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POLICY PERSPECTIVE

Entry Points for Considering Ecosystem Services within Infrastructure Planning: How to Integrate Conservation with Development in Order to Aid Them Both

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Abstract

New infrastructure is needed globally to support economic development and improve human well-being. Investments that do not consider ecosystem services (ES) can eliminate these important societal benefits from nature, undermining the development benefits infrastructure is intended to provide. Such tradeoffs are acknowledged conceptually but in practice have rarely been considered in infrastructure planning. Taking road investments as one important case, here we examine where and what forms of ES information have the potential to meaningfully influence decisions by multilateral development banks (MDBs). Across the stages of a typical road development process, we identify where and how ES information could be integrated, likely barriers to the use of available ES information, and key opportunities to shift incentives and thereby practice. We believe inclusion of ES information is likely to provide the greatest development benefit in early stages of infrastructure decisions. Those strategic planning stages are typically guided by in-country processes, with MDBs playing a supporting role, making it critical to express the ES consequences of infrastructure development using metrics relevant to government decision makers. This approach requires additional evidence of the in-country benefits of cross-sector strategic planning and more tools to lower barriers to quantifying these benefits and facilitating ES inclusion.

Introduction

Global infrastructure development is proceeding rapidly, with an estimated $57 trillion in investment anticipated by 2030 (Dobbs *et al.* 2013). Accounting for natural capital and associated flows of ecosystem service (ES) benefits when planning such investments has the potential to significantly improve outcomes for both society and nature compared to typical approaches (Polasky *et al.* 2008).

ES are the array of benefits that society receives from natural and managed ecosystems (Guerry *et al.* 2015). Infrastructure development and its associated changes in the wider landscape can affect important ES such as provision of clean water and air, food production, and nature-based tourism and recreation. ES also contribute to maintaining safe and functioning infrastructure by reducing risks from flooding, erosion, landslides, and coastal storms (Mandle *et al.* 2014). Governments and financial institutions have repeatedly called for considering these roles of ES in development decisions (e.g., Shilling *et al.* 2007; de la Mata 2012; IFC 2012; Hayes 2014). Yet, such accounting remains rare.

Here, we investigate potential explanations for why ES information is not a routine part of infrastructure development decisions at multiple levels, despite recognition of its importance by leaders of financial institutions and governments. We focus on road planning because of the magnitude of such development: road network length is projected to increase 60% globally by 2050 (Dulac 2013).

Roads can provide significant development benefits (Calderón & Servén 2014), but they also contribute to environmental degradation, both directly and indirectly via changes in land uses that they spur, such as mining and agricultural expansion (Laurance *et al.* 2009; Laurance, Sayer *et al.* 2014). Laurance, Clements *et al.* (2014) showed the significant regional variation in benefits to people through road development relative to environmental losses. For example, failure to recognize the relationship between roads and ES in the Ciénaga-Barranquilla highway in coastal Colombia has incurred economic, social, and environmental costs. Highway construction and other development resulted in degradation of mangroves, declines in fishery species reliant on mangroves as nursery habitats, and increased poverty rates in villages dependent on fishing (Mandle *et al.* 2014 and references therein). The associated loss of coastal protection services has also exposed the highway itself to erosion.

Effectively exploring the likely tradeoffs resulting from the many linkages among roads, the environment and development outcomes requires understanding the decision-making process governing road planning. ES information that is provided to decision makers in ways that match their authority and incentives is more likely to be used. Here, we suggest where and how ES information could be integrated into road development processes, with a focus on the role of multilateral development banks (MDBs).

MDBs have committed to providing $175 billion in transportation funding in the decade following Rio+20 (MDB Working Group on Sustainable Transport 2015). Given that MDBs are an important source of infrastructure funding and key policy and technical advisors to governments, we use the MDB-country engagement process as a lens through which to consider entry points for ES information. We outline a typical MDB-funded road project cycle (Figure 1) based on a review of procedures outlined in documents from major MDBs (African Development Bank, Asian Development Bank, Inter-American Development Bank, World Bank, and European Bank for Reconstruction and Development; details in Appendix A) and discussions with practitioners. We identify the decision makers involved at each stage and assess the potential for integration of ES information. We also evaluate likely barriers – both scientific and institutional – limiting inclusion of such information. Based on this, we suggest opportunities to integrate ES into road and other infrastructure development processes. Including ES information could help avoid development losses from ignorance of ecosystem function and reduce the likelihood of road investments causing large ES losses for small development gains.

Opportunities and impediments for integrating ES information in road development decisions

Strategic planning and project selection

Officials within country governments, typically ministries of transport and finance, periodically produce national- and regional-level transport plans, considering new road routes, upgrades, and maintenance. Such processes would ideally incorporate strategic environmental assessments (SEAs) to maximize development benefits and minimize conflicts across sectors (UNEP 2014). SEAs would be a natural place for consideration of ES (Slootweg & Beukering 2008; Geneletti 2011), but this rarely occurs in practice. At this stage of reconciling plans at different scales, understanding variation in ES benefits across the landscape has the greatest potential to guide decisions.

After the step of internal country planning, country officials and MDB representatives then consider how to match development needs identified by governments with MDB financing priorities. This yields a portfolio of roads to advance for loan proposals, guided by MDB country strategies and associated sector studies, along with a country's development plans.

At this stage, ES information can facilitate the selection of projects with greater development benefits, using development in both the narrower sense of economic development and in a broader sense of "sustainable development" that acknowledges environmental benefit alongside economic goals. At a landscape level, ES mapping can identify where services currently are being provided and to whom, likely reductions or enhancements of ES flows, and potential ES-related conflicts and synergies across sectors. Identification of critical sources of ES provision can direct the placement of infrastructure away from such sites, especially if mitigating ES losses due to development is likely to be expensive (Hayes 2014; Mandle *et al.* 2014). Planned early, road relocation can be low cost, or even save costs if ES contribute to road function. ES assessments can quantify how ecosystems reduce risks to infrastructure and what actions could secure these benefits (Arkema *et al.* 2013).

To date, however, transport planning such as road prioritization has rarely included such a systematic assessment of ES roles (MDB review, Appendix A; Tardieu *et al.* 2013). This is in part due to a lack of comprehensive strategic planning in general (Zhu & Ru 2008) and a lack

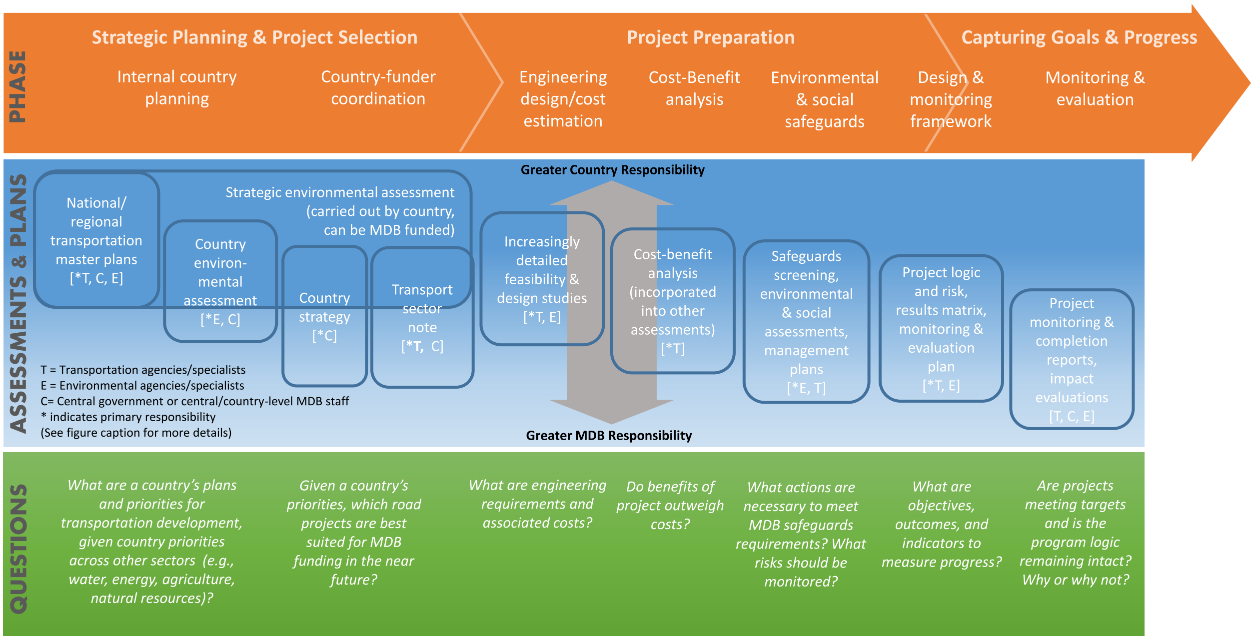

Figure 1 Key actors, processes, and products in a typical multilateral development bank (MDB)-funded road development process. The vertical position of boxes in the "assessments and plans" section indicates the relative responsibility and ownership between country and MDB actors. Actors are indicated in brackets within boxes, with an asterisk (*) indicating primary responsibility, while others have input into the processes. The term "central" (C) contrasts with transport (T) or environmental (E) specialists, and refers to ministries of finance or development planning on the country side and country specialists or country office staff on the MDB side. Depending on the stage, country transport responsibility may be at a ministerial or implementation agency level. Further details about the assessments and plans can be found in the main text.

of directives or incentives for cross-sector analyses. While MDBs may support strategic planning, it is generally not required for MDB financing, and countries own the process (MDB review, Appendix A). In practice, MDBs incentivize their staff to disburse funds, and so bank specialists fear that if their process is too slow or stringent, borrowing countries will look to other sources of financing with weaker environmental safeguards (Herbertson 2012; MDB review, Appendix A). As long as requirements imposed by infrastructure funding sources are not aligned, it will be difficult for particular MDBs to impose such planning efforts, rather than motivating them by demonstrating their benefits. Some incentives for harmonizing requirements across financial institutions may exist for global public goods, where fund stakeholders may see some benefit. When it comes to promoting practices that lead to local benefits in the borrowing country, incentives for funders to coordinate may be mostly political and potentially insufficient.

Inclusion of ES at the in-country planning stage could be increased if it is shown to reliably improve the metrics that in-country planners are accountable for managing. Toward this end, encouraging inclusive wealth accounting that incorporates nonmarket values and the value of natural capital stocks for the future (rather than flow measures like GDP) may make it easier for key officials to perceive the value of natural capital within their own countries, though comprehensive wealth accounting remains empirically challenging (Polasky *et al.* 2015).

The stage of coordination between countries and international funders holds additional promise for consideration of ES. In line with policies at many MDBs, ES are addressed in some strategic documents. Yet, even MDB-led country-level environmental assessments often remain disconnected from transport sector assessments that ultimately guide road decisions (MDB review, Appendix A). Isolating sectors into separate silos reduces the likelihood that development-environment tradeoffs can be identified and undesirable tradeoffs avoided (de la Mata 2012). Furthermore, when included in country-level assessments, ES analyses are typically descriptive and not spatially explicit, limiting their ability to inform project decisions related to routing, managing ES dependencies and mitigating impacts. Recent landscape-level mitigation planning with the Mongolian government is being adapted to inform funding choices by the European Bank for Reconstruction and Development, and could serve as a model for incorporating ES into MDB decision making (Heiner *et al.* 2013).

Project preparation

Once a road project has been selected for consideration, it enters an MDB's project preparation process. During this phase, projects are assessed through three parallel and interdependent fronts: engineering, economic, and environmental and social impacts. In theory, the economic analysis integrates costs and benefits across all of these aspects, though its scope is typically limited as discussed below.

Engineering design and cost estimation. Accounting for the ES benefits to roads as part of engineering design and cost estimation could reduce both risks to roads from environmental hazards and costs of construction and maintenance. In principle, preserving upstream catchments can mitigate flood risk, reducing risk of road washout, and ensuring well-anchored vegetation above roads can reduce landslide risks. Identifying and securing these ES benefits as part of project design could reduce costs by, for example, reducing the need for artificial retaining walls or the size of culverts. That said, roads funded by MDBs are already built to specific standards (MDB review, Appendix A). We have yet to see ES modeled with sufficient precision that road engineering design could be adjusted to reduce risks and costs. Methods for providing such finer-scale detail would be an important advance in ES science.

Economic analysis. Economic assessment of road projects is in the form of a cost-benefit analysis (CBA) that attempts to monetize benefits and costs that are directly related to a road project, ideally including environmental externalities (MDB review, Appendix A). This is intended to ensure that any investment is a wise use of funds at the country level and will make an effective contribution to economic development.

Including ES in project CBAs has frequently been proposed as a promising avenue to improve lending decisions by better capturing potential costs and benefits (de la Mata 2012). A variety of established economics methods, coupled with production function modeling of ES change, can be used to value the impacts of roads on ES. For example, changes in water quality downstream of roadways could be modeled and then valued using costs of drinking water treatment or lost fishery revenue.

This approach is not limited by existing methodologies, although data may sometimes be limited for their application. A more fundamental challenge to incorporating ES into CBA relates to treatment of indirect impacts. A road's indirect impacts on ES – through deforestation and land use change in surrounding areas – are often larger than its direct effects (Laurance *et al.* 2009; Mandle *et al.* 2013). Those direct ES costs may be small relative to the road's direct benefits, but total ES cost may not be (MDB review, Appendix A). However, based on our discussions with MDB staff, several factors limit the inclusion of indirect effects: their much greater uncertainty, the fact that activities producing the indirect effects are beyond the control of the implementing road agency or transport ministry, and the need for standard economic accounting.

Environmental and social safeguards. Assessments of environmental and social impacts are required in all MDB road loan decisions (MDB review, Appendix A). High-impact projects typically require a formal environmental and social impact assessment (ESIA), including cumulative impacts, direct and indirect impacts, and project alternatives. These assessments lead to the development of plans for mitigating any anticipated negative impacts.

Safeguards processes are heavily informed by project-level environmental assessments, such as environmental impact assessment or ESIA. Incorporating ES assessment into these products can inform more effective and efficient safeguard measures by more precisely describing which groups of people will be negatively impacted and how (Baker *et al.* 2013). A comprehensive baseline survey of ES would be a useful start. The science needed to include quantitative and spatially explicit assessments of impacts to ES, and for evaluating mitigation options, is well established (Mandle *et al.* 2013).

Unfortunately, in practice, such environmental assessments often do not explicitly address ES, or if they do, they often fail to do so in a quantitative and spatially explicit manner, which prevents the linking of impacts to appropriate mitigation actions (Rosa & Sánchez 2015). Lack of capacity among consultants or poor familiarity with ES by those requesting assessments may lead to superficial inclusion of ES, including failure to identify who benefits from ES and how (Rosa & Sánchez 2015). A growing body of guidance and tools (UNEP 2014) and efforts to lower the time and technical capacity required for analyses could alleviate this problem. Still greater benefits could be achieved by integrating mitigation of ES and of biodiversity loss, perhaps more feasible if decision processes are approached with an explicit focus on multiple objectives, rather than strict CBA and mitigation hierarchy approaches.

However, greater inclusion of ES in project-level environmental assessments may not substantially alter MDB road decisions or outcomes, due to other well-documented limitations of environmental assessment processes (Jay *et al.* 2007). Project developers often view environmental assessments more as a bureaucratic hurdle than as a tool to shape project design (Shilling *et al.* 2007). These shortcomings largely stem from a historically reactive approach to mitigation focused at small spatial scales on a project-by-project basis. A broader, proactive process could lead instead to the consideration of alternative development scenarios and mitigation opportunities. However, this may require mitigation in the surrounding landscape, typically beyond the jurisdiction of transport ministries or road agencies.

Capturing goals and progress

Economic, environmental, and social and engineering assessments are synthesized in a design-and-monitoring framework for a road project. This captures anticipated project impacts, assumptions underlying those impacts, and what should be monitored to demonstrate success and proactively manage risks (MDB review, Appendix A). When ES have been considered early, they should naturally be incorporated in these objectives and risks. But while ES assessments can help prioritize key indicators, the utility of monitoring ES can be difficult to demonstrate due to potentially significant time lags between project implementation and changes in ES flows.

Improving infrastructure development with ES information

ES science is most likely to effectively inform road decisions, and infrastructure development more broadly, when ES information is integrated into existing decision processes. Understanding the decision-making process and the institutional incentives and barriers at each stage can help make existing science more relevant and guide the development and application of new science.

We consider three categories of roads where additional ES information might reveal that a project should be redesigned or rejected: (1) roads that are undesirable at a project level because of costs resulting from dependencies on ES that have not been accounted for (e.g., where preventable flooding interrupts service and increases maintenance costs); (2) nationally undesirable roads, even if the road itself has some benefits, because of indirect or cumulative impacts that have not been accounted for (e.g., sediment from development around the road enters waterways, killing mangroves, and raising risks from natural hazards to coastal property); or (3) globally undesirable roads, even if in-country benefits are positive (e.g., the losses of carbon sequestration or biodiversity existence outweigh development benefits, when aggregated globally).

Road projects in category 1 may be easiest to influence with additional ES information, as the missing details on ES costs are within the scope of project-level economic and engineering analyses. These offer opportunities to further develop the science to better quantify and value these ES with adequate precision.

Far more proposed roads with significant tradeoffs and impacts are likely to be found in categories 2 and 3. The potential to influence construction of these roads is likely greatest when ES information is integrated early in planning, before specific investments enter the development pipeline. Such effective early consideration of ES requires assessment of the infrastructure's cumulative direct and indirect impacts on human well-being across sectors.

For ES information to be relevant for early planning requires that ES-based adjustments would affect outcomes of concern to in-country decision makers. Global impacts will be relevant only to the extent that country-based decision makers have incentives to hold global interests in mind, for instance due to trading or compensation schemes that are provided by the Global Environment Facility and REDD+ (Reducing Emissions from Deforestation and Forest Degradation).

However, ES assessments to identify even whether a road is in category 2 are rare, despite the apparent alignment with the scope of country-level decision makers and the availability of science and tools to support such analyses. While such a process is expected to reduce project risks, (thereby expediting project approval) and increase overall development benefits, this has not been sufficiently demonstrated. Evidence for the economic value of including ES in road planning remains limited (Scott *et al.* 1998); the same holds for other forms of infrastructure development (Morrison-Saunders *et al.* 2015).

Given this state of affairs, we suggest the following pathways for increasing the relevance of ES information for infrastructure development and lowering barriers to its inclusion in decision-making processes:

(1) Demonstrate the value of strategic development planning including cumulative effects on human well-being through ES for country-level decision makers. This work can build evidence for the benefits of such an approach and increase awareness of what is feasible, lowering barriers for replication elsewhere.
(2) Continue to develop data and easy-to-use science-based tools needed to produce relevant ES information and metrics at the diversity of scales outlined in the decision process above, again lowering barriers for decision makers and consultants to acquiring and applying this information.
(3) Engage with efforts to increase funding available to support ES-inclusive strategic assessments. Several new efforts are underway, such as the Latin American Conservation Council's Smart Infrastructure initiative.

Together, advancement along these pathways can contribute to overcoming the institutional barriers to inclusion of ES in strategic planning. Ultimately, it is critical that decision makers have the right information at the right time. Articulating the costs and benefits of infrastructure development options in a way that is relevant to decision makers, while considering the constraints and incentives they face, will be key to moving beyond rhetoric and guiding infrastructure development to benefit society without undermining the life support systems that nature provides.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Appendix A. MDB document review.

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