DEVELOPMENT CORRIDORS PARTNERSHIP

IMPACT ASSESSMENT FOR CORRIDORS: FROM INFRASTRUCTURE TO DEVELOPMENT CORRIDORS

Edited by:
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The Development Corridors Partnership

The Development Corridors Partnership (DCP) is a research and capacity development initiative. It is a collaboration between institutions from China, Kenya, Tanzania and the UK. The main objective is to deliver effective research and capacity-building to help improve corridor planning and management. It aims to ensure that development corridor decision-making is based on sound scientific evidence and effective use of available planning tools and procedures, to ensure that risks are avoided and opportunities exploited. The DCP comprises partners from the University of York, the University of Cambridge, London School of Economics, Sokoine University of Agriculture, the University of Nairobi, as well as the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), African Conservation Centre, the World Wide Fund for Nature (WWF), the Chinese Academy of Agricultural Sciences and the Chinese Academy of International Trade and Economic Cooperation (CAITEC).

DCP Partners:

For the purposes of this publication, DCP collaboration was extended to experts representing Netherlands Commission for Environmental Assessment, the Centre for Energy, Petroleum and Mineral Law and Policy at the University of Dundee, the University of Queensland, the Columbia Centre on Sustainable Investment, the GOBI Framework for Sustainable Infrastructure Initiative (comprising the University of Oxford, University of Central Asia and the Independent Research Institute of Mongolia), The Biodiversity Consultancy, the Wildlife Institute of India, the Endangered Wildlife Trust and Ecotecnia Ingenieros Consultores SRL.

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Foreword

In the course of a long and varied working life, I have been privileged to work with, or learn from, a stimulating panoply of individuals who are committed to contributing to the economic, social, and environmental development of all aspects of the United Nations Sustainable Development Goals.

Jon Hobbs and Diego Juffe-Bignoli are, thankfully, two of these individuals. I was delighted to learn that they had come together to produce, for the Development Corridors Partnership, a rich and stimulating collection of research reports, case studies and assessments relating to the array of efforts made under the rubric of 'development corridors'. They were determined to express the conviction that decisions made, primarily by governments, regarding the planning and building of Corridors, really must be informed by an evidence-based understanding of the consequences – positive or negative – of these decisions. And they have succeeded. But Jon Hobbs will never read these words. He was hospitalized after the bulk of the work was complete, and, to the deep sadness and regret of all who knew him, he passed away at the end of September, 2021.

Jon and Diego sought out and recruited a daunting array of researchers, scholars and stakeholders to shed light on the processes currently underlying the world of development corridors today. They certainly succeeded.

The work was initiated before the onset of the COVID-19 pandemic, and as governments turn to the formidable challenge of restoring economic vitality without further damage to the climate, it becomes even more imperative that impact assessment be understood, embraced and improved. Jon and Diego have shown us the way forward for a journey which absolutely must be embarked upon.

They would be first to recognise that the Development Corridors Partnership as a whole must be commended for showing – in many different ways and places – that, not only is the need for impact assessment clear and present, but so are the skills and commitment of researchers, scholars and stakeholders. These are to be found in an impressive coming together of universities, civil society organizations and business groups, and communities.

All are part of an outstanding initiative, funded by the UK Research and Innovation Council, and managed by the UNEP-WCMC. This initiative has been embraced by some of the best minds that have been turned to the task of ensuring that – while we attempt to bring economic and social benefits to people, in line with the United Nations Sustainable Development Goals – we do not risk significant environmental and social costs, and thus actually undermine long-term development successes.

So, I urge you to read this book, and figure out how you might improve your own contribution to the challenges ahead. Jon and Diego have set out a case. It needs to be taken up, not set aside; acted on, not just talked about. It is in your hands.

John Harker

Chair of the Development Corridors Partnership Independent Advisory Board,
Nova Scotia, Canada.

Dedicated to the memory of Jon Hobbs
who was the architect and driving force of this book

Executive Summary

Driven by increasing globalisation, the development aspirations of nations, and the need to access resources, an infrastructure boom is impacting many regions of our planet. New infrastructure projects are traversing diverse landscapes over hundreds of kilometres, often crossing international borders and penetrating into remote areas previously unaffected by industrialisation and urbanisation. These large-scale projects, mostly spanning several regions in a same country, but often linear and transnational in nature, are generically called corridors. Depending on the nature and objectives, they can be transport, infrastructure, growth, resource or economic corridors.

The rapid development of corridors globally presents environmental planning professionals with numerous challenges. **The primary need is to ensure that decisions about these developments are informed by an evidence-based understanding of their consequences – both positive and negative.** This will enable infrastructure development to meet development needs without adversely impacting ecological systems or human welfare. Improving the quality of infrastructure policies, plans, programmes and projects, by ensuring they include the necessary environmental and social scrutiny, is urgently required now - and will be for the foreseeable future. This challenge is the unifying theme of this publication.

Using insights from Africa, Asia and South America, this sourcebook compiles 24 contributed papers written in 2021, covering many facets of the opportunities and challenges presented by the rapidly growing number of infrastructure and corridor developments around the world. Prevailing planning practices are reviewed through case studies along with the efficacy of some of the available tools to conduct systematic and comprehensive impact assessments. The latter includes Strategic Environmental Impact Assessment (SEA) and Environmental Impact Assessment (EIA).

As the title suggests the underlying thesis of this publication is that, where they are justified, **there are significant benefits in ensuring that corridors that contain single purpose infrastructure developments (utility, infrastructure or transport) progress through a carefully planned sequential process of diversification and expansion to ensure the maximisation of benefits in full-blown 'development corridors'.** In this book, development corridors are therefore aspirational. They comprise areas identified as priorities for investment to catalyse economic growth and development. They should be developed with multiple stakeholders and social, economic and environmental interests and interdependencies in mind. With the integration of sustainability principles and appropriate environmental and social standards, development corridors could become true '(sustainable) development corridors'. They should be planned to maximise positive opportunities and minimise negative risks. Without this, today's short-term successes will become tomorrow's challenges and long-term human welfare and ecosystem integrity will be undermined.

Overview of contents

This book brings together a wide range of perspectives from experts, researchers, and practitioners around the world with the purpose to foster greater collaboration and increase our global understanding of corridors and their benefits and potential negative impacts. 13 of the 24 chapters are written by independent experts and researchers from Australia, Bolivia, Brazil, China, India, Kenya, Mongolia, South Africa, Tanzania, UK, and the USA. The book also includes 11 chapters containing material gathered by the Development Corridors Partnership, a programme of work led by UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) and funded by the UK Government via their Global Challenges Research Fund.

The collection of papers in this sourcebook is divided into five sections. First an introductory section where we introduce some key terms and definitions that underpin this work (Chapter 1). We then explore some key principles and aspirations of corridors such as delivering the Sustainable Development Goals (Chapter 2), ensuring theory and practice align (Chapter 3), ensuring financial sustainability (Chapter 4), properly assessing environmental sensitivity (Chapter 5) respecting human rights (Chapter 6), or maximising, co-benefits (Chapter 7).

In the next three sections, we present 15 case studies from three continents: Africa, Asia, and Latin America. These case studies explore key challenges and lessons learned from specific planned, ongoing, and already implemented developments. They are presented as individual stories that readers can explore.

The final and fifth section aims to summarise lessons learned from a 4-year research and capacity building programme specifically aiming to understand the key challenges and opportunities around corridors and that has been the major driving force of this work: The Development Corridors Partnership project (DCP). DCP is a collaborative partnership across UK, Kenya, Tanzania and China, funded by the UK Research and Innovation Global Challenges Research Fund (see Chapter 23).

The book finishes with an overview of the lessons learned from the contributed papers included in this book and develops ten principles for corridor planning and delivering a meaningful and comprehensive impact assessment (Chapter 24), which we summarise here as ten key messages.

Key messages

1

Corridors must seek to achieve positive sustainability outcomes:

The mindset underwriting environmental planning of most infrastructure developments has been to mitigate negative impacts. The planning of few existing corridors is based on their role in supporting a sustainability vision for a country or region in which they are situated. Corridor developments must therefore be based on sustainability principles and support progress towards national, regional and international sustainable development goals. A true development corridor will seek to do good, as well as to mitigate negative impacts.

2

Integrated and inter-disciplinary approaches are needed:

Corridor developments are extensive, complex, multifaceted features traversing many landscapes. They can bring about significant transformational change to physical, economic, social, and cultural systems, and serve as interconnecting features. Yet engagement in corridor planning is often constrained by limited disciplinary and institutional involvement, with projects often superimposed upon communities. Corridor developments need diverse expertise and experience in their planning and management, including local stakeholder knowledge, avoiding disciplinary, institutional, or sectoral silos, that can result in policy conflicts, contradictions, and inconsistencies.

3

Corridor proponents should clearly demonstrate consideration of alternatives:

Corridor options should not be limited to a preferred proposal favoured by an elite. Corridor developments must consider all feasible alternatives (including maintenance of the status quo and no corridor development) and make the risks and opportunities of each option explicit and transparent through meaningful consultation. An important requirement in all corridor planning is to justify the need for a wide choice of options and an explanation of the potential benefits it will bring and to whom, in comparison with the alternatives. Any necessary trade-offs and how any significant potential negative impacts will be effectively managed, and opportunities created must be explained.

4

Public participation and stakeholder engagement should be at the core of corridor planning:

Corridor planning frequently fails to include meaningful participation of all stakeholders. Corridors can profoundly affect the lives and rights of indigenous peoples and local communities, potentially for generations. A common failing is that the first opportunity for local stakeholders to engage arises only after all strategic decisions have already been made and the only option remaining is for them to react negatively to a fait accompli. The meaningful engagement of all stakeholders is necessary to ensure their role is more than reactive. The way corridors are viewed by different stakeholders must be identified, understood, and addressed. Corridor developments must ensure that all interested and affected people are provided with adequate information about a proposal and have meaningful ways to engage in decision-making processes from the outset of strategic planning.

5

Mainstreaming and tiering are fundamental for corridor success:

Corridor planning requires a tiered assessment process, ensuring that environmental and social issues are considered alongside financial and technical considerations from the start of strategic planning or programme development, right though to project specifics. Conceptual corridor planning is frequently dominated by technical and financial suitability criteria with environmental, social, cultural, and human rights sensitivity issues being considered, at best, as externalities, retrospectively, once issues and problems arise. Strategic planning is important because it is when the full range of options is still open for discussion. It also establishes the parameters that will frame and implement a corridor plan or programme. Environmental and social considerations (and the interactions between them) should be considered early in strategic decision-making alongside (and to inform) technical, financial, and economic considerations.

6

An iterative process is needed:

Corridors exist in dynamic environments and need to be responsive to changing circumstances and priorities. Planning must adjust as circumstances and available information changes. The process should identify, map, and engage all interested and affected stakeholders from the earliest stage of corridor planning and throughout the planning and management of the corridor. New concerns and evidence will likely emerge as a corridor development progresses. Corridor planning frequently places undue emphasis on the production of a report (Environmental Impact Report) and its influence on the decision to proceed. The process may not be so linear in nature. It may involve many adjustments and decisions as new evidence emerges and predictions improve. A good-quality report and recommendations is necessary, but they are dependent upon a comprehensive process of ongoing dialogue and engagement with all stakeholders.

7

Corridors must ensure effective use of available tools:

Many corridor environmental impact assessments fail to meet required international standards. Corridor planning and management should make systematic and adequate use of available impact assessment procedures, methods, techniques, and tools to ensure good-quality decisions. The available procedures discussed in this publication (notably Strategic Environmental Assessment and Environmental Impact Assessment) and their associated methods, tools and techniques should be used when appropriate to help ensure that a systematic process identifies all significant potential benefits and development outcomes, and that they outweigh the costs and risks to affected people and their livelihoods and environments. The objectivity and quality of corridor decisions are dependent upon the effective use of the available tools.

8

Plan corridors with resilience and adaptability in mind:

Prevention will always be better than cure in addressing the negative impacts of corridors, and this should be the priority. However, some circumstances dictate an inevitability of negative impacts. Corridors, therefore, need to be designed to be made resilient to anticipated changes and adaptation measures may be necessary as 'coping' mechanisms or to offset unavoidable impacts, such as the impacts caused by climate change. The suitability of measures will require ongoing monitoring and adaptation as needs arise.

9

Seek impact, influence, and implementation capacity:

The decision to proceed with a corridor is ultimately the responsibility of decision makers. They are usually the representatives of all stakeholders' interests and custodians of their natural resources. Any impact assessment report must provide adequate information to ensure sufficiently good-quality decisions. If they are to be effectively implement the recommendations provided. Attempts to improve the performance of planning and associated assessment processes of corridors must tackle the ways in which outcomes are shaped by political contexts and institutional capacities. Approaches to working on assessment processes should integrate political economy analyses and institutional capacity assessment from the outset and on an ongoing basis. Resulting insights should inform the design and implementation of interventions intended to improve planning practice.

10

Evolve from Infrastructure to Development Corridors:

The prospects for linear infrastructure projects to evolve into comprehensive development corridors are often left to chance and spontaneity. Infrastructure projects are often developed in isolation and in an incremental way. For infrastructure projects to progress and become true development corridors, the transition must be systematically sequenced into planning from the start. Assessments must include consideration of potential induced, secondary, synergistic, transboundary, and cumulative impacts likely to result from the corridor development. The progression from infrastructure to development corridors must be based on a systematic, comprehensive, and integrated assessment of the potential positive environmental, social and economic opportunities and the rigorous avoidance or management of negative impacts.

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Sensitive Planning and Design of Transportation Corridors: Vital Elements for Protecting India's Wildlife

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ABSTRACT

India's exceptionally rich biodiversity is being increasingly threatened by expanding transport networks. Roads and railways that are considered the largest enablers of economic growth are also widely recognized as drivers of habitat reduction and fragmentation, and population decline of rare endangered and threatened species. This chapter shares examples of how sensitive planning and design of mitigation structures can improve or impair the conservation prospects for wildlife species in their natural habitats. Science-driven planning for mitigation solutions and collaboration among all stakeholders in development of transport corridors are vital factors that can influence the efficacy of crossing structures for animal movements across their habitats. Strategic environmental assessment (SEA)-driven assessments can provide inputs during the planning stage of the transportation development sector, inform decisions and reform policies to prioritize areas within landscapes that can be developed, and those that need to be safeguarded as habitat networks for enhancing conservation prospects.

17.1 Introduction

Growth theories that universally acknowledge the importance of infrastructure for regional development also invariably recognize that transportation corridors are the biggest enablers of growth and development. The development is mostly manifested in the form of urban sprawls that may have a central core or multiple nuclei and ribbon developments along the roads and highways (Verbeek, Kobe and Pisman 2014). Most transport corridors that begin with physical connectivity facilitated by a road, highway or a railway track connecting two or more nodes ultimately transform into major economic corridors. The transport sector, which is undoubtedly central to propelling India's overall economic development, is experiencing the most explosive era of road and rail infrastructure expansion in human history. India's transport system is already one of the largest in the world, serving a

landmass of 3.3 million km^2 and a population of over 1 billion (Kapoor 2002, p. 3). Roads alone, with a network of over 5.8 million km, form the second-largest road network in the world.

Often, with much of the road proliferation being chaotic or poorly planned at a rapid pace, the development of other infrastructure within the larger economic corridor offers complex challenges that overwhelm the capacity of environmental planners, engineers and managers in implementing such projects. Integrative environmental assessments undertaken earlier in the planning process can provide a key solution in achieving balanced and inclusive growth.

Roads and highways that cut across a geographical space, connecting urban areas, generate economic agglomerations, while reducing transportation costs and travel time to reach such agglomerations. The same road corridors permeating natural areas that are vital for connecting natural habitats become the primary drivers of increased access to pristine landscapes, deforestation, fragmentation, illegal hunting and trade in animal parts (Clements Lynam and Gaveau 2014). Indirect impacts may include those from borrow pits, associated soil erosion, alteration of water channels, transportation of chemicals to water bodies and changes in land use. Road, particularly highway, development can attract large numbers of people, leading to increased commerce and shops, ultimately creating zones of urbanization (Rajvanshi *et al*. 2001)

With the impetus for economic expansion, new roads are being made and older ones widened, shrinking wildlife areas, including national parks and wildlife sanctuaries. It is estimated that nearly 24,000km of new roads will be built in tiger conservation landscapes in Asia by 2050 (Carter *et al*. 2020). India, which is potentially the most important foci for the global tiger conservation initiatives in Asia, will have approximately 14,500km of roads pass through its tiger habitats: a 32 per cent increase from current levels (Carter *et al*. 2020). Many of the roads would also traverse other natural areas that sustain exceptional biodiversity and provide vital ecosystem services.

17.2 Conservation challenges associated with transportation corridors traversing natural landscapes

The intrusion of roads through prime wilderness areas often extends into surrounding landscapes, transforming contiguous and integrated habitats into disconnected patches that no longer remain viable for supporting and promoting biodiversity conservation. Roads aligned through wildlife corridors can threaten forest integrity and pose barriers for animal movements and consequent population declines or localized extinctions (Laurance, W. F., Goosem and Laurance S.G.W 2009). Fahrig (2003) recognizes that the creation of isolated pockets of habitat that cannot support viable populations in the long term is one of the most serious consequences of habitat loss due to road construction. Increased mortality (Seiler and Helldin 2006) and avoidance of a zone around the infrastructure are other significant impacts (Forman *et al.* 2003; Van Der Ree, Smith and Grilo 2015; Tulloch *et al.* 2019). Although the ecological impacts of railway projects are similar in characteristic to those induced by roads, these have been less studied (Popp and Boyle 2017). Specific insights into ecological aspects of railway projects (Agua *et al.* 2017) have provided enhanced understanding of rail-induced impacts and mitigation options.

Notwithstanding these distinctions in the array of impacts from different forms of transportation infrastructure, integrating ecological considerations into all phases of road and rail development – from planning to construction to operation – becomes a formidable challenge that needs to be urgently addressed (Asian Development Bank 2019; Wildlife Institute of India 2016). Enabling legislation and decision-making processes regulating the development of infrastructure projects provides the first step for inclusive development. In view of significant environmental implications of roads and highway projects on account of their location, route alignment and associated activities stipulatory enforcements regulate their development in most countries.

17.3 Environmental legislation for regulating transportation projects in India

In India, EIA Notification (2006) and its subsequent amendments stipulates environmental clearance needs to be obtained by the executing agency before commencing the actual work or executing the proposed project based on the review of Environmental Impact Assessment (EIA) reports undertaken by recommendatory bodies such as Expert Appraisal Committee at the federal level and the State Environment Impact Assessment Authority (SEIAA) at the state level (Indian Roads Congress 2017).

The legislation mandates that all Category 'A' projects require environmental clearance from the federal nodal agency, the Ministry of Environment Forest and Climate Change (MoEFCC). These projects include all new highways and expansion of national highways greater than 100km in length, involving additional right-of-way or land acquisition greater than 40m on existing alignment and 60m on re-alignments or bypasses, and passing through more than one state. For Category 'B' projects that include all new State highway projects and expansion projects in hilly terrain (above 1000m above mean sea level) and ecologically sensitive areas, clearance needs to be obtained from the SEIAA. Roads and highway projects also require clearances under the Forest Conservation Act (1980) for roads requiring diversion of forest lands across various forest categories; and from Standing Committee of the National Board for Wildlife under the Wildlife (Protection) Act (1972) for projects aligned through or along the protected areas, wildlife corridors and within notified ecologically sensitive zones.

The impact assessment approach is generally adopted to appraise individual projects often representing sub-sections of road or highway proposed by the development agency for ease of execution. Such a piecemeal approach assigns the highest priority to EIAs of individual projects that is mandated by law. It seldom provides opportunity to assess the cumulative impacts of the entire road length spanning across different states or provinces. Clearly, the need for conducting SEA to provide significant inputs in planning of road transportation projects amidst other forms of development in a landscape is lacking in the existing decision-making frame.

The railway projects in India enjoy supremacy over all other infrastructure projects in terms of exemptions granted for their approval. Railway projects are exempted from the requirement to seeking environmental clearance, as the Indian Railways Act provides special dispensation for the railway to be exempted from seeking clearances under other statutes (MoEFCC letter dated 28 May 2020). In many sections of the Indian landscape, the ownership of land prior to the enactment of the Forest Conservation Act (1980) rested with the Indian Railways. This further exempted railway projects from seeking clearance under the provisions of the relevant legislations for protection and conservation of forest and wildlife.

17.4 Structural mitigation measures for connecting fragmented habitats: prospects and challenges

Wildlife-crossing structures are intended to improve habitat connectivity and increase permeability (the extent to which there are obstacles) for animal movement across roads. Connectivity conservation science has been addressing the crucial concerns of where and how to maintain linkages for wildlife between isolated habitat patches to help maintain gene flow and sustain population viability of target species (Forman and Alexander 1998). Literature and strategies employed in road and rail construction and improvement projects suggest that solutions exist to avoid, restore and even enhance connectivity through bridges, underpasses and overpasses for wildlife (Clevenger and Waltho 2005). The ability to successfully implement road and rail projects in high-biodiversity areas hinges on the commitment to pursue comprehensive transportation and conservation strategies that employ a range of measures, from environmentally sensitive road design to passage structures and management of on-site activities. Pursuing the twin goals of sound development and conservation would require adopting the principles of transportation ecology in planning, implementation and post-construction monitoring of transportation projects. Such an approach can encourage economically viable, ecologically responsive and technologically justifiable projects and prevent costly mistakes that may not even allow retrofitting later.

Very little experience has accumulated over time to demonstrate the success of measures to promote connectivity of habitats for wild animals in landscapes that contain roads. Few mitigation efforts demonstrate the success of ecological connectivity based on evaluation of efficacy based on the extent to which the barrier effect of roads and road-related mortalities is reduced (Lehnert and Bissonette 1997; Dodd, Barichivich and Smith 2004; Rytwinski *et al*. 2016) or gene flow between populations is enhanced (Corlatti, Hackländer and Frey-Roos 2009). The efficacy of crossing structures for wildlife appears to be significantly influenced by several factors, such as locations in relation to natural paths, size, design sensitivity, appropriateness in terms of ecological considerations, behavioural responses of species and visual appearance (Jackson and Griffin 2000; Clevenger and Waltho 2000). It is, therefore, critical that once the mitigation structures (tunnels, bridges and overpasses) are constructed to meet the mitigation compliance requirements for obtaining environmental clearance, science-driven monitoring of the uses of such structures is undertaken to establish their success. Studies from many different regions of the world also reiterate that evidence-based mitigation success provides opportunities for reconciling economic and social development and species conservation with environmental stewardship (Arcus Foundation 2017).

17.5 Structural mitigation measures applied to transportation projects in India

Case examples presented in this section highlight the strategies that could successfully restore the connectivity of habitats fragmented by roads and railways in India. At the same time, some examples also illustrate that the lack of integration of factors that are critical for ecological connectivity can jeopardize the prospects of conserving several targeted species.

17.5.1 Case example 1: canopy bridge construction for lion-tailed macaque in Western Ghats hotspot in India

17.5.1.1 Conservation risks for lion-tailed macaque in rainforest fragments of Western Ghats

The lion-tailed macaque (LTM; *Macaca silenus)* is the iconic symbol of the endemic and endangered primates of the Western Ghats hotspot (India). It inhabits numerous rainforest fragments of the Valparai plateau (220km^2) in the southern region of the Western Ghats. Forest clearance for tea, coffee, cardamom and eucalyptus plantations, and the associated infrastructural development (Joseph *et al*. 2009) including road-building and widening has resulted in extensive fragmentation from the early 1900s (Anitha *et al*. 2013). About nine troops of around 200 LTMs have been reported to live in fragmented rainforests in the Valparai plateau (Sridaran 2019).

One such forest fragment is the Puthuthottam forest (Fig. 17.1a), which harbours the largest population (Umapathy, Hussain and Shivaji 2011; Jeganathan *et al*. 2018), of LTMs (approximately 150 individuals) in three groups (Sridharan 2019). The main highway connecting the towns of Pollachi and Valparai, aligned through this fragment, further bisects the LTMs' habitat (Fig. 17.1a). This highway has destroyed the contiguity of the canopy cover that was vital for movement of LTMs between the forest patches. In the absence of connectedness of the tree canopy, LTMs climb down the trees to cross the road and then become victims of road-related injury and mortality. In the last 10 years, at least 10 LTMs have been killed on the road through Puthuthottam, as they were forced to cross on the ground due to gaps in the tree canopy (Jeganathan *et al*. 2018).

17.5.1.2 Construction of canopy bridges for restoring canopy connectivity

The Nature Conservation Foundation (NCF), a civil society organization of international repute conducted long-term research studies on LTM to identify the critical crossing points of animals and assess the gaps in canopy contiguity. Based on the findings of the research, NCF installed four canopy bridges in strategic locations in the Puthuthottam fragment wherein road widening led to canopy breakage, and in locations where LTMs and other arboreal animals such as the Nilgiri langur, and the Indian giant squirrel were frequently observed crossing the road.

The bridges are primarily made using the material that is used by firefighters for making high-pressure hoses. Two rolls of these are woven with each other, using cables/binding wires with PVC pipes in between, giving it a ladder-like appearance. These materials require limited maintenance, as opposed to use of bamboo in such high rainfall areas. These ladder-like bridges were tied using cables or ropes to trees on either side of the road at locations where the canopy gap is wide (Fig. 17.1 b).

The bridges were initially installed on a trial basis and, later on, more were installed after observing that LTMs (Fig. 17.1c) and even giant squirrels started using such bridges to cross over to the other side of the road (Pardikar n.d.). After the successful outcome of restoring canopy connectivity in the Valparai-Pollachi road corridor, a similar initiative was also undertaken in Chinnar Wildlife Sanctuary in Kerala.

17.5.1.3 Key lessons

» **Rigorous and long-term scientific research to identify the specific threats and their spatial characteristics is integral for designing mitigation measures for conservation of endemic and endangered species such as the LTM, which is threatened by the widening of the road corridor.**

» Understanding of the behavioural traits of LTM is critical for successful installation of canopy bridges in crossing zones and their subsequent use by the LTM.

» The canopy bridges erected by wildlife experts could better integrate the design sensitivity (suitability surface; height from ground; width of the bridge for movement of animals and their easy use).

Figure 17.1

17a State Highway 18 bisecting the Puthuthottam Reserved Forest. Illustration by: Roshni Arora

17b Canopy bridge connected to the trees on both sides of the Highway. Photo credit: Ganesh Raghunathan

17c LTM using one of the canopy bridges installed across the Valparai-Pollachi Highway. Photo credit: Ganesh Raghunathan

17.5.2 Case example 2: construction of canopy bridge across a rail corridor for hoolock gibbons in Hoollongapar Gibbon Wildlife Sanctuary, Assam State, India

17.5.2.1 Conservation values of hoolock gibbon

Hollongapar Gibbon Wildlife Sanctuary, which spreads over an area of 20.98km^2 in the tropical rain forest of Jorhat district in upper Assam, was initially set up in 1981 as a forest reserve. It was named Gibbon Wildlife Sanctuary in 1997 and Hoollongapar Gibbon Sanctuary in 2004 (Fig. 17.2a). This sanctuary holds the distinction of harbouring seven primate species, including the densest populations of gibbons (*Hoolock hoolock*), the only ape in India. Around 100 individuals belonging to 26 families are residing in this sanctuary (Chetiapator 2019). Hoolock gibbon (Fig. 17.2b) has been categorized as endangered in the International Union for Conservation of Nature Red List. It is also a protected species listed under Schedule-I of the Indian Wildlife (Protection) Act, 1972. Hoolok gibbon is an exclusively arboreal species that requires contiguous closed-canopy forests for moving between trees by swinging along the branches on the canopy of the forest.

17.5.2.2 Conservation challenge posed by the railway track

Extensive railway lines were laid in the 1980s, including the Meleng railway, which runs through the 20.98 km^2 Hoollongapar Gibbon Wildlife Sanctuary to connect the major towns Guwahati and Dibrugarh. The chopping off of the branches were chopped off the high canopy interlinking trees to clear out area for track alignment and maximise the visibility of passing trains. This fragmented the habitat into two havles. The gaps in the canopy severely impacted the dispersal, foraging and breeding opportunities of the gibbons and the groups were split on either side of the railway line. Consequently, the gibbons have been restricted to small areas, and are forced to compete for the limited resources within the available space.

17.5.2.3 Structural solution for restoring canopy connectivity

There is growing evidence that constructing canopy bridges for canopy-dependent species is critical for maintaining movement of arboreal mammal species (Donaldson and Cunneyworth 2015; Smith, Van Der Ree and Rosell 2015; Balbuena *et al*. 2019). Accordingly, the Assam Forest Department, with the help of the Northeast Frontier Railways, constructed a canopy bridge across the railway track to facilitate the movement of gibbons and other primate species in October 2015. This structure is in the form of an iron bridge, 10.5m in height and 9.5m in width, straddling the railway track. Iron ropes were tied on both sides of the green-coloured bridge and fixed to trees on either side of the track to serve as approachway to the bridge (Fig. 17.2d). This bridge is perhaps the country's first crossing structure to mitigate the impact of a railway track on arboreal species and its habitat.

The forest staff entrusted with manning the bridge, to observe whether the gibbons had started using it, confirmed that "the gibbons never came anywhere near the bridge" (Bhattacharya 2019). The challenge for the gibbons to use the canopy bridge to cross over between eastern and western parts of their habitat is compounded by the following factors.

- The gibbons that are high-canopy tree (25m high) dwellers are extremely shy. As the height of the iron bridge is mere 10.5m, it needs to be camouflaged by natural climbers to encourage gibbons to use it.
- Gibbons are reluctant to climb on thin wires attached to the canopy bridge from the two edges of the bridge overhanging the rail corridor.
- The nearest tree is almost 50-80m away from the two ends of the bridge, which further discourages the shy gibbons to walk on the ropes to access the bridge.
- Villagers, who often throng the area for firewood collection, indulged in cutting and removing ropes attached to the canopy bridge.

17.5.2.4 Exploring the prospects of erecting a natural bridge versus a metal bridge

Aaranyak, a biodiversity conservation group, under its Hoolock Gibbon Conservation Programme, which was launched in 2004-2006, initiated the development of a natural canopy through a plantation drive along the 1km long railway track with the help of the local community. The work was led by a primatologist, who provided insights about the different species of food and cover for the gibbon to be planted on either side of the railway track. After sustained efforts spread over thirteen years, a natural canopy started forming just above the track that is now used by hoolock gibbons to cross over between the fragmented forests on each side of the railway track (https://www.guwahatiplus.com/daily-news/assam-after-100-years-hoolock-gibbons-reunite-following-construction-of-natural-bridge).

17.5.2.5 Key lessons

The use of even the best-designed structures may be limited or even precluded if the ecological requirements and behavioural aspects of the species are not adequately integrated in the design.

Inputs from primatologists and wildlife ecologists can be critical at the design stage in sensitive planning for the efficient use of mitigation infrastructure.

Coordination and synergies among railway authorities, building agencies and conservation groups assumes importance for restoring the canopy contiguity for the hoolock gibbons, which command prime importance as the only ape species found in India.

While canopy bridges are no replacement for protecting intact habitats, they can play an important role in helping species survive in fragmented habitats.

- **Natural bridges created by planting plant species providing food and cover for gibbons have greater prospects of success as crossing structures.**

Figure 17.2

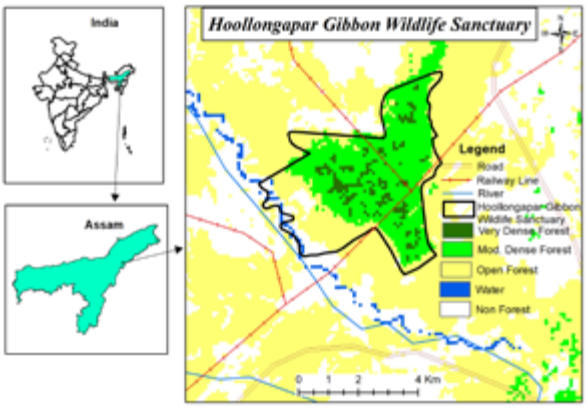

Figure 17.2a. Map of Hoollongapar Gibbon Sanctuary in Assam. Illustration by Panna Lal

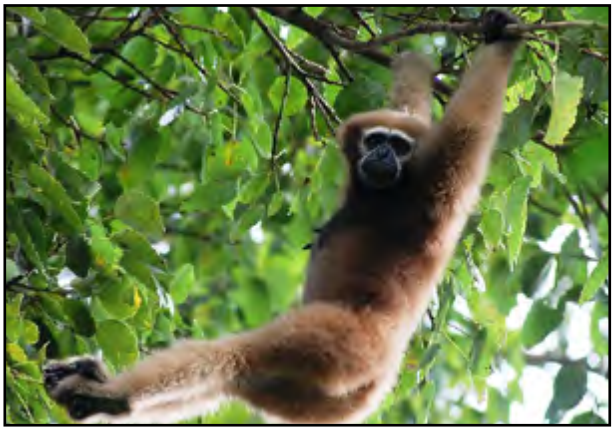

Figure 17.2b. Hoolock gibbon. Source: Creative Commons

Figure 17.2c. Iron bridge constructed over the train track in Hoollongapar Gibbon Sanctuary to serve as a canopy bridge for movement of hoolock Gibbons. Photo credit: Sonali Ghosh

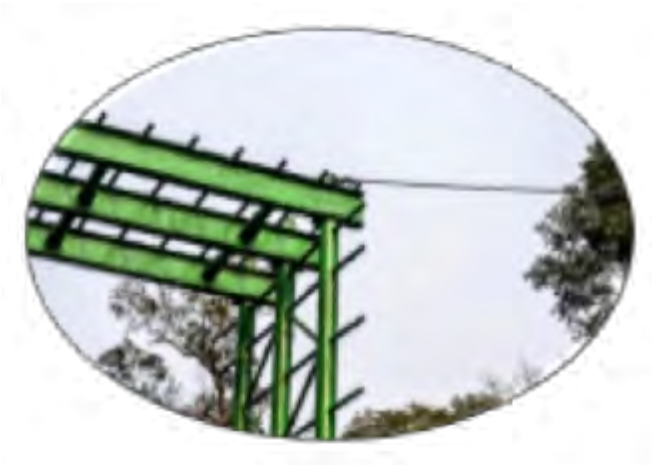

Figure 17.2d. Iron ropes providing approach way to the bridge. Photo credit: Sonali Ghosh

17.5.3 Case example 3: construction of crossing structures to improve animal movements across national highway running through Pench Tiger Reserve, Maharashtra State

17.5.3.1 Conservation values of the landscape

The central Indian landscape, consisting of parts of Maharashtra, Madhya Pradesh and Chhattisgarh States, has been a stronghold for several long-ranging wild mammals. Since tigers are an iconic feature of the landscape, these areas are also highly important as a tiger conservation landscape, with high potential for long-term tiger conservation (Jhala, Qureshi and Gopal 2015).

17.5.3.2 Conservation challenge posed by national highway 44 and its proposed upgrade

The central Indian landscape that was once characterized by a contiguous expanse of dense forests and rolling grasslands is being increasingly fragmented by expanding road and rail networks. National highway (NH) 44 – which runs along 3,806km of the north-south corridor, and is the longest national highway in India – traverses this landscape. About 232km of this highway, routed

through Maharashtra, cuts through the Kanha-Pench and Pench-Navegaon-Nagzira wildlife corridors that are critical for connecting tigers, co-predators and their prey in the central Indian landscape (Fig. 17.3a). As part of the National Highway Development Project, it was proposed that this highway should be upgraded from a two-lane to a four-lane highway. The widening of the NH 44 would invariably affect the dispersal and movement (ecological) corridors of long-ranging mammals, leading to isolation of their natural population into small island populations. Approval for road upgrade was granted, with the condition of provisioning animal crossing structures to reduce animal/vehicle collisions/mortality and also to ensure habitat contiguity in the landscape. The Wildlife Institute of India (WII) (www.wii.gov.in) was assigned the task of providing technical guidance for planning animal-friendly crossing structures as a standalone study that had the benefit of information on extensive use of the area that was generated from the earlier EIA that was also conducted by WII.

17.5.3.3 Mitigation structures for securing the connectivity of fragmented habitats

Based on extensive research, which aims to ascertain the pathways of animal movements and observations or evidence of habitat use along the highway in Pench Tiger Reserve, Maharashtra, a 16.1km section of the highway cutting across the tiger reserve and adjoining forests in three forest segments was identified for planning wildlife crossings to secure connectivity of habitats for permeability of animals.

Several global studies (Van Der Ree, Smith and Grilo 2015) have established that the body size of the animal and its behaviour (e.g. solitary or group living, diurnal or nocturnal), size and openness of the structures influence the design and use of the mitigation structures. Insights from these earlier studies and the outcome of field-based studies conducted by the team from WII guided the planning of underpasses at nine different locations (Habib *et al*. 2015). Four minor bridges and five animal underpasses were constructed. The spans of the underpasses on NH 44 range from 50m to 750m. Actions for habitat improvement (e.g. land levelling, habitat enrichment, raising shrub/herbaceous cover, constructing solar-powered water holes, camouflaging the concrete walls) and regular monitoring and patrolling were taken to enhance the use of underpasses (Fig. 17.3b and c). These animal underpasses on the NH 44 are the first of their kind in India, and perhaps the largest in the world.

17.5.3.4 Functional efficacy of the crossing structures constructed on NH 44

A camera-trapping effort (23,628 camera days) between 2018 and 2020 was made, to conduct evidence-based monitoring of the use of all nine crossing structures (Habib *et al*. 2020). A total of 89 tiger crossings by 11 individual tigers were recorded from six of the nine structures. A total of 18 species of wild animals, including wild ungulates *viz*., spotted deer, sambar, gaur, nilgai and wild pig, large and medium-sized carnivores *viz*., tiger, leopard, sloth bear, jackal and wild dog, small mammals *viz.,* hare, jungle cat, mongoose, common palm civet, porcupine, rusty spotted cat and small Indian civet was recorded. The rates at which animals crossed and used the underpasses varied between species and the dimensions of the underpasses.

17.5.3.5 Key lessons

- **Animal crossings should be designed and implemented to meet the varying needs of movement of all target taxa.**
- **Designing animal crossings for the biggest or most demanding species will invariably ensure that the needs of other species are also simultaneously met.**
- **The degree of use of underpasses varies with species, its behaviour, adaptability to the new structures and the neighbourhood characteristics (e.g. anthropogenic**

factors; habitat suitability; water availability; disturbance from light and noise).

» The dimensions of the crossing structures that influence openness of the structure influence use by animals. In landscapes where sambar, gaur and tiger are present, a minimum underpass height of 5m would be appropriate if the underpass is 300m long and has a span of 28-30m.

» Results of continuous monitoring of wildlife movements through these underpasses have established that the design and location of the structure is effectively facilitating the movement of a range of animals.

Figure 17.3

Figure 17.3a Aerial View of the Elevated Stretch of NH 44 through Pench Tiger Reserve. Source: Creative Commons

Figure 17.3b. Sloth bear crossing through the underpass beneath NH-44. Source_ Maharashtra Forest Department. Photo credit: WII Road Ecology Project 2020, Bilal Habib

Figure 17.3c. Tiger using one of the underpasses constructed beneath NH-44 in Pench Tiger Reserve. Photo credit: WII Road Ecology Project 2020, Bilal Habib

17.6 Relevance of SEA in the planning of multiple linear corridors

Experience from current planning assessments draw home the lesson that focus on transportation projects rarely integrates other land-management objectives and future utility infrastructure needs. The general lack of vision to systematically align the routes of linear infrastructures such as roads, railway lines, power lines or a transmission lines within the same landscape poses the risk of jeopardizing the connectedness of wildlife habitats. The dichotomy between project-level EIAs and regional EIAs or SEAs can be attributed to this failure in conceiving the multiple impacts of progressive developments within the same development corridor. Even in the case of a single highway project (e.g. NH 44), project proposals are developed for each of the segments or subsections of the highway aligned through different states or administrative jurisdictions. The EIAs conducted at the project level fail to capture the larger picture of cumulative impacts of total habitat loss or the spatial extent of fragmentation by a single highway.

Figure 17.4

Figure 17.4a. Unplanned developments can lead to multiple development corridors traversing the landscape Illustration by Sharmistha Singh

Figure 17.4b Planned developments can reduce the risk of large-scale fragmentation (Figure 4b) and improve the potential habitat use for wildlife species. Illustration by Sharmistha Singh.

Developing policy choices to balance mobility, economic growth, and conservation goals, though important, remain a challenging endeavour. A strategic assessment and planning approach is urgently needed for proactively zoning and prioritizing areas that can be opened up for development and those that need to be designated as no go areas for development to safeguard high-priority areas of conservation from avoidable impacts. While project-level EIAs are a legal requirement and a decision-supporting tool for individual projects, EIAs can rarely look beyond the impacts of individual corridors. SEA aids spatial planning to align multiple developments in common corridors within natural landscapes to reduce the scale of habitat fragmentation and optimize the habitat use by wildlife species in larger fragments (Fig. 17.4a and b). EIA of individual projects forming a unit of multiple developments planned in corridors can subsequently help in designing project-specific and location-specific mitigation measures.

17.7 Recommendations

Transport infrastructure that will continue to remain a pervasive element in modern landscapes for meeting the expanding demands of a growing human population for mobility and commerce, will result in far greater challenges for movement of wildlife in fragmented landscapes. Considering that transportation projects largely become economic arteries, avoidance of their ecological impacts is rarely adopted as the foremost strategy that is emphasized in the mitigation hierarchy (Wildlife Institute of India 2016). Given this situation, structural mitigation planning driven by conservation science can at least have a greater chance of success in securing connectivity of wildlife habitats fragmented by road or rail corridors. Mitigation planning must be oriented to address the concerns of most extinction-prone taxa in the landscape and species that are highly sensitive to the specific impacts of development. Insights about the ecological requirements of species, movement patterns, behaviour and response to physical disturbances associated with transport projects provide a starting point for developing animal-friendly mitigation structures. This obviously necessitates the engagement of wildlife experts early in the planning of road or rail projects to identify target taxa, ecosystems and landscapes that must command priority for conservation. Consultations with road planners at this initial stage can provide an opportunity to review alternative route alignments and discuss design alternatives that can be made sensitive to animals' need for cover and shelter; feeding and

foraging, moving and ranging.

Other ecological considerations, such as location and size of mitigation structures; adaptability of species to these and influence of neighbourhood features also need to be adequately and appropriately factored in at a fine scale of resolution in the earliest stages of planning of the context-sensitive mitigation measures. The science of road ecology and rail ecology (Van der Ree *et al*. 2011; Agua *et al*. 2017) emerged from this narrative and would be valuable in improving the understanding of the ecological implications of roads and railways and how to avoid, minimize and compensate for their negative impacts on species, habitats and landscapes ecosystems.

Planning and implementation of mitigation structures cannot be done solely by the road agency. It should be a collaborative craft that requires inputs from transport agencies, planners, builders, engineering experts, conservation scientists and wildlife ecologists to engage in research and development of sensitive and yet technically feasible designs of crossing structures for enhancing the permeability of the road for animal movement. Road building and mitigation planning should therefore be made inseparable from the earliest stages of project planning, designing, constructing and managing the road.

Continuous long-term monitoring of crossing structures will always be the key to closing the gap between planning and successful implementation of the design. Monitoring needs to be an integral part of a mitigation project to allow agencies to evaluate the performance of their mitigation investments and informed decision-making with regard to planning and design of mitigation on future projects. For conservation groups, monitoring of the use of mitigation structures would help evaluate the functional connectivity and identify winners and losers from the conservation standpoint. Evidence monitoring established that all of the six lemur species were found using canopy bridges to cross roads and pipelines around the mining area in Madagascar (Mass *et al*. 2011); Colobus monkeys effectively used the colobridges to cross transportation or service corridors in Kenya (Donaldson and Cunneyworth 2015); and artificial canopy bridges were successfully used by slender lorises, palm civets and by wide variety of birds for perching in Indonesia (Nekaris *et al*. 2020).

The success of connectivity conservation efforts requires innovative models of collaborative governance to guide sectoral development plans, in order to have a greater conservation impact than the sum of the parts. SEA-driven assessments must be encouraged to inform decisions and reform policies to promote development plans that adequately safeguard the integrity of forest and other natural landscapes where multiple development corridors are planned. The inclusion of landscape in sectoral policies is needed to identify and promote compatible developments in common corridors, to avoid and reduce the landscape-level impacts of unplanned developments.

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