

The Role of Ecological Corridors in Sustaining Biodiversity in India

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Abstract

India is acknowledged as a mega-diverse country nonetheless, the country's biodiversity is facing rising threats as a result of habitat fragmentation brought on by urbanization, the expansion of infrastructure, and the intensification of agricultural practices. Ecological corridors have evolved as an important conservation technique to combat these issues. They achieve this by re-establishing habitats that have been separated from one another and by allowing animals to move freely across landscapes that have been fragmented. By facilitating gene flow, seasonal movement, dispersal, and access to resources, these corridors contribute to an increase in population viability and ecological resilience hence boosting ecological resilience. There are corridors in India that link protected places like the Kanha Tiger Reserve and the Pench Tiger Reserve, as well as Kaziranga National Park and the Karbi Anglong Hills. These corridors highlight the significance of these protected areas in maintaining populations of tigers, elephants, rhinos, and several other types of wildlife. However, despite the biological relevance of corridors, they are subject to pressures from changes in land use, conflicts between humans and wildlife, and gaps in policy. For the purpose of preserving connection, it is vital to strengthen landscape-level planning, integrate infrastructure that is beneficial to wildlife, and encourage community participation. Therefore, ecological corridors are an extremely important factor in ensuring the preservation of biodiversity over the long run and maintaining ecological balance in India.

Keywords: Ecological Corridors, Biodiversity Conservation, Wildlife Connectivity, Habitat Fragmentation, Landscape Ecology, Protected Areas, Wildlife Migration, Gene Flow, Human–Wildlife Conflict, Ecosystem Resilience, Conservation Planning, Sustainable Development, Forest Corridors, Climate Change Adaptation, India.

Introduction

In India, ecological corridors are crucial, small strips of habitat that connect larger, fragmented forest sections. They ensure the exchange of genetic material, the safe movement of species, and the resilience of the ecosystem for future generations. By doing so, they prevent "islands" of biodiversity and reduce the habitat isolation that is produced by existing infrastructure. In India, many corridors do not have clear legislative protection, which creates significant needs for conservation. This is despite the fact that corridors are essential for animals such as elephants and tigers. There are a wide variety of ecosystems that can be found in India, ranging from the Himalayas and Western Ghats to deserts and mangrove forests. India is considered to be one of the most diverse countries in the world. These natural habitats, however, have become

progressively fragmented as a result of growing urbanization, the development of infrastructure, and the extension of agricultural land. This has resulted in the isolation of wildlife populations and poses a threat to the survival of many species. It is becoming increasingly apparent that ecological corridors are an essential conservation technique that can be utilized to preserve biodiversity and ecological resilience in the face of such challenges. In their most basic form, ecological corridors are parts of the landscape that connect habitat areas that would otherwise be separated from one another. This allows for the free movement of species, the flow of genes, and the continuity of ecological processes across locations. Natural corridors, such as riparian strips and forested landscapes, or human-assisted corridors, such as overpasses, underpasses, or linear rewilded strips beside infrastructure, are examples of corridors that can reduce the isolating impacts of human activities. As a result of the potential that ecological connectedness provides for the mobility of organisms, the flow of genes, and range shifts, it is an essential component in the long-term sustainability of populations, particularly for wild species. In landscapes that are dominated by humans, the loss of habitats and the alteration of their configuration have significantly altered and diminished connectedness, which has resulted in isolation. This isolation inhibits the ability of populations to adjust appropriately to shifts in their environment. Interconnectedness exists across the world's ecosystem. It is not good enough to build protected habitats that are isolated, such as islands that are enclosed by highways, fences, farmlands, cities, and other such things. This is something that ecologists have learnt when they have studied the species that they are attempting to conserve. The majority of organisms have not developed in this manner. In order for these ecosystems to fully blossom alive and be healthy enough to endure over the long term, they need to be connected to other habitats throughout the world through wildlife corridors. Increasingly, wildlife corridors are becoming increasingly relevant as essential instruments for the conservation of wildlife. These corridors are utilized by a variety of species for migration, breeding, and feeding purposes. Widespread habitat fragmentation and isolation have been brought about as a consequence of the rapid expansion in industrial and infrastructure development, particularly in the environment around forests.

Understanding Ecological Corridors

An ecological corridor, also known as a wildlife corridor, is not merely a path of habitat; rather, it is a functional connection between two or more key habitat areas that enables animals to move freely, feed, reproduce, and disperse across greater landscapes. However, modern conservation viewpoints increasingly recognize that any contiguous permeable landscape, including agro-forest mosaics, wetlands, riverbanks, and grasslands, can function as effective corridors if they allow unfettered movement of animals. This is in contrast to the traditional perception of corridors as narrow strips of forest.

The landscape context determines how corridors are classified:

- **Upland corridors:** Geographical features that are elevated, such as mountain ranges, that connect different habitats.
- **Lowland corridors:** Plains ecosystems are connected by riverine systems, floodplains, and drainage networks connected to the plains.

- **Anthropogenic corridors:** Environmentally friendly bridges, underpasses, and wildlife crossings are examples of engineered solutions that make it possible to travel around obstacles caused by infrastructure.

There are ecological corridors in India that are vital, protected, or semi-natural habitat strips that connect scattered forests. These corridors allow for the mobility of wildlife, the interchange of genetic material, and the reduction of conflict between humans and wildlife. There are almost 150 known elephant corridors and 32 identified tiger corridors, indicating that they are extremely important for species such as elephants and tigers. For the purpose of preserving biodiversity in the face of growing infrastructure, these corridors, which can range from riparian to landscape-scale, are absolutely necessary.

Importance of Ecological Corridors

1. **Mitigating Habitat Fragmentation:** The fragmentation of ecosystems is one of the most significant dangers to biodiversity. Animal migrations are restricted, populations decrease, and species become more susceptible to extinction when broad ecosystems are fragmented into isolated pieces by highways, farms, or settlements. This makes the ecosystems more susceptible to extinction. It is possible to overcome these gaps with the help of well-designed corridors, which reconnect populations that have been separated and increase the permeability of the terrain for animals.
2. **Facilitating Gene Flow and Genetic Diversity:** Small wildlife groups that are isolated from one another are more likely to experience inbreeding and genetic bottlenecks, which in turn reduces their resistance to illnesses and environmental stress. A essential necessity for the long-term survival of species is the maintenance of genetic diversity, which can be achieved by the interchange of genes across populations that are connected by corridors.
3. **Supporting Seasonal Migration and Life Cycle Needs:** A great number of animals, such as elephants, ungulates, and birds, engage in seasonal migrations for the purpose of foraging, breeding, or reacting to the effects of climate change. These naturally occurring movements are made possible by corridors, which in turn reduces mortality and increases survival rates. The Aravalli Range, which is located in Western India and is considered a vital ecological corridor, plays a significant role in facilitating migrations at the landscape level and connecting a number of different protected areas in India.
4. **Enhancing Ecosystem Services:** Corridors help with more than just the passage of animals; they also help with other ecological activities.:
 - The process of pollination and seed dissemination by animals that are mobile.
 - The transfer of nutrients between different ecosystems!
 - Support for keystone and umbrella species whose conservation has ripple impacts on other species.
 - By establishing interconnected riparian and forest networks, water security and erosion control can be achieved.

Ecological Corridors in India: Examples and Significance

There are a number of highly significant wildlife corridors in India, which have been acknowledged for their contribution to the preservation of biodiversity:

1. **Kaziranga–Karbi Anglong Corridor (Assam):** This makes it possible for animals such as rhinos and elephants to relocate to higher land during floods, which ensures their survival under particularly severe weather conditions.
2. **Kanha–Pench Corridor (Madhya Pradesh–Maharashtra):** There is a connection between two major tiger reserves, which ensures the movement of tigers and reduces inbreeding, both of which are essential for the maintenance of large carnivore populations.
3. **Periyar–Agasthyamalai Corridor (Kerala–Tamil Nadu):** Essential for the survival of Asian elephants and other species in the Western Ghats, the Western Ghats not only maintain biodiversity but also ensure the safety of the local water supply.
4. **Rajaji–Corbett and Ranthambhore–Kuno-Madhav Corridors:** The movement of large species, including as elephants, leopards, and ungulates, across protected areas is made easier by these, despite the fact that they are subject to pressure from human activities and infrastructure.

Challenges to Corridor Conservation

The creation and maintenance of ecological corridors in India encounter a number of obstacles, despite the fact that they are extremely important:

1. **Land-Use Change and Development Pressure:** Important connecting zones are frequently severed as a result of infrastructure (roads, trains), agricultural practices, and urban expansion. In the absence of thorough planning, corridors become fragmented, which reduces the efficiency of the corridors.
2. **Human-Wildlife Conflict:** Corridors frequently overlap with human landscapes, which can result in conflicts. This is especially true in regions where huge creatures like as elephants or tigers migrate through agricultural fields or villages. It is possible that local support for corridor protection may decrease if crop loss and safety concerns continue to escalate.
3. **Policy and Planning Gaps:** The preservation of corridors necessitates planning at the landscape level, going beyond the scope of discrete protected areas. In India, the practice of incorporating the requirements of corridors into regional development programs and the planning of infrastructure is still in the process of developing.
4. **Biological Limitations:** Because corridors can sometimes make it easier for invasive species or illnesses to spread, they can have unforeseen consequences for the environment. Because of this, they need to be constructed with rigorous ecological concerns in mind.

Strategies for Effective Corridor Conservation in India

India's conservation policy needs to include the following in order to maintain biodiversity through the use of efficient corridors:

1. **Landscape-Level Conservation Planning:** Rather than concentrating primarily on protected areas, conservation efforts should take into account matrix landscapes, which are

regions that are located between protected zones. This will ensure that there is permeable connectivity across vast scales.

2. **Infrastructure Mitigation Measures:** Maintaining connectedness without impeding development can be accomplished by the construction of overpasses, underpasses, ecological bridges, and passageways that are more hospitable to wildlife across linear infrastructure.
3. **Community Participation and Incentives:** It is common for corridors to pass through populated landscapes. Promoting cohabitation and protecting corridors can be accomplished by ensuring the involvement of local communities, providing equal remuneration, and offering incentives for conservation.
4. **Science-Based Monitoring and Research:** In order to improve corridor design, prioritization, and adaptive planning, tools such as decision support systems, landscape modeling, and geographic information system mapping are utilized.

Wildlife Corridors and India's National Wildlife Action Plan:

In the pursuit of conserving its diverse and endangered wildlife, India has been formulating long-term National Wildlife Action Plans (NWAPs) since 1983. These have emerged as critical advisory plans to guide different departments and committees in strengthening their efforts to protect India's wildlife. In this article, we explore the current status and key highlights regarding corridors within the framework of the latest plan. This article is the second segment in our series exploring the integration of wildlife corridors into the NWAP. For a concise overview of how NWAPs have evolved to incorporate wildlife corridors. The third version of the National Wildlife Action Plan (NWAP), covering the period from 2017 to 2031, builds upon the experience of the preceding two plans and the concurrent advancements in our understanding of landscape ecology over the decades. Unlike the first two versions, it adopts a landscape-level approach to conservation and suggests several actions and projects for strengthening and promoting the integrated management of wildlife and their habitats, including wildlife corridors. It calls for strategies for delineating landscapes, managing wildlife corridors, and involving stakeholders to maintain ecological connectivity. The proposal indicates that the delineation of critical landscapes is essential, along with the specification of land use, ecological characteristics, and administrative divisions within the region. These should be utilized to produce comprehensive land-use and land development maps of the designated landscapes, encompassing not only reserve and revenue forests but also corridors that link habitats within the landscape, particularly those that connect protected areas with adjacent forests. Moreover, corridors utilized by large species like tigers and elephants, previously recognized, must be "demarcated on the ground" as an initial measure to guarantee ecologically sustainable land usage throughout the corridors.

The National Wildlife Action Plan (NWAP) provides specific guidelines and measures to secure wildlife corridors. These include enhancing corridor management, ensuring habitat restoration along corridors, minimizing human disturbances, promoting community participation, and incorporating landscape planning that takes into consideration the requirements of wildlife movement. First and foremost, the NWAP suggested that centralized

rules be produced for the purpose of creating management plans for wildlife corridors and regulating land-use change in the corridors that were identified. These recommendations can be utilized by state forest departments in order to build corridor management plans with the purpose of preventing activities in the area that are not responsible for the environment. According to the plan, wildlife regions in India are "largely interspersed with human habitations, power and irrigation related infrastructures, industrial estates, and a variety of human activities." This makes it difficult to preserve wildlife in India. Consequently, it makes it abundantly clear that the preparation of corridor management plans have to be carried out following the active engagement of a variety of stakeholders. The National Wildlife Action Plan (NWAP) recommends that the plans for wildlife corridors should be incorporated into the management plans or working plans of the state forest departments. This is to guarantee that the plans are effectively translated into operational activities on the ground. For the purpose of objective management planning, it is necessary to conduct an assessment of the state of all wildlife species and their habitats that are located outside of the protected areas but within the defined landscape. For the sake of conservation, endemic and endangered species that are in need of protection should be the focus of particular recovery efforts. A periodic evaluation of the status of protected areas and corridors need to be carried out every ten years, according to the third NWAP, which also stipulates that this study must be carried out.

In light of the fact that protected areas are embedded inside and multiple corridors are a complex mosaic of land-use that is frequently controlled by humans, it is absolutely necessary for various government sectors to participate and cooperate in order for landscape-scale conservation to be successful. In the third plan, it is stated that there is a requirement for an appropriate framework that will provide effective coordination across the various ministries, agencies, and organizations. In addition, it argues that the concept of wildlife conservation ought to be incorporated into the strategies, plans, and programs of many industries, such as agriculture, fisheries, infrastructure, mining, petroleum, and tourism, among others. For instance, the plan advises that the Ministry of Road Transport and Highways, the Ministry of Railways, the Ministry of Mines, the Ministry of Coal, and the Ministry of Petroleum and Natural Gas should address issues regarding corridor connection throughout the development stages of their respective projects. As a consequence of this, they ought to implement suitable designs and technological solutions in order to protect themselves against the anticipated difficulties. The NWAP emphasizes the significance of education and training with direct management efforts for the long-term stewardship of corridors. The current processes for recruiting, training, and advancing the careers of wildlife managers in protected areas or territorial forests require evaluation and modification. The frontline personnel must be equipped to safeguard wildlife through the organization of training workshops, enhancement of forensic support, and implementation of advanced surveillance technology. Camera traps can be installed in critical routes to safeguard the migratory animal population. Furthermore, the curricula of many training and academic programs, including those provided by the Wildlife Institute of India (Advanced Post Graduate Diploma, Certificate, and Master of Science), must encompass the comprehensive spectrum of wildlife management, including the management of corridors. This is the first time that India has acknowledged the concerns regarding the

impact of climate change on wildlife and has placed an emphasis on integrating activities that need to be taken for the purpose of mitigating and adapting to the impacts. This is what makes the third iteration of the NWAP so distinctive. For instance, it recommends the establishment of a program that would facilitate the migration of species, particularly in highly fragmented landscapes and coastal regions, which are likely to be more affected by the effects of climate change.

According to the strategy, the potential for tourism outside of protected areas—particularly in forests, safari parks, etc.—should be investigated. This idea can be indirectly related to corridors because a large portion of India's wooded areas outside of protected areas are corridors. Tourism-related income can be reinvested in community development and animal conservation. The use of eco-development in protected area management was also recommended by earlier NWAPs. Eco-development is a multi-stakeholder, multi-disciplinary approach that links the livelihoods of local populations with the conservation value of a protected area. According to the third NWAP, eco-development initiatives ought to be expanded to other locations, such as conservation and community reserves, acknowledged wildlife corridors, significant wetlands, and elephant reserves, rather than being limited to tiger reserves, national parks, and wildlife sanctuaries. Notably, the plan also recommends that a feasibility study be carried out to evaluate the possibility of private sector participation in conservation initiatives both inside and outside of protected areas. Increasingly, wildlife corridors are becoming increasingly relevant as essential instruments for the conservation of wildlife. These corridors are utilized by a variety of species for migration, breeding, and feeding purposes. Widespread habitat fragmentation and isolation have been brought about as a consequence of the rapid expansion in industrial and infrastructure development, particularly in the environment around forests. The expanding development (for tourism, linear infrastructure, and other purposes) that has occurred surrounding protected areas, as well as the changing de facto limits of these regions, have both contributed to the intensification of this requirement. There is, however, no "hard" formal status that is granted to wildlife corridors in India, despite the fact that their significance in ecological protection has been recognized. The construction of key corridors in India is not strictly prohibited, nor is it prohibited within the corridors themselves. However, wildlife corridors have been mentioned in passing in certain conservation laws and guidelines that have been developed under those laws. These laws and guidelines aim to maintain animal habitat and limit the amount of conflict that occurs between humans and wildlife. These existing legal spaces have, for the most part, been shown to be ineffectual in protecting and conserving corridors, and the legal space that is dedicated to the protection and administration of corridors in India remains dormant.

Conclusion

For India's natural legacy, ecological corridors are essential lifelines that must be maintained. These corridors strengthen the resilience of India's biodiversity in an era of fast environmental change by connecting habitats that are fragmented, allowing for the movement of genes, providing support for seasonal migrations, and improving ecosystem services. In order to ensure that India's biological legacy is preserved for future generations, it will be necessary to

protect corridors and incorporate them into broader conservation and development plans. The national wildlife action plan acknowledges the importance of protecting wildlife corridors and connecting ecosystems. In general, the most recent NWAP has broadened its scope in order to answer contemporary concerns when it comes to the conservation of wildlife. Through the implementation of holistic methods, the participation of a wide range of stakeholders, and the acknowledgment of the influence of climate change, it endeavors to guarantee the long-term survival of wildlife. Nevertheless, the future of wildlife will be determined by the degree to which this strategy is successfully implemented and the degree to which it is able to adapt to the growing environmental and socio-economic dynamics. The dedication of implementing agencies, conservation organizations, and local people to work together to protect animals beyond the protected areas is another factor that will determine the success of this initiative.

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