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DISCUSSION PAPERS

Smart Green Infrastructure in Tiger Range Countries

A Multi-Level Approach

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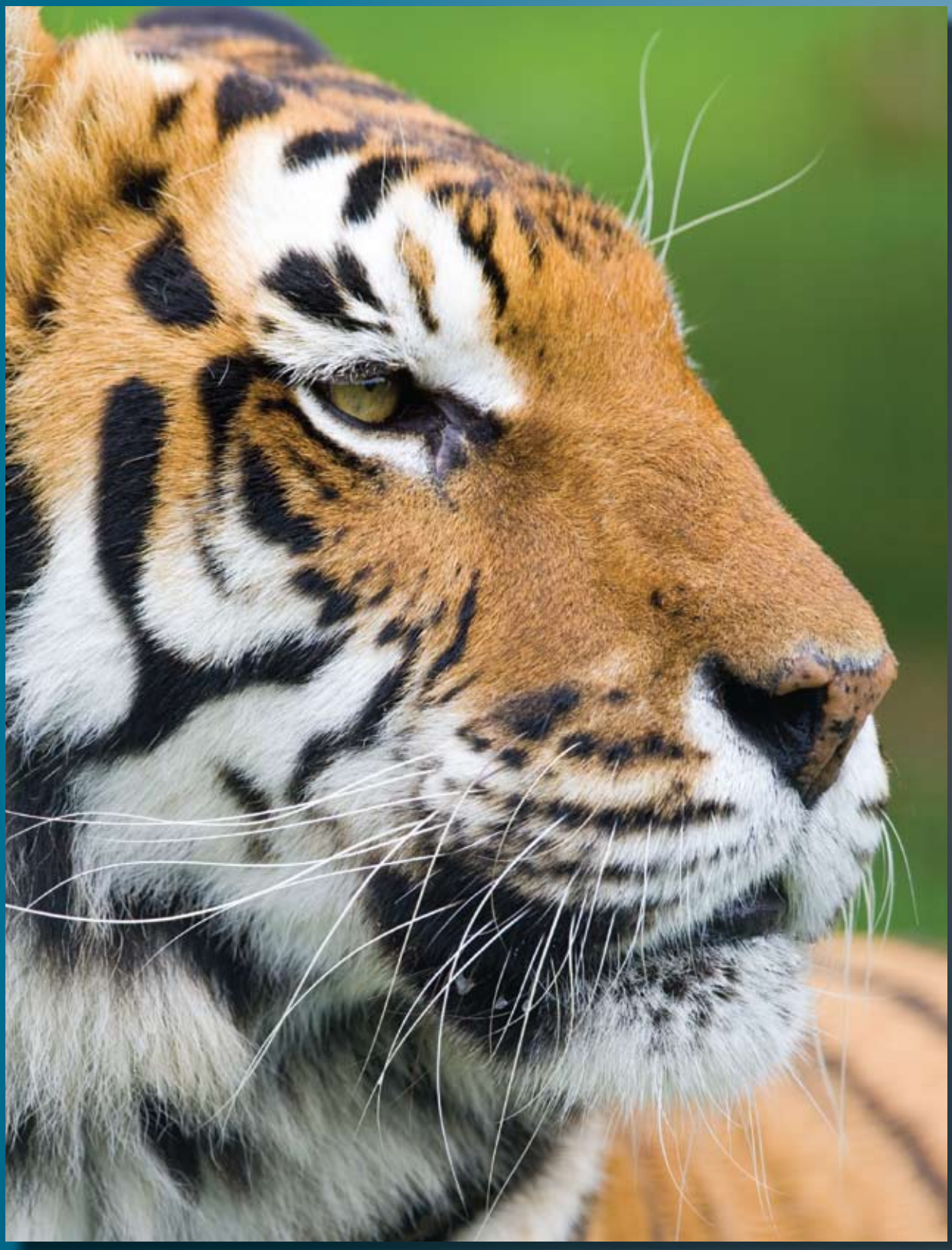

Smart Green Infrastructure in Tiger Range Countries

A Multi-Level Approach

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Environmental and natural resources management issues are an integral part of the development challenge in the East Asia and Pacific (EAP) Region. The World Bank's Environment Strategy in the East Asia and Pacific Region has provided the conceptual framework for setting priorities, strengthening the policy and institutional frameworks for sustainable development, and addressing key environmental and social development challenges through projects, programs, policy dialogue, non-lending services, and partnerships. This study provides a forum for discussions on good practices and policy issues within the development community and with client countries.

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FOREWORD

The nations of South and East Asia have been the world's most dynamic economies for the last 20 years. The pace of change is astonishing; investment in infrastructure to support economic growth is expected to reach more than US$500 billion a year over the next decade and more than a billion people will move into urban areas in South and East Asia by 2030. This growing human footprint, however, compromises Asia's biologically diverse natural ecosystems, and risks elimination of endangered species and their landscapes.

Wild tigers, the majestic animals that have captured the imaginations of many cultures, are already on the brink of extinction, in large part due to degradation, fragmentation, and loss of their forest habitat in Asia. In June 2008, the World Bank together with the Global Environment Facility, the Smithsonian Institution, and the International Tiger Coalition established the Global Tiger Initiative (GTI), an alliance of the 13 tiger range countries and the international community designed to restore wild tigers and conserve large landscapes across their range. The GTI is pioneering a new business model for biodiversity conservation which, if successful, could be replicated to conserve endangered, wide-ranging charismatic megafauna and their ecosystems around the world.

The GTI reflects the World Bank's commitment to development strategies that balance economic development with biodiversity conservation and environmental protection. We are moving to a "do measurable good" approach that reinforces the environmental sustainability of the World Bank Group's portfolio. Incorporating the principles of green infrastructure in infrastructure development is a major part of this approach. This green infrastructure approach is intended to reduce the significant downstream costs of environmental compliance and mitigation in the life cycle of infrastructure development projects.

Early on, the tiger range countries identified infrastructure development as a major contributor to the erosion of tiger habitat. Recognizing that such development is also essential to their economic growth and prosperity, the tiger range countries sought advice on making infrastructure tiger and biodiversity friendly. This report responds to that request. It shows how, with proper policies, advance planning, design, and implementation, the impacts of infrastructure development on tiger landscapes can not only be reduced but can actually contribute to protecting them. It also underlies the important role of ensuring the true value of landscapes and ecosystem services provided to people be factored into the development equation.

I also hope this publication inspires new ideas, dialogue, and action to make biodiversity-friendly infrastructure investments a reality. It would be a tragedy if we let wild tigers disappear in the name of development when we know how to enable both to thrive.

James W. Adams
Vice President
East Asia and the Pacific Region
The World Bank

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This report was ably edited by Susan Lumpkin and Anita Gordon, and pictures and other graphic materials were provided by multiple sources. James Cantrell designed the book.

This report is dedicated to the magnificent tigers still remaining in the wild.

ACRONYMS

BBOP	Business and Biodiversity Offset Program
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
EA	Environmental Assessment
EAP	East Asia and Pacific
EIA	Environmental Impact Assessment
EMS	Environmental Management System
ESIA	Environmental and Social Impact Assessment
FSC	Forest Stewardship Council
GIS	Geographic Information Systems
GTI	Global Tiger Initiative
GTF	Global Tiger Forum
ICDP	Integrated Conservation and Development Project
IUCN	International Union for Conservation of Nature
LEED-AP	Leadership in Energy and Environmental Design Accredited Professional
NGO	Non-Governmental Organization
NTAP	National Tiger Action Plan
PA	Protected Area
PES	Payment for Ecosystem Services
REC	Renewable Energy Certificate
REDD	Reducing Emissions from Deforestation and Forest Degradation
SEA	Strategic Environmental Assessment
SEPA	State Environmental Protection Agency
SGI	Smart Green Infrastructure
TCL	Tiger Conservation Landscape
TRC	Tiger Range Country
WBI	World Bank Institute
WCS	Wildlife Conservation Society
WWF	World Wildlife Fund-US

J. Quintero

EXECUTIVE SUMMARY

Tigers (*Panthera tigris*), are majestic animals that have captured the imaginations of many ancient and modern cultures. But tigers today are on the brink of extinction in the wild as a result of poaching—including their prey—illegal trade, combined with habitat loss and degradation. The world's population of wild tigers has plummeted by 95 percent in just over a century, from an estimated 100,000 in 1900 to about 3,500 today. In 2008, the World Bank, together with other stakeholders, established the Global Tiger Initiative (GTI)[1] "to assist the 13 tiger-range countries (TRCs)[A] with their efforts to restore wild tigers and their habitats." Early on, tiger experts identified infrastructure (transportation, mining, and hydroelectric power in particular)[2], as major factors contributing to habitat degradation. Although the situation for wild tigers is precarious, there are still excellent opportunities for financing agencies, governments, business owners/operators, engineers and local communities to ensure that infrastructure is tiger-friendly. We define such **Smart Green Infrastructure (SGI)** as infrastructure that avoids tiger habitats, minimizes and mitigates adverse impacts through tiger-friendly design, and compensates for any remaining damage to have a net positive impact.

This study addresses infrastructure's impacts on tigers at international, national, sectoral and project levels in combination with the 'mitigation hierarchy' which is based on avoidance, mitigation, minimization and compensation of impacts. It examines infrastructure policy challenges and opportunities, using lessons learned from case studies, along with regional and in-country analyses. While there are opportunities for improvement in all countries, Russia, India, Bhutan, and Nepal have, in particular, developed good foundations for tiger-related conservation, planning, and policy efforts. Best practices, drawn from case studies in non-tiger range countries , provide additional insights into infrastructure practices that could benefit tiger populations.

At the national level, government officials can use a range of regulatory and fiscal policies to promote tiger-friendly infrastructure development. Regulatory options for controlling impacts on tigers and their habitats include land-use and tiger-corridor planning, infrastructure permits such as licenses, transfer mechanisms, in the form of payment for ecosystem services schemes, and both environmental impact assessments and strategic environmental assessments. Environmental compensation policies and incentive programs can help drive investments in alternative livelihoods, as well as drive smart green infrastructure while preserving key habitat areas.

Avoiding Tiger Conservation Landscapes (TCLs) is the best and cheapest option available to all parties for saving wild tigers. We encourage a commitment from tiger range country governments to designate core tiger population habitats as "no go" areas for infrastructure development. In addition, it will not be possible to recover wild tiger populations without effective trans-

A. Tiger Range Countries: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Russia, Thailand, & Vietnam.

boundary conservation efforts, expanding the network of protected areas, creating buffer zones, restoring connectivity between patches of habitat within landscapes, reducing poaching and securing long-term funding. It is also key to apply stringent infrastructure development policies that factor in both poverty reduction and the reduction of human-tiger conflict so communities benefit from and support tiger conservation.

Independent of government action, sectoral leaders (private entities and industry involved in infrastructure) must also begin to explicitly consider tigers and related biodiversity considerations. Industry has numerous options within the mitigation hierarchy, including having explicit tiger conservation goals, effective stakeholder engagement, environmental management systems, and biodiversity offsets. Placing emphasis on development that has a lower impact, such as railroads, may assist tiger conservation. Overall, voluntary approaches at an industry level that demonstrate leadership can play a critical role in tiger conservation.

On a project level, engineers have various options available to them to ensure that habitat loss, fragmentation, and induced impacts, such as poaching, are minimized. In terms of road infrastructure design, the primary focus should be on 'tiger friendly construction, for example open-span bridges/bridge extensions, which are likely to be both cost-effective and preferred by both large cats and their prey. Minimizing paving and design that considers hydrological impacts is also important. Mining and hydroelectric infrastructure also have tiger-friendly options available throughout the project lifecycle. In particular, attention should be paid to limiting ancillary roads and settlements and establishing strict policies for workers with respect to hunting and poaching.

Beginning with the choices available for a project's location, SGI uses careful design, tiger-friendly construction practices, community engagement, strong assessments, monitoring, and adaptive management to ensure that infrastructure does not interrupt natural ecological processes. While avoidance of all adverse impacts on tigers and biodiversity in general should be a primary focus of any infrastructure planning, there is an array of policies and practices that can help ensure that there is a future for wild tigers.

1. INTRODUCTION AND THE GLOBAL TIGER INITIATIVE

Over the years it has become apparent that public works that support the way of life of millions of people in Asian countries—such as roads, hydroelectric dams, and mining operations—have contributed to the loss of the region's biodiversity[3]. The loss of tigers is of particular concern as predators at the top of the food chain are critical to maintain the overall health of various ecosystem processes. As top predators, tigers help keep populations of both prey and lesser predators in check[4]. Large, familiar animals such as tigers are often considered wildlife ambassadors and therefore attract funding and wider conservation support. In addition, tigers have symbolized beauty, power, religious beliefs, and fierceness for more than 5,000 years[5]. Unfortunately, tigers are listed as endangered on the IUCN (International Union for Conservation of Nature) Red List and are listed in CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna) Appendix I[6]. Their conservation is a major focus of the IUCN Species Survival Commission/Cat Specialist Group, and of many international and national non-governmental organizations (NGOs).

Tigers are threatened primarily by a combination of a) poaching and illegal trade in tiger parts and products and b) habitat fragmentation and loss[7]. Both threats require different and immediate interventions as the rapid pace of infrastructure development, land-use change, and population growth continues unabated throughout Asia[8]. The plight of the tiger in the face of these threats meant that in 2008, various stakeholders, in conjunction with the World Bank, established the Global Tiger Initiative (GTI)[9] "to assist the 13 tiger-range countries (TRCs) with their efforts in restoring wild tigers and their habitats"[10]. The World Bank has been, and continues to be, active in development projects as well as specific integrated conservation and development projects (ICDPs) in or adjacent to tiger conservation landscapes (TCLs)[11]. The Bank shares the challenge of tiger conservation along with various tiger range governments and NGOs.

In the report *A Future for Wild Tigers*[12], tiger experts identified infrastructure, noting transportation, mining and hydroelectric infrastructure in particular, as major contributing factors in habitat fragmentation and conversion in tiger conservation landscapes. Having identified the need to generate so-called "tiger-friendly infrastructure" or "smart green infrastructure (SGI)", *the purpose of this paper is to develop a set of multi-level tiger-friendly options (at a policy, sector planning, and engineering level) based on best practices for government officials, financing agencies, and project managers. These options will highlight the basic elements throughout a project's lifecycle (including planning, optimal site selection, design, operations, and construction) for roads, hydroelectric dams, and mining operations in tiger conservation landscapes.* **SGI is defined as infrastructure that avoids tiger habitats, minimizes and mitigates adverse impacts through tiger-friendly design, and compensates for any remaining damage to have a net positive impact.**

The ultimate goal is that options presented in this paper will form the basis for improved decision-making and be incorporated into country-level tiger conservation plans, national conservation policies, sectoral planning, and the construction of local projects[B]. In order to help determine where policies were already in place, and where gaps existed, the SGI team conducted a multi-level assessment of the status of tiger friendly policies and practices in tiger range countries (Appendix A). This was then supported with an array of case studies highlighting best practices throughout the world (Appendix B).

B. At the World Conservation Congress in Amman, Jordan, in October 2000, the IUCN Tiger Conservation Resolution was passed by consensus. It invited funding agencies and national, and local governments to desist from making financial investments that adversely affect tiger habitats and to heighten the priority given to tiger conservation within their policies.

2.
EFFECTS OF INFRASTRUCTURE ON TIGER CONSERVATION

Shocking numbers

Tigers (*Panthera tigris*) are majestic symbols in many ancient and modern cultures and are recognized by various civil society groups and governments as being important to save from extinction[6]. Tigers are on the brink of disappearing from the wild. The world's population of wild tigers has plummeted by 95 percent in just over a century, from an estimated 100,000 in 1900 to approximately 3,500 today. Tigers, have already disappeared from Central Asia. In Java and Bali in Indonesia, they occupy only 7 percent of their historic range—and their range has shrunk by 40 percent in the last decade alone[13]. Tigers are divided into six living subspecies: the Bengal (*Panthera tigris tigris*), Indochinese (*Panthera tigris corbetti*), Malayan (*Panthera tigris jacksoni*), Sumatran (*Panthera tigris sumatrae*), Siberian or Amur (*Panthera tigris altaica*), and South China tiger (*Panthera tigris amoyensis*), and three extinct subspecies: the Bali tiger (*Panthera tigris balica*), the Javan tiger (*Panthera tigris sondaica*), and the Caspian tiger (*Panthera tigris virgata)*[C]. The South China tiger is critically endangered, with as few as 20 remaining in the wild[14]. While the subspecies' populations vary in size and health, significant conservation opportunities exist for most of them. The remaining tiger habitat is spread across 13 countries and faces many challenges as a result of human population growth and development pressures[9]. These pressures vary from country to country, so solutions must be customized for each country and region.

Tigers have been reduced in number throughout their range primarily due to a combination of overhunting and poaching, loss of prey, and habitat degradation[15]. While addressing the former two factors is critical to stop the immediate loss of tigers, the latter driver, habitat loss, is typically a result of either land-use conversion, usually for agriculture or human settlement, or infrastructure development. Although the relative contribution of infrastructure development to the tiger's decline is less significant than poaching and land-use conversion, its magnitude should not be underestimated[9]. In fact, investments in both the urban and rural areas of Asia and the Pacific are estimated to reach US$4.7 trillion over the next 10 years in order to sustain growth in the region, with two-thirds of that amount going to new infrastructure[16]. As economic development, resource demand, and population growth continue to increase, infrastructure expansion will attempt to meet transportation, mining, and energy demands. Moreover, given the historical failure of efforts to avoid degradation of core tiger habitat, it is imperative that decision-makers consider long-term environmental and economic impacts and not allow short-term political rationale to

C. In a recent genetic study (Driscoll C.A., Yamaguchi N. Bar-Gal G.K., Roca A.L., Luo S., et al. 2009. Mitochondrial Phylogeography Illuminates the Origin of the Extinct Caspian Tiger and Its Relationship to the Amur Tiger. PLoS ONE 4(1): e4125. doi:10.1371/journal.pone.0004125), the authors concluded that P. t. virgata+P. t. altaica should be taxonomically considered a single subspecies.

trump decisions relating to core tiger populations and the placement of infrastructure.

Habitat loss and fragmentation has already occurred within tiger conservation landscapes, where many protected areas have become insular and often unable to support viable populations of tigers[8]. Thus, the creation of effective corridors that connect protected areas, forest reserves, and large intact habitat blocks using optimal approaches to conservation landscape design is essential in most tiger conservation landscapes[17]. In 2007, in Asia and the Pacific, the terrestrial area designated as legally protected was around 10 percent of total land area, slightly lower than the global average[18]. Forests outside protected areas are also at risk in tiger range countries. From 1990–2005, more than half of the countries in Asia and the Pacific for which data are available reported net losses in forest cover.

Currently, only 30 percent of the land area in Asia and the Pacific is covered by forest—one of the lowest proportions among global regions. Four countries accelerated their loss of cover between 1990 and 2005: Vietnam, Nepal, Indonesia and Cambodia, with Indonesia and Nepal reporting the greatest losses—more than 20 percent of 1990 levels[19].

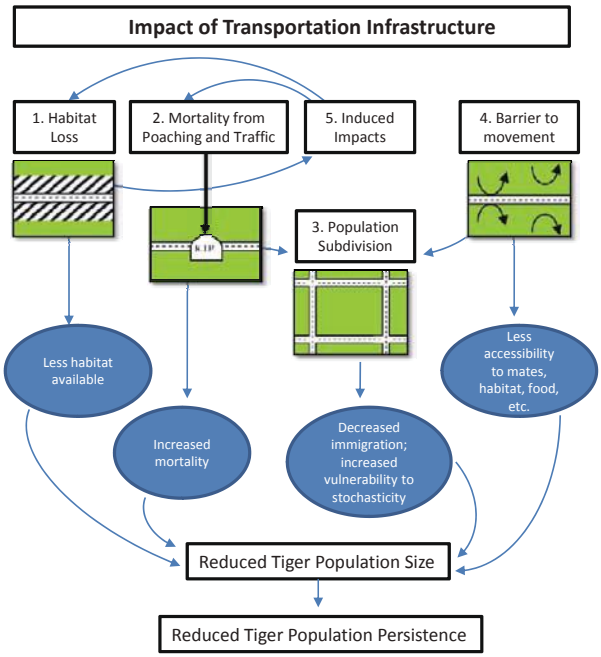
The largest tiger conservation landscapes occur in Myanmar (249,389 km^2), Russia (241,868 km^2), India (197,199 km^2), Thailand (115,884 km^2), Indonesia (88,314 km^2), and Cambodia (74,749 km^2), where controlling land-use change and habitat fragmentation has been identified as a critical issue[8].

Roads to ruin

Transportation infrastructure generates serious direct and cumulative adverse impacts if poorly planned. Road density can affect wildlife movement, cause population fragmentation, and give people greater access to wildlife areas[20]; these impacts increase as road density increases[21,22] (Figure 1). Roads often have downstream hydrological impacts. Perhaps most important, roads open up intact habitat and create opportunities for poachers to reach remote areas which once provided refuge for tigers and their prey. Roads also create the means for exporting tiger parts as most of the illegal tiger trade occurs by roads and trains[23]. While tiger populations may suffer few road-related casualties in an absolute sense because of their small population size, the loss of even a few individuals might lead to their local extinction[24]. Roads often produce induced impacts and these cumulative impacts can ultimately jeopardize tiger populations[25]. Nonetheless, well-designed infrastructure projects do have the potential to freeze and even reverse the degradation of natural habitats and the loss of biodiversity[26]. For a more detailed discussion of the impacts of roads on tropical biodiversity, and governments' response, see Laurence et al. (2009)[27] and Box 1.

The current trends in tiger numbers, habitat fragmentation, and infrastructure development in Asia underscore the fact that project-level mitigation efforts to date have not adequately included tiger conservation programs. The trends highlight the need for more comprehensive

FIGURE 1 Impact of transportation infrastructure (adapted from J. A. Jaeger, L. Fahrigh, and K. C. Ewald. *Does the configuration of road networks influence the degree to which roads affect wildlife populations?*)



BOX 1 Simpang Pulai-Kuala Berang Road Wildlife Viaducts, Malaysia

Major highways can act as significant barriers to wildlife movement as they fragment habitat and increase road kill. In response to this issue, in 2007, the Malaysian government completed the Simpang Pulai-Kuala Berang road, and along with it, a first for Southeast Asia: three wildlife underpass viaducts. These three crossing structures are located in the valleys of Sungai Kelempai, Sungai Kembur, and Sungai Purun and are intended to provide connectivity for large mammals such as the elephant, sun bear, tiger, tapir, and gaur. While the initial environmental impact assessment had suggested fences to mitigate impacts to wildlife, the Department of Wildlife and National Parks (Perhilitan) insisted that the viaducts were necessary, along with a realignment of the road further away from the Taman Negara National Park boundaries, to restrict access for poachers.

policies, regulations, and protocols to safeguard tiger populations and tiger conservation landscapes from poorly conceived infrastructure-sector planning and investments. Beginning with the choices that determine a project's location (see Appendixes D1 and D2), SGI uses careful sector-planning design, community engagement, strong assessments, monitoring, and adaptive management to ensure that infrastructure does not interrupt natural ecological processes. However, making infrastructure projects tiger-friendly is only a part of the complex set of actions needed to be adopted to address the impacts of encroachment, land-use conversion, poaching, and illegal trade. While the situation for tigers in the wild is precarious, excellent opportunities exist for government officials, business owners/operators, engineers, and local communities to ensure the development of SGI.

J. Quintero

3.
MULTI-LEVEL OPTIONS APPROACH

Because traditional project-based mitigation has proven to be insufficient to halt habitat fragmentation and tiger population decline, a multi-level approach is proposed here. Beginning with the international conventions and frameworks, tiger-friendly infrastructure must be driven and supported at all levels—the national policy level, the sectoral planning level, and finally, at the project level.

All the tiger-friendly infrastructure options presented below can be framed in the context of the mitigation hierarchy (Table 1): First, and most important, avoid, then minimize, then rehabilitate/restore, and then finally, when all options are exhausted, compensate. In other words, *avoidance, which lies at the top of the mitigation hierarchy, should be the primary aim of any policy or program designed to save wild tigers*.

With the mitigation hierarchy in mind, the remainder of this paper sets out various options at the policy, sectoral, and project level.

TABLE 1 The mitigation hierarchy[D]

***Avoidance**:* The preferred measures taken to avoid creating impacts from the outset, such as careful spatial or temporal placement of elements of infrastructure, in order to completely avoid impacts on certain components of biodiversity. This results in a change from a 'business as usual' approach.
Minimization: Measures taken to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided, as far as is practically feasible.
***Rehabilitation/restoration*:** Measures taken to rehabilitate degraded ecosystems or restore cleared ecosystems following exposure to impacts that cannot be completely avoided and/or minimized.
***Offset*:** Measures taken to compensate for any residual significant, adverse impacts that cannot be avoided, minimized and/or rehabilitated or restored, in order to achieve no net loss or a net gain of biodiversity. Offsets can take the form of positive management interventions such as restoration of degraded habitat, arrested degradation or averted risk, and protecting areas where there is imminent or projected loss of biodiversity.

D. The World Bank also subscribes to the mitigation hierarchy via its safeguard policies including Operational Policy OP 4.04 Natural Habitats, which looks to avoid habitat impacts and minimize/restore habitats. The Bank promotes and supports natural habitat conservation and offsets. The Bank does not support projects that involve the degradation of critical natural habitats. Mitigation measures include, as appropriate, minimizing habitat loss (for example, strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area.

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4.
INTERNATIONAL CONTEXT AND NATIONAL POLICY-LEVEL OPTIONS

Tiger range country governments are in the position to set the stage for tiger conservation as it relates to infrastructure development. With a mandate to drive the economic, social, and environmental wellbeing of their respective countries, governments, through their policies, can have a profound impact on tiger conservation.

International agreements often form the basis for national legislation. International expectations are usually harder for governments to ignore than local pressure. All tiger range countries are parties to the Convention on Biological Diversity (CBD) and, as signatories, have legally binding responsibilities. Such commitments set the stage for biodiversity conservation and theoretically require countries to create legislation to protect threatened species including tigers; however, protecting tiger habitats is not an explicit obligation being enforced through the Convention. The Global Tiger Forum (GTF) recognizes that efforts by national governments, both individually and as parties to multilateral agreements such as CITES, require additional and complementary support to guarantee the survival of tigers in the wild. Subsequent to the first general assembly of the Global Tiger Forum in 2000, all tiger range countries have developed, updated, or approved National Tiger Action Plans (NTAPs). These Plans give tiger range countries an opportunity to develop innovative approaches and more effective actions to address the multiple threats faced by tigers in the wild. A common approach to the implementation of National Tiger Action Plans is essential. These Plans should not only identify the threats posed by infrastructure; they should also underscore the inclusion of tiger-friendly development policies as part of the planning of infrastructure projects near or within existing tiger conservation landscapes through adequate political support, financing, and legislation. There are numerous policy options available to decision makers which, in some cases, can be tailored to be sector-specific.

"No Go" areas

Of particular note is a suggestion put forth by the GTI-SGI team to develop "no go" areas. Given the critical state of wild tiger populations, it is suggested that all core tiger habitats be designated as "no go" areas for infrastructure development (see section 5.1 for more details). It is the GTI's hope that governments can signal their intentions to pursue tiger-friendly infrastructure through a commitment such as this at the Year-of-the-Tiger Summit, November 21-24, 2010, in St. Petersburg.

In addition to such commitments, the following are highlights of some of the primary options and tools available to government officials (a more comprehensive list may be found in Appendix C):

- **Land-Use Planning Policy/Framework:** A robust and systematic national land-use planning policy is the foundation for avoiding impacts to tiger conservation landscapes. By concentrating development in lower-value habitats with exist-

ing human presence, areas of higher biodiversity value, including core tiger areas, can be spared for tigers and provide critical ecosystem services at the same time. Fragmentation[E] analyses can be a useful tool to inform the designation of "no go" areas. Furthermore, Spatial Decision Support Systems (as illustrated in the NSEC SEA; see Appendix K) can provide an intuitive and accessible approach to delineate suitability layers for infrastructure investments. These systems can be used to identify vulnerability zones and in the design of avoidance/mitigation measures for land-use planning.

- **Tiger Corridor Identification:** National-level tiger corridor analyses, such as that for Terai Arc[20], are another valuable approach that can inform both the National Tiger Action Plans, as well as tiger-friendly infrastructure planning. These analyses identify particularly important movement corridors for tiger populations, and can help to ensure connectivity between core tiger breeding habitats. Avoiding infrastructure development in these corridors should be a primary policy aim and should be a part of a comprehensive land-use plan.
- **Protected Area Networks:** Protected area (PA) networks form a critical part of tiger habitat conservation and should form a cornerstone of any National Tiger Action Plan and land-use framework. Ensuring optimal overlap with tiger conservation landscapes and connectivity between protected areas should be an explicit policy goal. It should also be noted that infrastructure projects (via offsets such as those noted on page 14) can provide transfer funds for protected area establishment and management. Software tools such as MARXAN[28] can be helpful in optimizing protected area networks and informing land-use planning.
- **Financial incentives:** Programs designed to provide incentives to avoid (and to a lesser extent minimize, rehabilitate, and compensate) adverse impacts on tiger conservation landscapes can be put in place. These can come in the form of expedited approvals, lower interest rates, taxation benefits, or direct cash subsidies. Encouraging the adoption of voluntary sectoral market certifications, such as Forest Stewardship Council[F] (FSC), through various means (such as national marketing), can be an inexpensive way to improve tiger and biodiversity management within a given sector. Experience from around the world, particularly in the industrialized countries, indicates that a combination of financial incentive programs, aggressive subsidy reforms, energy-efficiency policies, and renewable-energy legislation can all be powerful motivators for affecting development patterns. When the appropriate government institutions implement and enforce these policies in conjunction with private players and the domestic financial sector, it can go a long way toward greening infrastructure. It is also worth noting that incentive schemes can be put in place not only for developers, but also for local communities to help encourage tiger conservation (and thus not request further infrastructure development). While such integrated conservation and development projects (ICDPs) have met with mixed success, with improvement, such projects have the potential to support and drive tiger conservation and focus development away from key habitats. Developing such tiger projects could also potentially reduce human-tiger conflict.
- **Regulatory controls:** Legislation is always an option available to governments as a means of controlling infrastructure development. Whether through permitting processes or environmental acts, the government can use legal penalties as disincentives to projects adversely affecting tigers. These regulatory controls are often sector specific and can include requirements such as environmental impact assessments (EIAs), strategic environmental assessment (SEAs), financial sureties related to restoration, and legal measures related to preventing tiger poaching and prey hunting.

E. Fragmentation is defined as a disruption of ecological interrelation between two locations and structurally as obstacles to the movement of animals between separate patches of habitat.

F. FSC is an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests.

BOX 2 Compensation schemes

Case Study A: Brazilian Environmental Compensation Law. In 2000, Brazil passed a legal act based on the "polluter-pays" principle. It requires that development projects with a significant environmental impact (determined via an environmental impact assessment) must compensate for biodiversity losses by paying a sum (the specific amount varies by the degree of the impact) which is at a minimum 0.5 percent of total project costs and more than 6 percent in the case of sensitive rainforest. This money is paid to the National System of Protected Areas (locally known as SNUC) to set aside conservation and sustainable-use units. While the project developer proposes how the money should be used, it is the environmental authority (national or regional) that makes the final choice, with the money ultimately used to create and maintain only strictly protected areas.[31]

Case Study B: Compensatory Afforestation Fund in India. In 2002, the Indian Supreme Court ordered that any development project on forest land would have to pay the intangible benefits against loss of forests (in Net Present Value) in addition to the loss of trees, which was being charged till then as a compensatory afforestation cost. The scheme is called Compensatory Afforestation Fund and is to be administered by the Compensatory Afforestation Fund Management and Planning Authority (CAMPA). The value of forests for this purpose was set at an ad hoc amount between Rs 5.8 and 9.2 lakh per hectare (approx US$12,000 and US$19,000) and agencies have to pay a one-time fee. The money from various states was pooled in a central fund, to be managed by CAMPA. As of July 2009, Rs 11,000 crore, (approx US$2 billion) had been collected. The money will be released in phases; Rs 1,000 crore (approx US$200 million) every year for five years. Each state will get an amount proportionate to its contribution.

- ◊ **Environmental Impact Assessments:** EIAs are of particular importance in mainstreaming environmental and social issues into infrastructure development and merit additional consideration. National environmental regulations in most tiger range countries have references to environmental impact assessments, but only in the past 10 years have countries implemented formal regulations making them mandatory for projects. The degree of maturity and quality of environmental assessment practices varies from country to country, with implementation challenges existing almost everywhere. Some, including China, India, and Indonesia, have well developed environmental impact assessment policies while Bangladesh, Myanmar, and Cambodia are at an earlier stage and trying to build basic capacity. Countries such as Vietnam and Lao PDR are in between. Appendix A provides a full breakdown of environmental impact assessment regulations and other efforts in the tiger range countries.
- ◊ **Strategic Environmental Assessments:** Strategic environmental assessment (SEA) is an analytic and participatory approach that integrates environmental considerations into policies, plans, and programs and evaluates inter-linkages with economic and social considerations. Strategic environmental assessment is a relatively new concept and only China and Vietnam currently have regulatory frameworks for conducting them. Strategic environmental assessments are necessary in many cases because only a relatively small proportion of proposed actions and decisions are subject to environmental impact assessments. They are conducted at a later stage in the decision-making process, after selection of major alternatives is complete. Because tiger populations are most affected by the cumulative impacts of infrastructure siting, the environmental impact process is often too late to effect change. The strategic assessments provide the opportunity to identify and avoid tiger conservation landscapes earlier in the development process, saving money, time, and most important, tigers.

- **Biodiversity/Tiger Offsets:** Major infrastructure projects also offer unique opportunities to create and enhance the connectivity of critical habitats for tigers. Compensation actions have been

described using numerous terms including 'biodiversity offsets', 'compensatory mitigation', 'compensatory conservation', 'net conservation benefits,' and 'environmental enhancement', among others (see Box 2). However, offsets are actions of last resort, to be taken only after all reasonable measures have been taken first to avoid and minimize the impact of a development project and then to restore biodiversity at the site[29]. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function, and people's use and cultural values associated with biodiversity[30].

Various mechanisms for financing offsets include tax and subsidy shifts, protected-area transfer funding, and payment for ecosystem services (PES) schemes. Of particular note are both adaptation efforts and the emerging market for carbon sequestration through reduction of emissions from deforestation and forest degradation (REDD). To date, tiger range countries have shown a strong interest in advancing and incorporating these instruments into their environmental portfolios. While the proposed REDD schemes do not necessarily target areas of high biodiversity value and core tiger habitats[33], there are opportunities to combine ecosystem-based mitigation (forest/soil carbon capture and sequestration), ecosystem-based adaptation (maintenance of habitat and ecosystem services), and tiger-habitat conservation[22,34]. Similar opportunities exist around the emerging discussion of biodiversity offsets within the Business and Biodiversity Offset Program (BBOP).

Lastly, but critically, in addition to the various policies, regulations, and fiscal measures noted above, dedicated and properly resourced institutions with strong governance mechanisms will be indispensable to create an enabling environment for greening infrastructure. Enforcement and ensuring compliance has often proven to be a challenge to tiger conservation and should be a strong focus of all tiger range country governments to ensure the success of policy-based solutions.

BOX 3 Re-routing Russia's Siberian Pipeline to save endangered species

In 2004, the Russian government announced that the state-owned company Transneft would build the world's longest pipeline to transport oil from Siberia to the Sea of Japan.[1] The pipeline would end in Perevoznaya Bay, southwest of Vladivostok. Perevoznaya Bay forms a territory of Kedrovaya Pad State Biosphere Reserve, Far-Eastern Marine Reserve, and Barsovy federal wildlife refuge.[2] More than 15 percent of the animal species registered on Russia's endangered species list, including the Amur Leopard inhabit these areas.[1] A number of national and international NGOs launched a campaign to change the pipeline route and terminal site in order to protect the endangered species in the region. After a series of reviews by both the Ministry of Natural Resources and the federal expert committee, combined with visits by President Putin's representative for the Russian Far East, a decision was taken in 2007 to re-route the pipeline to a new terminal site in Kozmino Bay. This project demonstrates that both natural habitat conservation, specifically big cat conservation, and construction of large infrastructure projects can occur simultaneously if there are adequate stakeholder consultations and political will.

1. http://www.tigrisfoundation.nl/cms/publish/content/showpage.asp?pageID=24

2. http://www.panda.org/what_we_do/successes/?96640/Worlds-longest-oil-pipeline-re-routed-in-Russias-Far-East-endangered-leopard-habitat-spared

TABLE 2 Summary of national policy options

Level	*Project life cycle*	*Option*
National policy	*Applicable to all stages*	Land-use planning framework (including strengthening property rights, restrictions, tiger corridor analysis)
		Designing protected-area networks (new protected areas/ strengthening existing ones)
		Environmental impact assessments (including mandating stakeholder engagement and fragmentation analysis)
		Strategic environmental assessments
		Leveraging tiger/biodiversity funds from infrastructure project as compensation mechanism
		Payment for ecosystem services (PES) schemes including carbon (REDD), watershed-services, and biodiversity offsets
		Tiger-friendly construction permits
		Restrictions on ancillary infrastructure development
		Promoting and providing incentives for alternative livelihoods, such as eco-tourism/ tiger viewing, as integrated community development projects that support tiger conservation
		Strong compliance monitoring and enforcement via institutional strengthening
		Legal requirements regarding financial sureties
		Enforcement of remediation and removal of ancillary infrastructure

J. Quintero

5. SECTORAL-LEVEL OPTIONS

Having indicated some of the governmental policy instruments that would make infrastructure tiger-friendly, the next step is to explore sectoral-level options. Sectoral options must begin with the acknowledgement that developers and financial institutions have a significant role to play in wild tiger conservation as it relates to infrastructure development. While economic development is highly desirable, there is a general appreciation that it cannot come at the expense of social and environmental values. As developers have often learned, ignoring these values carries significant risk, from project delays and legal battles to bad publicity and mitigation costs. Invariably, finding solutions that meet the so-called "triple bottom line" (economic, social, and environmental well-being) is in everyone's interest[35]. Based on this premise, there are a number of actions that the private and public sectors—infrastructure being mainly in public hands—in tiger range countries can take throughout the lifecycle of an infrastructure project (see Appendixes E, F, G, H).

At the forefront of sectoral options are sector-level plans. This report suggests that *all sectoral plans rooted in a strategic environmental assessment should include a fragmentation analysis, tiger-specific considerations about tiger conservation landscapes and core habitats, funding transfer mechanisms including payment for environmental services, offset options, and minimization of cumulative, ancillary, and induced impacts.* In addition to planning, sectors can commit to voluntarily adopt best practices and seek additional training and awareness-building for their workers. The remainder of this section will assess the lessons learned at a sectoral level then explore these various options.

5.1 Lessons learned and voluntary adoption of best practices

The loss of biodiversity, including the decline of tigers, has allowed researchers to learn a great deal about ameliorating the affects of human activity such as infrastructure development on biodiversity. Successful SGI projects designed to improve populations of large carnivores often employ the following best practices:

- Commitments to entirely avoid large, intact habitat blocks with core tiger populations;
- Identification and use of natural corridors to situate wildlife crossings;
- Innovative and locally-customized engineering and design;
- Environmentally-friendly operations with environmental management systems that explicitly take biodiversity (such as tigers) into account when examining significant impacts;
- Explicit goals to restore native habitat and provide "net positive impact" compensation related to biodiversity. Efforts to establish new protected areas are started during project preparation when impacts are identified;

- Community-based environmental awareness/education programs;
- Robust monitoring and evaluation plans that are implemented at an early stage;
- Strong, independent environmental impact assessments conducted by accountable consultants;
- Well-defined terms of reference with explicit tiger (and other biodiversity) goals;
- Early involvement of stakeholders to improve project design, operation, and management;
- Careful considerations related to construction including the timing of construction, rules for contractors (especially related to hunting/poaching), noise and dust abatement during construction, and restrictions around settlement and ancillary development. Induced effects of camp followers and boom towns that accompany large infrastructure projects in or near tiger areas should also be closely monitored and removed as part of the overall plan;
- Localized projects enable more in-depth, site-specific actions such as good environmental management programs (EMP) during construction and post-project monitoring[21].

Environmental impact assessments in tiger range countries are at various stages of maturity in terms of their coverage of environmental and social impacts (see Appendix A for full details). In the course of developing this paper, several learning points emerged around the problematic areas for environmental impact assessment implementation. These challenges can be categorized as follows:

Timing of the Environmental Impact Assessment and Implementation: Timing issues are a common problem throughout the tiger range countries. Often the assessment starts when decisions on the project, including design, site, and construction preparation, have already been made. The EIA/SEA is often implemented too late to have a meaningful impact.

Government Models: In many cases the offices responsible for safeguarding the environment are under the authority responsible for the projects. It is thus hardly possible for them to make a truly professional or independent evaluation. Furthermore, biodiversity concerns (raised through EIA/SEA) can be perceived as costly issues with the potential to prevent foreign investment.

Enforcement and Penalties: Pursuit of short-term economic benefits override considerations of longer-term costs (including the degradation of ecosystem services) and become a main driver of *weak enforcement* of laws safeguarding biodiversity (such as the widely established legal statues of environmental impact assessments in the region). The recent "EIA storms" in China appropriately illustrates this problem. Thirty projects, mainly in the power sector and involving investment of US$1.3 billion in total, were suspended in 2005 by the State Environmental Protection Administration because they had been implemented without application or approval of environmental impact assessments[36]. In this case, developers knew that the penalties associated with government regulations were too low to prevent them from carrying out these types of projects; they simply accepted the penalties and went ahead with the development.

Lack of Coordination among Authority Channels and Agencies: There is poor coordination at both local and central levels. The authority of the environmental agency to formulate and implement environmental impact assessment guidelines is disregarded during the processes of evaluation and approval of environmental impact assessment reports, especially when the projects are under the authority of the sector ministries. Effective coordination can become quite complicated for cross-agency projects. It is critical that political support exists for environmental agencies to ensure that proper environmental procedures are followed.

Lack of Public Consultation and Information Disclosure Mechanism: Consultation is typically an evolving area in the implementation of EIA/SEA in the region. There are numerous possible explanations for this trend, including historical top-down administrative traditions in many countries. Public consultation is also impeded by the small number of effective information channels available to the public, and the limited time given to members of the public to assess the information, un-

derstand the process, and express opinions, despite the fact that these activities are often stipulated in the regulations. Finally, in many cases there are no mandatory actions or decisions that must be taken in response to concerns and complaints raised by the public.

Lack of Resources: There is often modest funding to collect data. From initial baseline data to follow-up monitoring and related activities, a lack of environmental information often affects the assessment and evaluation of infrastructure projects. For example, in Indonesia baseline research on ecological areas at the national scale, which is the precondition for regional environmental impact assessments, is far behind schedule because of lack of resources. In contrast, extensive monitoring of highway modifications in Banff, Canada, has resulted in improved design, reduced costs, and strong conservation results. This problem is further compounded by a paucity of qualified staff in governmental agencies. Ultimately, resource constraints result in deficient data sets, inadequate conservation science, and poorly informed infrastructure development.

Outdated Growth Paradigms: The prevailing paradigm of profitability and development is via growth and economic expansion. At a sectoral level, businesses and governments need to re-evaluate this approach in an effort to distinguish between "more" and "better." Approaches such as clustered development (transportation), demand management (water and energy), and recycling (mining) all present opportunities to increase profits and development ("better" development) while not placing additional infrastructure in intact habitats ("more" development).

In light of these lessons learned and the derived best practices, one of the first options available to sectoral leaders is to commit to voluntarily follow best practices. Sectors have a long history of such commitments. Examples include the chemical industry's Responsible Care voluntary commitment,[37] and the industry-created Sustainable Forestry Initiative[38]. Developing an equivalent commitment related to tigers, or biodiversity more broadly, is one option available to sectors.

5.2 Strategic environmental assessments and environmental impact assessments

A second option at the sectoral level involves strategic planning including conducting strategic environmental assessments. These should be conducted proactively at the initial stages of the decision-making process. Strategic environmental assessments serve as an early warning tool for the long-term cumulative, induced, and ancillary impacts of a policy, plan, or program, as compared to environmental impact assessments, which are project-specific and usually conducted at the end of the decision-making cycle. For example, a strategic environmental assessment of a land-use plan can take account of tiger habitat fragmentation associated with proposed development, or a strategic environmental assessment of a national road-building program can address its implications for an entire tiger conservation landscape.

Strategic environmental assessments complement the environmental and social impact assessment process by streamlining their scope and costs by ensuring that project proposals are set within a policy framework that has already been subject to environmental scrutiny[39].

The strategic environmental assessment process has to be rooted in legislation as an approach to sustainable development rather than only to mitigate damage, or even as an end in itself[40]. The process has to link with other policy approaches, ensuring the sustainability of the outcomes, and has to be integrated into all phases of the planning process from the earliest stage rather than applied as a separate procedure. Different levels of integration include[41]:

- *Vertical integration of assessments*, which are undertaken at different stages in the policy, planning, and project cycle ('tiering' – see Figure 2);
- *Horizontal integration of assessments*, that is, bringing different types of impacts—environmental,

economic, and social—into a single overall assessment at one or more stages in the planning cycle;
- *Integration of assessments into decision-making,* that is, integrating the assessment findings into decision-making at different stages in the planning cycle.

The broadness and complexity of biodiversity issues requires a participatory mechanism. Biodiversity-inclusive strategic environmental assessments and environmental impact assessments can facilitate a transparent decision-making process by serving as platforms for public participation. They can also provide operative frameworks through which ecosystem service valuation approaches can be practiced. Impact assessment should be adaptable to local planning processes and not be an 'add-on' process. Although we have mainly focused on large-scale sectoral plans, it is equally important to include biodiversity-inclusive environmental impact assessments and "tiger-friendly filters" in small rural infrastructure (for example, rural roads, water) projects in or near tiger core areas. These projects are usually carried out by rural development agencies and townships or municipalities with little oversight and without sufficient necessary environmental planning before construction. As a result, these projects are very likely to increase fragmentation of core habitats and the likelihood of additional encroachment and illegal tiger hunting and trade. Given the evolution and uneven degrees of maturity of environmental impact assessments in tiger range countries, we propose using adequate legislative and political channels to strengthen environmental impact assessments and to incorporate strategic environmental assessments throughout those countries. Both instruments can help conserve tiger populations, assuming that tiger-friendly filters are mainstreamed into the planning, design, and construction of infrastructure projects regardless of their scale.

5.3 Avoidance policy and land-use planning in priority tiger conservation landscapes

Another sector-level option is to voluntarily commit to a tiger-friendly approach to land-use planning that evaluates the consequences of potential land-use change on core tiger populations and habitats. Here we present a framework, flowchart (Figure 3), and spatial methodology to help integrate tiger-friendly policies into land-use decision making and apply the avoidance principle in global priority tiger conservation landscapes.

FIGURE 2 A tiered approach to strategic environmental assessment and project level environmental impact assessment

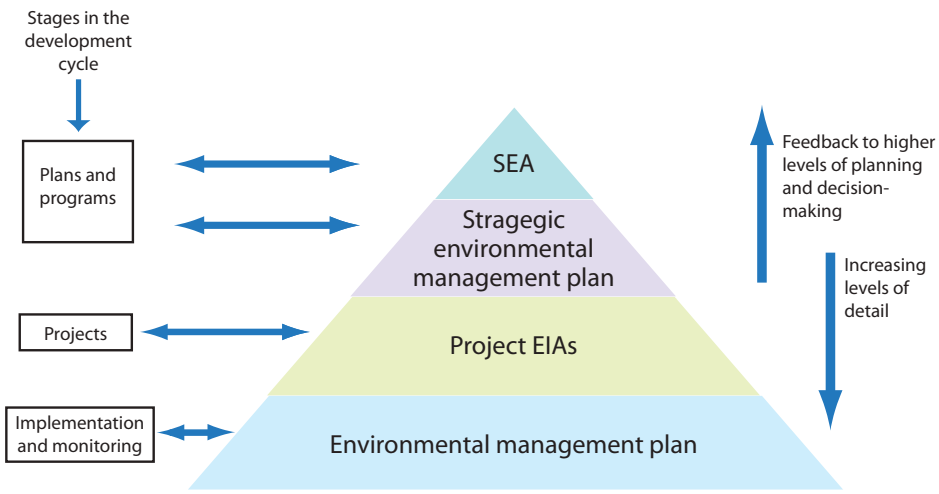
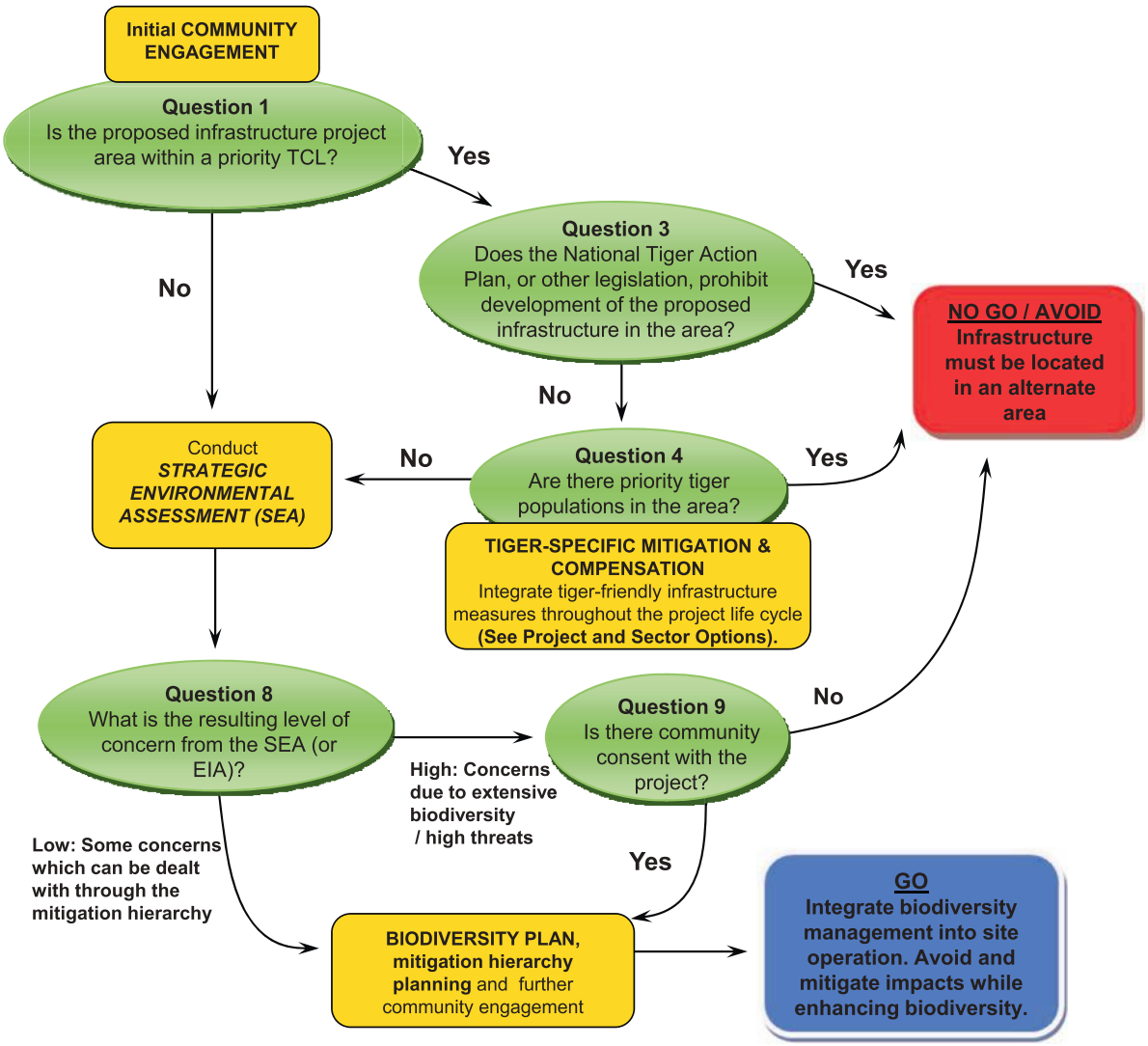


FIGURE 3 Simplified smart infrastructure planning flowchart (see Appendix D1 for a more comprehensive version)



Deciding where to site an infrastructure project

The site-selection process should begin as early as possible in the land-use planning and project lifecycle. The flowchart depicted in this figure helps identify and prioritize the risks and benefits of working in a certain area and guide choices about whether to pursue specific infrastructure development opportunities within or near tiger conservation landscapes. The SGI recommends evaluating impacts at all levels, encompassing the appropriate temporal and spatial scales, in priority tiger conservation landscapes. Basically priority landscapes containing tiger populations, core habitats, and protected areas should be avoided if governments are unable to apply tiger-friendly policies through a valid process. Even if the governments apply tiger-friendly policies but cannot mitigate impacts adequately, they should stop the project in the priority tiger conservation landscape area and perform alternative analysis. An expanded and more detailed flowchart including specific planning steps and mitigation hierarchy requirements is presented in Appendix D.

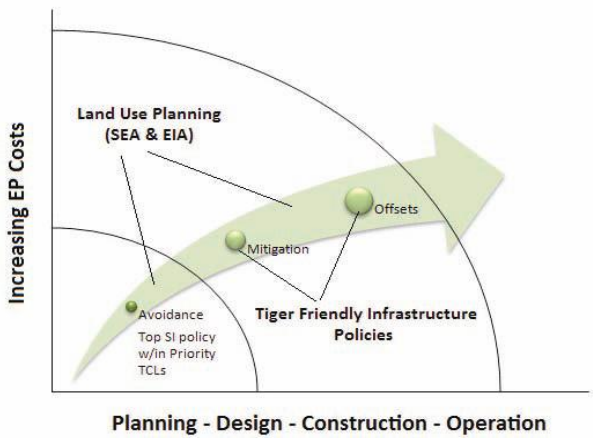
A key step included in the more detailed flowchart of Appendix D1 involves the application of Geographic Information System (GIS) cost-surface analysis (see Appendix D2, question 2a example). The cost-surface approach involves scoring various areas depending on their suitability for tigers; high- and low-cost areas are then mapped against proposed infrastructure to evaluate thresholds for "go" or "no go." Such cost surfaces could also guide the degree or cost of mitigation or compensation. This approach could safeguard tiger populations from further infrastructure development in priority tiger conservation landscapes (Appendix J).

It is recognized that the priority tiger conservation landscapes presented in Appendix J are clusters that need further refinement and prioritization; however they provide a useful framework for applying the tiger-friendly policies presented here.

Research indicates that avoidance is the least costly solution to environmental problems created by major infrastructure projects in high biodiversity areas[42]. Linear infrastructure is frequently associated with economic development, but it is often implemented without consideration for its economic feasibility or efficiency in terms of all of the costs, beyond planning and construction. It does not consider costs associated with deforestation, habitat fragmentation, habitat degradation, and loss of ecosystem services within or near protected areas[43]. Unfortunately, it is not uncommon to see political discussions lead to approval of economically inefficient projects. Frequently overlooked in road infrastructure development projects are the environmental and longer-term social and economic costs of the project (see, for instance, the cost-benefit analysis for Madidi NP in Appendix K). Appendix K summarizes not only exemplary cases but also current challenges and potential policy options for following the tiger-friendly policies presented here.

Major cumulative impacts from infrastructure projects could easily occur in priority tiger conservation landscapes if the avoidance principle is disregarded (see Appendix I). Tiger range countries including China, Vietnam, Lao PDR, and Thailand are already including avoidance and mitigation principles in major infrastructure projects (see Appendix K).

FIGURE 4 Relationship between environmental project costs, project cycle time line, priority tiger conservation landscapes, and land-use planning



Successful Smart Green Infrastructure projects designed to improve populations of large carnivores often depend on commitments to entirely avoid large, intact habitat blocks with core populations. Biodiversity-inclusive and tiger-friendly strategic environmental assessments and environmental impact assessments can provide the operative framework to identify avoidance priorities and adequate mitigation activities during the project lifecycle.

5.3.1 Global priority tiger conservation landscapes and development restrictions

WWF, WCS, the Smithsonian, and Save the Tiger Fund identified 76 tiger conservation landscapes across the tiger's remaining habitat[44]. These areas tend to be clustered, offering the potential to form even larger landscapes if habitat connectivity between them could be reestablished. For example, there is a cluster of tiger conservation landscapes in the Terai Arc of India and Nepal; another set in central India; and another in central Indochina, including Myanmar, Laos, and Thailand (see Appendix J). Such landscape clusters are large expanses of suitable habitat separated by four kilometer or longer stretches of terrain hostile to tigers.

Several tiger conservation landscapes cross political boundaries, and each mainland tiger range country hosts part of at least one trans-boundary tiger conservation landscape. For example, the Northern Forest Complex-Namdapha-Royal Manas has within its boundaries six different biomes and crosses the boundaries of Bhutan, Myanmar, and India. The Russia Far East bioregion contains two tiger conservation landscapes, including the world's largest, which is 270,000 square kilometers. This landscape is primarily in Russia, but extends into northeast China, which has recently recorded tigers on its side of the border[45].

There are a total of 342 nature reserves (including those in all IUCN categories) representing 23.1 percent of the land area within all tiger conservation landscapes. Restricting those protected areas to those in IUCN Categories I through IV, these areas form 12.5 percent of the land under protection. More than 87 percent of major core tiger habitat is not protected in tiger range countries[46].

Scientists developed a method to prioritize the tiger conservation landscapes[47], with the assumption that tiger populations in larger habitat areas would be more resistant to future disturbances. They established three well-defined priority levels:

- Global priorities for tiger conservation[G]
- Regional priorities for tiger conservation
- Long-term priorities for tiger conservation

In total, 20 tiger conservation landscapes are "Global Priorities for Tiger Conservation" representing all the major biomes and bioregions where tigers occur[48]. Global priority tiger conservation landscapes are the best places to conserve tigers based on ecological, conservation, and threat criteria, and therefore form the framework for applying tiger-friendly policies in terms of infrastructure development.

G. Global priority tiger conservation landscapes are classified as Class I: landscapes that have habitat to support at least 100 tigers, evidence of breeding, minimal-moderate levels of threat, and conservation measures in place.

Critically important for global tiger conservation are two areas that represent no less than seven biomes among them: the Russian Far East and the Northern Forest Complex-Namdapha-Royal Manas. When combined with Corbett-Sonanadi, the Tenasserims, the Southern Annamites, and the Sundarbans, these six landscapes capture the largest areas of habitat within all the major biomes for tigers across their range. All of these areas have breeding populations and some conservation measures in place.

A new genetic study found that the Bengal tigers living in India have much higher genetic variation than wild tigers elsewhere. Despite having experienced recent demographic declines and extensive habitat loss, wild tigers in India retain 76 percent of the mitochondrial diversity and 63 percent of the species' nuclear genetic diversity and are adapted to a greater diversity of habitats than tigers elsewhere[49]. The study also identified a few protected landscapes in India with high tiger densities and potential habitat connectivity. Conservation efforts must be focused in places such as the Western Ghats, Central India, and the alluvial flood plains in the Himalayan foot hills that potentially support large, high-density tiger populations. India's tigers are thus critically important from demographic, evolutionary, and ecological perspectives for the future survival and recovery of the species.

Accordingly, the SGI team identified "no-go" areas based on the following criteria: global priority, presence of tiger populations, growing threats, high biodiversity values, and genetic variation. The no-go areas thus identified are:

1. Russian Far East-Northeast China
2. Terai Arc Landscape of India and Nepal
3. Northern Forest Complex-Namdapha-Royal Manas (Bhutan/Myanmar/India)
4. The Tenasserims Semi-Evergreen Rain Forests of Thailand and Myanmar
5. Central Western Ghats (India)
6. Central Indian Landscape (India)
7. The Southern Annamites Montane Rain Forests of Lao PDR and Vietnam
8. Sumatran Lowland Rain Forests (Sumatra)

9. Lower Mekong Forests (Cambodia, Lao PDR, Vietnam, and Thailand)
10. Peninsular Malaysian Rain Forests (Malaysia and Thailand).

The list could be further refined using GIS to show where major ongoing and proposed infrastructure projects overlap with the above areas; however, securing tiger populations and core habitats in the largest tiger conservation landscapes will be critical to meeting the goal of restoring tiger populations. This will not be possible without effective trans-boundary conservation efforts, expanding the network of protected areas, creating buffer zones, restoring connectivity between patches of actual habitat within landscapes, reducing poaching, securing long-term funding, and applying stringent infrastructure development policies that factor in poverty reduction and reduce human-tiger conflict so communities benefit from and support tiger conservation.

5.4 Professional training and awareness

Finally, sectors have a history of coming together to provide professional training and certification or accreditation for their professional members. Leadership in Energy and Environmental Design Accredited Professional, or LEED AP[50], is an example. Sectors often offer training to their members to enhance credibility and ensure that professionalism is maintained. The various sectors that develop infrastructure often have little experience dealing with biodiversity challenges, let alone the specifics of tiger conservation. Developing tiger-specific training for workers, from the on-the-ground construction workers, through the project managers, and right up to designers and engineers, on how to build smart green infrastructure would be very helpful.

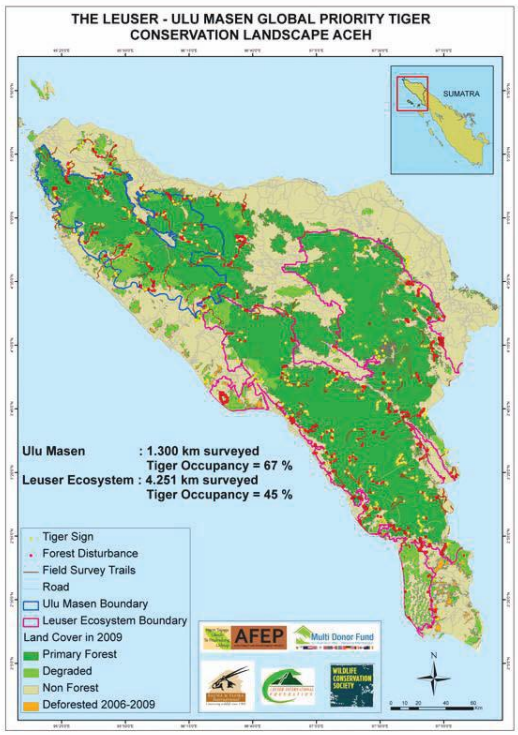
To help facilitate this, large institutional players may want to consider some of their available instruments for capacity building. For example, the World Bank Institute has committed more than US$1 million to build a "Conservation and Development Network that will train hundreds of rangers, foresters, and other habitat managers in the latest cutting-edge practices in biodiversity management, with a specific focus on preserving and increasing wild tiger populations."[51] Extending similar programs to the sectoral level is an opportunity that could be pursued. This would have numerous benefits in areas from sectoral planning to project design and implementation.

TABLE 3 Summary of voluntary sectoral options

Level	*Project Life Cycle*	*Option*
Sectoral planning	*Applicable to all stages*	Adopting best practices throughout the mitigation hierarchy, avoiding past mistakes, and pursuing voluntary commitments (see 5.1)
	Applicable to all stages	Develop national sectoral plans that include: integration of land-use planning (including fragmentation analysis and protected areas establishment), strategic environmental assessments that include tiger-specific considerations, funding transfer mechanisms including payment for environmental services (for example REDD), tiger-friendly project design and construction, compliance guarantees, considered construction rules and minimization of cumulative, ancillary, and induced impacts (see 5.2).
	Siting & development	Specific avoidance or "no go" of the 10 priority tiger areas (see 5.3)
	Applicable to all stages	Professional training and awareness building for workers on tiger conservation (see 5.4)

BOX 4 The Aceh Tiger Monitoring Program

The Aceh Tiger Monitoring (ATM) program is designed to monitor tiger numbers and habitat in Indonesia's Aceh province. The program involves on-the-ground surveys covering 1,300 square kilometers in Ulu Masen and 4,251 square kilometers in the Leuser Ecosystem to determine tiger population numbers. The program also employs satellite imagery and conservation planning tools, to identify core tiger areas and put management systems in place. Key to the success of the program has been the creation of strong local support and the empowerment of communities living in close proximity to tigers. Threats to tigers have been reduced through a community and forest ranger training effort. This aspect of the ATM program provides alternative employment for ex-loggers, ex-tiger poachers, and ex-combatants, and has already trained some 346 forest rangers and 46 community rangers. The training program has been instrumental in putting an end to illegal activities. The ATM program is an excellent example of what can be achieved for tiger conservation when monitoring is combined with local support.



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6. PROJECT-LEVEL OPTIONS — MAINSTREAMING TIGER CONSERVATION INTO ROADS, MINING, AND HYDRO PROJECTS

Where infrastructure development cannot be avoided within tiger conservation landscapes, there are ways to mitigate traditional infrastructure impacts through ecological engineering design[52]. At the project level, planners and engineers have a number of options available throughout the project lifecycle to help to ensure that infrastructure is both tiger and biodiversity friendly. The same principles can be applied in some cases where existing infrastructure is going to be expanded or improved. Drawing upon both the lessons learned and best practices for infrastructure projects taken from throughout the world, we present various cost-effective options available to sectoral decision-makers for project planning and development. An overarching principle of good design is that it should meet the needs of multiple stakeholders and species, and be resilient to impacts such as climate change and seismic activity. While there has been very little infrastructure design work applied directly to tigers, India has developed useful academic studies related to roads, spatial analysis and landscapes, and wildlife[53,54,55]. Our recommendations stem from the best practices available in case studies from selected countries. These case studies illustrate the various options in practice, from avoidance and mitigation to leveraging funds from infrastructure projects to benefit biodiversity conservation[56] (Appendix B).

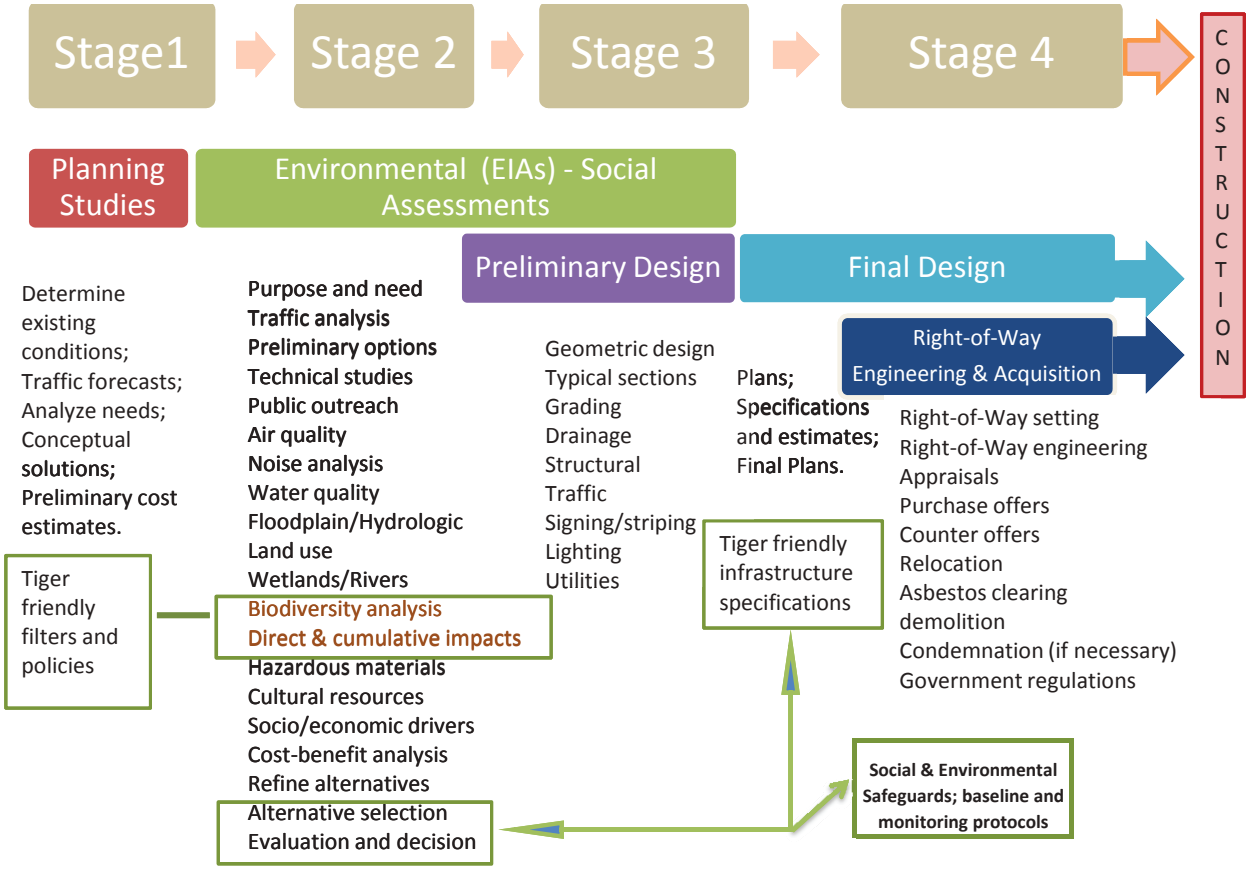
All of the following options are based upon the mitigation hierarchy, with an emphasis on avoidance. We explored both a so-called "tiger filter" (Appendix D1 and D2) as well as various infrastructure lifecycle options (Appendix E). To evaluate the applicability of the tiger filter and the options presented, the SGI team developed a set of in-depth case studies, which were distributed at the First Asian Ministerial Meeting on tiger conservation held in Hua Hin, Thailand in January 2010.

6.1 Transportation infrastructure/roads

Tigers are attracted to roads, a factor that should influence the type of infrastructure selected[57]. With respect to roads, engineers have an array of construction options to help ensure minimal impacts. These infrastructure modifications should be designed and funded at the beginning, before the project gets underway. Some researchers have also suggested avoiding roads altogether and building railroads instead. Railroads have been shown to result in fewer ancillary impacts than road infrastructure[58] such as requiring less land for right of way or having induced impacts mainly at stations.

Ideally, building infrastructure in large intact habitat blocks should be avoided to lower the risk of poaching and breaks in habitat connectivity[59]. However, there may still be a need for "micro-siting" to determine the exact location for infrastructure and when to apply tiger filters during the process (see Figure 5). Biologists, planners, and engineers can assist in the mitigation of impacts to tigers by identifying and avoiding tiger corridors[60]. In

FIGURE 5 Tiger-friendly road project and planning timeline



situations in which infrastructure is unavoidable, and overlaps with a tiger conservation landscape, tiger crossings should be properly planned and engineered to help facilitate tiger movements. Appropriate mitigation of the barrier effect caused by transportation infrastructure should be customized for tigers, taking into account their behavioral responses to habitats fragmented and modified by roads, fences, overpasses and underpasses. There is a major need to monitor both the initial fragmentation effects on tigers, as well as the effectiveness of project-level mitigation efforts.

To help identify the exact location of these tiger corridors ("connectivity planning"), a number of methods can be used including: aerial photography, vegetation maps, topographic maps, wildlife habitat maps, road kill information, interviews with local people and/or rangers (if applicable), footprint/scat trails, poaching information, and ideally (if available) photographs from camera traps. The wildlife crossing options listed in Appendix F are largely derived from a recommendation report developed for carnivore crossings in North America[61].

Appendix F provides a breakdown of options to help make transportation infrastructure tiger-friendly. Overall, research suggests that open-span bridges and bridge extensions are recommended for mitigating road impacts on tigers, and should also work for other species, including prey and other large mammals such as elephants[62].

Entrance to wildlife crossings should be natural, with gradients and curves rather than edges and lines[63]. Shielding tigers from the view of potential poachers is critical. Discordant, non-natural features should be removed from the vicinity of the crossing, and the substrate should be similar to that of the surrounding area. For all of the structures noted above, it is helpful to have a full line of sight across the crossing[64]. Lastly, fencing

decisively enhanced the effectiveness of crossing structures in North America[65]. It is of note that elephants, which co-occur with tigers in many tiger conservation landscapes[66], are not always amenable to fencing solutions[67,68,69] so this problem will require further research and monitoring, in particular to identify whether migratory routes of elephants and general movement corridors for both species overlap or are separate. Should fencing prove to be an option in particular areas, research on cougars suggests that it should be at least 8 feet/2.5 meters high (preferably higher) and should attach to the top of the crossing (versus the base). Furthermore, the fencing should run for longer than half a mile (>800 meters) and it may be desirable to fully fence-in certain areas to serve the dual purpose of keeping tigers in, and poachers out of, crossing areas.

No matter which crossing structures are used, monitoring is critical to evaluate effectiveness, which in turn will enable managers to adapt plans. Camera systems used for monitoring may also serve the secondary role of tracking tiger and prey populations and the incidence of poaching.

6.2 Mining

Mining has the potential to directly and indirectly affect tiger conservation landscapes and tigers throughout the lifecycle of a project. Impacts from mining can result from any activity that involves land clearance (for example access-road construction, exploration drilling, overburden stripping, or tailings impoundment construction) or direct discharges into water bodies (for example riverine tailings disposal, tailings impoundment releases, or unintended acid rock drainage), land use (for example overburden dumping), and inputs into the air (such as dust or smelter emissions).

The potential for significant impacts on tigers is greater when mining occurs within or near tiger conservation landscapes. Due to the continuing demand for minerals, the depletion of resources in readily accessible areas, and changing legislation, fiscal and regulatory reforms, technologies, and economics in the mining sector, mining is increasingly being proposed in remote and biodiversity-rich ecosystems that were previously unexplored and undeveloped for minerals. Despite the significant potential for negative impacts on tiger populations and their landscapes from mining operations, companies can do a great deal to minimize or prevent such impacts in areas identified as being appropriate for mining[70]. There are also many opportunities for companies to enhance biodiversity conservation within their areas of operations. Appendix G presents a set of recommendations based on best practices.

It is essential in tiger conservation landscapes that these practical realities be factored into the design of mitigation hierarchy measures, into the allocation of responsibilities for implementing the measures, and into construction supervision to ensure that adequate protection is afforded to tigers, their landscapes, and affected stakeholders.

6.3 Dams and hydroelectric power

The electric power and water demands of tiger range countries are growing rapidly[71]. Most of the countries already have multi-year development plans for dam construction near or within tiger conservation landscapes[72]. In addition to huge social impacts, large dams directly impact rivers in a variety of physical and biological ways. Most significant is the alteration of a river's flow, which affects downstream ecosystems and the landscape through which the river flows[73,74]. Riverbeds downstream of dams are typically eroded by several meters within the first decade following dam closing; the damage can extend for tens or even hundreds of kilometers below a dam[75]. During the flooding phase, large tracts of forest are impacted directly[76,77] and major tiger habitats could be lost irreversibly.

The majority of river basins within tiger conservation landscapes are noted as being at a high or very high risk of cumulative impacts from human activities, to which infrastructure is a significant contributor[78,79]. Accordingly, there is a strong need for integrated, precautionary

approaches to hydroelectric power planning and design, including avoidance of critical habitats. The same notions also apply to other forms of water-based infrastructure, such as pipelines. A strategic package of avoidance, protection, and offset policies near tiger conservation landscapes should include:

1. **Avoidance of core tiger habitats** and trans-basin/river water transfers to prevent introduction of exotic species;
2. **Protection of high-value or un- and under-represented lowland tiger habitats**, especially in watersheds that remain largely in their natural state, supported by clustering of hydroelectric power projects or their concentration in particular basins or parts of basins;
3. **Maintaining minimum downstream environmental flows** in terms of both water quality and quantity;
4. **Provision for equivalent or nearest comparable offsets** for all critical habitat loss or deterioration; and
5. **Fair valuation of losses and payments for maintenance of ecosystem services** such as enhanced watershed protection.

These principles can be augmented by many of those presented in the two previous sections on transportation and mining infrastructure, as well as hydroelectric power-specific recommendations (see Appendix H).

The hydroelectric power sector usually deals with a set of strategic issues at the policy, planning, and program level of analysis that require different instruments (see Table 4 below):

As a general frame of reference, the principles of the mitigation hierarchy provide a good-practice guide to managing the impacts and risks of current and proposed hydroelectric power development at all levels. In addition to a high quality environmental impact assessment, a strategic environmental assessment to hydroelectric power, road, and mining plans and projects (where they impact tiger conservation landscapes and tiger populations in particular and biodiversity in general) should be included in regional and project plans. In addition, more attention should be attached to the environmental impacts from ancillary infrastructures of projects in environmental impact assessments. Ancillary infrastructure, such as access roads, transmission lines, and boom towns, can also inflict considerable damage to the ad-

TABLE 4 Environmental issues in the hydroelectric planning process

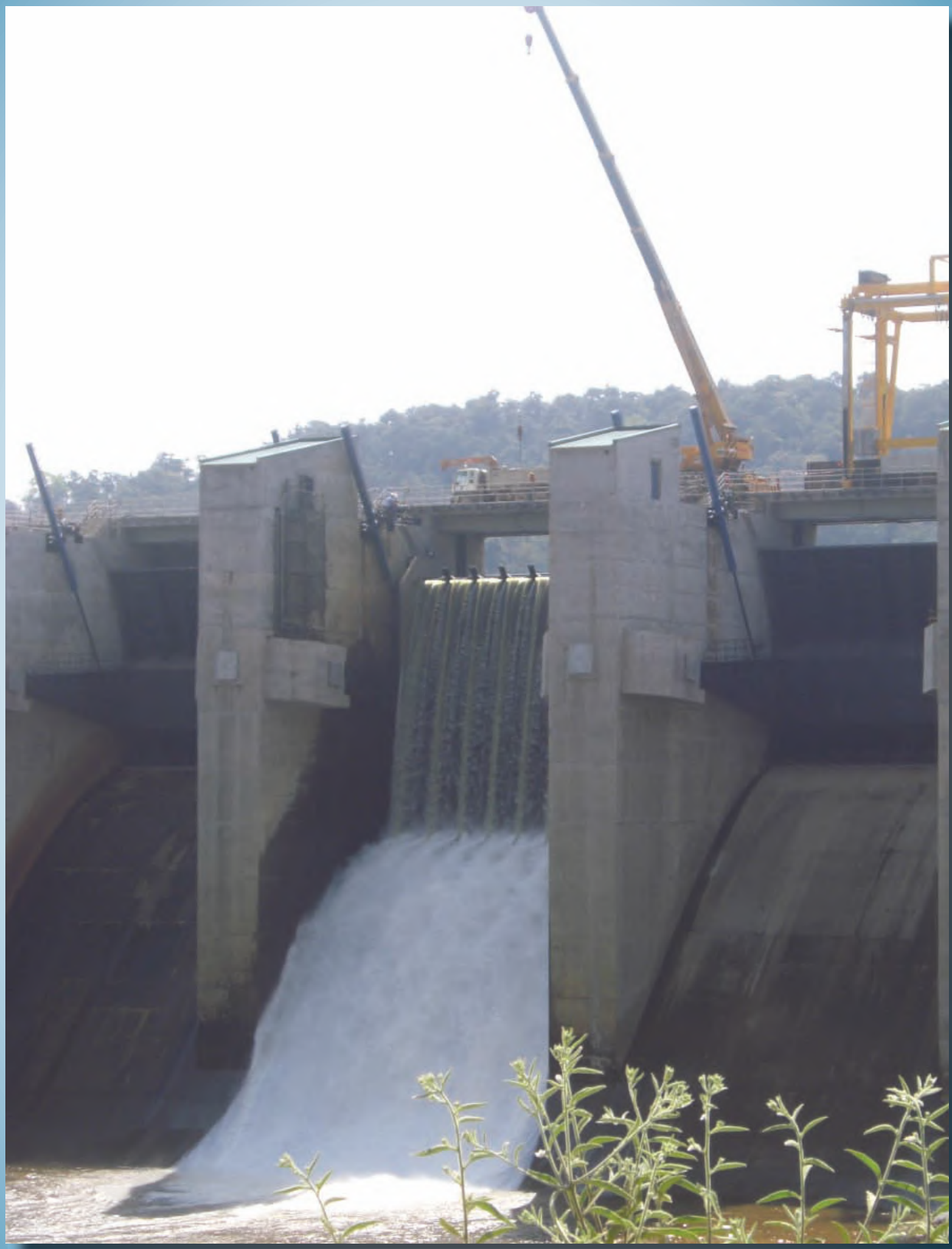
Level of Analysis	*Strategic issue*	*Instrument*
Policy	Trade-offs: hydroelectric development vs. greenhouse-gas emissions Loss of biodiversity	Strategic environmental assessment for energy matrix
	Water allocation priorities Water efficiency Inter-basin transfers "No-development" basins	Strategic environmental assessment for National Water Resources Strategy
Plan	Environmental criteria for hydroelectric project selection including impacts on critical natural habitats (tiger landscapes)	Strategic environmental assessment for 10-year Hydroelectric Plan
	Water allocation tradeoffs in watershed Water-use conflicts Environmental flows in watershed	Strategic environmental assessment for Watershed Water Resources Plan
Program	Cumulative impacts on biodiversity in watershed Regional environmental programs for mitigating/compensating cumulative impacts on biodiversity	Strategic environmental assessment for Watershed Hydroelectric Development Program

jacent environment to main construction sites. Often, environmental impact assessments do not pay enough attention to these ancillary impacts. Furthermore, strategic decommissioning of infrastructure that is causing great harm to tiger areas (such as old forest roads) should also be considered.

In summary, despite a track record of adversely affecting tiger conservation, infrastructure projects do have numerous options for positively affecting wild tiger conservation. These options, organized within the project lifecycle, are summarized in Table 5.

TABLE 5 Summary of project level options

Level	*Project life cycle*	*Option*
Project	***Exploration, planning, and design***	Early stakeholder engagement (including benefit-sharing agreements and informed consent)
		Tiger/large intact habitat block avoidance (includes screening and "no go" commitments)
		Conduct baseline studies and monitoring
		Legal compliance with all regulatory requirements throughout project lifecycle (including both environmental impact assessments and strategic impact assessments even if they are not compulsory)
		Tiger-friendly design and engineering (emphasis on open-span bridges/bridge arches for roads)
	Construction	Minimizing ancillary infrastructure development and clustering development
		Construction and worker behavior protocols (relating to workers, noise, dust, and induced development)
	Operations	Embedding tiger conservation performance objectives into environmental management systems
		Community tiger education programs
		Ongoing monitoring of tigers, tiger habitats, and crossing structure use (by various species)
		Ongoing reporting and disclosure of information to stakeholders
		Tiger patrols and poaching/hunting restrictions on workers
	Closure and remediation	Post-project reporting and communication of lessons learned



J. Quintero

7. PRIORITY ACTIONS

During 2009 and 2010, the GTI planned a series of meetings starting in Katmandu in October 2009 then Thailand in January 2010 and culminating in the Tiger Summit in November, 2010. Here is a set of priority actions that would facilitate activities following the Tiger Summit in St. Petersburg in November. (see also Appendix C for long-term policy recommendations):

7.1 Funding agencies

1. Develop capacity for building tiger-friendly policies into sectoral planning.
2. Initiate a policy of information sharing and open access to basic infrastructure development information among government agencies and, preferably, among other key partners, to assist in strategic environmental assessment and environmental impact assessment, help interagency coordination, and promote integrated planning.
3. Mainstream environmental/biodiversity considerations into the design, construction, and operation of infrastructure projects through application of strategic impact assessment at a sectoral level; prepare sector-wide tiger-friendly environmental safeguards including environmental protection commitments; and disseminate best practices.
4. Strengthen environmental policy and governance oriented to tiger conservation landscapes.
5. Ensure safeguards are operationalized and made to be tiger-friendly.
6. Maximize the use of non-financial instruments such as advisory services, grants and capacity development.

7.2 Governments

1. Publicly commit to a "no go" policy for infrastructure development within priority tiger conservation landscapes.
2. Engage in policy analysis and debate about appropriate options for tiger and tiger conservation landscape protection instruments.
3. Review and update national tiger action plans to include tiger-friendly policies.
4. Review land-use planning policy especially in and around priority populations/habitats to avoid tiger conservation landscapes. In cases where these habitats are trans-boundary, conduct bilateral work. Protected area networks should also be reviewed to determine whether these tiger conservation landscapes can receive additional support.
5. Discuss the possible regulatory policy, fiscal policy, and incentive program options presented here, with appropriate agencies.
6. Consider and discuss inter-country commitments.
7. Stipulate a tiger-friendly policy in EIA/SEA systems.

8. Ensure institutions responsible for tiger conservation and general habitat protection are strengthened adequately to perform monitoring and enforcement of policy.

7.3 Business and industry

1. Review corporate environmental/biodiversity policies to incorporate tiger-specific actions. Policies should ensure that a strong mitigation hierarchy is in place along with biodiversity- and tiger-specific elements.
2. Review planned and existing infrastructure projects within tiger conservation landscapes to incorporate tiger-friendly actions. In particular, ensure that there are explicit tiger conservation goals and strong community engagement. Conservation planning tools for this sort of work, available from NGOs, could be used.
3. Research and review engineering guidelines for carnivore crossings that are customized for application to tigers in Asia, along with performance monitoring for learning.

8. CONCLUSIONS

The fate of wild tigers hangs in the balance. Decision-makers who have the ability to guide infrastructure development in Asia will have a major say in whether or not tigers disappear from the wild within our lifetimes. While the challenges are complex, tiger-friendly options are available at various levels from national policies to business practices and project design.

Avoidance is by far the best, and cheapest, solution and should be adopted by tiger range countries.

A "no go" commitment at the 2010 Tiger Summit, combined with the range of infrastructure options (Table 6), from regulatory policies to fiscal policies that provide various incentive schemes, such as payment for ecosystem services and biodiversity funds, can help to promote avoidance.

Sectoral-level policies can also avoid such areas on a voluntary basis to minimize risk and avoid costly delays. There are also a number of cost-effective options around stakeholder engagement, education programs, offsets, and explicit incorporation of tiger conservation goals into infrastructure projects that can help drive tiger conservation. Lastly, should it come to it, there are project-level design elements that can minimize disruption to tiger (and their prey) movement, monitor performance, and help to reduce habitat loss. The mitigation hierarchy can act as a useful framework for these various options (see Appendix I).

Case studies from all over the world (Appendix B) illustrate how governments, sector leaders, and private-sector players have developed projects that demonstrate best practices in action. The significant lessons learned from these cases can help to inform actions of the tiger range countries.

Significant transformational action is required to save wild tigers and the ecological values they represent. If we do not take action, the future will be bleak for the billions of people whose lives and livelihoods depend on the ecological services, from carbon sequestration to watershed protection, of the forests and grasslands that remain under the tiger's umbrella. Decision makers who have the ability to guide infrastructure development throughout Southeast Asia will have a major say in whether tigers, and the ecosystem services they represent, disappear from the wild within our lifetimes or not.

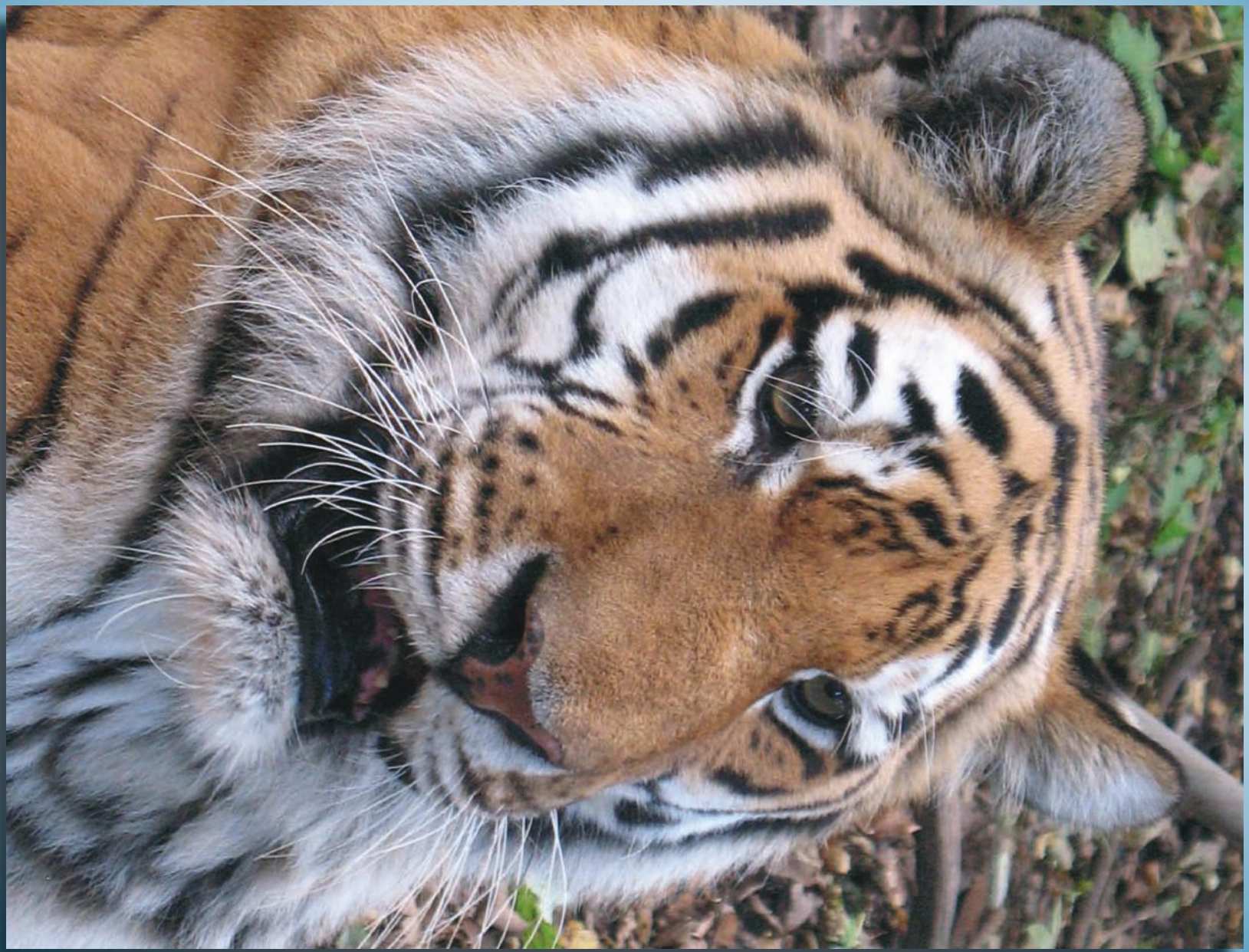
TABLE 6 Full summary of multi-level options

Level	*Project Life Cycle*	*Option*
National Policy	*Applicable to all stages*	Land-use planning framework (including strengthening property rights, restrictions, tiger corridor analysis, and tiger conservation landscape construction permits)
		Designing protected area networks (new protected areas/ strengthening existing ones)
		Environmental impact assessments (including mandating stakeholder engagement and fragmentation analysis)
		Strategic environmental assessments
		Leveraging tiger/biodiversity funds from infrastructure project as compensation mechanism
		Payment for ecosystem services schemes including carbon, watershed-services, and biodiversity offsets
		Tiger-friendly construction permits
		Restrictions on ancillary infrastructure development
		Promoting and providing incentives for alternative livelihoods, such as eco-tourism/tiger viewing, as integrated community development projects that support tiger conservation
		Strong compliance monitoring and enforcement via institutional strengthening
		Legal requirements regarding financial sureties
		Enforcing remediation and removal of ancillary infrastructure
Sectoral	*Applicable to all stages*	Adopting best practices throughout the mitigation hierarchy, avoiding past mistakes, and pursuing voluntary commitments
	Applicable to all stages	Develop national sectoral plans that include: integration of land-use planning (including fragmentation analysis and protected area establishment), strategic environmental assessments that include tiger-specific considerations, funding transfer mechanisms including payment for environmental services, carbon funding (for example REDD), tiger-friendly project design and construction, compliance guarantees, considered construction rules ,and minimization of cumulative, ancillary, and induced impacts
	Siting and development	Specific avoidance or “no go” in the 10 priority tiger areas
	Applicable to all stages	Professional training and awareness building for workers on tiger conservation

TABLE 6 Full summary of multi-level options (continued)

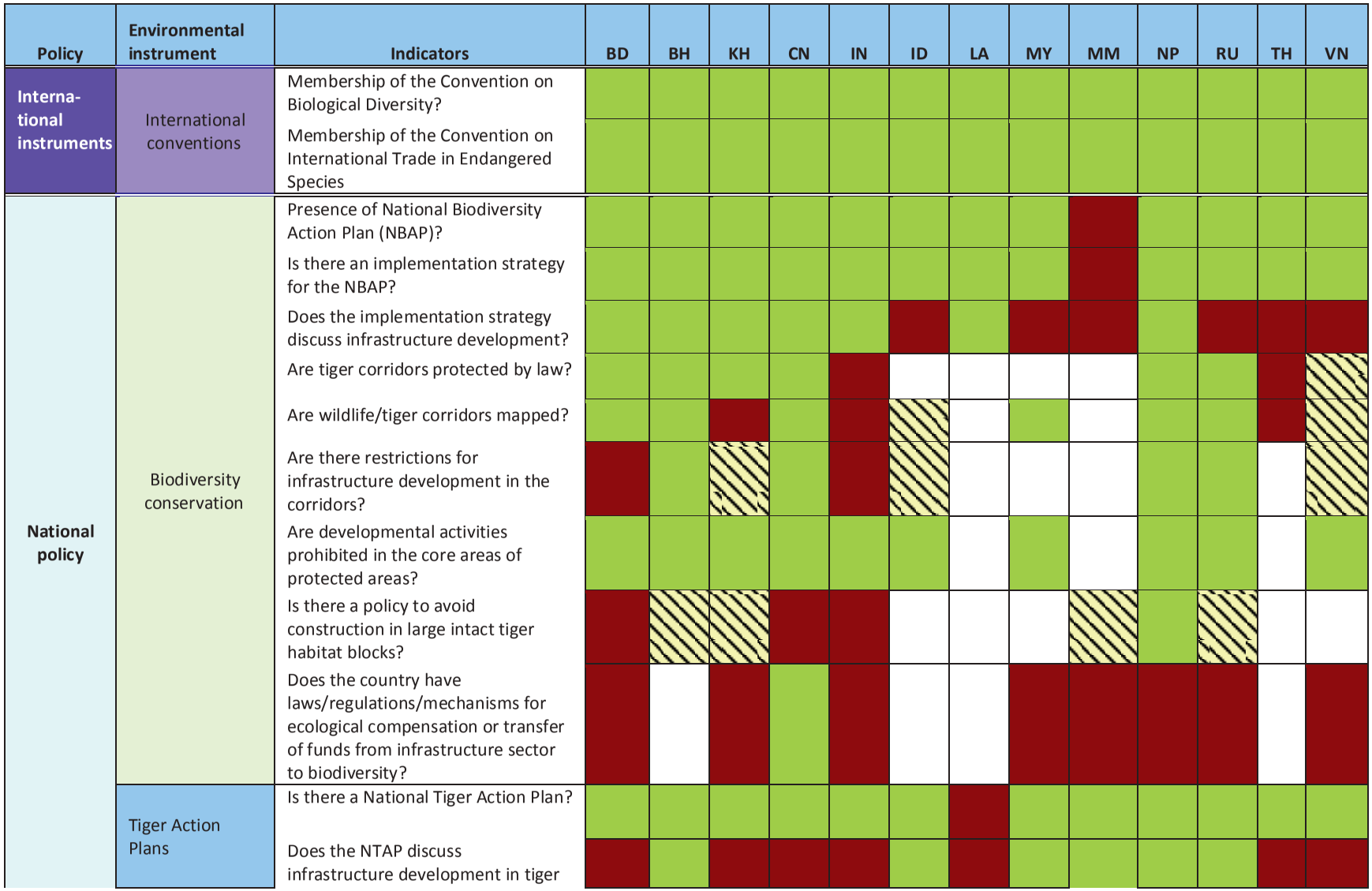
Level	*Project Life Cycle*	*Option*
Project	*Exploration, siting, and development*	Early stakeholder engagement processes (including benefit-sharing agreements and informed consent)
		Tiger/large intact habitat block avoidance (includes screening and "no go" commitments)
		Conduct baseline studies and monitoring
		Legal compliance with all regulatory requirements throughout project lifecycle (including both environmental impact assessments and strategic environmental assessments even if they are not compulsory)
		Tiger-friendly design and engineering (emphasis on open-span bridges and bridge arches for roads and tigers)
	Construction	Minimizing ancillary infrastructure development and clustering development
		Construction and worker behavior protocols (relating to workers, noise, dust, and induced development)
	Operations	Embedding tiger conservation performance objectives into environmental management systems
		Community tiger education programs
		Ongoing monitoring of tigers, tiger habitats, and crossing structure use (by various species)
		Ongoing reporting and disclosure of information to stakeholders
		Tiger patrols and poaching/hunting restrictions on workers
	Closure and remediation	Post-project reporting and communication of lessons learned

Global Tiger Initiative



APPENDIXES — CASE STUDIES

APPENDIX A: ASSESSMENT MATRIX OF TIGER FRIENDLY POLICIES AND PRACTICES IN TIGER RANGE COUNTRIES



Policy	Environmental instrument	Indicators	BD	BH	KH	CN	IN	ID	LA	MY	MM	NP	RU	TH	VN
		habitats													
		Does the NTAP explicitly lay out actions/guidelines for construction in tiger habitat?													
	Policy implementing institutions	Is there a separate national body/agency dedicated to tiger conservation?													
		Is there a Ministry of Environment/Government body responsible for environmental protection?													
		Does the Environment Ministry have other responsibilities such as development or energy?													
	Land use planning	Is there a national land use plan or zoning plan?													
		Is there a regional land use plan?													
		Is the development occurring in the tiger landscapes compatible with the regional/district land use plans?													
	Environmental assessment tools	Is there strategic environmental assessment (SEA) regulation?													
		Is there an environmental impact assessment legislation?													
Sectoral level implementation	Biodiversity inclusive strategic environmental	Are there SEA guidelines?													
		Is compensation for biodiversity loss required in SEA guidelines?													

APPENDIX A (CONTINUED)

Policy	Environmental instrument	Indicators	BD	BH	KH	CN	IN	ID	LA	MY	MM	NP	RU	TH	VN
	Assessment	Is biodiversity survey/analysis required for sensitive areas in SEA guidelines?													
		Do SEA guidelines include addressing cumulative impacts?													
		Do SEA guidelines include addressing fragmentation impacts?													
		Has SEA been carried out in a tiger landscape?													
Project level implemen-tation	EIA policy	Is the EIA procedure clearly laid out in the EIA regulation													
		Are there EIA guidelines?													
		Do EIA guidelines include addressing fragmentation impacts?													
		Do state authorities have the authority to approve EIAs?													
		Is public participation/stakeholder involvement mandatory in the EIA process?													
		Is project monitoring and post project monitoring mandatory?													
		Are special permits/clearance required for projects in wildlife/tiger habitat													
		Are penalties imposed for violating the provisions of the EIA regulations?													
		Does public participation occur throughout the EIA process?													
		Is compensation for biodiversity loss required in EIA guidelines?													

Policy	Environmental instrument	Indicators	BD	BH	KH	CN	IN	ID	LA	MY	MM	NP	RU	TH	VN
		Are biodiversity surveys/analysis required for sensitive areas in EIA guidelines?													
	Management instruments	Have funds transferred from a project been used as a tool to compensate environmental impacts in tiger habitat such as anti-patrolling and tiger protection?													
		Are there restrictions on ancillary infrastructure development in tiger habitat													
		Are environmental management plans prepared?													
		Is there any regulation which requires biodiversity awareness training for construction workers?													
		Are signs and warnings for local fauna required for infrastructure projects?													
Potentially applicable case studies in the short term			K, L, E,	I, L, E	I, A, M	B, I, K, C	B, G, I, K, C, P	H, I, E	G, H, I, L,P	B, H, C, E	G, K, L, P	B, I	F, E	G, I, L, K, P	B, G, H, K, L, A, M

	Policy is in place and favorable
	Policy is in place but has implementation issues
	Policy is not in place
	Data Pending

BD = Bangladesh; BH = Bhutan; KH = Cambodia; CN = China; IN = India; LA = Laos; MY = Myanmar; MM = Malaysia; NP = Nepal; RU = Russia; TH = Thailand; VN = Vietnam

APPENDIX A (CONTINUED)

Index for the Case Studies

A. Amoyá River Hydroelectric Project, Colombia
B. Banff National Park Wildlife Highway Crossings Project, Canada
C. Environmental Compensation Law, Brazil
D. Cerrejón Mine, Colombia
E. Payment for Environmental Services, Costa Rica
F. Gasbol Pipeline, Bolivia and Brazil
G. Mining Association of Canada and the proposed Tuktusiuqvialuk National Park, Canada
H. Economic Cost-Benefit Tools and Madidi National Park, Bolivia
I. Noel Kempff Climate Action Project and Reducing Emissions from Deforestation and Forest Degradation (REDD), Bolivia
J. North-South Economic Corridor SEA, Mekong region
K. Orca Aggregate Quarry, Canada
L. Oro Verde: Responsible Artisinal Gold & Platinum Mining, Colombia
M. Santa Anna Hydroelectric Project, Colombia
N. TransMilenio: Bogota's Rapid Transit System, Colombia
O. Hydro power SEA, Vietnam
P. Corridors and Fragmentation: Ensuring conservation and connectivity for tigers

The responses depicted in this matrix are a result of extensive surveys and interviews conducted with experts and government officials.

* Environmental clearance refers to an additional no-objection certificate required from a relevant authority clearing the project.

** The rating of the environmental impact assessment systems is based on a comparison among the 13 tiger range countries and has not been compared to environmental impact assessments systems in other parts of the world.

Adapted from World Bank. (2006). Environmental impact assessment regulations and strategic environmental assessment requirements: practices and lessons learned in East and Southeast Asia.

APPENDIX B: SUMMARY OF SECTORAL CASE STUDIES — BEST PRACTICES AND OFFSETS

These cases provide an extensive set of lessons for the tiger range countries looking to emulate the success of such projects. In the table below is a summary of some of the lessons learned and significance that are drawn from throughout the case studies, all of which represent opportunities for the tiger range countries.

Case study	*Sector*	*Lesson(s) learned*	*Significance for tiger range countries*
Amoyá River Hydroelectric Project	Hydroelectric power	Demonstrates the potential for synergies between carbon finance (Clean Development Mechanism, CDM) and GEF–funded activities on adaptation. Some of these revenues could be invested in actions that would contribute to maintain a sustainable water cycle, currently threatened by global climate change and other anthropogenic impacts.	Carbon financing resources could be used as a tool to foster some of the goals of the GTI in the context of the local social and environmental circumstances where each project is to take place, contributing to the objectives of protecting core tiger habitats and populations.
Banff National Park Wildlife Highway Crossings	Transportation	Mitigation measures for large mammals can be highly effective in reducing mortality; open-span bridges/ extensions hold promise for tigers; extensive monitoring is critical.	Proposed highway projects can amend design elements to incorporate experimental tiger/wildlife crossing structures and monitoring.
Brazilian Environmental Compensation	All Sectors	Large amounts of financial resources can be harnessed from infrastructure projects. Implementation capacity is fundamental to guarantee the success of any major compensation scheme.	Funding for anti-poaching and habitat conservation/ restoration can be funded via infrastructure compensation.
Cerrejón Mine	Mining	Significant and early investment in environmental action programs is critical (for example, environmental impact assessments, air/water quality control systems, programs for land acquisition and rehabilitation, native flora/fauna management, monitoring and control programs, etc.). Participatory decision making processes with stakeholders at an early stage are also very important in the long term.	Since mining has the potential to both directly and indirectly affect tigers and their habitats throughout the life cycle of a project, following best environmental practices, as well as ensuring local communities and key actors are included in the site selection, design, and methodologies is fundamental. Mining operations near tiger conservation landscapes have the ability to contribute to the conservation of critical core habitats and tiger awareness programs.

APPENDIX B (CONTINUED)

Case study	*Sector*	*Lesson(s) learned*	*Significance for tiger range countries*
Costa Rican Payment for Environmental Services (PES)	All Sectors	Costa Rica's payment for environmental services scheme took a long time to establish (more than two decades), but this was in part due to its pioneering aspects. Success has been heavily dependent on legislation (forestry laws), measuring and monitoring of the environmental services for the target market, adequate payment levels (with low transaction fees), and financial mechanisms to secure long term income streams. Significant numbers of environmental service providers and consumers are beneficial in a payment for environmental services scheme along with a strong governance structure for the funds.	The flexibility of payment for environmental services schemes could benefit tiger range countries if projects are customized and designed to secure core tiger habitat by providing financial resources to land owners and local communities in the long term. Initial efforts in Vietnam, China, and other tiger range countries can be built upon for specific tiger results.
Gasbol Pipeline	Oil & gas	Careful and considered design around the location of the pipeline is a primary concern; large infrastructure projects can drive both in situ and ex situ conservation; early and continual stakeholder involvement is key; environmental impact assessments underpinned the work.	Carefully planning infrastructure developments to avoid tiger conservation landscapes while also engaging local communities will be key for tiger conservation. Furthermore, the infrastructure can help drive tiger conservation through fund generation and insights from environmental impact assessments.
Mining Association of Canada and Tuktusiuqvialuk proposed National Park	Mining	Voluntary avoidance by sectoral representatives can be successful to optimize both resource extraction and habitat/species conservation.	Opening dialogues among environment ministries, NGOs, and sectoral representatives can result in improved land use planning.
Madidi National Park and economic cost-benefit tools	Transportation, oil and gas	Traditional finance/economic cost-benefit tools can provide great insight into the ongoing costs of infrastructure projects that may have significant biodiversity impacts. When opportunity costs are explored (let alone forgone environmental service costs), the economic valuation of a project may not appear as lucrative as originally perceived.	Proposed infrastructure projects should evaluate initial and ongoing project costs, as well as lost revenue from ecosystem services when determining project approvals. These tools can be brought to bear in advance of conducting full EIA/SEA analyses.
Noel Kempff National Park & REDD	Transportation (various)	REDD schemes, when conducted properly and with the right pre-conditions, can provide significant funding for habitat conservation.	Tiger range countries should look at win-win opportunities where high-biodiversity/priority tiger conservation landscapes overlap with carbon sequestration potential.
North South Economic Corridor SEA	Transportation	Strategic environmental assessment can provide a communicative and elaborative platform to maximize the potential of spatial planning tools to identify a "no-go" map with sensitive areas flagged for infrastructure development.	Strategic environmental assessment can be adopted by tiger range countries to facilitate the planning process to avoid infrastructure impacts in tiger conservation landscapes with stake holders extensively involved.

Case study	*Sector*	*Lesson(s) learned*	*Significance for tiger range countries*
Orca quarry	Mining	Strong community engagement complemented with voluntary measures (such as ISO 14001 EMS) that surpass regulatory compliance can create highly successful projects (financially, socially and environmentally).	Encouraging projects to go above and beyond regulatory compliance through community engagement and strong minimization/mitigation aspects with continual improvement.
Oro Verde Artisinal Mine	Mining	Artisanal mining can be an effective means of local economic development whilst minimizing biodiversity impacts.	Tiger range countries can explore means of engaging in low-impact responsible artisanal mining where appropriate deposits exist as a means of retaining additional wealth and promoting community economic development.
Santana Run-of-River Hydroelectric Project	Hydroelectric power	Small-scale CDM hydroelectric projects can replace dirty energy sources with clean energy; thereby lower the threat of climate change and generate funds through Certified Emissions Reduction credits (CERs). Such small-scale projects have minimal habitat disturbance but must be underpinned with comprehensive and successful stakeholder consultation processes.	Tiger range countries can adopt small scale CDM run-of-river CDM hydroelectric power projects generating income from CERs which in turn could be use to conserve tiger habitats and natural corridors associated with protected areas and tiger conservation landscapes.
Bogota's Rapid Transit System: TransMilenio	Transportation	TransMilenio last year became the only large transportation project approved by the United Nations to generate and sell carbon credits. Developed countries that exceed their emissions limits under the Kyoto Protocol, can buy credits from TransMilenio to balance their emissions budgets, bringing Bogotá an estimated US$100 million to US$300 million.	Energy and cost-effective Massive Transports Systems such as TransMilenio could be adopted by tiger range countries in order to generate CERs and long term funding which in turn could be used to support tiger awareness and conservation programs.
Viet Nam SEA	Hydroelectric power	Strategic environmental assessment can be flexibly integrated with the sectoral planning at policy, plan and program levels and provides a continuous view of addressing biodiversity issues in the decision formulation.	Tiger range countries can adopt strategic environmental assessment as a potentially effective tool to safeguard sectoral development initiatives with biodiversity, and especially tiger conservation issues, incorporated.
Corridors and fragmentation: Ensuring conservation and connectivity for tigers	All sectors	Mapping corridors of large cats is useful as a preliminary step in conservation. Effective mesh size—which measures the degree of landscape fragmentation—is a useful indicator to evaluate fragmentation and connectivity.	Conducting analyses to evaluate connectivity between tiger landscapes is critical to ensure viable populations. Furthermore, such analyses can inform land-use planning and ensure infrastructure avoids critical habitat (or minimizes its impacts). It can also be used to identify areas where compensation funds can be used to restore connectivity for tigers.

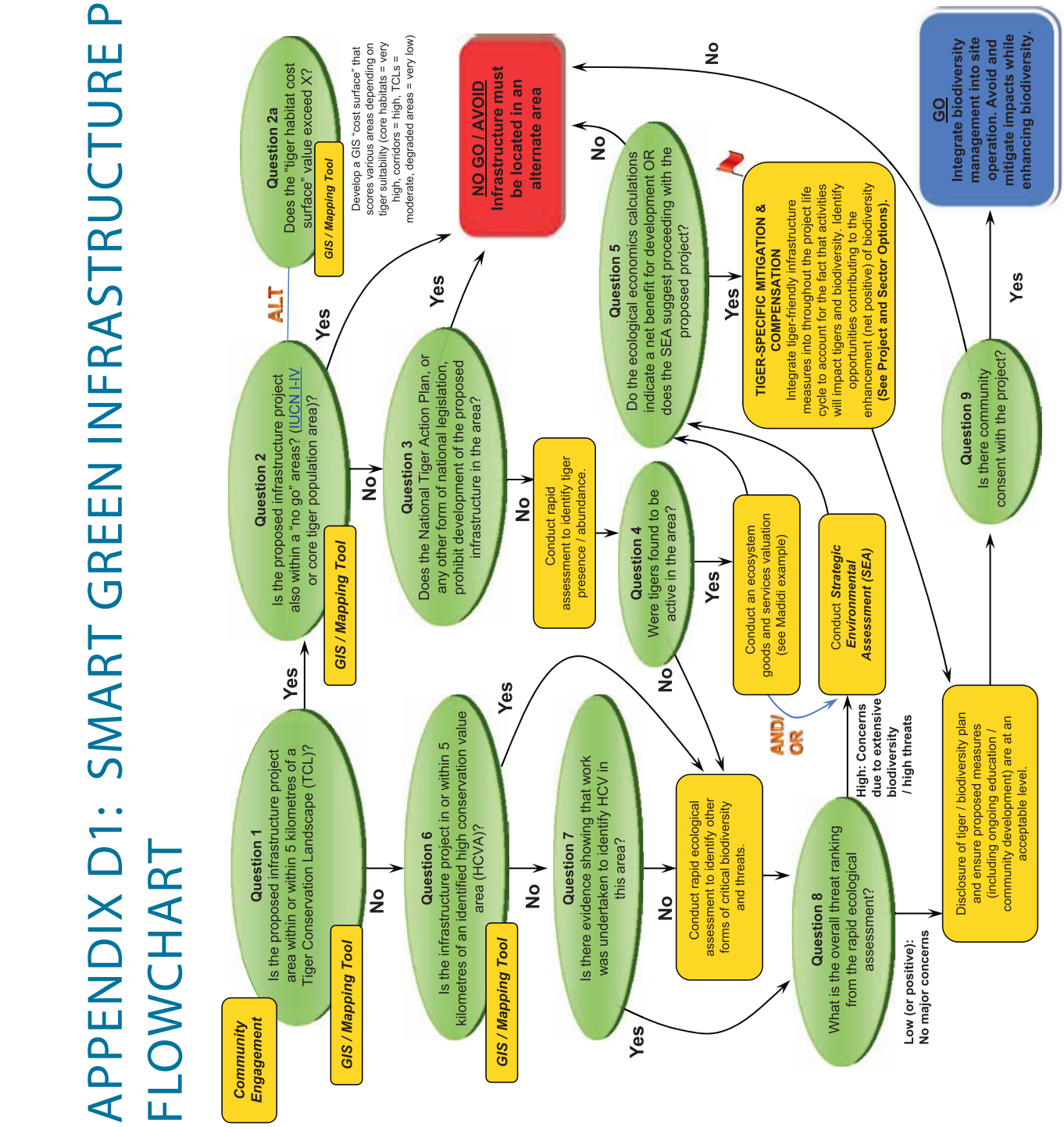
These case studies have numerous implications for the tiger range countries; the lessons can be applied directly to help to create tiger-friendly, smart infrastructure in a range of sectors.

APPENDIX C: A DESCRIPTION OF SMART GREEN INFRASTRUCTURE (SGI) OPTIONS

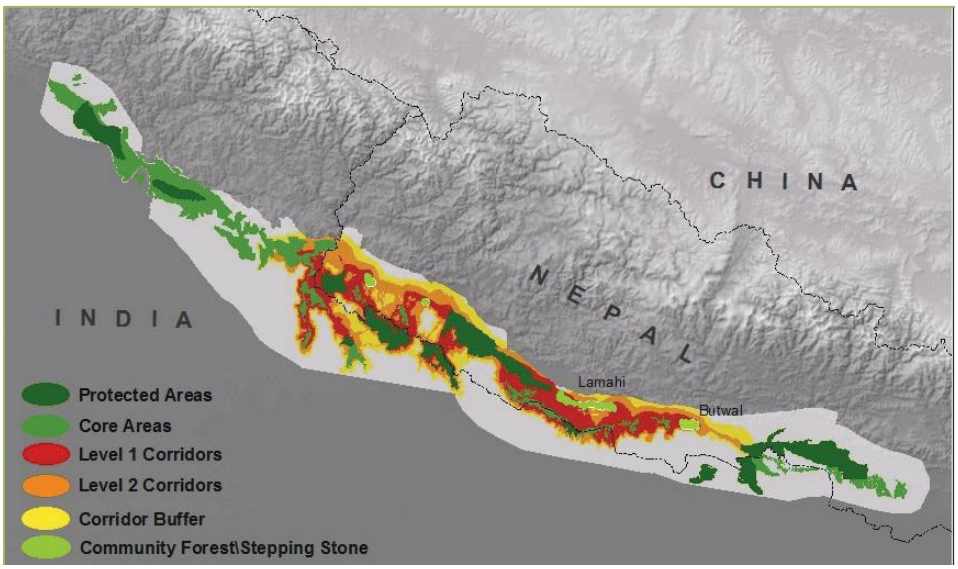
Regulatory Policies and Enforcement	***Description***
Designing Protected Area Networks (new protected areas/strengthening existing protected areas)	Protected area networks that incorporate tiger conservation landscapes are a cornerstone to an effective national tiger plan. Effective and adequately funded enforcement is required to ensure tiger poaching does not destroy tiger populations. There are habitat types that are currently underrepresented in terms of tiger conservation. The majority of protected areas within tiger conservation landscapes are located in montane and pre-montane habitats despite studies in Russia and Sumatra that observe and predict higher numbers of tigers in lower altitudes areas. Accordingly, protecting low-altitude tiger conservation landscapes should be considered a priority. Furthermore, research from Linkie et al. indicates that lowland areas in Sumatra are experiencing the greatest human pressure from oil palm cultivation, commercial and illegal logging, mining, and agriculture. Research also indicates that riparian habitat zones should also be protected, even in degraded habitat areas, to maintain movement corridors and retain tiger habitat.
Land-Use Restrictions	Placing restrictions on land uses in and around infrastructure can be helpful for land-use planning. It is important to ensure that tiger conservation landscapes remain in land uses that are compatible with tigers and their prey. These legal restrictions are well served when complemented by incentive systems such as land easements.
Tiger-friendly Permits	Typically any form of major infrastructure requires a permit for construction. Governments have an opportunity, through such applications, to help ensure infrastructure is tiger-friendly. Appendix C provides an example of a decision-tree filter that could be used to assess infrastructure development proposals. This sort of permitting restriction also works well in conjunction with other regulatory and fiscal policies.
Funding Regulatory Policies	While regulatory policies can be very powerful, it is also very important to ensure that both new and existing legislation has the funding necessary to ensure effective implementation and enforcement. This includes areas such as land-use planning and, in particular protected areas and anti-poaching enforcement.
Infrastructure Location Regulations	Research on the impacts of infrastructure on wild tiger populations supports the concept that infrastructure would better support tiger conservation if it occurred in areas outside of tiger conservation landscapes. In essence, deciding where to locate infrastructure will determine the vast majority of the impact to tigers. Since often this decision is one of the least expensive to change, and since it has the greatest impact, it should be the primary focus of government regulatory policies for tiger conservation landscapes so business and industry minimize their impacts upon tigers and their habitat. Once this decision has been made, the remaining decisions in terms of ecological engineering (highlighted in the next section) are of greater financial cost and of lesser value to tigers.
Environmental and Social Impact Assessments	
Tiger-friendly strategic environmental assessments and environmental impact assessments	Environmental impact assessments, as well as strategic environmental assessments have been shown to be a major factor in well planned infrastructure projects when it comes to biodiversity. Traditional environmental impact assessments do not always cover the induced and cumulative impacts of infrastructure projects (to which tigers are particularly sensitive) and thus strategic environmental assessments can play a key role in informing the range of factors to consider in advance of construction. Mandating strategic environmental assessments that evaluate tiger impacts specifically within tiger conservation landscapes would form a strong basis for smart green infrastructure development.

Environmental Management Systems	An environmental management system (EMS), such as ISO 14001, is designed to manage environmental concerns. Within this context, biodiversity, and specifically tigers, can be included when there is overlap with a tiger conservation landscape. Including tigers within the EMS framework ensures continual improvement of infrastructure management with respect to tigers. One particular element that should surface within the context of an EMS relates to human-tiger conflict. Therefore in areas where humans and tigers are likely to interact in proximity to infrastructure, strategies to mitigate conflict are important to consider.
Incentive Programs	
Leveraging tiger/biodiversity funds from infrastructure project	Siphoning off 1-3 percent of the total funds allocated for development and using these funds to fund tiger and biodiversity conservation efforts in the area of the project has been found to be an effective approach in other countries (see case studies). Such an approach can provide needed capital and operating funds for such measures as tiger patrols that would help mitigate the impacts of increased tiger poaching due to increased human access.
Payment for Ecosystem Services (PES) schemes including carbon/watershed	A more recent approach that has been adopted in numerous countries, such as Costa Rica, is the notion of payment for ecosystem services. Typically payment for environmental services schemes require the beneficiaries of ecosystem services to pay to ensure these services continue. For example, global carbon markets pay to set aside forests within a tiger conservation landscape (which acts as both a tiger habitat and a carbon store).
Alternative Livelihoods - Eco-tourism/tiger viewing	In numerous countries, there are examples of using federal funds to spur the development of industry. The development of tiger-viewing eco-tourism programs could help to link a sustainable livelihood for local communities to tigers, and also offset some of the opportunities lost by relocating infrastructure outside of tiger conservation landscapes.
Stakeholder Engagement	
Early stakeholder engagement processes	Stakeholder buy-in to an infrastructure project is often a key determinant of success and has been identified as a best practice. Engaging local and broader stakeholders early in the design process, including building and communicating the explicit tiger conservation goals, will help to lay a foundation for long-term success. Research suggests that community support for tiger conservation has a major role to play in ensuring that tiger poaching is minimized. Once the project is completed, local communities not only reap the benefits, but also ensure the continued success of both the economic development and environmental benefit. Providing local communities with an understanding, in the right language, of tigers, habitat connectivity, mortality impacts, and habitat loss is key for all parties. With the right understanding and incentives, engineers, officials, and members of the public can often develop strong solutions. This communication may require different approaches for each stakeholder group (for example. explain the requirements to engineers in terms of impacts on cost, timelines, and safety). Discussions should include an explanation of conservation efforts, benefit sharing, agreement upon “conflict,” and understanding and clear delineation of protected areas and buffer zones.

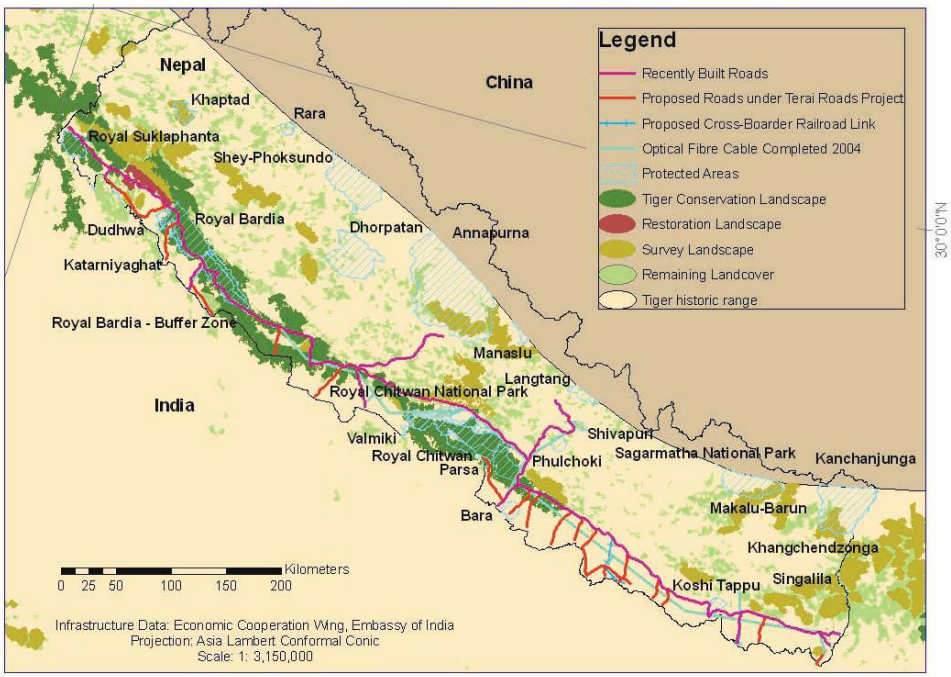
APPENDIX D1: SMART GREEN INFRASTRUCTURE PLANNING FLOWCHART



APPENDIX D2: EXAMPLE OF QUESTION 2A AND GIS SPATIAL MAPPING

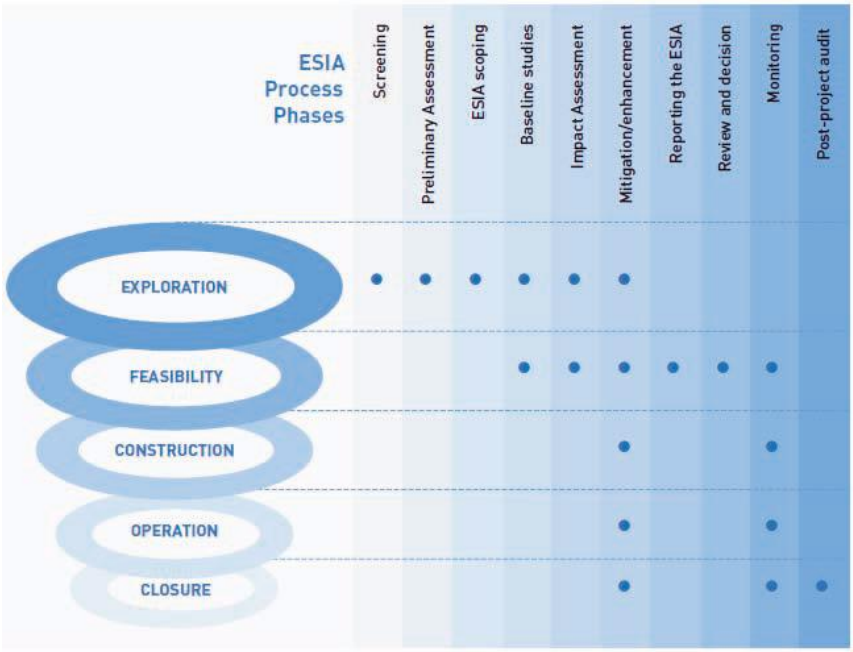


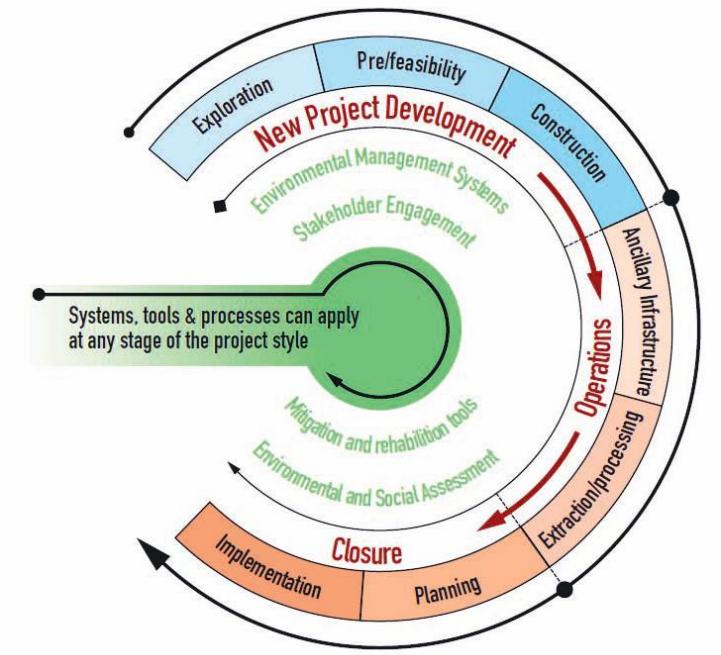
Example of a "cost surface" (red = high cost; grey = low cost). Such cost surfaces could also guide the degree and cost of mitigation and compensation.



This "cost surface" could then be mapped against proposed infrastructure to evaluate thresholds for "go" or "no go." *Source:* WWF-US.

APPENDIX E: INTEGRATING TIGER-FRIENDLY FILTERS INTO THE MINING PROJECT LIFECYCLE





Adapted from: Good Practice Guidance for Mining and Biodiversity. 2006. Published by International Council on Mining and Metals (ICMM), London, UK. Available from: ICMM, www.icmm.com, info@icmm.com

APPENDIX F: TIGER-FRIENDLY TRANSPORTATION INFRASTRUCTURE OPTIONS

- **Road Signs:** Signs indicating the presence of tigers are a cost-effective means of lowering road strikes. Signage useful for protecting tigers and their habitat, serves as a warning to the general public and public works people such as for people laying down transmission lines.
- **Round Culverts:** Culverts have been shown to be adequate for some large cat species such as cougars if they are of sufficient size (>10 feet/3 meters in height and >20 feet/6 meters in width). They may also be adequate for smaller prey species, but are considered only adequate (not ideal) for ungulates.
- **Multi-plate Arches:** Multi-plate arches are tunnels that are put in below roads, often using large metallic culverts in combination with concrete arches. These are lower cost than some other options, but have also been shown to be less effective than bridges and overpasses. Nevertheless, so long as they are at least 20 feet (6 meters) in width and 10 feet (3 meters) in height, they should prove adequate for both tigers and their prey.
- **Open-span Bridges and Bridge Extensions:** Open spans and bridge extensions are likely the best solution for tigers and road infrastructure. These solutions often take advantage of natural topography such as streams, valleys, wooded corridors and other landforms to enable tigers to pass underneath roadways. Since these bridges are often required for the road itself, they are often very cost effective as they require only moderate modification to make them tiger-friendly. Not only have these been shown to be the best solution for large cats, but are also ideal for ungulate species. *Open-span bridges and bridge extensions are the form of infrastructure recommended for mitigating road impacts to tigers.*
- **Wildlife Overpasses:** Overpasses are full bridges that enable wildlife to go over transportation infrastructure. These are the most expensive forms of mitigating infrastructure and while they will be used by large cats, and are highly effective for ungulates (especially if twinned), other forms of infrastructure are preferential for large cats (notably bridges—open span/extensions), especially given the high costs of overpasses.

APPENDIX G: RECOMMENDATIONS FOR MINING INFRASTRUCTURE AND TIGERS

Exploration:

- Complete avoidance of certain areas, such as known and protected tiger core breeding areas, via "no-go" commitments;
- Limit land clearing by using technologies and mining practices that minimize habitat disturbance;
- Avoid road building wherever possible by using helicopters or existing tracks. If roads are to be constructed, use existing corridors and build away from steep slopes or waterways;
- Use lighter and more efficient equipment to reduce impacts on biodiversity;
- Position drill holes and trenches away from sensitive areas;
- Cap or plug drill holes to prevent small mammals from becoming trapped;
- Remove and reclaim roads and tracks that are no longer needed;
- Use native vegetation to re-vegetate land cleared during exploration;
- Make details of the exploration project and potential impacts available, in culturally appropriate forms, to affected communities and area residents in an appropriate language and format, and make them accessible to the public—especially to marginal stakeholders.
- To cover the lasting environmental impacts of the exploration phase, companies should provide adequate financial guarantees to pay for prompt cleanup, reclamation, and long-term monitoring and maintenance;
- Companies should obtain the free, prior, and informed consent of indigenous peoples before exploration begins and before each subsequent phase of mining and post-mining operations;
- Companies should enter into binding contracts with communities that specify the terms under which a particular phase of a mining project may proceed. Such agreements should be mutually agreed upon and enforceable through the national court system in the country of operation or through mutually acceptable arbitration procedures.

Pre-feasibility—Environmental and Social Impact Assessments (ESIAs):

- Identify tiger conservation landscapes and tiger core habitats, whether protected or not, and the status of protected areas and tiger populations;
- Fund and conduct adequate tiger/biodiversity baseline research;
  An initial review of possible mining options (underground versus open-pit, for example), processing options and likely waste products, water demands, options for waste rock or tailings storage, etc., and consideration of the merits of each from a technical, economic, environmental (including biodiversity), and social perspective; and preliminary assessment of potential impacts, taking into consideration possible timeframes for development;
- Stakeholders should be given adequate notification, time, and financial support to pay for technical resources, and access to supporting information, so their participation in the environmental impact assessment process is effective;
- Environmental costs, including those associated with regulatory oversight, reclamation, closure, and post-closure monitoring and maintenance, should be included in the environmental impact assessment;
- Environmental assessment should include worst-case scenarios and analyses of off-site impacts. Companies should work with potentially affected communities to identify potential worst-case emergency scenarios and to develop appropriate response strategies;
- Companies should conduct adequate pre-mining and operational mine sampling and analysis for acid-producing minerals, based on accepted practices and appropriately documented, site-specific professional judgment. Sampling and analysis should be conducted in accordance with the best available practices and techniques.

Feasibility stage:

- Confirm the implications of legal provisions, protected areas and species, and any interfaces with the mining project;
- Assess results of baseline studies and evaluate the importance of tigers (from a technical perspective and based on in-depth consultations with a range of stakeholders) and a discussion of current threats to tiger conservation landscapes;
- The proposed mining project's impacts on tiger conservation landscapes and tigers (direct, indirect, and induced) and on the users of biodiversity;
- Discuss avoidance and mitigation measures (from construction through to closure), the prospects for successful implementation, and residual impacts on tiger conservation landscapes and tigers and related stakeholders;
- Discuss options for tiger conservation or habitat enhancement including payment for environmental services and biodiversity offset schemes. The mitigation measures to address potential impacts on tigers would be included in an environmental management plan (EMP).

APPENDIX G (CONTINUED)

Construction:

During this phase, thousands of temporary workers or contractors' staff, along with related infrastructure, can have significant impacts on tiger conservation landscapes. Of particular concern in ecologically sensitive areas is the likelihood of more permanent immigration following the construction period. This can result in significantly increased pressures on the natural resource base in general and on tigers in particular. One solution is to accommodate temporary workers in construction work camps, but these present their own problems for biodiversity (along with a range of associated social impacts). For example, workers may engage in hunting or make other demands on natural resources (for temporary gardens, for example, or fuel wood). To control the impacts on biodiversity during construction, some companies have adopted strict policies banning firearms or hunting, or fishing for which violators are immediately fired.

- Cluster construction and development as close as possible to existing infrastructure, in lower-quality/degraded tiger habitat;
- Continue on-going tiger/biodiversity monitoring;
- Adopt strict no-hunting/poaching policies;
- Establish anti-poaching patrols;
- Build tailings impoundments with liners if seepage would result in groundwater contamination, as well as monitor systems;
- Implement maximum noise level requirements at the project boundary.

Operation:

- Whereas the focus of efforts during new project development is almost exclusively on impact prediction and mitigation, the operational phase often provides opportunities for biodiversity protection and enhancement. Biodiversity may also be affected by maintenance activities on linear infrastructure, particularly weed and invasive species control and the transport of hazardous chemicals and waste materials. This can be minimized by implementing integrated pest management and hazard and risk assessment plans. Poaching and hunting policies are strongly recommended, along with ongoing biodiversity monitoring and, ideally, tiger patrols that would help to minimize both poaching and human-tiger conflict.
  - Release data on tiger impacts (direct and induced) as well as mine discharge data to the public;
  - Minimize mine dewatering to prevent all undesirable impacts on ground and surface waters, including seeps and springs;
  - Do not use water bodies (rivers, lakes, etc.) for tailings disposal (including shallow-water waste disposal) or mine waste;
  - Isolate and treat acid-generating materials on site;
  - Give communities the right to establish independent monitoring and oversight of the performance of the mine.

Closure implementation: Rehabilitation and pollution prevention

This commits the company to implementing good practice rehabilitation aimed at reestablishing pre-existing conservation values, but acknowledges that some impacts may be unavoidable. In the case of tiger conservation landscapes, national policies should enforce both legal requirement for restoration of the pre-mining land use, and post-mining uses with the regulatory authorities or with a broader set of stakeholders. Progress towards achieving this objective can be measured by comparing biodiversity parameters in the rehabilitated area with those in selected un-mined reference sites. Other objectives may address more specific aspects, such as the provision of habitat for tigers. Of particular importance is eliminating road access and restoring habitat connectivity. Reclamation plans with detailed cost estimates should be developed before operations begin. All disturbed areas should be re-contoured and stabilized with quantitative targets in place for both stabilization and re-vegetation. Mines should be backfilled wherever possible, assuming that groundwater contamination via acid-generating materials is not a concern. Finally, financial sureties, which guarantee funds available for reclamation, should be placed in escrow, reviewed regularly (including by the public), and be independently guaranteed. These sureties should not be released until reclamation and closure are complete and audited by an independent, third-party reviewer.

APPENDIX H: OPTIONS FOR TIGER-FRIENDLY HYDROELECTRIC POWER INFRASTRUCTURE

Planning

In this case, all of the strategic and project specific mitigation measures apply, especially:

- Reappraising the investment risks of the aggregate scale and regional distribution of hydroelectric power development and the policy options for addressing these, such as demand management, supply mix, and project scheduling and sequencing;
- Relocation of dams/infrastructure to avoid impacting important habitats, to reduce fragmentation, or to minimize increased access;
- National environmental and biodiversity protection policies, such as maintenance of minimum downstream flows and avoidance of trans-basin water transfers, to prevent introduction of exotic species and other impacts on biodiversity;
- Guidelines for impact zoning in river basin planning and hydroelectric power-project design that implement the mitigation hierarchy (avoid, minimize, and compensate). For example, low-impact site criteria for reservoirs, infrastructure, and resettlement zones that avoid, wherever possible, critical natural habitats for tigers and areas of karst* and peat swamp or concentrated development at low altitudes (particularly below 300 meters).

Construction

If construction is still at an early stage and tiger conservation landscapes have not yet been impacted, the following options could be considered:

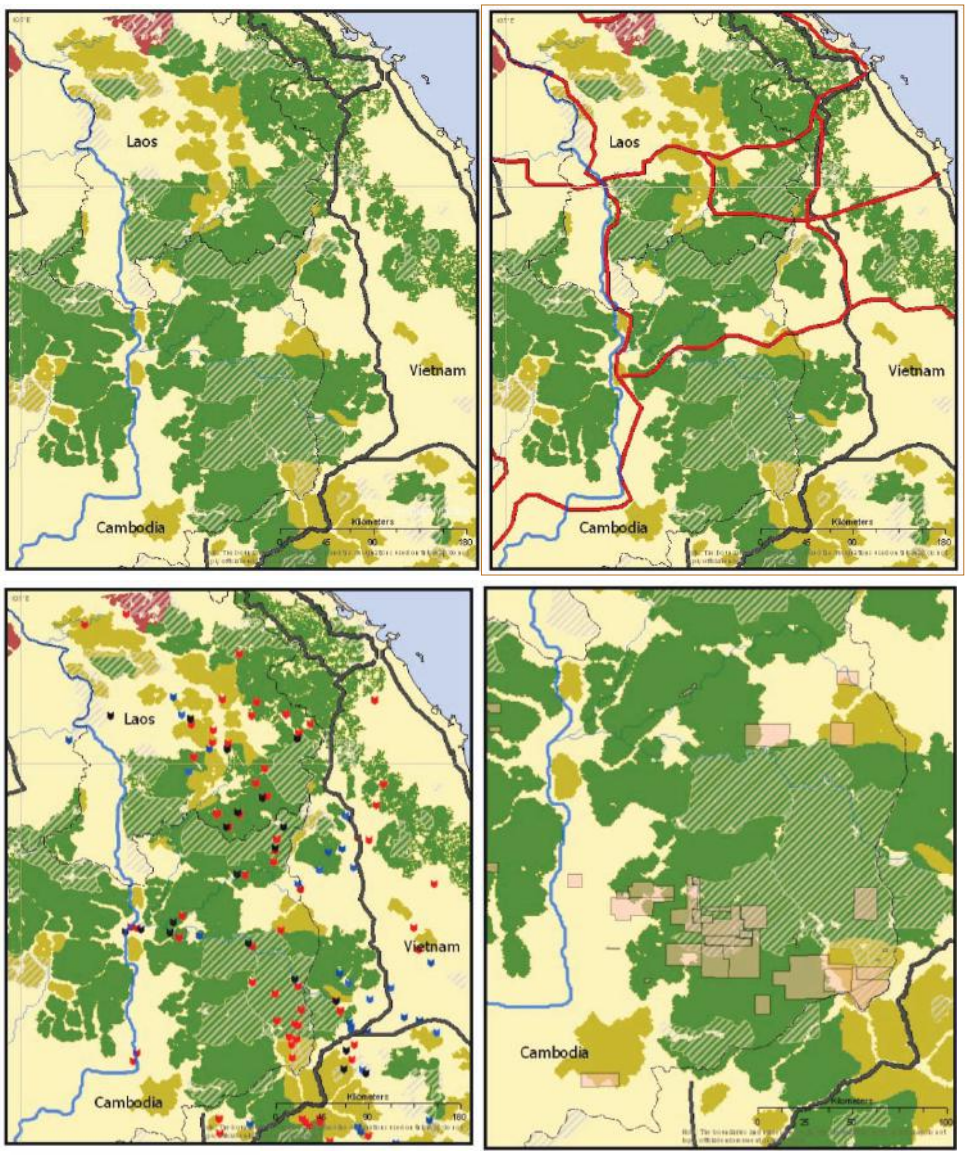
- For projects with high potential for biodiversity impacts, rescheduling or relocation of development;
- For all type of impact categories, assuming there is still time, modifications to project design and construction scheduling through measures such as a) inclusion of a regulation dam; b) operation of the main dam for continuous natural flow through construction and inundation stages; c) treatment of released water (to ensure a natural range of salinity, turbidity, temperature, oxygenation, etc); and d) various controls on access, hunting, and the like, and low-impact siting of resettlement areas and workforce camps.

Operation

In this case, direct impacts on biodiversity have occurred already and indirect impacts have begun. However, options to compensate for direct impacts or mitigate indirect impacts include: a) reducing, realigning, or rehabilitating the aggregate footprint of project infrastructure; b) identifying tiger-friendly offsets and compensatory opportunities for areas of high biodiversity value; c) supporting resettled people to achieve sustainable livelihoods; and d) development schemes for communities that are dependent on altered or affected resources.

* *Note:* Karst is an area of limestone terrain characterized by sinks, ravines and underground streams. It is usually a region of unique biodiversity.

APPENDIX I: CUMULATIVE IMPACTS FROM INFRASTRUCTURE IN PRIORITY TIGER CONSERVATION LANDSCAPES (LAO PDR-VIETNAM-CAMBODIA)



Southeast Asia has extensive infrastructure planned for the coming years. As can be seen in this example, the planned infrastructure fragments existing tiger conservation landscapes. Furthermore, where hydroelectric and mining projects are developed, additional ancillary road infrastructure will further compound habitat degradation and increase access to remote areas for poaching of tigers and hunting of prey. Below is a set of exemplary actions that could be taken at various levels to address the infrastructure seen in this example.

AVOIDANCE: National policy to prevent infrastructure in core tiger population habitats as well as IUCN I-IV protected areas that occur within tiger conservation landscapes; laws related to mandatory strategic environmental assessments and payment for environmental services transfer schemes.

MINIMIZATION: Strategic environmental assessment that identifies means to reduce cumulative impacts; land zoning around infrastructure to prevent settlement and land clearance; hunting/poaching HR policies for construction workers; bridge extensions in tiger corridors.

RESTORATION: Re-planting native vegetation along roads, ancillary road removal.

COMPENSATION: Transfer mechanism to provide funds for national parks and anti-poaching patrols

By combining strong national policy that re-directs incentives, systemic sectoral planning, and designing tiger-friendly infrastructure at the project level, wild tigers do stand a chance.

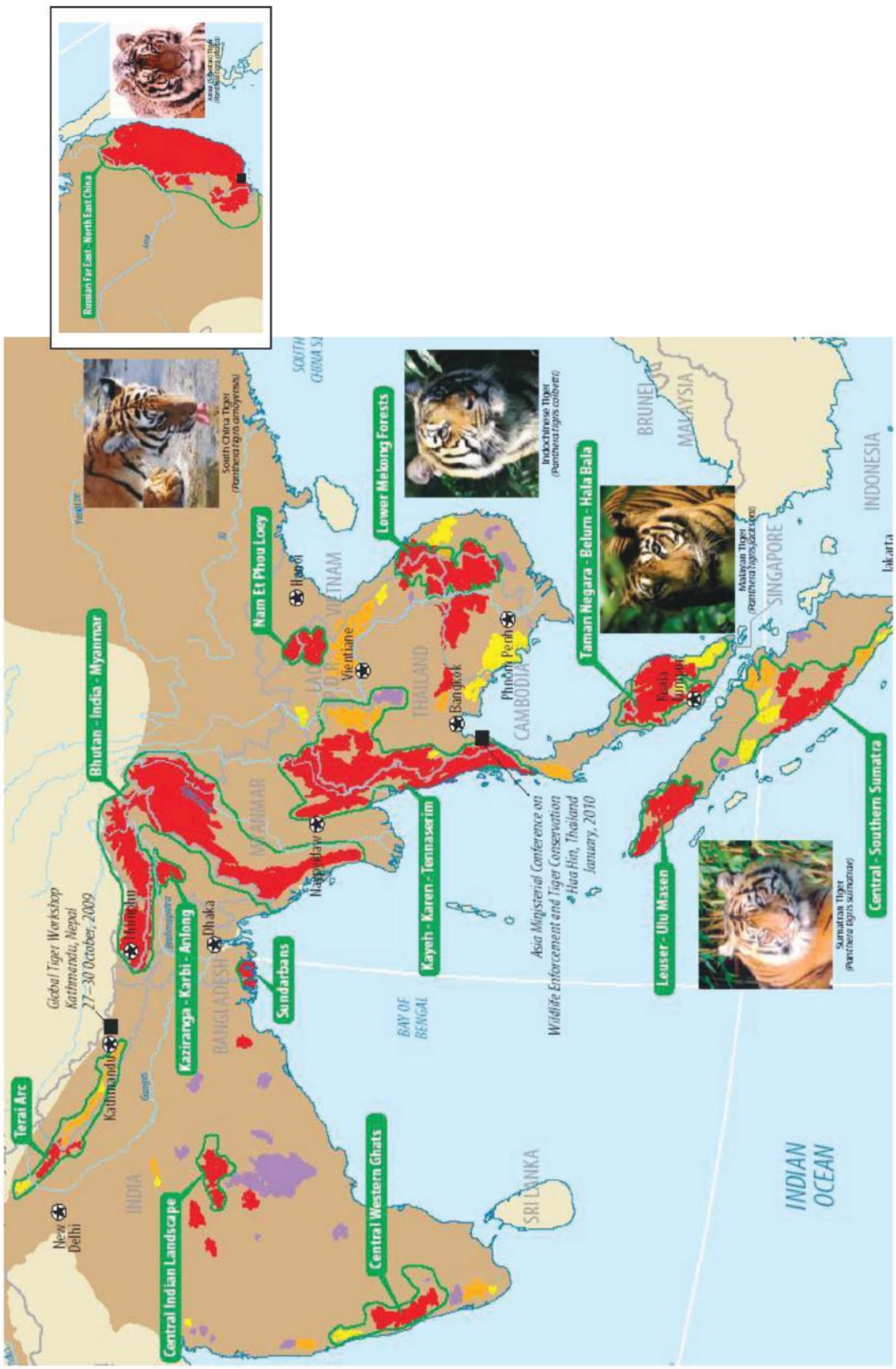
APPENDIX J: TIGER CONSERVATION LANDSCAPE GLOBAL PRIORITY AREAS (NO-GO AREAS)

Priority areas listed below appear in the map on page 59.

India
Central Western Ghats
Central Indian Landscape
Kaziranga-Karbi-Anlong
Sundarbans
Nepal
Terai Arc
Bhutan- India-Myanmar
Bhutan- India-Myanmar TCLs
Thailand
Kayeh-Karen-Tennaserim
Lao PDR - Vietnam
Nam Et Phou Loey
Cambodia
Lower Mekong Forest
Malaysia
Taman Negara –Belum-Hala Bala
Indonesia
Leuser – Ulu Masen
Central- Southern Sumatra
Russia- China
Russian Far East- North East China

Sources: WWF, WCS, Save the Tiger Fund, and Smithsonian's National Zoological Park. TCLs, Tiger Historic Range, and Remaining Habitat: Sanderson et al. 2006, Dinerstein et al. 2007

APPENDIX J (CONTINUED)



Map source: WWF-US

APPENDIX K: CASE STUDIES INVOLVING LAND-USE PLANNING AND MITIGATION HIERARCHY AND POLICY OPTIONS

Madidi Nationa Park and Integrated Management Area — Bolivia		
Project Description	***Land-use Planning and Conservation Challenges***	***Mitigation Hierarchy and Policy Options***
Apolo-Ixiamas road in Northwest Bolivia. This road would bisect the Madidi National Park and Natural Integrated Management Area, opening vast inaccessible tropical forest areas to illegal colonization and resource extraction. Madidi is widely recognized as one of the most important protected areas in the world.	**Cost-benefit Analysis:** Construction of the Apolo-Ixiamas road would result in a net loss to Bolivian society of US$16.31 million, before considering environmental costs associated with deforestation. The very high cost of building a road in the rough terrain of the Madidi protected area simply cannot be recovered due to the extremely low local demand for transport. Adding in the cost of carbon emissions from an estimated 30,000 hectares of deforestation induced by the road brings losses to a total of US$61.71 million. This project passes neither efficiency nor equity tests. It has a negative net present value (NPV) and transfers wealth to a very small group, consisting of a mix of poor rural people, logging company owners, land speculators, design and environmental impact assessment consultants, and construction firms.	The larger goal of this project is to facilitate transportation between the highlands (altiplano) and lowlands of La Paz. For travel anywhere but Apolo and its nearest neighbors, the existing route is the lower-cost option for travelers of all kinds. The sensible investment alternative would therefore be to upgrade the existing route. The cost-benefit analysis showed that increasing maintenance from once every four months to once every two months would yield net benefits of US$3.56 million.

KAZIRANGA NATIONAL PARK – Assam, India		
Kaziranga is one of the oldest protected areas in the world. It was decreed a forest reserve in 1905. The park harbors a variety of endangered species including rhino, elephant, tiger, wild buffalo, and swamp deer. The park currently covers 430 square kilometers although there are proposals to add an area of 454.50 square kilometers by including the Brahmaputra River to the north and part of the Miker Hills to the south. The park was designated a natural World Heritage site in 1985 on the basis of its *outstanding universal value.* The 54-kilometer length of the National Highway (NH) 37 along the southern boundary of the park has become a serious conservation issue due to the direct and cumulative impacts on the local wildlife. Plans are underway to convert the existing NH-37 to a six-lane expressway.	The main challenges come from outside, particularly regional pressures at a landscape scale as a result of both the Assam government's development priorities and more diffuse pressures caused by rising population and higher economic expectations. Future success will depend on the Government of Assam's commitment to adopting a landscape approach to conservation. The National Highway (NH) 37 running parallel to Kaziranga National Park, between Bokakhat to Ghorakati ranges, divides the landscape between the low-lying grasslands in the north and the elevated Karbi Anglong hills in the south. During the rainy season when flooding in Kaziranga National Park forces the wild animals to move south to elevated ground, many wild animals are killed by vehicles while attempting to cross NH-37.	There is an urgent need to conduct a comprehensive environmental impact assessment study and develop appropriate mitigation options. Options may include avoidance by re-aligning the expressway through Nagaon-Silghat-Tezpur-Lakhimpur-Jorhat to protect the ecological integrity of this World Heritage Site. The Kaziranga-Meghalaya region is one of the priority tiger conservation habitats in India. The application of a landscape approach for Kaziranga will require evaluation of current and future pressures (including strategic impact assessment), development of different scenarios, agreement on the optimal way forward and a series of strategic interventions, carefully monitored so that adaptive management can be applied as necessary.
The Guiguang Railway Project in China		
The Guiguang Railway line crosses eight nature reserves of various levels in the project corridor. The railway to be constructed will cross Shoucheng Natural Reserve mainly by tunnels.	The final design of the Guiguang Railway in China avoided seven out of eight reserves by at least 300 meters but has to cross the Shoucheng Nature Reserve (provincial level) through a tunnel-bridge-tunnel scheme. This crossing has received special attention during project design. The railway to be constructed will cross Shoucheng Natural Reserve mainly by tunnels (15.264 kilometers) and only a 1036 meter long railway line will be exposed between the exit of the Tiaopingshan Tunnel and the entrance to the Jiangjiashan Tunnel, joined by four bridges (668.4 meters long total), with the height from the rail foot in the bridges to the tunnel bottom of more than 8.5 meters with a maximum. of 23 meters, to ensure free passages of animals. No irreversible impacts will be generated on habitats over the tunnels, and the proposed railway line will not fragment habitats in the reserve.	An innovative three-fold approach to minimize environmental and social impacts in sensitive areas has been developed in the Guiguang Railway: (1) Avoidance: Alternative analysis has been regarded as one of the most important mitigation measures to minimize potential adverse environmental and social impact. (2) Sound Engineering: The project has been designed with state-of-the art engineering. Using tunnel-bridge-tunnel schemes avoids most sensitive issues. In some projects, close to 76 percent of the line comprise tunnels and bridges as shown below for the Guiguang railway line, currently under construction in southern China, in which over 75 percent of this 100-kilometer railway line is composed of tunnels and bridges. (3) Comprehensive Mitigation Plans: detailed environmental design plans (green corridors and landscaping), environmental management plans, resettlement action plans, and ethnic minority plans have been prepared in order to minimize unavoidable impacts from the project.

APPENDIX K (CONTINUED)

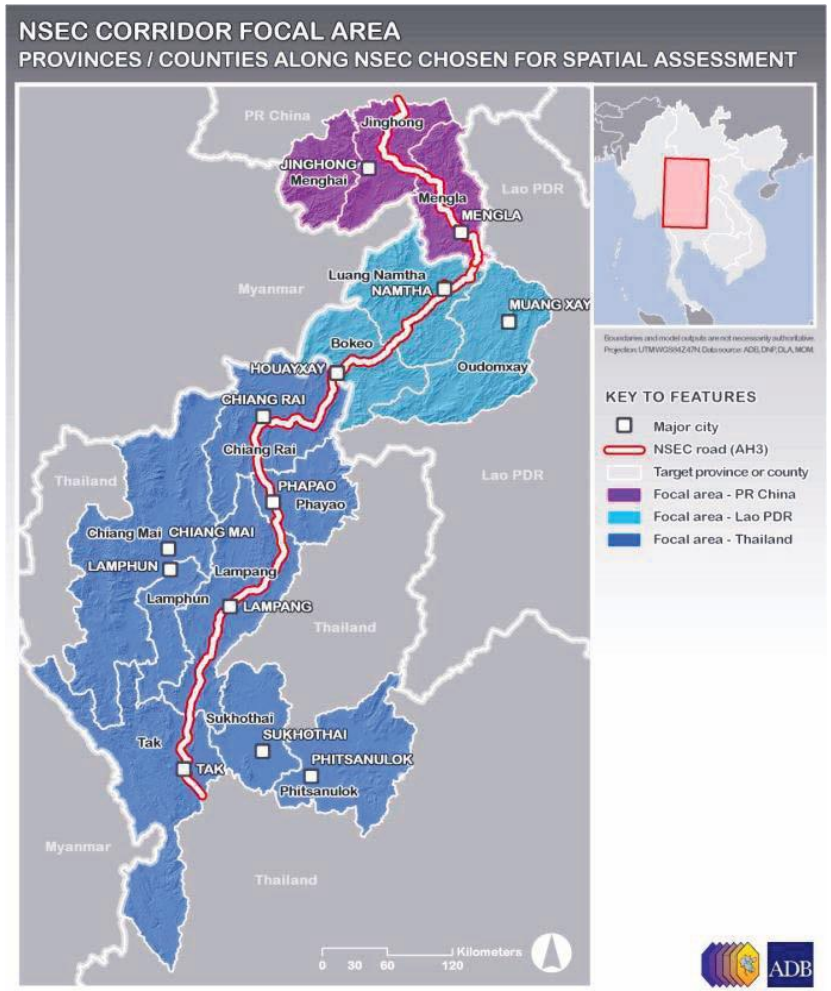
Trung Son Hydroelectric Project in Vietnam		
Trung Song Hydroelectric Power Project is located in the middle part of the Ma River. The tail of the reservoir is 9.5 kilometers from the Lao border. The dam site is located in Trung Son village, Quang Hoa district, Thanh Hoa province, North Central Vietnam, about 195 kilometers northwest of Thanh Hoa city. The project is about 0.7 kilometers downstream of the Ma River's confluence with Quang Brook.	The Trung Son Hydroelectric Power Project (TSHPP) is multi-purpose and includes (a) electricity generation, with an installed capacity of 260 MW that generates a total annual of 1.06 GWh which will be devoted to supply energy to the national grid; (b) flood control for the downstream stretch, by using 112 million m3 of the reservoir; (c) water supplementation during the dry season; and (d) an alternative energy resource for global greenhouse gases (GHG) emission reductions. Although the direct impacts on natural terrestrial ecosystems due to reservoir inundation are expected to be minor (no area of the nearby reserves will be flooded), the additional pressures on natural resources in the area of the dam are expected to be significant.	Overall this analysis should address the following issues: Analysis of effects on terrestrial animal and plant species. Pressures will stem from: (a) the opening of good-quality roads into remote areas; (b) the presence of a considerable work force (3,000 to 4,000) in and near protected areas; in-migration due to increased economic opportunities from the project activities; and, (c) the resettlement of local communities to different areas near the protected areas. As a result of these pressures, the natural reserves could see a progressive deterioration of vegetation cover (bamboo and natural forests) from increased slash-and-burn agriculture, and illegal hunting of wild animals for food served in restaurants and camps and for commercial uses. Design of a plan to strengthen the protection of the natural reserves. This plan should be based on the existing management plan and the capabilities in the Reserve Management Authorities.

The North South Economic Transport Corridor (NSEC) in the Greater Mekong Sub-region (GMS)		
The GMS NSEC is one of three priority corridors targeted for infrastructure development under the GMS Economic Cooperation Program (see NSEC map A in appendix L).	The NSEC will link important economic hubs: (a) the Kunming-Chiang Rai-Bangkok route via Lao PDR and Myanmar; and (b) the Kunming-Hanoi-Haiphong route through Yunnan province and entering Vietnam at Lao Cai; and more recently through a second route in the Guangxi Zhuang autonomous region that passes through the capital of that region, Nanning, and enters Vietnam through Lang Son. A number of major infrastructure investments in the NSEC are already being undertaken by GMS countries and more are planned. The cumulative impacts of the improved connectivity and trade along the corridor, and the sensitivity of the areas along the corridor, highlighted the need for wide-scale planning and environmental assessment to evaluate indirect/induced impacts on corridor natural assets and ecosystem services as well as on poor and vulnerable populations. A strategic environmental assessment was carried out.	A Spatial Multi-Criteria Assessment (SCMA) tool was used to integrate a wide range of factors such as construction costs and value of assets to be connected; it also considered spatial layers related to environmental and social factors such as biodiversity, water resources, livelihood and health, and security—all factors that add indirect costs if the targeted investment is not harmonised with them. The strategic environmental assessment used a set of spatial tools ranging from basic spatial overlays to complex thematic and predictive modelling, which provided inputs to a specific stage of the strategic environmental assessment process. The spatial work was split into three distinct components: a) baseline phase: ***overview of the present situation*** through map overlays, b) assessment phase: facilitating better ***understanding of changes and impacts*** through predictive models, and c) alternatives/ mitigation phase: supporting the development ***of solutions*** through better targeting investments and mitigation measures using a spatially explicit decision/criteria framework. Using map overlays resulted in a map which identifies areas of high suitability for a desired investment. At the same time, the SMCA outcome was used to identify areas of low suitability that are synonymous with vulnerable areas where the respective investments would come with considerably increased costs. The suitability map produced by the SMCA is also an ideal input into a least-cost path calculation, which can be used to find an optimal routing, such as a potential railroad alignment in the corridor (see map B in Appendix L).

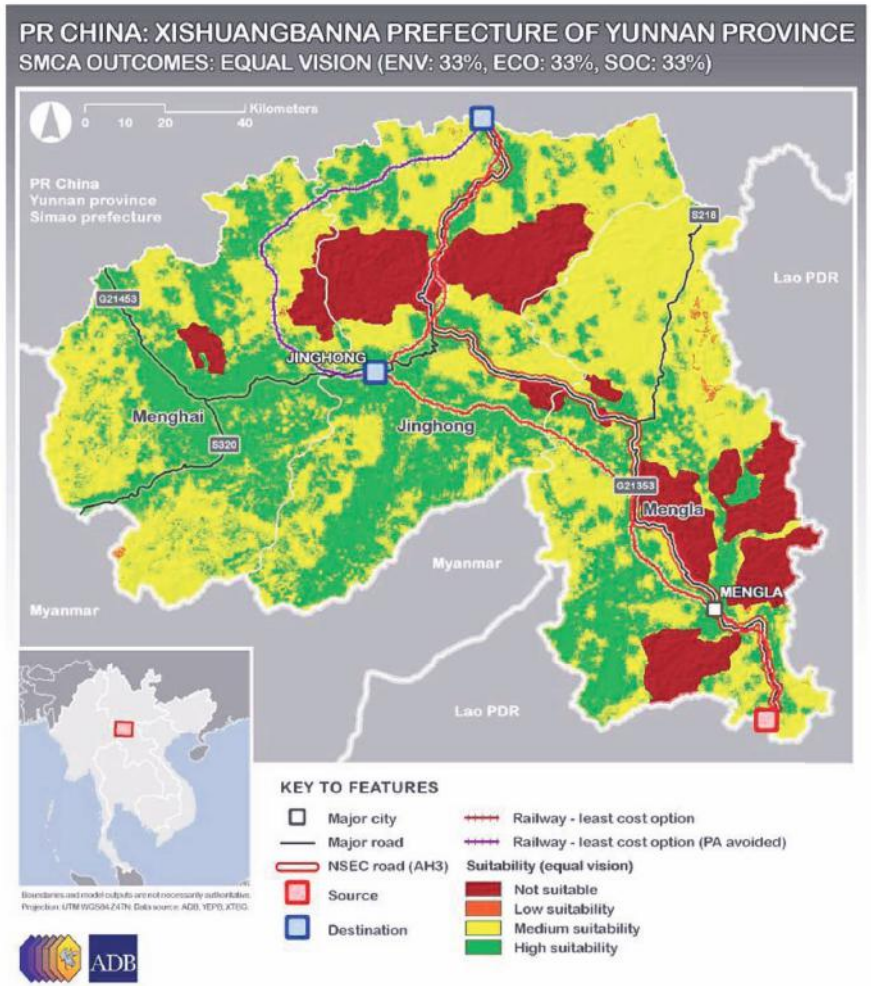
Sources: Fleck, L.C., Painter, L., Reid, J., Amend, M. (2006) A road through Madidi: An environmental-economic analysis. Conservation Strategy Fund. Technical Series No. 6. V.B. Mathur, Ashok Verma, Nigel Dudley, Sue Stolton, Marc Hockings, and Robyn James. Opportunities and challenges for Kaziranga National Park, Assam over the next fifty years. (2005). UNESCO Enhancing Our Heritage Project Team. EIA Trung Son Hydroelectric Project. 2009. Trung Son Project Management Board. The North South Economic Transport Corridor (NSEC) in the Greater Mekong Sub-region (GMS).

APPENDIX L: THE NORTH SOUTH ECONOMIC TRANSPORT CORRIDOR (NSEC) IN THE GREATER MEKONG SUB-REGION (GMS)

Map A



Map B



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