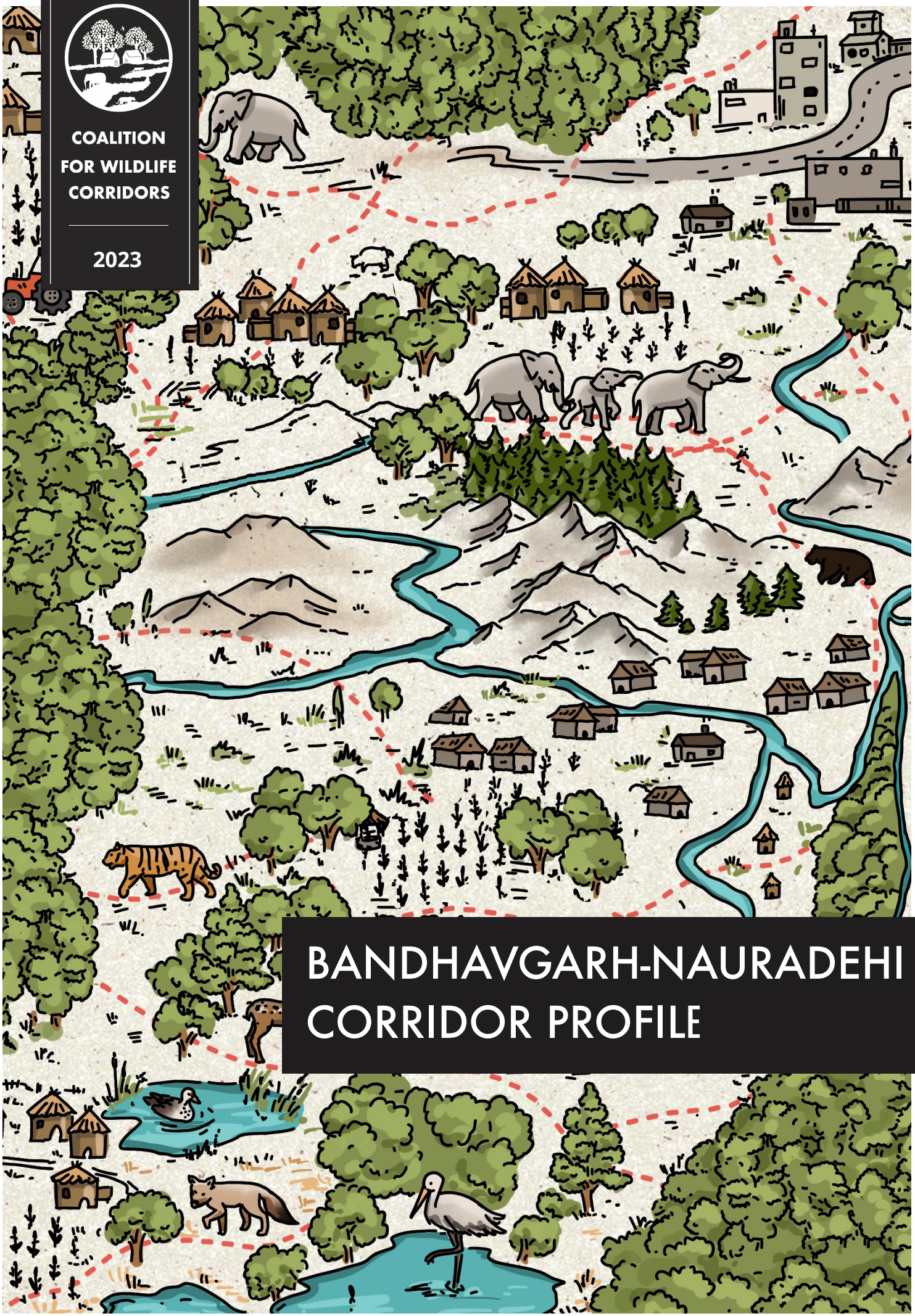
COALITION FOR WILDLIFE CORRIDORS

2023



BANDHAVGARH-NAURADEHI CORRIDOR PROFILE

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COALITION FOR WILDLIFE CORRIDORS

Contents

Corridor Overview

The Bandhavgarh-Nauradehi wildlife corridor connects Bandhavgarh Tiger Reserve and Nauradehi Wildlife Sanctuary in Madhya Pradesh, India. The corridor is encompassed within the municipal districts of Damoh, Umaria, and Katni, with small parts falling in Panna, Dindori, and Jabalpur districts. The corridor has an approximate area of 7,075 km^2 with flat terrain in most parts. The Vindhyan basin overlaps with the western part of the corridor, and the Satpura mountain range overlaps towards the eastern end. The corridor is a mosaic of forests, agriculture, and urban areas along with a large network of roads and railways. Several herbivores, including blackbuck (*Antilope cervicapra)*, chinkara *(Gazella bennettii)*, nilgai *(Boselaphus tragocamelus)*, and chausingha *(Tetracerus quadricornis)* and carnivores including leopard *(Panthera pardus)*, and wolf *(Canis lupus)* have been reported from the corridor. However, the land-use within the corridor has changed substantially over the last couple of decades with decline in open forests and an increase in scrub forests and agriculture.

Area of natural habitat
Medium
46 %

Area under forest department
Medium
37 %

Threatened species richness
Low
25 species/km^2

Human population
Medium
260 persons/km^2

Human modification index
Medium
0.50

Fragmentation index
Low
0.83

Landscape complexity
Medium
0.81

Landuse change index
——
——

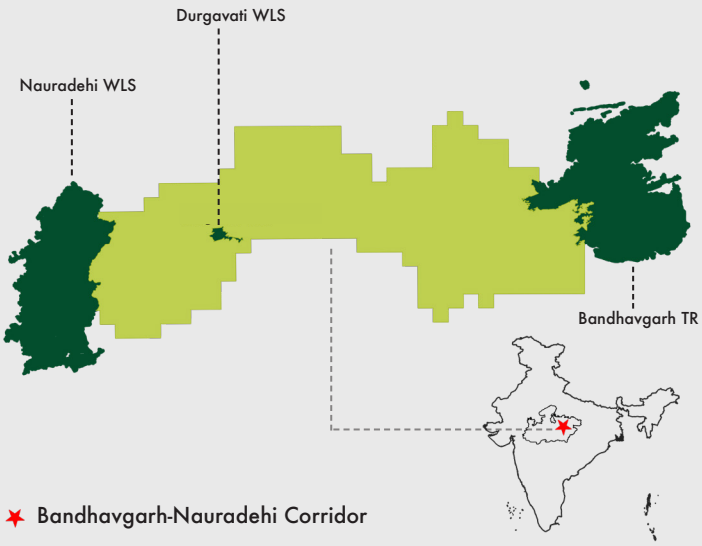
Habitat connected: Bandhavgarh Tiger Reserve and Nauradehi Wildlife Sanctuary

Area of corridor: 7075 km^2

Species of interest: Multiple mammalian species

Major threats: Fragmentation, land-use change

Coalition for Wildlife Corridors member(s): NA



*The indicators provided here are based on the crude boundaries and global datasets and are indicative in nature. Finescale data based on ground-truthed locations would provide a more accurate estimate of the indicators. See supplementary information for more details on the data used for calculating the indicators.

1 Corridor History

Geological history

The sedimentary rocks in the western part of the corridor have preserved a record of Earth's history through rich fossil assemblage. This region falls within the Vindhyan basin and contains layers of sedimentary rocks, the majority of which is sandstone, followed by shale and limestone. These were formed about 2.5 billion to 500 million years ago, during the Proterozoic eon (Dayal et al., 2014).

Some of the sedimentary rock layers can be seen along the present-day Katni-Bina railway line that passes through the northern part of the corridor, cutting through the Vindhyan hills (Rai, 1980). Katni and Damoh districts, which overlap with the corridor's western and central parts, are renowned for fossil discoveries.

Trace fossils, preserved remains of tracks or trails that an organism leaves on a surface, were found in the sandstone excavated from Sagoni village within the Patera tehsil of Damoh district. This trace fossil was an unbranched, smooth, meandering trail of an invertebrate organism found between 600 to 500 million years ago (Kulkarni et al., 1996).

Several Cyanobacteria (also called blue-green algae) fossils have been reported from around Katni town, close to the northern boundary of the corridor (Sharma and Shukla, 2009).

Bandhavgarh National Park
By Tom Thai (CC BY 2.0, Wikimedia Commons)

Modern history

In the Imperial Gazetteer of India (n.d.) published in the early 20th century, the British surveyors noted that the western side of the present-day corridor that overlaps with the Damoh district had teak *(Tectona grandis)* and saj *(Terminalia tomentosa)* as the principal timber trees, and achar *(Buchanania latifolia)*, tendu *(Diospyros tomentosa)* and palas *(Butea frondosa)* as other tree species found in the forest.Villages, they noted, were surrounded by mango *(Mangifera Indica)*, tamarind *(Tamarindus indica)*, pipal *(Ficus religiosa)*, banyan *(Ficus benghalensis)* and mahua *(Madhuca longifolia)*. Sambar *(Rusa unicolor)*, nilgai and spotted deer *(Axis axis)* were common in the region, while *'four horned antelope and mouse deer (Moschiola indica) were occasionally met with and wolves were rare'*. The forests in the eastern part of the corridor, which overlapped with the Murwara tehsil and the southern part of the erstwhile princely state of Rewa, were dominated by sal *(Shorea robusta)*, saj, tendu and khair *(Acacia catechu)*. The jungles of Rewa were known for tigers, while chinkara, sambar, sloth bears and leopards were also abundant in the region. During the late 19th and early 20th centuries, the present-day Bandhavgarh Tiger Reserve and surrounding areas were the hunting grounds of the Baghel Rajput rulers of Rewa. Two major railway lines passed through this corridor a hundred years ago, the Bengal-Nagpur Railway and the Great Indian Peninsula Railway. The two lines formed a junction at Katni station (Murwara town) in the Murwara tehsil of the then Jabalpur district (Imperial Gazetteer of India), just outside the northern boundary of the present-day corridor. Surrounded by limestone and sandstone quarries and a population of 14,137, Murwara was a rapidly growing town by 1901. Murwara, also known as Katni, is now a district and a much bigger junction.

Nilgai female with calf
(Boselaphus tragocamelus)

2 Corridor Significance

2.1 Importance of core habitats connected

Bandhavgarh Tiger Reserve (BTR):

This tiger reserve is located in the Umaria District of Madhya Pradesh, India. It is located in the Deccan Peninsular Central Highlands between the Vindhya range and the northern slopes of the eastern part of the Satpura range, with the highest elevation of 807 m. The core area of this tiger reserve is around 717 km^2 and includes Bandhavgarh National Park and Panapata Wildlife Sanctuary. The core area is surrounded by a buffer zone of around 820 km^2 (Jhala et al., 2016).

The tiger reserve has several perennial rivers and streams: Son, Charanganga, Janad, Damnar, Bhadar, Johila and Umarar. The vegetation of the tiger reserve falls under five categories: moist peninsular low-level sal forest, northern dry mixed deciduous forest, dry deciduous scrub, dry grasslands and west Gangetic moist mixed deciduous forest (Sankar et al., 2013). Declared as a tiger reserve in 1993, Bandhavgarh is home to 134 unique tigers with a density estimate of 7.5 (SE 0.65) tigers per 100 km^2 (Qureshi et al., 2023).

The reserve also supports 37 species of mammals, 250 species of birds, and more than 70 species of butterflies. Moreover, in 2018, a herd of elephants migrated to the reserve from Chhattisgarh, and is now settled within its boundaries. In 2023, a small population of barasingha was translocated in a boma in the core zone with the intention of barasingha population establishment in the long-term (India Today, 2023).

Bengal tiger at Bandhavgarh National Park. By Prabu Kumar (CC BY-SA 4.0, Wikimedia Commons)

Nauradehi Wildlife Sanctuary (NWS):

This wildlife sanctuary, created in 1975 under the Wildlife Protection Act, covers an area of 1197 km^2, making it the largest wildlife sanctuary in Madhya Pradesh. It spreads across Sagar, Damoh and Narsinghpur districts and lies in the Deccan Peninsula biogeographic zone (Rodgers et al. 2000), overlapping with two major river basins of India, namely the Ganges and Narmada.

The vegetation of the area is classified as southern tropical dry deciduous forest with teak being the predominant species. 150 species of birds and 21 species of mammals are reported from this sanctuary. After the reintroduction of tigers in the sanctuary in 2018 from Kanha and Bandhavgarh tiger reserves, the forest department officials spotted two cubs with a tigress in 2021 (Times of India, 2021), and the tiger population has since grown to five individuals within the sanctuary (Qureshi et al. 2023).

NWS, together with Durgavati Wildlife Sanctuary, was recently notified as the Veerangana Durgawati Tiger Reserve (Qureshi et al. 2023). NWS has also been identified as a potential site for reintroducing cheetahs in India (Free Press Journal, 2022; Qureshi et al. 2023)

Striped hyena
(Hyaena hyaena)

2.2 Wildlife utilising the corridor

Jhala et al. (2016) carried out wild mammal surveys in the districts overlapping with the corridor. They reported the presence of grey wolves and sambar in the Katni district, tigers and leopards in Umaria district and nilgai in the Damoh district. Veerangana Durgawati Wildlife Sanctuary, which likely forms an important stepping stone within the corridor, is home to several species of mammals, including leopard, blackbuck, chinkara, nilgai and jackals.

Niyogi et al. (2021) used geospatial information and species presence data to understand habitat connectivity for four wild antelope species - blackbuck, chinkara, nilgai and four-horned antelope *(Tetracerus quadricornis)* - and found that while Nauradehi Wildlife Sanctuary and Veerangana Durgavati Wildlife Sanctuary are well connected, connectivity further towards Bandhavgarh Tiger Reserve needs attention for all four focal species.

The corridor is home to 280 species of birds out of which 80 are migratory species. The critically endangered red-headed vulture, Indian vulture and white-rumped vulture and the endangered Egyptian vulture and steppe eagle are reported from the corridor. Based on the abundance trends and distribution ranges, the State of India's Birds report 2023 identifies 42 high priority birds in this corridor. These high priority species include sarus crane, great thick-knee, great grey shrike, and oriental skylark, among others.

Apart from the mammals and birds, various entomological surveys discovered that the area has five subfamilies of Scarabaeid beetles (Chandra and Gupta, 2011), 24 species distributed among 23 genera and over 9 families belonging to order Hemiptera, usually called as "true bugs" (Chandra et al.,2012), 23 spider species belonging to 12 genera under 7 families (Patil et at., 2013) and 12 species of hawkmoths belonging to 10 genera and 3 subfamilies (Kailash et al., 2013).

Indian vulture
(Gyps indicus)

2.3 Importance for connectivity at a landscape or regional level

BTR on the eastern end of the corridor is functionally connected to Sanjay Tiger Reserve in the east and Kanha and Achanakmar tiger reserves to its south. NWS, which lies at the western end of the corridor, has potential connectivity with Ratapani Wildlife Sanctuary and Panna Tiger Reserve.

Dutta et al. (2016) carried out a study to evaluate the contribution of each wildlife corridor within Central India towards facilitating tiger movement across the landscape. They found the Bandhavgarh-Nauradehi corridor to be of moderate importance for maintaining landscape-level tiger connectivity.

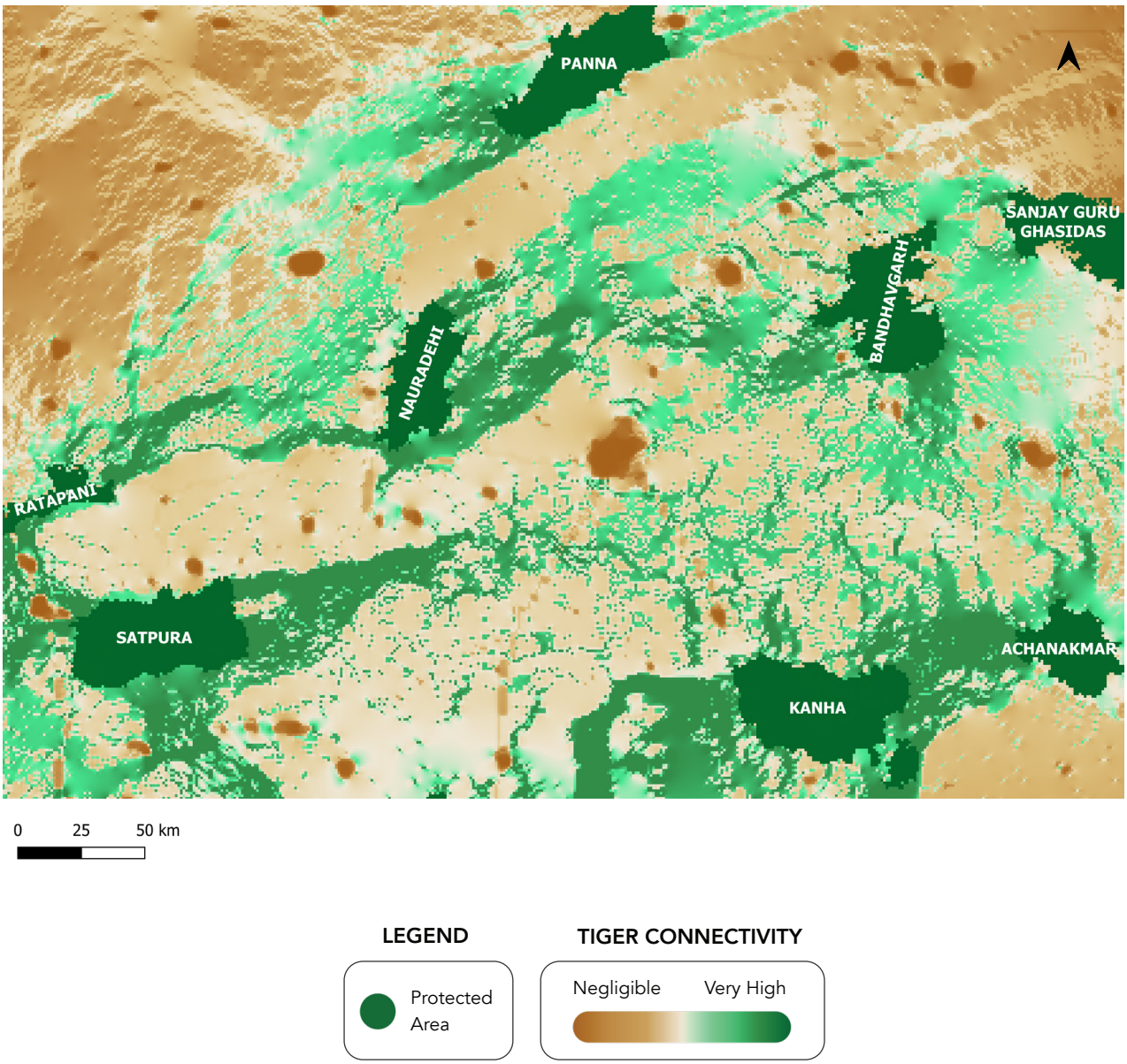


Figure 1: Tiger connectivity in the region around Bandhavgarh-Nauradehi Corridor. Connectivity map was generated using a circuit theory based approach and a base map from Thatte et al., (2018). Green regions depict the areas most likely used by dispersing tigers and the brown regions depict areas that impede movement.

3 Corridor Characteristics

3.1 Boundaries

Delineating the exact boundaries of a corridor is often a challenge. We carried out crude delineation of the corridor boundary using a circuit-theory-based modelling approach (Delineation details included in supplementary information). The corridor boundary encompasses a total area of ~7,075 km^2. Administratively, a major portion of the corridor falls in Katni (~41%), Damoh (~33%), Umaria (~17%) and Jabalpur (~9%) districts, with a small part under Panna and Dindori districts of Madhya Pradesh. Forested parts of the corridor fall under the jurisdiction of Damoh, Katni, and Umaria, with small fragments extending into South Panna and Jabalpur territorial forest divisions in Madhya Pradesh.

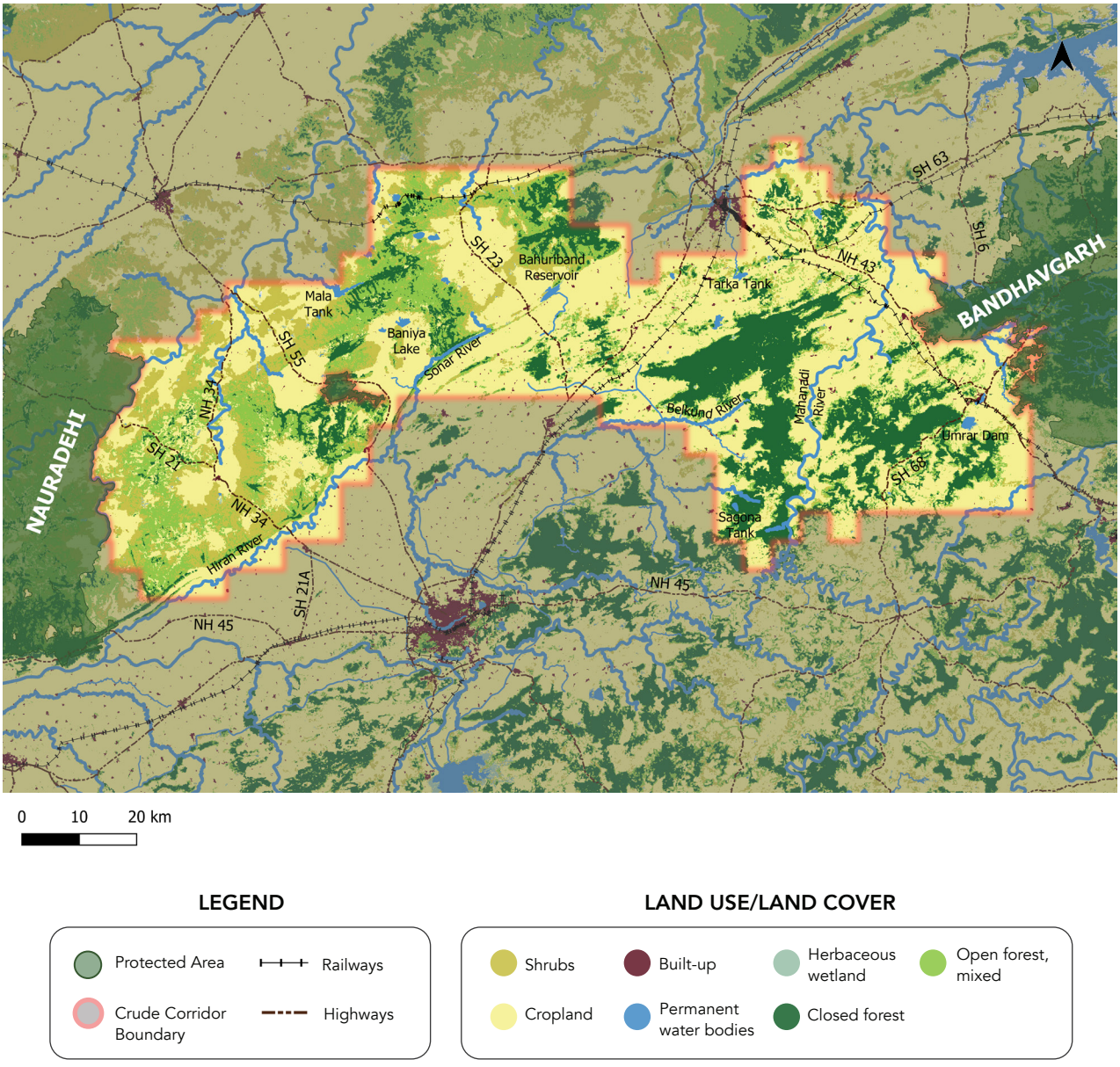


Figure 2: Map showing a crude boundary of the corridor between Bandhavgarh Tiger Reserve and Nauradehi Wildlife Sanctuary along with the river and road network

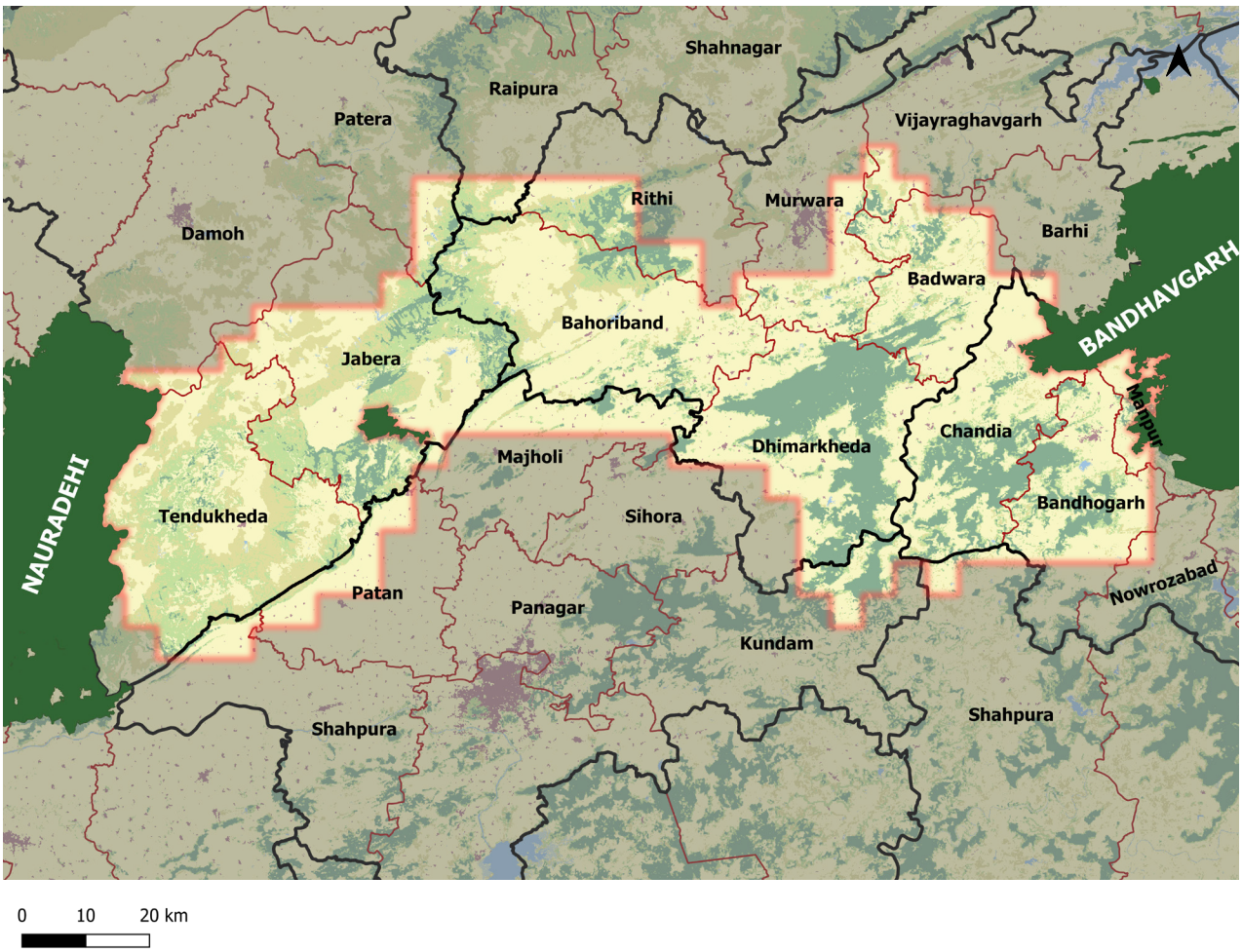


Figure 3: Administrative map representing the districts and tehsils overlapping the Bandhavgarh-Nauradehi Corridor. Damoh, Patera, Jabera and Tendhukheda tehsils are a part of the Damoh district; Patan, Majholi and Sihora are within the Jabalpur district; Bahoriband, Dhimarkheda, Badwara, Barhi, Vijayraghavgarh, Murwara and Rithi tehsils fall within the Katni district; Chandia, Bandhorgarh, Manpur and Nowrozabad tehsil falls within the Umaria district; and Raipura tehsil is a part of the Panna district.

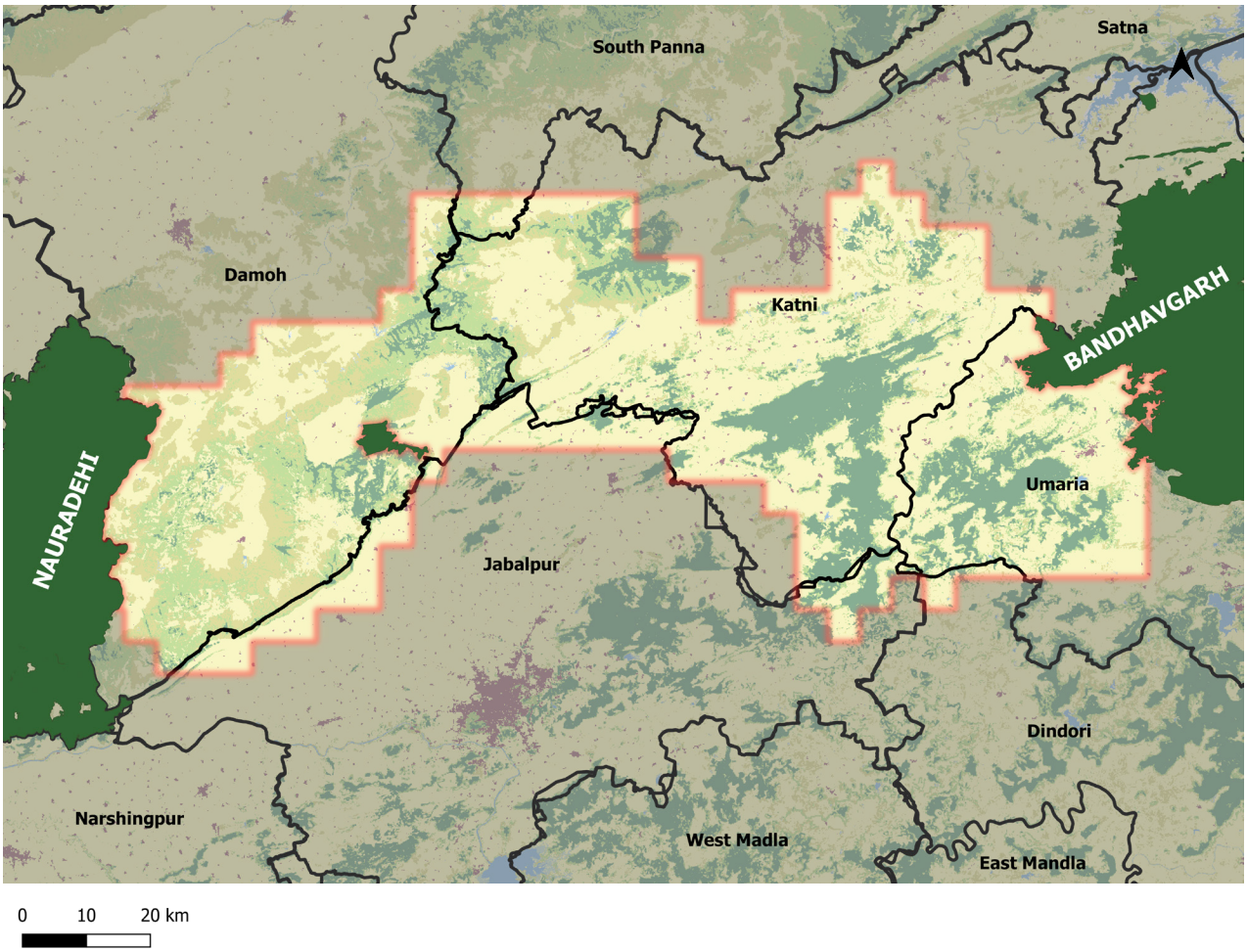


Figure 4: Administrative map representing the territorial forest divisions overlapping the Bandhavgarh-Nauradehi Corridor

3.2 Physical characteristics

A major part of the corridor area overlaps with the plateaus of Rewa and Panna (that fall within the Vindhyan highlands). The Narmada-Sone rift valley overlaps with the eastern end of the corridor which also has outlying spurs of the Vindhya and Satpura ranges. Vegetation in the region is dominated by southern tropical dry deciduous forests with teak being the dominant tree species.

3.3 Hydrology

The corridor overlaps with the upper Narmada and lower Ganga basins, specifically the lower Yamuna and upper Sone river basins within the Ganga basin. The low-lying areas in this corridor are prone to flood in the monsoon season, and the region has an annual average rainfall of 1080 mm (source: IMD data). The two major rivers passing through the corridor are the Hiran river, a big right-bank perennial tributary of the Narmada river, and Mahanadi, a perennial tributary of the Sone river. 50 km of Hiran river is in the corridor, and most of its headwaters fall within the corridor.

The major tributaries of the Hiran river are Sonar river and Belkund river. A major infrastructure in the corridor, the Bahuriband reservoir, is across the Sonar river. 43 km of Mahanadi flows through the corridor, and small tributaries join the river in this region. The headwaters of the Bearma river, a sub-tributary of Yamuna, and Katni river, a tributary of Sone, flow through the corridor. Many other small streams originate from the corridor region. Major water bodies within the corridor include Mala Tank, Baniya Lake, Tarka Tank, Sagona Tank and Umrar Dam.

Proposed in 2017, work commenced on the Satdharu medium tank project in 2020 on the Satdharu river, a tributary of the Bearma river. This project aims at increasing irrigation in the rural areas of Damoh district. It will require diversion of 10 km^2 of forest land, 1.2 km^2 of culturable land, 1.8 km^2 of unculturable land and 0.2 km^2 of revenue land. (Pariwakam, 2018; Projects Today, 2020). The Ghoghari tank irrigation minor project, proposed in the eastern part of the corridor near BTR, requires the diversion of 0.012 km^2 of forested land (Ministry of Environment, Forest and Climate change, 2014; Wildlife Conservation Trust, 2018).

While the construction of tanks and other infrastructure for irrigation continues, this region is already a moderately water-stressed area considering all the previously existing sectoral water-use and surface-groundwater availability (Clark et al., 2016). Based on long-term rainfall data, the State Disaster Management Plan (2012) declared Damoh, Katni, and Umaria as moderately drought-affected districts of Madhya Pradesh.

Great thick-knee
(Esacus recurvirostris)

3.4 Land use within corridor

Open and closed forests cover 17% and 16% of the corridor area, respectively, followed by shrubs and herbaceous vegetation at 13% (Buchhorn et al., 2020). Built-up areas cover 0.4% of the corridor, and permanent water bodies cover another 0.4%. The total length of state and national highways running through the corridor is 342 km, and the total length of railway lines passing through the corridor is 306 km.

With ~53% of the corridor area under cultivation, agriculture is the dominant land use in the corridor. Chickpea (gram), paddy and wheat are the dominant crops grown in the districts overlapping with the corridor. The corridor districts are among the top 20 lentil-growing districts of Madhya Pradesh (Puri et al. n.d.).

~ 53%

Agriculture

~ 46%

of the corridor is covered by natural habitat. This includes open forests (17%), closed forests (16%) and shrubs and herbaceous vegetation (13%).

~ 0.4%

Water bodies and wetlands

160 km

National highways

182 km

State highways

306 km

Railway length

Sal trees in Bandhavgarh National Park
By Ian Duffy (CC BY-NC 2.0, Flickr)

3.5 Critical corridor areas

The following critical area has been identified based on structural connectivity data and a connectivity modelling exercise (Dutta et al., 2018; Nayak et al., 2020). Apart from this specific area (Figure 5), Dutta et al. (2018) have identified several barriers close to NWS and on either side of the boundary of the Katni and Umaria districts in the southeastern portion of the corridor. Finer-scale studies must be conducted to substantiate the barriers and provide feasible solutions. Furthermore, systematic on-ground research is needed across the corridor to understand challenges and identify critical areas.

Critical area 1:

This part of the corridor has highly fragmented forests and several dolomite and marble quarries clustered in space (indiaunderconstruction.com). The Katni-Jabalpur railway line and the NH 30 that runs along it also cut through this area and likely impede wildlife movement (Dutta et al. 2018). Multi-stakeholder cooperation would be necessary in this critical area to ensure the landscape doesn't change further and break the connectivity between the PAs.

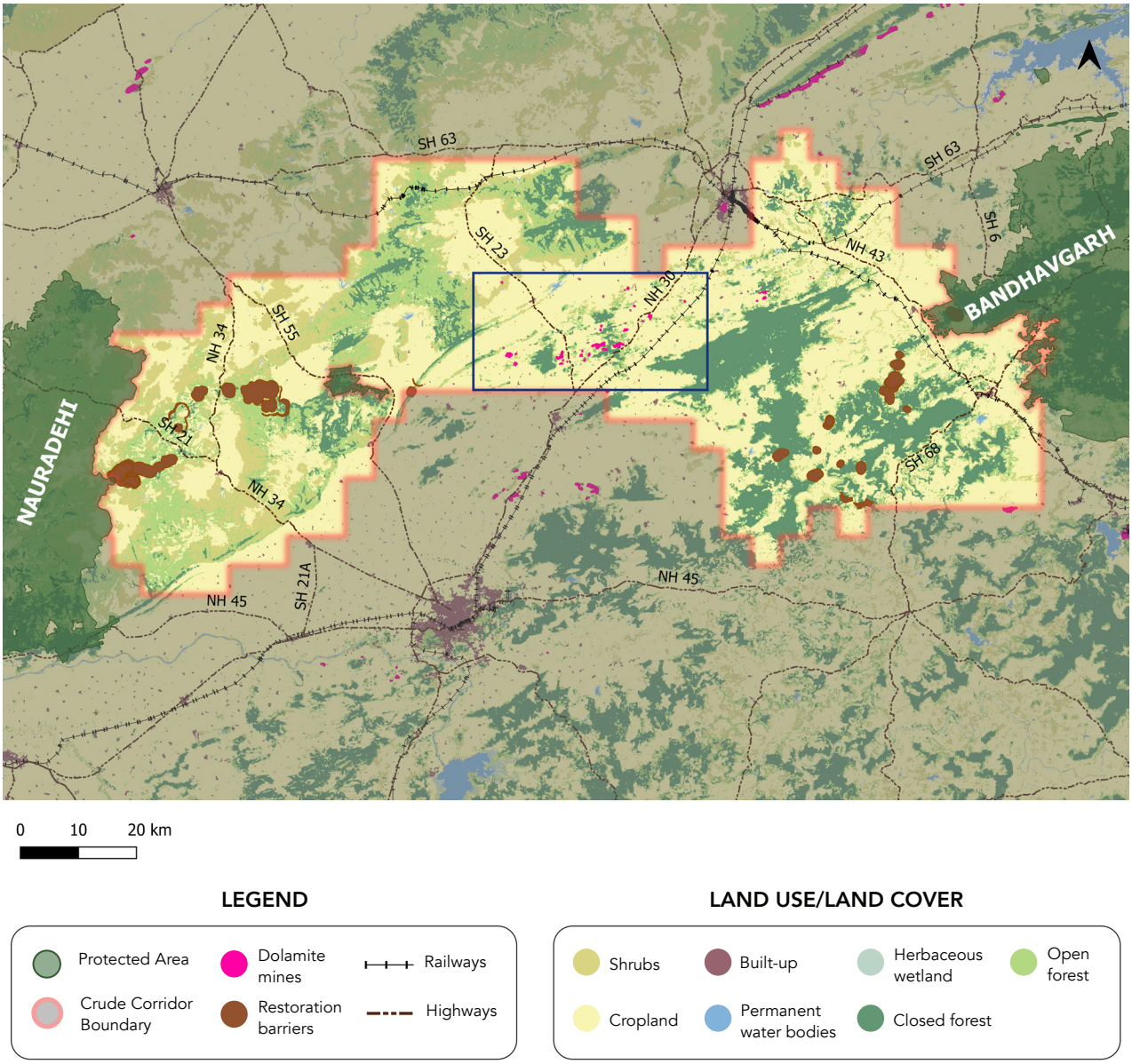


Figure 5: Critical corridor area in the Bandhavgarh-Nauradehi Corridor, as denoted by the black rectangle

4 Stakeholders and Management

4.1 Land tenure, holding and legal status

An area of 24 km^2 within the Bandhavgarh-Nauradehi corridor in the Damoh district of Madhya Pradesh is protected as the Veerangana Durgavati Wildlife Sanctuary, named after Rani Durgavati, a queen of the Gondwana kingdom (Chandra et al., 2012). Apart from the sanctuary, 37% of the land within the corridor is under the ownership of the territorial forest divisions of Madhya Pradesh. Agriculture land is largely privately owned. The land ownership is skewed towards medium and large farmers, who constitute only a third of the farmer families but own 80% of the land in the Damoh district that overlaps with the corridor (IGG, 2020). Similar patterns may be found in the other parts of the corridor, however the data is unavailable.

4.2 Settlements and communities

The average human population density in the corridor is 260 people/km^2, similar to the average population density across the Katni district and higher than the average of Damoh and Umaria districts. Human population density is not uniform throughout the corridor. It is much higher in and around the tehsil headquarters within the corridor and along the stretch of the national highway (NH 30) connecting Katni and Jabalpur towns that bisect the corridor (www.worldpop.org).

There are about 981 villages in the corridor with an average population of 791 people per village. 34% of the total population is tribal, and 12% belongs to the Scheduled Caste category (Census of India, 2011). Gond, Kol, and Bharia Bhumia are the most populous tribes in the region. The region is also home to Saur, Baiga, Bhil and Sonr tribes among others (Census of India, 2011). The major occupation of the people residing in the districts within the corridor, is agriculture and livestock rearing.

Damoh and Katni, districts that constitute a major portion of the corridor, come under the high literacy rate category (70-80%), whereas Umaria district, which covers 16% of the corridor, comes under the moderate literacy rate category (60-70%). According to the MP State Millennium Development Goals[1] (MDG) Report 2014-15, Umaria and Damoh were amongst the worst performing (bottom 10) districts in the overall ranking. According to the Equity analysis report for the state of Madhya Pradesh (Patrick et al., 2018), Damoh was among the districts with the highest neonatal, child and maternal mortality. The same report found that the Umaria district had the highest prevalence of diarrhoea and the lowest percent of households with improved drinking water sources and sanitation facilities. With ~75% of the population below the poverty line, Umaria had the third highest, and with ~59% below the poverty line, Damoh had the eighth highest poverty rate within MP. The poverty goal of the MDGs addressed issues of extreme poverty, hunger and malnutrition, which are closely related to the livelihoods and vulnerability of households.

Natural resource exploitation provides livelihoods for a high proportion of the world's population. Although there are no systematic studies, several people in this corridor likely depend on natural resources for a part of their livelihoods. While we work towards maintaining wildlife use and dispersal through this corridor, we need to understand the development values of biodiversity and landscape management approaches that can deliver both conservation and development benefits. Development values of biodiversity would include

Footnote: [1] The Millennium Development Goals (MDGs) were a manifestation of the Millennium Declaration (2000), an international pledge to create a more tolerant, peaceful and equitable world to be achieved by 2015. In 2015, the 193 countries that make up the United Nations (UN) agreed to adopt the 2030 Agenda for Sustainable Development and set the SDGs, which, in essence, are a continuation of the MDGs.

opportunities for income generation and enterprise development based on the natural resources within the corridor. Natural habitats, biodiversity and ecosystem services are currently at optimal levels in the corridor districts and span a large spatial extent (Srivathsa et al., 2023). Integrating biodiversity and corridor conservation concerns into plans for achieving poverty reduction, health and other development goals – and vice versa – making them mutually reinforcing would be necessary to meet conservation and development goals and targets in the districts overlapping with the corridor. Ensuring a rights-based approach to natural resource management and supporting strengthened local governance and decision-making would be crucial.

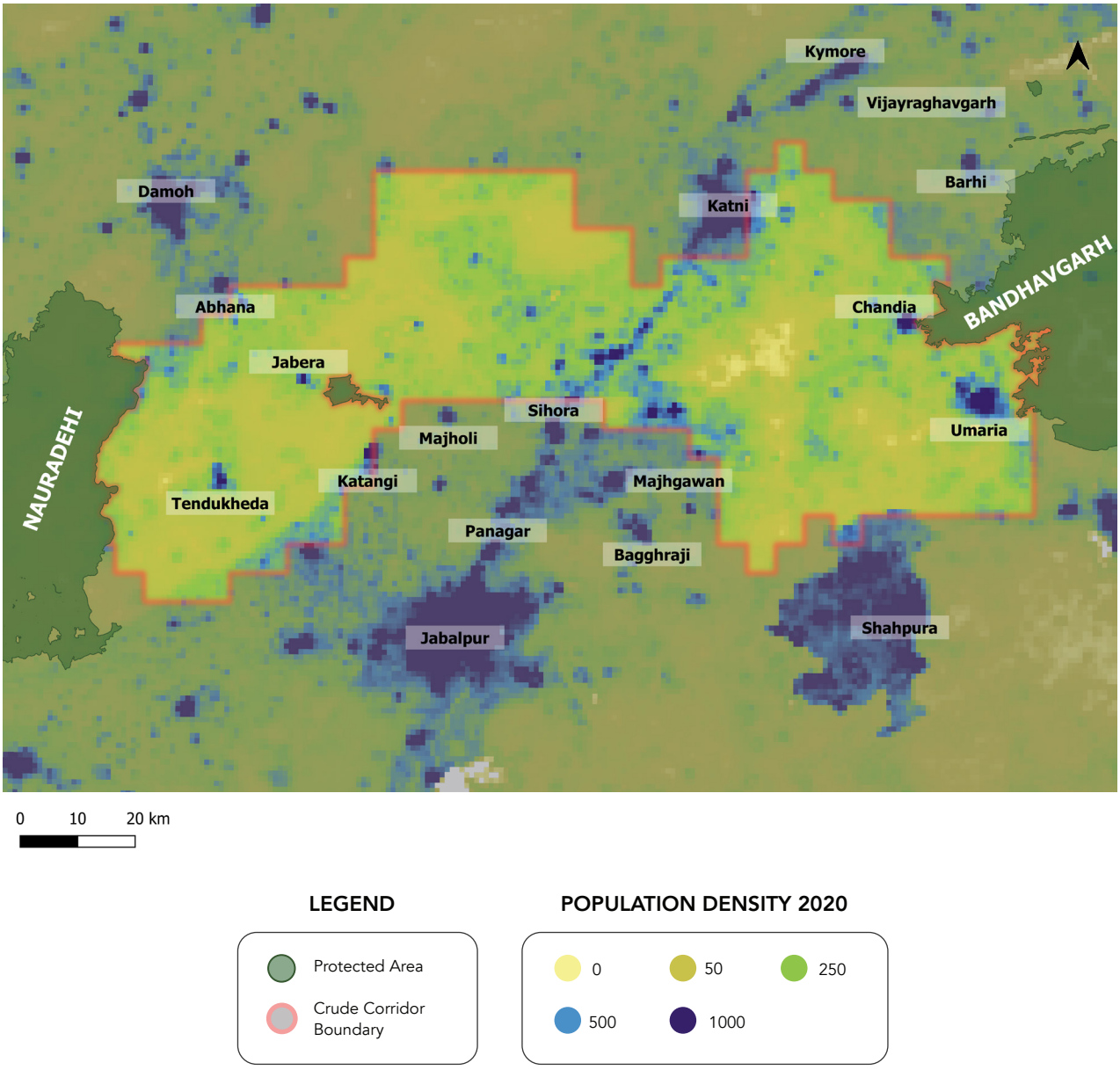


Figure 6: Population density in the Bandhavgarh-Nauradehi Corridor and the surrounding region.

5 Challenges

5.1 Linear infrastructure

Roads:
160 km of national highways (NH30, NH34, NH43) and 182 km of state highways (SH55, SH63, SH68, SH11, SH21 and SH23) criss-cross through the corridor. Apart from the highways, a large network of roads intersects the corridor, connecting villages to urban areas in and around the corridor. Recently, the Katni-Umaria-Shahdol road (NH 43) that passes through the corridor near BTR has been widened, which involved the acquisition of 23.287 ha of forest land and 7.136 ha of forest revenue land (Ministry of Environment, Forest and Climate change, 2015; Forest clearance 2015; Wildlife Conservation Trust, 2018). Although no systematic studies have been done to understand the impact of roads within this corridor, plenty of evidence suggests that roads impede wildlife movement. The two apex predators likely to use this corridor - leopard and tiger - are among the most at risk globally due to road accidents (Quintana et al., 2022). Mitigation measures, like underpasses and overpasses, ensuring animals can cross the roads safely are essential across all major highways passing through this corridor.

Railways:
A network of railways connecting Jabalpur, Katni, Damoh and Umaria passes through the corridor, which measures up to 306 km. Construction of a third rail lane along the currently two-lane Katni-Bilaspur railway line is underway. This railway line cuts the corridor towards its eastern boundary (Wildlife Conservation Trust, 2018) and bisects the Bandhavgarh Kanha corridor. There are several reports of wildlife mortality, including that of a tiger, hyena, wild boar and spotted deer, along this railway line (The Times of India, 2017). Apart from this track, the railway lines connecting Katni to Jabalpur and Damoh also cut through this corridor, however, there is a lack of information on the impact of these lines on wildlife movement.

5.2 Land-use change

Jhala et al. (2016) suggest that crucial forest patches of the Damoh and South Panna territorial forest divisions within the Bandhavgarh-Nauradehi corridor have lost their forest connectivity owing to high fragmentation and human settlements. Land-use change analysis based on LANDSAT post monsoon data reveals that built-up area in the corridor increased 1.5 times between 2008 and 2020. During the same period, scrub forests increased more than 3 times; from just 7% of the corridor area under scrub in 2008, the proportion increased to 23% of the corridor in 2020. Most of this increase was due to conversion of open and dense forests suggesting potential degradation. Understanding the nature and intensity of this potential degradation would need further on-ground verification. Open forests occupied 30% of the corridor area in 2008 and <10% in 2020. Area under agriculture has increased by 23% over the study duration. Almost 85% of the land classified as barren in 2008 has been converted to other landuse types over the study duration. Most of the barren land has been converted into agriculture. Area under dense forest cover saw a small increase.

Oleander hawk-moth
(Daphnis nerii)

5.3 Illegal activities

Recently, a combined team of Katni Police, Forest Department and Wildlife Crime Control Bureau (WCCB) seized 3 kg scales of pangolin, a Schedule-I endangered species in the Badwara area in Katni district, which comes under this corridor (The Hitavada, 2022). A study by the Wildlife Protection Society of India in 2019 highlighted that about 15 leopard deaths were recorded in the Katni forest division due to unnatural reasons, including illegal encroachment on forest land, deforestation, and smuggling of leopard organs (News 18, 2021). There has been a record of 16 wildlife crime (D1) cases from 2016-2020 in the overlapping tehsils of Katni district (data obtained from Madhya Pradesh Forest Department portal), using various methods such as traps, laying an obstacle line, local weapons and vehicular accidents. These records were found for sambar, chital, wild boar, leopard, bear, pangolin and barking deer. In 2012, a tiger died due to electrocution in the Khitouli beat of Badwara forest area of Katni district (Hindustan Times, 2012).

5.4 Climate vulnerability

Environmental Planning and Coordination Organization (EPCO), Bhopal in its study "Madhya Pradesh State Climate Change Vulnerability Assessment," developed a vulnerability profile for all the districts of Madhya Pradesh. The report classified the districts into four categories of projected vulnerability to climate change, viz. Very High, High, Moderate and Low, based on various indicators such as agriculture, economic, climate, health, forest, social and water resources. Katni and Damoh districts were found to have 'high' and Umaria 'very high' vulnerability to climate change (Green India Mission).

Indian pangolin
(Manis crassicaudata)

6 Opportunities and Recommendations

1. An extensive network of railway lines across the corridor and reports of wildlife being hit by trains highlights the need for carrying out systematic surveys within the corridor. Identification of stretches along the railway lines passing through the corridor with a high likelihood of wildlife accidents is a necessary first step for planning mitigation measures to minimise train hits.

2. Damoh district, which overlaps with the western part of the corridor, has been identified as a conservation priority district (Srivathsa et al., 2023) and is also a part of the Aspirational Districts Program[2] of the Government of India. The progress of the aspirational districts is measured across five socio-economic themes- health & nutrition, education, agriculture & water resources, financial inclusion & skill development and infrastructure. However, being a conservation priority district, the administration must also focus on retaining habitats, ecosystem services and biodiversity. The twin goals of biodiversity conservation and sustainable development can be achieved through both state-driven and participatory approaches. As a first step, it would be essential to understand the level of synergy between conservation and development goals at the district level and potential challenges to integrating the two approaches. In parallel, it would be crucial to engage with NITI Aayog[3] to address barriers to integrating conservation concerns into national development (including poverty reduction) frameworks, strategies, and programmes.

[2] Launched in 2018, the Aspirational Districts Programme aims to quickly and effectively transform 112 most under-developed districts across the country.

[3] NITI Aayog (National Institution for Transforming India) serves as the apex public policy think tank of the Government of India. It is committed to cooperative federalism, promotion of citizen engagement, egalitarian access to opportunity, and participative and adaptive governance. It works with the respective line Ministries and various partners to fast-track development in the aspirational districts.

3. The districts overlapping with the corridor are already moderately water-stressed and have been identified as highly vulnerable to climate change. As is the case very often, the communities in this corridor that need more development opportunities are also more exposed to the pressures of global challenges like climate change and likely have a greater dependence on ecosystem services. Further research is needed to understand the impact of predicted climate change on the wildlife, forests, agriculture and livelihoods of the corridor-dwelling communities. Understanding the impact is necessary for devising climate mitigation strategies.

4. Umaria is among the districts selected for implementing activities under the Green India Mission in MP. The activities aim to enhance forest ecosystem services and improve the livelihoods of forest dependent communities (MP Forest Department Green India Mission report). Focusing these activities within the corridor areas of the district would ensure the restoration of degraded forest patches in the corridor and contribute towards the well-being of the corridor dwelling communities.

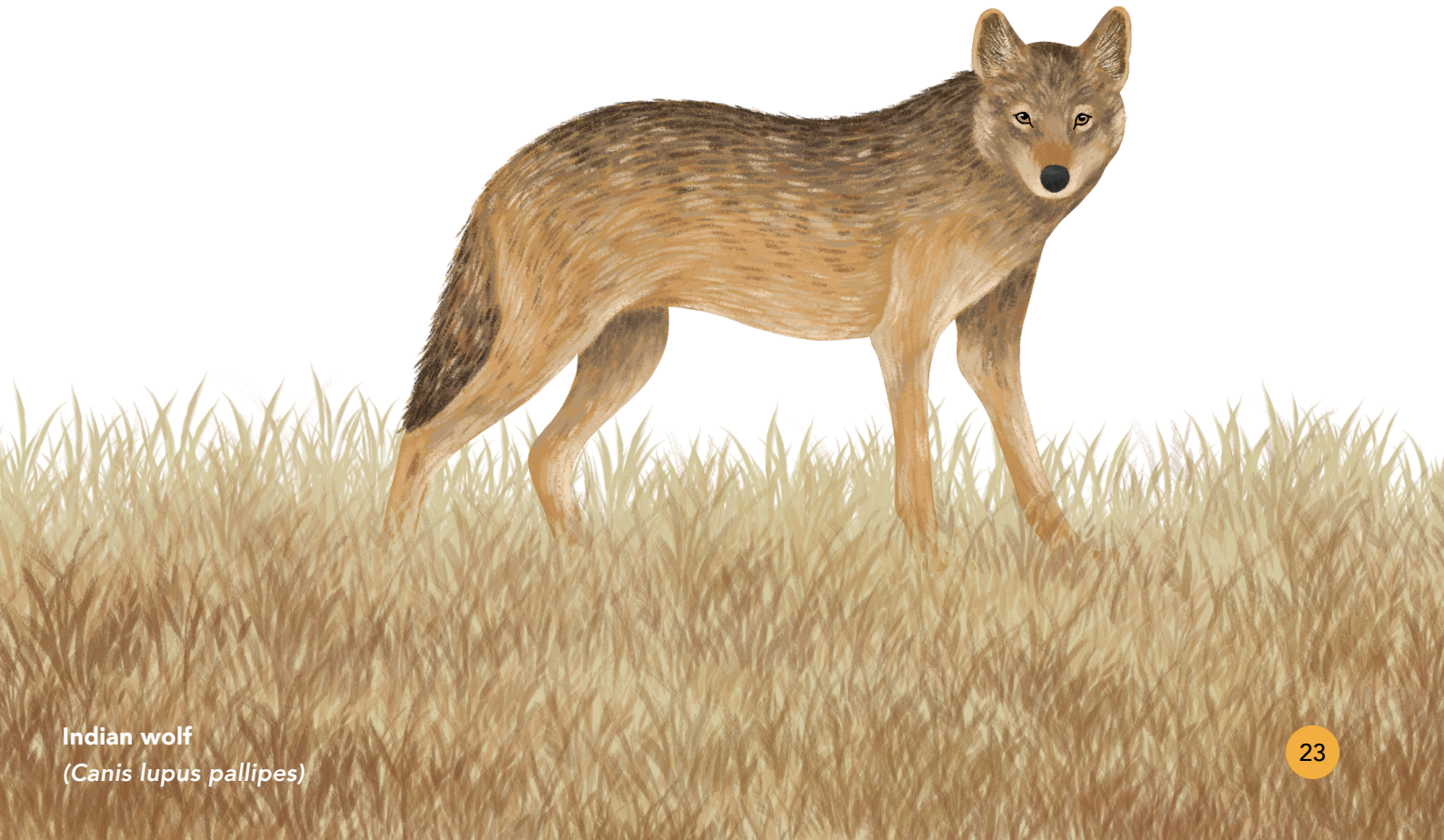
5. The territorial forest division of Umaria that overlaps with the eastern boundary of the Bandhavgarh-Nauradehi corridor is registered as a CAITS (Conservation assured | Tiger standards) site. Conservation Assured (CA) is a conservation tool that aims at setting best practice standards for effective management of tigers (and other target species) and protected areas in accordance with international agreements such as the Convention on Biological Diversity's (CBD) Programme of Work on Protected Areas and aspires to help national governments, and their partners, to meet the CBD's Strategic Plan for Biodiversity conservation. Registered sites must meet the required standards to be accredited as CAITS sites. Since the Umaria Forest Division has been registered as a site, it may be reasonable to expect increased focus and

conservation measures to be taken within the corridor in the upcoming future as it aspires to receive the CAITS accreditation.

6. Districts overlapping with the corridor have high poverty levels, and agriculture is a major occupation of most corridor dwelling communities. Enhancing rural livelihoods through improving farming systems can become a core strategy for both agricultural development and conservation of biodiversity. Focus can be on the identification of local win-win solutions— such as more productive and profitable farming systems, new markets for biodiversity-friendly products, and potentially innovative financing mechanisms such as direct payments to farmers for maintaining ecosystem services— that simultaneously protect biodiversity and maintain critical ecosystem services while reducing poverty.

7. Indian vulture (critically endangered) and Egyptian vulture (endangered) are among the most commonly reported bird species in the corridor. red-headed vultures and white-rumped vultures, both critically endangered, along with Himalayan vultures and griffon vultures are also found in the corridor. Diclofenac, a non-steroidal anti-inflammatory drug (NSAID) for cattle, was banned in 2006 as it causes renal failure in vultures and was responsible for the steep decline in vulture populations. However, the drug is reported to be still available for sale for livestock treatment in India (Galligan et al. 2021). Two additional NSAIDs given to cattle were banned recently- aceclofenac and ketoprofen. Research by Ghosh-Harihar et al. (2023) reveals that the diet of Gyps vultures in central and northern India is dominated by livestock. Hence, effective implementation of the NSAID bans in the corridor and surrounding areas would be critical to work towards reviving vulture populations.

8. As systematic surveys focused on this corridor have not been carried out, we recommend that more research, on ground data collection and monitoring be done to gather detailed information about wildlife habitat use, human-wildlife interactions and threats within the corridor.



Indian wolf
(Canis lupus pallipes)

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Sarus crane
(Antigone antigone)

8 Supplementary Information

Delineation of crude corridor boundary:

A circuit theory-based modelling approach was used to identify the corridor based on resistance surface generated using genetic data (Thatte et al., 2018). The cumulative current output values were classified into ten quantiles, and the top four quantiles were chosen. Corridors were also separately identified based on the same resistance surface using a linkage mapper for comparison. While most of the areas identified by the two approaches overlapped, linkage mapper did not identify some areas known to be used by wildlife. Hence, the two outputs were combined and overlaid with the least-cost-corridor identified in (Qureshi et al., 2014). A 5 km x 5 km grid was overlaid on the combined output and grid cells that overlapped with the identified potential corridor areas were selected and dissolved to get the final boundary represented on the map.

Estimation of principal indicators:

Seven principal indicators, namely area of natural habitat, area under forest department, threatened species richness, average human population, human modification index, landscape complexity index, and natural habitat fragmentation index, were calculated to provide the overall status of the corridor. The method of estimating the value of each indicator is available online at http://corridorcoalition.org/CWC/about.html

Four-horned antelope at Veerangana Durgavati WLS
By Arindam Aditya (CC BY-SA 4.0, Wikimedia Commons)

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