Biodiversity and development corridors: Where does the issue stand?

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Introduction

Development corridors are recognized as certain geographical area designed to captivate the new investments, enhance agricultural productions, unimpeded access of natural resources to ease their export in the global markets (Juffe-Bignoli *et al.,* 2021). Although economic objectives are accomplished, challenges of development corridors such as loss of ecosystem integrity, biodiversity, Natural Capital, and social cohesion can cause multiple major impacts. Due to the current 'boom' in infrastructure advancements, development corridors are forming strategic pathways in order to progress economic values. As stated by Laurance *et al.* (2015), in Africa, 33 corridors were noteworthy examples which potentially cross 400 protected areas, or initiatives in Latin America, Asia, Europe, and Oceania. As an example elaborated by Li Shuen Ng, *et al.*, (2020), the Belt and Road Initiative (BRI) is a concept being taken globally by the Chinese economic and political programme, initiated in 2013, consisting of minimum six interconnected corridors across the land and sea and over 15 countries in Asia and Europe. According to de Bruyn *et al.* (2014), China's BRI corridors overlap with biodiversity hotspots such as those across Southeast Asia. According to, Li Shuen Ng, *et al.,* (2020), Southeast Asia is among the most biodiverse regions in the world, home to four of the Earth's 34 biodiversity hotspots and supporting a large number of endemic species, thus pointing out a major conservation concern. If ill-made, these corridors can provide innumerable economic advantages as well as impacts laid upon its surrounding biodiversity resulting in land degradation which causes habitat loss and therefore animals lose their resources for living. Such development corridors can have potential risks that might happen due to illegal activities like poaching and logging if improperly

maintained. The main objective of this review article is to highlight the contemporary situation about strategical planning to monitor these corridors which have now become an utmost necessity in this present time.

Impacts on biodiversity

Research Questions and background context:

There could be three types of impacts which fall under the circumstances during the construction of such development corridor which are- **Direct**, **Indirect** and **Cumulative** impacts (Figure 1).

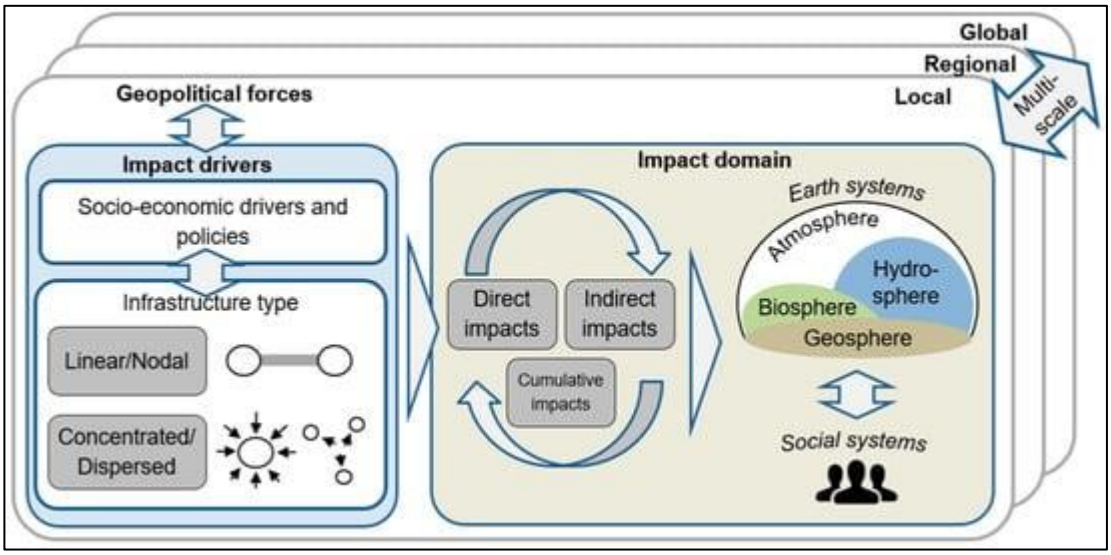

Figure 1: Various types of impacts generated from development corridor construction described in this image by Teo et al., 2019 (https://doi.org/10.3390/environments6060072)

Direct impacts are impacts directly imputable to a defined action or project activity (e.g., a road) **Indirect impacts** are the set off in response to the presence of a project, rather than being directly caused by the project's own operations (e.g., habitat loss due to population increase caused by the presence of the road). **Cumulative impacts** stands for the total combined impact emerging from another project (under the control of the developer); other activities (that may be under the control of others, including other developers, local communities, government), and other background pressures and trends which may be uncontrolled (e.g., other roads, other causes of population growth resulting in additional impacts, climate change impacts, etc.) (Juffe-Bignoli *et al.,* 2021). According to Juffe-Bignoli *et al.,* (2021), of all the scientific literature they

reviewed between 1971 and 2020 that refer to biodiversity and ecosystem services, some of the most important questions that arise, are following:

Do the responsible people really assess the ecosystem services and effects on biodiversity?

If they do, do they quantitate and evaluate how, in which stage of project an impact might happen?

In impact mitigation science, do these estimation methods really follow for what is considered as utterly appropriate practice?

Biodiversity impacts are infrequently considered in studies in a worthwhile way and impacts on ecosystem services are mostly neglected oftentimes. Of 271 studies performed by Juffe-Bignoli *et al.,* (2021) in a review article, only 100 (37%) assessed impacts on biodiversity and 7 (3%) addressed impacts on ecosystems services. A mix of biodiversity metrics combining species, protected areas or other important conservation areas are seen rarely in any publication (14%). It has been seen that most of the scientific studies hardly managed to follow the hierarchy of mitigation which is believed as an exemplary conducting framework to subside the impacts. It proposes four successive but ceaseless stages to manage impacts to achieve positive outcomes for nature: avoid, minimise, restore, and offset (Juffe-Bignoli *et al.,* 2021).

Infrastructure development and in particular linear infrastructure such as roads and railways cause the declination and extinction of wildlife populations in terrestrial ecosystems through habitat loss, degradation, and fragmentation. Fragmentation from linear infrastructure has a number of negative effects such as the isolation of remnant habitat, increased wildlife mortality from roadkill, facilitation of biological invasions, accelerated forest conversion and due to effortless obtainability, illicit activities like poaching have been escalated along with illegal exploitation of natural resources. As an example, across Africa, development corridors (networks of railways, roads, pipelines, and ports) that ease the mobilization of commodities between landlocked production areas, processing zones and global markets – are being built at an unprecedented pace (Li Shuen Ng *et al.,* 2020). Thus, it remains apposite to critique and reveal the BRI (Belt and Road Initiative) and the threat to natural assets at distinct scales with limited plans to manage the destruction. In Pakistan, some of the most crucial indigenous biodiversity are present, consistently contributing to natural ecosystems**,** but, the development corridors are

constituting ecosystem degradation by destroying this biodiversity (IUCN, 2012). The endless disturbance because of several topographic changes, arising in both intensity and scope, is increasing vulnerability of the ecosystem in the northern areas of Pakistan (Abbas *et al.,* 2016, Wahlen, 2019, Gilgit-Baltistan Wildlife Department, 2017, Arshad *et al.,* 2013). These changes are very essential to rationalize projects surrounding economic or development corridors by the help of pro-active mitigative actions to look after ecosystems.

As Juffe-Bignoli *et al.,* (2021) showed in their review article, it has been seen that, studies mostly look at direct impacts only and try to minimise those after they happen such as 62% of studies only assessed direct impacts, mostly using buffers to measure indirect impacts, and not measuring cumulative impacts and only 37% did this in the conception stage which is when more impacts can be avoided (Table-1) Plausible advances and policy instruments are present in mitigation science that can and should be used: tools and approaches are available to explore the best way to prosper the infrastructure needed without destroying the natural resources but the use of these for development corridors is yet to be explored. Strategic Environmental Assessments and Mitigation Policies are tools for policy which can help taking a strategic approach to mitigate impact and follow the positive outcomes paradigm.

Table 1: Different methodological aspects for biodiversity mitigation estimated for studies after screening in a full text level

Coded variables	Best practice recommendation	Definitions and scope of assessment
When were impacts assessed	Assess potential impacts in early stages of development to avoid significant impacts before the projects start.	• Stage of corridor when impacts were assessed (**Figure 1A**) • Assessment completed before (*ex ante*) or after (*ex post*) construction of a project within a corridor.
Types of impacts measured	Account for all potential direct, indirect, and cumulative impacts associated to development.	We searched for three types of impacts on biodiversity (BBOP, 2018): • Direct impacts: impact directly attributable to a defined action or project activity (e.g., a road) • Indirect impacts: impacts triggered in response to the presence of a project, rather than being directly caused by the project's own operations (e.g., habitat loss due to population increase caused by the presence of the road). • Cumulative impacts: total combined impact arising from another project (under the control of the developer); other activities (that may be under the control of others, including other developers, local communities, government), and other background pressures and trends which may be unregulated (e.g., other roads, other causes of population growth resulting in additional impacts, climate change impacts, etc.).
Methods used to assess impacts	Select appropriate metrics to account for all biodiversity losses due to development, including assessments of biodiversity extent and condition.	• Metrics used to measure biodiversity impacts. • Use of geographically referenced data and/or spatial analyses tools to assess impacts. • Techniques and combinatorial tools used to assess impacts for spatial and non-spatial analyses (e.g., modeling, buffer overlaps, field data collection, stakeholder surveys).
Use of the mitigation hierarchy	Follow all phases of the mitigation hierarchy (avoid, minimise or reduce, restore or rehabilitate, offset or compensate) to manage impacts of development and aim for no net loss or net gain of key biodiversity.	• Explicit use: publications mentioning or using the mitigation hierarchy as a framework to manage impacts. • Implicit use: publications mentioning phases of the mitigation hierarchy and/or actions that equal to mitigation hierarchy actions. • No mention of the mitigation hierarchy
Proposed mitigation measures	Consider existing biodiversity impact mitigation policies and develop strategies and action plans focusing on priority biodiversity elements and identify specific management actions. Monitor performance and impacts and do adaptive management.	• General to specific measures proposed to manage impacts on biodiversity. • In which phases of the mitigation hierarchy were those measures proposed. • Proposed indicators to monitor impacts and mitigation management.

Note. From "Methodological aspects of biodiversity mitigation evaluated for studies screened at full text level." by Juffe-Bignoli et al., 2021, "Mitigating the impacts of development corridors on biodiversity: a global review." Frontiers in Ecology and Evolution 9 (2021): 683949; (*https://doi.org/10.3389/fevo.2021.683949*)

A case study in brief:

A case study performed L.S. Ng *et al.* (2020), on the impacts of biodiversity for Belt and Road Initiative (BRI) (Figure. 2) in China, is an exceptional example for the biodiversity impacts to be understood factually. They assessed impacts on terrestrial and marine ecosystems of Southeast Asia including forest cover, terrestrial ecoregions, threatened species, biodiversity indicators (terrestrial and marine), Key Biodiversity Areas (KBAs), fragile ecosystems like coral reefs, mangroves, seagrasses. In Southeast Asia, BRI is increasingly seen as a threat to the already imperilled biodiversity, given the scale of its infrastructure footprint on frontier ecosystems and endangered biodiversity in the region.

Figure 2: The Belt and Road Initiative (BRI) shown in a world map basis (Source: Air Power Asia, Link: https://airpowerasia.com/2020/07/22/belt-and-road-initiative-strategic-goals-now-a-debt-trap-security-implications-india/)

It had been seen in the analyses that, of threatened species within the vicinity of Infrastructure were present. Within the 5 km buffer, BRI infrastructure overlaps with the ranges of 196 threatened species (81 mammals, 65 birds, 15 amphibians, and 35 reptiles). Linear infrastructure can fragment their habitat resulting in small patches which are too small to sustain viable

populations in the long term, leading to local extirpations and increasing the risk of global extinction. Amphibians that are threatened, found to be most vulnerable vertebrate class in the analyses (i.e., compared to birds and mammals). Because species with restricted distributions or small population sizes experience greater barrier effects and are more susceptible to extinction due to their sensitivity to stochastic changes (Jochimsen *et al.*, 2004).

Devoid of a proper strategic planning of these development corridors, the essential threatened species population can be doomed to their destruction due to high fragmentation leading to general isolation and thus threatening their long-term-survival.

One of the foundations for addressing BRI impacts is good spatial planning; thus, identifying routes, projecting future impacts, and identifying mitigation measures on the ground is fundamentally important. There is an urgency for detailed and greater clarification in and around proposed BRI routes and the advancement of a framework to understand and project impacts (Teo *et al.,* 2019). A way towards impact mitigation:

According to a review study performed by Juffe-Bignoli *et al.,* (2021), simple techniques were proposed as they suggest to assess the linear vicinity and overlapping of planned corridor footprint or overlapping occurring with a buffer established surrounding the corridor. Few based heir impact assessments through the collection of data by field surveys but there is a large gap in actual quantification of monitoring corridor performances. In a review article, scientists found that, there were only two publications especially analysing the impacts of development corridors on ecological connectivity (Heinicke *et al.,* 2019; Wierzchowski *et al.,* 2019), despite that habitat fragmentation is one of the most well-established effects of infrastructure development (van der Ree *et al.,* 2011; Barrientos *et al.,* 2019), which sometimes happens in early phases of corridor construction.

As stated by Bigard *et al.* (2017), and later by Simmonds et al. (2020), evidently, formal impact assessments have had enough scarcity in case of details on biodiversity impact mitigation. But as times progresses, some ways have unfolded to suppress via several mitigation procedures in order to fulfil lacunae. Tools for impact assessment, such as EIA (Environmental Impact Assessment) and SEA (Strategic Environmental Assessment) could be the conduit by which best practice and regulatory needs are implemented at a national level. SEAs seem particularly well-

suited to do this as SEAs necessarily involve stakeholders coming together to assess environmental, social, and economic risks and alternatives to development at policy, planning and programming levels. This outlook is critical for responding to the trans-frontier nature of development corridors, while providing these align with broad sustainability strategies and national policies (Ramachandran and Linde, 2011).

Conclusion

To plan a project strategically, one has to learn about sensitive regions, fragile habitats, and ecosystem conditions as much as possible so that impacts of developmental corridors on biodiversity can be mitigated in this everchanging world. Infrastructure advancement is necessary from different aspects around the globe but without a doubt, it is not supreme. As well as uncertainty in the ways and routes of development corridors, uncertainty accompanied with the biodiversity data and modelling of indirect impact procedures necessitate considerable amount of research. There is a general gap of research on the effects of road and rail on wildlife especially for rail impacts and especially within Southeast Asia (Li Shuen Ng *et al.,* 2020).

Honestly detailed Environmental Impact Assessment should be able to plan projects near vulnerable habitats of threatened, nearly threatened and vulnerable taxa and for the effortful conservation measures towards them. The development of associated infrastructure, both in the immediate vicinity and in the production of raw materials will also need careful planning to avoid further associated ecological damage to native ecosystems and species. Some of the efficient tools such as SEA (Strategic Environmental Assessment) and EIA (Environmental Impact Assessment) are highly effective in order to analyse impacts of proposed plans, projects and policies. Ultimately, the impacts are always dependent on initiatives being taken, how implementation of policies are done, how infrastructure is being developed to ease wildlife movement that is, to safely bypass in their route and inhibition of effortless human access. Thus, a multitude of impact mitigation role would be played appropriately by responsible people.

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