforts to mitigate bird mortality from power line collisions have prompted various undergrounding initiatives worldwide. These successful interventions illustrate effective strategies in ensuring the safety of avian species and preserving biodiversity. In the context of our case studies, we approached individuals to gather detailed information.

1) **Great Bustard *Otis tarda* in Europe -** In the West Pannonian region of Europe, encompassing western Hungary and parts of eastern Austria, as well as portions of several Balkan states, primarily Slovenia, Croatia, and Serbia i.e., Vojvodina, the Great Bustard population faced a significant decline in the latter half of the 20th century. According to Raab *et al*. (2012), the implementation of underground cabling and power line marking played a crucial role in population recovery. By burying 43.1 km of medium voltage power lines by 2011, at a cost of 27,28,87,200.00 INR (1 EUR = 90.36 INR; 1 INR = 0.01 EUR) (Table 1), and marking 89.7 km of power lines in Eastern Austria, the Great Bustard population increased from 130 individuals in 1995 to 376 by the winter of 2008/2009. Notably, power line collisions, accounting for 41% of bustard mortalities in the past decade, significantly decreased in the years following these conservation measures. (Raab unpubl. data).

2) **Black-necked Crane *Grus nigricollis* in Bhutan - (pers. comm. Jigme Tshering – RSPN; RSPN 2010) –** In Bhutan's Phobjikha Valley, encompassing Phobji and Gangtey subdistricts, an underground cabling initiative was undertaken from 2008 to 2012 aiming to preserve the scenic landscape and protect the wintering Black-necked Crane population. Collaborating with the Department of Energy, Bhutan Power Corporation, and Royal Society For Protection of Nature (RSPN), the project included 13.3 km of high-voltage underground lines and 44.6 km of low-voltage (11 kV) underground lines, with a total project cost of 153,290,012 Indian Rupees (1 BTN = 0.998632 INR; 1 INR = 1.001369874 BTN) (Table 1). By strategically placing underground cables near Black-necked Crane feeding and roosting habitats, and positioning overhead lines along tree zones, the initiative seamlessly blended modern infrastructure with traditional aesthetics. The main tasks were executed from April to September to minimize disruptions to the cranes.

3) **Flamingos in Kutch, India –** In Khadir, Kutch, India, Gujarat Energy Transmission Corporation Limited (GETCO) buried 66 kV power lines for 10 km in 2012–13 to protect flamingos (Table 1). Following a Supreme Court order, another 66 kV power line near Kunathiya village is

currently being buried to safeguard the Great Indian Bustard *Ardeotis nigriceps* (roundglass sustain 2023).

4) **Demoiselle Crane *Anthropoides virgo* in Khichan, Rajasthan, India (pers. comm. Sevaram Mali, Khichan, Phalodi) -** Documentation of birds colliding with power lines is an urgent need for initiatives to protect bird populations. According to Mali *et al*. (2023), 29 incidents were recorded between June 2010 and March 2021, involving 53 Demoiselle Crane individuals colliding with power lines leading to the involvement of local community to protect migratory Demoiselle Cranes. In Khichan village of Phalodi tehsil, Jodhpur (Rajasthan), Sevaram Mali and the local community took proactive measures to protect migratory Demoiselle Cranes. In 2017, they successfully advocated for

Site where power lines were made underground in Khichan to protect Demoiselle Cranes *Anthropoides virgo*, was shown by Sevaram Mali (R) to the BNHS team member (L)

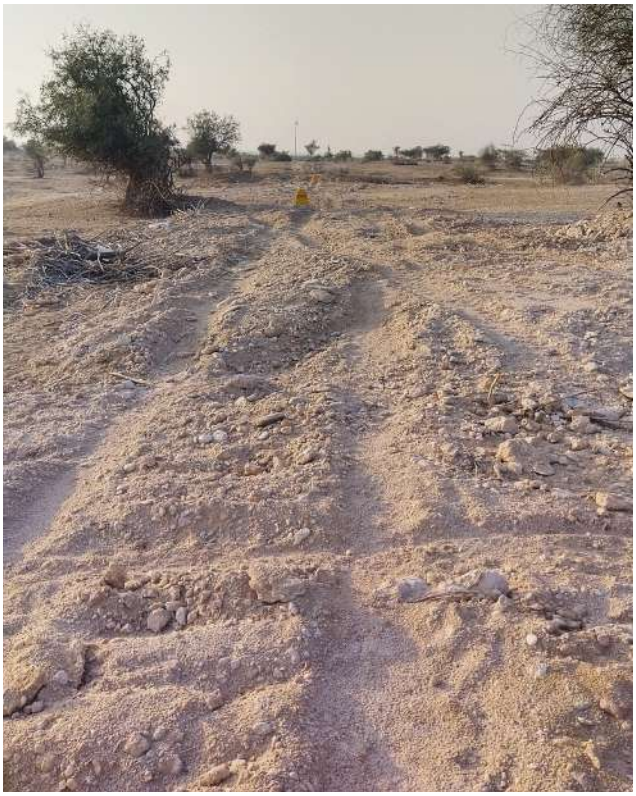
कुरजां संरक्षण: हाईटेंशन लाइन शिफ्टिंग 400 बीघा पर योजना बनाने आए अफसर

भास्कर न्यूज | खीचन

खीचन में गुरुवार को मुख्य सचिव के निर्देशानुसार उच्चाधिकारी ने स्थानीय अधिकारियों के साथ खीचन स्थित पक्षी चुग्गाघर, विभिन्न तालाबों व कुरजां संरक्षण के लिए आरक्षित जमीनों का निरीक्षण कर कुरजां के संरक्षण के लिए पुख्ता कार्य योजना बनाने के लिए मंथन किया। संभागीय मुख्य वन संरक्षक एवं सरिस्का के निदेशक जीएस भारद्वाज, संभागीय मुख्य वन संरक्षक जोधपुर रघुवीरसिंह शेखावत, अतिरिक्त जिला कलेक्टर फलोदी राकेश कुमार शर्मा, उप वन संरक्षक हनुमानराम चौधरी, पर्यटन विभाग के उप निदेशक भानुप्रतापसिंह, डिस्कॉम के अधीक्षण अभियंता अशोक कुमार राजपुरोहित, सहायक वन संरक्षक नरेंद्रसिंह शेखावत, फलोदी रेंजर जेठमाल सिंह सोढा, क्षेत्रीय वन अधिकारी धर्मदास, भारतीय वन्य जीव संस्थान के डॉ. सुतीर्थों दत्ता, बॉम्बे नेचुरल हिस्ट्री सोसायटी के सुरजीत नार्नवुडी ने पक्षी चुग्गाघर रातड़ी नाडी, विजय सागर तालाब, निंबली नाडी, गंवाई नाडी, 400 केवी की बिजली लाइन व खसरा नं. 151 व 170 में कुरजां संरक्षण के लिए आरक्षित जमीन का निरीक्षण किया व मौके पर उपस्थित संबंधित विभागों के अधिकारियों से विचार-विमर्श किया। इस दौरान अधिशासी अभियंता एचएल परिहार, सरपंच दिनेश कुमार जैन, पीईओ रामचंद्र व्यास, पक्षी प्रेमी सेवाराम माली, केशव नागौरा, मारवाड़ क्रेन फाउंडेशन के प्रबंधक सत्यनारायण सिंह, मोडाराम मेघवाल, पटवारी पवन जोशी, नायब तहसीलदार फलोदी हरिराम कुलदीप, अधिशेष निरीक्षक मिश्रीलाल, रेंजर नखताराम सहित गणमान्य नागरिक मौजूद थे। सीसीएफ भारद्वाज 400 केवी हाइटेंशन बिजली लाइन के पोल स्थानांतरित करने, वन विभाग के जमीन पर चारदीवारी बनवाने व फेसिंग करवाने, कुरजां पड़ाव स्थल का विस्तार करने, कुरजां संरक्षण के लिए आरक्षित 400 बीघा जमीन की चारदीवारी के बारे अधिकारियों से कार्य योजना पर चर्चा की।

खीचन| कई विभागों के अधिकारियों ने कुरजां संरक्षण पर चर्चा की।

By order of honorable High Court Jodhpur, an expert committee visited and suggested realignment of high-tension transmission line from crane roosting site



SUJIT NARWADE

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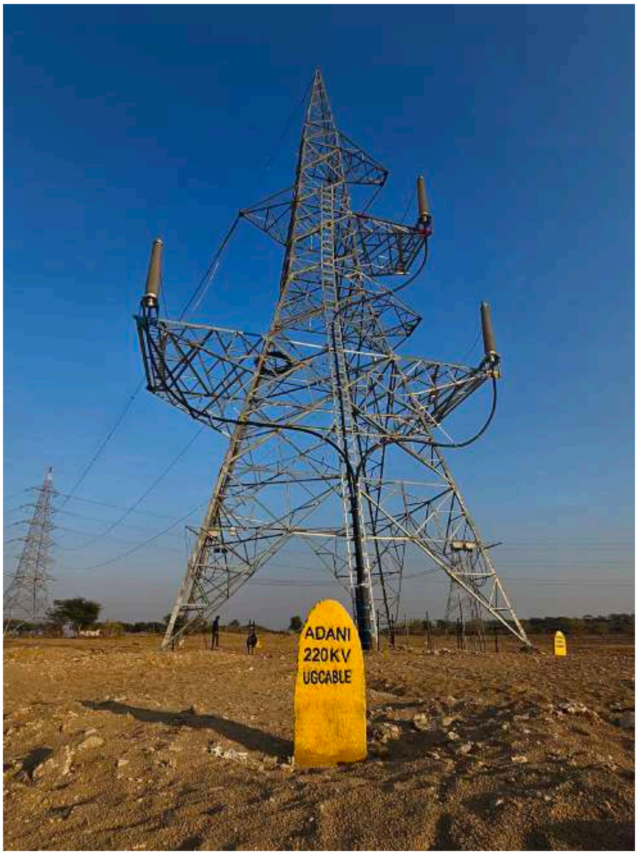


PANKAJ BISHNOI

SUJIT NARWADE

Underground cabling after completion of the work

PANKAJ BISHNOI

PANKAJ BISHNOI

Underground cabling in process

the underground installation of 33 kV and 11 kV power lines, incurring costs of 63,32,314 INR and 17,56,069 INR respectively (Table 1).

5) **Greater Adjutant *Leptoptilos dubius* in Bihar, India (Pers. comm. Arvind Mishra; Mishra 2023) -** In Bihar, a proactive community-led initiative near Kadwa-Khairpur, Bhagalpur successfully advocated for undergrounding a 11 kV high-tension transmission line laid in 2020. Unfortunately, three Greater Adjutants succumbed to electrocution post-installation. The power line, spanning 1 km with 500 m laid underground, covered the Kosi floodplain breeding area of Greater Adjutant, and 150 meters leading to the village was insulated. On February 25, 2022, Shri Arvind Kumar and others advocated for wire undergrounding near the nesting tree. Facilitated by Shri Dipak Kumar Singh, Additional Chief Secretary, MoEF&CC, Bihar State Govt, the initiative, involving South Bihar Power Distribution Company Ltd, completed successfully in 11–12 days from March 23, 2022 (Table 1). Aimed at protecting the significant nesting site for the near-threatened Greater Adjutant, this area is considered the third-most-popular breeding ground globally for the endangered species. .

6) **Great Indian Bustard *Ardeotis nigriceps* in Rajasthan, India —** Adani Power has recently installed a new power line in the Jaisalmer-Barmer region of Rajasthan, India. The project involved running 5 km of high-tension transmission lines underground from Ker Faquir ki Dhani to Amarpura near Devikot (Table 1). This change was made to enhance safety and reduce the impact of overhead wires on birds, particularly the Great Indian Bustard and raptors in the Thar Desert.

Adani Power's initiative is a significant milestone in the conservation of these birds, and it has led others to follow similar conservation and mitigation measures. The impact area of the conversion was 5 meters wide, and a trench 5 feet deep was dug to lay the bunch of cables. This underground system will ensure that these endangered bird species are protected from harmful impacts with minimal disturbance to the flora and fauna in the area. Implementing

BALASAHEB LAMBTURE

11 kV powerline passing through core area of the GIB Sanctuary from Akolekati to Madri

BALASAHEB LAMBTURE

Follow up with electricity and distribution boards and joint field visits

such initiatives can create a more sustainable future for India's bustards and raptors.

7) **Seabirds in Kaua'i Island, Hawaii, USA** – Seabirds in Kaua'i Island, Hawaii, USA, faced risks from power lines, prompting the Kaua'i Island Utility Cooperative to take significant measures, including undergrounding of wires, as part of the Underline Monitoring Project within the Kaua'i Endangered Seabird Recovery Project (KESRP) (Table 1). The initiative targeted collision hotspots for endangered species like Newell's Shearwater *Puffinus newelli*, Hawaiian Petrel *Pterodroma sandwichensis*, and Band-rumped Storm-Petrel *Hydrobates castro*. Other measures implemented to mitigate risks include lowering of wires, removal of the top static wire, and a creation of a 'laser fence' using lasers projected between poles. (LaserPointerSafety 2015; Kaua'i Endangered Seabird Recovery Project n.d.).

8) **Birds in Belgium -** In Belgium, the Stevin project, led by the transmission system operator Elia, addresses the potential impact on overwintering and breeding birds. To mitigate this, a planned 380 kV extra-high-voltage power line spanning 5 km will exclusively utilize underground cabling in the designated area (Table 1; Renewables Grid Initiative 2019, Dwyer *et al*. 2022 in Martin *et al*. 2022).

Realignment of Electric Line near Great Indian Bustard Sanctuary, Solapur, India (BNHS report 2017)

In response to the escalating threat of high-tension powerlines to bird populations, specifically the critically endangered Great Indian Bustard (GIB) *Ardeotis nigriceps*, the Great Indian Bustard Sanctuary initiated a crucial realignment project. The decision stemmed from documented incidents of GIB collisions and fatalities, coupled with the bird's evident efforts to avoid the dense powerline network during flights.

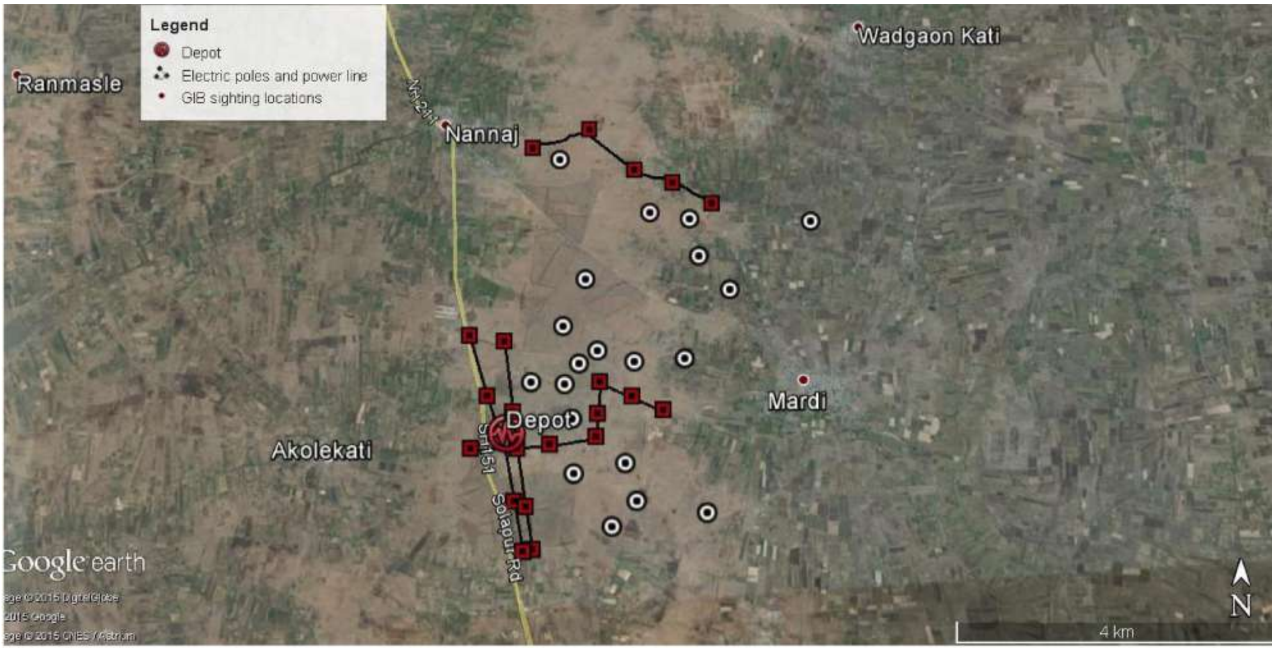
To address the issue, a detailed report outlining GIB usage areas and the intersecting powerlines was submitted to the Maharashtra Electricity Distribution Board. Urging the Maharashtra State Electricity Board (MSEB) to consider realignment, a letter dated 19/07/2016 from the office of the

Ranger, Maldhok Sanctuary Nannaj, highlighted the necessity to shift or underground two powerlines – a 33 kV existential line and a proposed 11 kV line within the GIB's core habitat.

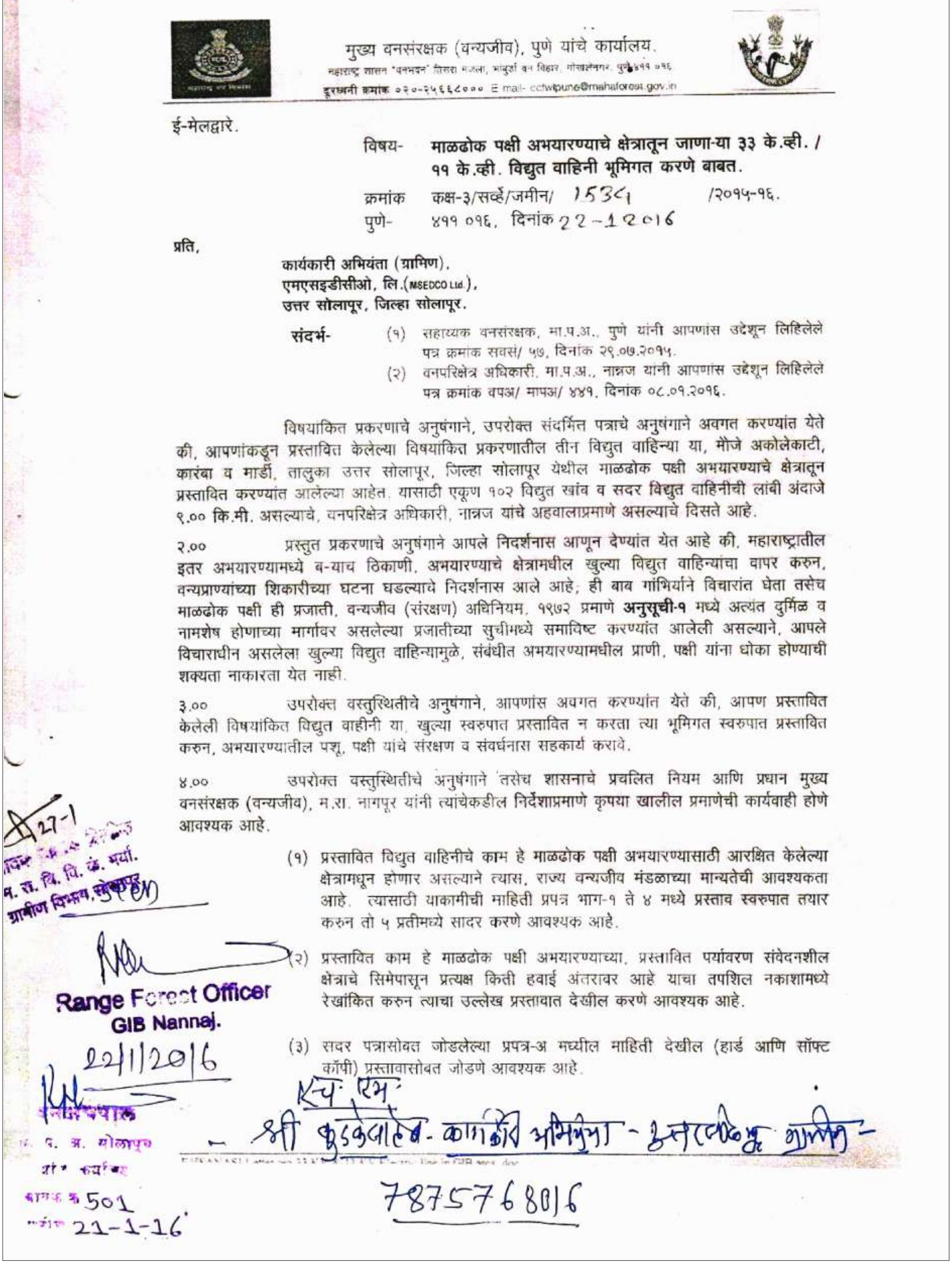
Realignment emerged as the practical solution due to the substantial costs associated with undergrounding. A comprehensive estimate for shifting the 33 kV Wadala feeder and 11 kV Mardi feeder overhead lines was prepared by the Maharashtra State Electricity Distribution Co. Ltd. Administrative approval for realignment was granted on May 24, 2018.

The realignment process, involving the relocation of each pole at an approximate cost of three and a half to four lakh Indian Rupees, commenced with a thorough inspection on August 12, 2021. The work completion report for the 11 kV line was submitted on August 09, 2021, while the report for the 33 kV line was submitted on January 10, 2022. As of April 26, 2022, the dismantling of the existing powerline structure for the 33 kV powerline is yet to be completed.

The initiative showcases a proactive and dedicated approach to mitigating the impact of power lines on the critically endangered GIB, emphasizing the importance of wildlife conservation efforts in the region.



GIB movement and powerlines going through the core area of GIB Sanctuary were mapped by BNHS and Pune WL division



मुख्य वनसंरक्षक (वन्यजीव), पुणे यांचे कार्यालय.
महाराष्ट्र शासन "वनभवन" तिसरा मजला, भांबुर्डा वन विहार, गोखलेनगर, पुणे ४११ ०१६
दूरध्वनी क्रमांक ०२०-२५६६८००० E mail- ccfwlpune@mahaforest.gov.in

ई-मेलद्वारे.

विषय- **माळढोक पक्षी अभयारण्याचे क्षेत्रातून जाणा-या ३३ के.व्ही. / ११ के.व्ही. विद्युत वाहिनी भूमिगत करणे बाबत.**

क्रमांक कक्ष-३/सर्व्हे/जमीन/ 1539 /२०१५-१६.
पुणे- ४११ ०१६, दिनांक 22-1-2016

प्रति,

कार्यकारी अभियंता (ग्रामिण),
एमएसइडीसीओ, लि.(MSEDCO Ltd.),
उत्तर सोलापूर, जिल्हा सोलापूर.

संदर्भ- (१) सहाय्यक वनसंरक्षक, मा.प.अ., पुणे यांनी आपणांस उद्देशून लिहिलेले पत्र क्रमांक सवसं/ ५७, दिनांक २९.०७.२०१५.
(२) वनपरिक्षेत्र अधिकारी, मा.प.अ., नान्नज यांनी आपणांस उद्देशून लिहिलेले पत्र क्रमांक वपअ/ मापअ/ ४४१, दिनांक ०८.०१.२०१६.

विषयांकित प्रकरणाचे अनुषंगाने, उपरोक्त संदर्भित पत्राचे अनुषंगाने अवगत करण्यांत येते की, आपणांकडून प्रस्तावित केलेल्या विषयांकित प्रकरणातील तीन विद्युत वाहिन्या या, मौजे अकोलेकाटी, कारंबा व मार्डी, तालुका उत्तर सोलापूर, जिल्हा सोलापूर येथील माळढोक पक्षी अभयारण्याचे क्षेत्रातून प्रस्तावित करण्यांत आलेल्या आहेत. यासाठी एकूण १०२ विद्युत खांब व सदर विद्युत वाहिनीची लांबी अंदाजे ९.०० कि.मी. असल्याचे, वनपरिक्षेत्र अधिकारी, नान्नज यांचे अहवालाप्रमाणे असल्याचे दिसते आहे.

२.०० प्रस्तुत प्रकरणाचे अनुषंगाने आपले निदर्शनास आणून देण्यांत येत आहे की, महाराष्ट्रातील इतर अभयारण्यामध्ये ब-याच ठिकाणी, अभयारण्याचे क्षेत्रामधील खुल्या विद्युत वाहिन्यांचा वापर करुन, वन्यप्राण्यांच्या शिकारीच्या घटना घडल्याचे निदर्शनास आले आहे; ही बाब गांभिर्याने विचारांत घेता तसेच माळढोक पक्षी ही प्रजात्ती, वन्यजीव (संरक्षण) अधिनियम, १९७२ प्रमाणे **अनुसूची-१** मध्ये अत्यंत दुर्मिळ व नामशेष होणाच्या मार्गावर असलेल्या प्रजातीच्या सुचीमध्ये समाविष्ट करण्यांत आलेली असल्याने, आपले विचाराधीन असलेला खुल्या विद्युत वाहिन्यामुळे, संबंधीत अभयारण्यामधील प्राणी, पक्षी यांना धोका होण्याची शक्यता नाकारता येत नाही.

३.०० उपरोक्त वस्तुस्थितीचे अनुषंगाने, आपणांस अवगत करण्यांत येते की, आपण प्रस्तावित केलेली विषयांकित विद्युत वाहीनी या, खुल्या स्वरुपात प्रस्तावित न करता त्या भूमिगत स्वरुपात प्रस्तावित करुन, अभयारण्यातील पशू, पक्षी यांचे संरक्षण व संवर्धनास सहकार्य करावे.

४.०० उपरोक्त वस्तुस्थितीचे अनुषंगाने तसेच शासनाचे प्रचलित नियम आणि प्रधान मुख्य वनसंरक्षक (वन्यजीव), म.रा. नागपूर यांनी त्यांचेकडील निर्देशाप्रमाणे कृपया खालील प्रमाणेची कार्यवाही होणे आवश्यक आहे.

(१) प्रस्तावित विद्युत वाहिनीचे काम हे माळढोक पक्षी अभयारण्यासाठी आरक्षित केलेल्या क्षेत्रामधून होणार असल्याने त्यास, राज्य वन्यजीव मंडळाच्या मान्यतेची आवश्यकता आहे. त्यासाठी याकामीची माहिती प्रपत्र भाग-१ ते ४ मध्ये प्रस्ताव स्वरुपात तयार करुन तो ५ प्रतीमध्ये सादर करणे आवश्यक आहे.

(२) प्रस्तावित काम हे माळढोक पक्षी अभयारण्याच्या, प्रस्तावित पर्यावरण संवेदनशील क्षेत्राचे सिमेपासून प्रत्यक्ष किती हवाई अंतरावर आहे याचा तपशिल नकाशामध्ये रेखांकित करुन त्याचा उल्लेख प्रस्तावात देखील करणे आवश्यक आहे.

(३) सादर पत्रासोबत जोडलेल्या प्रपत्र-अ मध्यील माहिती देखील (हार्ड आणि सॉफ्ट कॉपी) प्रस्तावासोबत जोडणे आवश्यक आहे.

Range Forest Officer
GIB Nannaj.
22/1/2016

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दिनांक 21-1-16

Letter submitted by RFO of GIB Sanctuary to concerned agencies for undergrounding the powerline

Table 1: Global insights into undergrounding case studies for bird species protection

S. No.	Bird species for which the undergrounding was implemented	Underground line location	Power line capacity (kV)	Existing line or New line	Length of underground wiring	Year of undergrounding implementtation	Cost (in respective foreign currency)	Estimated Cost in INR	Cost per km in INR	Agencies Involved
1	Great Bustard *Otis tarda*	Western Hungary and Eastern Austria	Medium voltage power lines	Existing	43.1 km	2011	€ 3.02 million (Euros)	27,28,87,200 (1 EUR = 90.36 INR; 1 INR = 0.01 EUR)	63,31,489	Not available
2	Black-necked Crane *Grus nigricollis*	Phobjikha Valley, Bhutan	11 kV and other high-voltage line	New	low voltage line – 44.6 km high voltage line – 13.3 km	2008 to 2012	Nu. 153.5 million	15,32,90,012 (1 BTN = 0.998 INR; 1 INR = 1.00135 BTN)	–	Department of Energy, Bhutan Power Corporation, and Royal Society For Protection of Nature (RSPN)
3	Flamingo	Kutch, Gujarat, India	66 kV	Existing	10 km	2012–13	–	Not Available	–	Gujarat Energy Transmission Corporation Limited (GETCO)
4	Demoiselle Crane *Anthropoides virgo*	Khichan, Rajasthan, India	33 kV 11 kV	Existing	0.9 km 0.51 km	2017 2017	–	63,32,314 17,56,069	70,35,904 34,43,272	Jodhpur Vidhyut Vitran Nigam Ltd. (JdVVNL)
5	Greater Adjutant *Leptoptilos dubius*	Bihar, India	11 kV	Existing	0.5 km	2022	–	Not Available	–	South Bihar Power Distribution Company Ltd
6	Great Indian Bustard *Ardeotis nigriceps*	Rajasthan, India	220 kV	New	5 km	2023–24	–	4,00,00,000	80,00,000	Adani power
7	Seabirds in Kauai Island: Shearwater, Petrel	Hawaii, USA	Not Available	Existing	Not Available	Not Available	Not Available	–	–	Kaua'i Island Utility Cooperative, KESRP
8	Overwintering and breeding birds	Belgium	380 kV	New	5 km	Not Available	Not Available	–	–	Elia, Belgium's high voltage transmission system operator

Note: Undergrounding of existing lines involved dismantling existing lines + Material Equipment for new lines + Civil work + other charges. Estimated cost as per available documents, in particular year.

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BUCEROS is an EIACP (Environmental Information. Awareness, Capacity Building and Livelihood Programme) newsletter published thrice a year by the EIACP Resource Partner on Avian Ecology at the BNHS, sponsored by the Ministry of Environment, Forests and Climate Change, New Delhi.

The Resource Partner collects, collates, stores, and disseminates information on Avian Ecology.
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Published by the Honorary Secretary for the Bombay Natural History Society, Hornbill House,
Shaheed Bhagat Singh Road, Mumbai 400 001.