Sustainability and Biodiversity Conservation

Biodiversity loss due to road widening and a new highway

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Abstract

A vast network of motorized roads stretches throughout the region, revealing an unexpected ecological border. Road construction and maintenance can decrease the permeability of the terrain, lead to habitat loss, and exacerbate habitat fragmentation. Road collaboration is a major global trend that is improving transportation networks, but it also poses potential dangers to wildlife that haven't been well evaluated. Road networks impede significant interior species because they disrupt horizontal biological fluxes and change the spatial layout of the landscape. The decline in the amount and value of natural habitat is mostly attributed to transportation facilities, particularly road networks. A significant global trend is the twinning of roads to improve transportation networks; however, this practice may pose unknown risks to wildlife. This highlights the need for more carefully thought-out and planned infrastructure and road development, as well as for a deeper comprehension of the nation's hunting customs.
Keywords: Road, Habitat loss, Wildlife, Highway, Biodiversity, Species, Ecosystem, Widening

Introduction

The demand for natural resources is high and will only get worse due to the threefold rise in human population over the past century, and the projected additional next few decades will see a 3 billion increase (U.N. Department of Economic and Social Affairs, 2017). A nation's infrastructure, including its highways, powerlines, telecommunication towers, and urban settlements, must inevitably grow in order to support industrialization and the ensuing economic expansion. Roads make it easier to access markets, healthcare, and education, but they can also have a negative influence on the environment, communities, and economy. Typically, a road widening project is started when more lanes are required or when the current road width is insufficient for the volume of traffic. Vehicle capacity and safety may be

enhanced by increasing the width of the road. In general, road twinning involves transforming a two-lane road into a four-lane highway, with the opposing lanes being divided by various kinds of middle barriers. Roads are a widespread form of linear infrastructure that has various environmental effects on animal species worldwide (Van der Ree et al., 2015; Ibisch et al., 2016). The effects that the environment is affected by highways and transportation networks, its species, and therefore ecosystem stability have been highlighted for the past thirty years by the study of road ecology (Bennett et al., 2011). It is widely known that roads severely damage wetlands, streams, prairies, and woodlands. In addition to the direct habitat loss caused by the road itself and the animal species that are killed on the road, roads also change the patterns of water flow, increase noise, water, and air pollution, and lead to disturbances that change the species composition of nearby vegetation, reducing the amount of habitat available for native animals in the area, and hinder the movement of animals. Due to the features of the fluvial environment and biota, biodiversity is especially vulnerable to the development of new highways (Forman & Alexander, 1998). Biodiversity is simply the variety that exists in life. Under the Convention on Biological Diversity (CBD), "the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part" is the definition that has garnered broad acceptance. This covers a variety of both inside and between ecosystem species (Wilson et al., 1988). The dynamics of regional populations, the diversity of species, and the overall well-being of ecosystems may all be negatively affected by the direct mortality of wildlife caused by roads, the physical and behavioural barriers that keep animals from migrating, and the loss and degradation of habitat (Bennett, 1999; Forman et al., 2003). Among these effects, one of the most significant and obvious is wildlife that has been killed by vehicles after colliding with wild creatures (Coffin, 2007; Ceia-Hasse et al., 2017). When populations are significantly impacted by roadways, roadkill can be the cause of a considerable decline in animal biodiversity, particularly when the likelihood of recovery is low and death rates are high (Fahrig et al., 2009; Borda-de-Água et al., 2014).

1. Biodiversity

Biological diversity is the variety found in living things from all sources, such as terrestrial, marine, and other aquatic environments, as well as the ecological complexes of which they are a part (Johnson, 1992). This includes diversity of ecosystems as well as diversity within and between species. The Convention on Biological Diversity served as the basis for this definition. Consequently, the diversity of all species on Earth is referred to as "biodiversity" and expressly

acknowledges how the interaction of various ecosystem components leads to the provision of social and recreational opportunities as well as essential ecosystem services, including assisting as a source of inspiration and cultural identity. One of the most important environmental issues facing the world today is the preservation of biological diversity, or biodiversity (Noss & Cooperrider, 1994; George, 1999; Diamantini & Zanon, 2000). Since biodiversity is essential to the existence and adaptability of ecosystems and ecosystem services, research on the effects of human growth on wildlife and biodiversity is vital (Millennium Ecosystem Assessment, 2005).

2. Biodiversity and Abundance

Variety in living things from all sources, including but not limited to aquatic, is known as diversity within species, between species, and among ecosystems. terrestrial and marine environments, as well as the biological complexes that comprise them. (Millennium Ecosystem Assessment, 2005) Increasing access to isolated locations and wild food sources has been made possible by expanded road construction. Overhunting has played a significant role in the defaunation of ecosystems (Benitez-Lopez et al., 2017). This process entails a decrease in species richness, abundance, distribution, and variability. Since it can happen without any explicit changes in land use, such as deforestation, it tends to be difficult to identify from satellite data. Therefore, it becomes essential to conduct more focused research on how development activities affect biodiversity.

3. Effects of Road Widening and New Highways on Biodiversity

The primary danger to biodiversity protection today has been found to be the loss of habitat. When a natural ecosystem is transformed into an artificial system, as is the case for road building, the most catastrophic loss of habitat occurs. One of the most common ways that the landscape has changed in the last century, especially since World War II, is through the construction of roads (Trombulak & Frissell, 2000). The habitat conditions are damaged and modified by road developments, and this has an impact on the biodiversity, the quantity, and distribution of plant and animal species in the affected areas. According to reviews on the issue (Byron et al., 2000; Tszmokawa et al., 1997), road plans have a far higher chance of affecting natural areas than other types of development because of their linear layout. The extent of the phenomena can be seen by keeping in mind that roads and roadsides occupy between 1% and 2% of the land in many industrialized nations (Forman, 2000; Seiler & Eriksson, 1995), making road networks a ubiquitous element of almost any landscape. Highways result in habitat destruction both directly and indirectly. When a road and its verges reduce the overall size of

an ecosystem, it means that the natural land cover, such as woods, grassland, wetland, etc., has been replaced with an artificial surface (Fig. 1). This is commonly referred to as a direct loss. The term "indirect loss" refers to effects such as ecosystem degradation, which is the biophysical alteration of an ecosystem caused by artificial light, noise, air and water pollution, etc., and ecosystem dispersion, which is the dividing of an ecosystem into smaller, more isolated areas. These consequences lessen an ecosystem's capacity to maintain its initial biodiversity, which results in an indirect loss of habitat.

Figure 1. Tree-felling related to road laying in the Western Ghats

3.1. Direct Impacts of Roads on Biodiversity

Over the past three decades, the most commonly accepted effect of roads has been the direct death of wildlife through wildlife-vehicle accidents. This is because these encounters may impact public safety, especially when there are large carnivores and herbivores present, in addition to being noticeable to the general public. The research included in the review also raised two concerns: 1) that maintaining roadside habitat provides high-quality forage, nesting sites, or breeding sites for different kinds, drawing in animals, which increases their risk of wildlife collisions with vehicles (Jochimsen et al., 2014; Boves et al., 2012; de Freitas et al., 2014; Santos et al., 2013); and 2) road mortality increases in the vicinity of a protected area (Carvalho et al., 2011; Garriga et al., 2012). The second concern is that any new or existing road construction close to a protected area may have an impact on the species that the area is intended to protect. In the mid-70s, for instance, a new highway was built on top of a dike on the coast between the municipality of Barranquillas and the municipality of Santa Marta, without proper drainage works. As a result, natural water flows were interrupted, and the salinity in the coastal lagoon changed. This caused thousands of hectares (1,200 acres) of

mangroves to die. In addition to the high environmental costs, this loss of mangroves also jeopardizes the survival of a number of endangered species of birds, including the Sapphire-Bellied Hummingbird, a rare bird found only in the mangroves of the Atlantic coast of Colombia (Collar et al., 1992). A total of 215 papers providing details about how highways and networks of roads affect wildlife have been discovered (Bennett, 2017). Animals from many different taxa were included in these investigations; 36 studies focused on 86 percent were mammals, 23 percent were reptiles, 17 percent were amphibians, five percent were invertebrates, three percent were fish, and sixteen percent were birds. A total of 73 studies examined the indirect effects of roads on wildlife, while 55 particularly examined the direct effects.

3.2.Indirect Impacts of Roads on Biodiversity

Roads can have a wide range of indirect effects on animals, from altering behaviour to changing the quality of the habitat. The indirect effects of roads on wildlife were examined in 82 studies. Of these, 30% examined whether behavioural avoidance, also known as displacement, affected the distribution and abundance of wildlife near roads; 29% examined the fitness implications of wildlife proximity to roads; 29% examined the capacity of wildlife to cross roads physically and behaviourally; and the remaining 12% examined the habituation or attraction of wildlife to roads. Nine studies found that the amount of traffic near roadways reduced species diversity and abundance, and three of these studies also tried to measure the traffic volume thresholds at which species density started decreasing. The deterioration of the air, land, and water caused by pollution from dust, salt, silt, chemical runoff, noise, and light can also have an impact on the effect of road widening. Such pollution from roads can lead to habitat loss by altering the area within the road effect zone to one that is not favourable for biodiversity. According to one study, tadpole mortality for *Rana temporaria* could result in even a 500 mg/L increase in salt concentration (Dananay et al., 2015). It has also been proposed that road networks may play a role in the decline of habitat that is suitable for the Great Indian Bustard (S. Dutta et al., 2011). Another impact of road networks on the natural landscape is fragmentation, which puts the habitat of Bengal tigers in danger (Gubbi et al., 2017). According to Rathore et al. (2012), tigers in particular seem to be more impacted by habitat boundaries, traffic volume, and road density than by the simple existence of roads. However, tigers appear to suffer when there is a large population density along with rail and road networks (Dutta et al., 2016). Vast (≥ four-lane) paved roads (herein designated as highways) are generally hazardous to local ecosystems due to their vast surface area, high traffic volume, and potential to encourage urban expansion

(Angermeier et al., 2004). Rather than focusing on new construction, a large portion of the goal of India's road network growth has been to enhance and expand existing roads (Gubbi et al., 2012). On the other hand, building inside protected areas is becoming more common and might have a significant impact on wildlife. Current research conducted in India indicates that species richness is still high in low-disturbance areas with difficult-to-reach topography (Roy & Behera, 2005). These locations will most likely be more impacted by infrastructure development than others. It has also been proposed that road networks may play a role in the decline of habitat that is suitable for the Great Indian Bustard (Dutta et al., 2011).

4. Consequences of Highway Systems and Wildlife Populations

The effects of road networks on wildlife were only taken into consideration in 10% of the papers that made up this review. We must comprehend how current Road networks can isolate populations, disrupt resource networks, and create irreversible habitat degradation at the landscape scale, all of which have an impact on wildlife, and how increasing the density of roads can impact local and regional population persistence. In essence, road networks reduced the quantity of available wildlife refuges by increasing the area of the landscape that humans could reach. For instance, the persistence of game species populations is under jeopardy due to a considerable growth in the bushmeat trade (Fa et al., 2015). There will probably be an initial and noticeable loss of species as road development proceeds to divide the remaining areas of natural habitat. Concerns about how the growth of road networks could affect protected areas were also brought up in one study. Even though they are protected, roads can make it easier for people to access these places, the habitats that surround them, and the species that are of conservation significance. Roads therefore efficiently facilitate poaching and the illegal pet trade, which may obstruct and risk conservation efforts for numerous listed and endangered species (Fig. 2).

Figure 2. An endangered Desert Cat was run over by a speeding vehicle

5. Role of Seasonal Variations

The interactions between humans and animals at the intersection of highways are also influenced by changing seasons. During certain Indian festivals, there is an increase in pilgrimages to specific locales, many of which are in isolated mountainous areas, woods, or protected areas. An increase in the number of pilgrims typically corresponds with an increase in the number of vehicles visiting the pilgrimage sites. This rapid rise over brief periods has the potential to dramatically raise the fatality rate of animals hit by cars in protected areas. (Seshadri & Ganesh, 2011). Road mortality of reptiles was found to be connected with ambient air temperature, but road fatalities of amphibians are unrelated to mammals and birds and rise with rainfall received (Dutta et al., 2016). In contrast to the monsoon season, another study by Sundar and Kittur (2012) indicates that roadside habitat occupancy is higher for woodland birds during the summer and winter.

Stats: According to Disha Shetty's article from 2022, "Building Through Forests: The Tale of a Road Widening Project in The Western Ghats," NH-4A, also known as NH-748, is a national highway that connects Belgaum and Goa. The governments of Karnataka and Goa did not obtain the necessary environmental and other permissions for the NH-4A widening. Around the whole 82-km stretch of the 153-km highway on the Karnataka side, which passes through the Western Ghats, will be widened by the National Highways Authority of India (NHAI), an organization under the Central Ministry of Road Transport and Highways (MoRTH), at an estimated cost of Rs 1,395 crore, starting in March 2018. While local activists assert that the actual number of chopped trees is closer to 100,000, the NHAI calculates that approximately 22,000 trees were felled along the 82-kilometer route in October 2018. Previously, a portion of the 475 square kilometer Dandeli Wildlife Sanctuary, a PA, was home to some of the felled trees. India boasts one of the world's largest road networks, spanning over 5.89 million kilometers. As of December 2019, the length of India's national highways stood at 132,500 km, up from 91,287 km in April 2014, as per the most recent data given in January 2020 by the MoRTH (Fig. 3).

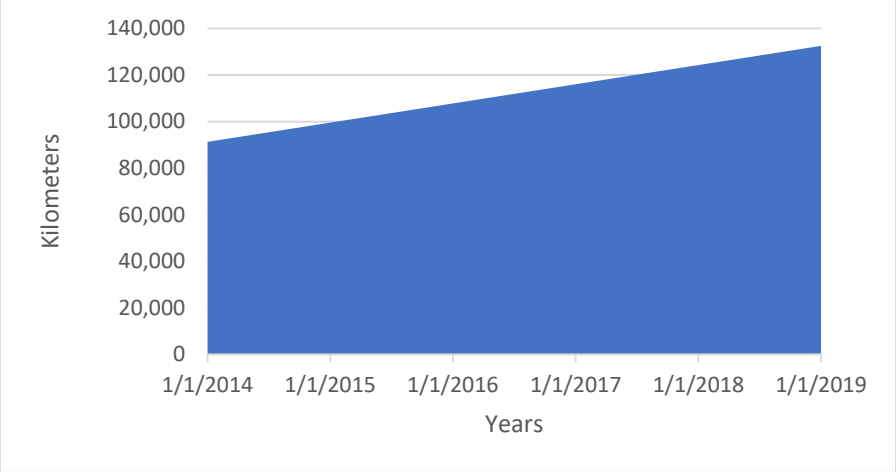

Figure 3. Length of highway increased **(**Data on expanding highways in India between 2014- 2019, given in January 2020 by the MoRTH)

Between 2013–14 and 2018–19, the Centre spent three times as much on national highways: Rs 33,745 crore and Rs 1.37 lakh crore, respectively. Ninety percent of all passenger traffic in India and around 64.5% of all products are transported on this road network. A kilometer-long section of this land [between Belgaum and the Goa-Karnataka border] has, on average, 1,000 trees. The forests beside NH-4A have been losing trees and gradually getting thinner over time, months after 22,000 trees were cleared by the NHAI in October 2018The Wildlife Protection Society of India reported that in 2018, 161 wild animals perished in incidents involving trains and roads throughout India. The Society supplied information on roadkill records for two species of animals: leopards and tigers (Fig. 4).

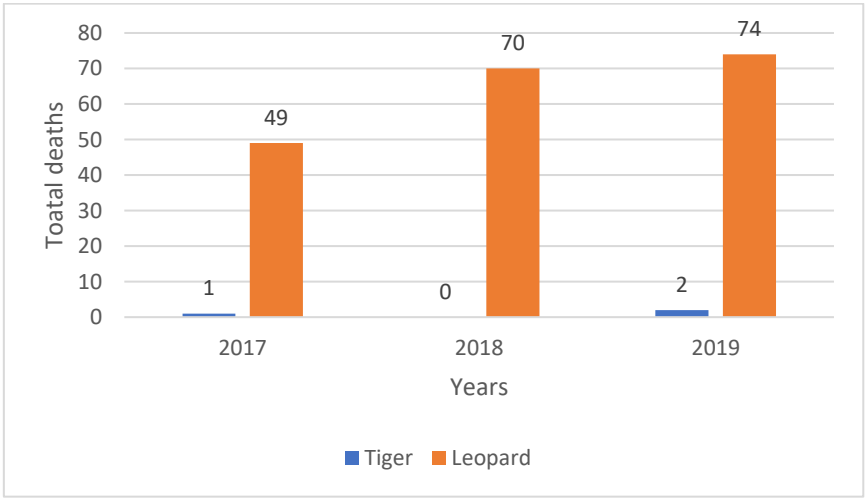

Figure 4. Tiger & Leopard deaths in road accidents in India
Sources: Wildlife Protection Society of India (WPSI). WPSI provided India Spend details of the number of tigers and leopards killed in road accidents
from 2017-19.

In addition to causing physical disruption, building roads in mountainous areas generates a lot of waste, which is frequently disposed of in neighbouring streams and rivers. This can lead to the destruction of riverine habitat and contaminate the water that is essential for the survival of birds and other wildlife.

6. Measures taken to avoid biodiversity loss

The following recommendations aim to lessen the detrimental direct effects that road construction, upgrading, rehabilitation, and maintenance have on natural habitats and biodiversity.

6.1.Project Site Selection

Similar to induced impacts, the most crucial step in preventing or minimizing negative direct impacts on biodiversity may be choosing the right road corridor and alignment. Environmental assessments that specifically take biodiversity into account are highly helpful in this regard (Tsmokawa et al., 1992; Byron et al., 1997) New or upgraded roadways must be situated to prevent crossings or other impacting highly sensitive regions, such as essential natural habitats, to reduce threats to biodiversity (Unless visiting these locations is specifically intended for a project (like tightly regulated tourism). Since many creatures that live in the woods are unable to safely traverse highways, it is especially crucial to reduce the fragmentation of natural forests to conserve biodiversity. For example, several monkey species live their whole lives in the trees and never venture across roads or other ground-level openings, such as the black-bearded saki (*Chiropotes satanas*), Humboldt's woolly monkey (*Lagothrix lagothrica*), and spider monkeys (*Ateles spp*.) in the Amazon jungle. In the absence of suitable infrastructure corridor planning, the numbers of these organisms may become severely subdivided and genetically isolated, jeopardizing their long-term survival.

6.2.Road Engineering

Effective road design and construction can significantly reduce damage to biodiversity while also lowering other types of damage. Making sure the road has adequate drainage beneath it is one of the most crucial engineering decisions. In particular, sufficient bridges, culverts, or other drainage projects are required to preserve the natural water flows of streams, lagoons, and other wetlands. Significant harm to aquatic and terrestrial biodiversity can occur when a road serves as a dike or dam due to absent or insufficient drainage infrastructure (as with the Colombia mangrove example cited earlier). Many highways in forested locations could be built with a partial tree canopy covering them. Forest fragmentation would be lessened and a large number of animals may safely cross the road via arboreal "bridges" in this way. Strategically positioned

speed bumps, keeping important road segments at lower standards to limit traffic speeds, caution, and animal-crossing signage, and more extensive educational programs are further ways to reduce wildlife road deaths (Evink et al., 1999; Brown et al., 1999).

6.3.Complementary Works

The location of construction sites, storage yards, and other related projects can have an impact on biodiversity, just as the highways themselves. These facilities ought to be located as far away from marshes, woods, and other natural ecosystems as is practical. Such facilities ought to be planned in a way that minimizes the destruction of native plants while still meeting efficiency and safety standards in natural habitat areas.

6.4. Construction and Maintenance Practices During construction

It can be crucial to adhere to sound environmental practices to preserve biodiversity, particularly aquatic biodiversity. Installing sediment traps and other safeguards to prevent runoff and soil loss during construction is one way to help preserve the water quality and aquatic life in surrounding ponds, streams, and other wetlands. To prevent the pollution of wetlands and rivers, excavated soil must be disposed of in pre-approved places along with all other solid and liquid wastes. These artificial ponds should have the following characteristics to be most beneficial to biodiversity: (a) gradual, rather than steep, banks to encourage the growth of flora and wildlife use; and (b) an irregular, rather than straight, size, especially with small regions, bays, and even islands. Appropriate Important biodiversity can often be preserved by natural plant management along a right-of-way or legal corridor of a road. For human safety (emergency parking, pedestrian walking space, and visibility around curves), it is crucial to keep a narrow strip next to the road clear of tall vegetation. However, if natural vegetation is preserved, the remaining right-of-way may be useful for biodiversity conservation**.**

6.5. Worker Behaviour

Controlling field worker behaviour is crucial to minimizing damage to biodiversity when building (or improving, renovating, or maintaining) roads. It needs to be expressly prohibited for personnel on construction projects or on roads to go hunting, fishing, or trapping wildlife, including pets. gathering plants, or burning natural vegetation anywhere on or close to the project site. Handguns should be restricted to security officers alone. Not permitted for other employees. Employees must be made fully aware of these and related environmental codes of conduct, and there must be obvious, severe consequences for breaking them.

6.6. Environmental Supervision

Strict environmental supervision of road construction is required to guarantee that harm to biodiversity (or other environmental problems) is prevented or appropriately mitigated in the field. Projects in natural habitats and other environmentally delicate regions particularly need to consider this. Road construction contracts and bid agreements should outline the environmental regulations that contractors must adhere to, as well as the procedures for environmental supervision and noncompliance fines (Quintero et al., 1999). First implemented in the early 1990s, these standards set institutional norms and offer a way to incorporate best practices and mitigating measures into projects funded by the World Bank, such as the ones mentioned. The policies of Natural Habitats and Environmental Assessment, 1999.

Conclusion

Roads' adverse impacts on biodiversity can include higher death rates, evictions, habitat degradation, and a loss of landscape connectivity. Road networks and transportation infrastructures are largely held responsible for the decline in natural habitat quantity and quality, endangering biodiversity conservation measures. With a few notable exceptions, most animals and birds tend to decrease in number of groups, herd/group sizes, population density, abundance, and group count as they get closer to roads and other infrastructure. In the environment around the road, roadside vegetation serves a wide range of important purposes. In large part, the vegetation cover makes it possible to restore the natural environment's equilibrium after it was upset by the expansion of road infrastructure. Roads may help herbivores create microhabitats when they are less disturbed, but this also makes the animals more vulnerable to road deaths, particularly at night. According to Rathore et al. (2012), tigers in particular seem to be more impacted by habitat boundaries, traffic volume, and road density than by the simple existence of roads. Enforcing guidelines effectively would significantly lessen the disputes that arise between road construction and biodiversity preservation. Following good environmental standards during project seated, construction, engineering, and maintenance can significantly reduce conflicts between road building and biodiversity protection. Reducing the immediate harm that road construction projects cause to biodiversity entails. It is necessary to adhere to best practices in environmental aspects of project siting, engineering, construction, and maintenance to decrease the detrimental direct effects of road projects on biodiversity.

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