# SAHYADRI-KONKAN CORRIDOR PROFILE

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## SAHYADRI-KONKAN CORRIDOR PROFILE





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## **Corridor Overview**

The Sahyadri-Konkan Corridor is a linear corridor spread north to south across the northern Western Ghats. It connects Sahyadri Tiger Reserve and Radhanagari Wildlife Sanctuary in Maharashtra with Kali Tiger Reserve and Bhimgad Wildlife Sanctuary in Karnataka as well as four protected areas in Goa, viz. Mollem National Park and Mhadei, Netravali, and Cotigao wildlife sanctuaries. The corridor spans across a large area of ~10,785 km<sup>2</sup>, which supports wide-ranging species such as dhole (*Cuon alpinus*), leopard (*Panthera pardus*),



Threatened species richnes Medium 39 species/km<sup>2</sup>

Average human population Medium 169 persons/km<sup>2</sup>



Human modification index Medium 0.44



Natural habitat fragmentation index Medium 0.62



Landscape complexity index Medium 0.82



Area of natural habitat High 86%



Area under forest department



Land use change index ------- gaur (Bos gaurus), sloth bear (Melursus ursinus), and tiger (Panthera tigris). Though it supports large carnivores, their density in the corridor area is relatively low. Further, connectivity in this corridor is affected by landscape-level threats such as bauxite mining and linear infrastructure. Moreover, this corridor has a significant percentage of area under private forests, which are at risk of arbitrary land-use change. Persistence of mammal species within the corridor area requires maintenance of functional connectivity.

Habitat connected: Sahyadri TR, Radhanagari WLS, Mhadei WLS, Mollem NP, Netravali WLS, Cotigao WLS, Kali TR Area of corridor: 10,785 km<sup>2</sup> Focal species: Tiger, dhole, sloth bear, and gaur Major threats: Land-use change, bauxite mining,

commercial plantation, and linear infrastructure CWC members: Wildlife Conservation Trust



\*The indicators and the quantitative description in the corridor profile have been calculated using a crude corridor boundary. Section 8 provides the details about boundary delineation and principle indicators.

# **1** Corridor Significance

## 1.1 Importance of core habitats connected

#### Sahyadri Tiger Reserve:

Notified in 2010, Sahyadri Tiger Reserve (TR) spreads across Satara, Sangli, Kolhapur, and Ratnagiri districts of Maharashtra, India. It covers a total area of about 1,166 km<sup>2</sup> (core area of 600.12 km<sup>2</sup>) and includes Koyna Wildlife Sanctuary (WLS) and Chandoli National Park and their buffer zones. It forms the northern range limit for the distribution of tigers in the Western Ghats (Bawa et al., 2007). However, it has no viable tiger population, and all evidence suggests the presence of male tigers that have dispersed from connected forests further south. The 2018 census reported 3 tigers and 40 leopards within the tiger landscape (Jhala et al., 2020; 2021). The TR also houses the endemic brown palm civet (Paradoxurus jerdoni), and vulnerable mammal species, such as gaur (Bos gaurus), sloth bear (Melursus ursinus), and four-horned antelope (Tetracerus quadricornis) (Shameer et al., 2021). A total of 151 bird species have been reported from the Chandoli National Park, including endemic species such as the Malabar grey hornbill, Nilgiri wood pigeon, blue-winged parakeet, white-bellied blue flycatcher, Malabar barbet, yellow-browed bulbul, greyfronted green pigeon, Sahyadri sunbird,

and crimson-backed sunbird (Ramchandra, 2013).

#### Radhanagari Wildlife Sanctuary:

Radhanagari WLS is situated in the Kolhapur district at the southern side of the Sahyadri range in Maharashtra, India. Situated about 60 km south of Sahyadri TR, it spreads across an area of 351.16 km<sup>2</sup> and includes two large water reservoirs. It was established in 1958 as the Dajipur WLS and was reconstituted as the Radhanagari WLS in 1985 by including a larger area of the surrounding forest. This sanctuary is home to 47 species of mammals, 58 species of reptiles, 20 species of amphibians, and 66 species of butterflies (Sangale, 2022). The gaur is the flagship species of the region. In addition, the occurrence of 284 bird species (resident and migratory) has been reported, which includes the rare Nilgiri wood pigeon, great pied hornbill, Malabar pied hornbill, yellow-browed bulbul, and Ceylon frogmouth (Sangale, 2022).

#### Wildlife Sanctuaries of Goa:

A nearly linear cluster of four protected areas (PAs) is situated along the Goa-Karnataka border; these include Mhadei WLS (208.48 km<sup>2</sup>), Bhagwan Mahavir WLS Park) (240 km<sup>2</sup>), Netravali WLS (2011.05 km<sup>2</sup>), and Cotigao WLS (85.65 km<sup>2</sup>), in order from north to south. Bhagwan Mahavir WLS—formerly, the Mollem Game Sanctuary—was declared as a WLS in 1969, and its core area was designated as the Mollem National Park in 1978. The famous "Dudhsagar Falls" is located on the Mandovi River within this WI S. The forest cover of these PAs is classified as tropical evergreen, semi-evergreen, moist deciduous, or Indian subtropical hill savannah woodland (Champion and Seth, 1968). The dominant vegetation in this region includes oil nut, nutmeg, bandicoot berry, Indian rosewood, wild guava, dhaman, Indian thorny bamboo, and Calamus (Gad and Shyama, 2009). Some of the prominent faunal species found in the PAs of Goa include tiger, leopard, barking deer, mouse deer, spotted deer, gaur, sambar, pangolin, slender loris, bonnet macaque, common langur, civet cat, flying squirrel, and giant squirrel (Jadhav and Pati, 2012). The bird species found here include ruby-throated yellow bulbul, Malabar parakeet, Nilgiri wood-pigeon, Malabar grey hornbill, Crimson-backed sunbird, emerald dove, Malabar pied hornbill, three-toed kingfisher, among others. In addition, reptiles such as the king cobra, common krait, and Indian cobra, as well as endemic amphibians such as Malabar gliding frog, Maharashtra bush frog, and marbled ramanella, and Beddome's Indian frog are also found in these PAs (Jadhav and Pati, 2012).

#### Kali Tiger Reserve:

Kali TR is situated in the Uttar Kannada district of Karnataka and comprises two contiguous PAs, Anshi National Park and Dandeli WLS (both were notified in 1987). It spans across an area of 1345.71 km<sup>2</sup>, of which 814.88 km<sup>2</sup> forms the core. The vegetation types in Kali TR include south Indian moist deciduous teak forests, southern moist mixed deciduous forests, west coast semi-evergreen forests, moist bamboo brakes, and cane brakes. Kali TR supports populations of various mammals, including tiger, leopard, sloth bear, dhole, chital, muntjac, four-horned antelope, wild pig, sambhar, and mouse deer (Jhala et al., 2020). Dandeli WLS also houses the endangered Asiatic elephant, and Dandeli Elephant Reserve (under Project Elephant)—with the sanctuary as its core—was notified in 2015. Kali TR was notified in 2007 and supports a resident population of 4 tigers and 114 leopards (Jhala et al. 2020; 2021).



## 1.2 Wildlife utilising the corridor

The corridor supports a rich assemblage of sympatric wide-ranging species, including tiger, sloth bear, leopard, and dhole (Punjabi and Kulkarni, 2015). However, the occupancy of tigers in the corridor is low, which can likely be attributed to high resistance to their movement and low prey base (Johnsingh et al., 2010, Punjabi and Kulkarni, 2015). Similarly, probability of occupancy of sloth bears in the corridor between Chandoli National Park and Radhanagari WLS is extremely low, suggesting that the sub-population of sloth bears in Sahyadri TR is likely isolated from those in the PAs lying towards the southern end of the corridor (Punjabi and Kulkarni, 2015). In contrast, the corridor forms a contiguous habitat block for leopards and dholes, which have high probability of occupancy between the PAs (Jhala et al., 2020; Punjabi and Kulkarni, 2015).

In addition to the large carnivores, other species that have been reported from the corridor include sambar, gaur, wild pig, Indian chevrotain, Indian crested porcupine, Indian hare, muntjac, chital, striped-neck mongoose, and smallclawed otter (Punjabi et al. 2014, Punjabi and Rao 2017, Rege et al., 2020). Moreover, Asiatic elephants have been occasionally reported from Sindhudurg and Kolhapur districts in the southern end of the corridor, especially along the forest-plantation-farmland mosaic (Baskaran 2013; Mehta and Kulkarni, 2013). Interestingly, the range of Asiatic elephants-which traditionally did not include Maharashtra and Goahas extended further north after the movement of an elephant herd from Karnataka to Belgaum Forest Division of Maharashtra in 2001 (Baskaran, 2013; Mehta and Kulkarni, 2013).



## 1.3 Importance for connectivity at a landscape or regional level

In 2020, camera trap images from Kali TR revealed the presence of a male tiger that was first photo-captured in Sahyadri TR in 2018, thereby suggesting the viability of movement of large carnivores in the corridor (Jelil et al. 2020). However, Sahyadri TR does not have a viable population of tigers, and the Sahyadri-Konkan Corridor forms the only route for potential recolonization of tigers from Kali TR in Karnataka. Connectivity at a landscape level is crucial for large carnivores to persist in this corridor and to recolonize the Sahyadri TR.



## 1.4 Recognized biodiversity conservation sites within the corridor

The Sahyadri-Konkan Corridor is a part of the Western Ghats, which was identified as a UNESCO World Heritage Site in 2012 (UNESCO World Heritage Convention). The Western Ghats, along with Sri Lanka, are also identified as one of 34 global biodiversity hotspots for conservation.

Additionally, the corridor connects twelve Important Bird Areas (IBAs), which include Chandoli National Park, Koyna and Radhanagari wildlife sanctuaries, and Amboli-Tillari Reserve Forest (declared as Conservation Reserves in 2020-21) in Maharashtra; Bhagwan Mahavir, Netravali, Cotigao, Bondla, and Mhadei wildlife sanctuaries in Goa; and Dandeli National Park, Anshi WLS, and Bhimgad WLS in Karnataka. Of these, one IBA—Amboli-Tillari Reserve Forest—is situated within the corridor. In addition, the Sahyadri-Konkan Corridor houses a rich cluster of sacred groves. The Sindhudurg and Ratnagiri districts have the highest number of sacred groves or Devrais in Maharashtra (about 1500 and 830, respectively) (www.ncbi.org. in/sacredgrooves). At a local scale, the religious beliefs and sanctity of Devrais play an important role in biodiversity conservation using community engagement (Khan et al., 2008).

## **2** Corridor Characteristics



### .1 Boundaries

It can be challenging to delineate rigid boundaries to wildlife corridors. Here, we used a slightly modified boundary of the Sahyadri-Konkan corridor, which was previously delineated by the Critical Ecosystem Partnership Fund (Bawa et al., 2007). We carried out a crude delineation of the corridor boundary using a circuit theory-based modelling approach. More details about the delineation of the corridor boundary are included in the Supplementary Information (Section 8).

The crude corridor boundary of the corridor extends from Maharashtra to Goa and Karnataka. The corridor covers an area of ~10,785 km<sup>2</sup>, of which approximately 67% is spread across five districts of Maharashtra (Kolhapur, Satara, Sangli, Sindhudurg, and Ratnagiri), whereas 21% and 11% lie in the districts of Karnataka (Belagavi and Uttar) and Goa (North and South Goa), respectively.

Figure 1 shows the delineated corridor boundary along with railway, highway, and river network within the corridor area. This figure also shows the conservation reserves (indicated using different colours and numbers) that were recently notified within the Sahyadri-Konkan Corridor area.



Figure 1: Sahyadri-Konkan corridor delineated by a crude boundary. The figure also depicts rail, road, and river network and the conservation reserves (CR). 1: Vishalgadh CR; 2: Panhalgadh CR; 3: Dodamarg-Amboli CR; 4: Chandgadh CR



Figure 2. Map showing the administrative units (districts and tehsils) across the Sahyadri-Konkan Corridor

### 2.2 Physical characteristics

As suggested by the name, the Sahyadri-Konkan Corridor constitutes montane habitat of the Sahyadri hills along with small areas of the Konkan region towards the west. Though the corridor covers a large area, it is narrower than 1 km in a few places. The vegetation in the corridor primarily comprises tropical moist deciduous and tropical semi-evergreen forests (Champion and Seth, 1968). The main species found here include Terminalia paniculata, Memecylon umbellatum, Syzygium spp., Olea diocea, Actinodaphne hookeri, Tectona grandis, Terminalia tomentosa, Delbergia latifolia, Adina cardifolia, and Madhuca indica. The composition and structure of these forests vary widely as we move along the length of the corridor. Furthermore, the corridor area is also punctuated with lateritic plateaus, montane grasslands, bamboo brakes, and riparian forests (Champion and Seth, 1968). Laterite rock outcrops are spread across the northern western ghats and Konkan region, especially in Satara, Kolhapur, and Ratnagiri districts (Jog et al., 2002; Watve, 2003). Though these rocky plateaus can be confused as barren wastelands, studies have revealed that they are associated with high floral endemism, and a few new species have been recorded from these rocky plateaus (Lekhak and Yadav, 2012; Watve, 2007).

### 2.3 Hydrology

The ranges of the Western Ghats, which run almost parallel to the western coast of India, separate the drainage system of the corridor into east and west flanks. The eastern side of the corridor lies in the Krishna basin, whereas the western side spans across the basins of several west-flowing tropical rivers between Tapi to Tadri (68% of the corridor area) (India WRIS). The key tributaries of Krishna river that pass through the corridor include Koyna, Varna, Panchaganga, Wainganga, Hirayankeshi, Ghatprabha, and Malprabha. The west flowing rivers in the corridor include Vashishti, Shastri, Kajli, Machkandi, Kodavil, Vanhatan, Sav, Gad, Karli, Terekhol, Chapora, Mahadayi, Zuari, Talpona, and Kalinadi. The corridor boundary encompasses headwaters (source) of several of these river systems, and the forests within the corridor support the critical hydrological functions of these rivers. In addition, several water resource infrastructure have been constructed across the river networks that lie within the corridor. Some major dams include Koyna and Warna dams in the northern part (in Maharashtra), Kalammawadi and Radhanagari dams in the central part (in Maharashtra), and the Supa dam in the southern part of the corridor (in Karnataka) (Table 1). Areas within the corridor show variations in precipitation, with annual rainfall ranging from 1464 mm to 3564 mm across regions.

S No.	Name of Dam	River
1	Supa Dam	Kali
2	Koyna Dam	Koyna
3	Warna/Chandoli Dam	Waarna
4	Kalammawadi Dam	Doodhganga
5	Radhanagri Dam	Bhogwati
6	Gagan Bawda Dam	Kumbha
7	Tulashi Dam	Tulashi
8	Bomanahalli Dam	Kali
9	Patgaon Dam	Ved Ganga
10	Gelawade Dam	Kasari
11	Kadave Dam	Kadave
12	Tillari Dam	Tillari
13	Lakhmapur Dam	Kumbha

Table 1: Some of the major dams within the Sahyadri-Konkan Corridor



## 2.4 Land use within the corridor

Though Sahyadri-Konkan corridor has a high percentage of forest cover (84.2%), private forests form a large part of this cover, especially in Maharashtra (Kulkarni and Mehta, 2013). In terms of canopy density classes, the corridor area under closed and open forests is 60.6% and 23.6%, respectively. Shrub and herbaceous vegetation constitute 2% of the corridor area, whereas builtup area occupies 0.2%.

This corridor has several sites that are rich in bauxite and iron ores, and hence, mining has developed as an important economic activity. About 11.4% of the corridor area is occupied by agriculture, with paddy as the chief kharif crop. Some paddy farmers across the Konkan region adopt an ancient practice known as rabing, which includes burning of land to prepare the nursery bed for growing seedlings (Dahiphale et al., 2020). Other crops grown in the region include sugarcane, cereals (such as maize, finger millet, pearl millet, prosomillet, and sorghum), and oilseed crops (primarily, groundnut) as well as horticultural crops like cashew, mango, and rubber (Data for corresponding districts from International Crops Research Institute for the Semi-Arid Tropics).



Of the corridor is covered by natural habitat. This includes open forests (~60%), closed forests (~24%) and shrubs and herbaceous vegetation (~2%).



Of railway line intersects the corridor.



Of the corridor area is covered by permanent water bodies, including reservoirs

An extensive network of roadways exists within the corridor and includes national (~365 km) and state (~587 km) highways, and small roads connecting villages.

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## 2.5 Critical corridor areas



Figure 3: Critical areas within the Sahyadri-Konkan corridor identified using data from Punjabi and Kulkarni (2015) Critical areas within the corridor were identified by Punjabi and Kulkarni (2015) using Circuitscape, which utilizes resistance and current flow to investigate the functional connectivity of different species (McRae et al., 2008; McRae and Shah, 2011). The critical areas were identified as regions that have high movement of animals but limited connectivity, which makes these areas highly susceptible to fragmentation. Boxes in Figure 3 show the critical areas in this corridor.

### Box 1:

The area between Sahyadri TR and Radhanagari WLS has been identified as a critical area for the movement of sloth bears and leopards. It is important for maintaining contiguity of Chandoli National Park with the areas further south. The conservation of forest areas around Ambaghat, which extends till Vishalgad, is essential for ensuring connectivity (Edgaonkar, 2014). This area has high to very high human modification, as seen in Figure 3, which can likely be one of the reasons for high resistance of the landscape to the movement of tigers and dholes.

#### Box 2:

This area is a part of Dodamarg-Chandgad reserve forests (declared as Tillari Conservation Reserve and Chandgad Conservation Reserve, respectively) and has been reported as critical for all four landscape species found in the corridor, namely tiger, dholes, sloth bears, and leopards (Punjabi and Kulkarni, 2015). It constitutes a part of the only contiguous forest patches that link forests of Western Ghats in Karnataka to those in Maharashtra. Moreover, it can be a potential corridor for elephants (Edgaonkar, 2014); however, further studies and regular monitoring would be required to establish its role in elephant movement.

## **3** Stakeholders and Management

### 3.1 Land tenure and holding

The PAs of the corridor are structurally connected with each other via forests or plantations. In Maharashtra, the reserved forests within the corridor are managed by the Maharashtra Forest Department. However, a substantial percentage of the corridor area in Maharashtra is privately-owned, which makes these areas vulnerable to landuse changes (Kulkarni and Mehta, 2013). These private forests face serious threats from unsustainable practices, such as clear-felling of trees at short-rotation cycles and rabing (Kulkarni and Mehta, 2013). Ratnagiri district has the largest area under private forests, whereas Sindhudurg district has the largest area under evergreen private forests (Kulkarni and Mehta, 2013). The large area under private forests underlines the importance of community participation in the conservation of Sahyadri-Konkan corridor.

## 3.2 Settlements and communities

The population density of the corridor area is 169 persons/km<sup>2</sup>. About 8.31% and 2.38% of the total population of the tehsils overlapping with the corridor area belong to the scheduled caste and scheduled tribes, respectively (Census of India, 2011). Literate population comprise 74.16% of the total population of the overlapping tehsils, with 80.20% of all males and 68.13% of all females being literate (Census of India, 2011). About 45% of the total population includes the working population or population involved in paid work (Census of India, 2011). Agriculture is the primary profession of people in the tehsils. Majority of the working population (>80%) comprise "main workers" (i.e., they work for at least 183 days in a year for economic productivity), of which majority work as cultivators or agricultural labourers (Census of India, 2011).





Figure 4. Population density in the Sahyadri-Konkan Corridor and surrounding areas

## 3.3 Legal status

In 2020, an area of 250.66 km<sup>2</sup> around Radhanagari WLS was notified as an eco-sensitive zone (The Indian Express, 2020). In the same year, the Government of Maharashtra declared 29.53 km<sup>2</sup> of Dodamarg forest ranges in Sindhudurg district as Tillari Conservation Reserve (Deshpande, 2020). This is an important decision for conservation of the corridor as the forests of Dodamarg have been threatened by iron and bauxite mining. Furthermore, the Government of Maharashtra declared seven more conservation reserves that lie within the corridor, out of which four were notified in 2021, viz. Amboli-Dodamarg in Sindhudurg district and Vishalgad, Panhalgadh, and Chandgad (Kulkarni, 2022). These new conservation reserves will make Sahyadri-Konkan Corridor as one of the few regions in the country where the entire corridor is under some form of protection. Figure 1 shows the indicative boundaries of the four conservations reserves that have been notified.

# **4** Challenges

## 4.1 Infrastructure as a barrier to movement

#### Mining:

The corridor lies in the principal bauxite-bearing belt of Maharashtra, which includes Kolhapur and Ratnagiri districts (Directorate of Geology and Mining, Government of Maharashtra). Though they are now closed, two large open cast bauxite mines were located in Kolhapur in close proximity to PAs—Udgiri mine bordered Chandoli National Park, whereas Durgamanwadi mine was active in the area adjoining Radhanagari WLS. Further, several bauxite mines, including Girgaon, Burambal, and Dhangarwadi mines, are located in the corridor area between these two PAs (Lad and Samant, 2012). There is a grave threat from proposed bauxite mines in Shahuwadi area of Kolhapur district and iron ore mines in Sawantwadi area of Sindhudurg district. If allowed, these will further constrict the already fragmented corridor.

### Roads:

A dense network of 8 national highways (~365 km) and 29 state highways (~587 km), in addition to several rural roads, intersect the corridor. Most of these highways intersect the entire width of the corridor from east to west, thereby fragmenting the landscape into forest patches.

#### Railways:

The total length of all railway tracks that cross through the corridor is ~187 km. A railway track dissects the entire width of the corridor from east to west between Mollem National Park and Kali TR. Several animal casualties due to collisions with trains have been reported in this region (Punjabi et al., 2021). A railway project, part of which falls within the corridor, has received clearance for expansion of the rail tracks between Hospet in Karnataka and Vasco port in Goa. In addition, construction of a 168km railway line received environmental clearance between Hubbali and Ankola in Karnataka (Rao, 2017). The major area of this project falls within the Kali TR, which houses the source population of tigers in this corridor.

### Wind Farms:

The corridor is a suitable site for wind farms owing to its topographical features, such as table-top plateaus, absence of vegetation, and proximity to the coast. Vankusawade Wind Park (situated within the Koyana National Park) with a total capacity of 259 MW is one of the three prominent wind parks in Maharashtra (Kumar et al., 2022). Few smaller wind farms are located within the corridor, including those at Kas and Humabre (Maharashtra Energy Development Agency, 2018). The annual bird fatality rate at a wind farm outside the corridor, located 5 km away from Chandoli National Park, is 1.9/ turbine (Pande et al., 2013). Wind farms in Chalkewadi plateau—a greater part of which lies within the corridor—have cascading effects through trophic levels as they reduce the abundance of predatory birds, which consequently increases the density of lizards (Thaker et al., 2018).

#### **Power Lines:**

A total of 26 substations are situated within the corridor, including 9 substations that are located within the PAs. The total length of transmission lines (110 kV or above) that crisscross the corridor landscape is ~576 km, including 140 km of high voltage power lines (400 kV). Power transmission infrastructure, including substations and power lines, can negatively affect the surrounding wildlife during the construction as well as operational phases (Bagli et al., 2011). al., 2011). The Chief Wildlife Warden of Maharashtra has called for an action plan, which includes digitizing maps of 11kV lines and phasing out overhead feeders for areas up to 2 km from the tiger reserves (Pinjarkar, 2022).

## 4.2 Human-wildlife conflict

The cases of human-wildlife conflict are escalating in the corridor, especially in Kolhapur district (Gayakwad and Dighe, 2021; United Nations Development Programme, 2022). There are numerous reports of crop raiding by gaur in the farms around Radhanagari WLS. Dense sugarcane plantations in Kolhapur and Satara districts have increased human-leopard and humangaur conflicts during the harvest period (Jain, 2019; Gayakwad, 2021). Crop-raiding by elephants have also been reported along forestagriculture fringes in Kolhapur and Sindhudurg districts (Patil and Patil, 2019). To mitigate their losses, farmers in the region use several crop protection methods including the use of firecrackers and drums, night vigilance, solar/electric fencing, and even trenches (Patil and Patil, 2017). To avoid further increase in manelephant conflict, the Kolhapur Forest Department has proposed to use radio collars to locate elephants (Gayakwad, 2021).

## 4.3 Land-use change over time

The Sahyadri-Konkan Corridor faces threats of land-use change due to

several factors, including the conversion of forest areas into monoculture plantations. A recent study from the Sawantadi–Dodamarg region of the corridor reported that statesponsored subsidies between the 1980s and 1990s influenced the expansion of land under the cultivar cashew as well as conversion of land from paddy cultivation and privately owned forest to cashew plantations (Rege and Lee, 2022). In the same study, Rege and Lee (2022) interviewed cashew farmers and found that they avoided applying for government-sponsored compensation in case of crop losses due to wildlife depredation; instead, they chose to expand cultivar cashew into forested areas to overcome the losses. A preliminary study has reported that some mammal species, such as Indian crested porcupine, sambar, and wild pig use cashew plantations for movements,

but further research is warranted to assess how such plantations affect animal movement in this landscape (Rege, 2020). Rubber and pineapple plantations have also increased in the corridor. Until 1990s, rubber plantations were confined to Goa, but they have now moved to the Konkan region, especially Sindhudurg, owing to comparatively low land and labour costs (Venkatesan R, 2018). In addition to expansion of plantation, mining activities around Mollem, Kulem, Malpaon in Goa and agricultural expansion around Chandgad in Maharashtra also pose a risk due to land-use change. In response to a

Lok Sabha query, the Minister of Mines, Steel and Labour & Employment revealed that 27 environmental clearances were granted by the Ministry of Environment, Forest, and Climate Change for bauxite mining projects in Maharashtra between 2006–2014 (Illegal Mining of Bauxite, 2014).

Western Ghats, in general, have witnessed a loss of forested area in the last decade, which has also been associated with secondary issues, such as the rapid spread of Kyasanur Forest disease in Western Ghats including the region corresponding to the Sahyadri-Konkan Corridor (Walsh et al., 2019).



## 4.4 Illegal activities

Several cases of illegal bauxite mining have been reported from the corridor area in Maharashtra (Chatterjee, 2018). In addition to illegal mining, various irregularities with respect to mining, such as submission of fraudulent Environmental Impact Assessment reports and absence of clearances, have been reported (Western Ghat Ecology Expert Panel Report, 2011). For example, Durgmanwadi mines continued mining operations within 1 km from Radhanagari Wildlife Sanctuary without obtaining wildlife clearance from National Board for Wildlife for nearly a decade; the mining activities

were stopped after a show-cause notice was issued by the Supreme Court in 2018 (Thomas, 2018; Chatterjee, 2018). In the same year, the Supreme Court also banned iron ore mining in Goa and canceled all mining ore leases that were renewed by the state government (Banerjee, 2018). In addition to rampant mining activities, illegal wildlife trade and rising demand for several wildlife species—especially pangolins—have also affected animal populations in the corridor. In 2015, 44 kg. of pangolin scales were seized near Chiplun (which lies at the western border of the Sahyadri–Konkan corridor) in Maharashtra (Unwalla and Singh, 2020).



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## **5** Recommendations and Opportunities

- **1.** Radhanagari WLS can be notified as a satellite core of Sahyadri TR. As the occupancy of tigers and sloth bears is low in the areas between these two PAs (Punjabi and Kulkarni, 2015), notifying Radhanagari WLS as satellite core can help ensure connectivity in this region.
- 2. To avoid degradation of private forests and ensure their sustainable management, financial incentives can be provided to landowners via schemes such as payment for ecosystem services (PES). A similar "Community Nature Conservancy" model has been successfully implemented by the Tadoba-Andhari TR management. Under this model, the landowners of private land can be compensated for not cultivating or damaging the private forest every year. Such PES schemes can ensure successful management of private land for wildlife conservation using direct community engagement.
- **3.** Camera trap images have revealed that the Ajra–Budhargah forest range (~246.63 km<sup>2</sup>) in Kolhapur district of Maharashtra supports rich biodiversity of wildlife (Punjabi and Kulkarni, 2015).

Though this area has been proposed as a conservation reserve, it has not been declared or notified yet. To ensure connectivity and protection, the entire area of this conservation reserve can be notified as a WLS. This would help provide legal protection to the corridor area.

**4.** The Western Ghats run parallel to the west coast of India, and hence, new linear infrastructure projects can be aligned along the hill ranges, i.e., in the north-south direction to reduce the fragmentation of the forested area in the corridor (Nayak et al., 2020). These infrastructure projects can be bundled together to reduce the impact of individual projects (Nayak et al., 2020). Furthermore, as the road and rail networks in the Sahyadri-Konkan corridor are vulnerable to upgradation and expansion, it is essential to identify and implement mitigation strategies for all future expansions in order to prevent detrimental impacts on wildlife connectivity and population viability, especially in the critical areas.

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# **6** Current Conservation Activities

#### Wildlife Conservation Trust (WCT):

WCT is involved in carrying out population estimation surveys and monitoring of animal movement by using camera traps and GIS. Their study sites include not only the protected areas, but also the Sahyadri-Konkan Corridor.

#### Sahyadri Nisarga Mitra:

Founded in 1992, the Sahyadri Nisarga Mitra is an organization based out of Chiplun, Ratnagiri district, Maharashtra. It has been involved in identifying and resolving local environmental problems as well as in carrying out population estimation surveys. In addition, they have undertaken long-term projects for vulture conservation, marine turtle conservation, and alternate livelihood options for locals.

#### Vanashakti:

This is a non-profit environmental non-governmental organization based in Mumbai, Maharashtra. It aims to address issues of environmental conservation using "education, awareness and litigation." Over the years, it has used litigation to protect the area between Sawantwadi and Dodamarg in the Sahyadri-Konkan Corridor.

## Wildlife Research and Conservation Society (WRCS):

Through the Sahyadri Corridor Project, WRCS was involved in identifying critical linkages in the corridor area that are vital for ensuring connectivity for large carnivores in the Sahyadri-Konkan corridor.



# 7 Bibliography

## 7.1 Literature

1. Bawa, K.S., Das, A., Krishnaswamy, J., Karanth, K.U., Kumar, N.S., Rao, M., 2007. Ecosystem Profile: Western Ghats & Sri Lanka Biodiversity Hotspot, Critical Ecosystem Partnership Fund.

2. Jhala, Y.V., Qureshi, Q., Nayak, A.K., 2020. Status of tigers, co-predators, and prey in India, 2018. National Tiger Conservation Authority, Government of India, New Delhi and Wildlife Institute of India, Dehradun.

3. Jhala, Y.V., Qureshi, Q., Yadav, S.P., 2021. Status of leopards, co-predators, and herbivores in India, 2018. National Tiger Conservation Authority, Government of India (New Delhi) and Wildlife Institute of India, Dehradun.

4. Shameer, T.T., Backer, S.J., Yogesh, J., Mujawar, A.N., Ali, S.Z., Raman, S., Kaushal, K.K., Reddy, S.R., Sanil, R., 2021. Phenotypic variations, habitat suitability, and diel activity of the endemic brown palm civets. Geol. Ecol. Landsc., 1–12. https://doi.org/10. 1080/24749508.2021.1971411

5. Gad, S.D., Shyama, S.K., 2009. Studies on the food and feeding habits of Gaur Bos taurus H. Smith (Mammalia: Artiodactyla: Bovidae) in two protected areas of Goa. J. Threat. Taxa 1, 128–130 https://doi.org/10.11609/JoTT.o1589.128-30

6. Punjabi, G.A., Kulkarni, J., 2015. Examining large carnivore connectivity and creating conservation networks in the Sahyadri-Konkan corridor. Critical Ecosystem Partnership Fund and Ashoka Trust for Research in Ecology and the Environment (CEPF-ATREE).

7. Johnsingh, A.J.T., Pandav, B., Madhusudan, M.D., 2010. Status and conservation of tigers in the Indian subcontinent, in: Tilson, R., Nyhus, P.J. (Eds.) Nyhus, Tigers of the World (Second Edition). William Andrew Applied Science Publishers, pp. 315-330. https://doi.org/10.1016/B978-0-8155-1570-8.00024-4

8. Punjabi, G.A., Borker, A.S., Mhetar, F., Joshi, D., Kulkarni, R., Alave, S.K., Rao, M.K., 2014. Recent records of Stripe-necked Mongoose Herpestes vitticollis and Asian Smallclawed Otter Aonyx cinereus from the north Western Ghats, India. Small Carniv. Conserv. 51, 51–55. 9. Punjabi, G.A., Rao, M.K., 2017. Large herbivore populations outside protected areas in the human-dominated Western Ghats, India. Mamm. Biol. 87, 27–35. https://doi.org/10.1016/j.mambio.2017.05.004 10.
Rege, A., Punjabi, G.A., Jathanna, D., Kumar, A., 2020. Mammals make use of cashew plantations in a mixed forest–cashew landscape. Front. Environ. Sci. 8, 556942. doi: https://doi.org/10.3389/fenvs.2020.556942

11. Rege, A., Lee, J.S.H., 2022. State-led agricultural subsidies drive monoculture cultivar cashew expansion in northern Western Ghats, India. PLoS ONE 17, e0269092. https://doi.org/10.1371/journal.pone.0269092

12. Sangale, S.B., 2022. Radhanagari Wildlife Sanctuary: A Geo-Environmental and Biodiversity Study. Bhumi Publishing, Kolhapur.

13. Ramchandra, A.M., 2013. Diversity and richness of bird species in newly formed habitats of Chandoli National Park in Western Ghats, Maharashtra State, India. Biodivers. J. 4, 2013, 235–242

14. Jadhav, S., Pati, S.K., 2012. Fauna of Protected Areas of Goa. Edited by Director, Zoological Survey of India, Kolkata.

15. Census of India, 2011. Provisional Population Totals, Paper 1 of 2011 India, Series-1. New Delhi: Office of the Registrar General and Census Commissioner.

16. Ministry of Mines (Government of India), 2014. Illegal Mining of Bauxite. Available at: https://mines.gov.in/writereaddata/UploadFile/NO93\_ILLEGAL\_MINING\_OF\_BAUXITE. pdf (Accessed February 22, 2023).

17. Mehta, P., Kulkarni, J., 2013. Past, present and future of wild elephants in Maharashtra, India. Gajah 39, 3–11.

18. Jelil, S.N., Gaykar, A., Girkar, N., Vyas, V., Ben, V.C., Ramesh, K., 2020. Recent record of tiger from Sahaydri Tiger Reserve, India. CATnews 71, 16–17

19. Khan, M.L., Khumbongmayum, A.D., Tripathi, R.S., 2008. The sacred groves and their significance in conserving biodiversity: an overview. Int. J. Ecol. Environ. Sci. 34, 277–291.

20. Qureshi, Q., Saini, S., Basu, P., Gopal, R., Raza, R., Jhala, J., 2014. Connecting Tiger Populations for Long Term Conservation. National Tiger Conservation Authority and Wildlife Institute of India, Dehradun.

21. Champion, H.G., Seth, S.K., 1968. A revised survey of the forest types of India. Manager of Publications, 1968.

22. Watve, A., 2003. Vegetation on rock outcrops in northern Western Ghats and Konkan region, Maharasthra. Geobios 30, 41–46. 23. Jog, S.R., Wakhare, A., Chaudhuri, S., Unde, M., Pardeshi, S.D., 2002. Maharashtra landscape: A perspective, in: Diddee, J., Jog, S.R., Kale, V.S., Datye, V.S. (eds.). Geography of Maharashtra. Rawat Publications, Jaipur & New Delhi, pp. 19–57.

24. Watve, A., 2007. Plant communities on rock outcrops in Northern Western Ghats. Report submitted to Department of Science and Technology. Agharkar Research Institute, Pune.

25. Lekhak, M.M., Yadav, S.R., 2012. Herbaceous vegetation of threatened high altitude lateritic plateau ecosystems of Western Ghats, southwestern Maharashtra, India. Rheedea 22, 39–61.

26. Kulkarni, J., Mehta, P., 2013. A Study of Status, Distribution and Dynamics of Private and Community Forests in Sahyadri-Konkan Corridor of Maharashtra Western Ghats. Technical Report submitted to CEPF-ATREE. Wildlife Research and Conservation Society, Pune.

27. Dahiphale, A.V., Bhagat, S.B., Mhaskar, N.V., Jondhale, D.G., Bedse, T.J., Vanve, P.B., 2020. Rabing: A traditional skill of rice nursery management in tribal area of North Konkan coastal zone of Maharashtra. J. Pharmacogn. Phytochem. 9, 435–437.

28. McRae, B.H., Dickson, B. G., Keitt, T.H., & Shah, V.B., 2008. Using circuit theory to model connectivity in ecology, evolution, and conservation. Ecology, 89, 2712–2724.

29. Shah, V.B., McRae, B.H., 2008. Circuitscape: A tool for landscape ecology. In Proceedings of the 7th Python in Science Conference Vol. 7, pp. 62–66. Pasadena, California: SciPy.

30. Edgaonkar, A., 2014. Ecological and anthropogenic correlates of large carnivore occupancy in the Sahyadri-Konkan corridor. Technical Report submitted to Critical Ecosystem Partnership Fund (CEPF).

31. Lad, R.J., Samant, J.S., 2012. Studies on the impact of bauxite mining activities on environment in Kolhapur district. In Proceeding of International Conference SWRDM pp. 188–192.

32. Punjabi, G., Jayadevan, A., Jamalabad, A., Velho, N., Niphadkar-Bandekar, M., Baidya, P., Jambhekar, R. Rangnekar, P., Dharwadkar, O., Lopez, R., Rodrigues, M., 2020. On the inadequacy of environment impact assessments for projects in Bhagwan Mahavir Wildlife Sanctuary and National Park of Goa, India: A peer review. J. Threat. Taxa 12, 17387–17454. https://doi.org/10.11609/jot.6650.12.18.17387-17454 33. McRae, B.H., Dickson, B. G., Keitt, T.H., & Shah, V.B., 2008. Using circuit theory to model connectivity in ecology, evolution, and conservation. Ecology, 89, 2712–2724.

34. Shah, V.B., McRae, B.H., 2008. Circuitscape: A tool for landscape ecology. In Proceedings of the 7th Python in Science Conference Vol. 7, pp. 62–66. Pasadena, California: SciPy.

35. Edgaonkar, A., 2014. Ecological and anthropogenic correlates of large carnivore occupancy in the Sahyadri-Konkan corridor. Technical Report submitted to Critical Ecosystem Partnership Fund (CEPF).

36. Lad, R.J., Samant, J.S., 2012. Studies on the impact of bauxite mining activities on environment in Kolhapur district. In Proceeding of International Conference SWRDM pp. 188–192.

37. Punjabi, G., Jayadevan, A., Jamalabad, A., Velho, N., Niphadkar-Bandekar, M.,
Baidya, P., Jambhekar, R. Rangnekar, P., Dharwadkar, O., Lopez, R., Rodrigues, M., 2020.
On the inadequacy of environment impact assessments for projects in Bhagwan Mahavir
Wildlife Sanctuary and National Park of Goa, India: A peer review. J. Threat. Taxa 12,
17387–17454. https://doi.org/10.11609/jot.6650.12.18.17387-17454Patil, M.D., Vinayak,
K., 2017. Farmers' perceptions about elephant crop raiding in Sindhudurg District,
Maharashtra, India. Gajah 47, 4–9.

38. Walsh, M.G., Mor, S.M., Maity, H., Hossain, S., 2019. Forest loss shapes the landscape suitability of Kyasanur Forest disease in the biodiversity hotspots of the Western Ghats, India. Int. J. Epidemiol., 1804–1814.

39. Gadgil, M., 2011. Western Ghats Ecology Expert Panel. Ministry of Environment and Forest, Government of India.

40. Nayak, R., Karanth, K.K., Dutta, T., Defries, R., Karanth, K.U., Vaidyanathan, S., 2020. Bits and pieces: Forest fragmentation by linear intrusions in India. Land Use Policy 99, 104619. https://doi.org/10.1016/j.landusepol.2020.104619

### 7.2 News Articles

- Banerjee, S., 2018. SC cancels mining leases in Goa, slams state government, environment ministry for favouring miners. Down to Earth. February 7, 2018. Available at: https://www.downtoearth.org.in/news/mining/sc-cancels-miningin-iron-ore-leases-in-goa-sets-aside-hc-order-which-allowed-renewal-of-mininglicenses-59648
- Chatterjee, B., 2018. Take action against mining units without clearances on Western Ghats, Centre tells Maharashtra. Hindustan Times. February 10, 2018. Available at: https://www.hindustantimes.com/mumbai-news/take-action-againstmining-units-without-clearances-on-western-ghats-centre-tells-maharashtra/storyfDTFvYsW4ml1j4iwXEO8fM.html
- 3. Deshpande, A., 2020. State notifies Tillari forest as conservation reserve. The Hindu. June 24, 2020. Available at: https://www.thehindu.com/news/states/state-notifiestillari-forest-as-conservation-reserve/article31901758.ece
- 4. Gayakwad, R., 2021. Radio collars proposed for tuskers in Kolhapur. The Times of India. December 22, 2021. Available at: https://timesofindia.indiatimes.com/city/ kolhapur/radio-collars-proposed-for-tuskers-in-kolhapur/articleshow/88418497.cms
- Gayakwad, R., Dighe, S., 2021. As bison count rises, more animals stray near cities, say experts. The Times of India. December 19, 2021. Available at: http://timesofindia.indiatimes.com/articleshow/88363378.cms?utm\_ source=contentofinterest&utm\_medium=text&utm\_campaign=cppst
- Kulkarni, D., 2022. Maharashtra gets 18 new conservation reserves. Hindustan Times. September 22, 2022. Available at: https://www.hindustantimes.com/cities/ mumbai-news/maharashtra-gets-18-new-conservation-reserves-101663786177484. html
- Pinjarkar V, 2022. PCCF seeks action plan to curb electrocution. The Times of India. February 9, 2022. Available at: https://timesofindia.indiatimes.com/city/nagpur/ pccf-seeks-action-plan-to-curb-electrocution/articleshow/89438445.cms

- 8. Rao, M.M., 2017. Hubballi-Ankola railway project moves ahead, environmental concerns remain. The Hindu. July 11, 2017. Available at: https://www.thehindu. com/news/national/karnataka/hubballiankola-railway-project-clears-first-environmental-hurdle/article19259475.ece
- The Indian Express, 2020. Environment ministry declares 250 sq km area around Radhanagri wildlife sanctuary as eco-sensitive zone. The Indian Express. October 23, 2020. Available at: https://indianexpress.com/article/cities/mumbai/ maharashtra-environment-ministry-declares-250-sq-km-area-around-radhanagriwildlife-sanctuary-as-eco-sensitive-zone-6842668/
- Thomas, A., 2018. Supreme Court orders shutdown of Hindalco Maharashtra units with no wildlife clearance. DNA India. October 26, 2018. Available at: https:// www.dnaindia.com/business/report-supreme-court-orders-shutdown-of-hindalcomaharashtra-units-with-no-wildlife-clearance-2679419#:~:text=YOU%20MAY%20 LIKE%20TO%20READ&text=In%20a%20big%20blow%20to,sanctuary%20 without%20any%20wildlife%20clearance
- United Nations Development Programme, 2022. Buffaloed by the climate in Kolhapur. United Nations Development Programme. Accessed July 5, 2022. Available at: https://www.undp.org/india/buffaloed-climate-kolhapur
- 12. Unwalla, Z., Singh, A., 2020. Pangolins in Peril. Sanctuary Asia, Vol. 40, April 2020. Available at: https://sanctuarynaturefoundation.org/article/pangolins-in-peril.
- Venkatesan, R, 2018. For Kerala's rubber planters, the grass is greener in Sindhudurg. The Hindu Businessline. January 8, 2018. Available at: https://www. thehindubusinessline.com/economy/agri-business/for-keralas-rubber-plantersthe-grass-is-greener-in-sindhudurg/article9828723.ece

# 8 Supplementary Information

## Delineation of the crude corridor boundary:

A crude boundary of the corridor was identified by Critical Ecosystem Partnership Fund (2007) by analyzing the distribution of key biodiversity areas (such as PAs, reserved areas, or community lands), existing and potential connectivity of suitable habitat, movement of landscape species (such as tigers and elephants), and topography. We slightly modified this boundary to include the corridor identified using the least cost path algorithm by Qureshi et al. (2014) and areas with moderate to high probability of occurrence of dholes and tigers identified by Punjabi et al. (2017). Finally, the potential corridor areas were identified, and the corresponding grid cells were merged to get the final crude boundary.

#### 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.htm









COALITION FOR WILDLIFE CORRIDORS The Coalition for Wildlife Corridors is a collaborative network of people and organizations working to advance connectivity conservation in India.

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