Economic Approaches for Reconciling Development and Conservation Goals in Linear Infrastructure Development

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Acknowledgments and Report Contributions

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Acronyms

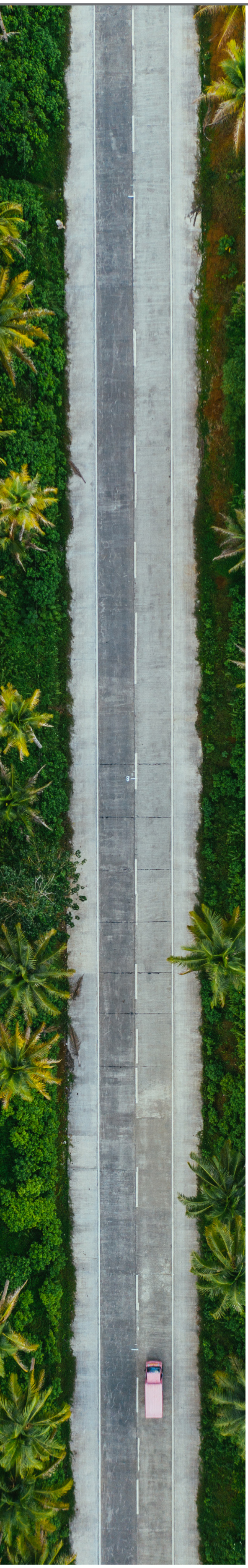
ADB	Asian Development Bank
BRI	Belt and Road Initiative
CBA	Cost-benefit analysis
CSF	Conservation Strategy Fund
EIA	Environmental Impact Assessment
ESIA	Environmental Social Impact Assessment
GDP	Gross Domestic Product
NR	Nepalese Rupee
OECM	Other Effective Area-Based Conservation Measure
RMB	Renminbi, the Chinese Yuan currency
UNESCO	United Nations Educational, Scientific, and Cultural Organization

Glossary

Economic Analysis	Approach to evaluate the costs and benefits of a project considering the impacts on the environment and society. An economic analysis is done from the society's perspective.
Economic Efficiency	Economic term for the optimal allocation of resources such that all available resources are fully used to produce a given output desired by society. This definition refers to Efficiency in Production.
Environmental Impact Assessment	Tool to identify all potential environmental and social impacts that would be caused by the implementation of a project. This assessment should be done at an early stage of project development and should be used to support the decision-making process.
Financial Analysis	Approach to evaluate the costs and benefits of a project to the project developers and investors. It does not include the impacts on third parties not directly involved in the project. The financial analysis is done from the investors' perspective.
Mitigation Hierarchy	Tool developed by the International Finance Corporation's Performance Standard 6 to support decision-makers and project developers to achieve no net loss of biodiversity. The steps in order are: avoid, mitigate, restore, and offset.
Net Present Value	Profitability indicator. It is used by investors and decision makers to analyze the feasibility and profitability of a project. It consists of the difference between costs and revenues throughout the project's time horizon.
Sustainable	Term that refers (1) to sustainable use, i.e., a resource that is used wisely and that will not be permanently damaged; and (2) sustainable activities, i.e., the adoption of activities that combine different long-term goals, including financial, social, and environmental goals.

I. Introduction

Infrastructure development enables decision-makers to address multiple social and economic goals, but can also erode natural systems on which these goals depend (World Bank, 2007; Alamgir et al., 2015). Energy and transportation infrastructure are essential to economic development, increasing productivity and efficiency in private and public sectors, and providing vital access to healthcare, education, and other services (Hettige, 2006; Redwood, 2012; Donaldson, 2018; Thacker et al., 2019). However, large-scale infrastructure investments (such as roads, railways, and transmission lines) can cause irreversible damage to biodiversity, ecosystem services, community stability, and human well-being (Laurance et al., 2009; Laurance et al., 2014; Alamgir et al., 2017). Moreover, the interactions between infrastructure and the environment can also change ecosystems' complex and dynamic capacity to self-regulate (DeFries & Nagendra, 2017; Hynes et al., 2020). As a result, these interactions can render ecosystems less resilient and more vulnerable to increasingly frequent shocks and unpredictable changes.



Because of this dichotomy, national governments around the world face acute pressure to find equitable, just, and participatory pathways for addressing development and conservation goals, from local landscape level plans to national and international commitments. However, decision-makers have traditionally favored infrastructure development goals over conservation goals, despite evidence that the implementation of infrastructure projects does not necessarily lead to economic growth. On the contrary, large-scale infrastructure investments, especially in remote areas, often generate significant environmental and social impacts that are rarely measured adequately or mitigated post-construction (Amend et al., 2013). Based on the literature reviewed in this study, these impacts result from a lack of planning, failure to apply globally recognized quality standards, detrimental siting or design, and other factors that could benefit from additional oversight and expertise from traditionally excluded stakeholders. Roads in rural areas and wildlife habitats, for example, often bring a wave of illegal activity, unsustainable resource extraction, immigration, and local community disruption (Fearnside, 2002; Suárez et al., 2013; Farhadinia et al., 2019).

Underlying many business-as-usual scenarios is the fact that infrastructure planning is often implemented by siloed governance bodies, each tasked with achieving potentially conflicting goals (Fearnside, 2005; Hammerschmid & Wegrich, 2016). In addition to these potential conflicts, the lack of coordination among these disparate institutions results in inadequate measurement of the diverse impacts and inequitable distribution of benefits, and often a small number of decision-makers drive these large infrastructure projects. These characteristics – variable quality[1], concentrated decision-making, economic flaws, and design shortcomings – point to a significant opportunity to improve infrastructure project planning and construction to achieve development goals at a much lower financial, social, and environmental cost.

Within this context, incorporating environmental and social costs from the beginning of the planning process can help prioritize linear infrastructure investments that generate greater benefits for society and maintain ecological integrity in critical wildlife habitats. Less environmentally harmful alternatives are often less costly from both a financial and economic point of view, and investing in planned avoidance of impacts can be less expensive than investing in mitigation (see Section I for more on the Mitigation Hierarchy Tool). For those impacts that cannot be avoided, the benefits, and not just the financial costs, of safeguard mitigation measures such as wildlife crossings should be incorporated into the feasibility analysis at the planning stage.

[1] This refers more to considerations of economic inefficiency and the negative social and environmental impacts, but could also include variable technical quality if engineering standards are not being met.

Feasibility analysis tools such as cost-benefit analysis (CBA) assess the economic efficiency of proposed investments by comparing their financial, social, and environmental costs and benefits. Included in these analyses are “external” costs and benefits, which are neither borne by nor currently received by project developers, but instead by other groups or society at large. These include changes in quantity and quality of natural resources, such as water or local food sources like fish, as well as globally important services like biodiversity and carbon sequestration. Furthermore, comprehensive CBA enables the analysis of costs and benefits from the perspective of multiple groups of actors, including local communities, municipal governments, private companies, and society as a whole. Applying CBA at the planning stages of infrastructure development in high priority conservation landscapes or rural areas also encourages multiple systems of governance and administration to consider landscape planning as the starting point of future development, removing the challenge of current siloed functioning and encouraging accountability in multiple actors.

Quantitative analyses like CBA help stakeholders and decision-makers to assess alternatives, share, and debate information on tradeoffs early in the process, establish clear policies for project approval, mitigation and compensation, and have financial incentives in place to ensure compliance with those policies. Our objective in this report is to highlight existing economic tools that can guide more socially beneficial and less environmentally harmful infrastructure planning and development, and identify the potential human welfare gains if these tools are used effectively to allow both wildlife and people to thrive in the context of true sustainable development.

II. Role of Economics in Reconciling Development and Conservation Goals

Infrastructure projects (e.g., the construction of new railways, pipelines, and highways) contribute to countries' economic and social development by improving "firms' production capabilities and consumers' consumption possibilities" (UNCTAD, 2013). One study shows that investing US$1 in infrastructure projects (transportation, energy, water, and communication) can raise the Gross Domestic Product by 20 cents in the long run (Bielenberg et al., 2020). However, the same study also shows that this increase in GDP depends on the quality of infrastructure projects, i.e., projects that generate tangible benefits to society, improve existing infrastructure networks, and address the needs of stakeholders.

In this section, we demonstrate how the use of economic tools can help project proponents and government authorities develop higher quality projects. We focus on the relationship between infrastructure projects and the environment and society. Historically, economists have described the relationship between development and the environment using the Environmental Kuznets Curve (Kuznets, 1955). Kuznets' assumption was that as countries grow, the initial impact on the environment is negative (due to habitat loss, for example). However, at a certain level of economic development, the impact on the environment becomes positive. At this point, he suggests that countries will allocate higher amounts of financial resources to recover and improve natural resources (for example, cleaning water and improving air quality). This behavior creates an inverted U-shaped curve, with environmental degradation on the y-axis and economic development on the x-axis. Based on this logic, "economic growth is both the cause and solution to environmental harm" (Mauroner et al., 2021). This assumption can lead decision-makers to pursue rapid economic development while overlooking environmental impacts due to the belief that environmental issues (e.g., CO_2 emissions) can be solved once the country is "developed" (Webber & Allen, 2010).

However, many studies have demonstrated that Kuznets' assumption is not necessarily correct and that evidence of its existence is mixed (Dasgupta et al., 2002; Beyene & Kotosz, 2019; Verma et al., 2021). Although some empirical evidence supporting Kuzntes' curve exists, they rely on examples of specific environmental issues; the environmental Kuznets curve "has never actually been shown to apply to all pollutants or environmental impacts" (Karsch, 2019). As a matter of fact, the validity of the environmental Kuznets curve depends on the regeneration capacity of the environment. If the damage is irreversible, then the underlying assumption of the Kuznets curve is false and the proposed dynamic between economic growth and the environment is no longer valid (Dasgupta & Maler, 2002; Prieur, 2009). Studies on natural ecosystems have shown that after a threshold of disturbance, certain essential characteristics are irretrievable and therefore the damage cannot be mitigated (IPCC, 2022). In such cases, the solution to environmental damages cannot be economic growth by itself.

The development of nature-based infrastructure[2] and better environmental regulations (to account for market failures[3]) can help countries overcome the initial association between economic development and environmental damage (Bassi et al., 2021). Indeed, studies have shown that it is possible to achieve conservation goals while investing in infrastructure development, such as by enabling multiple users to share existing infrastructure, investing in green infrastructure, and following environmental and social standards (Runge et al., 2017; TNC, 2018; Echeverri et al., 2022).

[2] Nature-based infrastructure solutions can be understood as "natural systems or engineered systems that mimic natural processes built to minimize flooding, erosion, and runoff. Nature-based infrastructure projects may include features that are completely natural, such as open lands and trees (e.g., coastal mangroves), or may incorporate varying degrees of hard or "gray" steel and concrete structures, such as seawalls" (Lipiec, 2020).

[3] Market failures describe an inefficient allocation of resources because the true cost of a good is not reflected in its price. This might occur for different reasons (e.g., asymmetric information and externalities - when the action of an agent or industry causes a positive or negative effect on others not involved in the initial action). As a result of this situation, the final outcome is not economically efficient.

In addition to investing in sustainable technologies and following best practices, it is equally important to account for (and, when possible, monetarily quantify) the impacts of projects on the environment before the project is approved and implemented. Focusing on linear infrastructure (e.g., railways, pipelines, and highways), studies have shown the significant short- and long-term damages to the environment and local communities caused by the lack of environmental accountability at the early stages of a project (Blake et al., 2007; Laurance et al., 2009; Barber et al., 2014). Among the possible reasons for the continued implementation of such projects, we highlight a key factor for the difference between social and private costs. Most of the social and environmental damages caused by infrastructure projects are not explicitly considered in economic feasibility studies, because they do not represent a direct cost to project developers, but rather to other groups such as local communities or society at large (Vilela et al., 2020). Not accounting for environmental impacts renders it impossible to achieve economic efficiency – defined as the resource allocation that will maximize benefits for society. Project proponents, governments, and other stakeholders can be encouraged to use comprehensive cost-benefit analysis and other economic tools that explicitly account for these external social and environmental impacts in order to improve resource allocation and avoid over-use and degradation of environmental goods and services.

Applying an economic lens early in the planning and design process can support better decision-making and help projects achieve economic efficiency by including social and environmental costs in the project feasibility studies, and by identifying and calculating the trade-offs (e.g., comparing overall costs and benefits) among project alternatives. In both cases, the relationship between decision-making and valuation of the environmental goods and services is significant since “every time a decision is made values are expressed, whether explicitly as part of an appraisal or implicitly revealed by the choice that was made and the alternative options that were therefore rejected” (Bateman & Mace, 2020). Participatory mechanisms allow for a more diverse set of values to be expressed in decision-making and are ideally placed within early-stage planning exercises as opposed to soliciting participation once diverse values cannot be integrated into infrastructure siting, design and build-out.



The use of economics is also fundamental when applying the decision-making framework known as the Mitigation Hierarchy (Fig. 1). This framework was initially designed by the International Finance Corporation's Performance Standard 6 to address the impacts of development projects (including infrastructure projects) on the environment (IFC, 2019). Based on this framework, project proponents should develop their projects considering at least the following four sequential steps: (1) avoidance, (2) mitigation, (3) restoration, and (4) offset of residual impacts. The first step is the most important within this framework (Losos et al., 2019) as often the most effective and least costly way to reduce the impact is to avoid it completely. The last step is the most controversial since it requires accepting the implementation of a project under the assumption that the harm caused by this project would be correctly quantified and balanced by benefits in other places (Arlidge et al., 2018).

Figure 1: *The Mitigation Hierarchy. Source: IISD.*

There are several challenges to the implementation of the Mitigation Hierarchy. Here we highlight two: ecological equivalency and least cost. The former relates to demonstrating the equivalence between the biodiversity loss caused by the implementation of an infrastructure project and the expected gain from an offset. For example, some countries (e.g. Colombia) are requiring that project proponents compensate for residual[4] biodiversity loss by restoring or protecting equivalent biodiversity areas in other places. The equivalence between these areas is determined by their ecological value (which can be estimated in monetary terms or not). In the case of Colombia, the proportion varies between 1:4 and 1:10 (Quintero, n.a.). For each hectare degraded, the project proponent should restore or protect at least four hectares of a similar (in ecological terms) area. The main challenges related to equivalency are (1) defining the timeframe (and the discount rate), and (2) measuring and estimating the loss (cost) and expected gain (benefit) (Sneyder & Desvousges, 2013; Clarke & Bradford, 2014; Reid et al., 2015).

[4] Residual here implies those impacts that were not avoided or mitigated.

Least cost refers to “guiding actions economically by costs so that efficiency dictates that each hierarchical step be undertaken to the point at which marginal costs are equalized” (Arlidge et al., 2018). In other words, the least cost aims to estimate the costs of each step in the Mitigation Hierarchy. It is challenging, however, to identify the costs related to each one of the four steps as usually there is not enough information about all the short- and long-term impacts caused by an infrastructure project, or the potential benefits and costs associated with each mitigation step. Additionally, we do not have enough data to fully understand nature’s capacity to recover from the damage in every case. As a result of this situation, avoidance should always be considered first. Depending on the project and impacts, the lowest cost alternative can be the one associated with impact avoidance instead of mitigation, restoration, or offset.

In both cases (equivalency and least cost), the use of economic tools can help quantify the costs and support the development of sustainable infrastructure projects. The ability to capture important socio-ecological values and translate them into the economic language of development creates a pathway to explicitly include these values in decision-making in ethical, novel, and vital ways.

III. Most Common Economic Tools Used to Evaluate Infrastructure Projects

How are financial and economic analyses different?

Financial analysis is a tool used by investors and project proponents to evaluate the financial feasibility and profitability of a project (e.g., expected return on investment). It compares the costs and benefits of a project from an investor's perspective. The financial analysis does not include the potential costs and benefits to the environment or to members of society not directly involved in the project. One way to account for these potential impacts is through an economic analysis (Sartori et al., 2015). Such an analysis involves evaluating a project from a societal perspective. A goal of this type of analysis is to estimate the project's net benefit to society as a whole. Thus, it should include as many of the costs and benefits associated with the project as possible, including those which impact or will impact the environment and society (Nielsen et al., 2016).

Current usage of financial analysis	Why use economic feasibility instead?
Most countries require a financial feasibility study during the early stages of project development to approve an infrastructure project and procure financing. In these studies, the variables accounted for are financial costs and revenues to the project developer and operating firm (if not the same) throughout the project's life cycle. In the case of linear infrastructure projects, most countries and international funders (e.g., development banks) also require project proponents to conduct an Environmental Impact Assessment (EIA). However, the quality and timing of its execution vary by country, project, and assessor (Gleason et al., 2014). Biswas & Modak (1999) highlight three stages when an EIA is commonly conducted. The first is following the feasibility study and engineering plan. In this case, the assessment is intended to identify the impacts and propose mitigation measures to integrate into plans. Second, the EIA is conducted concurrently with the feasibility study and engineering plan (by two different teams). In this case, the EIA aims to evaluate project alternatives as well as mitigation measures. Third, the EIA is integrated into the planning process (i.e., feasibility study and engineering plan). Biswas & Modak (1999) recommend the third option as it "prevents avoidable losses of environmental resources" and saves valuable time and expense for the project proponent and regulator agencies.	The identification of the potential environmental impacts of the infrastructure project at the planning stage offers an opportunity for project developers to conduct a more accurate economic feasibility study. In this case, in addition to the financial costs and revenues generated by the project, the costs of external positive and negative effects would also be included in the analysis. A benefit of conducting an economic feasibility study is to avoid, or at least minimize, inefficiencies in terms of the best use of resources (including natural resources).[5] There are several tools that can be used to conduct an economic analysis and help project developers and public decision-makers reconcile conservation goals with economic growth. In this study, we will focus on the most commonly used economic tools (although we will also highlight some non-economic tools frequently found in the literature as well). Table 1 presents a summary of these tools. These tools do not need to be used exclusively; on the contrary, they typically complement each other.

[5] From an economic perspective, inefficiency occurs when the resources (goods and services) are not being optimally used; they are either being underused or overused. As a result of this situation, it is possible to improve the original allocation of the resources in a way that at least one individual/group benefits and no one is disadvantaged.

Table 1. *Common tools that enable the combination of development and conservation goals in the evaluation of infrastructure projects. Notes: 1Stobierski (2019). 2GEF LME:LEARN (2018). 3Ozdemiroglu & Hails (2016).*

Most Common Tools	Application	Pros	Cons
Cost-Benefit Analysis[1]	This analysis is used to evaluate the economic feasibility of projects (Dicks, Dellacio & Stenning, 2020).	This analysis supports decision-makers by offering a transparent approach and making the decision simpler (as the decision is reduced to comparing costs and benefits in monetary terms)	The comparison between the benefits and costs requires that (1) all positive and negative impacts be identified, and (2) be measured in monetary terms. It can be difficult to predict all variables as well as to assign a monetary value to them – especially environmental variables.
Cost-effectiveness[2]	This analysis identifies the lowest cost option to achieve a specific conservation goal (e.g., Mwedde et al., 2015)	The goal does not need to be quantified in monetary terms.	All costs should be identified and quantified in monetary terms, which can be difficult to assign. This approach does not include an assessment of the benefits.
Life-cycle cost analysis	This analysis assesses the overall cost of a project (from initial costs to the costs incurred at the end of the life of the project). It is used to compare similar projects but with different cost distribution.	This analysis supports decision-makers by making the decision simpler (as the decision is reduced to compare costs among alternatives)	All costs should be identified and quantified in monetary terms, which can be difficult to assign. In the case of this approach, only the costs are accounted for.
Economic valuation[3]	This approach is used to quantify the monetary value of environmental goods and services (Ntujju et al., 2016; Emerton & Aung, 2013)	The monetary quantification of environmental goods and services allows easier comparisons between the external impacts generated by a project to its financial costs and benefits.	The estimation of the value depends on several factors, including location, current bio-physical, demographic and socio-economic conditions, and population being surveyed. It can be time-consuming depending on the approach used to conduct the economic valuation exercise (e.g., benefit transfer, contingent valuation, choice experiment).
Multi-Criteria Analysis[2]	This analysis is used to compare project alternatives (e.g., Vilela et al., 2020)	This approach usually substitutes for Cost-Benefit Analysis when the monetary values cannot be estimated. Additionally, this approach allows the integration of non-quantitative criteria, and multiple (and sometimes conflicting) objectives (or criteria).	This approach requires the identification of all positive and negative impacts and criteria to consider. These impacts are then ranked in terms of their importance (through a weighting process). This process is usually subjective and time-consuming.
Least-Cost Path Analysis	This approach is used to identify the “cheapest” alternative route (e.g., Barr et al., 2015).	The approach is based on the creation of a “cost layer” which combines multiple cost variables. There is no need to monetarily quantify all costs (e.g., environmental damages, slope, topography, etc.)	It is sensitive to the variables used in the “cost surface” layer.

Box 1. *The following are resources and reports where readers may find more information about the economic tools mentioned above.*

For more on cost-benefit analysis

- Society for Benefit-Cost Analysis (*website*)
- SPREP/ SPC/ PIFS/ Landcare Research and GIZ (2013). *CBA for Natural Resource Management in the Pacific: A Guide*
- OECD (2006). *Cost-Benefit Analysis and the Environment: Recent Developments*
- OECD (2018). *Cost-Benefit Analysis and the Environment: Further Developments and Policy Use*
- European Commission (2014). *Guide to Cost-Benefit Analysis of Investment Projects*
- Australian Government (2006). *Handbook of Cost-Benefit Analysis*
- United States Environmental Protection Agency (2016). Chapter 9: Economic impacts. In: *Guidelines for Preparing Economic Analyses*

For more on valuation

- A global project providing valuation training, discussion forums, and online tools (*ValuES*). More examples of how valuation is applied can be found by visiting their *cases* page.
- Integrated valuation of ecosystem services and tradeoffs (*InVest*)
- Wealth Accounting and the Valuation of Ecosystem Services (*WAVES*)
- The Economics of Ecosystems & Biodiversity (*TEEB*)
- USAID Integrating Ecosystem Values into Cost-Benefit Analysis: Recommendations for USAID and Practitioners (*link* to the report)
- IUCN Tools for measuring, modeling, and valuing ecosystem services (*link* to the report)

For more on economic tools (including cost-effectiveness and multi-criteria)

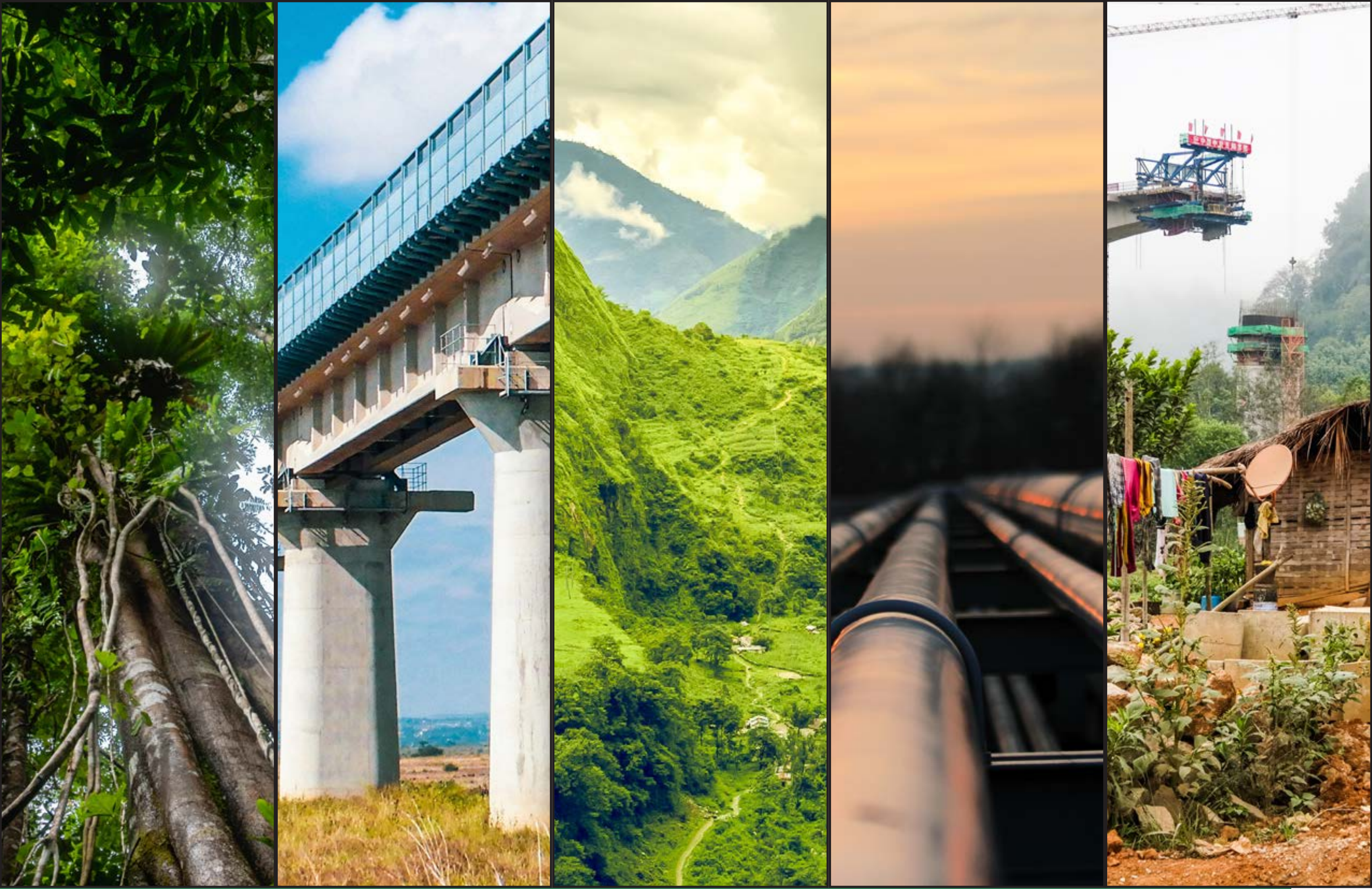
- Conservation Strategy Fund (CSF) *Video Lessons*
- Online training courses and additional resources: *Numbers For Nature Training Institute*

CSF study examples of transportation and energy infrastructure

- *Oil pipelines in Uganda*
- *Bwindi road in Uganda*
- *Local economic costs of a dam, Kenya*
- *Amazon road network analysis*
- *Transmission lines in the Darien Gap* (In Spanish)
- *Cumulative impacts of multiple dams in Peru* (in Spanish)
- *Ecosystem service losses to communities from the Tapajós dam in Brazil* (in Portuguese)

Additional studies from the Natural Capital Project staff on using ecosystem service modeling to inform spatial planning and government policies and financing, with case studies from Belize and China:

- Global: *Global modeling of nature's contribution to people (2019)*
- Belize: *Embedding ecosystem services in coastal planning leads to better outcomes for people and nature (2015)*
- China: *Using gross ecosystem product (GEP) to value nature in decision making (2020)*
  Realizing the values of natural capital for inclusive, sustainable development: Informing China's new ecological development strategy (2019)
  Improvements in ecosystem services from investments in natural capital (2016)



IV. Case Studies

In this section we illustrate how economic tools have been used in practice for infrastructure projects across five countries. We analyze each case to understand how the tools were used and with what outcomes. The selection of the linear infrastructure projects was based on two criteria: (1) their social and environmental impacts – we selected projects that would impact highly significant areas (such as protected areas) and/or local communities; and (2) the economic tools used to evaluate the feasibility of the projects and the impacts that would be caused by their implementation – more specifically, we selected projects that were economically evaluated using one of the tools in Table 1.

The countries and economic tools used are:

- Indonesia — least-cost path analysis
- Kenya — cost-benefit analysis
- Nepal — cost analysis
- Uganda — cost-effectiveness analysis and economic valuation
- Laos — financial feasibility analysis

Infrastructure

Location

Approach

Mining Road in Harapan Forest, Indonesia:

A priority weight for known high biodiversity results in safer alternate routes in spite of deviation penalties

Infrastructure:	Location:	Approach:
Road	Indonesia	Least-cost path analysis

Project overview

In 2019, the Indonesian government granted permission to the coal-mining corporation PT Marga Bara Jaya to construct a paved road in the middle of the Harapan Forest (Pramita et al., 2020), an OECM[6] (Gloss & Ahmed, 2019). The proposed road extension is 88 km, of which about a third of the road, or 26 km, would cut directly through the Harapan Forest (Fig. 2). The road would be used to transport coal from mining companies in the Musi Rawas district to power plants in Musi Banyuasin district in South Sumatra province (Diana, 2020). At the time, the mining companies used a non-paved road with a capacity to transport about 1,000 tons of coal per day. Companies, however, have the potential to extract more coal from the region. It is estimated that there are 406 million tons of coal in the area, but the exploitation of these deposits depends on solving the current transportation bottleneck (Hermawan & Sedayu, 2020).

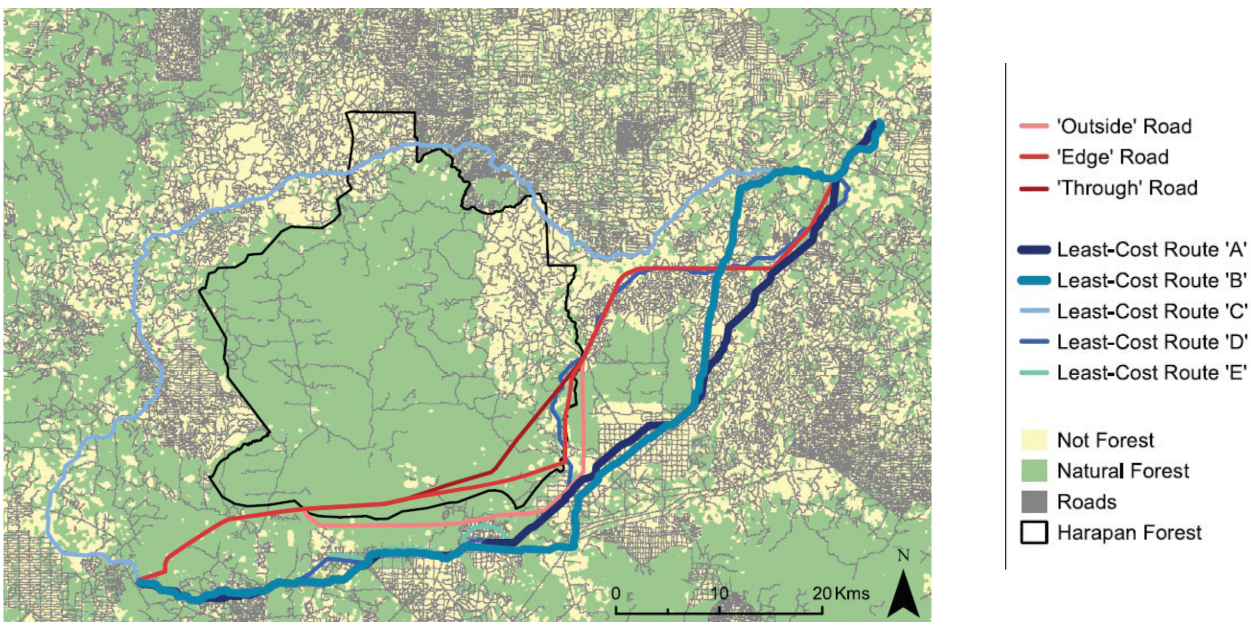


Figure 2. *The alternative routes for the mining Road in Harapan Forest, Indonesia. Source: Engert et al., 2021.*

The situation is aggravated because of the unique location where the deposits and coal mining companies are located: the Harapan rainforest, a globally recognized biodiversity hotspot. This 986-km2 forest represents 20% of the remaining dry lowland forest in Sumatra, Indonesia (de Kok et al., 2015). It is home to numerous endangered species, including the Sumatran elephant, Sumatran tiger, Sunda pangolin (de Kok et al., 2015), the spiny turtle, and the world's rarest species of stork – Storm's stork (Hermawan & Sedayu, 2020). Indigenous communities also rely on the forest for non-timber products vital for their livelihoods. For example, indigenous peoples use forest products to treat illnesses as the closest hospital is too far from the communities (Pramita et al., 2020).

[6] OECM is an acronym for Other Effective Area-Based Conservation Measure: an area achieving effective in-situ conservation of biodiversity outside of protected areas.

Expected impacts

The construction of the 88-km mining road would require the deforestation of 4.24 km2 of land. However, other negative impacts will likely follow the road construction. For example, the incursion of loggers, illegal miners, hunters, and small-scale farmers along the road (Engert et al., 2021). Following the guidelines determined by the Environment and Forestry Ministry, the mining corporation PT Marga Bara Jaya conducted an EIA – later approved by the same Ministry. In this assessment, three alternative routes were considered, but the shortest route was chosen by the company, which simply acknowledged that the “winner” route would cut through the Harapan Forest, destroy the habitat of critically endangered species, and sever wildlife connectivity in the region (Pramita et al., 2020).

Project analysis

Using the least-cost path approach, Engert et al. (2021) created five alternative routes and compared them to the three original routes proposed by the mining company. They compared the routes in terms of cost; meaning that the best route is the one that minimizes cost. However, within this approach, cost represents a combination of multiple variables with different weights. For example, Engert et al. (2021) used three variables: forest value, construction cost, and a factor to penalize routes that deviated from the original location of the proposed mining road (or simply, deviation penalty). The authors calculated these variables using geospatial analysis and combined them to form a single cost layer. To combine these variables, the authors considered different weight sets, and created different scenarios. They considered five specific scenarios (or routes): (a) all layers weighted equally, (b) forest value layer weighted higher, (c) forest value layer weighted much higher, (d) forest value and deviation layers weighted higher, and (e) forest value and deviation layers weighted much higher.

Based on this approach, the authors found that the alternative routes they proposed would lead to lower environmental impacts and lower construction costs when compared to the three routes proposed by the company. They concluded that the best route for the mining road would be in nearby lands outside Harapan Forest. These lands are already largely deforested, and for that reason, the impact on the environment would be less significant. Furthermore, the mining company would benefit from a lower construction cost despite the rerouting.

Lessons learned

This case demonstrated that it is possible to integrate environmental considerations in infrastructure planning at early stages, and doing so could result in improved environmental and financial outcomes. Although no further information exists regarding the future of this mining road, the analysis conducted by Engert et al. (2021) showed that project proponents and governments could minimize both environmental and financial costs while meeting the original goal to connect mining sites to power plants; an apparent win-win situation.

It is worth mentioning that the authors do not account for the effect of the project on the local population. Ideally, to provide a more holistic analysis of the project, these effects should also be included in the analysis of alternatives to guarantee that the project is sustainable to the environment and society.

In terms of the methodology, the least-cost path approach has two advantages. First, it allows the combination of multiple variables and the creation of different scenarios. Second, it contributes to avoiding damage, the most important principle in the Mitigation Hierarchy.

Standard Gauge Railway from Mombasa to Malaba, Kenya:

Adequate financial risk assessment can safeguard people and wildlife without incurring the costs of a comprehensive ESIA process

Infrastructure:	Location:	Approach:
Railway	Kenya	Cost-benefit analysis

Project overview

The construction of the Mombasa–Malaba railway is part of a development plan to expand the rail network in East Africa and meet the needs of the growing economy in the region (CPCS 2009); it is also part of the Kenya Vision 2030 development agenda launched in 2008. Among the goals, the long-term development agenda seeks to increase the railway capacity in the country from 5% to 50% of the cargo freight from the port of Mombasa (GoK 2021). Currently, the remaining cargo (about 95%) is transported by road (GoK 2021). The construction of the railway, which started in 2014, is being funded by the Exim Bank of China (through loans) and the Government of Kenya (Irandu & Owilla 2020; Zhu et al. 2020; Nyumba et al. 2021).

The construction of the almost 1,000-km railway is divided into three phases. Phase I, from 2013 to 2017 (Irandu & Owilla 2020), corresponds to the construction of a 472-km railway from Mombasa to Nairobi (Fig. 3). This phase is complete and the railway is already operational (Habitat-Planners 2016). Phase 2 corresponds to the construction of a 120-km railway from Nairobi to Naivasha. The construction of Phase 2 started in 2018 (BRI International Green Development Coalition 2020) and it is estimated to take 54 months to be completed (Habitat-Planner 2019). Finally, Phase 3, yet to start, corresponds to a 369-km railway from Naivasha to Kisumu and Malaba (Irandu & Owilla 2020).

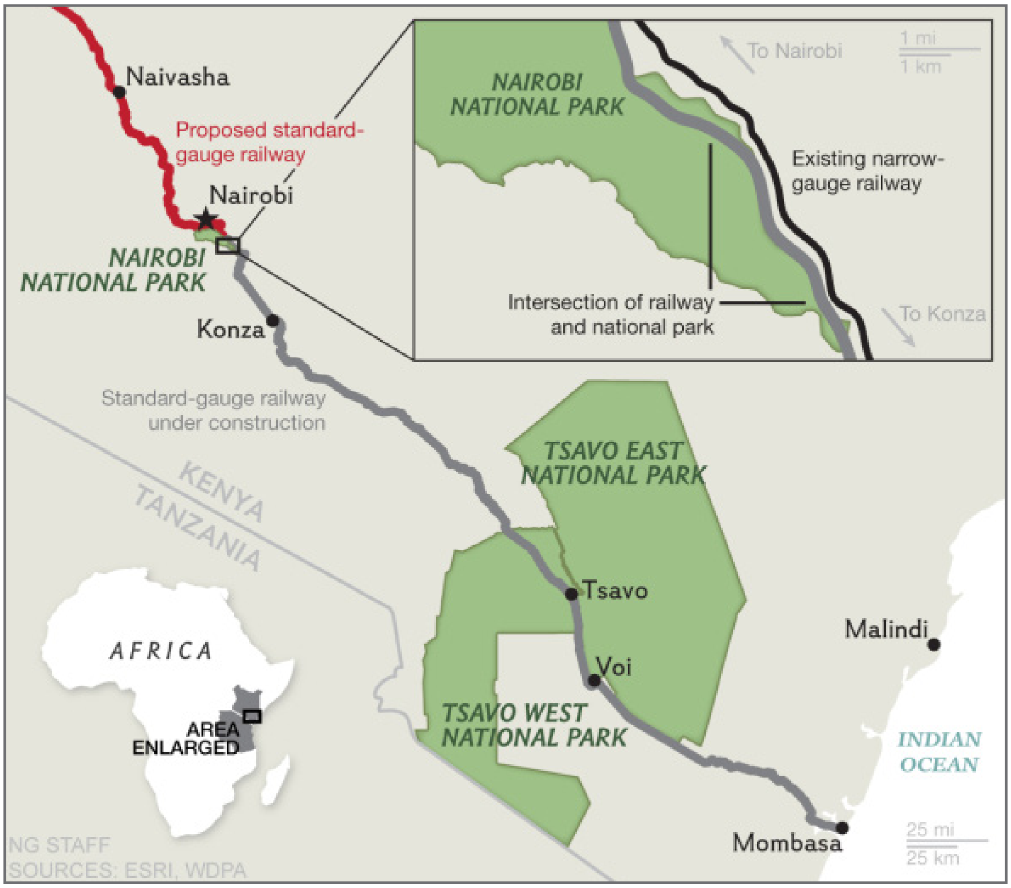


Figure 3. *Map of the Standard Gauge Railway from Mombasa to Malaba, Kenya. Source: Kushner, 2016.*

Expected impacts

The construction of the initial 472-km railway resulted in the loss of 87 hectares, or 0.75%, of the Nairobi National Park. In the case of Phase 2, the Environmental and Social Impact Assessment (ESIA) evaluated seven routes (Fig. 4). All of the alternatives would result in significant social and environmental impacts such as crossing over or passing along the edge of Nairobi National Park and/or crossing through densely populated areas leading to the displacement of numerous families. Using four thematic factors (route suitability, social impacts, affected ecosystems outside Nairobi National Park, and environmental impacts in Nairobi National Park) and 27 impacts (social and environmental), the EIA identified the most suitable option. The construction of the winning route would cut directly through Nairobi National Park, affecting 42 hectares and numerous species of wildlife, including black rhino, lion, and coke's hartebeest (Ambani & Mulaku, 2021). Several mitigation measures, including the construction of a 6.5-km bridge traversing the park (BRI International Green Development Coalition, 2020), are proposed in the ESIA. The winning route in this case was identified in the vacuum of monetary quantification of the impacts of the railway on the environment and nearby communities, or the impacts of the mitigation measures.

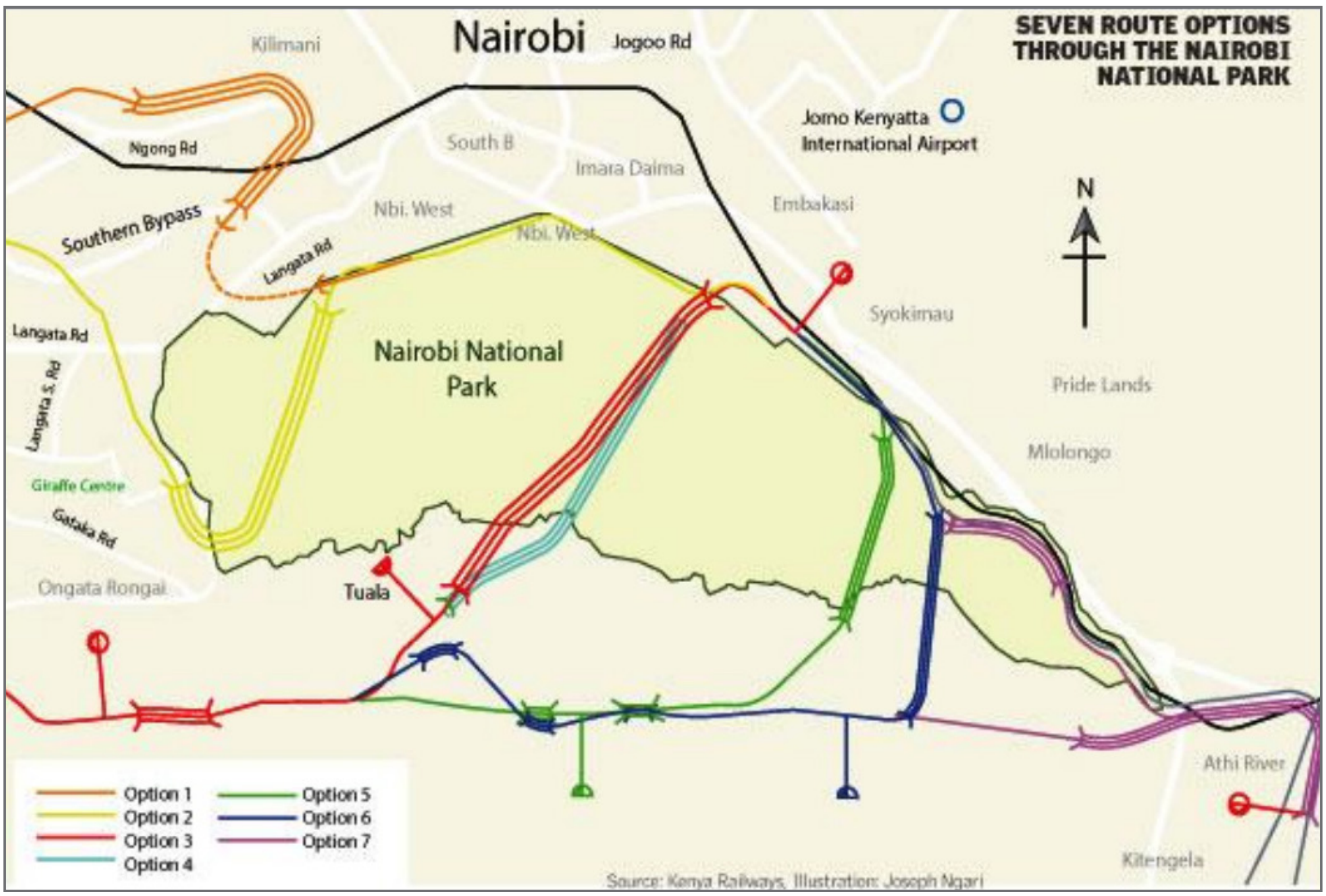


Figure 4. *Map of the alternative routes for the Standard Gauge Railway from Mombasa to Malaba, Kenya. Source: Habitat-Planners, 2016.*

Project analysis

In 2013, the World Bank conducted a cost-benefit analysis of four alternatives, including investing in better maintenance and upgrading the existing rail network in the East Africa region (World Bank, 2013). The study compared the costs (investment cost per kilometer) to the freight volume and expected revenue benefits. The estimated costs ranged from US$0.18 million to US$3.25 million. Based on the freight volume in 2009 and assuming that rail freight traffic would increase from 1.6 million tons in 2009 to 14.4 million tons in 2030, the study estimated a maximum revenue of US$585 million per year. Using these values, each alternative was evaluated. The study concluded that upgrading the existing railway network would be the most suitable option to meet the growing demand. Constructing a new railway, such as the Mombasa-Malaba line, would result in higher costs and require a freight volume of 55.2 million tons per year to be financially justified. According to the ESIA, the forecasted freight volume is about 13 million tons per year in the short term (2023) and 22 million tons per year in the long term (2028) (Habitat-Planners, 2016).

Lessons learned

The route was selected using qualitative data and under the assumptions that the factors and attributes were equally important. To improve this process, sensitivity analysis could be done to test how results would change if the assumption of equal weights were removed.[7] We acknowledge that having equal weights might be initially beneficial to avoid bias or favor certain groups of stakeholders in the analysis, but alternative distributions of the weights should be tested to account for stakeholders' preferences.

Additionally, the cost-benefits analysis could have been more thorough by including social and environmental considerations. Guidelines on how to conduct a more holistic cost-benefit analysis exist (Dixon, 2013; EPA, n.a.). However, it is worth mentioning that, despite the simplistic approach, the World Bank found that even excluding the impacts of the railway on the environment and nearby communities, its construction is not financially feasible. Often showing a financial argument that a project is not feasible can be more powerful than conducting a more holistic exercise of incorporating environmental and social variables in the analysis. Indeed, based on this study alone, the World Bank, a traditional lender, rejected the project (Wissenbach, 2019).

[7] Sensitivity analysis is done at the end of the analysis to identify how the main results change when one input variable changes. It is important when accounting for uncertainties in the data. It helps decision-makers to deal with information gaps and assess risk.

East-west electric railway, Nepal:

The Mitigation Hierarchy as a planning tool with international participation to illustrate the importance of biodiversity areas

Infrastructure:	Location:	Approach:
Railway	Nepal	Cost analysis

Project overview

In 2013, the Government of Nepal announced a plan to upgrade the East-West Electric Railway, a 945-km railway connecting Mechi to Mahakali (IBN, 2020). They highlighted the project as one of "national pride" (Rai & Pandey, 2014). According to the government, the improvement and construction of the electric railway would benefit the country as a whole: besides potentially connecting to the Trans-Asian Railway network, less fossil fuel would have to be imported as a result of this project (Chitrakar, n.a.).

The total project cost is estimated at US$3 billion and will be financed via a public-private partnership (IBN 2020). The project is divided into nine sections and each one is being evaluated independently. Table 2 presents each section's length and estimated costs (in Nepalese rupee).

Table 2. *Estimated length and cost of the nine sections of the East-West Electric Railway project in Nepalese rupee (NRs) (Chitrakar, n.a).The values corresponding to the length are rounded up and because of that do not add to 945. In parenthesis, we have the year of the cost estimation.*

Section	Length (km)	Estimated cost (NRs)
Kakarbhitta - Inaruwa	127	90,028,286,240 (2017)
Inauwa - Bardibas	139	116,194,171,910 (2017)
Bardibas - Simara	136	70,968,055,770 (2013)
Simara - Tamsariya	127	108,265,158,481 (2014)
Tamsariya - Butwal	108	64,504,062,699 (2014)
Butwal - Lamahi	106	74,272,914,908 (2018)
Lamahi - Kohalpur	114	100,110,878,676 (2018)
Kahalpur - Sukkhad	94	72,698,769,962 (2018)
Sukkhad - Gaddachowki	89	72,425,184,362 (2018)

Construction began in 2014 and was scheduled to take nine years (RITES Ltd. & SILT Consultants, 2012). However, it has been delayed for several reasons, including natural disasters (earthquakes and floods) and land compensation issues (Republica Nepal, 2021). At the time of writing this study, only a small fraction of the railway has been completed (Ament et al., 2021).

Expected impacts

Although the 945-km electric railway might bring some economic and social benefits to Nepal, it is unclear if these expected benefits would be enough to overcome the expected negative impacts. Besides the expected deforestation and land acquisition, 215 km of the railway will intersect priority conservation areas, including Shuklaphanta National Park and Chitwan National Park, a UNESCO World Heritage Site (Ament et al., 2021). The latter is home to numerous species (GoN, n.a.) and, since its implementation in 1973, it has played a key role in the preservation of two endangered species, the Bengal tiger and the One-horned rhino. From 2013 to 2014, the number of both species in these areas has quintupled (Hance, 2014). The park also harbors other globally-threatened animals and represents an important source of local livelihoods. For example, in 2013, the number of tourists visiting the park exceeded 150,000, generating approximately US$2 million in entry fees (Hance, 2014).

An alternative route parallel to the East-West Highway that does not cross the national park exists but was dismissed early in the project development because it is longer (Rai & Pandey, 2014; Dhakal, 2018) (Fig. 5). Due to Chitwan's importance, however, from 2015 to 2017, UNESCO opposed the project and appealed to the Government of Nepal to seek an alternative route (Joshi 2019). Some of the potential impacts of the construction of this section of the railway include habitat fragmentation, increased illegal poaching and logging activities, and reduced ecotourism. In 2018, after international and local pressure, the Government of Nepal agreed to search for alternatives that would not cross Chitwan National Park and to conduct an Environmental Impact Assessment for the alternative routes (GoN, 2018; 2021).

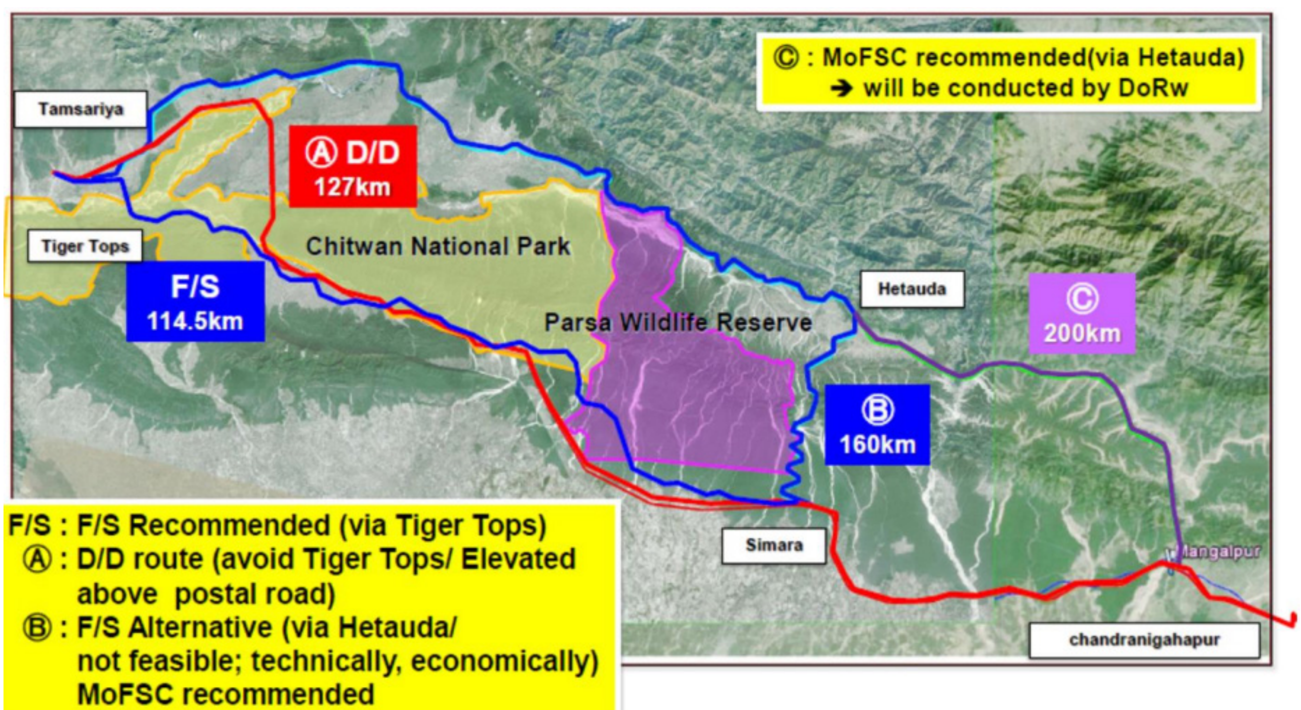


Figure 5. *Map of the alternative routes for the East-West Railway, Nepal. Source: Dhakal (2018).*

Project analysis

In 2018, a cost analysis was done to compare the environmental and financial costs associated with the original route and alternatives. Several routes were considered by the Government of Nepal in consultation with stakeholders (Dhakal, 2018). The Department of Railway, which is responsible for conducting the Detailed Project Report, is currently considering the final proposed alternative route. This route, which would run parallel to the East-West Highway and not cross Chitwan National Park was initially rejected by the project proponent because the length of this new route would increase from 127 km to 200 km. Table 3 presents the estimated environmental damage and financial cost comparison.

Table 3. *Environmental damage and financial cost comparison of alternative routes (Dhakal, 2018).*

Environmental damage (hectares)		
	Original route	**Alternative route**
Private land	395	493
Forest land	205	128
Other land	36	61
	636	682
Financial cost (US$ million)		
Cost per km	7.5	6.7
Total cost	2,962.5	3,303.1

In terms of the environmental damage, the results are presented as hectares lost. Although the new route would result in greater land loss, the amount of forest loss would be reduced by 37%, from 205 hectares to 128 hectares. In terms of financial cost, despite being longer, the new route would be 11% cheaper than the original route per kilometer of construction.

Lessons learned

There are four main lessons from this case study. First, the importance of involving all stakeholders in the decision-making process, including the determination of the route. Once the local community understood that the project could negatively impact revenue from tourism, opposition to the project grew. Second, the importance of recognizing that the assumption that a longer route would result in higher costs per kilometer bears testing with actual calculations of costs. The Government of Nepal initially excluded the alternative route under the assumption that the longer length would mean greater cost. But the cost analysis showed that this was not the case. Third, a full assessment of the benefits and negative impacts on the environment and society is crucial when developing infrastructure projects. Fourth, this case study showed the importance of considering the mitigation hierarchy at the planning stage. In this case, due to international and local pressure, it was possible to avoid the damage (or at least most of the damage) by proposing a new route. Some conservationists – in disbelief that this would be possible – were working under the assumption that the route would not be changed and because of that, they were more focused on proposing mitigation measures such as underpasses for wildlife and fencing to reduce disturbances (Rai & Pandey, 2014). All in all, this project makes the case for greater awareness and acceptance of the mitigation hierarchy (e.g., avoidance) as a planning tool for project proponents, governments, international conservation bodies as well as local communities and conservationists.

Crude oil pipeline in the Albertine Rift, Uganda:

Environmental considerations during the planning stage lead to more informed decision-making

Infrastructure:	Location:	Approach:
Pipeline	Uganda	Cost-effectiveness and economic valuation

Project overview

In 2006, Uganda discovered commercially viable quantities of crude oil in the Albertine Rift. Initially, the reserves were estimated at 3.5 billion barrels, but in 2014 the estimate was raised to 6.5 billion barrels (Tanzania Invest, 2016). However, despite the increase, only 2.2 billion barrels can feasibly be extracted (EPCM holdings, n.a.). Nevertheless, the potential financial gains from exploring this reserve could be significant for one of the poorest countries in the World (EPCM holdings, n.a.).

Within this context, in 2017, the Government of Uganda started to plan the construction of a crude oil pipeline. Because of its location and importance to all east African countries, the pipeline would go from the "shores of Lake Albert on the border between Uganda and the Democratic Republic of the Congo through Tanzania to the port of Tanga on the Indian Ocean" (Holden, 2021) (Fig. 6). The project is estimated to cost US$3.5 billion (Vyawahare, 2021) and it is still in the planning stage despite it being many years since the reserves were first discovered.

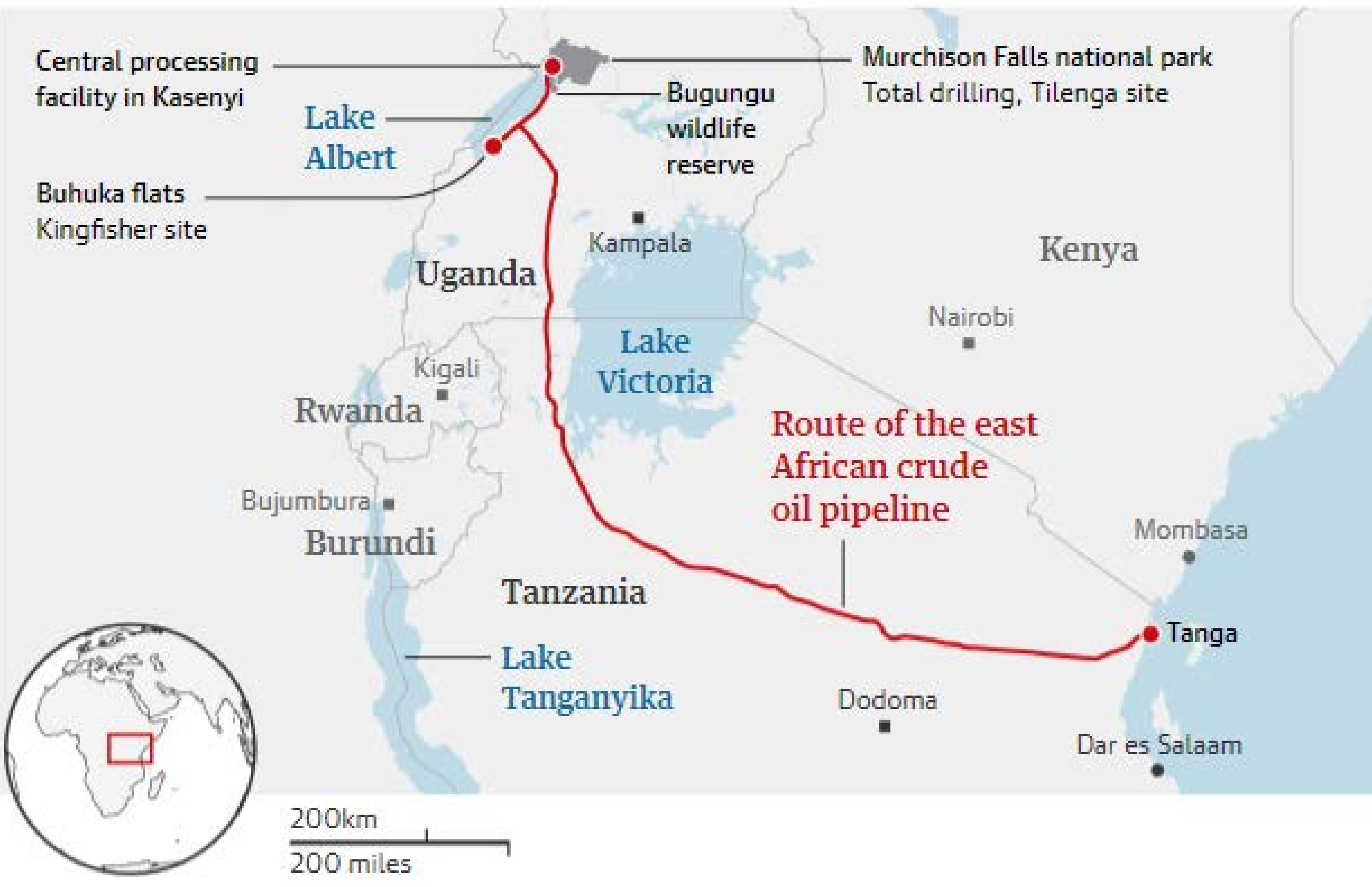


Figure 6*. Map of the crude oil pipeline in the Albertine Rift, Uganda, Source: Holden, 2021.*

Expected impacts

If constructed, the pipeline would be the longest heated pipeline in the world (Holden, 2021) at 1,400 km (Vyawahare, 2021). The pipeline would go from Uganda's largest national park – the Murchison Falls National Park (at the end of the Albertine Rift) – to Tanzania. In terms of environmental and social impact, Vyawahare (2021) highlights that the pipeline could negatively affect 2,000 km2 of protected areas and about 12,000 families would be displaced from their land.

Project analysis

In 2015 and 2016, Conservation Strategy Fund (CSF) and partners conducted a cost-effectiveness analysis and an economic valuation of a small section (about 30 km) of the pipeline located in Uganda. The pipeline would go from central processing facilities in the Buliisa District to a refinery in the Hoima District.

The cost-effectiveness analysis was divided into three steps. First, CSF identified areas of conservation priorities. Second, CSF identified potential alternative routes using a Least Cost Path analysis. In this step, two scenarios were considered. The first one only accounted for financial costs. The second one added the conservation areas identified in the first step to the overall cost analysis. Third, CSF quantified the environmental impacts of both routes. Three factors were considered in this step: vegetation loss, land cover change, and the establishment of species migration barriers. As a result of this analysis, CSF showed that although the route with environmental considerations would have a higher financial cost, its environmental impact would be considerably lower when compared to the financial route (Fig. 7). For example, in the case of the financial route, there would be a loss of 32% of mangabey[8] habitat, a loss of 100% of the hyena habitat, and 60% of the landscape's grassland. In the case of the environmental route, the loss would be 1.3%, 0%, and 47% respectively (Mwedde et al., 2015).

[8] A relatively rare species of long-tailed, forest-dwelling monkey.

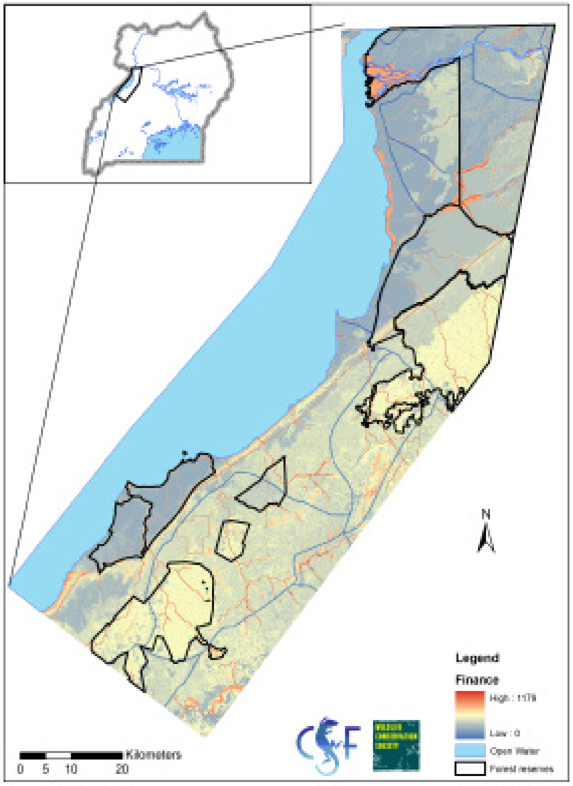


Plate 1: Resistance Layer Financial LCP

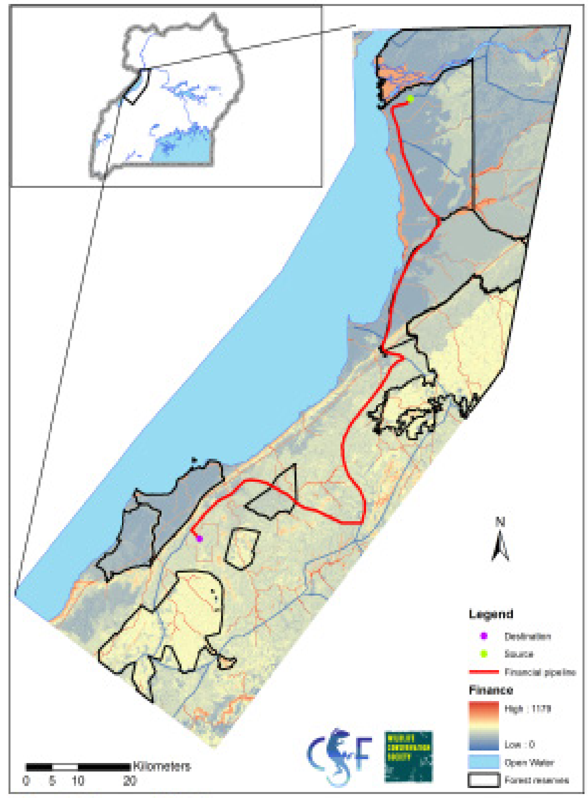


Plate 2: Financial LCP

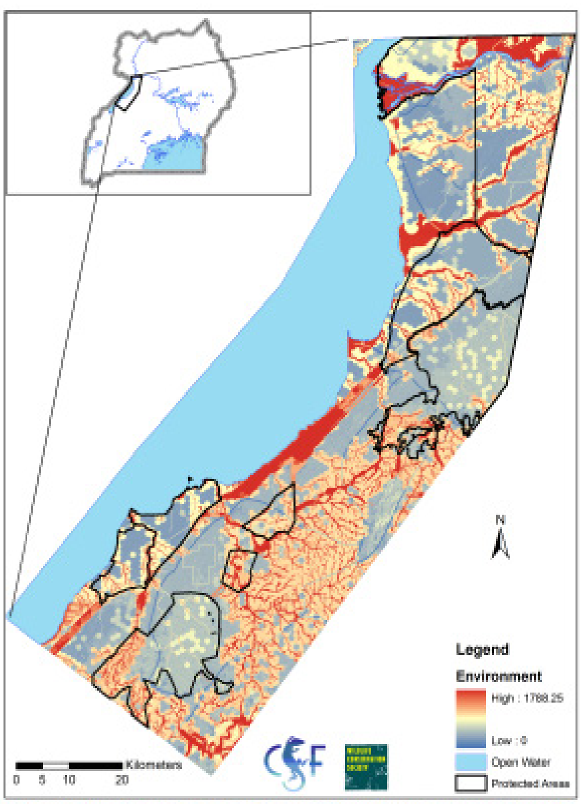


Plate 3: Resistance Layer Financial LCP with Environmental Considerations

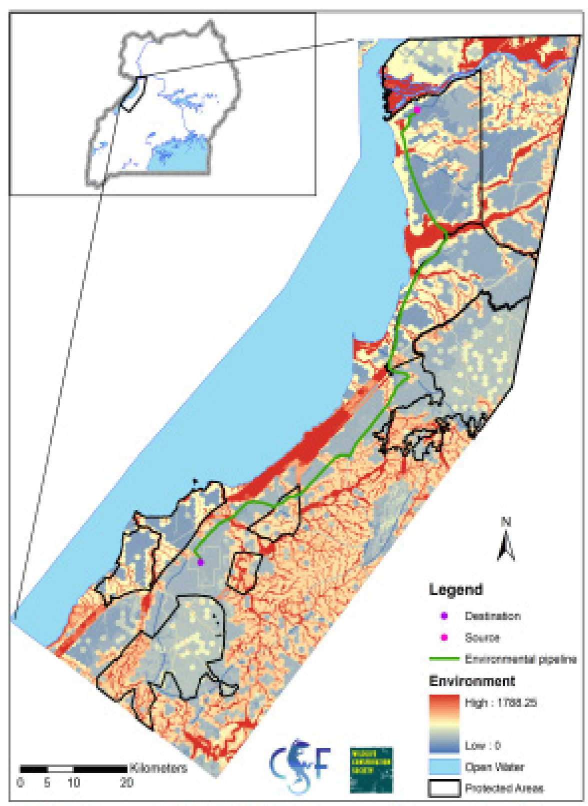


Plate 4: Financial LCP with Environmental Considerations

Figure 7. *Map of the crude oil pipeline in the Albertine Rift, Uganda, under the financial and environmental scenarios. Source: Mwedde et al., 2015.*

For the economic valuation, analysis was divided into four steps. In the first, CSF conducted a stakeholder workshop to determine the weights of the financial and environmental factors that would be included in the analysis. In the second step, using these factors, CSF used the least-cost path approach to identify alternative routes for the pipeline. As before, two scenarios were considered: financial and environmental scenarios. For the former, a total of 70% weight was given to financial factors and 30% to environmental factors. For the latter, the opposite percentages were considered. In the third step, CSF defined buffer zones using as reference the Right of Way. In the fourth and final step, using benefit transfer, the environmental impacts within the Right of Way were valued for the environmental scenario. Following these four steps, CSF estimated that the environmental damage that would be caused by construction of the small section of the pipeline would be US$626,426 (2015 prices). Among the environmental factors considered, we highlight water regulation, soil retention, genetic diversity, provision of food, raw materials and forest, and some cultural services (Ntujju, 2016).

Lessons learned

The studies conducted by CSF complement each other. While the cost-effectiveness analysis shows that there is scope for reducing environmental impact by including environmental considerations at the planning stage of the project development, the economic valuation study represents the next necessary step for all infrastructure projects. A valuation of the potential impacts that would be caused by the project is important for two main reasons. First, it can reveal information about the area that will be affected by the project, including the buffer zones. Second, it can inform decision-makers about the overall costs and benefits that the project may generate for society as a whole.


Photo credit: DiCarlo, 2019

Laos-China railway:

Banking on future national gains at the cost of high and unmitigated present local losses

Infrastructure:	Location:	Approach:
Railway	Laos	Financial feasibility study

Project Overview

In 2009, the governments of Laos and China approved the construction of a 427-km railway connecting the village of Boten at the China-Laos border, to the capital of Laos (DiCarlo, 2020; DiCarlo, 2021) (Fig. 8). This railway project is part of China's Belt and Road Initiative and it is owned and operated by a joint venture of Chinese and Laos state-owned enterprises (World Bank, 2020). The construction of this railway was estimated at US$5.8 billion (RMB 38,714,977,800)[9] in 2016 and took about five years to be completed, from 2016 to 2021 (DiCarlo, 2021). The Laos–China railway was inaugurated at the end of 2021 (Medina, 2021).

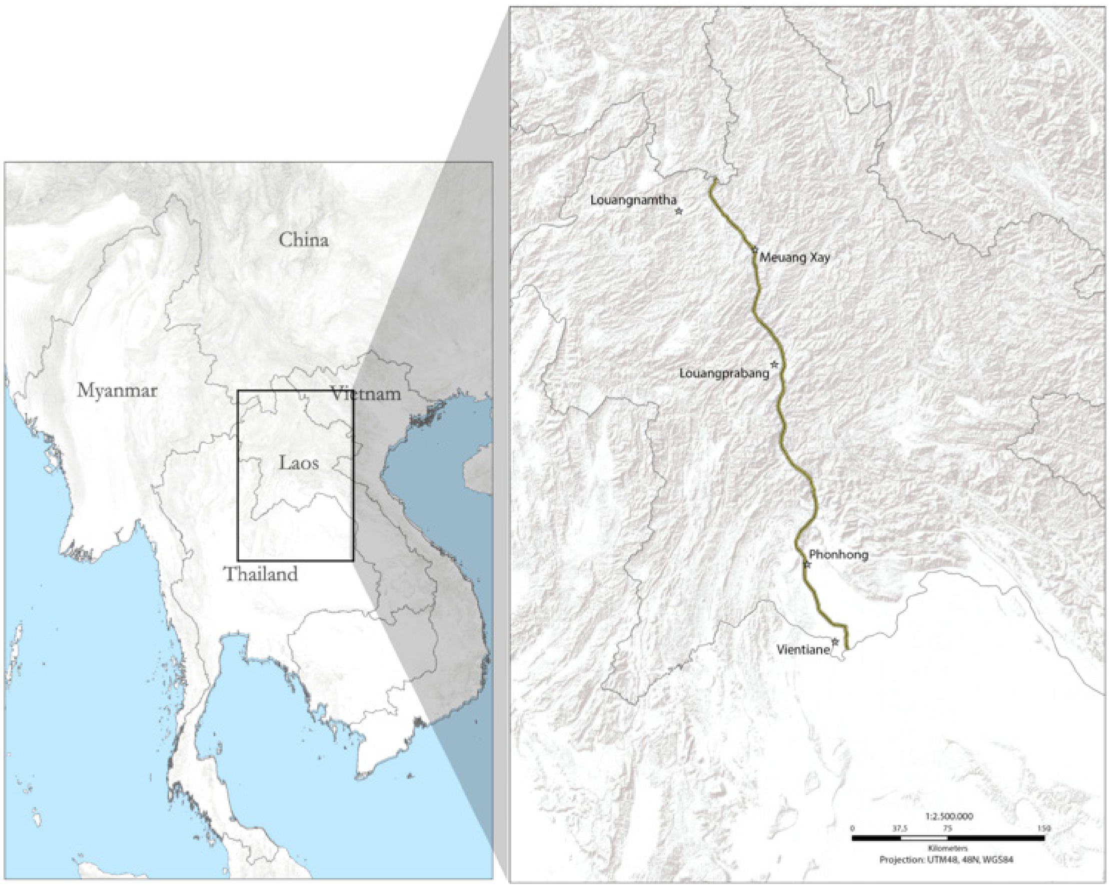


Figure 8. *Map of the railway line through northern Laos. Source: DiCarlo, 2020.*

According to both governments, the construction of this railway is important for three key reasons. First, it will improve local transportation infrastructure, encouraging and facilitating the development of new economic activities in the areas surrounding the railway. Second, this national transportation project aims to improve economic connectivity in Laos. Third, it would integrate with the larger regional railway networks (e.g., Trans-Asia Railway Corridor) across Southeast Asia and with China.

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[9] Average exchange rate in 2016: US$0.1506.

Expected Impacts

Despite the potential benefits that the construction of this railway might generate in terms of trade and economic development in the medium- and long-term for both countries (World Bank 2020), the construction of Laos-China Railway has negatively impacted local rural communities and the environment (DiCarlo, 2020). For example, for the construction of the railway approximately 4,000 acres of land were acquired by the government of Laos and an estimated 4,400 families were displaced (Business & Human Rights Resource Centre, 2021). Besides losing their homes and agricultural land, local communities were also negatively impacted by water pollution. The latter has resulted in additional livelihood losses (via a reduction in agricultural productivity) and health issues (Patel et al., n.a.).

Compensation for land loss has been granted by the government of Laos, however, given the lack of transparency, it is difficult to assess the fairness of the value and distribution of these compensations among the affected families (Chen & DiCarlo, 2021). The medium- and long-run impact on biodiversity and wildlife due to pollution is also uncertain since an environmental and social impact assessment was not conducted by the project proponents during the feasibility study (DiCarlo, 2021) nor during the initial construction phase (Webb, 2016); the environmental and social impact study (done at a late stage in the project development) is not publicly available.

Few studies have quantified the impact of the railway on forest cover. One that has attempted to do so uses satellite data to show that approximately 25 km2 of primary forest have been permanently lost due to the railway in the first year after its construction (Zhouying & DiCarlo, 2021). It is worth mentioning, however, that despite this loss, the development of the Laos-China railway took into consideration some environmental concerns during the planning stage. For example, project proponents designed the railway route to avoid crossing nature reserves; the railway bypasses seven reserves – the Xishuangbanna Biosphere Reserve, Xishuangbanna National Nature Reserve, Nanhe National Biodiversity Reserve, Phou Khao Khoay Biodiversity Reserve, Phou Phanang Biodiversity Reserve, Naban River Basin Nature Reserve, and Dongfiya-Khaoyilai Forest World Heritage (Zhouying & DiCarlo, 2021). The authors also show that other environmental considerations were incorporated, such as the construction of animal corridors and bridges to minimize interference with animals and plants.

Project Analysis

A financial feasibility study was conducted in 2016. In this study, using a social discount rate of 12%, the authors calculated the Net Present Value (i.e., the value of all cash flows associated with the project throughout its lifespan discounted to the present) and the Internal Rate of Return (i.e., the discount rate that makes the Net Present Value equal to zero). Under assumptions about the operating and maintenance costs, and the expected revenues, the Net Present Value is estimated at US$759 million (RMB 5,037,830,000) and the Internal Rate of Return at 24.57% (DiCarlo, 2021). Thus, from a financial perspective, the feasibility study shows that the project is feasible, i.e., the financial benefits are greater than the financial costs. This financial study, however, is narrow in the sense that it does not account for the social and environmental costs resulting from the construction of the railway, as well as the capacity of the government of Laos to pay for the loans and debts taken to pay for the initial investment cost.

Lessons Learned

There are three main lessons from this case. First, the Laos-China Railway has the potential to positively impact Laos, however, more research is needed to fully understand the distributional impacts of this project. Based on the literature review, it seems that even if the project succeeds and the country benefits from increasing trade, the benefits are less clear for the local communities directly affected by the construction of the railway.

Second, also related to the impacts on local communities, the developers of this project have neglected the importance of completing an environmental and social impact study prior to the construction of the railway.[10] Webb (2016) highlighted that if an assessment of the environmental and social impacts were to be done, it would simply be to comply with funder requirements (e.g., Exim Bank of China), and that the project itself would not change based on the outcomes of the study.

Third, the financial feasibility study, although an important analysis to support decision-making, could be complemented by other economic analyses (e.g., cost-benefit analysis including the quantified social and environmental impacts) and stakeholder engagement. These additional activities (by no means exhaustive) could lead to better informed decision-making and foster a path to more sustainable infrastructure development in Laos.

[10] Although the construction of the railway started without having the ESIA completed, the assessment was eventually done, but not shared with the public by the government or project proponents.

V. Lessons Learned and Recommendations for Infrastructure Projects

Despite strong regulations and the development of multiple guidelines and impact assessment procedures for sustainable infrastructure, projects with poor social and environmental outcomes and with net economic losses continue to be proposed, approved, and constructed by governments, lenders, and contractors. Based on the literature review, we highlight three possible explanations for the current scenario.

1. The lack of utilizing economic and financial analysis tools that consider costs and benefits, especially social and environmental costs and benefits, as planning tools. These are typically integrated into business-as-usual scenarios later on in the project development process to the detriment of all stakeholders.

2. The lack of requirements to quantify (in monetary terms or established metrics) the negative and positive social and environmental impacts that would be caused by the implementation of the project.
    a. The estimation of the costs of the impact should also consider the costs associated with the mitigation measures defined in each step of the Mitigation Hierarchy (avoidance, mitigation, restoration, and offset).

3. The lack of requirements to quantify the positive impacts of the mitigation measures (defined by the Mitigation Hierarchy) proposed by project proponents in comparison to the initial damage that would be caused by the project.

4. The lack of connection between the different stages of project development.
    a. If the Mitigation Hierarchy is to be followed and avoidance pursued by project proponents, then the identification of the environmental and social impacts and the design of the project should be done at the same time and in a coordinated way.

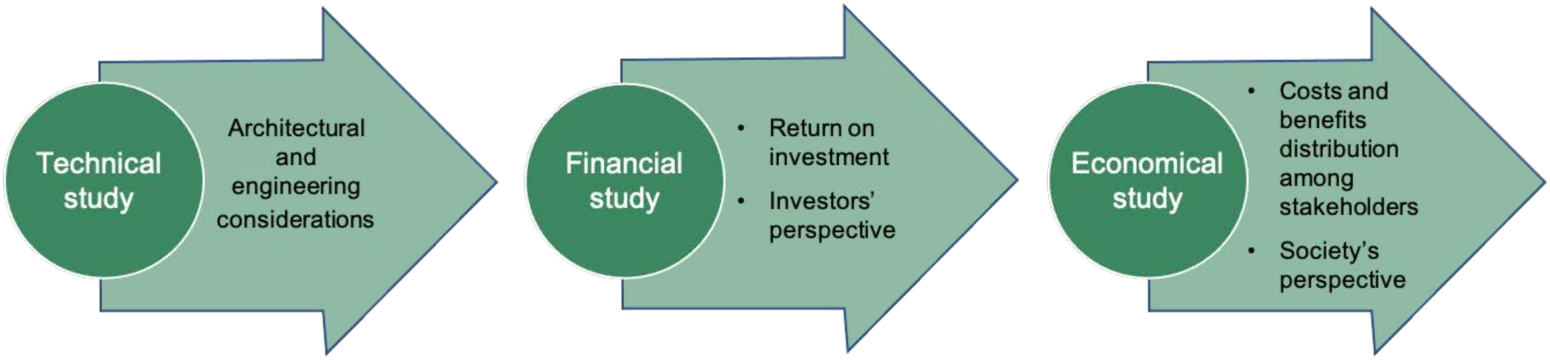

Figure 9. *Sequential stages to better project development.*

Based on the experience of CSF, during the early stages of the development of an infrastructure project, project proponents should follow three sequential steps (Fig. 9). In the first step, project proponents should conduct a technical feasibility study in which the details on how the project would be done in terms of material, equipment, technology, labor, etc. is described. In the second step, project proponents should conduct a broader feasibility study. The goal of this study is to evaluate if the project described in the first stage will generate the intended benefits to investors. In this step, analysis is done under the investor's oversight. We are interested in learning if the implementation of the project will result in net gains (i.e., benefits greater than costs) to investors. If the project is not financially feasible, it is important to reevaluate its implementation and try to understand if there would be some additional benefits not initially captured in the financial study. In the third step, project proponents should conduct an economic analysis. This step should capture all the potential social and environmental impacts that would be caused by the project. Ideally, once all these stages are complete, we would have a better understanding of the costs and benefits, as well as their distribution among various stakeholders.

Figure 10 details additional considerations for step three. If the project is economically feasible, then additional criteria could be defined, for example, to improve the distribution of the benefits. If the project is not economically feasible, then one must assess the reason for preceding with implementation (e.g., provision of basic needs). This step is important due to limitations in the cost-benefit analysis (not all impacts can be monetarily quantified). However, if the project is not economically feasible and does not provide basic needs, then it seems unreasonable to implement the project.

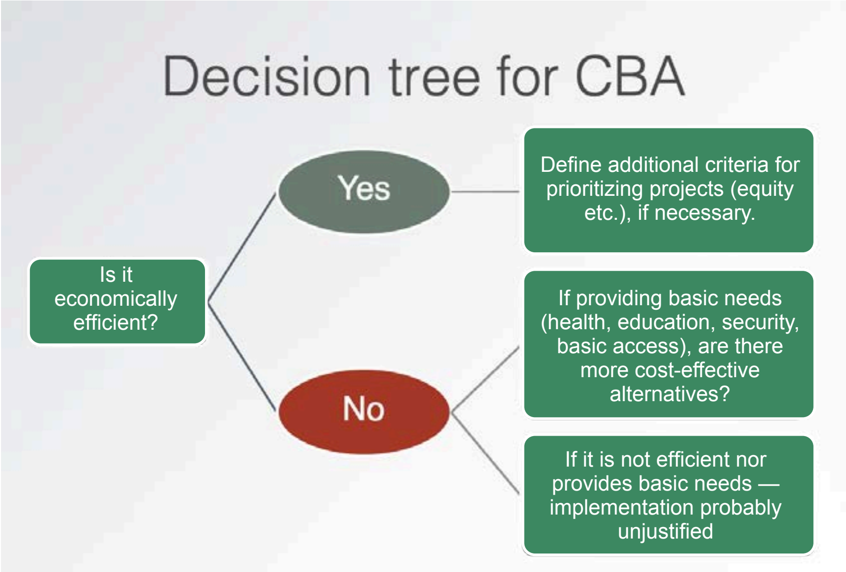

Figure 10. *Decision tree for cost-benefit analysis. Based on a presentation from a CSF course in Palau in 2015, given by Anna Fink and Anna Rios Wilks while at the Secretariat of the Pacific Community (SPC).*

VI. Recommendations

Below we present a summary of the most commonly mentioned recommendations found in the literature:

Stakeholders:

- Involvement of stakeholders during all stages of the development of a project, including the initial stages of designing the project.

Early stages of project development:

- Inclusion of additional criteria (e.g., environmental, social, and institutional) in the planning stage of projects to develop sustainable infrastructure.

- Consideration of alternative routes to the main project and identification of all major costs and benefits associated with these alternatives so the trade-offs can be fully understood by all stakeholders.

- Establishment of transparent and objective criteria to identify areas where linear infrastructure projects should be implemented and areas where these projects should be avoided.

- Adoption of sustainable frameworks such as the Mitigation Hierarchy and prioritization of avoidance over the establishment of mitigation measures (e.g., safeguards), restoration, and offsets.

- Implementation of EIAs at early stages of project development. As highlighted in Brent & Petrick (2007), the assessment of environmental impacts is usually done too late in the project lifecycle; only a few are conducted during the feasibility study.

- Identification of all major costs and benefits resulting from the implementation of an infrastructure project. Project proponents should go beyond showing only that the financial benefits exceed the financial costs.

    - The feasibility study should be composed of two sections. The first section would contain the financial analysis. The second section would complement the first by incorporating the social and environmental dimensions into the analysis. The use of one of the economic approaches presented in this study could be used here to help project proponents conduct the analysis.

Post-construction:

- Continuously monitor the impacts of the project on the national and local economies, as well as on the environment and society.

Recommendations

To conclude, there are numerous guidelines and studies on best practices available. However, despite the availability of information, projects continue to be implemented without following rigorous and transparent feasibility studies and without thorough engaging stakeholders. Through the use of more holistic economic tools, the case can be made that investing in strategies that avoid and reduce negative impacts on the environment and society is both financially and economically worthwhile. The studies conducted by CSF over the past two decades suggest that it is equally important that project proponents try to better justify the financial feasibility ("make the business case") for the development of the project in the first place.

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