ANNEX 2: CASE STUDIES OF WILDLIFE-FRIENDLY LINEAR INFRASTRUCTURE AND THEIR COMPARATIVE ANALYSIS

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ACRONYMS

ADB	Asian Development Bank
BBA	Biodiversity Baseline Assessment
CLLC	Center for Large Landscape Conservation
CNP	Chitwan National Park (Nepal)
CWS	Chunati Wildlife Sanctuary (Bangladesh)
DNPWC	Department of National Parks and Wildlife Conservation (Nepal)
DoRW	Department of Railways (Nepal)
EDC	*Electricité du Cambodge* (Cambodia)
EIA	Environmental Impact Assessment
FWS	Fasiakhali Wildlife Sanctuary (Bangladesh)
IUCN	International Union for the Conservation of Nature
LI	Linear Infrastructure
MNP	Medhkachhapia National Park (Bangladesh)
NB	Narayanghat to Butwal (Nepal)
PA	Protected Area
PLN	Perushaan Listrik Negarat
PNP	Parsa National Park (Nepal)
PWS	Phipsoo Wildlife Sanctuary (Bhutan)
QTR	Qinghai – Tibet Railway (China)
RNP	Road Network Project
SASEC	South Asia Subregional Economic Cooperation
USD	United Stated Dollars
WCS	Wildlife Conservation Society
WFLI	Wildlife-Friendly Linear Infrastructure

WHC	World Heritage Committee
WTI	Western Transportation Institute
WWF	World Wide Fund for Nature (formerly World Wildlife Fund)

INTRODUCTION

Case studies can be useful when there is a need to feature practical principles and methods that help accelerate progress in addressing challenges (Crowe et al., 2011). This annex presents a compilation of of linear infrastructure (LI) plans or projects for the three modes—roads, railways, power lines—that have implemented wildlife safeguards. We examine the processes, policies, and decision making that differentiate successful projects deploying wildlife-friendly linear infrastructure (WFLI) from those that failed to mitigate their adverse impacts effectively. We sought to include recently built or planned LI developments in Asia that serve as exemplary WFLI projects.

Implementation of biodiversity safeguards is relatively new in Asian LI projects, but is clearly gaining attention and institutional acceptance in recent years (Clements et al., 2014; Donggul et al., 2018; Menon et al., 2015). The projected growth in LI projects in Asia in the coming years (see Annex 1) underscores the critical need to ensure that projects are properly evaluated, use reliable field data, and are based on the best available science when recommending WFLI practices and mitigation measures.

In the past, environmental impact assessments (EIAs) have often focused on general, broad-based LI project impacts on the ecological and physical elements of biodiversity protection. Few have focused on species-specific requirements, nor on the critical landscape connectivity needs of wildlife, their movement, and migrations. The case studies that follow have been selected as examples of WFLI-based methods, practices, and outcomes. Collectively, they will inform LI practitioners in Asia as they move toward sound biodiversity safeguard practices.

Comparisons of the costs and benefits of implementing WFLI safeguards are scarce for most Asian LI projects. As a result, some agencies and other LI proponents regard environmental safeguards only as a project cost. Today, a growing number of proposed LI projects includes not just the cost of implementation of these safeguards, but also the economic benefits of such investments, most often in the financial feasibility analyses. As cost-benefit analyses for WFLI safeguards are becoming more common, two of the selected case studies focus on projects that conducted economic analyses and describe the tools used to conduct these investigations.

METHODS

Potential case studies were identified and collected from across Asia via the literature review (Annex 4), by attending virtual international meetings on road ecology, by an e-mail request to members of the appropriate International Union for the Conservation of Nature (IUCN) Specialist Groups, and through direct contact with transportation practitioners in Asia. We identified, compiled, reviewed, and evaluated 23 potential case studies for inclusion in this annex. Ultimately, we selected eight case studies—six ecological and two economic—for inclusion in this annex (Figure 1).

In selecting case studies, we strived to represent Asia's broad geography, the three modes of LI, and important IUCN-listed species impacted by the projects that represent the diverse taxa of the continent. We include projects that described new or innovative policy, economic assessment, planning, or performance evaluation of WFLI safeguards in Asia.

Figure 1: A map of case study types and locations.

CASE STUDIES

Among the six ecological case studies, two were of road projects, three of railways, and one of power lines. The six case studies encompass five countries: Bangladesh, Bhutan, Cambodia, China, and Nepal. The economic case studies consisted of a power line in Indonesia and a road project in Malaysia. Thematically, the ecological case studies covered aspects of project planning (biodiversity baseline assessments [BBAs]), environmental impact assessments [EIAs], and post-construction implementation of safeguards and their performance.

CASE STUDY 1. RAILWAY: CHITTAGONG – COX'S BAZAR (BANGLADESH)

BASIC INFORMATION

Linear infrastructure mode: *Railway*

Country: *Bangladesh*

Project name/location: *Chittagong – Cox's Bazar Railway, Dohazari to Cox's Bazar (Districts of Chittagong, Bandarban, Cox's Bazar)*

Proponent: *Government of the People's Republic of Bangladesh, Asian Development Bank*

SAFEGUARD PLANNING AND POLICY

Impact Assessment

The Chittagong – Cox's Bazar Railway is a proposed dual-gauge rail line that will run for 102 km from Dohazari to Cox's Bazar in southeastern Bangladesh as part of the Trans-Asian Railway system. Intended to carry both passengers and freight, the railway will advance the South Asia Subregional Economic Cooperation (SASEC) program's goal of strengthening regional transport and trade. However, the proposed railway alignment crosses through three of Bangladesh's 24 legally protected areas (PAs): Chunati Wildlife Sanctuary (CWS), Fasiakhali Wildlife Sanctuary (FWS), and Medhkachhapia National Park (MNP) (Figure 2). All three PAs are known to support Asian elephants, which the IUCN lists as endangered. Since the rail alignment passes through PAs that harbor one or more endangered species, the Chittagong – Cox's Bazar Railway has been classified as a Category A project in accordance with the Asian Development Bank (ADB)'s Safeguard Policy Statement. All Category A projects require an EIA.

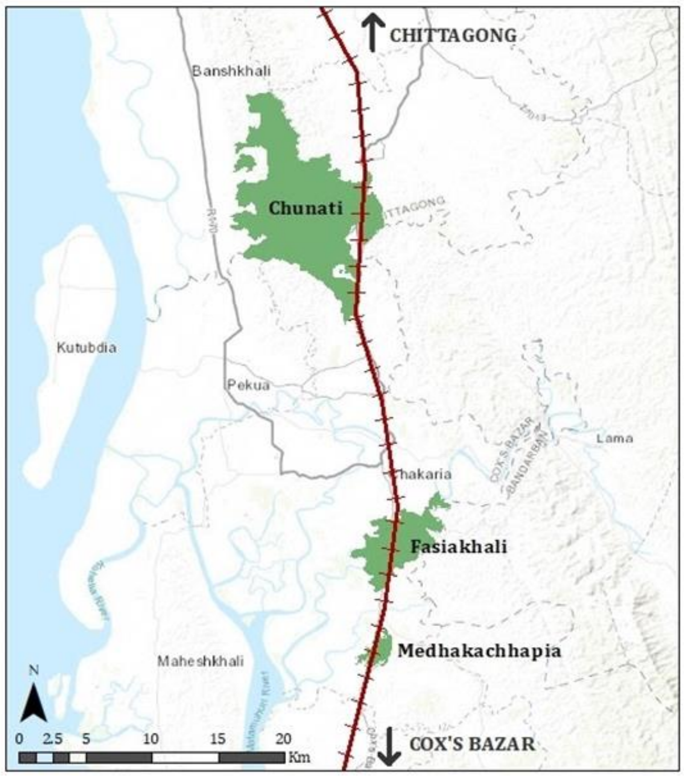

Figure 2: A map of the proposed alignment for the Chittagong – Cox's Bazar Railway relative to the locations of three protected areas: Chunati Wildlife Sanctuary, Fasiakhali Wildlife Sanctuary, and Medhkachhapia National Park.

Bangladesh's National Environmental Policy (MoEF, 1994) sets out the basic framework for environmental action and states that EIAs must be conducted before projects are undertaken. Under the Bangladesh Environment Conservation Act (1995) and its Rules (1997), the project was classified as Category Red by the Department of Environment, which also triggers a full EIA. As part of the EIA, the IUCN conducted a rapid assessment in 2014, which surveyed the status of Asian elephants within the project area, identified elephant travel corridors and crossing points that intersected the proposed alignment, and interviewed locals regarding human-elephant conflict (IUCN, 2014). The study found that the proposed railway would intersect with five active and six seasonal elephant crossing points, and proposed subsequent management options for promoting elephant connectivity and minimizing potential elephant-train collisions (IUCN, 2014). Based on this study, a BBA was then conducted with a specific focus on elephants in the PAs to provide recommendations for mitigation measures (Dodd & Imran, 2018). Using elephant signs (e.g., dung, tracks, and vegetation damage), surveys, and camera trapping, the BBA identified elephant crossing areas along the proposed route of the railway within all three PAs.

IUCN Red Listed or Focal Species

Asian Elephant (*Elephas maximus*), Indian wild boar (*Sus scrofa cristatus*), Barking deer (*Muntiacus muntjac*), Fishing cat (*Prionailurus viverrinus*)

EIA recommendations

The BBA found that approximately 27 kilometers (km) of the proposed 102-km rail line would pass directly through the three PAs, parts of which constitute critical habitat for Asian elephants. The alignment would impact each park differently, passing through a mixture of Core Zones (relatively intact forest), Buffer Zones (degraded, but no new human settlement or cultivation), and Impact Zones (degraded, settlement and cultivation permitted). The BBA found that the Core Zones typically corresponded with critical habitat for elephants. While the majority of the railway alignment falls outside of the Core Zones, the BBA found that it would still block crossings in a few key Core Zones in CWS and was likely to hinder elephant movement in other locations.

A conservation and mitigation strategy was developed by the authors of the BBA based on the best available science for WFLI. Using a "toolbox" approach, the authors used a combination of best practices to address both the direct (e.g., collisions) and indirect (e.g., habitat fragmentation) impacts of the project on wildlife and biodiversity. This strategy included several mitigation measures: wildlife overpasses and underpasses, technology for detecting elephants within a certain distance of the railway, and funneling treatments such as fencing to direct elephants to safer railway crossing points.

In CWS, the mitigation strategy focused on protecting elephant corridors by promoting landscape connectivity and preventing elephant-train collisions at concentrated crossing locations. The BBA recommended two wildlife overpasses (50 meters (m) wide), although one site was later found to be technically unsuitable; one underpass (10 m x 4.5 m); and an open span bridge (30 m x 4.5 m). These will be the first wildlife crossing structures built in Bangladesh and some of the first in Asia for elephants impacted by a railway. To ensure that elephants and other wildlife use these structures, the BBA also proposed a total of 6.8 km of funneling fencing along both sides of the rail, with level-at-grade crossings at four fence termini, two with elephant detection systems to alert trains to approaching/crossing animals.

In FWS, the focus was on the resolution of human-elephant conflicts. The BBA found that elephant movement out of the Core Zone (and thus crossing the proposed alignment) was limited to seasonal crop raiding. Recognizing that installing crossing structures would only perpetuate this conflict, the BBA instead recommended approximately five km of elephant exclusion treatments, which would also serve to prevent elephant-train collisions. However, as implementation was pursued, the Bangladesh Forest Department was not supportive of fencing on their land, and the goal was thus amended to prevent elephant-train collisions by fencing three stretches where elephants cross to raid crops (1.8 km total), installing six level at-grade crossings, and deploying animal detection systems at fence termini. In addition to fencing, the strategy also included elephant forage enhancement, including salt licks and water enhancement.

In MNP, 2.8 km of funneling treatments and two elephant detection systems were recommended to allow safe at-grade passage at the ends of the funnel fences. Also, in addition to tree afforestation, over 300 hectares (ha) of elephant forage enhancement has been funded and 60 ha planted to date, with funding of salt licks and water enhancement funding forthcoming (Figure 3).

Within the three PAs, there are also 28 concrete box culverts planned to facilitate the movement of smaller species under the rail-line. The culverts would be three m or taller, and spaced throughout the PAs, approximately one culvert per km. There are also nine bridges planned (in addition to the oversized elephant underpass) to provide passage for species such as deer, cats, civets, and porcupines. Collectively, these structures will also help maintain connectivity within populations, reduce the potential for wildlife-train collisions, and preserve the unique and rich biodiversity of the Cox's Bazar region.

Figure 3: ADB environmental specialists planting trees in tree plantations program in Medhkachapia National Park. Credit: Asif Imran.

Safeguard sufficiency

According to both the project EIA and the BBA, all three PAs contain critical habitat that supports populations of endangered Asian elephants, despite impacts from past human activities (Dodd & Imran, 2018; Ministry of Railways, 2016). The PAs also still contain high biodiversity value, which provides vital ecosystem services to local communities. However, the BBA does make clear that certain non-Core Zone areas around the proposed alignment, such as in FWS, are not necessary for elephant survival. Balancing the facilitation of elephant movement and the mitigation of human-elephant conflict was thus considered in determining safeguards for some areas.

The safeguard strategy was designed to balance cost-effective engineering and construction with the conservation of biodiversity, while also complying with ADB's Safeguard Policy Statement. Using a data-driven approach and drawing from both the BBA and engineering design information, this novel strategy addressed mitigation of the railway impact from multiple perspectives, including preserving Asian elephant corridors, preventing elephant-train collisions, and resolving the causes of human-elephant conflict. The greater socio-ecological context of each PA was also considered, leading to different primary and secondary goals tailored to each situation. By drawing from a "toolbox" of safeguard techniques, the authors of the BBA ensured that their mitigation recommendations, whether passage structures, detection systems, or funneling treatments matched the potential issues at each location.

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

At the time of publication, the project had not yet entered into the post-construction phase during which monitoring can be conducted to assess performance.

Of the BBA recommendations for safeguards, one of the two wildlife overpasses in CWS was not built because it was determined infeasible after it was designed, due to its location less than 1 km from the other overpass. The international road ecology consultant who conducted the BBA has been serving as an independent monitor during construction of the railway, and is contracted to conduct post-construction monitoring for the ADB. Post-construction monitoring of the three passage structures will begin in 2023 and has been programmed to last a minimum of two years.

Camera monitoring continues to assess the impacts of railway construction on elephants and other wildlife species. The underpass is currently under construction, and construction of the planned bridge is nearing completion (Figure 4). Design of the overpass has been redone and construction is anticipated to begin in 2021. A 0.7-km construction "quiet zone" was also established around the overpass site to limit impact to elephant use of the corridor during construction, until a nearby underpass was completed as an alternative for elephant passage (Figure 5).

Figure 4: Wildlife underpass abutments awaiting girders and then excavation on Chittagong – Cox's Bazar railway project. Final dimensions: 4.5-m height, 30-m length. Credit: Asif Imran.

Figure 5: Elephant tracks detected near the construction site of a wildlife underpass. Credit: Asif Imran.

Success or Failure?

While the Chittagong – Cox's Bazar Railway and its proposed wildlife safeguards are still under construction, the BBA should be considered a success. Under the Terms of Reference, the BBA was required to last a full year to encompass season variation. By extending from April 2017 to March 2018, the authors were able to better understand the full scope of habitat use by elephants and other species, and thus make more informed safeguard recommendations. Additionally, the authors were able to make crucial partnerships with local experts, including those from the Bangladesh Forest Department. Other local residents, such as the Community Patrol Group, were involved in the process, providing knowledge on the local flora and fauna. Once implemented, this project will constitute one of the most advanced, socially responsible, and environmentally friendly LI projects in Asia and perhaps, the world.

LESSONS LEARNED

There are several important lessons that can be gleaned from the Chittagong - Cox's Bazar Railway case study. The project is a great example to follow for other LI projects in Asia and worldwide. It provides a particularly important and relevant model of what to do when critical ecosystems, endangered species, and unique biodiversity assets can potentially be harmed by a new LI project. The three important lessons are described below.

1) *Understanding of project complexities*. We are reminded of the complexities of LI projects and the impacts that land use change has not only had on wildlife, but also on local communities and

their economies. In certain cases, safeguard measures that may seem to benefit wildlife could actually trigger increased human-elephant conflict.

To account for this type of nuance, the biodiversity baseline, including elephant distribution and relative abundance, was examined along the railway alignment within each PA to develop a targeted mitigation strategy. The approach was entirely novel and highly integrated. In addition to the ecological impacts of LI such as wildlife mortality and decreased connectivity, the BBA objectives also had to consider a myriad of social impacts, including (1) human-elephant conflicts and how those may change with the new project, (2) land use change effects on elephant crop raiding activity, and (3) property rights of local villagers.

2) *Rigorous BBA study design and surveys*. This study highlights how critically important it is to conduct a rigorous, well-designed pre-construction BBA to inform the design of environmental safeguards (Figure 5). The critical pieces of this Chittagong - Cox's Bazar Railway case study are, (1) the use of newly collected or current field data, rather than data with spotty coverage or none at all; (2) sampling and surveys that are conducted with adequate time frames to sample seasonal changes throughout the annual cycle; and (3) the use of local and regional expert data that had already been collected, rather than generalized estimates of species impacted and their response to LI projects based on literature and species occurrence maps.

3) *External and specialized oversight*. An important factor in the success of the Chittagong – Cox's Bazar BBA and subsequent recommendations for environmental safeguards lies in the ADB hiring of an external (international) road ecology consultant to co-lead the assessment. To understand the potential impacts to biodiversity and required safeguard measures, it is crucial to bring in consultants (biologists) with experience and background in preparing impact assessments and knowledge of the most current and effective environmental safeguards specific for LI. The partnership between both local and external experts to address the complex issues unique to the Chittagong – Cox's Bazar Railway project has set a high standard for future LI projects.

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CASE STUDY 2. ROAD: SOUTHERN EAST-WEST NATIONAL HIGHWAY (BHUTAN)

BASIC INFORMATION

Linear infrastructure mode: *Road*

Country: *Bhutan*

Location: *Raidak-Lhamoizingkha and Phipsoo Wildlife Sanctuary*

Project name: *Southern East-West National Highway (Dagana District)*

Proponent: *Government of Bhutan, Asian Development Bank*

SAFEGUARD PLANNING AND POLICY

Impact Assessment

Located in the Eastern Himalayas, the mountainous terrain of Bhutan supports tremendous biodiversity. Ten PAs, seven biological corridors, and one botanic park encompass a staggering 51.44 percent of Bhutan's land area (Wildlife Conservation Division, 2016), highlighting the country's commitment to nature conservation. Prior to 1960, Bhutan had no paved highways and as of 2016 only 30 percent are paved (Royal Government of Bhutan, 2017b). As Bhutan's economy expands and the population continues to increase, so does the need for reliable and enduring transportation options. Bhutan's 2007−2027 Road Sector Master Plan includes the Road Network Project (RNP) II, which prioritizes the construction of the Southern East-West highway to better connect communities and support economic development in the south of the country (Chogyel et al., 2017).

To date, five segments of the RNP II totaling 183 km have been completed. Two of the priority road segments—the 25-km *Raidak-Lhamoizingkha* road project (hereafter referred to as NH2) and the 24-km long *Samdrupcholing – Samrang* road project (hereafter referred to as NH5)—pass through critical habitat for endangered Asian elephants (*Elaphus maximus*) and other important species including gaur (*Bos gaurus*), clouded leopard (*Panthera pardus*), and Bengal tiger (*Panthera tigris*) (Department of Roads, Royal Government of Bhutan, 2009). To minimize and mitigate the effects of RNP II, wildlife crossing structures have been integrated into construction designs that maintain connectivity and reduce barriers to movement for Asian elephants and other wildlife.

Bhutan's Department of Roads also proposed three potential road alignments through the Phipsoo Wildlife Sanctuary (PWS). The PWS is Bhutan's smallest PA (269 km^2) and harbors high biodiversity and important populations of Bengal tiger, Asian elephant, leopards *(Panthera pardus)*, muntjac (*Muntiacus muntjac)*, golden langur (*Trachypithecus geei)* and other species of conservation concern. It lies along the Indo-Bhutan border and has historically been an area of intense conflict (poaching, smuggling, and armed conflict). This part of the project was classified as a Category A project in accordance with the ADB's Safeguard Policy Statement, and an EIA is required.

IUCN Red Listed or Focal Species

Asian elephant (*Elephas maximus*), Dhole (*Cuon alpinus*), Gaur (*Bos gaurus*), Himalayan serow (*Capricornis sumatraensis thar*), Sambar (*Rusa unicolor*)

EIA Recommendations

The EIA confirmed that NH2 and NH5 may impact the daily movements of wildlife (Department of Roads, Royal Government of Bhutan, 2009). To ensure compliance with the environmental requirements, planners devised an alternative alignment that avoided critical habitat and resulted in no net loss of biodiversity, showcasing a viable alternative for conservation and development (Asian Development Bank, 2019a).

The EIA utilized Asian elephants as the focal species for both the NH2 and NH5 segments due to their endangered conservation status and their role as an "umbrella species," where their protection benefits a myriad of other species. The EIA identified road segments that were likely to limit the movement of elephants and other migratory wildlife; these road segments were considered high priority for mitigation. Previous report findings indicated that elephants frequently use stream channels and riverbeds as regular feeding routes and for long distance travel (Department of Roads, Royal Government of Bhutan, 2017), and so wildlife crossings were constructed to allow for continued use of these drainages below bridge structures and through enlarged steel culverts. Underpasses for elephants were constructed on all known elephant crossing points.

In addition to the EIAs for NH2 and NH5, there was a need for a BBA of the PWS project due to its Category A status. In 2014, ADB contracted national and international consultants to conduct the assessment (Asian Development Bank, 2018) to provide a biological baseline for the sanctuary and the proposed road project. Surveys took place in four zones based on differences in terrain, elevation, and vegetation. The consultants determined that two of the three alignments were going to impact critical habitats and were therefore ADB non-compliant. The northern alignments passed through areas of highest biodiversity, and as a result, government officials selected the most southern alignment along the border to avoid the most critical habitats in PWS. The Government of Bhutan later cancelled the road project entirely in spring 2015, suspending the BBA; however, substantial information and insights were gained during the field studies.

Safeguard Sufficiency

Transboundary, Indo-Bhutan wildlife connectivity considerations were incorporated into the planning and design of both road segments, and four wildlife underpasses (three for NH2 and one for NH5) were included by the Bhutanese Department of Roads with agreement by the multilateral funding institutions.

On the NH2 segment, three stream crossings with confirmed elephant utilization were constructed with an increased height and width to accommodate elephant movement, making them the first wildlife crossing structures ever built in Bhutan. No wildlife fencing was used due to the steep-walled terrain leading to the underpasses, which would naturally direct wildlife to the crossing points. The dimensions of the underpasses ranged from 6.4-10.0 m wide and 5.6-7.6 m high. All underpasses were 9.9 m in length. On the NH5 segment, one underpass was constructed at the Neuli River west of the Saathpokhare and Samrang settlements. The underpass measured 10 m wide, 7.6 m high, and 9.9 m long.

Despite extensive field work and surveys conducted in PWS for the BBA, the government decided not to build the road and therefore no environmental safeguards were enacted.

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

As recommended by the EIA and ADB, each of the four wildlife underpasses were monitored with the use of camera traps (Figure 6), post-construction, beginning in 2015. The NH2 underpasses were monitored for two years, from 2015 to 2017 (Asian Development Bank, 2018; Figure 7). Seven species were detected utilizing the underpasses; however, elephants were the only species found using all three underpasses (Figure 8). A total of 70 elephant groups were detected by the cameras around the crossings, of which 76 percent passed through the underpasses.

Figure 6: Field team sets up camera trap for collecting pre-construction baseline biodiversity data in Phipsoo Wildlife Sanctuary, Bhutan. Credit: Norris Dodd.

Figure 7: Wildlife underpass designed primarily for elephant passage on the NH2 road (Raidak-Lhamoizingkha). Credit: Karma Chogyel.

Figure 8: Elephant using a wildlife underpass on NH2 road in Bhutan. Credit: Norris Dodd.

At the NH5 underpass, only elephant and sambar deer were detected, with regular elephant use of the underpass beginning in January 2015. However, since March 2016, there has been no detection of elephant use. Several theories exist as to why the elephants stopped using the underpass:

- *Human encroachment.* Human use of the area increased substantially between 2015 and 2016. Human activity adjacent to the underpass may be a physical barrier for elephant movement along the stream banks.
- *Livestock*. Elephants avoid cattle and herding activities, which have increased in the area due to pasture being created 300 m upstream from the underpass. These land use changes are a result of the new road and increased access.
- *Use of an alternative movement corridor*. It was observed that elephants started using an alternate route close to the underpass to cross the highway. A camera placed on the alternate route has recorded their movement.

Reliable data collection was problematic in both project areas. At two of the NH2 underpasses, only one camera was installed, which was insufficient for detecting wildlife movement through the underpasses. Camera theft and the insufficient number of cameras made monitoring difficult and regular weekly or biweekly camera checks have been recommended for future monitoring efforts.

Success or Failure?

The RNP II upheld Bhutan's commitment to the protection of ecological connectivity through the utilization of pre-construction data to realign planned infrastructure, resulting in no net loss of biodiversity. The NH2 and NH5 projects also resulted in the implementation of the country's first wildlife crossing structures, setting the stage for further development. The project also took critical steps to ensure that post-construction monitoring of the wildlife underpasses continues; while monitoring challenges have arisen, recommendations have been made to strengthen the current monitoring program. Information collected from the post-construction monitoring program will be used to inform the planning and construction of future wildlife crossing structures, both within Bhutan and across additional Asian elephant range states.

Although a BBA was not conducted on the NH2 and NH5 projects, it was conducted for the first time in Bhutan for the PWS road project. This novel biodiversity assessment will serve as a model for future LI projects in Bhutan and the region.

LESSONS LEARNED

Some of the lessons learned from Bhutan RNP II projects include the following:

Pre-construction data is incredibly important for making informed decisions on route selection, mitigation measure selection and locations, and post-construction monitoring needs. The wealth of information collected during the feasibility stage of this project allowed planners to select a route and plan for mitigation measures, which resulted in no net biodiversity loss. The rigorous post-construction data collection was invaluable for assessing the efficacy of safeguard performance. This information can now be used to guide future projects within the country and for elephant crossing designs across the species' range outside Bhutan.

This project resulted in the first wildlife crossings constructed in Bhutan, and post-construction monitoring revealed that a high wildlife passage rate was achieved for a wide range of species within the first two years, with quick adaptation to the underpasses by elephants. The project also showed that successful crossings were possible without the inclusion of costly and maintenance-intensive wildlife fencing. The prefabricated metal-plate arches utilized in the crossing structures have been deemed cost-effective and highly suitable for remote applications and areas with difficult access.

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CASE STUDY 3. POWER LINE: TONLE SAP PROTECTED LANDSCAPE (CAMBODIA)

BASIC INFORMATION

Linear infrastructure mode: *Power Line*

Country: *Cambodia*

Location: *Northern Tonle Sap Protected Landscape, Tonle Sap floodplain*

Project name: *Kampong Cham to Battambang Transmission Line*

Proponent: *Government of Cambodia, Electricité du Cambodge (EDC)*

SAFEGUARD PLANNING AND POLICY

In 2015, the Cambodian government announced that a new power line would be built that would cut through the Northern Tonle Sap Protected Landscape. The Tonle Sap floodplain is crucial habitat for the Southeast Asian sub-species of the critically endangered Bengal florican (*Houbaropsis bengalensis blandini*) (Mahood et al., 2018), which has experienced a population decline of an estimated 10 percent per year since 2005 (Packman et al., 2014). Bengal floricans reproduce slowly, laying one or two eggs each year; thus, even low levels of adult mortality can be unsustainable for the population. The location of the proposed power line could disrupt Bengal florican migration to their breeding grounds, further threatening the survival of the species (Mahood et al., 2018).

The proposed power line comes as part of Southeast Asia's efforts to meet the electricity demands of a fast-growing economy. Hydropower has been seen as a leading solution, with dams along the Mekong River providing low carbon energy in addition to other benefits such as water for consumption, irrigation, and flood control (Chandran, 2018). While such dams have direct environmental impacts, including the blockage of fish passage and trapping of sediment upstream (Xia, 2020), the high-voltage power lines that are built to transport electricity from the dams to distribute throughout the country also have major impacts on migratory bird movement (Mahood et al., 2018).

As Cambodia's economy grows and infrastructure reaches previously unserved areas, the country is also taking note of how development is impacting the environment. In recent years, the Cambodian government has worked to improve its environmental legal structure, including the environmental code that governs environmental impact assessments (Xia, 2020). Large projects such as hydro-power development and their power lines provide important examples of balancing the needs of environmental protection and economic growth.

IUCN Red Listed or Focal Species

Bengal florican (*Houbaropsis bengalensis*), Yellow-breasted bunting (*Emberiza aureola*), Painted stork (*Mycteria leucocephala*), Spot-billed pelican (*Pelecanus philippensis*), Greater spotted eagle (*Clanga clanga*)

EIA Recommendations

A pre-EIA was conducted for the Tonle Sap power line in advance of a full EIA. The pre-EIA was comprehensive and included potential measures for mitigating the impacts of power lines, such as using line markers in key sections to increase visibility for birds. However, the government issued press releases even before the pre-EIA was conducted that indicated that Prime Minister had already approved the power line (Electricite du Cambodge, 2015a, 2015b).

The most effective mitigation measure for power lines is to avoid critical habitats and migration routes by realigning the power line to areas outside of where Bengal floricans breed; burying the power line is also an effective option (Mahood et al., 2018). Bird flight deflectors (disks or spirals that make it easier for the birds to see the power line) can also be easily fitted along the wires prior to erection of the power line to lessen mortality (Eng, 2016). This is considered a low-cost, technically simple, and effective measure at reducing bird collisions with power lines. These mitigation measures can theoretically be attached to power lines after construction is completed, but it is more costly and logistically difficult (Mahood, 2021). These types of mitigation measures are standard in many countries where power lines traverse areas used by globally threatened species that are susceptible to power line mortality (Dixon et al., 2013).

Safeguard Sufficiency

Unfortunately, Electricité du Cambodge (EDC), the proponent for the project, did not follow the explicit mitigation recommendations of the pre-EIA in its proposed designs for the power line. When the power line was constructed in 2019, no environmental safeguards were applied to mitigate the impact of the power line on the movement of Bengal floricans or to reduce collision rates. The EDC claimed that it did install line markers; however, on inspection by third parties it was apparent that these measures were excluded from the project.

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

Although the Cambodian government did not include environmental safeguards on the Tonle Sap transmission line, the Wildlife Conservation Society (WCS) – Cambodia still collected data on the impact of the power line along a 5-km stretch using globally accepted methods.

WCS conducted a carcass survey once each week from June 2019 to January 2021; the study was curtailed due to the COVID-19 pandemic but will be continued in the future (Mahood, 2021). The survey was conducted by a team of community members who have been working for the WCS Bengal florican project for many years and are experienced with the bird species of the area. Survey methodology followed standard protocols for assessing mortality of birds associated with power lines.

A total of 62 power line censuses were undertaken. Surveyors found 108 carcasses, comprising at least

36 species including four Bengal floricans (Figure 9 and Figure 10). In addition, one yellow-breasted bunting was found, another critically endangered species, as well as one spot-billed pelican and three painted storks (both near threatened). The 108 carcasses discovered along the 5-km study area over the 18-month study period should be treated as a minimum estimate of the number of birds killed by the power line during that time. In this context, the power line mortality of four Bengal floricans is not trivial, constituting a loss of nine percent of the Tonle Sap population in just 18 months.

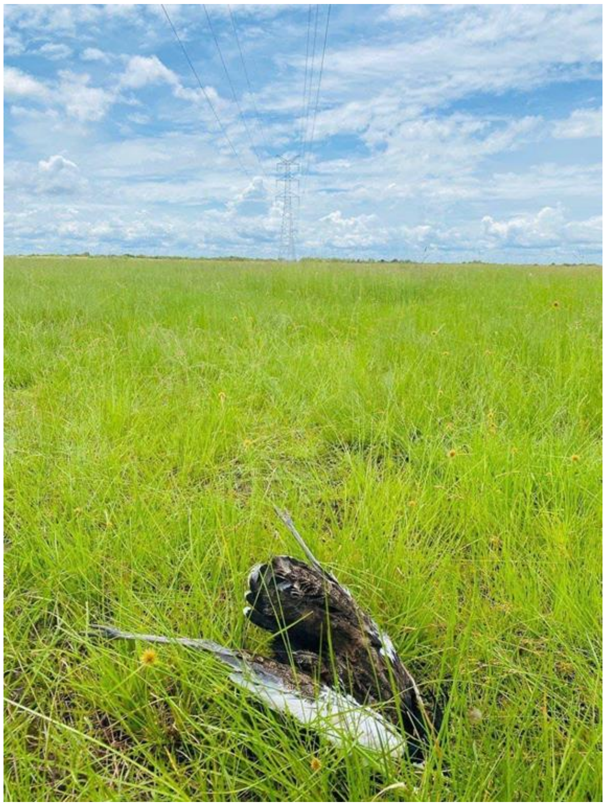

Figure 9 (left): A Bengal florican (*Houbaropsis bengalensis blandini*) power line collision mortality on the Tonle Sap floodplain, Cambodia. Credit: Simon Mahood.

Figure 10 (right): This Painted stork (*Mycteria leucocephala*) and many other bird species have collided with the new power line on the Tonle Sap floodplain. Credit: Simon Mahood.

Bengal florican was the sixth most abundant bird species in the power line mortality dataset. This finding is in keeping with other global studies that have found that members of the bustard family are highly vulnerable to collisions with power lines (e.g., Martin & Shaw, 2010; Shaw et al., 2018). Additionally, all Bengal florican mortalities recorded during the survey occurred during migration; the locations and flight height during Bengal florican migration puts the birds at risk of collision with power lines.

WCS-Cambodia presented these results to EDC, but EDC claims that there is no proof that the power lines caused the bird mortalities—the birds may have died for some other reason (S. Mahood, Mekong Drivers Partnership, pers. comm.). The opinion that power lines do not result in casualties to Bengal florican and other birds is widespread and accepted within EDC.

Success or Failure?

EDC failed to comply with the standards set out in Cambodia's environmental code to address impacts of the Kampong Cham to Battambang Power Line in the Tonle Sap Protected Landscape. Bird flight deflectors were never installed despite the pre-EIA recommendation for the measures.

WCS-Cambodia has presented evidence to EDC that the power line resulted in many casualties of seasonally migrating birds, including four Bengal florican. However, the EDC does not believe the power line has a harmful effect on any birds in the area, including species listed as threatened by the IUCN.

There is a general reluctance in the EDC to accept that power lines kill birds and therefore there is a reluctance to install line markers on new power lines. There is a need for more political will and administrative commitment to implement environmental provisions in Cambodia in the future (Xia, 2020). As demonstrated by the lack of safeguards for the Kampong Cham to Battambang Transmission Line, government institutions have enforced environmental regulations insufficiently and failed to assure proper monitoring of power line impacts.

LESSONS LEARNED

The construction of the power line through the Northern Tonle Sap Protected Landscape resulted in a level of Bengal florican mortality that is likely to have population-level impacts. Bird flight deflectors, as recommended in the pre-EIA, could help lower mortality of Bengal florican and other bird species, but they were never installed. Adding them post-construction is unlikely since it is costly and technically difficult to retrofit or add bird flight deflectors to existing power lines.

It is recommended that when new power lines are constructed in areas where Bengal floricans or other globally threatened species are present, that bird flight deflectors are attached during construction when it is a simple and low-cost procedure. Mandatory compliance and regulatory checks by the government are recommended to ensure that EIA safeguard measures are installed on future projects. Mandatory monitoring is also recommended to determine the effectiveness of the mitigation measures.

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CASE STUDY 4. RAILWAY: QINGHAI, BETWEEN HOH-XIL AND SANJIANGYUAN (CHINA)

BASIC INFORMATION

Linear infrastructure mode: *Rail*

Country: *China*

Location: *Qinghai, between Hoh-Xil and Sanjiangyuan*

Project name: *Qinghai-Tibet Railway (QTR)*

Proponent: *Government of China*

SAFEGUARD PLANNING AND POLICY

Impact Assessment

In rural western China, the highest railroad on earth transports visitors 1,956 km from Qinghai to Tibet. At an average elevation of 4,000 m above sea level, the railway was constructed through the harsh terrain of the Tibetan plateau to improve accessibility to Tibet and to reduce the developmental gap between western and eastern China (Railway Technology, 2006). It was listed as a key national railway project in 2001, and construction began the same year. Construction of the Qinghai-Tibet Railway (QTR) required an investment of 33 billion RMB (USD 4.2 billion) from China's central government and was completed in October 2005 (He et al., 2009). The railway has been in operation since July 2006.

With its vast expanse and diverse geography, the Tibetan plateau is a distinct biome with numerous endemic species; of particular importance is the Tibetan antelope. The Hoh-Xil population of Tibetan antelope is one of four migratory populations characterized by its long migration between the Hoh-Xil (or Kekexili) and Sanjiangyuan Nature Reserves (Schaller, 1998; Figure 11). The Tibetan antelope migration is synchronized with their reproductive cycle and almost all long-distance migrants are females (Leslie & Schaller, 2008), which move from wintering sites to calving sites in May and later return with their newborn calves (Figure 12). Thus, any disturbance to the migratory pathway is likely to affect population demographics disproportionately and have critical impacts on population sustainability. The long-distance migration of Tibetan antelope is directly affected by the QTR as it bisects their migration route approximately 40 km from their summer calving area.

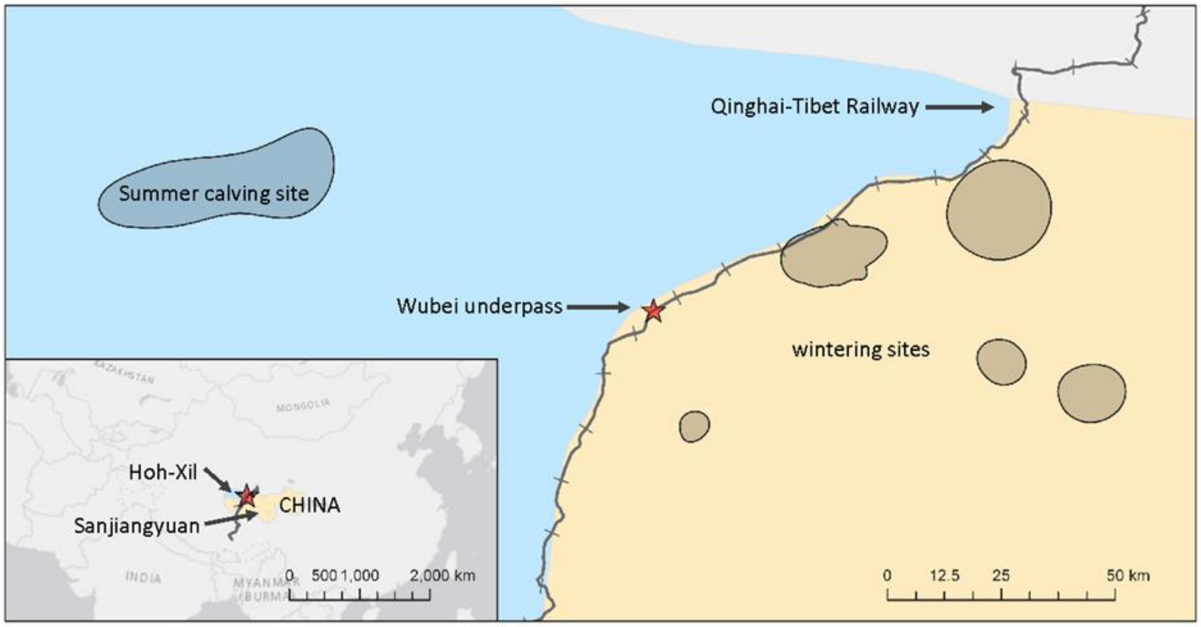

Figure 11: Location of the Qinghai-Tibet Railway alignment and Wubei underpass. Summer calving sites for Tibetan antelope are located in the Hoh-Xil Nature Reserve (blue), and wintering sites are in the Sanjiangyuan Nature Reserve (yellow) on the other side of the railway. Credit: Wenjing Xu.

Figure 12: Tibetan antelope near the Qinghai-Tibet Railway. Tibetan antelope migrate between calving grounds and wintering areas. Their migration is closely associated with reproduction and migration disruptions are especially detrimental on the return trip when lactating females must migrate to meet energy demands and feed their offspring. Credit: Wenjing Xu.

IUCN Red Listed Species

Tibetan antelope (*Pantholops hodgsonii*), Tibetan gazelle (*Procapra picticaudata*), Wild yak (*Bos mutus*), Kiang (*Equus kiang*), Asian badger (*Meles leucurus*), Mountain weasel (*Mustela altaica*)

EIA Recommendations

The total environmental mitigation investment for the QTR project is claimed to be over USD 220 million, which includes a total of 15 railway crossings (bridges and viaducts) built within the Hoh-Xil–Sanjiangyuan segment by the China Railway Corporation to preserve landscape connectivity for ungulates and other wildlife.

Specific to Tibetan antelope, four major crossing structures were planned for the Hoh-Xil area (Wubei underpass, Chumaer Bridge I and II, and Wudaoliang Bridge), all of which were designed to facilitate connectivity between antelope core areas, such as wintering and calving grounds. Except for the crossing locations, the Hoh-Xil section of railway is fully fenced, making the crossing structures the only means for antelope to cross the railway.

Safeguard Sufficiency

No systematic study was conducted using pre-construction data to fully assess the potential impacts of the QTR on the migration of Tibetan antelope or to inform the best mitigation options. Most of the impact evaluation on Tibetan antelope was based on field observations of where their migratory pathways intersected with the railway and the nearby highway (Wenjing Xu, personal communication).

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

Although no formal tracking record exists for the antelope migration prior to the construction of the Hoh-Xil section in 2001, some reports note that thousands of antelope have used the wildlife underpasses after construction, and that the rate of use is increasing over time (Li et al., 2008; Xia et al., 2007).

However, two issues have been revealed by the post-construction monitoring. First, among antelope using crossing structures, 100 percent of the animals moving westward and 97 percent of the animals moving eastward used one single crossing, the Wubei underpass (Xia et al., 2007). Second, observations along the QTR have found that antelope travel along the fenced railway before crossing, suggesting that disruption still exists to the animals' natural migration behavior and route of travel (Buho et al., 2011; Manayeva, 2014). To date, the QTR crossings have only been evaluated by counting the number of animals using each structure. Although these are all successful crossing events, counts of successful passage do not necessarily measure or reflect movement efficiency and whether the crossing structures are fully functional for maintaining habitat connectivity.

Given the heavy bias toward the Wubei underpass, an additional study was conducted on antelope activity around this structure (Figure 13 and Figure 14). The study examined the effect of the Wubei underpass on migration patterns and migratory connectivity using movement models (Xu et al., 2019).

Specifically, the underpass was evaluated to determine how its locations affected migration routes and movement efficiency. The study utilized a Tibetan antelope tracking global positioning system [GPS] dataset to compare the actual migrations with "optimal" migration, or the route with the least energy expenditure according to topography. The study found that while the underpass did facilitate antelope migration, animals deviated from their optimal migration route of travel. This deviation led to increased distance traveled and greater energy expenditure. Animal migration is closely associated with reproduction, and migration disruptions are especially detrimental on the return trip when lactating females must migrate to meet energy demands and feed their offspring. Despite two other underpasses being closer to the optimal migration routes, few antelope used them. The lack of use was believed to be attributed to the fact the other underpasses were smaller in size (width) and closer to the highway and that disturbance from traffic may have prevented more use (Wenjing Xu, personal communication).

Figure 13: The Qinghai-Tibet Railway in Central China. The long-distance migration of Tibetan antelope is directly affected by the Qinghai-Tibet Railway. Four major crossing structures were constructed for the Hoh-Xil area, including the Wubei underpass. Credit: Wenjing Xu.

Figure 14: The Wubei Underpass allows for Tibetan antelope to pass underneath the railway. The four underpasses are the only means for Tibetan antelope to cross the railway, as the entire railway is fenced. Of the four underpasses, the Wubei underpass is used the most by Tibetan antelope. Credit: Wenjing Xu.

Success or Failure?

The QTR is the first railway project in China that included wildlife mitigation measures in its design and construction. From a policy and implementation standpoint, the project has been successful in advancing the practices of mitigating LI impacts on wildlife populations using methods proven effective elsewhere in the world. The QTR has received much publicity within and outside China, thus raising awareness of wildlife passage techniques for LI projects. Context is important, as are the specific needs of wildlife impacted by LI. However, more important is the use of reliable pre-construction data to inform the location and type of recommended environmental safeguards. While the inclusion of crossing structures is important, the QTR project failed by not conducting a proper pre-construction analysis of Tibetan antelope migration patterns and specific travel routes between wintering and calving areas.

While the Wubei underpass does facilitate Tibetan antelope migration by allowing animals to cross the QTR, research suggests that the Wubei underpass is not located in the correct location, causing animals to deviate from their optimal migration route to use the structure (Xu et al., 2019). This deviation was most prominent in the area closest to the underpass, which indicates that antelope unnecessarily lengthen their travel and migration route to cross the railway via the Wubei underpass, and thus expend more energy.

LESSONS LEARNED

From this case study on a migratory ungulate, we learn that animal movement and behavioral studies should be conducted before and after the construction of underpasses to reveal true impacts and the effectiveness of mitigation structures intended to facilitate connectivity. This is especially important for migratory ungulate species that connect calving grounds with wintering areas.

Planning for the mitigation of LI impacts benefits from having scientists involved in research at the early stages of design. Comprehensive scientific research pre-construction is necessary to inform solutions that best balance the needs of both LI and wildlife populations. Post-construction monitoring is equally important, to be able to assess safeguard performance and determine whether the design goals and objectives are met.

Criteria for evaluating success is also important and needs to be part of the pre-construction planning. In the QTR case study, no criteria were established other than determining whether antelope used the underpasses, not how the placement of the underpasses affected seasonal long-distance migration, a critical need for antelope. Such thorough and focused studies are necessary, not just to ensure crossings are placed at critical locations, but to have the most effective designs to facilitate animal passage needs. These lessons learned, positive or negative, need to inform future LI project planning and design.

The Wubei underpass modeling study utilized the first and only available Tibetan antelope tracking dataset for a comparison with the two optimal corridor prediction models. Other complex methods, such as resource selection or step selection functions, together with more accurate tracking technologies such as GPS collars, may offer a better data-driven resistance surface to model movements of species wth specific habitat needs during migration.

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CASE STUDY 5. ROAD: EAST-WEST HIGHWAY, NARAYANGHAT-BUTWAL (NEPAL)

BASIC INFORMATION

Linear infrastructure mode: *Road*

Country: *Nepal*

Project name/location: *Mahendra Highway, Narayanghat-Butwal (NB)*

Proponent: *Government of Nepal, ADB*

SAFEGUARD PLANNING AND POLICY

Impact Assessment

The Narayanghat to Butwal (NB) section of Nepal's Mahendra Highway is a paved two-lane road that runs for 115 km through south-central Nepal, and there are plans to widen it to four lanes in the next three years. It contains a 64-km stretch that passes through the forested Terai Arc Landscape, including 24 km of road that forms the northern boundary of the buffer zone for Chitwan National Park (CNP) (Figure 15). The project area has some of the most diverse wildlife species in Nepal, including the Asian elephant, one-horned rhino, and leopards. The area is also home to the Bengal tiger, which IUCN lists as endangered and Nepal's National Parks and Wildlife Conservation Act protects. As tigers and other species move between CNP and other forested areas to the north, they are forced to cross the NB road. The proposed widening of this road section is listed as Category A in accordance with the ADB's Safeguard Policy Statement, which means that the project is "likely to have significant adverse environmental impacts that are irreversible, diverse, or unprecedented" (Asian Development Bank, 2009).

The proposed four-lane road will be widened to a 50-m right-of-way, and will cross through six forest patches in CNP's buffer zone for a cumulative length of 47 km (Figure 16). Specific long-term risks of expansion included in the project's EIA were (1) an increased number of wildlife roadkills, (2) increased poaching due to improved human accessibility; and (3) further degradation of forests and natural habitat along the road's edges due to increased vehicular traffic and human activity.

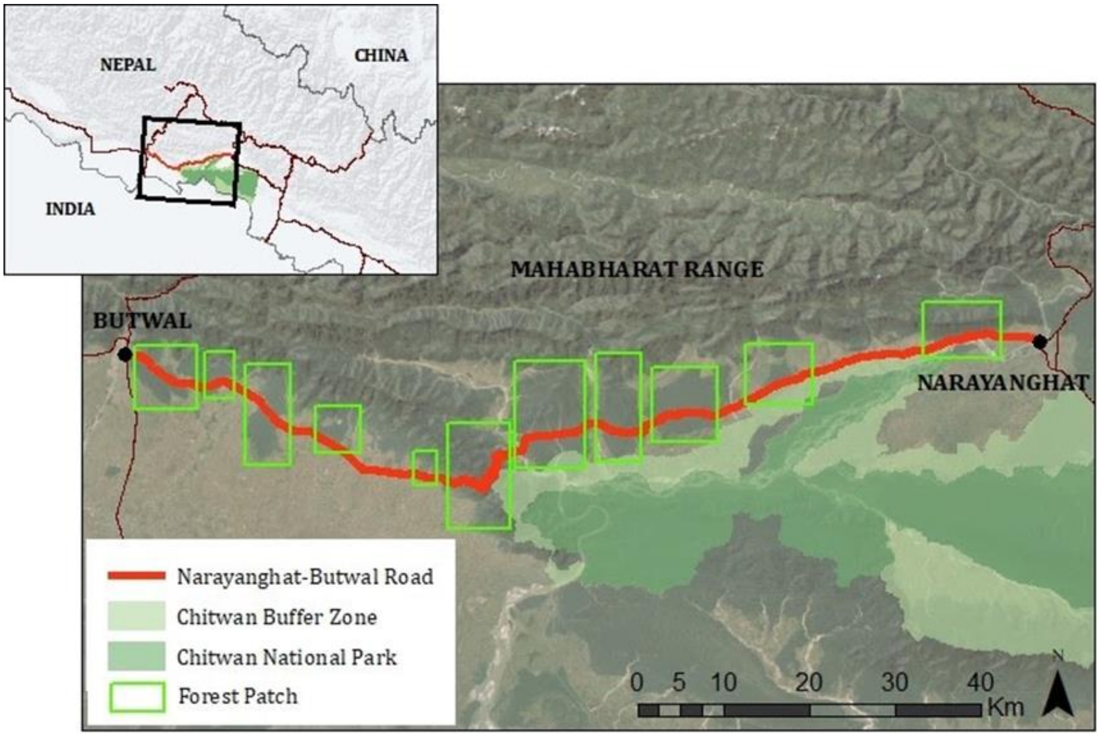

Figure 15: Length of the Narayanghat-Butwal (NB) highway and location of forest patches where pre-construction monitoring was conducted. The Chitwan National Park (CNP) buffer zone on the northern boundary of the park and the adjacent forest patches connect CNP to the Mahabharat Range. Based on Karki, 2020.

Figure 16: The existing two-lane road between Narayanghat and Butwal (NB). Credit. Anthony P. Clevenger.

There was very little pre-construction data collected that could be analyzed to inform the EIA. No information was collected or available from national agencies regarding wildlife-vehicle collisions on the NB section of road. Movement patterns of tigers, other IUCN-listed species, and focal species were based on anecdotal information and expert opinion from meetings with key stakeholders.

IUCN Red Listed or Focal Species

Bengal tiger (*Panthera tigris tigris*), One-horned rhino (*Rhinoceros unicornis*), Leopard (*Panthera pardus*), Sloth bear (*Melursus ursinus*), Spotted deer (*Cervus axis*), Sambar (*Rusa unicolor*), Barking deer (*Muntiacus muntjac*), Gaur (*Bos gaurus*), Jackal (*Canis aureus*)

NB Project EIA Recommendations

Within the EIA, recommendations to safeguard wildlife for the project were derived from several sources: (1) relevant data published in scientific literature and tiger conservation reports in Nepal and CNP, (2) guidance from Nepalese natural resource agencies and nongovernmental organizations, and (3) guidelines from the report, "Smart Green Infrastructure in Tiger Range Countries" (Quintero et al., 2010).

The project's EIA recommended several mitigation measures to ensure no net loss of biodiversity and address potential risks to wildlife, including (1) construction of five wildlife underpasses, coupled with the planting of forests, to direct wildlife to the structures for safer road crossing; (2) implementation of a biodiversity conservation plan; and (3) implementation of a compensatory afforestation program (DoR, 2016). Based on the proposed measures, it was concluded that the project fulfilled the three conditions of mitigation, compensation, and biodiversity enhancement for projects falling inside critical habitat under the ADB Safeguard Policy Statement.

After the release of the EIA, during the pre-construction stage, a wildlife study was conducted to verify and reconfirm the suitability of the location, design, and numbers of wildlife underpasses. The study results were eventually used to refine recommendations as part of a safeguards sufficiency evaluation.

Safeguard Sufficiency

A USAID post-approval field review was conducted for this ADB-financed project (project number 48337-002). USAID selected this project to review based on concerns expressed by the United States government to ADB prior to project approval related to the analysis, mitigation, and monitoring of potential adverse impacts to critical habitat of wildlife in the project area.

USAID identifies projects for post-approval review that are likely to have harmful impacts on natural resources, the environment, Indigenous populations, or public health (USAID, 2013). With these reviews, USAID aims to assess the effectiveness of safeguard implementation, including the extent to which previous U.S. government recommendations were incorporated and their adequacy. The post-approval review also provides an opportunity for USAID to further strengthen the environmental and social performance of the project by providing additional safeguard recommendations.

The review was informed by desk and field research, including a literature review, more than 40 interviews with project stakeholders and experts, and observations in and around the project area (Figure 17).

Figure 17: Representatives from USAID, the U.S. Department of the Treasury, WWF-Nepal, and the Wildlife Conservation Trust India during field review of EIA recommended wildlife passage locations on the Narayanghat-Butwal road in June 2019. Credit: WWF-Nepal.

The USAID review findings (Dear et al., 2019) regarding the deficiencies of the project were:

- The project guidelines for WFLI were insufficient and did not meet international standards.
- Pre-construction wildlife surveys were not designed to reliably determine the most suitable locations, numbers, and design of mitigation measures to protect biodiversity.
- Cross drainages that were designed for hydrology but could potentially serve as wildlife crossings were not monitored to determine whether these structures actually functioned as passages for wildlife.
- The proposed recommendations did not follow international or regional design guidelines for structure type, frequency, spacing, dimensions, fencing, and sound attenuation.
- Funding for pre- and post-construction monitoring and evaluation was not adequate in the project budget.
- The loss of habitat was not contemplated in the safeguard recommendations.
- No road ecology experts had provided direct input or oversight.

- The project budget was likely inadequate to construct proper safeguards.

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

The project started construction on initial segments in early 2020 (Figure 18). No monitoring or research has been conducted at the time of this writing; however, monitoring of wildlife movements (camera traps) and roadkill surveys are planned for segments that are not yet built (pre-construction) and those under construction (during construction).

After the USAID report was released, data from the wildlife study were reanalyzed in a BBA to verify and reconfirm the suitability of the location, design, and numbers of wildlife underpasses (Karki, 2020). This work resulted in a new mitigation strategy recommendation that proposed 112 wildlife underpasses (varying in size from small to very large) and two wildlife overpasses (50 m wide) along the 115-km section of NB road. The recommended mitigation strategy included many existing drainage structures located in priority forest patch habitats, which could be upgraded to accommodate wildlife movement (Figure 19).

Figure 18: Construction started on right-of-way clearing of vegetation on two-lane road between Narayanghat and Butwal (NB). Credit. Anthony P. Clevenger.

Figure 19: An existing twin-cell minor bridge currently exhibiting limited wildlife passage potential. This structure is planned for replacement with a 6-m high and 16-m wide single span minor bridge. Credit: Anthony P Clevenger.

Success or Failure?

Initially, the project failed to adequately assess the adverse impacts to wildlife and properly develop a rigorous mitigation strategy based on pre-construction field research and best practices. USAID's request for a suspension of construction resulted in project delay and allowed Nepal's Department of Roads (DoR) and ADB to reevaluate the project's impacts and develop a more comprehensive mitigation strategy by incorporating both field data and international best practices. Ultimately, this improved the capacity in Nepal to address the impacts of a four-lane highway more adequately on wildlife and the need for habitat connectivity. Increased capacity resulted in the development of a BBA, better wildlife study designs, improved wildlife data collection methods, higher quality analyses, and the use of this information in more meaningful wildlife safeguard recommendations.

LESSONS LEARNED

Originally, the NB road project's EIA (DoR, 2016) included the identification of five dual function (water drainage and wildlife passage) structures to ensure safe passage by a diverse group of wildlife species across the highway. These consisted of two culverts and three minor/small bridges. They were located within six identified wildlife movement corridors in the 53 km of designated tiger critical habitat bisected by the NB road project, which averages to just one wildlife passage structure per 10.6 km of forested habitat.

The revised NB road mitigation strategy reflects a joint commitment by the Nepal DoR and ADB to develop a more comprehensive approach to preserving biodiversity. The assessment of planned drainage structures relied upon four design criteria considered for effective wildlife passage structures (Asian

Development Bank, 2019b): (1) structure openness, (2) structure size, (3) structure type, and (4) spacing of structures.

This revised mitigation strategy reflects the rapid evolution of effective green infrastructure applications in Asia to protect biodiversity over the past five years. The EIA report was published in 2016 when there were no guidelines nor experience in Nepal or the Terai Arc Landscape to address four-lane highway impacts to wildlife mortality and habitat connectivity sufficiently. Since that time guidelines have been developed by ADB, the Wildlife Institute of India, and World Wide Fund for Nature (WWF)-Nepal. These are foundational guidelines and will be improved with additional research and monitoring of future transportation projects.

This case study demonstrates the importance of local commitment and capacity among project stakeholders to plan, design, and implement mitigation measures. Another lesson is the importance of external oversight and the value of national or regionally specific guidelines to inform projects in the planning and design phase.

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CASE STUDY 6. RAILWAY: EAST-WEST RAILWAY (NEPAL)

BASIC INFORMATION

Linear infrastructure mode: *Railway*

Country: *Nepal*

Project name/location: *East-West Railway, Chitwan-Parsa section*

Proponent: *Government of Nepal*

SAFEGUARD PLANNING AND POLICY

Impact Assessment

The East-West Railway is a planned single-track electric railway that will run for 945 km across Nepal, crossing through 24 Terai districts. This railway is one of Nepal's national priorities and will be part of the Trans-Asian Railway network, which the Government of Nepal signed on to as a partner in 2006 and ratified in 2012. The project is managed by the Department of Railways (DoRW) within the Ministry of Physical Infrastructure and Transport. The Government of Nepal conducted an initial feasibility study for the railway in 2010 to determine an optimal alignment. Alternative routes were also reviewed with consideration of constructability, economics, environmental impact, and access of local populations to railway stations.

One section of the proposed railway alignment (Simara to Tamsariya) cut directly through Chitwan National Park (CNP), a United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site, and the neighboring Parsa National Park (PNP; Figure 20). The Terai landscape and PAs of CNP and PNP are rich in wildlife species, some of the most diverse in Nepal. The Chitwan-Parsa complex is also a high tiger density landscape, and is currently relatively unfragmented by LI. The World Heritage Committee (WHC) was concerned that the construction and operation of the East-West Railway would impact habitat connectivity for populations of regionally important wildlife and impact the "Outstanding Universal Value" of the site negatively. The WHC thus requested that all construction be put on hold until the EIA was completed (World Heritage Convention, 2014). Acknowledging that Nepal's Department of National Parks and Wildlife Conservation (DNPWC) also opposed the alignment through the park, the WHC further requested that additional alternative options be considered, as all alternative alignments also passed through the park (Van Merm & Talukdar, 2016; World Heritage Convention, 2014).

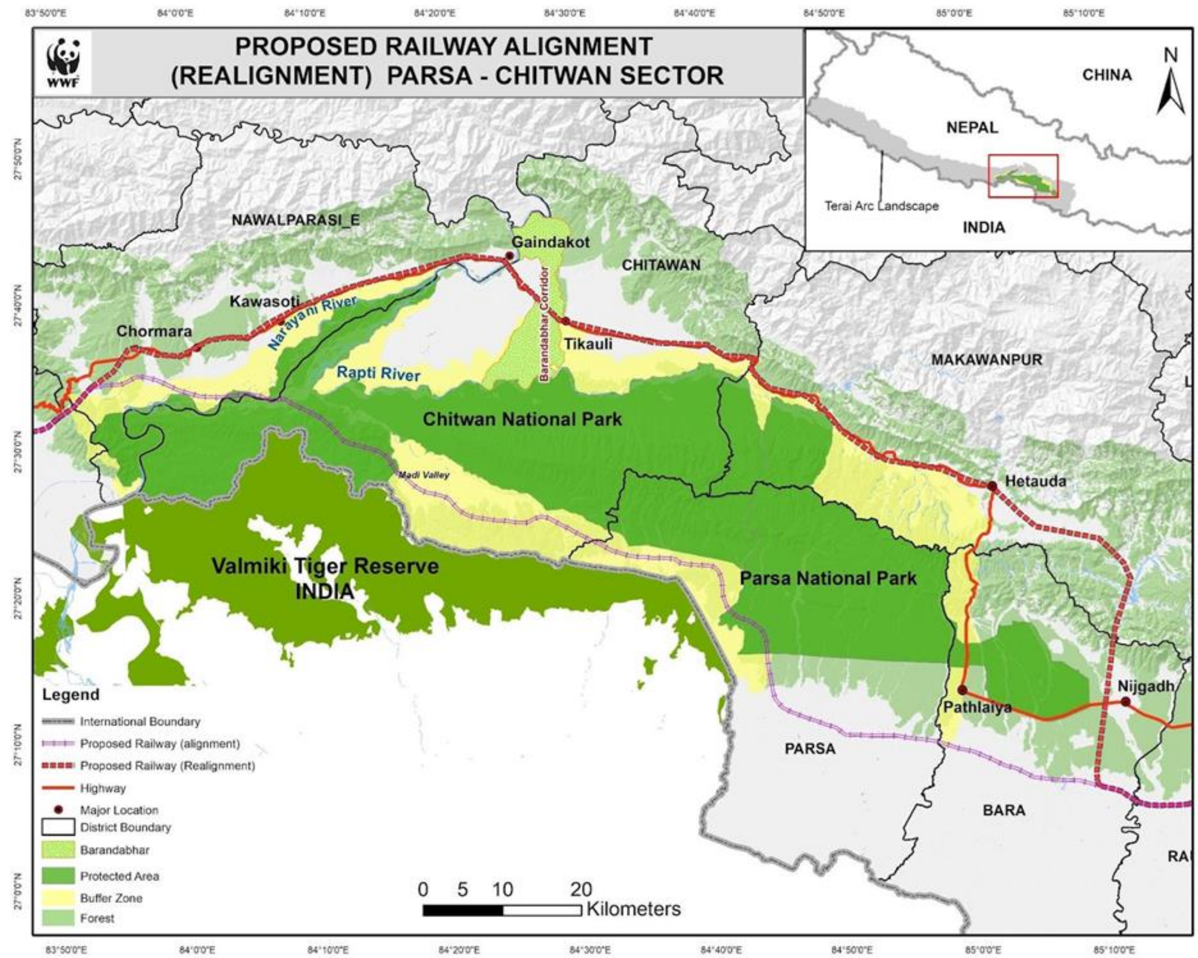

Figure 20: Proposed alignments of East-West railway at Chitwan-Parsa section. This railway section was earlier planned through Chitwan National Park (purple line) but later realigned (red line) away from parks following the adjacent alignment of Mahendra highway from Hetauda to Chitwan. This realigned section is currently under Detailed Project Report preparation phase. Credit: WWF-Nepal.

IUCN Red Listed or Focal Species

Bengal tiger (*Panthera tigris tigris*), Asian elephant (*Elephas maximus*), One-horned rhino (*Rhinoceros unicornis*), Leopard (*Panthera pardus*)

EIA Recommendations

In 2016 additional alignment feasibility discussions took place in CNP and were attended by the following stakeholders:

- Department of Railways, Ministry of Physical Infrastructure and Transport
- Ministry of Forest and Soil Conservation
- Ministry of Federal Affairs and Local Development
- Natural Resources and Fiscal Planning Commission

- National Planning Commission
- Judicial Commission
- DNPWC
- IUCN wildlife specialists
- WWF - Nepal

Following these discussions, two alignments were proposed: one that cut through the national parks, and one that avoided them entirely (Figure 20). DNPWC officials demonstrated that the alignment through the national parks would do long-lasting and irreparable damage to the parks' most important wildlife populations (DNPWC, 2016). From a social standpoint, it was found that the alignment that avoided the parks would also better serve the local communities in the region by passing through more significant economic centers. Thus, despite any additional costs for a longer route around the parks, it was determined that the alternative alignment would provide long-term economic benefits, in addition to environmental benefits (Van Merm & Talukdar, 2016).

Given the environmental, social, and economic benefits, the stakeholders agreed that the railway would be realigned outside the national parks. Unit construction costs per km were lower for alignment outside the PAs (USD 6.7 million) compared to alignment through the PAs based on preliminary estimates of the DoRW (USD 7.5 million). Several additional mitigation recommendations were made for sections of the rail in the buffer zone of the PAs, including wildlife crossing structures, tunnels, sound barriers, and lowering of the design speed.

In 2018, the DoRW published an Expression of Interest calling for consulting services to lead the survey, design, and preparation of the Detailed Project Report for the alternative alignment, now called the Nijgadh-Hetauda-Bharatpur section (DoRW, 2018). As of 2021, an EIA is still being prepared for this section.

Since 2018, the DNPWC has continued to engage the DoRW regarding the new alignment to ensure that ecological processes outside the parks are also conserved. In coordination with international agencies and organizations such as IUCN and WWF, DNPWC organized a program on "Linear Infrastructure and Wildlife Conservation" in Kathmandu in 2018 (DNPWC, 2018). This event brought together various government departments, including the Departments of Railways and Roads, providing an opportunity to share technical expertise and best practices on mitigating the impacts of LI to wildlife. The DNPWC has pushed for mitigation measures such as underpasses and overpasses to maintain connectivity between the parks and other critical habitats (DNPWC, 2021).

Safeguard Sufficiency

Because this project is still in the early planning phase, no safeguards have been formally proposed (Figure 21). Even though the alignment is no longer passing through the parks, the DoRW is still consulting with subject matter experts to minimize wildlife-train collisions and to mitigate the disruption of population connectivity for wildlife that disperse in and out of Chitwan and Parsa National Parks to the Churiya and Mid-Hill habitats. Concerns are especially high for the section near Bharatpur, where the railway will bisect the critically important Barandabhar wildlife corridor, and will also pass near Beeshazari Lake, an important wetland area designated as a Ramsar site.

A B

Figure 21: (A) Constructed railway embankment as seen in Bardibas section of Mechi Mahakali electrified railway. (B) Culverts designed and installed for hydrological purposes. Credit: Pramod Neupane, WWF-Nepal.

SAFEGUARD IMPLEMENTATION AND OUTCOMES

Monitoring and Research

No post-construction monitoring or research has taken place since the project is still in the early planning phase. However, the EIA and BBA will recommend that monitoring and research on the efficacy of implemented safeguards be required.

Success or Failure?

The reconsideration of the original alignments and ultimate decision to reroute the railway around Chitwan and Parsa National Parks to avoid critical habitat should be considered a success for conservation. The stakeholder cooperation and review of alternative alignments were critically important to arriving at consensus of which alignment would have the least harm to the areas of high biodiversity, including a tiger population.

Regarding the updated alignment, the project is still in the planning phase and so no safeguards have been constructed yet. Post-construction monitoring and research will need to be conducted to assess project success or failure.

LESSONS LEARNED

This case study is one of the few examples in Asia where the “avoidance” part of the mitigation hierarchy (avoid, minimize, restore, compensate) has been applied. LI projects can have lasting irreparable effects on species and ecosystems, and few projects completely avoid areas of high biodiversity and endangered wildlife populations.

The Chitwan-Parsa section of the East-West Railway demonstrates the importance of proactive planning and collaboration. Coordination between project developers or proponents and conservation stakeholders is critical for ecologically sustainable railway projects. In reaching success, this example illustrates two key points:

- Extensive homework is needed to compile relevant field data early in the planning stage to inform planning and design of projects that will pass through and have significant impact on areas of high conservation concern and biodiversity hotspots.

- Multi-state stakeholder consultation must occur before any decision making on alignment regarding potential impacts to areas of high biodiversity and species of conservation concern.

The East-West Railway in Nepal will serve as an example to other LI projects in Asia and provide support for the avoidance option for high-stakes projects that will cause long-term impacts on species of conservation concern and critically important ecosystems and PAs.

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CASE STUDY 7. ECONOMICS: POWER LINE: JAVA-BALI 500 KILOVOLT POWER TRANSMISSION CROSSING PROJECT (INDONESIA)

BASIC INFORMATION

Linear infrastructure mode: *Power line*

Country: *Indonesia*

Location (province/state): *Java and Bali*

Project name: *Java-Bali 500 Kilovolt (kV) Power Transmission Crossing Project*

Proponents: *Perusahaan Listrik Negarat (PLN) (Indonesian State Electricity Company) and ADB (lending institution)*

INTRODUCTION TO PROJECT AND ECONOMIC TOOLS

The island of Bali is one of the most important tourism destinations in Indonesia and as a result, Bali's economy contributes significantly to the country's national gross domestic product (Asian Development Bank, 2021). Currently, Bali suffers from frequent power outages and blackouts due to low generation reserve margin and transmission bottlenecks. Bali's power system is linked to the Java grid by four 150-kV undersea cables with installed capacity to transfer 400 megawatts (MW), but the reliability of these transmission lines is poor. In addition to this system, Bali previously produced electricity through diesel generation (thermal power stations). However, the use of diesel was restricted in 2013, as the provincial government declared Bali an environmentally protected area. To improve power supply in Bali, the best option, according to Perusahaan Listrik Negarat (PLN)(Perusahaan Listrik Negarat, 2013) was to strengthen the power transmission system between Bali and Java.

The Java-Bali 500-kV Power Transmission Project was proposed in 2009. It aimed to construct 220 km of extra high voltage lines between Java and Bali, with the capacity to transmit 1,500 MW of power. The project also aimed to extend a 500/150-kV substation in East Java, build a new 500/150 kilovolt substation in Bali, and upgrade eleven 150/20-kV substations (Figure 22 and Figure 23). The project also included consulting services to support project management in construction supervision, safeguards, and capacity building.

Figure 22: Location and description of the components 1 to 6 of the Java-Bali 500-kV project. Source: Asian Development Bank. Indonesia: Java-Bali 500-kV Power Transmission Crossing Project. Completion Report. February 2021.

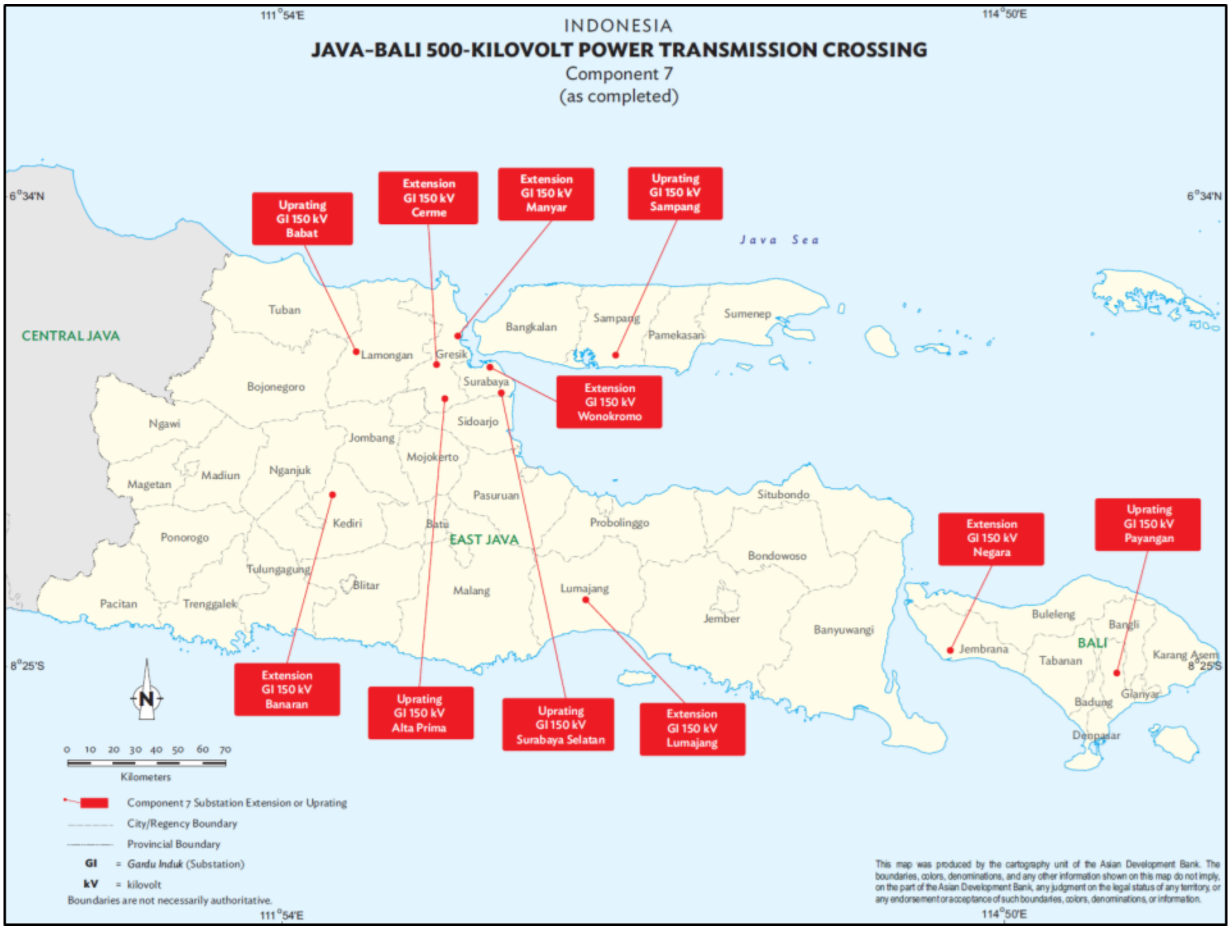

Figure 23: Location and description of component 7 of the Java-Bali 500-kV project. Source: Asian Development Bank. Indonesia: Java-Bali 500-kV Power Transmission Crossing Project. Completion Report. February 2021.

The Java-Bali 500-kV Power Project was selected as a case study for three reasons. First, the power line alignment is near two national parks, Baluran National Park and Bali Barat National Park, meaning that impacts to wildlife were possible and safeguards were likely needed (Figure 24). Second is the availability of data. In 2016, the ADB (one of the funders of this project) conducted an economic analysis of this LI project to evaluate the ADB Safeguards Policy of 2009. The analysis showed the importance of accounting for indirect costs to parties not related to the project and the benefits of implementing environmental safeguards into traditional project evaluations. The third reason is that due to the ADB analysis, the Java-Bali project is a good example of demonstrating explicitly the monetary benefits that result from the implementation of environmental safeguards. ADB estimates that the benefits from the environmental safeguards implemented in this project equal USD 3.9 million over 10 years (Asian Development Bank, 2016).

The economic analysis conducted by ADB does not follow the traditional business-oriented project assessment. ADB calculated the Net Present Value[1] of the Java-Bali project, including the costs and

1 Net Present Value is an indicator used to assess the financial feasibility of a project. The indicator is calculated by subtracting the expected costs from the expected benefits in each period of analysis. The difference between the costs and benefits is discounted in each period so

benefits of indirect impacts to third parties caused by the project and the benefits of the environmental safeguards implemented by the project (Asian Development Bank, 2016). Usually, these variables are not included in the calculation of the Net Present Value of a project. Indeed, when assessing the feasibility of the Java-Bali 500-kV Project in 2009, PLN did not account for these variables in its feasibility analysis.

ECONOMIC ANALYSIS

The analysis conducted by ADB was a cost-benefit analysis of the Java-Bali 500 kV Project (Asian Development Bank, 2016). The analysis was done in the four steps below (all calculations considered a time horizon of 10 years):

1. Calculating the Net Present Value, taking into account the financial costs and benefits of the project;
2. Quantifying negative externalities resulting from the project in monetary terms;
3. Calculating the benefits associated with two environmental safeguards; and
4. Combining all values and calculating an adjusted Net Present Value of the project.

In the first step, the costs consisted of the initial investment and the operational and maintenance costs. In the case of this project, the environmental safeguard costs were also accounted for in this stage. Total costs were estimated at USD 2,282 million. The benefits were measured in terms of revenue from the consumption of electricity and amounted to USD 2,470 million. By subtracting the costs from the benefits, the authors calculated that the Net Present Value was positive and equaled USD 188 million.

In the second step, two negative externalities were considered. The first consisted of the need to change the flight paths of airlines to avoid the transmission lines. The authors estimated that the change would increase flight distances by five percent, on average. This increase would represent an additional cost to national airlines of USD 822,900 per year or USD 15 million over 10 years. The second negative externality was the loss of revenue resulting from fewer tourism activities in Bali Barat National Park during the project's construction phase. In this case, the authors assumed that the parks' revenue would reduce by 5.4 percent, based on the size of the area that would be impacted. The cost of this externality was estimated at approximately USD 11 million over the time horizon of the analysis.

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all values are comparable and translated into today's currency. If the Net Present Value is positive, then the project is financially feasible, i.e., the benefits are greater than the costs.

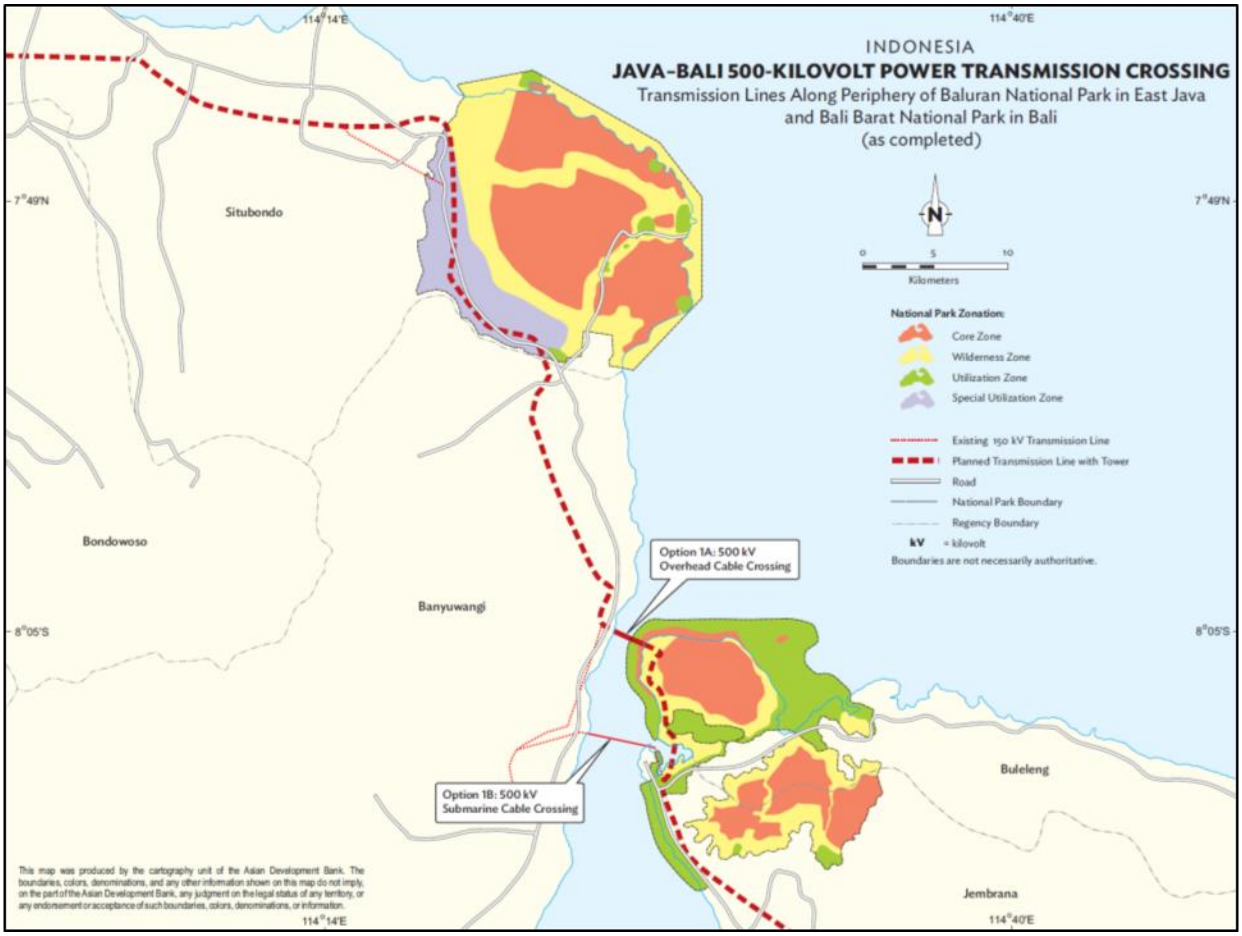

Figure 24: Power line along Baluran National Park in East Java and Bali Barat National Park in Bali. Source: Asian Development Bank. Indonesia: Java-Bali 500-Kilovolt Power Transmission Crossing Project. Completion Report. February 2021.

In the third step, the benefits of two mitigation measures were estimated. First, the authors quantified the economic benefit of implementing measures for reducing air pollution. The benefits of having cleaner air were estimated at USD 50,000 over 10 years. The estimations were done using secondary data from a study conducted in the Jakarta Metropolitan Area (Asian Development Bank, 2016). Second, the authors estimated benefits coming from PLN's funding of a conservation program called the Bali Starling Project. The Bali Starling, *Leucopsar rothschild*, is a rare but popular bird that is the Bali Barat National Park's mascot. This species is categorized as critically endangered by IUCN and has been under national and international protection status since 1970. It was estimated that about 200 Bali Starling birds lived in the Bali Barat National Park (Asian Development Bank, 2016). From this total, it was expected that 100 birds would be affected by the noises and movements resulting from the implementation of the project over 10 years (Asian Development Bank, 2016). Avoidance, in this case, was not possible, and so PLN transferred resources to the conservation program as compensation and to fund rehabilitation efforts.

The Bali Starling Project started in 1983 and has bolstered the wild bird population through the release of captive-bred birds. The project provided the foundation for the development of the Bali Starling Recovery Plan (Perusahaan Listrik Negarat, 2013). ADB (2016) estimated the benefits of preserving this species using the market price method. The authors used USD 500 per bird. However, it is worth mentioning that the market price of Bali Starling varies considerably depending on the number of birds existing in nature. Indeed, one of the main goals of the Bali Starling program is to increase the number of birds to reduce local and international demand, since buyers pay more for rare bird species. The economic benefits of this program were estimated at USD 3.8 million over 10 years.

In the fourth and final step, the authors showed that the Net Present Value falls by 12 percent, from USD 188 million to USD 166 million, when negative externalities and environmental safeguards are taken into account. Despite this reduction, the adjusted Net Present Value showed that the project continues to have large benefits to society, even though these benefits are smaller than a purely economic analysis would predict.

Thorough cost-benefit analyses, such as the one conducted by ADB, should play an important role in the decision-making process of sustainable LI projects. It is not always easy to identify and quantity externalities associated with a project, either positive or negative. However, accounting for them is essential for determining which projects should be prioritized. They may also point to the necessity of mitigation measures and provide guidance on which specific measures are most cost-effective.

LESSONS LEARNED

The economic analysis conducted by ADB showed that the safeguards selected and implemented in the Java-Bali 500-kV Project created a positive value. A rigorous cost-benefit analysis, one that is incorporated into a project's evaluation, can demonstrate that environmental safeguards not only protect environmental and wildlife values, but can add to an infrastructure project's overall net value. If projects continue to ignore the benefits of safeguards but include their costs, then stakeholders will only view safeguards as a cost. Equally important, the type of cost-benefit analysis conducted for this project needs to be replicable so it can be used for other LI projects, both in Indonesia and throughout Asia.

It should be noted that there are two main challenges in conducting this type of analysis. First is the lack of data. Second is the accessibility of the existing data. Often the proponent of a project conducts an evaluation study, but the reports are not available to the public. Transparency in the decision-making process is important so that independent evaluations can be conducted. Additionally, a review of the documents created for the Java-Bali 500-kV Project showed that even when the official documents were available to the public, they often lacked detailed and relevant data.

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CASE STUDY 8. ECONOMICS: ROAD: FEDERAL ROUTE 4, EAST-WEST HIGHWAY (MALAYSIA)

BASIC INFORMATION

Linear infrastructure mode: *Road*

Country: *Malaysia*

Location (district/state): *Gerik/Perak and Jeli/Kelantan Peninsular Malaysia*

Proponent: *National government (Malaysian Public Works Department)*

INTRODUCTION TO PROJECT AND ECONOMIC TOOLS

Federal Route 4 is a 307-km highway in the north of Peninsular Malaysia and part of the East-West Highway, a road that connects the east coast to the west coast of Peninsular Malaysia (Figure 25). The Malaysian Public Works Department in the 1970s began construction of the East-West Highway, including Federal Route 4, as a defense-related highway during the Communist insurgency in Malaysia from 1968 to 1989; and it was completed in 2005. The road connects the cities Gerik in the west to Jeli in the east before extending to Lunas.

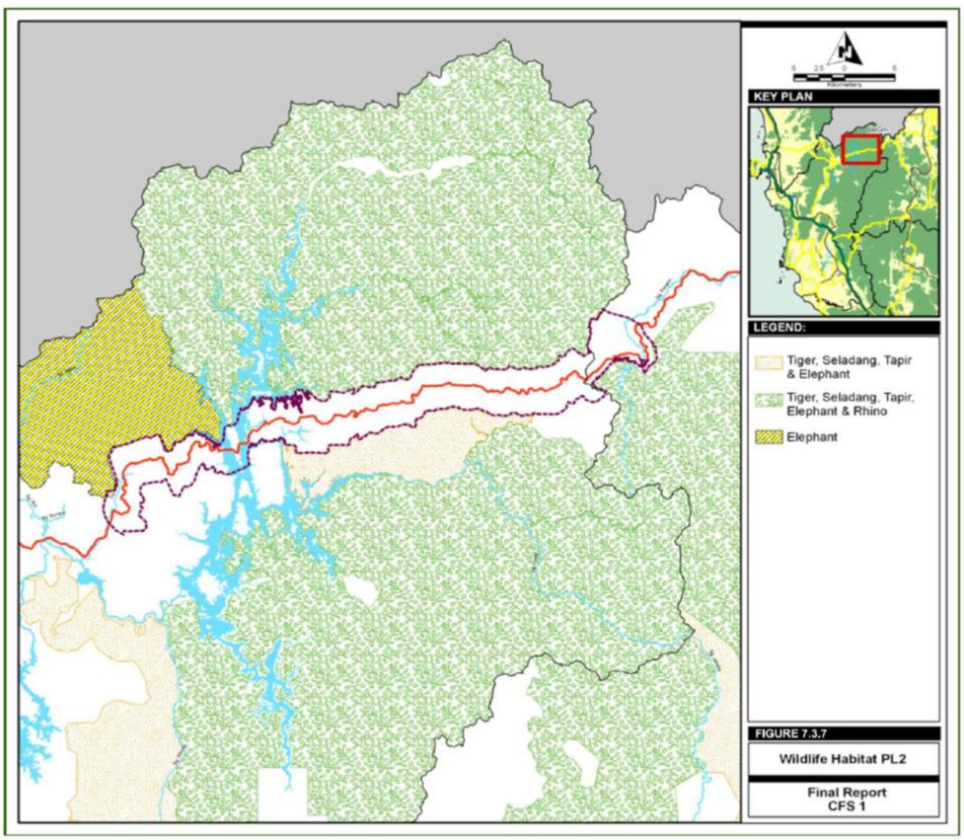

Figure 25: Wildlife habitat and the location of the Federal Route 4 highway. Source: Department of Town and Country Planning. CFS I: Master Plan for Ecological Linkages. Final Report. 2009.

This project was selected as a case study because of two economic analyses conducted in 2009 by the Department of Town and Country Planning as part of a Master Plan to create several ecological corridors in Peninsular Malaysia. The objective of the first economic analysis was to determine the economic viability of implementing the environmental safeguards identified in the Master Plan. The second economic analysis was to demonstrate the costs and benefits associated with the implementation of environmental safeguards. These two types of analyses complement each other and are important to show that environmental safeguards do not only represent costs, but they generate benefits in terms of avoided costs that should be included in any feasibility study of LI projects.

Currently, a growing number of proposed LI projects are including the expected environmental safeguards and their implementation costs into the financial feasibility analysis. This growth might be explained by either new environmental regulations in some cases and funding institutions' safeguard policies in others (Losos et al., 2019; Narain et al., 2020). However, the comparison between the costs and benefits of implementing environmental safeguards remains relatively rare for most Asian LI projects. As a result of this oversight, environmental safeguards are still regarded by some stakeholders solely as a cost. This situation has significant implications in policy because it fails to demonstrate how the economic value of environmental safeguards can be additive to conservation values.

ECONOMIC ANALYSIS

The Master Plan elaborated by Malaysia's Department of Town and Country Planning contained two economic analyses to show the costs of implementing the environmental safeguards envisioned by the plan and how these costs would compare to the benefits of implementing the environmental safeguards (Department of Town and Country Planning, 2009). The intended results of these two analyses were to show that the benefits of environmental safeguards exceed the costs, and that investing in safeguards is a wise decision as it generates a positive gain to society.

The economic analyses were done initially by identifying the safeguard measures that would need to be implemented to mitigate negative impacts resulting from Federal Route 4. The analysis was done after the construction of the road, and because of that, analysts well knew the impacts. The main effect caused by the road was the obstruction to wildlife movement. Many large animals (e.g., elephants and tigers) used this stretch of the East-West Highway to move between the Temenggor Forest Reserve and Royal Belum State Park (Figure 26). The road fragmented habitat and created a barrier. To mitigate this problem, the Master Plan proposed three measures.

1. Acquisition of lands surrounding both parks to expand connectivity between them and reduce the number of people living close to these parks to reduce human-wildlife conflicts.

2. Establishment of wildlife crossings, wildlife warning signs, and speed limits in the forested corridors used by wildlife.

3. Establishment of guidelines for adopting sustainable agriculture management in the areas close to both parks.

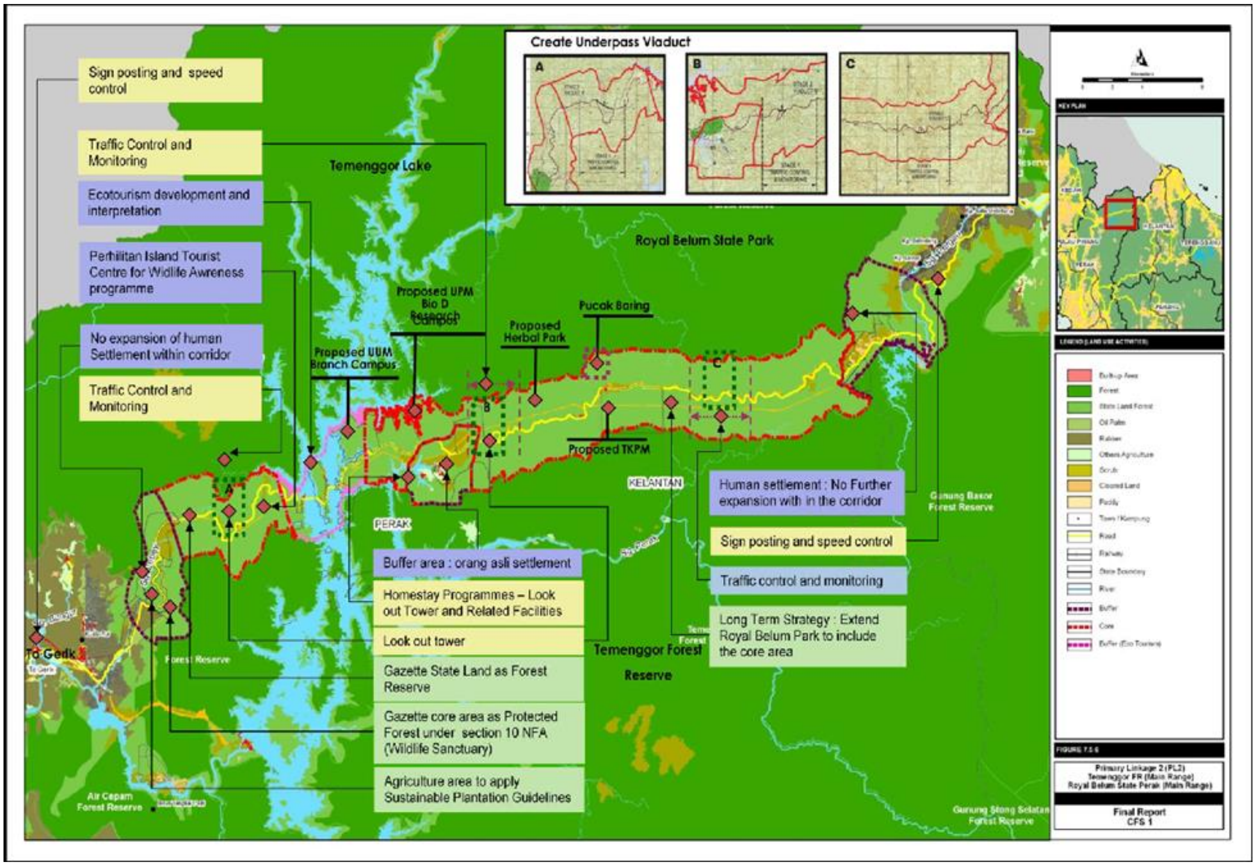

Figure 26: Location and description of the environmental safeguards implemented in the Temenggor Forest Reserve – Royal Belum State Park corridor. Source: Department of Town and Country Planning. CFS I: Master Plan for Ecological Linkages. Final Report. 2009.

The estimated cost of these measures was RM 465,127,865 (USD 131,280,797) in 2009. Out of this total, about 71 percent (RM 328,477,865 or USD 92,711,788) of the estimated cost was related to land acquisition (25,227 ha).

The benefits of implementing the three environmental safeguards were calculated using different approaches. In the case of the land acquisition, the approach used was the market price. Assuming a market price of USD 30 per ton of carbon, the authors calculated that the area could generate a revenue stream of RM 308 million (or USD 87 million) annually. If this were the case, the payback for the proposed measures would be two years.

In the case of the second and third environmental safeguards, the authors used the avoided cost method. Under a hypothetical scenario in which the safeguards were not implemented, what would be the costs? To conduct this analysis, the authors focused on human-elephant conflicts. If no environmental safeguards were implemented, then human-wildlife conflicts would increase in the region as wildlife (mainly elephants) would encroach into nearby agricultural farms and villages, damaging fences and feeding on young rubber trees and other tree species. Economic losses—and psychological fear—would be incurred by villagers. The Master Plan estimated the losses faced from human-elephant conflicts as the loss from damaged crops and the loss from other damages, such as property damage and the psychological fear of facing an incident of an elephant incursion into the village.

Using data on quantity and price, the authors estimated the loss from damaged crops at RM 2,578 (USD 728) per villager per year. To estimate the costs associated with property damage and psychological fear, the authors surveyed village members. The authors estimated these costs at RM 399 per villager per year. By adding both values, the authors estimated the total value of human-elephant conflict to be RM 2,977 (USD 840) per villager. The aggregate value of these losses was estimated by multiplying these values by the number of villagers potentially affected by the lack of environmental safeguards. Using an estimated number of 150 households, the authors calculated that the aggregate value was approximately RM 450,000 per year. This result is the same as saying that the cost of not having environmental safeguards equaled RM 450,000 per year (or about USD 127,000 per year).

The economic analysis in the Master Plan showed that the benefits from the three safeguard measures were greater than the costs. However, despite these results, the safeguards were not completely implemented. The main reasons for this were (1) the cost of deploying the measures was too high, regardless of net benefits that they would provide; and (2) the roles of the national and regional/state governments were not aligned. The Master Plan was created by one federal department that did not have the necessary financial resources to implement the safeguards. Collaboration among different federal, regional, and state governments and their respective departments would be necessary to achieve the complete implementation of the Master Plan.

To improve the plan and the feasibility of implementing the wildlife safeguards, Malaysia's Department of Town and Country Planning is developing an adjusted version of the Master Plan, which should be released at the end of 2021.

LESSONS LEARNED

This case study demonstrates the importance of conducting a cost-benefit analysis of the environmental safeguards selected for implementation in regional LI plans. By comparing the costs to the benefits of implementing safeguards, the authors were able to show that the various measures proposed in the Master Plan resulted in positive gains to society. However, demonstrating the positive economic gains that would accrue for a plan's mitigation measures was not enough to guarantee that the environmental safeguards were implemented. In this case study, the proposed safeguards were to be implemented by the state and regional governments, but the estimated costs were too high; they were above the amount that governments were willing to pay. Therefore, in terms of demonstrating the importance of safeguards, the two economic analyses done in the Master Plan might be considered a success. However, in practical terms, the implementation of the proposed safeguard measures has been slow and incomplete.

Many other LI projects in Asia would benefit from the type of economic analyses conducted for Malaysia's Federal Route 4, ones that describe both the costs and benefits of environmental safeguards and other mitigation measures in their feasibility study. Although the inclusion of the costs of LI mitigation is becoming more common in LI plans and project feasibility studies, it is important that their economic benefits also be included in these evaluations. Such analyses create a more balanced economic perspective and can demonstrate that the economic returns on investment in safeguard measures can often exceed the expenditures.

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COMPARATIVE ANALYSIS

We found that five keywords provide useful insights for evaluating all case studies. Each keyword reflects various aspects of the case studies that nearly all had in common but resulted in variable outcomes. These aspects of project development were used to evaluate, compare, and contrast the relative success of the projects (Table 1).

Table 1: List of case studies and their mode from linear infrastructure (LI) projects in Asia, including keyword and main outcomes associated with project.

TABLE 1: LIST OF CASE STUDIES AND THEIR MODE FROM LINEAR INFRASTRUCTURE (LI) PROJECTS IN ASIA, INCLUDING KEYWORD AND MAIN OUTCOMES ASSOCIATED WITH PROJECT. EXEMPLARY OR MODEL CASE STUDIES ARE DENOTED BY *

NO.	LI MODE – PROJECT NAME	COUNTRY	KEYWORD	MAIN OUTCOMES
		ECOLOGICAL		
1	*RAILWAY – Chittagong – Cox's Bazar	Bangladesh	BBA	Data informed; pre-construction data; expert input post-construction evaluation; adaptive management
2	*ROAD – Southern East-West National Highway	Bhutan	BBA	Data informed; Collection of pre-construction data; expert input post-construction evaluation; adaptive management
3	POWER LINE - Tonle Sap	Cambodia	Politics	Data informed; expert input; political; lack of capacity
4	RAILWAY – Qinghai-Tibet Railway	China	EIA	Deficient EIA; post-construction evaluation; political obstacle
5	ROAD – East-West Highway	Nepal	EIA	Data deficient; lack of capacity
6	*RAILWAY – East-West Railway	Nepal	Avoidance	Data informed; stakeholder input
		ECONOMIC		
7	*POWER LINE – Java-Bali	Indonesia	Positive value	Data informed; transparent process; cost-benefits
8	ROAD – Federal Route 4	Malaysia	Coordination	Cost-benefits; lack of implementation; lack of funding

Data Quality (or lack of)

Pre-construction data from rigorous research and monitoring to assess impacts are essential for designing and recommending adequate WFLI safeguards. Sound pre-construction data were obtained from BBAs or other research to inform safeguard planning in four projects (Southern East-West National Highway/Bhutan; Chittagong-Cox's Bazar Railway/Bangladesh; Tonle Sap Power Line/Cambodia; East-West Railway/Nepal), while data were inadequate to ensure proper safeguards in one project (East-West Highway/Nepal).

Post-construction data and evaluations help determine whether safeguards are functional and effective at meeting their objectives. One project conducted post-construction assessment of mitigation efficacy for Tibetan antelope and found that measures were incorrectly situated and therefore less effective in meeting population connectivity goals (Qinghai-Tibet Railway/China).

Expert input: Increasingly LI projects have included subject matter experts (e.g., road ecologists) in design of biodiversity assessments, environmental safeguards, and post-construction performance assessments. Positive examples of expert involvement were found in four projects (Southern East-West National Highway/Bhutan; Chittagong-Cox's Bazar Railway/Bangladesh; Tonle Sap Power Line/Cambodia; East-West Railway/Nepal), while two projects lacked input and the projects resulted in weak environmental safeguards and did not meet international standards (East-West Highway/Nepal; Qinghai-Tibet Railway/China).

Capacity: Two projects stand out as examples where the lack of capacity and proper training of project personnel in designing WFLI safeguards had a negative effect on project design, scheduling, and outcomes in terms of implementation of mitigation measures (East-West Highway/Nepal; Tonle Sap/Cambodia).

Politics: One project (Tonle Sap/Cambodia) was informed with rigorous information to design environmental safeguards based on expert input; however, the government ignored these recommendations and evidence of substantial adverse impacts on IUCN-listed species. This is an example of the lack of capacity and training within the government, but also demonstrates how politics can work to invalidate science-based input of safeguard recommendations.

Adaptive management: Post-construction monitoring can serve to identify deficiencies of mitigation measures and help design more effective measures in future projects. Not all case studies included post-construction monitoring, but we present two excellent examples of how monitoring is being used in Asia to better inform future designs of wildlife crossing structures (Southern East-West National Highway/Bhutan; Chittagong-Cox's Bazar Railway/Bangladesh).

The *economic case studies* share some of the common patterns and issues (positive and negative) that resulted in success or failure in those projects. Both projects strongly benefited from data to help in assessing the cost-benefit of deploying WFLI safeguards in the projects as opposed to excluding them. The Java-Bali project was an excellent example of a data-informed, transparent process to evaluate the economics of proper environmental safeguards in the power line project. The Federal Route 4 road project in Malaysia was also informed with adequate data in the planning documentation; however, errors in budgeting the project's costs and which jurisdiction was fiscally responsible for safeguard costs, resulted in the project not meeting its stated safeguard objectives.

KEY FINDINGS

The case studies suggest the following key findings from this project:

High-quality data from properly designed BBAs before construction are critical for ensuring that LI project safeguard plans are informed by best practices.

1. LI projects require qualified subject matter experts, at minimum in project oversight, and preferably leading all aspects of study design, data collection and analysis to feed into biodiversity safeguard recommendations.

2. Project requirements for WFLI safeguards need to meet international standards and current best practices.

3. Post-construction monitoring and evaluation are essential to determine the effectiveness of the mitigation measures and their design. Monitoring needs to be properly budgeted, appropriately designed, and conducted by subject matter experts with experience evaluating biodiversity safeguards such as wildlife crossing structures.

4. Mitigation performance evaluations can help future project design and planning by using an adaptive management approach, where lessons learned from the monitoring of past projects inform and improve future projects.

5. Economic analysis can show that WFLI safeguards do not represent only costs, but they generate benefits in terms of species and habitat conserved, as well as avoided costs. Cost-benefit analyses should be included in any feasibility study of linear infrastructure projects.

6. Economic analysis can demonstrate the importance of accounting for indirect costs to parties not related to the project and the benefits of implementing environmental safeguards into traditional project evaluations.

7. A rigorous cost-benefit analysis, one that is incorporated into a project's evaluation, can demonstrate that WFLI safeguards not only protect environmental and wildlife values, but can add to an infrastructure project's overall present net value.

8. Lack of training and capacity has led to inadequately prepared BBAs and superficial EIAs. As a result, poorly informed mitigation recommendations have resulted in the suspension of project funding, harmful impacts to animal movement, and the inefficient use of wildlife crossing structures (safeguard designs).

9. Politics can negate good data and science inputs to project safeguards.

RECOMMENDATIONS

The case study findings suggest the following recommendations for future projects:

1. LI projects should use the best available science in terms of study design and methods to assess impacts on key biodiversity values and wildlife populations.
2. Infrastructure ecology subject matter experts with extensive experience in assessment of LI impacts and design of biodiversity safeguards are critical to ensure that projects meet international standards and that best practices are employed.
3. Post-construction monitoring of mitigation measures, with sufficient funding, is needed to properly evaluate safeguard performance.
4. Lessons learned from post-construction monitoring of safeguards should be used to inform future designs for projects in Asia.
5. Economic analysis of WFLI safeguards should be conducted in feasibility studies to determine whether net positive values result. Cost-benefit analyses need to be replicable for use in other projects.
6. Increased training and capacity building is urgently needed and is foundational if Asia is to have ecologically sustainable LI projects in the future. Education of current best practices in planning, design and evaluation of mitigation measures is needed to begin institutionalizing WFLI safeguards in Asia.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Asian Development Bank. (2009). *Safeguard Policy Statement* [Policy Paper]. ADB.

Asian Development Bank. (2016). *Real-Time Evaluation of ADB's Safeguard Implementation Experience Based on Selected Case Studies* [Thematic Evaluation Study]. Asian Development Bank. https://www.adb.org/sites/default/files/evaluation-document/177678/files/safeguards-evaluation.pdf

Asian Development Bank. (2018). *Biodiversity Baseline Assessment: Phipsoo Wildlife Sanctuary in Bhutan* (Bhutan). Asian Development Bank. https://www.adb.org/publications/biodiversity-baseline-assessment-bhutan

Asian Development Bank. (2019a). *Bhutan: Road Network Project II. Completion Report* (p. 73). https://www.adb.org/sites/default/files/project-documents/39225/39225-022-pcr-en.pdf

Asian Development Bank. (2019b). *Green Infrastructure Design for Transport Projects: A Road Map to Protecting Asia's Wildlife Biodiversity*. Asian Development Bank. https://doi.org/10.22617/TCS189222

Asian Development Bank. (2021). *Indonesia: Java–Bali 500-Kilovolt Power Transmission Crossing Project* [Completion Report]. Asian Development Bank. https://www.adb.org/sites/default/files/project-documents/42362/42362-013-pcr-en.pdf

Buho, H., Jiang, Z., Liu, C., Yoshida, T., Mahamut, H., Kaneko, M., Asakawa, M., Motokawa, M., Kaji, K., Wu, X., Otaishi, N., Ganzorig, S., & Masuda, R. (2011). Preliminary study on migration pattern of the Tibetan antelope (Pantholops hodgsonii) based on satellite tracking. *Advances in Space Research*, *48*(1), 43–48. https://doi.org/10.1016/j.asr.2011.02.015

Chandran, N. (2018, August 10). *Southeast Asia is betting on hydropower, but there are risks of economic damage*. CNBC. https://www.cnbc.com/2018/08/10/hydropower-in-southeast-asia-dams-may-risk-economic-damage.html

Chogyel, K., Dodd, N., & Yangzom, K. (2017). Wildlife use of highway underpasses in southern Bhutan. *2017 Proceedings of the International Conference on Ecology and Transportation, Center for Transportation and the Environment, North Carolina State University, Raleigh, USA.*

Clements, G. R., Lynam, A. J., Gaveau, D., Yap, W. L., Lhota, S., Goosem, M., Laurance, S., & Laurance, W. F. (2014). Where and How Are Roads Endangering Mammals in Southeast Asia's Forests? *PLOS ONE*, *9*(12), e115376. https://doi.org/10.1371/journal.pone.0115376

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*(1), 100. https://doi.org/10.1186/1471-2288-11-100

Dear, C., Melnyk, M., Sharma, N., Berg, K., Ament, R., Shrestha, M., & Pariwakam, M. (2019). *Post-Approval Field Review Report: SASEC Roads Improvement Project (Nepal)*. USAID.

Department of Roads, Royal Government of Bhutan. (2009). *Bhutan: Road Network Project II, Environmental Assessment and Measures*. Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-document/64997/39225-bhu-seia.pdf

Department of Roads, Royal Government of Bhutan. (2017). *Use of underpasses by Asian elephants. Final wildlife monitoring report (draft). Road Network Project II, Project No. 39225-012.*

Department of Town and Country Planning. (2009). *CFS I: Master Plan for Ecological Linkages* [Final Report]. https://conservationcorridor.org/cpb/Peninsular_Malaysia_Regional_Planning_Division_2009.pdf

Dixon, A., Maming, R., Gunga, A., Purev-Ochir, G., & Batbayar, N. (2013). The problem of raptor electrocution in Asia: Case studies from Mongolia and China. *Bird Conservation International*, *23*(4), 520–529. https://doi.org/10.1017/S0959270913000300

DNPWC. (2016). *Tiger Conservation Action Plan for Nepal (2016-2020)*. Department of National Parks and Wildlife Conservation.

DNPWC. (2018). *State of Conservation of Chitwan National Park 2018*. Department of National Parks and Wildlife Conservation.

DNPWC. (2021). *State of Conservation of Chitwan National Park 2021*. Department of National Parks and Wildlife Conservation.

Dodd, N., & Imran, A. (2018). *Assessment of Biodiversity Baseline and Asian Elephant Distribution within the Chittagong-Cox's Bazar Rail Project Area of Influence, Bangladesh*. Asian Development Bank.

Donggul, W., Park, H.-B., Seo, H.-S., Moon, H.-G., Lim, A., Choi, T., & E. Song. (2018). Assessing Compliance with the Wildlife Crossing Guideline in South Korea. *Journal of Forest and Environmental Science*, *34*(2), 176–179.

DoR. (2016). *Environmental Impact Assessment, SASEC Roads Improvement Project, August 2016.* Prepared by Department of Roads, Ministry of Physical Infrastructure and Transport, Government of Nepal for the Asian Development Bank.

DoRW. (2018). *Expression of Interest Document for DPR of Nijgadh-Hetauda-Bharatpur Sector of MMER*. Nepal Department of Railways. https://bolpatra.gov.np/egp/download?alfId=17369569-a106-442b-b4d2-cbf57b9ffaf6&docId=60666627

Electricite du Cambodge. (2015a). *Press Release: 230 kV Electricity Transmission Line Project from Battambang Province–Siem Reap Province–Kampong Thom Province–Kampong Cham Province.* Electricite du Cambodge.

Electricite du Cambodge. (2015b). *Press Release: 230 kV Electricity Transmission Line Project from Kampong Thom Province–Preah Vihear Province.* Electricite du Cambodge.

Eng, M. (2016, December 8). *Cambodia's Bengal Floricans Threatened by Planned Power Line Development*. https://cambodia.wcs.org/About-Us/Latest-News/articleType/ArticleView/articleId/9430/Cambodias-Bengal-Floricans-Threatened-by-Planned-Power-Line-Development.aspx

He, G., Zhang, L., & Lu, Y. (2009). Environmental impact assessment and environmental audit in large-scale public infrastructure construction: The case of the Qinghai-Tibet Railway. *Environmental Management*, *44*(3), 579–589. https://doi.org/10.1007/s00267-009-9341-5

IUCN. (2014). *Elephant route identification project for construction of single line meter gauge railway track from Dohazari−Cox's Bazaar via Ramu and Ramu to Gundurn near Myanmar border. Final Report to Bangladesh Railway.* IUCN-Bangladesh.

Karki, J. (2020). *Biodiversity baseline assessment and mitigation strategy, Narayanghat-Butwal Road Project, Nepal* (p. 110). Report submitted to Nepal Department of Roads, Project Directorate (Asian Development Bank).

Leslie, D. M., Jr., & Schaller, G. B. (2008). Pantholops Hodgsonii (Artiodactyla: Bovidae). *Mammalian Species*, *817*, 1–13. https://doi.org/10.1644/817.1

Li, Y., Zhou, T., & Jiang, H. (2008). Utilization effect of wildlife passages in Golmud-Lhasa section of Qinghai-Tibet Railway. *Zhongguo Tiedao Kexue/China Railway Science*, *29*, 127–131.

Losos, E., Pfaff, A., Olander, L., Mason, S., & Morgan, S. (2019). *Reducing Environmental Risks from Belt and Road Initiative Investments in Transportation Infrastructure*. World Bank, Washington, DC. https://doi.org/10.1596/1813-9450-8718

Mahood, S. P. (2021). *Avian power line mortality in the Northern Tonle Sap Protected Landscape (NTSPL), June 2019 – January 2021*. Wildlife Conservation Society Cambodia Program.

Mahood, S. P., Silva, J. P., Dolman, P. M., & Burnside, R. J. (2018). Proposed power transmission lines in Cambodia constitute a significant new threat to the largest population of the Critically Endangered Bengal florican Houbaropsis bengalensis. *Oryx*, *52*(1), 147–155. https://doi.org/10.1017/S0030605316000739

Manayeva, K. (2014). *Migration patterns and habitat use of the Tibetan antelope (Pantholops Hodgsonii) based on Argos tracking in Qinghai-Tibetan plateau, China* [Rakuno Gakuen University / 酪農学園大学]. http://oatd.org/oatd/record?record=handle%5C%3A10659%5C%2F3708

Martin, G. R., & Shaw, J. M. (2010). Bird collisions with power lines: Failing to see the way ahead? *Biological Conservation*, *143*(11), 2695–2702. https://doi.org/10.1016/j.biocon.2010.07.014

Menon, V., Tiwari, S. K., Jahas, S., Ramkumar, K., Rathnakhumar, S., Ramith, M., Bodhankar, S., & Deb, K. (2015). *Staying Connected: Addressing the Impacts of Linear Intrusions on Wildlife in the Western Ghats (CEPF Grant No. 62921)*. Wildlife Trust of India. https://www.cepf.net/sites/default/files/final_report_by_wti_on_staying_connected_linear_intrusion_in_western_ghats.pdf

Ministry of Railways. (2016). *BAN: SASEC Chittagong – Cox's Baxar Railway Project Phase 1. Environmental Impact Assessment.* Government of Bangladesh.

MoEF. (1994). *Draft National Environmental Management Action Plan (NEMAP) Volume II: Main Report*. Bangladesh Ministry of Environment and Forest.

Narain, D., Maron, M., Teo, H. C., Hussey, K., & Lechner, A. M. (2020). Best-practice biodiversity safeguards for Belt and Road Initiative's financiers. *Nature Sustainability*, *3*(8), 650–657. https://doi.org/10.1038/s41893-020-0528-3

Packman, C. E., Showler, D. A., Collar, N. J., Virak, S., Mahood, S. P., Handschuh, M., Evans, T. D., Chamnan, H., & Dolman, P. M. (2014). Rapid decline of the largest remaining population of Bengal Florican Houbaropsis bengalensis and recommendations for its conservation. *Bird Conservation International*, *24*(4), 429–437. https://doi.org/10.1017/S0959270913000567

Perusahaan Listrik Negarat (PLN). (2013). *INO: Java-Bali 500 kV Power Transmission Crossing Project: Environmental Impact Assessment* (p. 439). Prepared by T Perusahaan Listrik Negara (Persero) for the Asian Development Bank.

Quintero, J. D., Roca, R., Morgan, A., Mathur, A., & Shi, X. (2010). *Smart Green Infrastructure in Tiger Range Countries* (p. 80). International Bank for Reconstruction and Development/The World Bank.

Railway Technology. (2006, September 21). Qinghai-Tibet Heavy Rail Line. *Railway Technology*. https://www.railway-technology.com/projects/china-tibet/

Royal Government of Bhutan. (2017b). *National Transport Policy of Bhutan—Second Draft*. Amstelveen: KPMG International. https://www.moic.gov.bt/wp-content/uploads/2017/08/Second-Draft-National-Transport-Policy-Bhutan.pdf

Schaller, G. (1998). *Wildlife of the Tibetan steppe.* University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/W/bo3646086.html

Shaw, J. M., Reid, T. A., Schutgens, M., Jenkins, A. R., & Ryan, P. G. (2018). High power line collision mortality of threatened bustards at a regional scale in the Karoo, South Africa. *Ibis*, *160*(2), 431–446. https://doi.org/10.1111/ibi.12553

USAID. (2013, July 24). *Title XIII: International Financial Institutions Act of 1977, As Amended*. https://www.usaid.gov/our_work/environment/compliance/title13

Van Merm, R., & Talukdar, B. K. (2016). *Report on the Mission to Chitwan National Park, Nepal from 14 to 21 March, 2016*. IUCN. https://whc.unesco.org/en/soc/3900

Wildlife Conservation Division. (2016). *Summary: Bhutan's State Of Parks Report 2016*. WWF and Wildlife Conservation Division, Department of Forest and Parks Services, Ministry of Agriculture and Forest, Thimphu.

World Heritage Convention. (2014). *Chitwan National Park (Nepal): State of Conservation 2014*. UNESCO. https://whc.unesco.org/en/soc/2873

Xia, H. (2020). The Role and Problems of Environmental Impact Assessment in Governing Hydro-Power Projects in Cambodia. *Beijing Law Review*, *11*(02), 501. https://doi.org/10.4236/blr.2020.112031

Xia, L., Yang, Q., Li, Z., Wu, Y., & Feng, Z. (2007). The effect of the Qinghai-Tibet railway on the migration of Tibetan antelope Pantholops hodgsonii in Hoh-xil National Nature Reserve, China. *Oryx*, *41*(3), 352–357. https://doi.org/10.1017/S0030605307000116

Xu, W., Huang, Q., Stabach, J., Buho, H., & Leimgruber, P. (2019). Railway underpass location affects migration distance in Tibetan antelope (Pantholops hodgsonii). *PLoS ONE*, *14*(2), e0211798. https://doi.org/10.1371/journal.pone.0211798