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Essay

Reducing the global environmental impacts of rapid infrastructure expansion

William F. Laurance[1,*], Anna Peletier-Jellema[2], Bart Geenen[3], Harko Koster[3], Pita Verweij[4], Pitou Van Dijck[5], Thomas E. Lovejoy[6], Judith Schleicher[7], and Marijke Van Kuijk[8]

Infrastructures, such as roads, mines, and hydroelectric dams, are proliferating explosively. Often, this has serious direct and indirect environmental impacts. We highlight nine issues that should be considered by project proponents to better evaluate and limit the environmental risks of such developments.

We are living in the most explosive era of infrastructure expansion in human history. By mid-century, it is expected that there will be 25 million kilometers of new paved roads globally [1] — enough to encircle the Earth more than 600 times. Nine-tenths of these new roads will be in developing nations [1], which sustain many of the planet's most biologically rich and environmentally important ecosystems. In the Amazon basin, more than 150 large (>2 megawatt) hydroelectric dams have been planned or are under construction [2]. In Southeast Asia, a dozen major hydroelectric projects are being planned for the lower Mekong region [3], with massive dams also planned for the Congo Basin (http://tinyurl.com/lulgwny). Africa is experiencing a frenzy of foreign investment for mineral exploitation, with China alone investing over $100 billion annually [4]. Such investments are the principal economic impetus for 29 major 'development corridors' that will crisscross Sub-Saharan Africa and open up vast expanses of land for economic exploitation [5].

Large infrastructure projects have a wide variety of proponents. Among these are major international lenders — such as the World Bank, the African, Inter-American and Asian Development Banks, the Brazilian Development Bank (BNDES), and the Chinese-dominated Asian Infrastructure Investment Bank. They also include national donors and aid agencies, private enterprises, commercial banks and the planning, energy and transportation ministries of the target nations. Development banks generally favor large infrastructure projects, because they have extensive funds available and the administration of a few large projects requires less input and oversight than many small ones. Similarly, governments often seek external funding specifically for large infrastructure projects, as smaller projects can be funded with government resources. For example, the Asian Development Bank invested over $2 billion in India in 2012, two-thirds of which was for major infrastructure projects [6].

Unfortunately, the contemporary avalanche of infrastructure expansion is having severe impacts on many ecosystems and species [7–13]. Roads that penetrate into wilderness areas often have particularly serious effects, potentially opening a Pandora's Box of environmental problems (Figure 1), such as promoting habitat conversion and fragmentation, poaching, illegal mining, wildfires and land speculation [7,10,11,13].

Similar environmental impacts exist for other kinds of infrastructure related to natural resource exploitation, such as hydroelectric dams, mining and fossil fuel projects. Large dams cause major disruptions in the hydrological and biological characteristics of free-flowing rivers, with potentially major impacts on migratory fish, spawning habitats, aquatic biodiversity, fisheries and riverine communities [14]. Mining and fossil fuel projects can have intensive local environmental impacts and also provide a major economic impetus for road building in frontier regions [5,13]. Such projects are increasing rapidly; for instance, the Amazon region now has nearly 53,000 mining leases encompassing 21% of the basin's land area [15].

The impacts of new roads and other infrastructure on wilderness and frontier areas are often exacerbated in regions where land-use zoning and the rule of law are limited. In the Brazilian Amazon, for instance, for every kilometer of legal road there are nearly three kilometers of illegal roads [16]. Such roads are reported to facilitate a variety of illegal activities, such as timber theft, poaching, illicit drug production and illegal gold mining, that defraud governments of needed revenues and can provoke serious environmental harm [17,18].

However, not all infrastructure is 'bad' for the environment. In appropriate contexts, new infrastructure can yield sizeable social and economic benefits with only limited environmental costs. For instance, road improvements in already-settled areas can facilitate increases in agricultural production and improve rural livelihood by giving farmers better access to urban markets, fertilizers and new agricultural technologies [8,19]. Such roads can also provide rural residents with better access to health care, schools and employment, while encouraging private investment [20].

Although infrastructure can provide important socioeconomic benefits, managing its environmental and social impacts will be a great challenge, given the unprecedented scale of planned investments in new infrastructure in the coming decades. For instance, at their annual summit in 2014, the G20 nations committed to invest US$60–70 trillion worldwide in new infrastructure by 2030, thereby more than doubling the current value of global infrastructure [21]. We highlight nine specific issues that should be considered carefully by financial institutions, planners, and others involved in major infrastructure developments, in order to limit their environmental costs. We mainly focus on environmental impacts, as an accounting of the social implications is beyond the scope of this essay, although we acknowledge the importance of social impacts.

Nine important issues

In intact habitats, avoid the first cut

New roads in forested areas can greatly increase deforestation, both because forest loss is spatially highly contagious [22] and because an initial road often spawns networks of secondary and tertiary roads that can greatly increase the spatial extent of habitat disruption. For instance, the first paved highway across the Brazilian Amazon, linking Belem and Brasília, began in the early 1970s as a narrow cut through the

Figure 1. Road kill.
Roads in relatively pristine areas such as national parks and wilderness can open a Pandora's Box of environmental problems. Here, a road-killed tapir in Peninsular Malaysia (© WWF-Malaysia/Lau Ching Fong).

rainforest. Since then, it has evolved into a 400 km-wide slash of forest destruction across the eastern Brazilian Amazon [13]. For such reasons it is often argued that the only viable, cost-effective way to ensure the integrity of natural areas is to 'avoid the first cut' (Figure 2) — keeping them road-free [8]. Wilderness regions, parks and protected areas, remnants of rare ecosystems, surviving fragments of intact habitat within biodiversity hotspots and regions with many locally endemic species, such as islands and isolated mountaintops, are examples of environments where roads and other infrastructure should be stringently limited or avoided altogether [8,10,12,23].

Serious impacts of upgrading roads

In recognition of the transformative impacts of roads, financial institutions, such as development banks, often have policies in place not to construct new roads in areas of critical habitat. Yet, many institutions support road upgrades, such as the paving of a bulldozed track, in and near sensitive areas. One of the rationales is that, if a prior road exists, there will be only limited environmental impacts from paving it.

However, in wetter environments, such as rainforests, unpaved roads typically become impassable during the wet season and thereby tend to have far smaller spatial impacts than paved roads, which provide year-round access to forests and their natural resources [13,16]. Paving of the Interoceanic Highway, for instance, has led to dramatic increases in deforestation and illegal gold mining in the Peruvian Amazon [18]. Paved roads also facilitate faster and more traffic, which increases the likelihood of road kill of wildlife [12,13]. Hence, great caution is needed when considering and planning road upgrades.

Secondary effects can be severe

For large natural resources projects, such as in the mining and energy sectors, the secondary and tertiary effects of the associated infrastructure are often worse than the project itself [4,5]. This underscores the need to incorporate the full indirect effects of associated infrastructure into cost-benefit analyses and environmental-impact assessments (EIAs).

For instance, many new dams are planned for the Amazon and Andes regions in relatively remote areas and will require extensive road and power-line networks [2] that will open up forests to a range of additional human impacts [24]. According to a recent analysis, the 12 dams planned for the Tapajós River would increase Amazon deforestation by 950,000 hectares by 2032, because they will require extensive road networks that promote migration and illegal forest colonization [25].

Development banks are required to assess these indirect effects — known as 'induced impacts' — in line with their own environmental guidelines, but can fail to do so adequately. The associated facilities are often (wrongfully) considered to fall outside the scope of the EIA because they are not funded by the project itself, although their viability and existence depend exclusively on the project. Far too often, EIAs are funded by the project proponent, are conducted too quickly, and are virtually a rubber-stamp process that fails to assess the true impacts of a project and its associated infrastructure, often recommending ineffective mitigation or offset measures.

Two additional measures could immediately help to improve the rigor of EIAs. First, true stakeholder consultations — not merely superficial box-ticking — should be conducted prior to project approval. Second, the transparency of the EIA process could be greatly improved by requiring that all EIAs be made publicly available online, well before the proposed project is approved. This would allow the project to be scrutinized by a wider community.

Greater emphasis on 'offshore' projects

Given the enormous potential for secondary and tertiary impacts from road networks, a key goal is to increase the use of so-called 'offshore' natural-resource projects that operate without associated road networks. For example, the Camisea natural-gas project deep in the Peruvian Amazon has no road linkages, with all personnel being transported to and from the site by helicopter. Two pipelines that carry natural gas from Camisea to western Peru were buried and the area above them revegetated (however, this project has been heavily criticized on social grounds [26]). Similarly, the

Current Biology
Magazine

Urucú natural-gas project in the central Brazilian Amazon is being established as an offshore project without road linkages. Where road building is unavoidable, such as for a major hydroelectric project, the closure and re-vegetation of high-risk roads with native plant species after construction could be stipulated as a condition of project approval.

Rigorous early screening is vital

Far too often, when a government requests funding from a financial institution for a particular project, it has either already approved that project or is well on the way to doing so. As a result, the financial institution might subject the project to a relatively superficial review, confirming that it is compliant with national legislation and clearance procedures. The larger picture of ensuring long-term environmental sustainability may not receive adequate attention during the loan-approval stage.

There is great scope to improve this process. Lenders and other relevant parties should be more engaged in projects during early stages, when there is scope to make fundamental changes to the project or cancel funding altogether. For instance, the Mekong River Commission recommended delaying approvals for a slate of new dam proposals for at least 10 years [3], because they felt that they had too little information to approve these projects. Unfortunately, this advice, provoked by major concerns regarding the displacement of people and potential impacts on migratory fish, has been ignored [27]. More optimistically, two large hydropower dams that would have flooded 40,000 hectares of forest in Juruena National Park in Brazilian Amazonia were removed from near-term development plans because of environmental and social concerns [28].

Better decision-making tools are needed

Financial institutions need to integrate long-term environmental protection into country-level planning and into the business case of individual projects. To achieve this, those involved in planning, promoting and evaluating infrastructure projects need better and more accessible tools to aid their efforts. These include good maps of social and biodiversity indicators and natural values at national and regional scales, accurate spatial data on roads and other infrastructure, and decision-support tools [8,29], to determine where infrastructure should and should not be permitted. Such decision-support tools can help to advance integrated land-use planning, which is a key near-term priority. There is much scope for environmental and social scientists to increase their influence in these contexts [15].

Decision-support tools need to be made available in a timely manner. For example, the World Bank financed a major land-use-zoning exercise in Rondônia, Brazil, but this occurred only 15 years after an initial, highly environmentally destructive road project was undertaken there with World Bank support [30].

Financial institutions need more environmental and social expertise

The World Bank, regional development banks and other financial institutions need to place increased emphasis on recruiting talented and assertive environmental and social specialists who can hold their own in high-stakes discussions with economists and project proponents. This is a crucial prerequisite for the lenders to reduce risks and potential backlash, but most importantly to improve the environmental and social outcomes of projects. In addition, rigorous, independent monitoring of the outcomes of funded projects is vital, and should become a priority to ensure such projects meet their intended impacts and provide lessons from which to learn in the future.

For example, three authors of this paper have served as environmental experts or specialists with the World Bank (T.E. Lovejoy, J. Schleicher), Asian Development Bank (A. Peletier-Jellema), and Inter-American Development Bank (T.E. Lovejoy), and were able to improve the implementation of environmental and social safeguards. The Asian Development Bank and WWF have a long-term partnership, with a WWF expert embedded within the bank to promote cooperation on issues, such as the Coral Triangle Initiative, Heart of Borneo, Living Himalayas Initiative, and the Greater Mekong Sub-region. Ultimately, environmental and social risks translate into financial risks, and it is incumbent upon the banks to work proactively to reduce such hazards.

Figure 2. The first cut is the deepest.
A key principle for conservation of many native ecosystems is to 'avoid the first cut' — keep them road-free — whenever possible. Shown here is a logging road in Sabah, Malaysian Borneo (© Rhett Butler).

Avoiding the 'devil you know' dilemma

Those evaluating proposals for infrastructure projects will sometimes rationalize having an environmentally risky project proceed under the aegis of an international institution, such as a development bank, because 'if the bank doesn't do it, then someone less scrupulous will.' This is an inherently dangerous scenario because, under such circumstances, it becomes virtually impossible to halt any project.

For instance, the German development bank (KfW) is proposing to pave and upgrade a number of low-grade roads through Cambodia's greatest biodiversity hotspot, the Seima Protection Forest, to service indigenous villages there. The bank recognizes the large potential for environmental problems from the road upgrades, such as increased poaching and illegal logging. It has asked conservation scientists working in the area to advise them on potential mitigation measures. Although they are greatly concerned about the project, the scientists see no alternative but to support it, because otherwise they believe that Chinese proponents would do it more cheaply and without environmental mitigation, leading to a greater level of illegal logging and forest encroachment than would occur under a KfW-supported project.

Such quandaries highlight a dire need for governmental and nongovernmental organizations to increase pressure on institutions such as the Chinese-dominated Asian Infrastructure Investment Bank and the Brazilian Development Bank, which are widely regarded as having less-stringent environmental safeguards than do many other international lenders and donors (for instance, see http://tinyurl.com/kc8l9ks and http://tinyurl.com/pnbh82x). Project proponents working with such banks should not be given credit for 'good housekeeping' that is often afforded to those dealing with more environmentally and socially responsible institutions.

Greater NGO and public engagement

Those working in the major development banks often face great pressures from governments and project proponents with vested financial interests to approve infrastructure proposals. Input from non-governmental environmental and social-welfare groups and the general public, especially those directly impacted by the project, are direly needed to help balance these pressures. A key strategy in many situations is to emphasize that lenders need to be more conservative in their decision-making, adopting the precautionary principle in cases where conflicts are possible or relevant information is lacking.

Urgent steps

In conclusion, the veritable explosion of roads and other infrastructure globally is causing great environmental harm [7–13,16,24]. It is therefore vital that those involved in evaluating, promoting and funding such projects engage not just with those who stand to gain from such projects, but also with those who stand to lose. Key elements are greater transparency, increased public engagement and a more careful analysis of both the indirect effects of new roads and road upgrades, and the induced impacts of infrastructures and facilities associated with large natural-resource projects. Such measures will help to ensure that powerful political and economic interests do not swamp vital environmental and social concerns.

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[1]Centre for Tropical Environmental and Sustainability Science, and College of Marine and Environmental Sciences, James Cook University, Cairns, Queensland 4878, Australia. [2]PCS Environmental and Social Impacts, A. Van Burenlaan 54, 2012 SM Haarlem, Netherlands. [3]WWF-Netherlands, Driebergseweg 10, 3708 JB Zeist, Netherlands. [4]Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, Netherlands. [5]Centre for Latin American Research and Documentation, Roetersstraat 33, 1018 WB Amsterdam, Netherlands. [6]Environmental Science and Policy, George Mason University, Fairfax, VA 22030, USA. [7]Department of Geography, University of Cambridge, Downing Place, Cambridge CB2 3EN, UK. [8]Faculty of Science, Utrecht University, Padualaan 8, 3584 CH Utrecht, Netherlands.
*E-mail: bill.laurance@jcu.edu.au

