PROTECTING NATURAL HABITATS IN ROAD DEVELOPMENT: A MULTI-LEVEL APPROACH

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ABSTRACT

The development of new roads can cause major direct and indirect impacts on natural habitats, and of particular concern for the health of species and ecosystems is habitat fragmentation. To date, traditional project-based mitigation approaches have proven insufficient to arrest habitat fragmentation and biodiversity loss associated with road development. This paper proposes a multi-level approach for road development to address these impacts at various levels, from public/governmental (international, national, sector plans and policies) to private/corporate (voluntary measures, financing, and project design and operations). The paper argues that only multi-level solutions will be able to effectively minimize biodiversity impacts of road infrastructure; efforts made at only one level (as has been common to date) will continue to be insufficient. At the national level, a range of regulatory policies, fiscal policies, and incentive programs can be applied to promote biodiversity-friendly road development. At the sectoral level, considerations for habitat conservation need to be explicitly included in road sector plans through biodiversity-inclusive strategic environmental assessments, in addition to effective stakeholder engagement, environmental management, and biodiversity offsets. Lastly, at the project level, engineers have a number of options available to ensure that fragmentation, habitat loss, and other induced impacts are minimized.

1. INTRODUCTION

Road development is recognized as a major contributing factor in global natural habitat loss. Habitat fragmentation, increased poaching, land-use changes, and many other disturbances likely to result from road development exert significant pressure on natural habitats [1][2]. While there is no lack of attempts in road projects worldwide to ease the conflicts between mobility enhancement and habitat conservation, the fact remains that the loss of natural habitats due to road development has been increasing over the years. In order to effectively reduce habitat loss caused by road development, there is an urgent need for a multi-level approach that coordinates and combines actions at multiple decision-making levels (national policy, sectoral planning, and project engineering) to address road development's direct and long-term impacts on natural habitats in a systematic manner, thereby overcoming major limitations of the traditional project-by-project approach. This paper outlines such a multi-level approach, synthesizing ideas from the state-of-the-art in habitat conservation practices. First examined are common impacts of road development on natural habitats and why many of these impacts are often inadequately addressed. Then, based on an extensive review of international best practices, a framework of actions to address these impacts at three decision-making levels is proposed. Finally, the benefits of the proposed approach and implementation challenges are discussed.

2. THE IMPACTS OF ROAD DEVELOPMENT ON NATURAL HABITATS

Direct and long term impacts from roads occur easily if habitat conservation activities cannot be undertaken systematically and strategically. This section starts with an overview of the direct and long-term impacts from roads. These impacts, as will be illustrated, are often unable to be successfully addressed at the project level.

2.1 Direct Impacts

Direct impacts of road development pertain to the effects of roads themselves on natural habitats or species of conservation concern [3]. Roads, linear transport infrastructures, connect places and also act as barriers between adjacent spaces, splitting ecosystems into discrete and isolated patches and leading to habitat fragmentation, one of the major direct impacts of road development [4][5][6]. Roads create barriers over an area larger than that occupied by the physical infrastructure itself, owing largely to disturbance/edge effects [7]. In both construction and operation phases, there are a series of physical and chemical disturbances including noises, vehicle movement, traffic lighting, sedimentation, soil erosion as well as environmental contamination by petroleum and other substances which trigger various physical and biotic changes on the verges of roads [8]. Poorly planned vegetation along the right-of-way can also introduce invasive species [1]. These disturbances collectively result in biotope degradation along roads [9].

The barrier effects of roads impair the connectivity between habitat patches and restrict faunal movements across landscapes, resulting in habitat fragmentation. Fragmentation reduces the genetic diversity of both fauna and flora by subdividing populations into small units that can no longer sustain genetic processes and disturbing their reproductive activities (e.g., migration for breeding, pollination) [10]. Population dispersal and genetic exchange of local fauna can be directly disrupted by: (a) road avoidance, and (b) animal-vehicle collision [11]. In the first case, some species avoid areas adjacent to roads due to the afore-mentioned physical and chemical disturbances [12][13]. Animal-vehicle collisions, which are also a traffic safety issue, occur frequently when the configuration of a road network blocks animals' migration routes or access to prey areas. Collisions are another major direct human cause of fauna casualties in addition to hunting [14][15]. The verges of roads can often serve a positive function of providing habitat and movement corridors for wildlife [16][17]. These effects are illustrated in Figure 1.

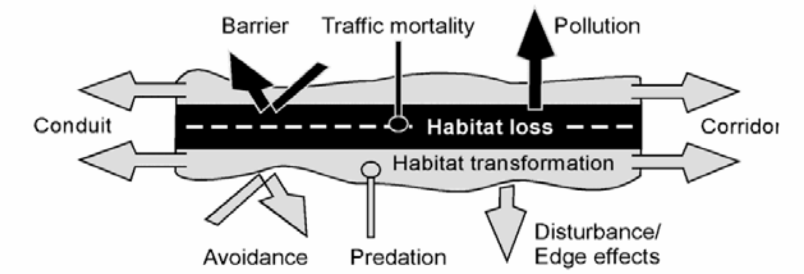

Figure 1 – Primary ecological effects of roads, source [2]

2.2 Long-term Impacts

Road development and expansion brings long-term and induced impacts which amplify through time and space. Long-term and induced impacts are usually associated with human activities that road construction or improvement makes possible. They tend to be both more serious and more difficult to control than the direct impacts [3]. Increased illegal collection of natural resources, downstream hydrological effects, and land-use change which may lead to habitat degradation or even destruction are three major long-term impacts of poorly planned road networks. These long-term impacts are cumulative and can be considerable when accounting for the interactions between the configuration of road network, its surrounding habitats, and different types of impacts [18].

Illegal collection of natural resources (e.g., wildlife, forest products) is one destructive disturbance to natural habitats which may cause species extinction and deforestation [19][20]. It is likely to increase along with the enhanced availability of roads in and around natural habitats if there is no effective implementation of strict restrictions on human access to these areas. Roads and ancillary roads built during construction open up intact habitats, thereby increasing the chances for poachers and collectors of other forest products to access remote protected areas and transport their goods to outside markets. In some countries, benefitting from convenient transport, market networks of illegal trading of natural resources are actually located along roads [19][20].

Construction and maintenance activities of roads can alter downstream hydrological processes and geomorphologic conditions, and ultimately cause degradation of aquatic ecosystems [3][21]. Because road construction involves channel relocation, obstruction of wetland water system for flood prevention, building of embankments, drains, cuts and fills, it often negatively influences local hydrology. Moreover, surrounding hydrological system can also be severely affected by high erosion rate and sedimentation caused by improper road siting, construction, maintenance, or heavy traffic [21][22]. Roads can be constant sources of sediments to streams as they accelerate runoff and their construction, maintenance, and operation activities increase the volume of loose material [23]. In addition, erosion impacts of roads facilitate gully development below their drainage structures (e.g., culverts, water bars, rolling dips) and eventually lead to channel extension, diversion of existing stream channels, and increase of drainage density [24]. These impacts cumulatively damage the spawning conditions required by aquatic species and shorten the life of downstream structures (e.g., reservoirs, bridges) and water supply systems relying on ecosystems of natural habitats [25].

In the long run, road networks accelerate land-use change, which results in permanent habitat loss [26]. Natural habitats may be transformed into areas of agriculture, human settlement, and other industrial purposes as roads improve opportunities for economic exploitation of resources in these areas [27]. New roads in previously intact habitats are often followed by clusters of roadside settlements and constructions of more community roads extended from the original roads, which ultimately grow into zones of urbanization [22]. These land-use changes, together with other human colonization-induced impacts, can considerably affect native terrestrial and aquatic ecosystems [11].

2.3 Limitations of a Project-by-project Approach to Habitat Conservation

The construction of new roads will continue in response to the changing land uses around the world. The conflict faced by habitat conservation in road development is, as the above review indicates, that roads inevitably generate impacts to their natural surroundings with different levels of significance on various time scales. This pervasive reality casts doubt on whether habitat loss can be resolved at a single decision-making level.

Efforts to mitigate road impacts on natural habitats have been made in many individual road projects, by building overpasses and underpasses to enhance fauna mobility across roads, restoring or creating corridors to connect habitat patches, strengthening construction management and maintenance, or adopting good siting criteria [28]. However, these techniques often focus on environmental management at project scale and not all of them can demonstrate significant effectiveness [29]. In fact, a project-by-project approach appears, and in many cases undeniably is, insufficient to halt habitat loss [30]. In particular, the traditional project-based approach shows limitations in (a) addressing long-term impacts of road projects, (b) restoring habitat connectivity, and (c) lowering human and monetary costs of conservation activities.

Firstly, it is outside the scope of a single road project to address long-term impacts. While the impacts of individual road projects may fall below the defined critical thresholds, the totality of the incremental contribution of each project over a period of time can be disastrous to the natural habitat [31]. Long-term impacts from road projects usually extend beyond the temporal and spatial scale of the project *per se* [4]. The long-term impacts of multiple road projects, including additive and synergic impacts, need to also be addressed in the context of broader development plans, such as land-use plans or socio-economic plans. In order to address such impacts, the spatial scale and horizon of road development needs to be expanded [22]. Long-term impacts of road development, with their wide areas of influence and time horizons, therefore can usually only be adequately tackled with actions at the program and policy level [4][32].

Secondly, mitigation measures at the project level to counter the adverse effects of fragmentation cannot fully restore connectivity. The spatial arrangement and the movement of organisms among habitat patches determine the connectivity of habitats, which is a vital element of landscape structure [33]. Connectivity is indicated by the degree to which the landscape facilitates or impedes individual movements among habitat patches to acquire resources [34], and the level of habitat connectivity is species-specific. In road projects, various structures are designed to reduce the isolation effects: wildlife culverts, tunnels, underpasses, overpasses, and fences are built to facilitate animal mobility across road structures; expanded bridges, tunnels and viaducts are chosen for road sections which have to cross sensitive habitats [4]. However, species do not adapt to these man-made structures at the same level, as they have different preferences to the conditions provided by these structures such as their placement, size, substrate, and noise, temperature, light and moisture levels [12]. Trying to find the right type of structure for the full variety of species in the vicinity of a single road project would be impractical, as much as it would be a misguided proposal for restoring habitat connectivity.

Critical habitats and connectivity zones need to be avoided in road development in order to effectively address the issue of fragmentation. In order to achieve this, conservation actions have to look beyond project engineering into sectoral planning and national policy making. Current conservation practices, mostly mitigation and restoration activities, focus inordinately on reducing impacts of roadways on local natural populations without understanding the ongoing degradation of metapopulation dynamics and wider ecological processes from a landscape perspective [35][36]. Ideally, according to the “mitigation hierarchy” (see Figure 2), road development needs to first avoid, then minimize, then restore, and finally, when the previous options are exhausted, offset its ecological impacts [37][38]. Framing around this hierarchy, there are four types of measures that can be undertaken to conserve habitats, including expanding protection areas, enhancing the quality of existing habitats, minimizing impacts from surrounding land use, and providing connectivity within fragmented landscapes [39]. Yet, avoidance by protecting natural habitats and their connectivity zones is the fundamental and essential basis for nature conservation [40]. It is not only a matter of project siting, but indeed an imperative for both land-use planners and transportation planners. Many infrastructure projects have gone beyond the no-net-loss concept and have contributed to a net gain for biodiversity providing win-win conditions for conservation and infrastructure development [41].

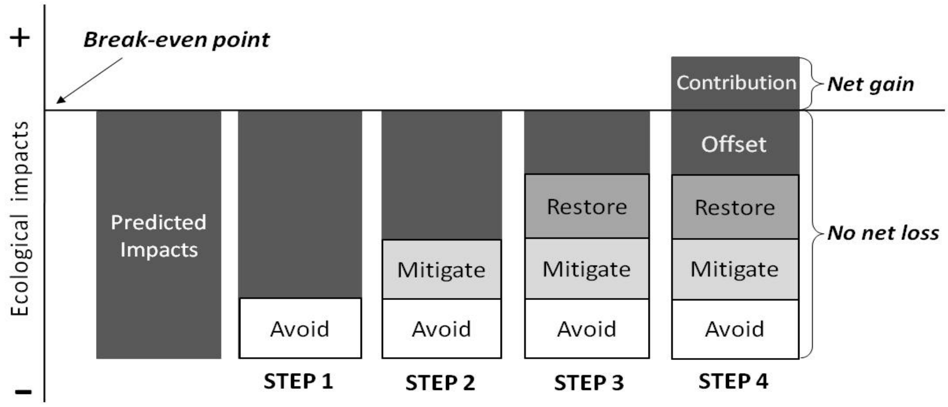

Figure 2 - Mitigation hierarchy, adapted from [37]

Finally, a project-by-project approach requires high human and monetary cost. The application of restoration and mitigation techniques can be too expensive and ineffective to be attractive to individual projects if strategic planning and allocation of resources in the road sector is not in place. From an administrative perspective, conservation efforts undertaken in an uncoordinated and piecemeal manner are likely to cause delay in project delivery. Furthermore, they might not provide the best environmental outcome. Permitting agencies have to individually review multiple mitigation proposals and projects within areas which are ecologically connected, many of which should ideally be put under the same conservation plan [29][42]. From an economic perspective, many of the most effective structures for habitat conservation in road projects are costly, with price tags in the thousands and millions of dollars [43][44][45]. Moreover, field surveys and monitoring to determine the right type of connectivity restoration measures in several small projects can be not only very expensive but also time consuming [46]. It is a better solution to conduct them for multiple road projects if they are planned in ecologically connected areas, rather than carrying them out separately in each project. In this manner, a more holistic vision of road impacts on natural habitats can be obtained. This is important because sometimes conservation of particular species may be of lesser concern than maintaining the overall habitat connectivity, or sometimes it is more worthwhile to conserve fragments which are still linked by a corridor of habitat rather than isolated ones of similar size [12][47]. Therefore, an economical strategy is to reserve these costly measures for the maintenance of connectivity between habitats of the greatest ecological value [48][49]. Additionally, incentives should be provided for implementing sound engineering practices in road projects, and sectoral or even national level planning is needed to identify the natural habitats of high conservation priority.

3. THE MULTI-LEVEL APPROACH

As demonstrated above, conventional project-based conservation activities need to be combined with supporting national policies and sound planning in the road sector. Otherwise, gains from these activities may not outweigh their cost. In this section, a multi-level approach is proposed and discussed. It aims to overcome the three major deficiencies of a project-by-project approach and address the issue of habitat loss in road development more effectively. The options provided in the multi-level approach to conserving natural habitats in road development are framed in three tiers (national policy, sectoral planning, and project engineering) in the context of the mitigation hierarchy (avoid, mitigate, restore, offset). They are synthesized from an extensive review of international best practices and are strongly recommended to countries that are still in the process of building up a comprehensive decision-making system for road development.

3.1 Options for National Policy Making

There are four main considerations at the national policy level: (a) mainstreaming natural habitat conservation in land-use policies/frameworks/strategies; (b) providing financial incentives to road projects and sectoral plans to proactively reduce their adverse impacts on natural habitats, (c) using biodiversity offsets to make sure that road projects do not cause net loss of habitats; and (d) setting up a national Environmental Assessment (EA) system to ensure that habitat conservation considerations are integrated in transport planning, construction, and operation.

The first option to be introduced is setting aside critical habitats and their vital linkages from intensive road development in national land-use policies, frameworks or strategies, The national level is the most appropriate level of decision-making to practice “avoidance” in the mitigation hierarchy. Land-use policies should ensure that core ecological networks of natural habitats are designated as “no go” areas. Subsequently, as land-use policies are modified, adding habitats, buffer zones, or connectivity corridors in national nature reserves might be needed in order to conserve habitat networks, as well as the ecological processes they support (e.g., long distance migration) [39][50][51]. Besides mapping out a new national land-use plan, other planning tools can also be adopted to supplement the existing land-use plan, including landscape planning, ecological planning, ecosystem management planning, or habitat conservation planning [52][53]54].

Technically, Geographic Information System (GIS) tools, land-use prediction models, and map overlays are widely-used techniques to support decision-making. In the transportation planning of the North South Economic Corridor in the Greater Mekong Sub-region (GMS), a Spatial Multi-Criteria Assessment (SMCA) methodology was used to generate suitability maps with the ecological sensitivity of different areas indicated by a color scheme [55]. Such maps, with sensitive areas clearly red-flagged as “no go” areas, can be used as a basis in road planning to identify the most appropriate configuration of road networks in a given landscape [56]. There are other computational technologies, such as MARXAN, which can be of assistance in the afore-mentioned planning processes [57].

The second national-level option is to use incentive mechanisms to promote habitat conservation activities in road plans and projects. These incentives can be in the form of national conservation programs/initiatives, taxation benefits, funding sources for habitat protection, or direct cash subsidies [30][58]. Examples from the United States may provide valuable reference points for designing incentives, such as the 2001 U.S. Congress-initiated State and Tribal Wildlife Grants Program, which mandates the completion of Comprehensive Wildlife Conservation Plans (CWCPs) in each state by 2005 [58]. Generated from federal government gas tax, funds are appropriated annually to state agencies to develop these conservation strategies [46][56]. Alternatively, countries can also provide subsidies for habitat-friendly practices in road projects, such as the 1991 U.S. Congress-created Transportation Enhancements (TE) program, which allows projects to apply for TE funding for environmental mitigation activities, including an array of conservation activities such as construction of fauna passages, research on wildlife passages, and enhancement of existing fencing structures [59].

The third measure that can be considered by national governments is establishing channels to transfer a portion of road project profits to financially support habitat conservation through biodiversity offsets. Biodiversity offsets, in the context of this paper, are measureable conservation actions designed to compensate for residual and unavoidable harm to habitat caused by road development, after prevention and mitigation measures have been taken [37][60]. Before applying biodiversity offsets, supportive policy/regulative/legislative frameworks need to be established. For example, there are a variety of laws in the U.S. that require transportation projects receiving federal money to compensate in some way for their adverse environmental impacts [46]. In Brazil, a law requires up to 0.5% of the total cost of an infrastructure project be transferred to support the creation or maintenance of priority conservation units [45]. The exact percentage is determined by various factors and increases with environmental sensitivity, thus acting as an incentive to developers to offset harms and/or avoid ecologically sensitive areas. Comprehensive offset and biodiversity protection programs have been put in place in the sensitive Mocoa–Puerto Asis road in Colombia financed by the Inter-American Development Bank [61].

Generally, there are two ways that biodiversity offsets can be applied. First, offsets can be used as actions undertaken by individual projects, which means that a project needs to develop an offset proposal and compensate impacts though its own action [3]. The implementation of the offset proposal, which is essentially a mitigation plan, can be guaranteed by project licensing requirements [45]. Second, offsets are transferred in the form of “credits” in a market involving developers, locals, and bankers: developers can fulfill their mitigation obligations by implementing their own mitigation initiatives or purchasing from bankers, while bankers can create or restore a conservation area to earn credits and sell them at market rates to recapture their investments. Through trading offset credits, stakeholders receive financial gains from protecting habitats [46][62], as is envisioned in the emerging financial mechanism to reduce emissions from deforestation and forest degradation (REDD) [63][64][65][66] at local, national, and international levels.

A fourth, very important option for policy makers is the setting up of a national Environmental Assessment (EA) system. Typically, an EA system is comprised of two main instruments: Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). Along with the formulation of decisions, the former is used to analyze the effects of development projects, while the latter is applied to assess the impacts of policies, plans and programs (see Figure 3). Currently, nearly all countries have some experience with EIA and many have been actively testing SEA over a much broader range of decision-making [67]. A sound EA mechanism, effectively implemented, sets the ground on which concerns about habitat loss can be acted upon during road planning and design [68]. Also, as previously discussed, the three national-level options can be embedded in the EA process [69]. For instance, SEA can initiate an integrated process to link traditional transport planning, land use planning, and ecological planning. It also helps to address the cumulative impacts of multiple projects [70]. In the next section, the use of EIA/SEA for integrating habitat conservation and biodiversity considerations (sometimes known as biodiversity-inclusive EIA/SEA) in road development will be further discussed.

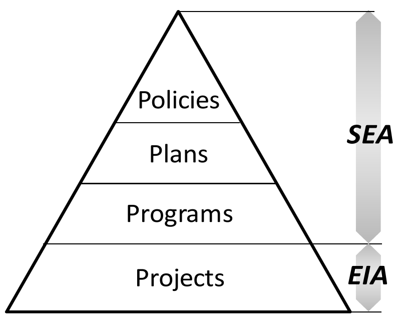

Figure 3 - A tiered EA system

3.2 Options for Sectoral Planning

This section firstly elaborates on the topic of biodiversity-inclusive EA, and then discusses other sectoral actions to reduce impacts on natural habitats, including: seeking interagency coordination in road network planning; expediting approval for habitat-friendly projects; and strengthening environmental management and supervision in road projects.

Firstly, the road sector should implement biodiversity-inclusive SEA and EIA to mainstream habitat and biodiversity conservation in road development [71]. Two concepts regarding biodiversity-inclusive EA are emphasized here: (a) linking SEA and EIA, and (b) using them as platforms for cross-agency coordination and communication among different social groups. The concept of linking SEA and EIA, which is called "tiering" in academia, refers to the application of a sequence of EAs at different decision-making levels (again, indicated in Figure 3) and linking them [72][73]. Implementing tiering is important because it helps to trickle down habitat conservation concerns from broad-brush narratives at the policy level to concrete actions in road projects [45][70][74].

The concept of using biodiversity-inclusive EAs as platforms for coordination and communication is important for habitat and biodiversity conservation. The broadness and complexity of biodiversity issues requires a participatory mechanism. Very often, biodiversity offsets are designed on the basis of valuation of ecosystem services [75]. Quantifying an area's ecosystem services requires extensive stakeholder participation, because ecosystem services (provisioning, regulating, cultural, and supporting) encompass various functions ranging from food and fuel provision, carbon sequestration, and nutrient cycling to recreational and aesthetic uses [71][76][77]. By undertaking public participation, one of EA's process components, biodiversity-inclusive EA can facilitate the integration of as much local knowledge as possible and transparent decision-making for ecosystem service evaluation. Moreover, one of the most important principles of EA is that the assessment process should be integrated as early as possible in the project design/planning process [78][79][80][81]. This principle can contribute to the improvement of traditional conservation practices, which usually determine mitigation measures at late stages in road planning and further cause expensive delays in projects [58].

Secondly, interagency coordination should be enabled in road network planning. The road sector can, of course, use biodiversity-inclusive SEAs to involve conservationists, biologists, and forestry/wildlife/environmental agencies in planning road systems so as to reduce adverse impacts systematically. In addition to impact assessment, reducing adverse impacts can also be achieved by taking advantage of existing road planning mechanisms, national ecological planning, or landscape planning as opportunities for the input of habitat conservation considerations [82]. From an operational perspective, setting up meetings, workshops, transport decision-making committees with conservationist/ biologist representatives involved, and developing memoranda of cross-agent agreement on conservation issues are actions which hold promise in promoting more collective and effective efforts on habitat conservation at strategic levels [83]. Efforts at sectoral coordination can be catalyzed and facilitated by mandates issued at the national level. For example, in 2005, the U.S. Congress mandated that each state complete a State Wildlife Action Plan. It was under the Action Plan that Congress intended to enhance cooperation in and between government agencies [58]. Inter-sectoral initiatives are highly dependent on specific institutional contexts, so appropriate approaches would vary accordingly.

Thirdly, the road sector should consider working with environmental or land use agencies to provide expedited approval for road projects that have only minor impacts on natural habitats. Under such an arrangement, projects can increase their chances of receiving a streamlined approval if they adopt standards of best mitigation practice. The rationale is simply because as project approvals take longer, developers' holding costs, investment risk, and investment confidence are negatively affected [84]. Moreover, such low-impact projects usually involve habitats with small area and may not possess sufficient resources to withstand long delays [85]. Therefore, the allowance of streamlined permitting processes and environmental reviews can be an incentive for conservation activities at the project level. The road sector may take the lead in teaming up with relevant government agencies to refine the methodology for decision-making on road projects under existing legislative and regulatory systems [56].

Lastly, the road sector needs to strengthen environmental management and supervision of projects. Using state-of-the-art physical structures (e.g., tunnel-bridge-tunnel schemes in sensitive areas) alone is still insufficient to reduce adverse impacts in projects. Seemingly negligible impacts from poor environmental management during road construction and operation phases can cumulatively bring destructive change to surrounding habitats. Therefore, environmental management is an indispensable element of reducing habitat loss in road projects [86]. As a basic requirement, there should be a set of regulations, standards, and design specifications available, which explicitly describe the institutional framework for project management and specify engineering standards [87], see for example [88]. Most road agencies in Latin America have adopted environmental guidelines for road design and construction [89], and Indonesia has adopted engineering codes of practice for road construction in sensitive areas [90]. Standards developed in the US and China show other approaches [21][91][92][93][94][95]. Despite the existence of standards, road projects near natural habitats are usually administrated by rural agencies, townships or municipalities with little experience or limited capacity in project management, particularly long-term management [30] and supervision and implementation of EMPs. Thus, effective supervision from higher levels in the road sector (possibly requiring collaboration with environmental agencies in some institutional settings) is important for enforcement of environmental standards in road projects. In addition to supervision support, the road sector can also organize professional training for contractors/construction workers to build environmental awareness and improve environmental performance in road projects.

3.3 Options for Project Engineering

Without doubt, road engineering needs to comply with technical regulations, standards, and specifications offered by the road sector and other relevant agencies. To promote habitat conservation effectively, engineering practices should also be based on scientific information and strategic planning and management from national and sectoral levels. Besides this, there are two additional good practice considerations important to mention. *The first one is road siting*. Siting and road alignment are perhaps the most important measures for a project to reduce disturbances to natural habitats [3]. Moreover, good siting criteria can also help to reduce the construction cost of road projects [21]. Siting criteria are further discussed by various authors [3][21][96][97]. The second good practice consideration is to use physical structures to restore and conserve habitat connectivity. Experience has demonstrated that there are considerable possibilities for man-made facilities to substantially ease habitat fragmentation in a landscape (see Figure 4). They counter the fragmentation effects by sustaining the genetic viability of fauna within habitat patches [10]. Some of the principal types of structures to maintain wildlife mobility include long tunnels/bridges, boulders in the right-of-way, fencing, viaducts, elevated roads, river crossings, culverts, overpasses, and underpasses [4][44].

While options are abundant, projects need to seek out their own solutions to several issues. Firstly, as discussed before, habitat preferences of different species are often at odds with one another. Therefore, a mix of several types of crossing structures and fencing, when it is appropriate, is more effective than using one type alone. Secondly, there is no general answer as to the placement of structures. Local ecology should be deliberately assessed before determining the best combination of structures. Lastly, monitoring is needed to evaluate the effectiveness of installed structures and to provide knowledge for improving the design of structures in future projects or maintenance efforts [12][18].

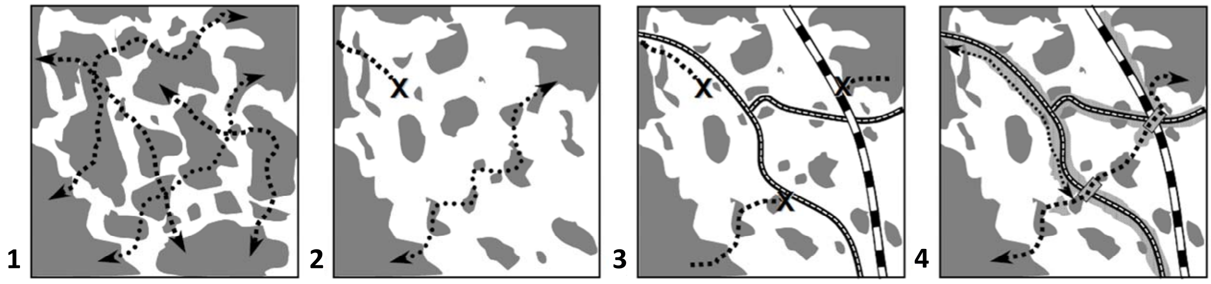

Figure 4 - Habitat connectivity in road projects, adapted from [9]. (1) Fragmentation of habitat (shaded areas) reduces fauna movements across the landscape; (2) some connectivity sustained through small habitat fragments or corridors; (3) barriers, isolation and fragmentation of habitat due to roads; and (4) mitigation measures (e.g., fauna passages, integrated road verge management) to restore or improve habitat connectivity.

3.4 Benefits of the Multi-level Approach

The multi-level approach combines options — ranging from policies to engineering designs to development of roads — without sacrificing natural habitats. What sets the multi-level approach apart from other approaches is primarily its emphasis on “combination,” which gives it at least five advantages over a traditional project-by-project approach.

First, it provides a comprehensive basis for improved decision-making in road development. Options presented in the approach are selected based on extensive review of international experiences. They either sit at the forefront of recent development of habitat conservation or have been proven to be effective. Hence, the approach provides a baseline for road sectors with which the existing decision-making methodology in the sector can be compared so as to identify gaps. While this framework of options represents a beginning rather than an end, it can be used as a guide to direct conservation activities at all levels in road development.

Second, a multi-level approach promotes the early integration of conservation considerations within road sector decision-making to solve habitat loss systematically. Traditional conservation activities are usually undertaken in a late stage in the lifecycle of road development, which extends from mapping out road corridors/alignments, design, construction, and operation. Practices introduced at late stages tend to make only small contributions to the reduction of road impacts, because usually few decisions are still open to change at the project level. In addition, preparing individual conservation plans for each road project often causes delays in road development as these conservation plans have to be reviewed on a project by project basis, even if the projects affect more or less the same habitats. In order to overcome such deficiencies of conventional conservation practices, the multi-level approach emphasizes systematic planning by suggesting that land-use/ecological/landscape plans be linked with road plans.

Third, a multi-level approach addresses cumulative impacts of road projects in a more effective manner by advocating strategic planning of both roads and conservation activities. Ignoring cumulative impacts occurs easily in the project-by-project approach. Because roads are linear infrastructures and their zones of influence usually cross different jurisdictions [98], there is a great need to enhance inter-sectoral and inter-administration cooperation so as to tackle cumulative impacts with large temporal and spatial scales. Therefore, implementing the multi-level approach, which comprises actions that need to be taken at national and sectoral levels, presents numerous opportunities for improving collaboration among government agencies.

Fourth, a multi-level approach helps to reduce the high cost of habitat conservation. As discussed in Section 2.3, project-by-project conservation practices often have high cost, which still does not guarantee that ecological processes will be conserved/restored. Generally, as conservation actions are taken later in the lifecycle of road development and go down along the mitigation hierarchy (from avoidance, mitigation, restoration to offset), the cost of environmental protection goes higher (see Figure 5). Avoidance at early stages of decision-making in road development (e.g., avoid “no-go” areas defined in land-use plans/road corridor plans) is the cheapest and probably the most effective action to conserve habitats [30]. The multi-level approach — which advocates the early integration of conservation considerations following the mitigation hierarchy — offers a clear picture of how to reduce road developers’ costs in relation to habitat conservation.

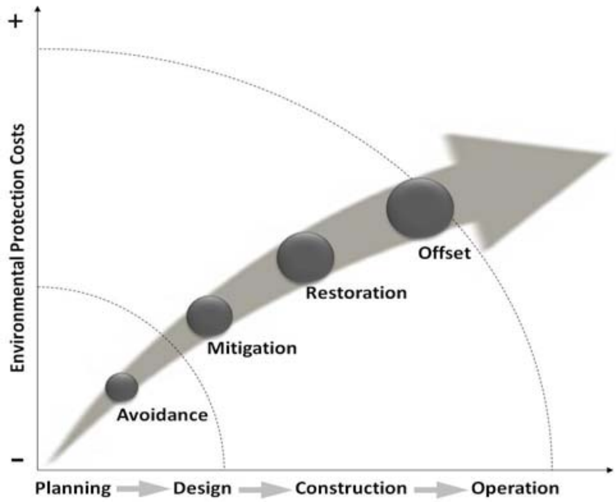

Figure 5 - Relationship between the cost of environmental protection, mitigation hierarchy, and lifecycle of road development, adapted from [30]

Fifth, a multi-level approach can be adapted to address habitat loss in infrastructure development more generally. Infrastructure development needs to expand as basic living facilities are still lacking around the world. In many developing countries, lands are being developed faster than ever. Very often, places where infrastructure is most needed overlap with areas of severely threatened, sensitive habitats. One contribution of the multi-level approach is that it presents a general framework to address habitat loss which is applicable to other infrastructures, including non-road transportation, dams, transmission lines, and mining sites [41]. It is of particular importance that this approach be further developed and applied in areas where infrastructure development is still greatly needed.

3.5 Overcoming Implementation Challenges

Whereas conventional project-based conservation practices tend to focus more on technical solutions, such as evaluating economic values of ecosystems, predicting wildlife behavioral changes due to man-made structures, or designing EA processes, the multi-level approach also emphasizes more non-technical measures such as enhancing institutional capacity, optimizing resource management, and conducting strategic planning. Following are some insights to help navigate potential challenges relating to the non-technical aspects of implementing the multi-level approach.

The context of a country's decision-making system determines what will make the best combination of options for the multi-level approach. As stressed earlier, this approach provides a framework and starting point for effective action rather than a final solution. Existing multi-level decision-making methodologies in the road sector show significant variation from country to country; thus, there is a need to systematically assess current decision-making methodologies in road development prior to implementing this approach.

Users of the multi-level approach need to determine whether an adaptation of the approach is needed. Because options at the three decision-making levels are more or less connected, the framework of multi-level approach is more dynamic than strictly defined. In some cases, the achievement of a conservation action at a certain decision-making level depends on support from a higher level. For instance, in order to streamline the approval of road projects with minor impacts on natural habitats, coordination by national government might be necessary to initiate conversations between the road sector and other relevant sectors (e.g., natural resources, environmental sector). For some issues, road planning may also need to be examined and coordinated at an additional level, the regional level, such as for tiger conservation in East Asia [30].

The capacity of institutions to work in a cross-agency and cross-jurisdictional environment can pose challenges. This capacity is crucial for effective and efficient management of funds for habitat conservation as well as for conducting holistic planning processes which integrate road development and habitat conservation. Particularly for roads that cross large habitats in more than one jurisdiction, difficulties can arise from poor coordination among local governments in addressing such issues as the compensation payments from projects.

Enhancing the effectiveness of environmental supervision of road construction and operation is greatly needed. Roads crossing natural habitats are often under the management of local agencies with limited experience in project supervision. As a result, environmental management plans are often not fully implemented due to insufficient supervision. While environmental agencies are responsible for supervising the environmental performance of projects under the framework of EIA, collective efforts on this from higher levels in the road sector are of equal importance.

Last but not least, dialogues between agencies and decision-makers in the road sector and conservationists should be established to enable the integration of road development and habitat conservation. Since the two sectors tend to speak different "languages," efforts will need to be made on both sides to communicate optimally. Conservationists need to present the issues in "languages" that are clear to the decision-makers. There are means to achieve this — as introduced in the multi-level approach — such as using suitability maps and economic evaluation of ecosystem services. Road sector decision-makers need to commit to effectively addressing the issue of habitat loss, which affects not just species, but the human populations that use the roads and depend on the services provided by surrounding habitats and ecosystems.

CONCLUSION

The paper proposes a proactive, systematic, and holistic multi-level approach to addressing habitat loss in road development. Going beyond project-by-project conservation measures, the paper explores a wide range of conservation options at national and sectoral levels, including policies, market-related instruments, and sectoral management. By emphasizing a combination of actions at multiple decision-making levels, this approach increases the likelihood of reducing the cost of habitat protection and maximizing the effectiveness of conservation measures. While the multi-level approach offers a comprehensive basis for decision-making, informed by current state-of-the-art conservation practices, challenges remain in implementing the multi-level approach. It requires commitment to addressing habitat loss at high decision-making levels, solid management and incentive mechanisms, and strengthened coordination among government agencies. It calls for a collective learning process across agencies, both in and outside the road sector, to innovatively combine the best options available at different decision-making levels and put this package of actions into practice.

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