Green Road

Infrastructure Guidelines for Colombia

El futuro es de todos
Gobierno de Colombia

WWF

FCDS
Conservación y Desarrollo

Green Road Infrastructure Guidelines for Colombia

August 2020

Green Road Infrastructure Guidelines for Colombia

The present document has been prepared within the framework of the Inter–Ministerial Environmental Agenda signed between the Ministry of Environment and Sustainable Development (Minambiente) and the Ministry of Transport (Mintransporte). This instance of intersectoral dialogue represents a permanent channel for communication and joint action aimed at the incorporation of environmental considerations in the early stages of planning and the execution of sectoral policies, plans, programs, and projects for transportation infrastructure. The Inter–Ministerial Environment Agenda, within its plans of action during the periods 2015–2016 and 2017–2018, included the following priority: *To prevent and manage conflict between transportation infrastructure and the conservation of in situ biodiversity and its ecosystem services by means of the generation of specific regulations and guidelines, and general technical guidelines, proposals aimed at the development of green infrastructure, and early warnings.*

Since 2015, the Foundation for Conservation and Sustainable Development (FCDS) and the World Wildlife Fund (WWF–Colombia) have been gathering information and technical knowledge related to the environmental and social impacts that road infrastructure causes, as well as the opportunities that the development of sustainable transportation infrastructure represents to the country, all of which contributed to the formation of the Green Road Infrastructure Guidelines for Colombia.

INSTITUTIONAL REPRESENTATIVES

President of the Republic

Ivan Duque Márquez

Vice–President of the Republic

Martha Lucía Ramírez Blanco

Ministry of Environment and Sustainable Development – Minambiente

Carlos Eduardo Correa Escaf
Minister

Francisco Cruz Prada
Deputy Minister of Environmental Policies and Standardization

Alex José Saer Saker
Director de Asuntos Ambientales Sectorial y Urbana – DAASU

Ministry of Transport –Mintransporte

Ángela María Orozco Gómez
Minister

Olga Lucia Ramírez Duque
Deputy Minister of Infrastructure

Pablo Mejía González
Director of Infrastructure

National Institute of Roads –INVÍAS

Juan Esteban Gil Chavarría
General Director

Guillermo Toro Acuña
Technical Director

Jairo Fernando Arguello
Deputy Director for Environment and Social Management

National Agency of Infrastructure – ANI

Manuel Felipe Gutiérrez
President

Diego Morales
Deputy President of Planning, Risks, and Environment

Lilian Bohórquez
Environmental Manager

National Planning Department –DNP

Luis Alberto Rodríguez
Director

Jonathan David Bernal González
Director of Infrastructure and Energy

Juan Felipe Vallejo
Deputy Director of Transportation

AUTHORS

Ministry of Environment and Sustainable Development – Minambiente

Mario Orlando López Castro
Daniel Camilo Rodríguez Pava

Foundation for Conservation and Sustainable Development –FCDS

Rodrigo Botero García
Jaime Carrizosa Lora
Darío Correa Quiñones
Gordon Keller
Alejandra María Laina Agudelo
Juan David Quintero Sagre

WWF–Colombia

Sofía Alejandra Rincón
María Alejandra González
Juan Azcárate

TECHNICAL SUPPORT AND REVISION TEAM

Ministry of Transport – Mintransporte

Magda Constanza Buitrago Ríos
Esperanza Ledezma Lloreda
María Ximena García Narváez
Santiago Cock Quintero
Sandra Paola García
Arley Beltrán
Zuly Cabezas

National Institute of Roads –INVÍAS

Mario Alejandro Casallas Rubio
Julián Leyva Díaz
Julián Fajardo Ruiz
Marly Norela Muñoz Garnizo
Adriana Paola Rodríguez Álvarez
Juan David Oidor
Daniel Vélez Parra
Carlos Alberto Valencia Escobar
Telva Leti Galván
Lady Diana Merchán Jaramillo

National Agency of Infrastructure – ANI

Norma Liliana Gutiérrez
Álvaro Pabón Lozano
Luisa Fernanda Tamayo Arias
Verónica Villalva Campos
Diana Carolina Orjuela García
Juan Fernando Millán Villaneda

National Planning Department –DNP

Norma Liliana Castellanos Coy

Autoridad Nacional de Licencias Ambientales–ANLA

Jorge Eliécer Prada Ríos

WWF–Colombia

Mauricio Cabrera Leal
Oscar Guevara

Publishing Coordination

Carmen Ana Dereix — WWF–Colombia
Daniela Nieto — WWF–Colombia
Adriana Vásquez Cerón — FCDS

Supporting Organizations

WWF–UK

Gordon and Betty Moore Foundation.

United States Agency for International Development (USAID). Environmental Initiative for Peace in Colombia (EPIC).

Andes Amazon Fund. Consolidation Project National Park of Serranía del Chiribiquete.

Design and Layout
El Bando Creativo

Spanish to English translation
Padraic Quinn
ProofreadNOW

Table of Contents

Figures and Illustrations

List of Acronyms and Initials

AEIA: Special Areas of Environmental Interest (Áreas de especial interés ambiental)

ANI: National Agency for Infrastructure (Agencia Nacional de Infraestructura)

IADB: Inter–American Development Bank (Banco Interamericano de Desarrollo)

CAR: Regional Autonomous Corporation (Corporación Autónoma Regional)

CAV: Center for the Attention and Assessment of Wildlife (Centro de Atención y Valoración de Fauna Silvestre)

CAVR: Center for the Attention, Assessment, and Rehabilitation of Wildlife (Centro de Atención, Valoración y Rehabilitación de Fauna Silvestre)

CECAD: Central American Commission on the Environment and Development (Comisión Centroamericana de Ambiente y Desarrollo)

CONPES: National Council for Social and Economic Policy (Consejo Nacional de Política Económica y Social)

DOI: United States Department of the Interior (Departamento del Interior de los Estados Unidos)

EAE: Strategic environmental assessment (Evaluación Ambiental Estratégica)

EAER: Regional strategic environmental assessment (Evaluación Ambiental Estratégica Regional)

EICDGB: Comprehensive Strategy for the Control of Deforestation and Forest Management (Estrategia Integral de Control de la Deforestación y Gestión de los Bosques)

EIA: Environmental Impact Assessment

EIT: Early Intervention Approach (Enfoque de Intervención Temprana)

EOT Territorial Planning Scheme (Esquema de Ordenamiento Territorial)

FCDS: Foundation for Conservation and Sustainable Development (Fundación para la Conservación y el Desarrollo Sostenible)

IGAC: Geographical Institute Agustín Codazzi (Instituto Geográfico Agustín Codazzi)

INVÍAS: National Institute for Roads of Colombia (Instituto Nacional de Vías de Colombia)

GRI: Green Road Infrastructure

IPAM: Amazonian Environmental Research Institute (Instituto de Pesquisa Ambiental da Amazônia)

GRIG: Green Road Infrastructure Guidelines

MTI: Inter–Ministerial Technical Round Table (Mesa Técnica Interministerial)

OECD: Organización para la Cooperación y el Desarrollo Económicos

SDG: Sustainable Development Goals (Objetivos de Desarrollo Sostenible)

PEIIT: Strategic Plan for Intermodal Transport Infrastructure for Colombia (Plan Estratégico de Infraestructura Intermodal de Transporte para Colombia)

GDP: Gross Domestic Product (Producto Bruto Interno)

PMA: Environmental Management Plan (Plan de Manejo Ambiental)

PMTI: Intermodal Transportation Master Plan (Plan Maestro de Transporte Intermodal)

PNGIBSE: National Policy for the Integrated Management of Biodiversity and its Ecosystem Services (Política Nacional de Gestión Integral de la Biodiversidad y sus Servicios Ecosistémicos)

PNN: National Natural Parks (Parques Nacionales Naturales)

POT: Plan for Territorial Planning (Plan del Ordenamiento Territorial)

PNR: Regional Natural Park (Parque Natural Regional)

RECOSFA: Colombian Network for the Follow–up of Runover Animals (Red Colombiana de Seguimiento a la Fauna Atropellada)

SPNN: System of National Natural Parks (Sistema de Parques Nacionales Naturales)

UPME: Mining and Energy Planning Unit (Unidad de Planeación Minero–Energética)

USGS: United States Geological Survey (Servicio Geológico de Estados Unidos)

VITAL: Integral Window for Online Environmental Procedures (Ventanilla Integral de Trámites Ambientales en Línea)

WWF: World Wildlife Fund (Fondo Mundial para la Naturaleza, WWF)

Scope of the guidelines

These guidelines are aimed at orienting the structuring of plans, programs, and projects for road infrastructure development. The intention is to ensure that, from the early stages of planning, environmental and sustainable development considerations are taken into account, and that measures of location, layout, design, engineering, and management are incorporated in order to guarantee that their execution generates a net positive environmental benefit.

It is important to note that the guidelines for green road infrastructure are in line with environmental regulations issued within the framework of environmental licensing in Colombia. These guidelines are included as complementary directives to the requirements of environmental management of road infrastructure projects established within the regulatory framework, so that in practice the objectives of environmental licensing are achieved. Thus, the road construction projects that are designed and executed must consider the necessary management measures to avoid, prevent, mitigate, correct, and/or compensate for the totality of the significant environmental impacts that they may generate.

The road construction projects that are designed and executed must be accompanied by management measures that avoid, prevent, mitigate, correct, and/or compensate for the totality of the significant environmental impacts that they may generate.

The guidelines for green road infrastructure presented in the present document have been classified according to the stage of the road infrastructure development process to which they must be applied:

- Sectoral strategic planning.
- Project planning at the level of prefeasibility.
- Project planning at the level of feasibility and definitive design.
- Construction.
- Operation.
- Intervention (improvement, rehabilitation, and maintenance).
- Decommissioning.

The guidelines to be applied during the strategic planning of the transportation sector are aimed at ensuring that the environmental implications of transportation infrastructure are incorporated into decision making from the early planning stages. These guidelines aim to ensure that the transportation infrastructure solutions are strictly in line with territorial planning, so that they contribute to its consolidation, incorporating environmental and sectoral policy guidelines, and promote compliance with international commitments and national environmental goals.

Protected areas and forest reserves, for example, are environmental determinants and territorial planning figures. Fulfilment of the objectives of these two types of conservation and management entities could be threatened in the event that construction projects or road infrastructure interventions are planned within them or in their buffer zones and/or areas of influence. This supports the need for strategic planning exercises in the transportation sector to explicitly state that these types of areas will not be affected or, failing that, to include the special analysis and treatment that these types of proposals would require.

The use of instruments such as the strategic environmental assessment (EAE in Spanish), including the regional EAE, prior to or during the structuring of policies or sectoral planning instruments (such as master plans, directive plans, regional plans, and departmental plans) facilitates the identification and incorporation of environmental and sustainable development considerations, improving their recommendations and decisions.

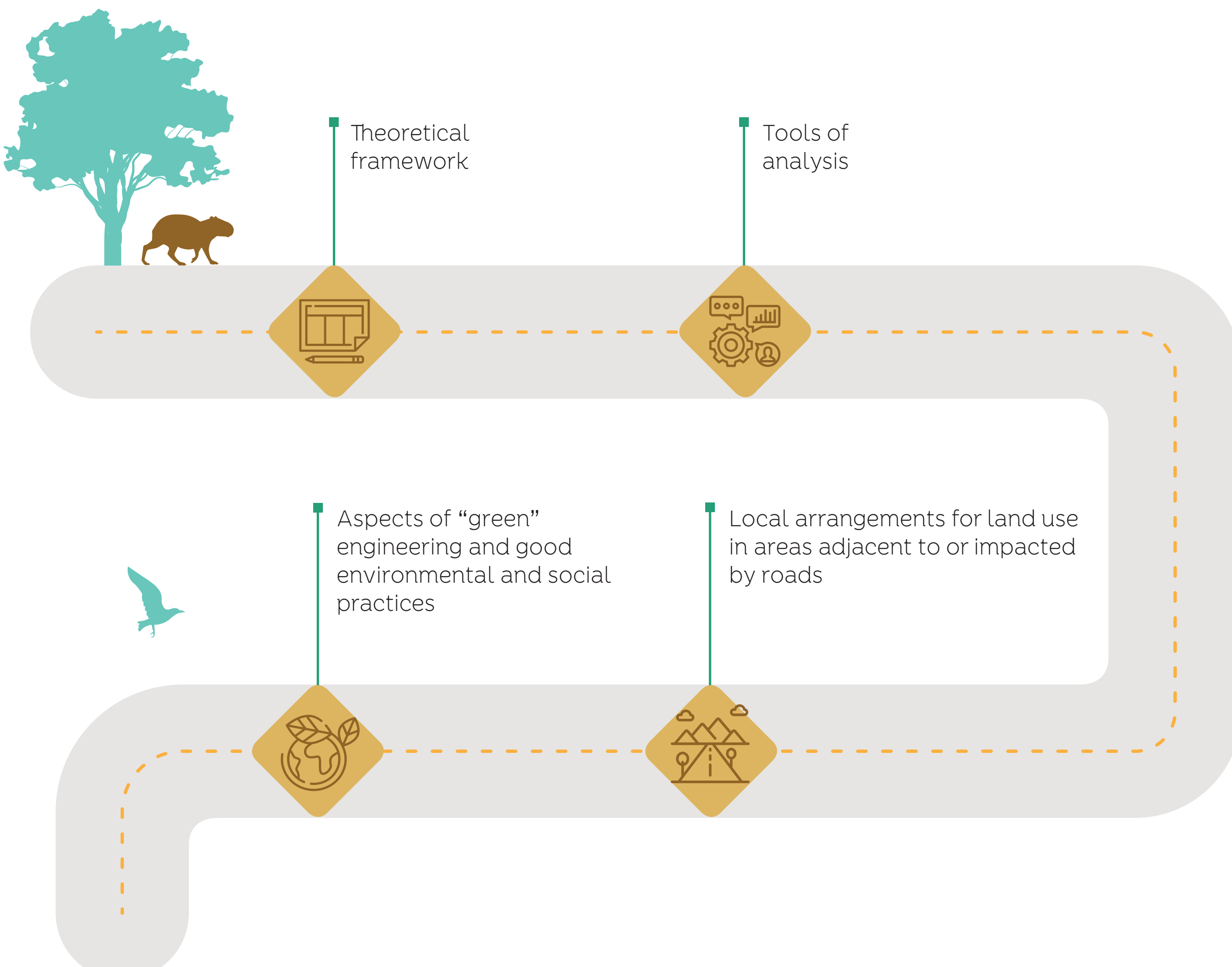
Summary sheets

In what follows, the summary sheets of the Early Intervention Approach will be presented along with each one of the stages in which the green road infrastructure guidelines will be applied.

Early Intervention Approach (EIT)

The EIT constitutes a conceptual, analytical, and practical approach that highlights the benefits of incorporating concepts, instruments, and the best available information for decision making at each stage of project conception, planning, and execution in the timeliest manner possible. Moreover, this includes the analysis of territorial planning at the landscape level, studies of ecosystem connectivity and capillarity, road clusters, and the analysis of climate variability.

Components



1 Guidelines for strategic sectoral planning

These guidelines are aimed at integrally incorporating environmental considerations into sectoral transportation policies, plans and programs by means of Strategic Environmental Assessments and/or Regional Strategic Environmental Assessments. It is important that they link elements related to environmental policies, land use planning, and alternative modes of transportation to sectoral transportation initiatives in order to guarantee their environmental sustainability.

Guidelines

1.1. Develop strategic environmental assessments as part of the process of structuring and issuing sectoral policies, plans, and programs.

1.2. Contribute to the achievement of Sustainable Development Goals (SDGs) 15 and 13.

1.3. Include territorial planning determinants in the process of structuring and issuing sectoral policies, plans, and programs.

1.4. Incorporate environmental sustainability into the objectives of the sectoral policies, plans, and programs.

1.5. Consider and incorporate alternative modes of transportation to road transportation in the process of formulating sectoral policies, plans, and programs.

1.6. Define as a policy the incorporation of prefeasibility and feasibility analyses for the structuring of construction and improvement projects for secondary and tertiary roads.

2 Guidelines for project planning at prefeasibility level

These guidelines are intended to incorporate considerations for intermodality and environmental sustainability in the feasibility analysis of transportation infrastructure projects, including governance criteria, as well as ensuring the incorporation of the costs associated with the development of the project in its entirety.

Guidelines

2.1. Formulate solutions to transportation connectivity needs that consider and incorporate alternative modes of transportation to road transportation.

2.2. Identify and select alternatives for the execution of construction projects or road infrastructure interventions that do not affect Areas of Special Environmental Interest (AEIA) or minimize the impact on them.

2.3. Identify and select alternatives for the execution of road infrastructure construction or intervention projects that do not affect ecological connectivity corridors at regional, subregional, and local levels, or that minimize the impact on them.

2.4. Identify and select alternatives for the execution of construction projects or road infrastructure interventions that do not affect areas of distribution of endemic or migratory fauna and/or endangered or vulnerable species, or that minimize the impact on them.

2.5. Verify compliance with governability requirements that legitimize the formation process of road infrastructure construction or intervention projects.

2.6. Quantify in detail the approximate costs of planning and execution of road infrastructure construction or intervention projects for all their stages and ensure the availability of the respective resources.

3 Guidelines for project planning at feasibility and definitive design level

Part 1

These guidelines are aimed at generating transportation infrastructure job designs that incorporate environmental considerations related to the protection of Areas of Special Environmental Interest (AEIA), ecological connectivity corridors, water bodies and their buffer zones among other areas. In this way, the intention is to avoid and mitigate the highest number possible of direct, indirect, synergistic, and cumulative potential environmental impacts.

Guidelines

3.1. Develop environmental studies for transportation infrastructure construction projects that do not require an environmental license.

3.2. Develop studies and designs for the execution of road infrastructure construction or improvement projects that do not affect or minimize the impact on Areas of Special Environmental Interest (AEIA).

3.3. Develop studies and designs for the execution of projects for the construction or improvement of road infrastructure that do not affect ecological connectivity corridors at regional, subregional, and local levels, or that minimize the impact on them.

3.4. Develop studies and designs for the execution of construction projects or road infrastructure interventions that do not affect or minimize the impact on water bodies and their buffer zones.

3 Guidelines for project planning at feasibility and definitive design level

Part 2

Guidelines

3.5.

Develop studies and designs of wildlife crossings for the construction or improvement of road infrastructure.

3.6.

Formulate environmental impact compensation measures that add to and complement those proposed by other projects.

3.7.

Incorporate design considerations for the generation of net positive environmental impacts on flora and fauna in the study and design elaboration process.

3.8.

Verify the application of governance requirements in the process of developing studies and designs for the execution of road infrastructure construction or intervention projects.

3.9.

Quantify in detail the costs of the elaboration of studies and designs, and of the execution of road infrastructure construction or intervention projects and ensure the availability of the respective resources.

4 Guidelines for construction

These guidelines are aimed at materializing the definitive designs in a detailed manner so that they incorporate all of the environmental considerations conceived during the planning of the green road infrastructure project in the construction of transportation infrastructure.

Guidelines

4.1. Verify compliance with design specifications for the execution of road infrastructure construction projects.

4.2. Contemplate strategies and undertake actions to preserve and consolidate ecological connectivity corridors for the execution of road infrastructure construction projects.

4.3. Execute drainage works that do not affect or minimize the impact on water bodies and their banks.

4.4. Generate infrastructure for the mitigation of negative impacts on wildlife in the execution of road infrastructure construction projects.

4.5. Generate infrastructure to mitigate negative impacts on vegetation cover and wild flora for the execution of road construction projects.

4.6. Optimize the management of materials during the execution of road infrastructure construction projects.

4.7. Verify compliance with governance requirements for the execution of road infrastructure construction projects.

4.8. Guarantee the availability of financial resources for the construction of road infrastructure projects.

5 Guidelines for operation

These guidelines are intended to mitigate and correct the environmental impacts that emerge from road operation, identifying the flaws in the existing road infrastructure with the aim of establishing actions for improvement and the implementation of measures for impact management at this stage.

Guidelines

5.1. Characterize the existing road infrastructure with the aim of identifying the need for contemplating strategies and undertaking actions to preserve and consolidate the ecological connectivity corridors during the operation of such infrastructure.

5.2. Make an inventory of crossings with water bodies and their buffer zones and drainage works in order to identify the need for building or adapting these types of structures.

5.3. Monitor wildlife mobility during the operation of road infrastructure.

5.4. Monitor natural cover during the operation of road infrastructure.

5.5. Preserve and maintain infrastructure to mitigate negative impacts on wildlife during road infrastructure operation.

5.6. Preserve and maintain infrastructure to mitigate negative impacts on vegetation cover and wild flora during road infrastructure operation.

6 Guidelines for intervention (improvement, rehabilitation, and maintenance)

These guidelines are established in order to diagnose the state of road infrastructure, and to incorporate environmental sustainability considerations in the framework of improvement, rehabilitation, or maintenance projects. This in turn promotes alignments, structures, drainage works, and wildlife crossings that mitigate and correct negative environmental impacts, whilst at the same time being aimed at ensuring adequate environmental management during interventions.

Guidelines

6.1. Apply the technical environmental criteria methodology to prioritize roads for intervention

6.2. Perform a diagnosis of the characteristics of the alignment and the road structure prior to the intervention.

6.3. Carry out adjustments to drainage works in order to re-establish fauna mobility in water bodies and their buffer zones.

6.4. Identify potential ecological connectivity corridors prior to intervention.

7 Guidelines for decommissioning

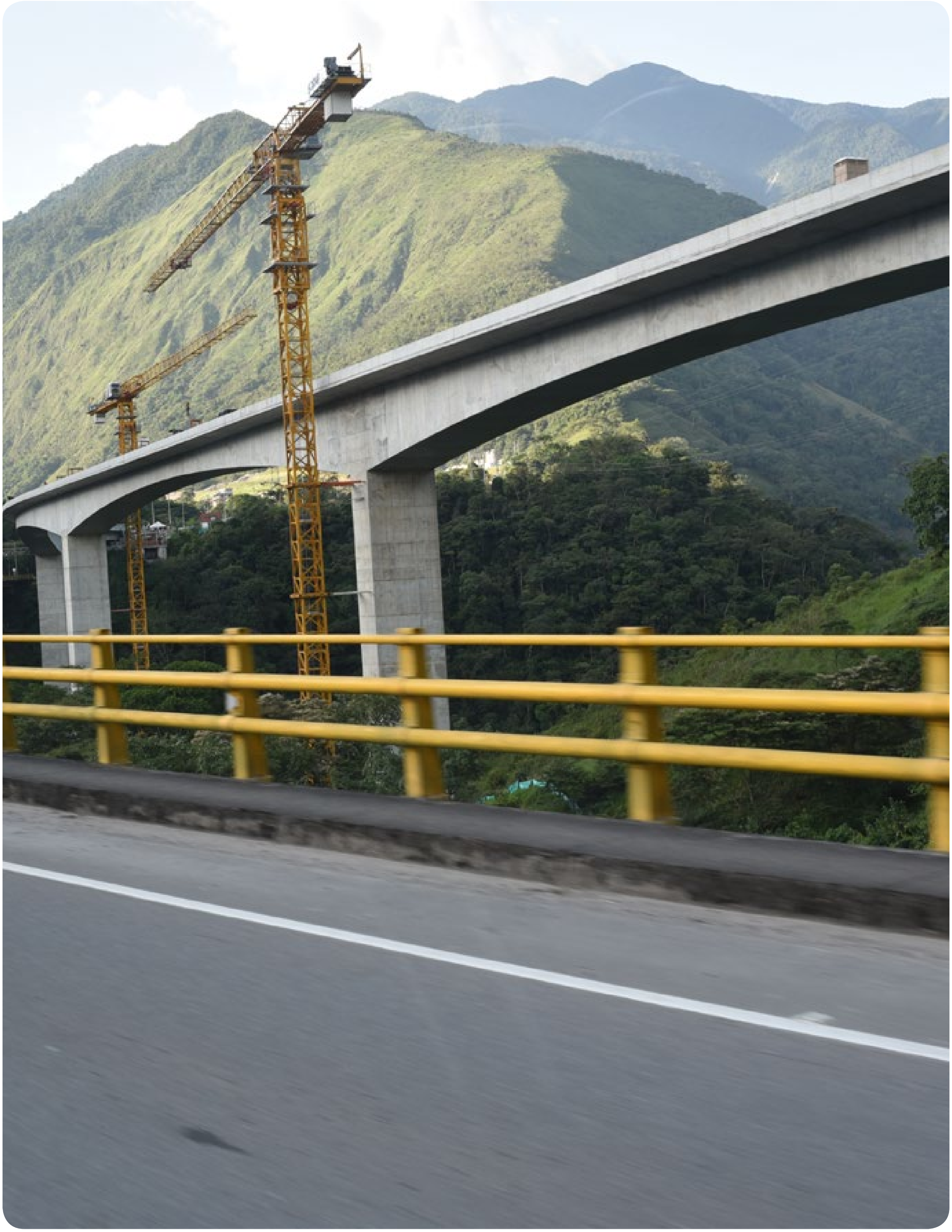
These guidelines orient the identification and removal process of road infrastructure that has become obsolete, or which has been replaced for whatever reason. Furthermore, these guidelines are oriented toward actions that must be carried out to remove infrastructure that no longer comports with current laws, and which was built without meeting territorial planning requirements and the environmental determinants, in such a way that the conditions prior to the construction of the road infrastructure are re–established.

Lineamientos

7.1. Identification of road infrastructure that needs to be decommissioned.

7.2. Removal of existing infrastructure for decommissioning.

7.3. Restoration of the affected area.



© Mario Orlando López Castro / Asesor DAASU Minambiente

Introduction

Transportation infrastructure fulfils an important supporting role in the economic activities of all types of societies. The Colombian transportation sector has established, in different planning instruments, the need to contribute to economic growth, enhance national participation in global dynamics, and respond to the need for increased competitiveness and accessibility. All these factors will enable the country to catch up with decades of backwardness in this area (PMTI, 2016).

These purposes have to be met within the framework of three mandatory global reference instances: first, the Sustainable Development Goals (SDGs), not just in the sense of considering them as general guidelines, but also in their capacity as principal aims to whose fulfilment transportation infrastructure must contribute effectively. Second, the effects associated with climate change that emerge in two directions: towards the environment, due to inadequate design, planning, construction, and operation of transportation infrastructure that increases these effects, or towards infrastructure, due to its increased vulnerability to critical climate variability events. And third, the objectives of the Convention on Biological Diversity (CBD, 1993) which seek to promote the conservation of biodiversity, the sustainable use of its components, and the just and equitable sharing of the benefits resulting from the use of genetic resources.

Globally, the development of infrastructure is advancing at an accelerated rate: by the year 2030, it is estimated that 60% of infrastructure investment – which will reach 90 trillion dollars – will correspond to the energy and transportation sectors (The New Climate Economy, 2016). Investment that will be made in the transportation infrastructure sector by 2025 will demonstrate an annual increase of 5% globally, with roads being the major investment area in growing markets (PWC, 2015).

© Ministerio de Transporte

Transportation infrastructure fulfils an important supporting role in the economic activities of all types of societies.

For countries in Latin America, transportation infrastructure constitutes a driver of economic development, competition, and integration of communities among themselves and in local and regional markets. Throughout the last decade, the region has invested between 2 and 3% of its gross domestic product (GDP) in infrastructure (EFE, 2015), of which 40% corresponds to the transportation sector. However, the existing gap in quality between infrastructure in our region and in other countries in the Organization for Economic Co–operation and Development (OECD) continues to be significant. This is even more telling if we consider that according to various studies, the average recommended investment in order to overcome this difference should reach 5% of the annual GDP (Cepal, 2011).

In Colombia, investment in transportation infrastructure has been prioritized as one of the pillars of the national economy which is essential for the achievement of purposes of social and territorial integration and the promotion of equality in a post–conflict scenario. In recent years, the country has intensified its investment in road infrastructure.[1] However, there still remains an important distance between supply and demand in infrastructure, which places it in the position number 108 of 144 countries in terms of infrastructure quality (World Economic Forum, 2016). The Inter–American Development Bank (IADB) considers it necessary to close the infrastructure gap in order to reduce the elevated logistical costs in the country and to increase competition, for which reason it is estimated that, in the subsector of roads alone, a sustained investment of at least 3% of the GDP is needed until 2020, which equals approximately US$11,500 million per year. Importantly, of this amount, 80% is needed just for responding to growth in demand. Accordingly, the intent for the basis of the National Development Plan (PND) 2018–2022 is to consider alternative financing for the development of efficient, competitive, and high–quality infrastructure that incorporates environmental sustainability.

Therefore, it is necessary that this commitment to transportation infrastructure takes into account the risk scenarios and the potential impacts that they represent to the environment. In order to ensure that the transportation infrastructure achieves functionality whilst at the same time guaranteeing environmental sustainability and resilience when faced with climate change events, the environmental element must be incorporated as early as possible, right from the very evaluation of mobility alternatives and the selection of means and modes of transportation that are seen to be necessary to meet demand.

Solving the need for transportation infrastructure projects to offer a comprehensive response to functional requirements of communication and mobility, without compromising environmental territorial planning, or threatening conservation of the biodiversity of the territory and the ecological services they offer, involves close coordination between public entities in the transportation, environment,

1. In accordance with initial estimates made by ANI, the program for fourth–generation motorway concessions (4G) involves a constant investment of approximately $47 billion pesos 2012 – CAPEX, in which CAPEX is understood as representing the required investment resources for the construction of the project. This investment is projected to be made over a period of 8 years from contracting, with infrastructure maintenance periods of between 25 and 30 years (CONPES, 2013).

agriculture, and mining and energy sectors, as well as those in territorial entities and the communities who will benefit from this infrastructure.

As a response to this need for intersectoral dialogue, the Ministry of Environment and Sustainable Development and the Ministry of Transport have maintained an active Interministerial Environmental Agenda for nearly 20 years as a permanent channel for communication and joint action. This relationship has been aimed at incorporating environmental considerations into early stages of planning, as well as executing policies, plans, programs, and sectoral projects for transportation and mobility infrastructure in the national territory. Moreover, it is aimed at contributing to their governability and promoting the strict fulfilment of regulations in environmental territorial planning, within which sustainable development of transportation infrastructure must be framed.

In order to achieve its goals, the Interministerial Environmental Agenda included in their plans of action for the periods 2015–2016 and 2017–2018 the prevention and management of conflicts between transportation infrastructure and the conservation of *in situ* biodiversity and its ecosystem services as a priority action. This was achieved by means of the development of specific regulations, guides, and general technical guidelines, as well as proposals oriented toward the development of green infrastructure and the identification of early warnings.

Thus, within this framework, interinstitutional work was carried out from 2015 onwards, which included the participation of non–governmental organizations such as the World Wildlife Fund (WWF–Colombia) and the Foundation for Conservation and Sustainable Development (FCDS). This work has led to the generation of information and technical knowledge on various themes related to the environmental and social impacts caused by transportation infrastructure on the Colombian Amazon, which in turn has allowed for the identification of the need to formulate guidelines for the country on green road infrastructure, among other things, which are proposed in the present document.

The green road infrastructure guidelines are a set of directives which have been formulated with the aim of being incorporated into road infrastructure projects. Specifically, the objective is to include environmental, social, technological, and engineering elements within these projects in order to avoid, prevent, mitigate, and correct any potential negative environmental impacts that they may cause, with a net positive environmental balance being the desired outcome. The established guidelines must be applied at the different stages, beginning from the very conception of the project and the structuring of plans and programs, as well as during planning, design, construction, operation, intervention (improvement, rehabilitation, or maintenance), until the decommissioning of road infrastructure projects.

The application of the guidelines in optimal conditions materializes only when they are executed comprehensively, in each and every one of the stages, or from the earliest stage possible. However, in the case that this optimal application is not

© Ministerio de Transporte

possible, it is nevertheless beneficial to employ the guidelines at whichever stage a project may be at.

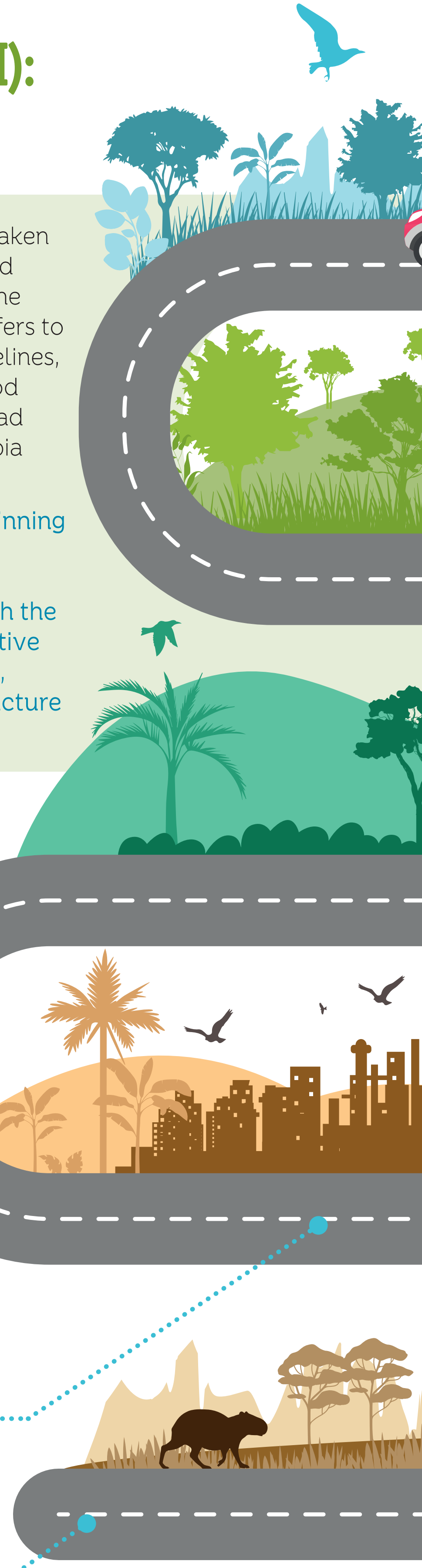
In terms of the content, the document *Green Road Infrastructure Guidelines for Colombia* presents, at the beginning, a theoretical framework which includes an initial definition of green road infrastructure for Colombia as well as a section aimed at guiding the employment of these guidelines. Throughout the remainder of the document, the Green Road Infrastructure Guidelines are presented according to each stage: i) strategic sectoral planning, ii) project planning at prefeasibility level, iii) project planning at feasibility and definitive design level, iv) construction, v) operation, vi) intervention, understood as the activities of improvement, rehabilitation, and maintenance, and vii) decommissioning.

The document *Green Road Infrastructure Guidelines for Colombia* presents, at the beginning, a theoretical framework which includes an initial definition of green road infrastructure for Colombia as well as a section aimed at guiding the employment of these guidelines.

Green Road Infrastructure (GRI): Theoretical Framework

This theoretical framework is the result of collaborative analyses undertaken between the Ministry of Environment and Sustainable Development and the Ministry of Transport in fulfilment of the priority actions defined in the framework of the Interministerial Environmental Agenda. Specifically, this refers to the priority action of generating and applying early warnings, technical guidelines, and proposals for the development of green infrastructure, among other good environmental practices, which can be used as input for the structuring of road and port projects. An initial definition of green road infrastructure for Colombia was agreed upon, and is as follows:

Road infrastructure which, throughout all its stages of development, beginning with the very sectoral strategic planning itself, and during its planning, construction, operation, intervention, and decommissioning, integrates environmental, social, technological, and engineering considerations, with the aim of avoiding, preventing, mitigating, and correcting the potential negative environmental impacts that this type of project can cause (be they direct, indirect, synergistic, and cumulative impacts). Thus, Green Road Infrastructure will generate a net positive environmental balance.



Green road infrastructure demonstrates the following **attributes:**

- It is the result of coordination between the entities responsible for planning, design, and execution of projects, the environmental authorities, and the national and territorial entities and communities that seek to benefit from such infrastructure.
- It identifies, at early stages of project structuring, the main potential impacts, be they direct, indirect, synergistic, and/or cumulative, aiming to consider them in the cost/benefit analysis. In this manner, Green Road Infrastructure contributes to the incorporation of environmental costs in the viability decision making process.
- It is functionally and structurally integrated into the transportation network in an intermodal and environmentally sustainable manner.

It incorporates management measures that tend to avoid social and environmental conflict associated to the road project, and/or it contributes to its management which empowers the community in the environmental component of the project.

It incorporates environmental considerations to guarantee the respecting of territorial planning, environmental determinants, and land use permitted in Areas of Special Environmental Interest (AEIA) in the case that these areas of influence for such transportation infrastructure projects overlap with these types of areas.

It follows strict application of the impact mitigation hierarchy.

© Ministerio de Transporte

It identifies direct, indirect, synergistic, and cumulative impacts, and it establishes adequate and effective management measures that tend to generate a net positive environmental balance.

It favours landscape ecological connectivity.

It contributes to the conservation and/or restoration of the structure, function, and dynamics of land and aquatic ecosystems.

In the case of the persistence of environmental impacts that were not possible to prevent, mitigate, or correct, Green Road Infrastructure promotes and applies environmental compensation measures, being both aggregate and follow-up measures, to those proposed by other projects, or with regards to the initiatives for the strengthening of territorial environmental planning, with the aim of achieving effects on a local and regional scale.

It incorporates criteria and measures that tend to allow for transportation infrastructure to contribute to the mitigation of climate change and risk management in all phases of the road infrastructure project.

© Thomas Cristofoletti / WWF-US

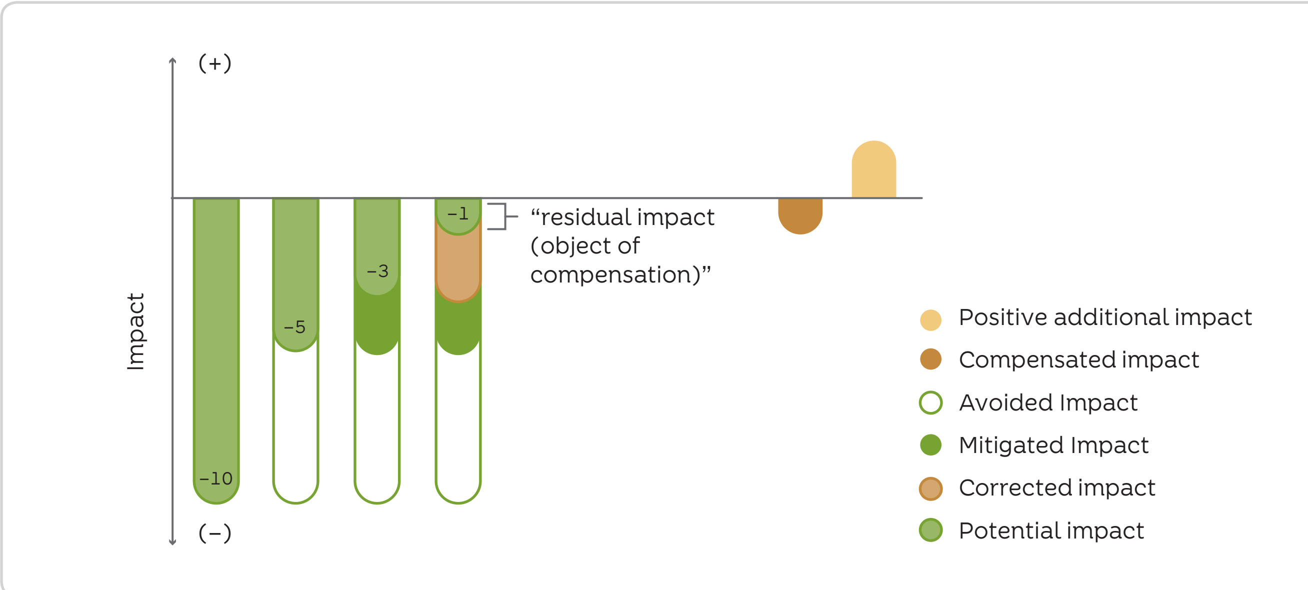
The green road infrastructure projects are, by definition, comprehensively compatible with conservation and the improvement of conditions that renewable natural resources and existing environments present in their area of influence, which then translates into projects that achieve a net positive environmental balance. The construction and operation of green road infrastructure implies that, from the structuring stage of this type of project as well as throughout the other stages of its execution, the impact mitigation hierarchy be applied.

The aim of this application is for establishing and implementing, in the first instance, the location, layout, design, engineering, and management measures that are designed to avoid causing most negative environmental impacts. In the second instance, and in a subsidiary manner, the aim is to apply those measures which are intended to mitigate the negative impacts which are not possible to avoid, whereas in the third instance, it is to apply those measures directed at correcting the negative environmental impacts that are not able to be avoided nor mitigated, re-establishing the conditions of the setting that existed before the execution of the project. Finally, in the fourth and last instance, the mitigation hierarchy contemplates the application of the measures designed for compensating the negative environmental impacts that are not able to be avoided, prevented, mitigated, or corrected.

In addition to the fulfilling of these necessary but insufficient conditions, green road infrastructure projects must integrate environmental, social, technological, and engineering elements so that they generate changes that benefit the pre-existing environmental conditions prior to commencing the execution of the project. Furthermore, when compared with these pre-existing conditions, they ought to represent a net positive environmental balance that is evidenced in one or several of the biodiversity and ecosystem services that they offer (Figure 1).

The green road infrastructure projects end up, by definition, comprehensively compatible with conservation and the improvement of conditions that renewable natural resources and existing environments present in their area of influence.

Figure 1. Management measures hierarchy



Source: Adapted from OECD (2016).

On the other hand, the variety and complexity of the potential impacts that construction, operation, and intervention projects of transportation infrastructure can generate transcend the spatial limits of the works. Thus, it is not in vain that this type of infrastructure is assessed as one of those with most capacity for transformation of a territory, because of the multiplying effect that it has over other projects and activities. Transportation infrastructure is recognized as a driver of development activities.

This means that all direct, indirect, synergistic, and cumulative impacts must be considered during the process of delimitation of an area of influence of a transportation infrastructure project, which is defined as a zone in which the significant environmental impacts caused by the execution of the project are manifested. A green road infrastructure project must incorporate considerations related to planning and environmental territorial planning on a regional scale.

Early Intervention Approach (EIT)

© Mario Orlando López Castro / Asesor DAASU Minambiente

The formulation of the Green Road Infrastructure Guidelines has considered an analytic, conceptual, and practical approach that highlights the benefits of incorporating the concepts, instruments, and the best available information to support the decision–making process at each one of the stages of conception, planning, and execution of projects in the timeliest manner possible. This approach has thus been denominated: **The Early Intervention Approach (EIT).**

For the EIT, the carrying out of analyses of the economic, technical, and environmental viability of works prior to decision making is inherent, to which concepts such as governance, the mitigation hierarchy, and the road cluster applied to the management of direct, indirect, and cumulative impacts are incorporated.

For the EIT, the carrying out of analyses of the economic, technical, and environmental viability of works prior to decision making is inherent, to which concepts such as governance, the mitigation hierarchy, and the road cluster applied to the management of direct, indirect, and cumulative impacts are incorporated. Moreover, the EIT promotes the application of technical instruments such as the Environmental criteria for the prioritization of roads, the Sectoral guides of good practice and the environmental determinants of territorial planning. This is conceived in such a way as to permit the strengthening of decision making associated to the viability of transportation initiatives and the planning of viable projects, and which prevent the construction of roads which present a low deterioration resilience, and vulnerability when faced with extreme climate events, social conflicts, or cost overruns.

With a view to the incorporation of the analysis tools that comprise the EIT, a description of both the approach itself and the tools that comprise it in its application is conducted.

Theoretical framework

The EIT is a set of tools for analysis that are recommended to be applied in early planning instances in the execution of each one of the stages of the project cycle. It includes prior preparation, addressed from the perspective of territorial planning, which allows for the creation of initial conditions of land use and occupation with the intention of avoiding, preventing, mitigating, and compensating impacts. Furthermore, it permits the generation of conditions of stability for the populations that may be vulnerable to the pressures exercised by legal and illegal players in a context of difficulties of property legalization in environmentally sensitive areas. The concept incorporates the elements of ecological connectivity and ecosystem fragmentation, capillarity, analysis of environmental conflict, governance, the analysis of direct, cumulative, and synergistic impacts, and the effects caused by the road clusters.

The EIT proposes to carry out additional analyses to those that are currently required for environmental licensing, which are fundamental when determining economic, technical, and environmental viability of works, taking into account that some may have special requirements due to being in environmentally sensitive zones.

The Early Intervention Approach highlights the importance of generating and incorporating relevant, updated, and precise information in decisions. This provides benefits which includes, among others, the prevention of cost overruns due to the construction of roads which are not very resilient (those which suffer early deterioration, are vulnerable to losing their structure and functionality, require permanent intervention for maintenance, rehabilitation, or improvement, and which cause environmental liabilities and damages), and that cause social conflicts (they increase risks and threats and generate negative impacts on the population).

The EIT incorporates the mitigation hierarchy as one of its conceptual bases in view of the methodological approach that this model has established. In this way, the projects, works, or activities that have the potential to impact upon environmental components can plan and execute effective measures for, in the first instance, avoiding, or alternatively, minimizing, then correcting or finally compensating for the impacts caused. The carrying out of these measures has the objective of achieving a net zero loss of biodiversity (BBOP, 2009; Price Waterhouse & Coopers, 2010).

Finally, it is pertinent to mention that the EIT emphasizes the importance of including: i) agro–ecological arrangements in the context of the execution of road construction or intervention projects, with the aim of generating an interaction pattern between the road project and the environment to conserve the natural coverage and the ecological processes that are developed within them and ii) good environmental and engineering practices aimed at minimizing the negative impacts caused by projects.

Tools for analysis

The main analysis tools used by the EIT are: i) Governability and governance, ii) Territorial planning, iii) Direct, indirect, cumulative, and synergistic impacts, iv) Ecological connectivity, v) Capillarity, and vi) Road clusters, in relation to which the actions described throughout this chapter are proposed.

Governability is the expression of the State's capacity for ensuring fulfilment of its goals in an efficient and effective manner. This is understood as a result of inter–institutional action and the participation of communities at the decision–making level of governmental policies, plans, programs, and projects that concern their territory, and which are applied and executed there. On the other hand, **governance** is understood as being the capacity for government actions to have been agreed via participative mechanisms, in which there is efficient inclusion of interests and opinions of the different members of society and, in light of this, there is a generalized appropriation of such actions. In this sense, State intervention is assessed as being efficient, legitimate and of high quality.

The construction of green road infrastructure implies harmonious coordination between social organizations and State institutions, a condition which is incorporated in the concepts of governability and governance.

Territorial planning is a set of planning actions undertaken by authorities to guide the development of the territory and to regulate the use, transformation, and occupation of space.

Guaranteeing the respecting of environmental determinants of territorial planning is a necessary condition so that infrastructure projects can be undertaken without affecting the areas of special environmental interest, and in other territorial planning figures that impose restrictions upon their use.

Environmental impact is understood as any alteration in the environment, be it beneficial or adverse, partial or total, that can be attributed to the development of a project, work, or activity.

The analysis of impacts is often limited to those which are direct, without considering the **indirect, synergistic, and cumulative** impacts which can be of greater magnitude than the first ones. For this reason, the EIT emphasizes the need to analyse those which are generated, not because of the activities of the project, but instead as a product of the driving effect that the project has, and those which are generated as a combined effect of various individual, spatial, and temporary impacts.

Ecological connectivity is understood as being the necessary condition of ecosystems to maintain the natural movement and dispersion of the wild flora and fauna species, genetic exchange, and other ecological flows (matter and energy). At the same time, the connectivity corridor is understood as being a delimited geographical space that provides connectivity between landscapes, ecosystems, and natural or modified habitats, and which ensures the maintaining of biological diversity and ecological and evolutionary processes (CCAD, 2020).

For projects that are evaluated as being green, the fact that their structuring, design, execution, and operation consider characteristics and measures that contribute to conservation and strengthening of ecological connectivity corridors is an inherent element.

In view of the present document, the concept of **capillarity** is understood as being the capacity of a structure (e.g. a road) to maintain the flow of matter and energy by means of the preservation of the natural cover and vegetation structure along the road and the buffer zones of water bodies with which the road overlaps, thus mitigating the impact upon ecological connectivity. A road intervention or construction project that is evaluated as being green must consider the measures for improving the permeability of biodiversity movement (e.g. the enriching of natural cover in the buffer zone of water bodies, the adaptation of drainage works, the design and construction of wildlife crossings, the establishment of multifunctional reticles of ecosystem connectivity, and the conformation of agroecological arrangements).

The measuring and analysis of the level of capillarity of a road permits the orienting of efforts to design and implement measures and technological solutions to reduce impacts and to improve the permeability of the road infrastructure project.

Finally, a **road cluster** is a set comprised of road infrastructure, the centres of occupation, and their articulation nodes regarding social and territorial dynamics.

In order to analyse the impacts of the construction of roads, it is necessary to consider not only those which are generated by individual roads, but instead those which are produced as a set which form a part of road networks. The concept and the information on road clusters allow for this type of analysis.

As an example, applying some elements of analysis from the established tools, the following actions could be undertaken:

- Determine with absolute clarity the objectives, purposes, and aims of executing the road project, and to which communication and transportation needs it offers a solution.
- Generate all the information about the project and the context (physical, biotic, and socioeconomic) in which it will be executed in order to take better execution decisions.
- Make the best information available to the community so that it can contribute to decision making in a documented manner.
- Determine the area of influence of the green road infrastructure project, which at a minimum corresponds to the area in which the potential direct and indirect, synergistic, and cumulative impacts manifest themselves at a regional level.
- Identify the environmental determinants of territorial planning that exist in the area of influence of the project and plan the project in accordance with such determinants.
- Undertake the identification of the regional ecological connectivity corridors as areas for carrying out management measures.
- Apply the mitigation hierarchy at a regional level including the indirect, synergistic, and cumulative impacts.
- Design and incorporate "green" engineering solutions (structures for the management of water bodies and buffer zones, wildlife crossings, and landscape design) and good environmental management practices.

Governability and governance as bases of a green road infrastructure project in areas of high environmental and social sensitivity

The construction of harmonious coordination between social organizations and State institutions for the achieving of social objectives and the sustainable development of transportation infrastructure requires constant institutional and social articulation. This is particularly relevant in order to achieve a transition toward governability and governance in the context of post–conflict Colombia. For this reason, it is necessary to contribute to the strengthening of the capacity of social organizations to facilitate their participation in topics related to the environmental management of projects of transportation infrastructure in their territories. The mechanisms that are described below contribute, in a unique manner, to this objective, and more generally, to the construction of legitimate governability and participative governance, with the objective of planning, executing, and generating the very benefits of green road infrastructure projects:

- Educate in environmental regulation, and citizen participation and social control mechanisms, in the context of the development of transportation infrastructure projects.
- Facilitate local participation in development and planning proposals through the Rural Plans of Sustainable Development[2].
- Disseminate among the community the information on environmental impacts, social conflicts, and opportunities that these transportation infrastructure projects offer.

2. Planes Veredales de Desarrollo Sostenible.

- Generate permanent channels of communication and articulation between communities and State entities in the context of project development.
- Guarantee the community participation in the decision–making processes about the viability and characteristics of the project.

Territorial planning

The recognition of territorial planning and its environmental determinants is a necessary condition for the protection of special areas of environmental interest, as well as for other planning figures within the framework of a green road infrastructure project. Areas such as National Natural Parks (PNNs) and Regional Natural Parks (PNRs) with the greatest restrictions on land use, as well as other areas with an environmental management zoning that allows for the sustainable use of some of their areas, should be considered in project decisions early on in the selection of routes. Likewise, ecological connectivity corridors, areas with natural cover or where agroecological arrangements have been implemented that allow for sustainable land use without compromising forest structure, biodiversity and ecosystem services, should be the object of measures to avoid negative environmental impacts and generate positive environmental impacts.

The recognition of territorial planning and its environmental determinants is a necessary condition for the protection of special areas of environmental interest as well as for other planning figures.

Attention to direct, indirect, synergistic, and cumulative impacts.

For the purpose of attending to environmental impacts adequately, the EIT acknowledges that the environmental assessment and the formulation of management measures for transportation infrastructure projects can be strengthened. In this manner, they foment actions which are aimed at ensuring that the environmental measures generate a net positive environmental balance and that they transcend the local scale, ensuring that they make an impact at the regional scale in which the effects of road construction and operation are visible at the level of ecosystems.

The EIT recognizes that from the moment in which a transportation initiative is publicly formalized, expectations are generated in its area influence that can cause environmental and social impacts, particularly in the areas which demonstrate conditions of high environmental sensitivity and low levels of governance, such as those affected by conflict. Studies carried out in countries in the Amazon basin by the Institute Pesquisa Ambiental de Amazônia (IPAM) have shown that the main cause of deforestation associated to the construction of roads is illegal land grabbing, especially those in areas denominated government–owned lands or the Nation's "wastelands". This is primarily because in these areas, there is little governance due to the low level of institutional influence, or the existence of illicit economies (mining, illegal crops, grabbing and undue accumulation of lands, etc.).

Even though planning and design activities are currently developed using environmental and social information, and are supported by cost models developed with simulations to minimize this type of impact, it is nevertheless especially important to include the following considerations:

- Select road layouts conceived to avoid the affects on the protected areas, the ecological corridors, the vulnerable ecosystems, and areas of high historical, cultural, or religious value.
- Achieve a balance between the costs of building activities, the environmental sensitivity of the areas of intervention, and the management of environmental impacts of the project.
- Incorporate specially designed hydraulic works adapted to the conditions of climate variability and extreme events.
- Promote the conservation of areas of special environmental interest involving the communities near road infrastructure projects.

One of the premises of the EIT is that sensitive and strategic ecosystems must include prior preparation to the undertaking of any project, work, or activity that can impact upon them. This is achieved by means of the incorporating of agreements among the environmental, agricultural, and planning sectors that restrict land uses in order to guarantee the maintenance of natural cover and the stability of the local population.

Moreover, at the prefeasibility stage, the evaluation of structural ecosystem connectivity must be carried out for the affected landscapes, based on an area that incorporates the cumulative and synergistic impact zones.

From the earliest instances of the planning of road infrastructure projects, works, or construction and intervention, direct, indirect, synergistic, and cumulative social and environmental impacts are generated due to the creation of expectations in the area of influence. Some of the impacts that, despite their importance, are generally overlooked in a timely analysis are:

- Price speculation of land in the areas adjacent to the road infrastructure project.
- Land appropriation and grabbing and irregular purchases in areas of low governability.
- Accelerated deforestation of natural areas to incentivize low-investment productive systems (cattle).
- Displacement of vulnerable populations by players and interests in the project.
- Accelerated immigration.

In the aim of mitigating the generation and magnitude of these impacts, the EIT promotes:

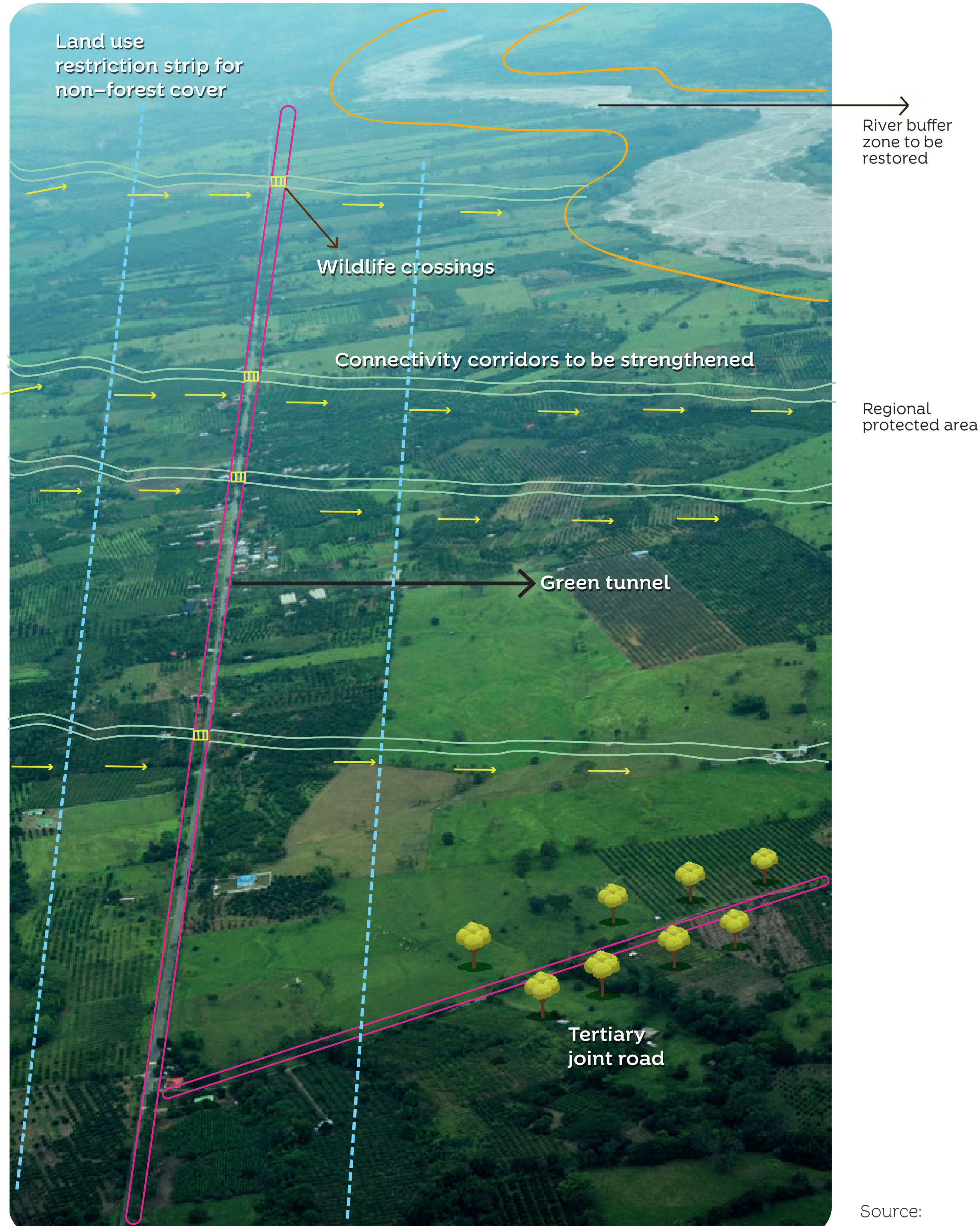
- Generating and disseminating accurate, pertinent, and timely information to all of the interested stakeholders.
- Identifying, recognizing, and embracing the figures of territorial planning and their environmental determinants.

© Ministerio de Transporte

- Fostering the strengthening of the governability and governance scenarios in the context of project planning.
- Carrying out actions for planning and regulating the economical valuation of land, with the aid of property valuations and the identification of potential socioeconomic impacts.
- Identifying and evaluating the direct, indirect, synergistic, and cumulative environmental impacts of the road infrastructure project within a range of no less than 5km from one side to another along the road. The analyses of changes in global forest cover (Laurence, 2017) and in the Colombian Amazon (FCDS, 2017) indicate that 90% of deforestation is caused within these first 5 kilometres.
- Identifying the location of hydrographical subbasins, water bodies and their buffer zones.
- Monitoring, throughout its life cycle, the natural cover, population centres, transportation infrastructure, and land accesses that are not part of the project. This is to be achieved by flyovers at low heights, with the aim of early identification of phenomena of deforestation, drainage networks, possible ecological connectivity corridors, unplanned changes in land use, and the construction of illegal terrestrial accesses.
- Undertaking retrospective and prospective (trend) modelling of human intervention and deforestation.
- Periodically carrying out land and population inventories in the project's area of influence.

In order to illustrate the above, in the following figure part of the area of influence of a stretch of road that is the object of structuring of an intervention project can be observed. In this figure, some of the actions that have been recommended by the EIT to be considered in the process of planning of these types of projects are also observable.

Figure 2. Examples of actions recommended for consideration by the EIT to identify and manage the direct, indirect, synergistic, and cumulative environmental impacts of road projects.



Source: FCDS, 2020

It is important to note that the early consideration of environmental impacts and the consequent formulation of measures to avoid or mitigate them can prevent the generation of cost overruns, in that they constitute a mechanism that facilitates the structuring of a project which is resilient to deterioration and the occurrence of extreme climate events or other types of threats.

◇ Regional ecological connectivity corridors: retrospective and prospective scenarios

In the initial stages of road infrastructure project conception, retrospective and prospective spatial analyses must be developed, being principally focused on the identification of deforestation trends and in the identification of the state of ecological connectivity corridors at a regional scale (1:100.000). The modelling exercises ought to be carried out based on these areas of reference, as well as the analysis of the landscape and critical area transformation vectors.

Following this, in the elaboration of definitive studies and designs, the modelling of ecological connectivity corridors must be modelled on a subregional or local scale (1:25.000 or more detailed). These should be based on studies of endemic, migratory, and under-threat or vulnerable fauna, with the aim of avoiding their being affected, or to even promote their strengthening (e.g. by means of conservation and restoration of natural cover in connectivity corridors), as well as the designing and establishing of complementary mitigation and correction measures, such as the construction of wildlife crossing systems.

The undertaking of analysis on the level of capillarity that a road presents permits the directing of efforts to design and implement measures and technological solutions to reduce the barrier effect and to improve the permeability of the road.

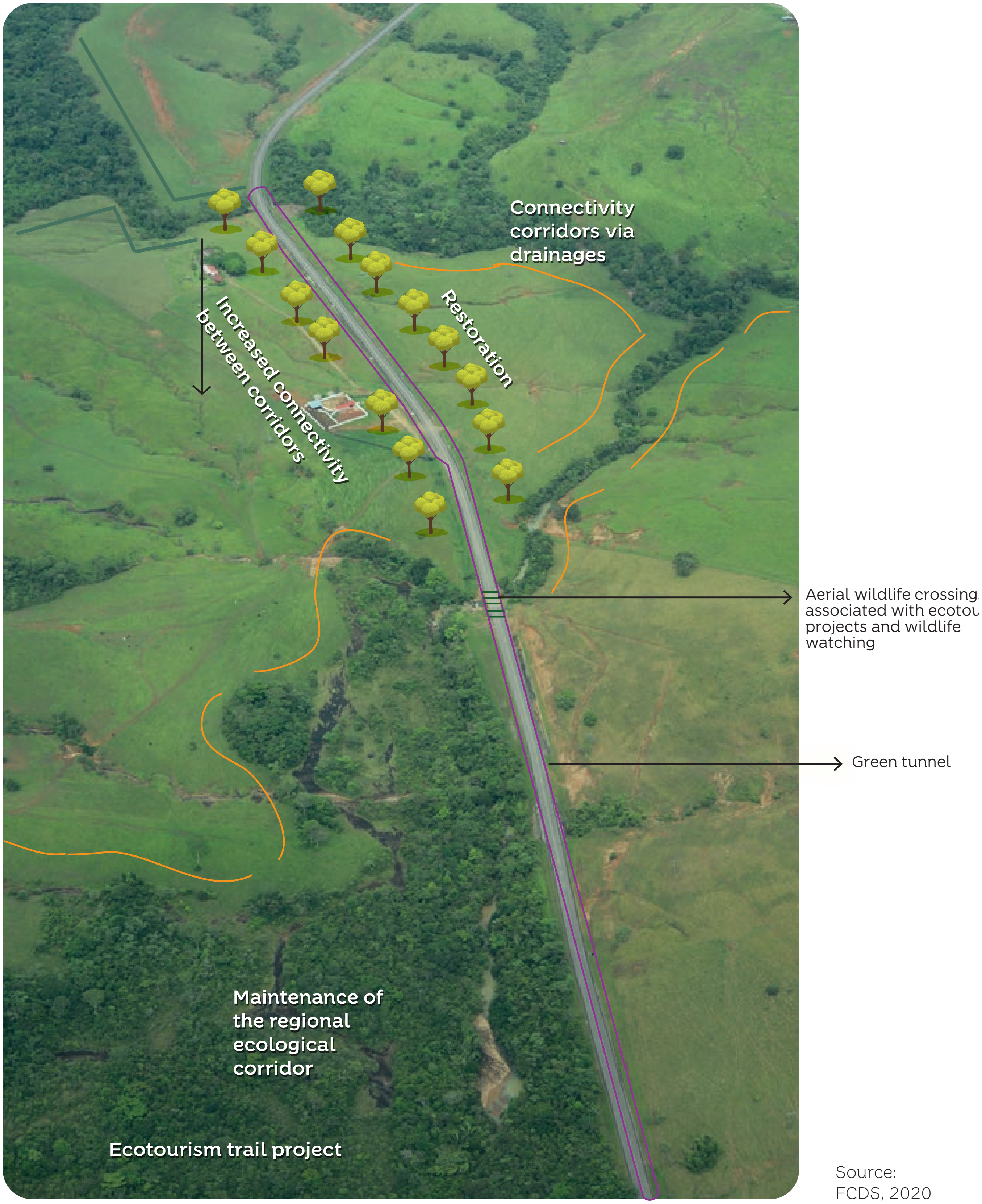
◇ Capillarity

The undertaking of analysis on the level of capillarity that a road presents permits the directing of efforts to design and implement measures and technological solutions to reduce the barrier effect and to improve the permeability of the road, thus mitigating the interruption of matter and energy flows of the ecosystems affected by transportation infrastructure. The importance of applying a capillarity strategy[3] as a tool for the execution of management measures that should be incorporated into the design of road infrastructure is highlighted in order to contribute to the maintenance of the functionality of regional and local ecological connectivity corridors.

Below is an image of part of the area of influence of a stretch of road in which some actions that could be implemented to improve road capillarity are shown: reconnection of ecological connectivity corridors, establishment of corridors in the buffer zone of water bodies, enrichment of natural cover, creation of green tunnels and construction of wildlife crossing systems.

3. Generally speaking, the capillarity strategy consists of focusing efforts to maintain the functional connectivity of the ecosystems affected by road infrastructure, in the conservation of the natural conditions of the water bodies and their buffer zones, and in the adaptation of wildlife crossing systems that optimize the permeability of the road infrastructure.

Figure 3. Actions to improve the capillarity of a road



Source: FCDS, 2020

Road clusters

In the framework of the EIT, the analysis of the dynamics of road clusters makes it possible to identify the possible generation of indirect, synergistic, and cumulative environmental impacts at the regional or subregional scale. While these impacts may not necessarily be evident based solely on ad-hoc information and analysis, it is nevertheless possible to detect alterations in the processes of land occupation, use, management, and utilization due the construction of roads.

The accessibility generated by a road when it is built in the vicinity of natural areas is not only limited to the corridor in which the road is built, as it also affects distant areas insomuch that they enhance the economic dynamics and the generation of new accesses.

© Ministerio de Transporte

Local land use arrangements in areas adjacent to or impacted by the roadway.

Local land use arrangements are defined as social and institutional agreements to establish strategies to conserve natural land cover, water bodies, and areas for productive activities, allowing for the conservation of biodiversity and its ecosystem services as well as soil productivity. In order to adequately establish these agreements and carry out appropriate land management, detailed information on soil suitability is needed, as well as on the existence of ecological connectivity corridors, and the presence of key wildlife species such as dispersers.

For all the above, carrying out wildlife monitoring with community participation in the project's area of influence at different times of the year is a strategy which is useful for generating the relevant information for the definition of measures and the management of impacts. Moreover, it is a powerful tool for the appropriation, valuation, and conservation of biodiversity by the local population.

Aspects of "green" engineering and good environmental and social practices

Green engineering and good social and environmental practices in the context of environmental management of transportation infrastructure involves a set of actions oriented toward minimizing the negative impacts on the environment and communities in a project's area of influence, as well as using environmental information aimed at the strengthening of decision making or by means of the execution of technological and engineering solutions.

Accordingly, and within the framework of the proposed approach, one of the good practices to be adopted involves the undertaking of landscape modelling on a subregional scale (1:25.000 to 1:10.000). This modelling supplies strategic information to support the definition of the layouts and the construction of engineering works using environmental and economic sustainability criteria on a landscape scale.

Additionally, and as a good practice, areas with the presence of endemic, migratory, or threatened or vulnerable wildlife should be identified, especially when taking into account how sensitive this resource is to the impacts caused by road infrastructure projects during both construction and operation. One easy way to identify the presence of wildlife species is the systematic use of camera traps, and in what follows, some images that capture the presence of wildlife in road project's areas of influence are shared:

Figure 4. Images of wildlife captured with camera traps.

Source: FCDS, 2020

Source: FCDS, 2020

Similarly, another good practice is the carrying out of geomorphologic analysis of the water bodies upon which bridges, box culverts, and culverts are planned to be built. The purpose of such an analysis is to not only optimize project design but also to avoid impacting water flow at different periods of the year, and to adapt the structure to allow the passage of wildlife. In the image below, some structures with adaptations that allow for the passage of wildlife in the buffer zone of water bodies are shown.

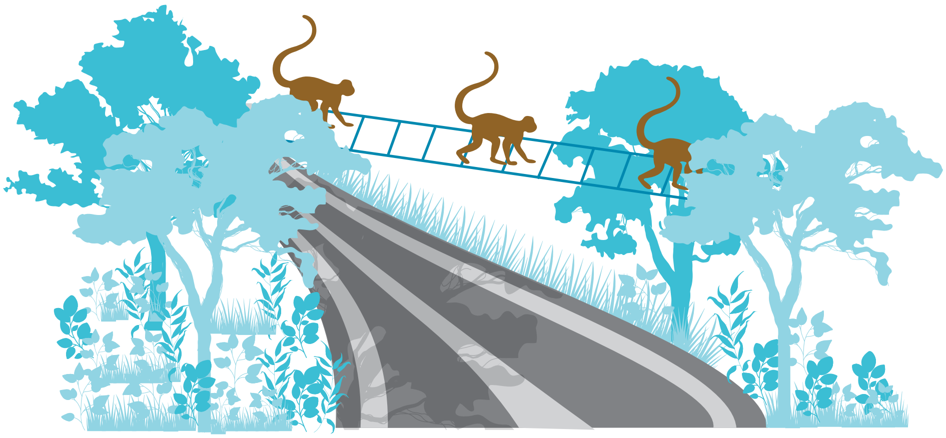
Figure 5. Examples of road structures at water body crossings with adaptations that allow for the passage of wildlife.

Source: FCDS, 2020

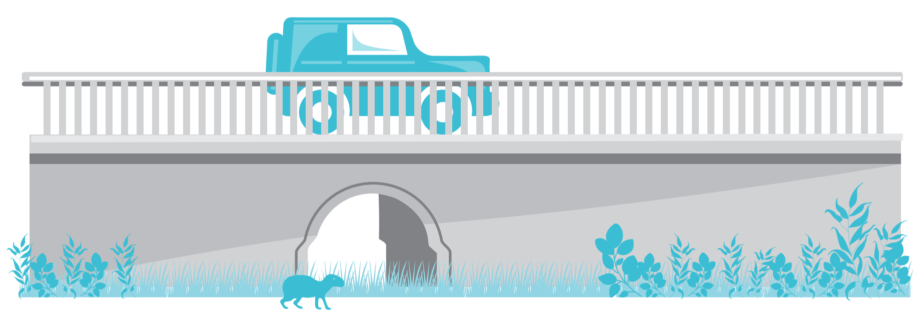
These same considerations ought to be taken into account for the design and construction of aerial, land, and aquatic wildlife crossing systems related to roads and other transportation infrastructure, with the aim of minimizing the running over of animals. The following provides a basic diagram of these types of wildlife crossings.

Figure 6. Diagrams of types of wildlife crossings

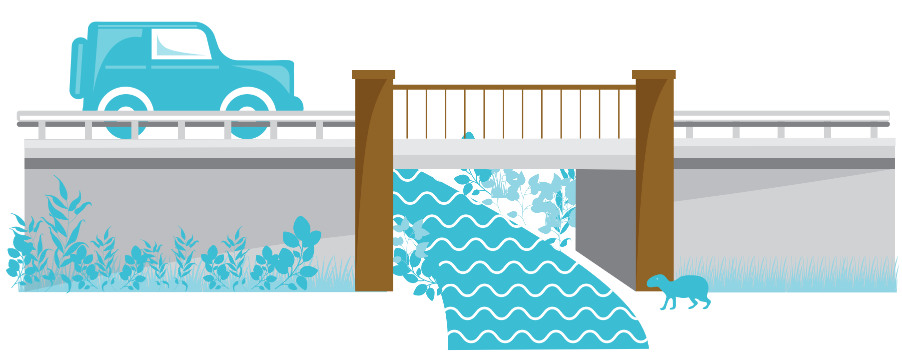
1. Aerial crossings



2. Dry land crossings



3. Aquatic crossings

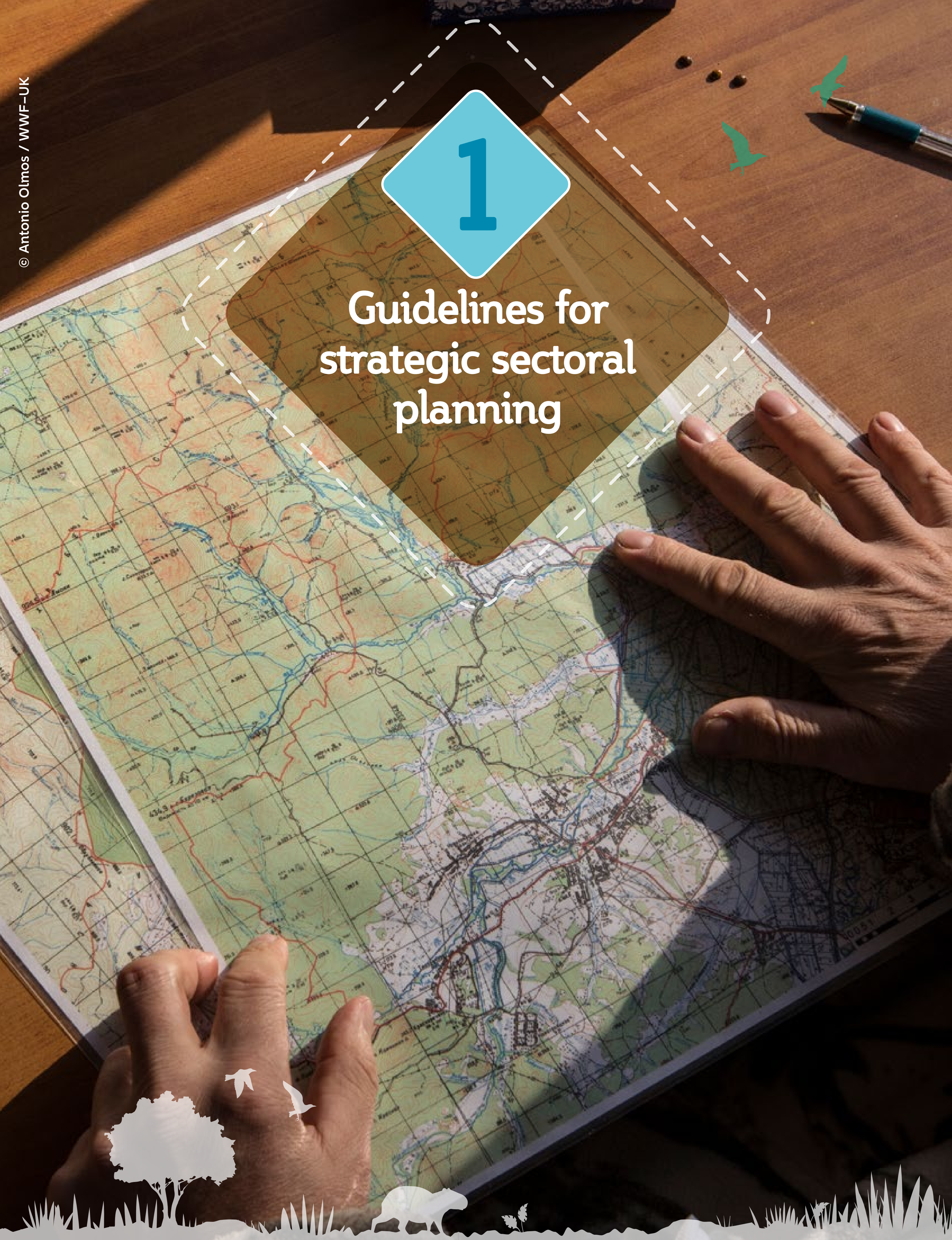


Source: FCDS, 2020

The structure of the wildlife crossings should be complemented in some cases with the inclusion of other accompanying structures that guarantee their functionality, such as mesh fencing created to direct the wildlife to the crossing structures, as can be observed in the following images:

Figure 7. **Examples of mesh fencing used as adaptations for wildlife crossings.**

Source: FCDS, 2020



© Antonio Olmos / WWF–UK

1

Guidelines for strategic sectoral planning

1.1 Develop strategic environmental assessments as part of the process of structuring and issuing sectoral policies, plans, and programs

The Strategic Environmental Assessment (EAE) is a support instrument for the incorporation of the environmental dimension in strategic decision making, as well as in policies, plans, and programs contributing to the strengthening of these planning instruments (Cepal & Minambiente, 2009).

Since the strategic planning policies and strategies impact a broad set of subsequent decisions that are generated based on directives or orientations, it is appropriate that prior to or during their structuring, either EAE or regional strategic environmental assessments (REAE) be created. Further, the recommendations for sectoral policies, plans, and programs they present ought to be effectively incorporated so that their guidelines are as environmentally sustainable as possible.

Using the long-term analyses of the EAEs, the early identification of transportation infrastructure development alternatives that are environmentally sustainable is possible. In territories whose use has been determined to be for conserving biodiversity and the ecosystem services that they offer (e.g. protected areas, forest reserve areas), the development of transportation infrastructure – especially road infrastructure – can generate undesirable impacts due to its considerable power for transformation. These undesirable impacts need to be prevented by means of clear messages that are explicitly manifested in the planning policies and instruments. Proposals that incorporate green intermodality and infrastructure can constitute the alternatives that make, from an environmental point of view, communication and transportation solutions viable for the territories in which this type of conservation or special management figure exists.

Furthermore, from the transportation infrastructure policies, plans, and programs in the EAEs, general guidelines can emerge in terms of the type of projects that should be developed afterwards. Among those highlighted are the level of economic resources needed to finance the studies, including the environmental ones, and the execution of green infrastructure projects that help avoid, mitigate, and correct a large part of the significant environmental impacts. Finally, these guidelines can also incorporate considerations for mitigating climate change and the management of risk, in addition to providing net positive environmental benefits.

The Strategic Environmental Assessment (EAE) is a support instrument for the incorporation of the environmental dimension in strategic decision making, as well as in policies, plans, and programs.

1.2 Contribute to the achievement of Sustainable Development Goals (SDGs) 15 and 13

- The SDG 15 is aimed at the sustainable management of forests, the fight against desertification, the stopping and reversing of land degradation, and the stopping of biodiversity loss.

> **During the formulation of sectoral planning policies and instruments, it is essential to analyse the implications that the guidelines have on the conservation of land ecosystems, as well as guaranteeing the formulation of guidelines that contribute to fulfilling the cited SDGs.**

- At the same time, the SDG 13 has as its objective the strengthening of resilience and adaptation capacity to the risks associated with the climate and natural disasters in every country.

Transportation sector strategic planning policies and instruments generate expectations that promote the definitive transformation of a territory. When this pressure is exercised on natural areas, the transformation threatens the complete fulfilment of the objectives and goals that have been proposed.

During the formulation of sectoral planning policies and instruments, it is essential to analyse the implications that the guidelines have on the conservation of land ecosystems, as well as guaranteeing the formulation of guidelines that contribute to fulfilling the cited SDGs.

1.3 Include territorial planning determinants in the process of structuring and issuing sectoral policies, plans, and programs

Law 388 of 1997 establishes a number of determinants of territorial planning, which are higher-ranking norms that must guide the formulation of land-use plans, with the purpose of integrating the variables of the environmental dimension in land-use planning and in the management of occupancy processes. The first set of determinants is related to the conservation and protection of the environment, natural resources, and the prevention of natural hazards and risks, also known as environmental determinants.

The formulation of sectoral transportation policies, plans, and programs must include environmental determinants, with the purpose of not only harmonizing the developmental objectives of transportation infrastructure with territorial environmental planning, but also achieving a synergistic effect between development planning and planning for land use.

The Areas of Special Environmental Interest (AEIA) are an example of an environmental determinant to be considered. These are areas which, due to their environmental characteristics, ecosystem importance, the biodiversity that they house, the ecosystem benefits they provide, and their location, must be conserved in terms of their structure and function. The purpose of this is to guarantee the continuity of ecological and evolutionary processes, ensuring the offer of environmental goods and services for human well-being, and for guaranteeing the continuity of the natural environment and its components.

The National Agricultural Frontier, established by the Ministry of Agriculture and Regional Development (Minagricultura), is another figure related to territorial planning. In this case, it is related to the productive and social planning of rural property which promotes efficient rural agricultural soil use and the strengthening of productivity and competition in the sector's activities. According to the definition established in Resolution 261 of 2018 of Minagricultura, it is the boundary of rural land that separates areas where agricultural activities are carried out, conditioned and protected areas, those of special ecological importance, and the other areas in which agricultural activities are excluded by law.

In consideration of the above, sectoral policies, plans, and programs aimed at supporting agricultural activities should be directed toward the interior of the agricultural frontier, thus avoiding impacting on ecosystems in natural areas.

1.4 Incorporar la sostenibilidad ambiental en los objetivos de las políticas, planes y programas sectoriales

Sectoral transportation policies, plans, and programs should contribute to the fulfilment of national environmental policies in order to guarantee environmental sustainability. To this end, the promotion of initiatives compatible with environmental policies and strategies, as well as with their territorial guidelines, should be incorporated in early stages of sectoral planning for transportation and other sectors that have an impact on transportation planning, such as mining, hydrocarbons, agriculture and livestock, among which the following are indicated:

- The Policy for Comprehensive Management of Biodiversity and Ecosystem Services (PCMBES).
- The National Policy for Comprehensive Management of Water Resources.
- The Policy for Sustainable Land Management.
- The Comprehensive Strategy for Deforestation Control and Forest Management (CSDCFM).
- The National Policy for Sustainable Production and Consumption.
- The National Policy for Climate Change.

1.5 Consider and incorporate alternative modes of transportation to road transportation in the process of formulating sectoral policies, plans, and programs

Due to the dynamics of land use, management, and occupation which, in the Latin American context, generate or strengthen the construction of roads, they are recognized as having the capacity to generate significant environmental impacts.

Given that some of these impacts are negative, it is advisable to consider complementary or alternative infrastructure and transportation solutions to roads during the formulation of sectoral policies or in the structuring of planning instruments.

This is especially so because these negative impacts can introduce processes that conflict with land use planning, threaten the fulfilment of environmental policy objectives, or are detrimental to the goals or commitments that a country has established in order to achieve sustainable development.

Some possible alternative modes of transportation to roads include air, rail, maritime and river transportation, one or more of which might meet the objectives of transportation connectivity without compromising the environmental heritage of a given territory.

1.6 Define as a policy the incorporation of prefeasibility and feasibility analyses for the structuring of construction and improvement projects for secondary and tertiary roads

The transportation sector has determined that prior prefeasibility and feasibility analyses should be conducted before obtaining designs[4], with the aim of progressively assessing the economic viability of a project for the construction of maintenance of primary roads. This best practice constitutes an opportunity for evaluating the economic viability of an option that involves an alternative of low environmental impact in the early stages of structuring of a road project. At the same time, it includes the corresponding costs in the development of, among others, environmental studies, and those related to the execution of environmental management plans.

Just as with the case of primary roads, the construction and maintenance of secondary and tertiary roads require a similar process of economic viability evaluation of alternatives that adequately incorporate the technical, social, and environmental components. In fact, not having done so in this manner is a possible cause of the fact that in the country "there are (...) a number of tertiary roads constructed with inadequate outlines, designs, and technologies that generate significant negative environmental impacts which are vital to quantify and assess, and upon which actions ought to be taken to prevent this from continuing to happen", as expressed in CONPES 3857 of 2016.

4. INVÍAS – National Institute for Roads, 2008. Manual of Geometric Design.

2

Guidelines for project planning at prefeasibility level

© Becca Skinner / WWF-US

2.1 Formulate solutions to transportation connectivity needs that consider and incorporate alternative modes of transportation to road transportation

It is the responsibility of the Ministry of Transport, the National Institute for Roads (INVÍAS), the National Agency of Infrastructure (NAI), the Governors' Offices, the Mayors' Offices, and the special districts (Law 105 of 1993), according to their respective scopes of action, to structure and execute sustainable transportation and mobility solutions that respond to the needs of transportation connectivity in the country, the regions, and the local communities.

In exercising this responsibility, the transportation sector and the territorial entities have usually responded by formulating solutions specific to roads, without adequately taking advantage of the potential that aerial, rail, maritime, fluvial, and non-road land options offer. At the same time, they have ignored the direct, indirect, synergistic, and cumulative environmental impacts caused by the construction and operation of roads, which are comparatively of more diversity, intensity, and magnitude than those caused by the other modes of transportation mentioned.

Therefore, it becomes essential that the objectives of connection and mobility in the territory be achieved, not only by minimising the impacts upon biodiversity and the ecosystem services that it offers, but also by contributing to conservation and the mitigation of climate change and the adequate adaption of territories.

Operationally, this guideline translates into the conception of long-term comprehensive transportation solutions, supported by alternative modes to roads, or intermodal options, which:

1. Strictly apply the mitigation impact hierarchy (avoid, prevent, mitigate, and correct) during initial structuring.
2. Incorporate environmental criteria and carry out analysis of road clusters during the process of diagnosis and identification of present and future communication, transportation, and mobility needs.
3. Identify pre-existing elements and conditions that favour alternative modes of transportation to roads (e.g. sea or river piers, maritime areas, rivers with navigable stretches, airfields, geographic barriers such as canyons, flood zones, areas of geological instability, areas with railroad potential).
4. Identify and evaluate the restrictions that the territory imposes, as well as the regulations, policies, goals, and sectoral, environmental, and other commitments.
5. Identify the information that needs to be obtained, processed, and analysed in order to support the structuring of comprehensive transportation solutions.
6. Consult with the various stakeholders who will either benefit or be harmed by the planned solutions, in order to identify preferences and willingness to pay.
7. Preliminarily quantify costs of the alternative solutions associated with construction as well as operation and maintenance.
8. Incorporate a cost-benefit analysis in such a way that the proposed solutions are cost-effective in a scenario which must comprehensively incorporate environmental costs.

In what follows, some of the alternative modes of transportation are included, classified by mode:

Aerial

- Plane
- Seaplane
- Airship

Aquatic

- River navigation
- Maritime navigation

Land

- Aerial cable
- Hovercraft

Rail

- Electric train
- Diesel train
- Monorail

2.2 Identify and select alternatives for the execution of construction projects or road infrastructure interventions that do not affect Areas of Special Environmental Interest (AEIA), or minimize the impact on them

Using the denomination Areas of Special Environmental Interest (AEIA), different environmental planning figures are grouped, among them those of the National System of Protected Areas (SINAP), those corresponding to Complementary Strategies for Conservation and Sustainable Development, and those referring to Strategic Ecosystems. Together, these are aimed at protecting strategic and highly sensitive ecosystems and, in general, at conserving biodiversity and the ecosystem services they provide, which is one of the main objectives of the Convention on Biological Diversity.

As was mentioned in the previous guideline, the construction and operation of roads cause direct, indirect, synergistic, and cumulative environmental impacts of great magnitude. These environmental impacts have the ability to profoundly transform the territory in which they are located. For this reason, right from the early planning stages of construction projects, it is vital to identify and prioritize alternatives for locations, layouts, engineering, technology, and design that make execution viable without affecting the AEIA.

Some of the AEIAs, such as National Natural Parks (PNN) and the Regional Natural Parks (PNR), due to the nature of their creation and the conservation objectives that they have, involve significant restrictions for developing infrastructure within them and their buffer zones, which makes the construction of primary, secondary, or tertiary road infrastructure non-viable within their jurisdictions. In terms of the AEIAs that do not impose restrictions on the development of these types of projects, the selected alternatives should not compromise their integrity, affect the conservation objectives that they strive for or the functions that they carry out, or encourage their illegal occupation or use, which would ultimately lead to their transformation.

2.3 Identify and select alternatives for the execution of road infrastructure construction or intervention projects that do not affect ecological connectivity corridors at regional, subregional and local scales, or that minimize the impact on them

Ecological connectivity corridors are strips of territory within which the movement and dispersal of species of wild flora and fauna, genetic exchange, and other ecological flows (matter and energy) are maintained, that constitute part of natural landscapes in which such connectivity has been affected.

The construction and operation of roads creates physical barriers and stimulates processes of transformation of land use, management, and occupation that fragment natural areas, in turn affecting ecological connectivity and producing the isolation of populations of biodiversity species at both landscape and ecosystem scales. Thus, in the early instances of road construction project planning, the presence of ecological connectivity corridors must be acknowledged, with the aim of identifying and prioritizing the location, outline, engineering, technological, and design alternatives that do not overlap or affect said corridors.

The identification of connectivity corridors should be carried out at regional, subregional and local levels, for which it is recommended to use information at the following scales:

- **Regional: 1:100.000**
- **Subregional: 1:25.000**
- **Local: 1:5.000 or the most detailed scale possible for field work.**

The information on regional and subregional corridors is used to characterize connectivity dynamics at landscape, coverage, and ecosystem levels while the information on local corridors is used to characterize the mobility conditions that a species or a group of species may have, which is of interest in a specific zone. **The identification of corridors at this scale must take into account the following aspects, amongst others:**

- Identification of natural and artificial barriers.
- Types of cover.
- Identification of drainage networks, water bodies, and flood areas.
- Inventory of wildlife species that are present, and their classification according to the following: extinct, in critical danger of extinction, threatened or vulnerable, endemic, migratory, canopy, seed dispersers, and key for ecosystem balance.
- Identification of populations of species with high mobility needs.
- Habits and mobility requirements of wildlife species populations.

2.4 Identify and select alternatives for the execution of construction projects or road infrastructure interventions that do not affect areas of distribution of endemic or migratory fauna and/or endangered or vulnerable species, or that minimize the impact on them

The construction and operation of roads significantly affect the faunal component of biodiversity, and directly and indirectly cause loss of habitat, isolation, population reduction and losses, reduction of food supply, reduction of genetic variability, and mortality of individuals, among other negative impacts. For this reason, early in the planning of road construction projects, the presence of endemic, migratory and/or endangered or vulnerable species of fauna should be recognized in order to identify and prioritize alternatives for location, layout, engineering, technology and design that do not overlap with these areas.

Conditions of endemism, migration, threat, and vulnerability of wildlife species are intimately related to the importance that these species have for biodiversity, the level of sensitivity that characterizes them, and the level of risk of extinction that they are exposed to. At the same time, these situations are valuable for the structuring and execution of public policies and the execution of conservation actions (e.g. identification of special conservation values, preparation of biodiversity inventories, adoption of protection figures and measures, and definition and application of best practices to avoid affecting the areas in which these species are distributed).

To facilitate the identification of the natural areas of distribution of wildlife species, the NGO International Conservation Colombia, with the support of the Ministry of Environment and Sustainable Development, the Embassy of the Kingdom of the Netherlands, the Regional Autonomous Corporation of Cundinamarca (CAR), the Mining and Energy Planning Unit, and the Ministry of Mines, developed an early warning system called Tremarctos–Colombia. This system allows for identifying the areas of the national territory where the presence of endemic, migratory, and/or endangered or vulnerable species of fauna has been identified.

The document *Technical environmental criteria for the prioritization of third–order roads* developed in 2018 by the Ministry of Environment and Sustainable Development describes the procedures that must be carried out in order to verify if an area of influence of a road infrastructure project overlaps with distribution areas of endemic and migratory wildlife, and/or which is in a state of threat or vulnerability.

2.5 Verify compliance with governability requirements that legitimize the formulation process of road infrastructure construction or intervention projects

Governability is the expression of the State's capacity to achieve the fulfilment of its purposes in an effective and efficient manner. This emerges as a result of inter–institutional action and the participation of communities at the decision–making levels of government policies, plans, programs, and relevant projects that are applied and executed in their territory.

Satisfying legal requirements, the environmental determinants of territorial planning, the rational, adjusted, and transparent allocation and execution of resources for the preparation of prefeasibility studies, and the guarantees of comprehensive and effective community participation, allows for the configuration of a governability scenario during the planning process of transportation infrastructure projects.

In the process of formulating a project at the prefeasibility stage, it is necessary to establish and verify that a governance framework is in place which in turn confirms the legal viability of all the activities involved. Furthermore, this framework establishes the legality of the origin of the public or private resources available for execution, and the legitimacy of the purposes and stakeholders involved in project formulation.

Governability is the expression of the State's capacity to achieve the fulfilment of its purposes in an effective and efficient manner, which emerges as a result of inter–institutional action and the participation of communities.

The governability framework must be effective in only making viable those transportation initiatives that respond to the legitimate interests of the State, which originate from various government agencies. This is especially relevant for those agencies in charge of building and managing transportation infrastructure and identifying the social benefits that are derived from these, as well as identifying the communities that are benefitted or affected by such infrastructure.

As well as the initiatives formulated by the entities of the transportation sector and by the territorial entities, the projects formulated by the communities must comply, in their entirety, with the governability requirements. For this purpose, the technical support of INVÍAS, of the different governmental and mayoral agencies, and of the responsible environmental authorities is recommended.

In accordance with the above, the prefeasibility stage planning of a transportation infrastructure project should carry out the following actions:

- Identification of the promoting entities and/or communities, and the verification of their legitimacy to promote such an initiative.

© David Estrada Larraneta / WWF

- Identification of the executing entities of the prefeasibility studies and designs, and the verification of their legitimacy to develop said studies.
- Justification of the purpose, need, and pertinence of the initiative, as well as the legitimacy of its objectives.
- Determination of the legitimacy and legality of financing sources.
- Verification of compliance with regulations and legal requirements, with the aim of determining legal viability.
- Verification of compliance with the environmental determinants of territorial planning.
- Verification that the project integrates the transportation network functionally and structurally, in an intermodal and environmentally sustainable manner.
- Verification that the assigning and executing of resources allocated to the development of prefeasibility studies and designs is carried out in a rational, transparent manner.
- Verification that community participation in the project is complete and effective.

The role of governability is highlighted in relation to the capacity of the State as a whole to guarantee compliance with the environmental determinants of territorial planning of transportation infrastructure. For example, in the Brazilian Amazon it has been found that 95% of deforestation occurs within 5.5 km of roads, or 1 km from rivers (Barber, Cochrane, Souza Jr. and Laurance, 2014). This situation would not arise if the State were to take adequate territorial control.

2.6 Quantify in detail the estimated costs of planning and execution of road infrastructure construction or intervention projects for all their stages and ensure the availability of the respective resources

In the prefeasibility planning stage for road infrastructure construction or intervention projects, a preliminary economic evaluation is made by comparing, through economic analysis, the sum of the initial cost of construction or improvement, the cost of routine maintenance, and the cost of periodic maintenance, with the economic benefits that would be obtained with the changes generated by vehicle operation.

The estimate of construction and maintenance costs is based on information obtained from the execution of similar projects. However, these projects do not usually fully incorporate the costs involved in carrying out the environmental studies necessary to conclude the environmental feasibility of the project. Moreover, they also tend to ignore the costs for formulating and executing the environmental and social management measures aimed at avoiding, preventing, mitigating, and correcting negative impacts. This practice of underestimating costs is inadequate and leads to projects advancing to later planning stages that should actually be declared unfeasible at the early planning stage.

The execution of green road infrastructure projects requires a detailed quantification of project execution costs.

The execution of green road infrastructure projects requires a detailed quantification of the costs of executing the project at the prefeasibility level, in order to avoid initiating projects whose financial closure is not guaranteed. This quantification also includes all the environmental costs and the scope of promoting a net positive environmental balance, as established in the conceptualization of the term.

The concomitant and timely allocation of adequately estimated financial resources not only leads to the successful execution of the project, but also allows for the minimizing of construction times. Moreover, this eliminates rehabilitation costs, reduces maintenance costs, mitigates emergency risks and their associated costs, and finally avoids the omission of environmental management measures designed to avoid, prevent, mitigate, and correct direct, indirect, synergistic, and cumulative impacts.

3

Guidelines for project planning at the feasibility and definitive design level

© Mario Orlando López Castro / Asesor DAASU Minambiente

3.1 Develop environmental studies for transportation infrastructure construction projects that do not require an environmental license

The environmental impact assessment (EIA) is the basic instrument for making decisions on projects, works, and activities that require an environmental license, i.e. those with the capacity to generate significant environmental impacts and noticeable modifications to the landscape. The information gathered during the creation of an EIA is useful for, among other things:

- Describing and understanding the environmental conditions and characteristics of projects.
- Identifying and evaluating the environmental impacts and the use of ecosystem services.
- Establishing homogenous zones.
- Defining environmental management plans and programs that avoid, mitigate, and correct the impacts (strictly applying the mitigation hierarchy) that could potentially be generated by these projects. For this reason, it is an instrument of great value in terms of ensuring that projects that are finally executed have a net environmental balance at least equal to zero.

The environmental impact assessment (EIA) is the basic instrument for making decisions on projects, works, and activities that require an environmental license.

In accordance with the provisions of environmental regulations, some transportation infrastructure construction projects do not require an environmental license to be executed (Decree 1076 of May 26, 2015, in article 2.2.2.3.2.1). However, if these are to correspond to green road infrastructure projects, the preparation of an environmental study in accordance with its magnitude and complexity is required. This study is needed to establish the conditions of the context where the project will be executed, identify the environmental impacts that can potentially be generated, and establish measures to avoid, prevent, mitigate, and correct their occurrence. In this way, these conditions contribute in such a way that the project, while generating the economic and social benefits expected by society, does not affect the conservation of biodiversity and the ecosystem services provided. Furthermore, it should contribute to the maintenance of the health conditions of the ecosystems and the species of wild fauna and flora that they contain, whilst not affecting the availability of renewable natural resources, and even contributing to compensating for pre–existing environmental damages.

The construction and operation of aerial cables for passenger and cargo transportation, the construction and operation of airfields other than airports, and the construction of river docks are examples of transportation infrastructure projects to which environmental studies apply, even though they are not necessarily required from a regulatory standpoint (Decree 1076 of 2015).

3.2 Develop studies and designs for the execution of road infrastructure construction or improvement projects that do not affect or minimize the impact on Areas of Special Environmental Interest (AEIA)

The Areas of Special Environmental Interest (AEIA) group together different environmental management figures, including those of the National System of Protected Areas (SINAP), which are aimed at protecting strategic and highly sensitive ecosystems and, in general, at conserving biodiversity and the ecosystem services they provide. Land occupation, use, and management is defined in territorial planning, in which the environmental determinants are regulations of superior hierarchy that ensure the conservation and protection of the environment and natural resources, and the prevention of natural hazards and risks (numeral 1 of article 10 of Law 388 of 1997).

Considering that transportation infrastructure, especially road infrastructure, has a high potential to transform the territory in which it is constructed, it is necessary to identify, during feasibility planning and final design of this type of project, the presence of AEIAs. Moreover, their nature, characteristics, and the use restrictions they impose ought to also be identified, in order to adopt project designs that consider:

- Layouts that avoid or minimize overlap with the AIEAs.
- Structures that favour ecological connectivity.

At the same time, project designs should include technological solutions that avoid or minimize negative impacts, which have the potential to generate positive environmental impacts. Some examples of such technological solutions include:

- Viaducts.
- Tunnels.
- Bridges.
- Wildlife crossings.
- Drainage works sized to meet the needs derived from the multiyear variability of water flows.
- Drainage works conditioned to facilitate the transit of aquatic and terrestrial fauna.
- Enrichment of the vegetation cover of affected areas and waterways, in order to facilitate ecological connectivity.

The indirect environmental impacts caused by road construction and operation in areas which are predominantly natural must be taken into account in both the structuring of projects as well as in the decisions related to land use territorial planning processes. This is seen as being one of the most cost-effective conservation strategies (Alagmir et al., 2017).

3.3 Develop studies and designs for the execution of projects for the construction or improvement of road infrastructure that do not affect ecological connectivity corridors at regional, subregional, and local levels, or that minimize the impact on them

By definition, in ecological connectivity corridors, the movement and dispersion of wild flora and fauna species, genetic exchange and other ecological flows persist, which is where their importance lies. Such conditions are threatened and even violated, partially or totally, by processes of land use, transformation, and occupation.

In view of the above, it is necessary, right from the planning stage of road infrastructure construction or improvement projects in terms of feasibility and final design definition, to identify ecological connectivity corridors of different scales (regional, subregional, and local) that overlap with the area of influence of such projects. Thus, this identification assists in avoiding or minimizing impacts in these areas, and on the other hand, promotes the conceiving and materializing of designs (technological and engineering solutions) that favour the conservation and consolidation of the functionality of the corridors.

As needed, a green road infrastructure project should carry out actions to improve ecological connectivity in its area of influence.

However, in order to ensure that the designs are in accordance with the functional needs of the connectivity corridors, it is necessary to obtain and analyse basic information to guide such designs, some of which is listed below:

- The existence and distribution of natural cover.
- The existence and distribution of ecosystems.
- The presence of extinct, critically endangered, threatened, or vulnerable species of fauna, which are endemic, migratory, umbrella, or seed dispersers, and those that are assessed as being key to ecosystem balance.
- The identification of habits and mobility requirements of the populations of wildlife species present in the area.
- The identification of natural and artificial barriers to wildlife mobility.
- The identification of drainage networks, water bodies, and floodable areas.

Likewise, and as needed, a green road infrastructure project should carry out actions to improve ecological connectivity in its area of influence, identifying areas where such connectivity has been affected. Consequently, it should also anticipate, from this feasibility and final design stage, measures such as reforestation, the enrichment of natural cover, and the signing of agreements with landowners to carry out these types of actions.

3.4 Develop studies and designs for the execution of construction projects or road infrastructure interventions that do not affect or minimize the impact on water bodies and their buffer zones

Water bodies and their associated water resources constitute support for biological processes that determine the existence and characteristics of aquatic ecosystems, which is why environmental regulations have established measures for their protection and management. The water bodies and their buffer zone are highly sensitive to anthropic activities that can result in occupation, alteration of their morphology, change of use, contamination, and overexploitation of water resources.

The construction and improvement of road infrastructure has the potential to generate this type of impact, a fact that demonstrates the need for green infrastructure projects to be especially rigorous in carrying out studies and in the conception of designs that incorporate the analysis of the existence, distribution, characteristics, and dynamics of the water bodies located in the area of influence of such projects. This rigorous work is carried out in order to conceive designs in accordance with such conditions which do not violate the availability and quality of the water resource, or negatively affect the structure and functionality of aquatic ecosystems, and that incorporate considerations related to climate change mitigation and risk management.

The process involved in the design of transverse and longitudinal drainage works must consider the analysis of climatological, pluviometric, hydrometric, and flow information, that spans return periods of 200 years for major works and 25 years for minor works. Moreover, it must include within this analysis the temporal information based on time series, including climate change and climate variability scenarios determined by the competent entities. An adequate design of this type of work minimizes the possibility of the road project generating negative impacts on the environment and reduces the levels of risk and vulnerability of the road infrastructure to the effects of both climate variability and extreme events.

© Ministerio de Transporte

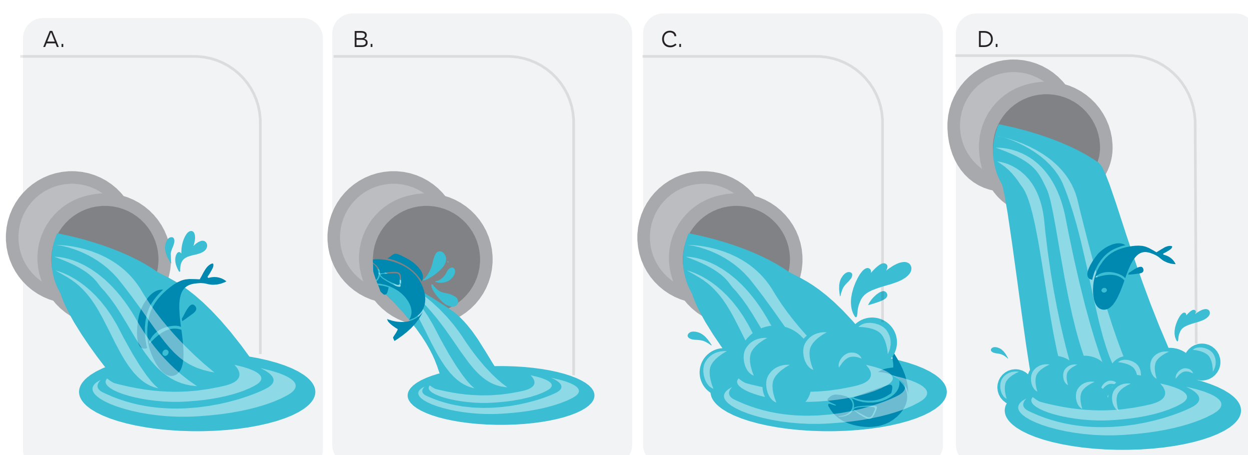
In carrying out the studies, it is important to use the spatial information available from public institutions, research centres, private organizations, universities, and the group of networks, such as Geographic Institute Agustin Codazzi (IGAC) or the United States Geological Survey (USGS), which has a digital terrain elevation model with a resolution of 30 meters for the entire world.

It is necessary that the transverse drainage work designs incorporate layout and structural considerations to preserve the natural morphology of the banks and channels, hydraulic capacity, and the dynamics of water flow. It is important to emphasize that vegetation cover constitutes an integral part of the water course and therefore drainage works should be designed so that they do not affect them.

The design of drainage works must also take into consideration that they should not impact upon the functionality of a water body and its buffer zone, which makes up the habitat and means of transit for aquatic and terrestrial fauna.

Inadequately conceived, designed, and constructed drainage works end up becoming barriers for aquatic and terrestrial wildlife (Figure 8).

Figure 8. **Example of deficiencies in the design of transverse drainage works that constitute barriers for the displacement of aquatic wildlife**



The figure illustrates four situations where a culvert produces a barrier to the passage of aquatic fauna:

A. Increase in the flow velocity of the water due to the decrease in the section of the channel, concentrating the flow.

B. Decrease in the flow rate, generating a shallower passage than necessary.

C. Absence of a backwater tank, causing a turbulent zone that makes passage difficult.

D. Unevenness in the channel, either by design or by undermining processes.

Source: Adapted from Keller and Sherar (2004).

© Ministerio de Transporte

Some general and specific recommendations to avoid or minimize the impact of water bodies are listed below:

- Define layouts and develop road designs that avoid or minimize intervention in flood–prone areas, marshes, wetlands, and mangroves (avoid layouts that overlap with water courses or areas with slopes greater than 30% and subsurface drainage).
- Refrain from including designs that contemplate the construction of embankments or ditches in wet or flood areas, and the concrete channelling of riverbanks.
- Select the type of work for transverse and longitudinal drainage according to the climatic regime, flows, and the water course (viaducts, bridges, pontoons, and box culverts).
- Design transverse drainage works that do not involve encroachment on the riverbeds and water courses (either by their structures or foundations).
- Include climate change considerations such as extreme weather events in the design analysis.
- In the event that the construction process has involved the alteration of the natural morphology of riverbeds and watercourses, restore the original conditions, especially riverbed slopes, bank slopes, bottom substrate, and vegetation cover.
- Prefer drainage works designs that favour the transit of aquatic and terrestrial fauna.
- Design adaptations for previously constructed drainage works, in order to correct or improve the conditions that have created barriers to the mobility of fauna.

In natural watercourses, the presence of stones, rocks, small slopes, logs, and other solid structures generates areas of turbulence and backwater that form small habitats differentiated by hydrodynamic conditions and subsequent conditions of sediment dynamics and turbidity. Such differential conditions favour the permanence or displacement of some aquatic organisms. The backwaters are areas for the location, reproduction, spawning, feeding, and resting of some species.

Therefore, the design of hydraulic works for a green road infrastructure project should seek to avoid altering the natural conditions of the environments in which such works are to be carried out. In cases where the construction involves making alterations to the natural environment, the design must contemplate the reconditioning of natural conditions.

3.5 Develop studies and designs of wildlife crossings for the construction or improvement of road infrastructure

The construction and operation of road infrastructure generate significant impacts on wildlife populations and communities, including habitat reduction, alterations in the composition of communities and populations, and the direct loss of individuals. Road traffic accidents are one of the main causes of the loss of wildlife specimens.

The execution of green infrastructure projects, and the identification of the management measures that this type of project should implement according to the mitigation hierarchy, should be implemented in a manner that avoids and mitigates the negative impacts on wildlife in a cost-efficient way. This project execution requires that during the study and design stage, primary information is obtained for the comprehensive characterization of the existing wildlife in the ecosystems present in the area of influence, as well as its spatial distribution, mobility habits and species' ethology, among other information. All of the above will allow for the alignment, design, and construction of project decisions to guarantee the continuity of the mobility needs of the species.

To meet this objective, characterization studies should consider the main faunal groups represented in the area of influence, highlighting the presence of endemic, endangered, threatened, vulnerable, and migratory species, as well as those sensitive to transportation infrastructure and susceptible to being run over (e.g. sloths, anteaters, opossums, and armadillos). It is also essential to determine their habits, behaviours, and mobility needs.

This set of information guides the final decisions to be made on the layout, designs, works, or adaptations and management measures to be implemented to guarantee the aforementioned wildlife mobility needs. The following are examples of possible types of solutions:

- Opt for layouts that avoid or minimize the impact on wildlife mobility (those that do not intervene in connectivity corridors or areas of natural vegetation, and which do not form steep slopes).
- Consider technological and engineering solutions that benefit the permeability of road infrastructure (e.g. viaducts, tunnels, bridges, wildlife crossings).
- Consider measures to conserve and re-establish vegetation cover, especially trees, both longitudinally and transversally to the road axis (e.g. by establishing exclusion zones, forming longitudinal corridors and canopy bridges, implementing generalized cover enrichment activities).
- Design the system of wildlife crossings for the road project, establishing the types of crossings to be built, the species of wildlife to which they are directed, their number, location and complementarity, signage, mobility routes, infrastructure and associated and complementary management measures to prevent wildlife access to the road corridor and at the same time to guide them to the wildlife crossings.
- Include designs aimed at reducing speed in sectors where the road presents some degree of susceptibility to wildlife being run over, involving signs, speed-reduction elements, or modifications to the geometric design of the road.

- Include design considerations aimed at controlling noise and/or light pollution associated with the road, such as vegetation barriers, lighting with motion sensors, and physical barriers to avoid affecting ecosystems because of vehicle headlights.

It should be noted that these mobility or permeability solutions for wildlife are not mutually exclusive; on the contrary, they should be implemented in a complementary manner to ensure their efficiency.

Wildlife crossings

These are systems that seek to ensure the safe passage of wildlife from one side of a transportation infrastructure to the other, in such a way that functional connectivity is not affected, and the barrier effect normally generated by the road infrastructure is avoided or minimized.

To fulfil their purpose, they must:

- Respond to a functional connectivity analysis at regional and local levels, in which potential connectivity routes and the species that would use them are identified (including identification of their mobility limitations and habitat requirements).
- Include the generation and/or maintenance of functional connectivity corridors that facilitate the movement of wildlife between safe passage structures and their natural ecosystems.
- Include barriers that channel wildlife to safe passage structures and limit their access to the road corridor.

Act in accordance with strategies for the conservation of natural ecosystems, in order to guarantee the long-term functionality of the structures.

The prior analysis must be intended to respond to the following questions:

- Are wildlife crossings needed?
- Which species (or groups of species) would condition the designs?
- Where should they be located?
- What type of structure should be used?
- How many should there be?

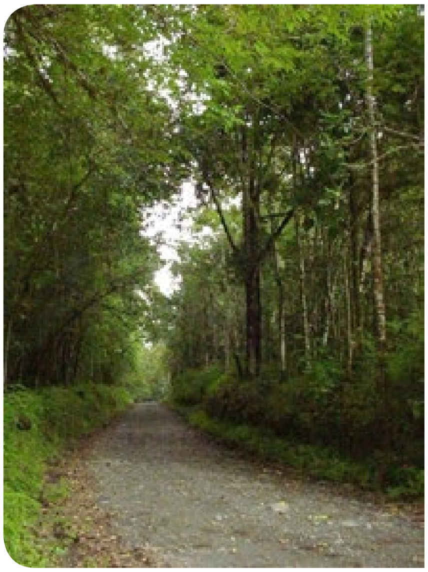
The options for structures that can be used are classified in the first instance as overpasses and underpasses, depending on whether the wildlife passes over or under the road surface of the stretch of transportation infrastructure. In general terms, they can be:

- Overpasses: canopy bridges (for arboreal species) or ecoducts (Figure 9).
- Underpasses: viaducts, bridges, pontoons, box culverts, culverts, or covered ditches.

The design of the wildlife crossings must consider:

- The functionality it is required to provide (e.g. single-species, multi-species, aerial, at-grade, subway).
- Its connection with natural areas and ecological connectivity corridors.
- The vegetation cover that is part of its structure and access.
- Habits, behaviours, and mobility needs of the species for which they are designed.
- The feasibility of using natural, recycled, and low-cost materials that still guarantee the functionality, strength, and durability of the structures.
- The incorporation of attractive, deterrent, and shielding structures.

Figure 9. Examples of canopy bridges



Source: Darío Correa, 2019

3.6 Formulate environmental impact compensation measures that add to and complement those proposed by other projects

The environmental impact mitigation hierarchy contemplates the orderly application of measures so that the possible impacts of a project do not materialize with its execution. Initially, this involves prioritizing those measures aimed at preventing the impacts from being generated, and consequently, those aimed at minimizing the impacts that could not be avoided. Following these, measures aimed at correcting the fraction of the impacts that could not be mitigated are included, finishing with those aimed at compensating for the impacts that could not be avoided, prevented, mitigated, or corrected.

This guideline is set out so that in the situations in which it is necessary to formulate compensatory measures, these are conceived in a complementary manner and are added to the actions that have been formulated or are being executed within the framework of other projects. This articulation with the compensation actions proposed by other projects could, according to the magnitude of the areas selected for their development, have effects on a local and even regional scale that contribute to the strengthening of territorial environmental management.

The integration of compensation measures for projects, works, or activities in the territory favours the generation of synergistic effects in management measures at the level of the structure and functionality of the landscape, ecosystems, and biodiversity, as well as the incorporation of considerations related to climate change mitigation, by virtue of which positive environmental impacts can be generated.

3.7 Incorporate design considerations for the generation of net positive environmental impacts on flora and fauna in the study and design elaboration process

Roads generate indirect, synergistic, and cumulative impacts of great magnitude on natural land cover and ecosystems, which transcend the area in which the project infrastructure is located; therefore, designs must incorporate specifications aimed at avoiding and mitigating such impacts.

For a green road infrastructure project, it is also necessary to include designs aimed at promoting direct and indirect positive net impacts on the environment. This includes, for example, restoring natural ecosystem cover, recovering ecological connectivity corridors and wildlife habitat, and re-establishing the natural distribution of wild flora and fauna species.

These design specifications and measures aimed at generating net positive environmental impacts can be undertaken outside the area first identified as being influenced by the project and, in any case, are additional to the management measures aimed at avoiding, preventing, mitigating, correcting, and compensating for the environmental impacts caused by the project.

3.8 Verify the application of governance requirements in the process of developing studies and designs for the execution of road infrastructure construction or intervention projects

As previously mentioned, a governance scenario for transportation infrastructure projects is configured once it is possible to establish compliance with legal requirements, territorial planning, resource execution and community participation, which is verified in the planning and execution stages of such projects.

In the formulation process of a project at the study and design stage, it is necessary to verify the application of the previously mentioned governance requirements, so that they are reflected in the final designs. This means that the primary and secondary information obtained during the prefeasibility stage and the detailed information generated during the feasibility stage have been used as input for the development of the final designs.

Roads generate indirect, synergistic, and cumulative impacts of great magnitude on natural land cover and ecosystems.

3.9 Quantify in detail the costs of the elaboration of studies and designs, and of the execution of road infrastructure construction or intervention projects and ensure the availability of the respective resources

In the planning stage at the study and design level for road construction or intervention projects, the activities to be carried out in accordance with the final designs, their costs, and the time required for their execution are identified. It is necessary to ensure that cost estimates are made taking into account the infrastructure and activities required to structure and implement environmental and social management measures aimed at avoiding, preventing, mitigating, correcting, and ultimately compensating for negative impacts and, simultaneously, those aimed at generating positive impacts.

© Ministerio de Transporte

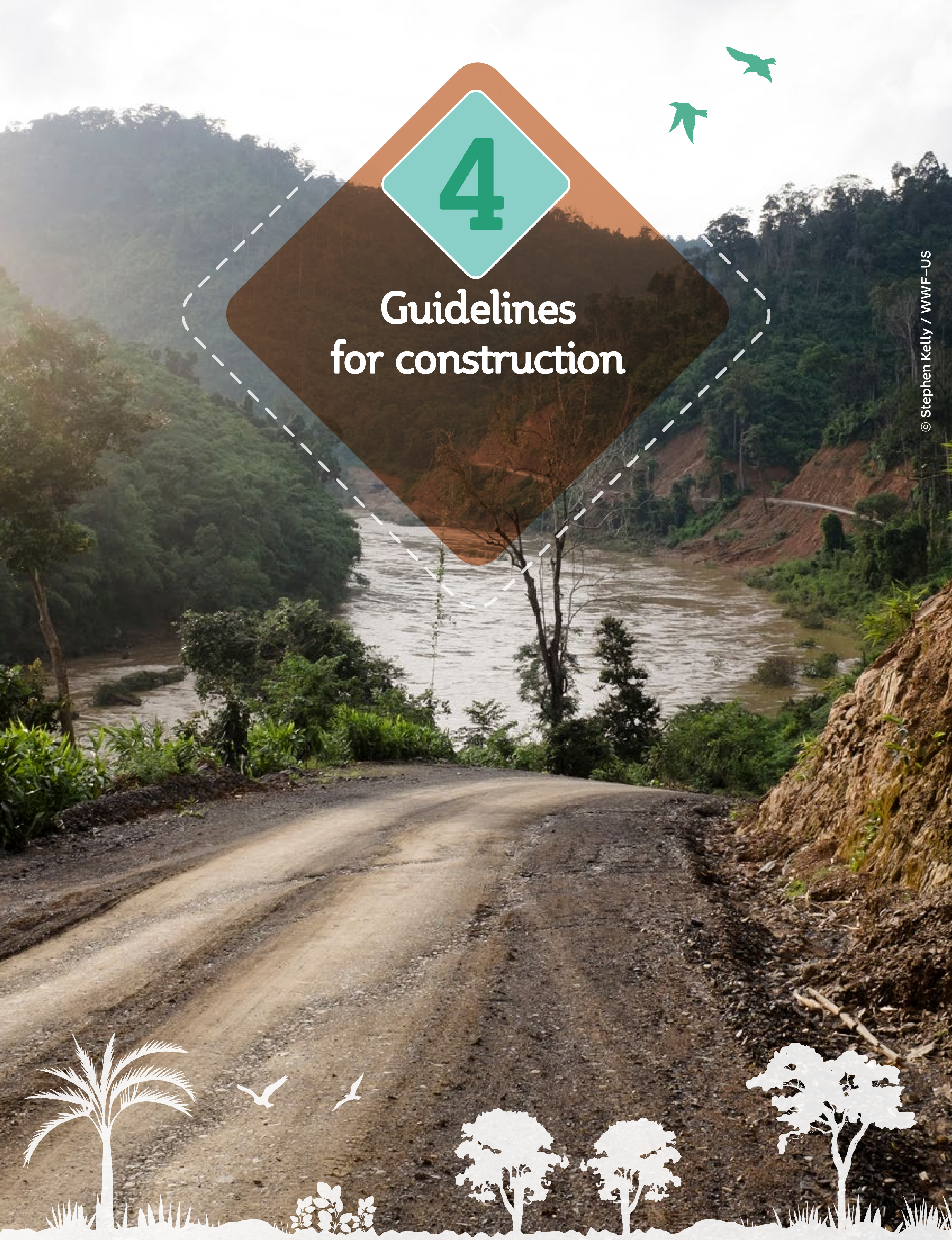
The construction of a green road infrastructure project requires the availability of all the estimated resources to carry out the studies and designs as well as the respective construction. In this way, the project avoids suffering from a lack of resources which can lead to design modifications at the time of execution of the works, which implies the omission of the environmental considerations that determined such designs. Further, it also avoids truncating the decision to generate a positive net environmental balance as it is defined from the very conception of the project, given that it is a green road infrastructure project.

The concurrent and timely allocation of adequately estimated financial resources not only helps materialize the execution of the project in its entirety, but also allows for:

- Minimizing construction times.
- Avoiding rehabilitation costs.
- Reducing maintenance costs.
- Mitigating emergency risks and their associated costs.
- Averting the omission of environmental management measures aimed at avoiding, preventing, mitigating, and correcting direct, indirect, synergistic, and cumulative impacts.

4

Guidelines for construction



4.1 Verify compliance with design specifications for the execution of road infrastructure construction projects

The designs corresponding to a green road infrastructure project, while satisfying the requirements of transportation infrastructure, incorporate considerations to achieve efficiency standards in the fulfilment of infrastructure and mobility objectives. Moreover, they include specifications to avoid the generation of negative environmental impacts associated with their construction and operation, conceived in accordance with the mitigation hierarchy.

In the project planning stage at the feasibility and final design level, the development of studies and designs that do not affect or minimize impacts on AEIAs, ecological connectivity corridors, water bodies and their water courses, and which contemplate the construction of wildlife crossings were considered. Due to this, it is now necessary, at this stage, to verify the strict materialization of such designs in compliance with the objectives for which they were conceived. The inclusion of works not originally contemplated in the design stage, or the exclusion of works that were in fact included, as well as the change of designs, must be carefully considered so that they do not generate unforeseen environmental impacts. Irrespective, the design modifications required during construction must guarantee the minimization of environmental impacts already obtained in the design stage.

4.2 Contemplate strategies and undertake actions to preserve and consolidate ecological connectivity corridors for the execution of road infrastructure construction projects

There are several actions that are part of those that a road construction project must take in order to consolidate itself as green infrastructure. Some of these include the conservation of ecological connectivity corridors within which the movement and dispersion of wild flora and fauna species, genetic exchange, and other ecological flows are maintained, as well as the incorporation of strategies to favour such connectivity.

Early in the planning of road construction projects, the presence of ecological connectivity corridors in their area of influence should be recognized in order to identify and prioritize alternatives for location, layout, engineering, technology, and design that will help prevent the infrastructure from overlapping or negatively affecting these corridors.

In this case, the management measures considered in the previous studies must be applied, of which the following are examples:

i) the establishment of strips on both sides of the road, guaranteeing the permanence of the natural vegetation cover, in such a way as to minimize the barrier effect (attenuating the generation of resistivity to the mobility of wildlife species), prevent the deforestation of areas that will now be accessed as a result of the new infrastructure (avoiding the generation of indirect, cumulative, and synergistic impacts), and avoid the formation of new land accesses that will be detached from the road, ii) the recovery and enrichment of natural cover both in these strips and within the ecological connectivity corridors, favouring the recovery of habitats for different species of wildlife, iii) the establishment of a program to monitor the state of the natural vegetation cover associated with the road, in order to timely identify phenomena that represent a threat to the cover of the strips and the functionality of the existing ecological connectivity corridors, and iv) the involvement of both the landowners and the community settled in the area of influence of the road in the process of conservation and enrichment of the vegetation.

However, it is possible that in the execution of construction projects, due to deficiencies in previous stages, the ecological connectivity corridors that at different scales (regional, subregional, and local) may be affected by the project will not have yet been identified. In this possible scenario, it is necessary to locate these corridors, gather information for their characterization, and define strategies and actions aimed not only at preserving them, but also at consolidating their structure and functioning, such as adjusting layouts and designs, incorporating technological solutions, and applying management measures.

4.3 Execute drainage works that do not affect or that minimally affect water bodies and their buffer zones

Water bodies and associated water resources constitute the support for biological processes that determine the existence and characteristics of aquatic ecosystems, which is why environmental regulations have established measures for their protection and management. These water bodies and their buffer zones are highly sensitive to anthropic activities that result in occupation, alteration of their morphology, change of use, contamination, and overexploitation of water resources.

The construction of roads has the potential to cause permanent and transitory impacts on water bodies and associated water resources, affecting the biological processes that support them.

The drainage works that are built must avoid fragmenting the terrestrial and aquatic ecosystems present in the area of influence of the project, which would affect the morphology and subsequent functionality of the water bodies and their buffer zones due to their permanent occupation by the drainage works structure, or modifying the flows, availability and physicochemical and biological quality of the water. For these reasons, the type of drainage works to be chosen, as well as their characteristics, materials, dimensions, and layout must be the result of a comprehensive evaluation of the physical and biological conditions of the environment in which these engineering solutions are to be placed. In order to select the optimal construction solution, it is also recommended that considerations of adaptation to climate variability and risk management be taken into account.

It is important to highlight that the vegetation cover forms an integral part of the watercourse, and therefore drainage works must avoid affecting it directly or indirectly.

On the other hand, and due to the fact that both water bodies and their buffer zones are a habitat and means of transit for aquatic and terrestrial fauna, drainage works must be integrated into the structure, function, and dynamics of the natural landscape and become effective and safe mechanisms for wildlife mobility.

4.4 Generate infrastructure for the mitigation of negative impacts on wildlife in the execution of road infrastructure construction projects

During the construction stage, the plans that were conceived during the formulation of studies and final designs with the intention of avoiding negative impacts on the mobility of wildlife (e.g. viaducts, bridges, and tunnels) must be carried out. In addition to these technological and engineering considerations, it is necessary to take into account complementary infrastructure during construction to help mitigate this type of impact.

The construction of a system of wildlife crossings for the road project constitutes the most effective measure to mitigate the barrier effect and the loss of wildlife due to the operation of the road infrastructure. For this to be effective, it is important that the crossings be built in accordance with the considerations foreseen in the feasibility stage and final designs, establishing the types to be built, the species of wildlife to which they are directed, their number, location and complementarity, signage, mobility routes, infrastructure and associated and complementary management measures to prevent wildlife access to the road corridor and at the same time to guide them to use the wildlife crossings.

Another measure aimed at mitigating impacts on wildlife is the construction and/or strengthening of Wildlife Care and Assessment Centres (CAV) and Wildlife Care, Assessment, and Rehabilitation Centres (CAVR) located near the project's area of influence. During the construction stage, these centres provide fundamental support for the correct application of the measures outlined in the construction project's environmental management plan, aimed at mitigating impacts on wildlife. Examples of such measures include species identification, identification of the presence and location of individuals, definition of mechanisms for capturing specimens, application of rescue and transfer protocols, specialized primary veterinary care for injured specimens, monitoring and maintenance of individuals, and rehabilitation and reintroduction of animals.

These centres also serve as scenarios for training jobsite personnel and communities on the importance of wildlife conservation.

The actions carried out by a green road infrastructure construction project for the construction or strengthening of care centres can be enhanced with those carried out by other types of projects or activities developed in the region where the project is located (e.g. mining and energy exploration or exploitation, construction of infrastructure, agriculture, and industry), even generating net positive environmental impacts.

4.5 Generate infrastructure to mitigate negative impacts on vegetation cover and wild flora resulting from the execution of road construction projects

One measure aimed at mitigating impacts on vegetation cover and wild flora is the construction and/or strengthening of multifunctional nurseries located near the project's area of influence. During the construction stage, these nurseries support compliance with the measures set out in the construction project's environmental management plan, with the purpose of mitigating impacts on vegetation cover and wild flora. Examples of such measures include species identification, the collection of germplasm and seedlings of the different representative taxonomic groups, the reproduction of plant material, the selection of planting material, the enrichment of cover for different purposes, the monitoring of plantings, and the replacement of planting material as necessary.

The plant material generated in the multifunctional nurseries can be used for the enrichment of covers in areas such as ecological connectivity corridors, waterways, and attractive, dissuasive, and shielding structures associated with wildlife crossings. Moreover, they can be used in areas of food supply and habitat for wildlife, landscaping, those threatened by geological instability or erosion processes, and even areas containing banned, endemic, or endangered or vulnerable species.

These nurseries also serve as scenarios for training jobsite personnel and communities on the importance of land cover and wild flora conservation.

The actions undertaken by a green road infrastructure construction project for the construction or strengthening of multifunctional nurseries can be enhanced with those carried out by other projects or activities that are developed in the region where the project is located (e.g. mining and energy exploration or exploitation, construction of infrastructure, agriculture, industry), even generating net positive environmental impacts. The strengthening of the multifunctional nurseries could even be extended to the formulation and implementation of productive projects that improve the quality of life of the communities settled in the project's area of influence.

4.6 Optimize the handling of materials during the execution of road infrastructure construction projects

Inadequate handling of construction materials generates a wide variety of negative impacts that affect the different components of the environment (e.g. geomorphological, hydrological, soil, air, fauna, flora, hydrobiological, and economic components).

Some of the measures aimed at optimizing the environmental management of materials during extraction, transportation, use, and disposal are the following:

- Comply with the determinations that are explicitly stated in the environmental license for material management.
- Isolate and protect wetlands and water buffer zones from extractive activities.
- Encourage the reuse of materials from excavations, residues from other works, and demolitions which are duly authorized by the responsible environmental authority.
- Encourage the use of materials from sources close to the project in such a way as to minimize the environmental impact caused by their transportation.
- Separate, confine, and individually cover organic and sterile material.
- Carry out actions to recover the morphology of the affected areas according to their own characteristics.
- Reuse organic soil for the rebuilding of temporarily affected vegetation areas and for areas destined for landscape management.
- Apply wildlife management measures.
- Avoid excavation and cutting of slopes in sections longer than 0.5 km until they are completely stabilized.
- Control temporary stockpiling of materials in order to avoid adding sediment to the project's ditches and drains.
- Use materials and supplies that are free of hazardous substances, or adequately manage their use and final disposal.
- Avoid using materials or supplies whose impact on the environment is uncertain.
- Remove the structures and materials that have been used on the work fronts and those that are used for temporary accesses or unused sections.
- Dismantle the temporary access infrastructure to the project areas and completely restore these areas to avoid promoting processes of reoccupation, such as access roads to sources of materials, industrial zones, and camps.

On the other hand, it is obligatory to use construction materials that come exclusively from sources that have a mining title or temporary authorization and the respective environmental license. This license must explicitly authorize the supply for the specific construction project in question.

4.7 Verify compliance with governance requirements for the execution of road infrastructure construction projects

As mentioned previously, applying a framework of governance requirements at all stages of the planning and execution of an infrastructure project allows for its execution to be carried out in strict adherence to planning budgets. Verifying compliance with governance requirements includes:

- Verifying fulfilment of legal requirements and strict compliance with the guidelines established in territorial planning in which the construction project is framed.
- Ensuring transparency in the assigning, use, and execution of funds, as well as their timely availability.
- Establishing the execution of all projects and programs foreseen in the Environmental Management Plan to avoid, prevent, mitigate, correct, and compensate for negative environmental impacts.
- Carrying out environmental monitoring by the environmental authorities and providing the necessary spaces for the development of citizen oversight exercises.

The following is a list of the governance requirements that must be verified during the construction process of a green road infrastructure project:

- The execution of the project is being undertaken by the entity entrusted with the administration of the road section to be built. In other words, the executing entity is sufficiently competent to carry out the project.
- The project is included in a road plan duly approved by the relevant authority.
- The project to be executed adopts all the specifications established in the definitive studies and designs.
- The project has an environmental license granted by the relevant authority.
- The project is included in territorial planning, or at the very least is compatible with it.
- The project complies with the environmental determinants of territorial planning.
- The objective of the project is legitimate, in the sense that it is aimed at satisfying the connectivity needs of a community and corresponds to the level of road infrastructure for which the executor is competent.
- The assigning of resources is carried out by means of pre-established and publicly known mechanisms.
- The project has a work plan and a budget execution schedule that are permanently monitored by the relevant executing agency, ensuring the permanent availability of the resources required for execution.
- The project has its respective auditors in the event that the amount of funds to be spent requires overseeing.

- The environmental management plan is executed in its entirety in order to avoid, prevent, mitigate, correct, and compensate for the negative environmental impacts that the project has the potential to generate.
- The relevant environmental authority periodically performs the environmental monitoring and control of the license granted for the execution of the project.
- The managing and executing entities and units of the project provide adequate, sufficient, and timely information related to the execution of the project to the different types of stakeholders.
- The managing and executing entities and units of the project generate spaces, strategies, and actions that guarantee the effective participation of the communities that benefit or are affected by the execution of the project.

On the other hand, the project must inform and allow the communities to access information, as well as monitor compliance with the objectives of the green infrastructure project.

4.8 Guarantee the availability of financial resources for the construction of road infrastructure projects

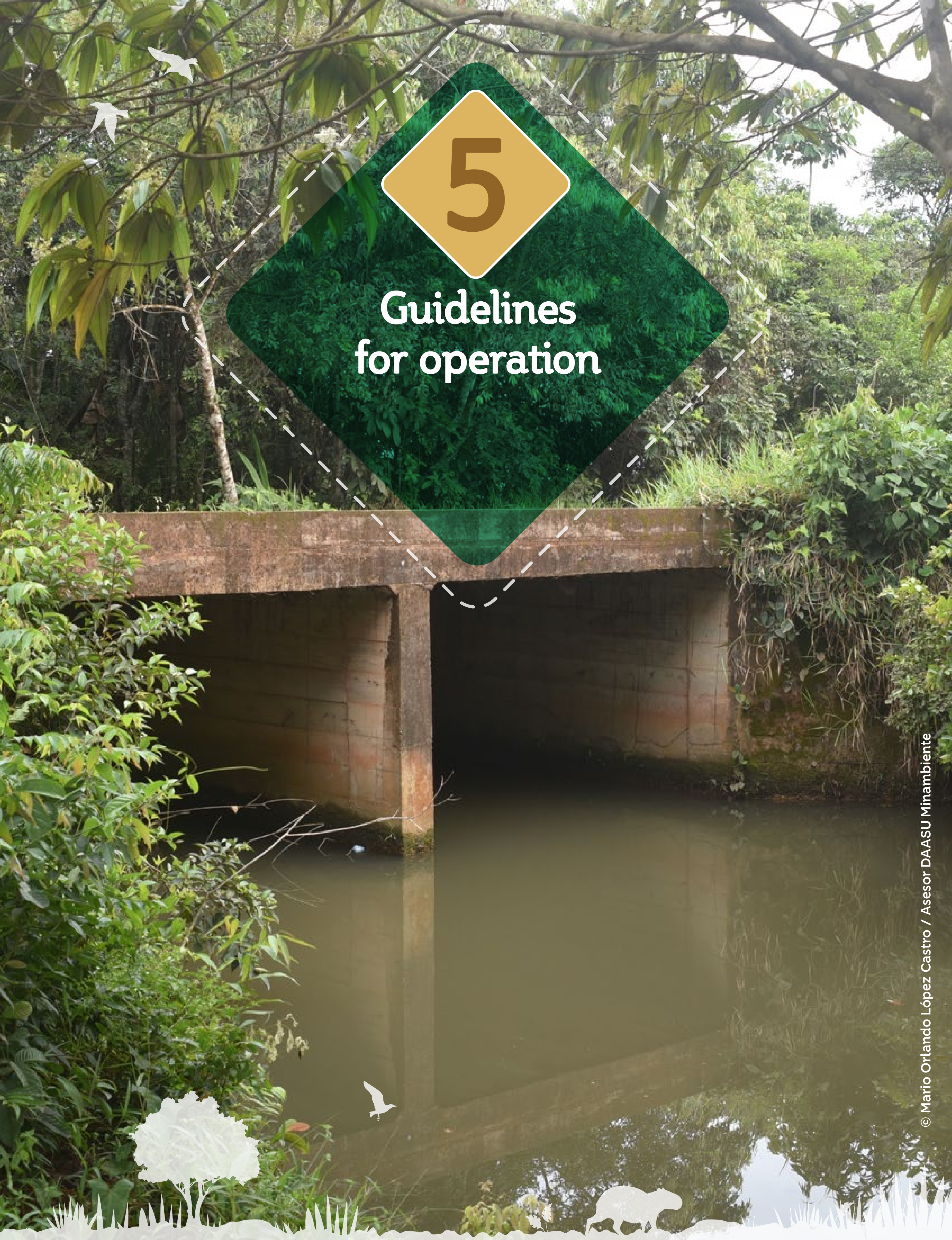
The construction of a green road infrastructure project requires the availability of all the estimated resources to be guaranteed so that the final designs can be efficiently implemented. In this way, the project can avoid a lack of resources which could lead to modifications that negatively affect the environmental balance, as defined from the very conception of the green road infrastructure project.

The timely availability of resources for the financing of the works not only brings about the execution of the project in its entirety, but also allows for minimizing construction times, avoiding rehabilitation costs, reducing maintenance costs, mitigating emergency risks and their associated costs, and avoiding the omission of environmental management measures aimed at avoiding, preventing, mitigating, and correcting direct, indirect, synergistic, and cumulative impacts.

The construction of a green road infrastructure project requires the availability of all the estimated resources to be guaranteed so that the final designs can be efficiently implemented.

5

Guidelines for operation



© Mario Orlando López Castro / Asesor DAASU Minambiente

5.1 Characterize the existing road infrastructure with the aim of identifying the need for contemplating strategies and undertaking actions to preserve and consolidate the ecological connectivity corridors during the operation of such infrastructure

The functionality of ecological connectivity corridors is essential to maintaining genetic exchange, the dispersion of wild flora and fauna species, and other ecological flows. For this reason, both their conservation and the incorporation of strategies to favour such connectivity are part of the actions that should be included in the green road infrastructure during the operation stage.

Although the most opportune moment to identify the presence of ecological connectivity corridors associated with road infrastructure projects is in the early stages of planning, many projects are actually in operation without having been subject to measures that contribute to preserving and consolidating this important conservation feature.

Consequently, and within the framework of generating green road infrastructure, it is necessary that those responsible for the administration of roads or the entities in charge of maintaining them in good operating condition, characterize the road infrastructure and the associated ecological connectivity corridors in order to establish strategies and take actions to preserve and consolidate them.

Some examples of this type of strategy are:

i) ensuring that existing vegetation cover in the area of influence of the road is not negatively affected; ii) avoiding generating new road construction initiatives that aim to connect to the road infrastructure, which generate indirect, cumulative, and synergistic impacts; and iii) evaluating relocation, layout, engineering, technology, and design alternatives that prevent infrastructure from overlapping or affecting ecological connectivity corridors.

Some examples of actions aimed at preserving the corridors include:

i) the enrichment of the strips located on both sides of the road with native plant species, preferably trees, minimizing the barrier effect caused by the roadway; ii) the establishment of a program to monitor the condition of the natural vegetation cover associated with the road, in order to identify phenomena that represent a threat to the cover of the strips in a timely manner; iii) the establishment of a program to monitor the presence of wildlife in the road's area of influence as well as the running over of individuals; iv) the involvement of landowners and the community living in the road's area of influence in the process of wildlife conservation and vegetation enrichment; and v) the identification of sites where it would be necessary to build wildlife crossings.

5.2 Identify crossings with water bodies and their buffer zones, and drainage works in order to identify the need for building or adapting these types of structures

Water bodies represent the vital support for biological processes in aquatic and terrestrial ecosystems, and importantly, they and their buffer zones serve as both habitat and medium of transit for wildlife. Yet given their high vulnerability to anthropic activities that cause alterations in their morphology, changes in their use, and pollution, they should receive special attention during the operation of road infrastructure in order to avoid generating negative environmental impacts at this stage. Well-designed and constructed road drainage works, on the other hand, can themselves become effective and safe mechanisms for wildlife mobility.

The operation of road infrastructure has the potential to cause negative environmental impacts on water bodies and associated water resources, especially when the drainage works present at the intersections with water bodies are not appropriately located, or lack designs or dimensions to allow adequate continuity of water and ecological flows through the watercourses and buffer zones.

Therefore, an inventory should be carried out of road crossings with water bodies and their buffer zones, as well as the drainage works constructed. This inventory would allow for the identification of the needs for new drainage infrastructure and wildlife passages, the adjustment of pre-existing drains improving designs, capacities, and functionality to contribute to the genetic flow of aquatic and terrestrial fauna, and the enrichment of the natural cover associated with these water bodies, their buffer zones, and the existing drainage infrastructure.

5.3 Monitor wildlife mobility during the operation of road infrastructure

Wildlife mobility is affected by the operation of roads, particularly by the barrier effect caused by high-speed vehicle traffic, light and noise pollution, and the running over of individuals.

In order to determine the level of impact that the operation of road infrastructure is having on the mobility of fauna, it is essential to determine the conditions of fauna mobility in the area of influence of the infrastructure, and identify the mobility corridors. This type of study also makes it possible to identify the effectiveness of the measures adopted by the road project during the construction stage, with the aim of avoiding and mitigating wildlife being run over.

Wildlife mobility monitoring should preferentially evaluate umbrella species, endemic species, endangered or vulnerable species, and species with limited mobility[5], using one or more of the following actions:

- Undertaking of standardized sampling per road section.
- Installation of camera traps.
- Installation of animal footprint tracking spots.
- Conducting field observation transects.
- Reporting and analysing of information from the Colombian network for monitoring wildlife roadkill (Recosfa).

The information obtained from monitoring the mobility of wildlife makes it possible to direct efforts and economic resources accordingly. Primarily, it permits the evaluating of the efficiency and effectiveness of the road–related infrastructure that was built to avoid, prevent, mitigate, and correct the environmental impacts generated on wildlife, as well as the management measures formulated and implemented for these purposes. The information related to the monitoring of wildlife roadkill is also used to guide actions aimed at avoiding the loss of individuals in this manner.

For the collection of information on wildlife roadkill, it is recommended to evaluate the feasibility of involving universities, research institutes attached and linked to Minambiente, the environmental authorities, other research institutes working on this matter, environmental non–governmental organizations, entities attached or linked to the road transportation sector, and the communities settled in the road's area of influence.

Studies aimed at evaluating the effectiveness of sampling of run–over wildlife (Zimmermann Teixeira, Pfeifer Coelho, Beraldo Esperandio, & Kindel, 2013; Smith & van der Ree, 2015; Abra, Huijser, Pereira, & Ferraz, 2018) reached the following conclusions:

- **The observer's travel speed should be equal to or less than 30 km/h so they can detect small vertebrate carcasses.**
- **The recording of samples should be extended to the shoulder of the road.**
- **The sampling journeys should be made before the carcasses are removed by maintenance personnel.**
- **Carcasses already recorded should be removed from the road in order to avoid over–recording.**
- **The monitored sections should include sections with wildlife passage structures to evaluate their effectiveness.**
- **The monitoring team should include specialized personnel for taxonomic identification of specimens.**
- **Monitoring should be long–term as the points with the highest frequency of wildlife roadkill tend to vary over time.**

5. For this last group, it is recommended to consider species belonging to the Superorder Xenarthra (sloths, anteaters, armadillos).

5.4 Monitor natural cover during the operation of road infrastructure

The road operation supports, incentivizes, and strengthens the development of productive activities and the exchange of goods and services that generate land occupation and loss of natural cover due to changes in use. The loss of natural cover, in turn, transforms and affects terrestrial and aquatic ecosystems over a surface area that extends beyond that in which the road infrastructure operates.

In order to avoid, mitigate, prevent, and correct these negative environmental impacts in a timely manner, which are both direct and indirect, as well as cumulative and synergistic, it is necessary to monitor the dynamics of change of natural cover in the area of influence of the roads during their operation.

Based on the experience in the country to date, the most significant transformation impacts caused by the existence of a road occur at a distance of up to 5 kilometres on either side, which is why it is recommended that monitoring covers this width and is concentrated on identifying deforestation hotspots. Monitoring should focus on properties adjacent to the right–of–way, water courses, ecological connectivity corridors, areas destined for the development of compensation activities, and areas that have been enriched by landscaping activities.

In the event that affected areas with loss of vegetation cover are identified, the relevant environmental authority with jurisdiction in the area must be informed immediately. This ensures that actions can be taken, in coordination with the municipal authorities, to stop and reverse the damage caused.

5.5 Preserve and maintain infrastructure to mitigate negative impacts on wildlife during the operation of road infrastructure

During the construction stage of green infrastructure road projects, structures have been established to avoid negative impacts on wildlife mobility (e.g. viaducts, bridges, tunnels, wildlife crossing systems). Additionally, complementary infrastructure has also been established to mitigate and correct other impacts on this resource (e.g. CAV and CAVR), which must be preserved and maintained to ensure their functionality.

It is necessary to carry out a periodic evaluation of each of the structures associated with the road that are performing impact mitigation functions, such as fragmentation of ecosystems, affecting ecological connectivity corridors, and impermeability to wildlife crossing. Such structures include viaducts, bridges, tunnels, box culverts, and adapted culverts, wildlife crossings, fencing and perimeter fences, ramps, escape mechanisms, attractive, dissuasive and screening structures, and associated signage. Thus, the evaluation of all these structures is required in order to identify, in a timely manner, the need to undertake maintenance, repair, or modification measures to ensure their good condition and functionality in their operation.

It is also essential to verify, through permanent monitoring, that these structures are effective and efficient as a means for the crossing of the different wildlife specimens in the road's area of influence. If necessary, changes should be implemented to optimize their operation.

At the same time, it is also necessary to periodically check the activities carried out by the CAVs and CAVRs, confirming their permanent and correct functioning. This helps ensure that the facilities, equipment, supplies, and personnel are operating in accordance with the requirements of the road infrastructure and the environmental impacts that these generate on wildlife resources. If necessary, actions must be taken to correct weaknesses and strengthen their performance.

5.6 Preserve and maintain infrastructure to mitigate negative impacts on vegetation cover and wild flora during the operation of road infrastructure

During the construction phase of green road infrastructure projects, structures have been established to support mitigation and correction measures for negative impacts on vegetation cover and wild flora (e.g. multifunctional nurseries). These structures generate plant material for the enrichment of cover in areas such as ecological connectivity corridors; water bodies and their buffer zones; attractive, deterrent and shielding structures associated with wildlife crossings; areas of food supply and habitat for wildlife; landscaping areas; those threatened by geotechnical instability or erosion processes; or those with the presence of banned or endemic species or species in a state of threat or vulnerability.

It is also necessary to ensure that these nurseries maintain their conditions as training scenarios for the communities associated with the road infrastructure in terms of the importance of the conservation of vegetation cover and wild flora. Maintenance, repair, and modification measures should be undertaken to ensure their good condition and functionality in their operation, which can be enhanced with those carried out by other projects or activities developed in the region where the road is located (e.g. mining and energy exploration or exploitation, construction of various infrastructure, agriculture, industry), all of which can even generate net positive environmental impacts. The strengthening of multifunctional nurseries could be extended to the formulation and implementation of productive projects that improve the quality of life of the communities settled in the project's area of influence. In the case that this type of infrastructure does not exist, it is possible to build and adapt it during the road's operation stage.

6

Guidelines for intervention (improvement, rehabilitation, and maintenance)

© Mario Orlando López Castro / Asesor DAASU Minambiente

6.1 Apply the technical environmental criteria methodology to prioritize roads for intervention

The methodology of using technical environmental criteria for the prioritization of roads for intervention is a tool that facilitates decision making, and which was developed by Minambiente with the support of Mintransporte and some of its affiliated and related entities. This tool incorporates the evaluation of technical environmental criteria from the early stages of planning of road infrastructure projects related to improvement, rehabilitation, and maintenance, thus avoiding the creation of land accesses that have complete or very high environmental restrictions that make them unfeasible.

The application of the methodology ensures that the roads prioritized for intervention (improvement, rehabilitation, or maintenance) correspond to those that were built before the coming into force of Law 99 of 1993[6], or failing this, those that were built after that date, having previously obtained an environmental license granted by the relevant environmental authority. Likewise, this exercise avoids the prioritizing of land access which overlaps with a protected area in the System of National Natural Parks (SPNN) or the Regional Natural Parks (PNR), as this would constitute a complete environmental restriction.

Other environmental criteria considered with the application of this methodology seek the identification of high and very high environmental restrictions, so that the intervention project contemplates the implications of such conditions at this early stage. Such restrictions imply having to obtain permits prior to the intervention of and/or conducting studies to establish the feasibility of implementing the project, as well as identifying the management measures to be implemented to avoid, prevent, mitigate, and correct the impacts caused by the road as a result of its operation. Examples of these type of restrictions are:

- overlapping with areas covered by forest reserves
- areas with natural vegetation cover or wetlands
- ecological connectivity corridors
- areas of natural distribution of endemic wildlife species or in any category of threat

The methodology of using technical environmental criteria to prioritize roads for intervention is a tool that facilitates decision making, and which was developed by Minambiente with the support of Mintransporte and some of its affiliated and related entities.

6. Article 49 of Law 99 of 1993 establishes that "The execution of works, the establishment of industries, or the development of any activity, which, in accordance with the law and regulations, may produce serious deterioration to renewable natural resources or the environment, or introduce considerable or evident modifications to the landscape shall require an Environmental License". For their part, Articles 2.2.2.3.2.2 and 2.2.2.3.2.3 of Decree 1076 of 2015 state that the construction of roads requires an environmental license.

6.2 Perform a diagnosis of the characteristics of the alignment and the road structure prior to the intervention

The intervention of road infrastructure for maintenance, rehabilitation, or improvement represents a good opportunity to evaluate the alignment (layout) of the road, its design, the components of its infrastructure, and their incidence in the generation of direct, indirect, synergistic, and cumulative environmental impacts in the road's area of influence. The objective of conducting such an assessment is to identify and consider works or activities that will prevent these impacts from continuing, and correcting the effects caused, taken as a part of the intervention project. To this end, an examination of the infrastructure must be made which takes into consideration, among others, the following conditions:

- Winding stretches of road.
- Mid-slope cuts.
- Steep slopes on the road surface.
- Slopes with steep gradients.
- Unstable areas susceptible to landslides.
- Geotechnical instability.
- Troughs.
- Embankments.
- Drainage structures (their presence or lack thereof in places of crossings with water bodies, their number, and capacity).
- Stretches of road parallel with bodies of water that occupy its buffer zone.
- Structures for the crossing of aquatic and terrestrial wildlife (their presence or lack thereof in sites associated with ecological connectivity corridors, their number, and the effectiveness of their operation).
- Sites that pose a threat to road safety.
- Sites associated with reports of traffic speed higher than that intended or permitted.
- Sites associated with continuous reports of roadkill.
- Sites associated with Areas of Special Environmental Interest (AEIA) and ecological connectivity corridors, or with the potential for conservation or recovery.

The identification of road characteristics that are generating negative environmental impacts, or environmental or road safety risks, should be reflected in the formulation of recommendations. In this way, and within the framework of the planned intervention, the application of technological solutions aimed at correcting the deficiencies recorded can be included. Some types of works or activities to be considered are:

- Road realignment.
- Adaptation of extended road widths.
- Modification of the layout.
- Disabling and dismantling of stretches of road.
- Construction of viaducts.
- Construction, extension, and readjustment of bridges.
- Construction of tunnels.

- Construction, extension, and readjustment of structures that favour the crossing of terrestrial and aquatic wildlife.
- Construction, extension, and readjustment and replacement of pontoons and box culverts.
- Stabilization and improvement of embankments.
- Replacement of troughs, embankments, and culverts.
- Protection meshes.
- Restoration of natural watercourses, their buffer zones, and dry crossings in drainage systems.
- Installation or improvement of horizontal and/or vertical signage.
- Monitoring of mobility and roadkill of wildlife.

6.3 Carry out adjustments to drainage works in order to re-establish fauna mobility in water bodies and their buffer zones

Road infrastructure drainage works perform essential functions, not only in relation to the stability and durability of the work, but also to the preservation of the integrity of water bodies and water resources that are permanently affected as a result of the replacement of the natural soil cover with the road. It is essential that the implementation of green road infrastructure projects guarantees the protection and good management of water bodies and water resources for several reasons. First, due to their role as support for diverse biological processes and aquatic ecosystems, as well as to their high sensitivity to anthropic activities. These human activities can lead to land occupation, alteration of their morphology and change of use, as well as contamination and overexploitation of these important water resources.

Drainage works must avoid fragmenting the terrestrial and aquatic ecosystems present in the area of influence of the project. This is because fragmenting can affect the morphology and subsequent functionality of water bodies and their buffer zones due to the drainage structure's presence, or even modify the flows, availability, and physicochemical and biological quality of water. Therefore, these works must be the result of a comprehensive assessment of the physical and biological conditions of the environment where these engineering solutions are to be placed.

The intervention of roads for maintenance, rehabilitation, or improvement represents a good opportunity to carry out an evaluation of the road's drainage works, which allows for determining the need to widen, readjust, or replace this type of structure, or to even build new ones. In this manner, the road intervention permits complying not only with drainage's basic function of guaranteeing that neither the bodies of water nor the road are negatively affected in the places where they overlap or cross, but also avoiding negative impacts on the mobility of aquatic and terrestrial wildlife.

Water bodies and their buffer zones are, by their very nature, corridors for the mobility of aquatic and terrestrial wildlife, which is why the drainage works of the road infrastructure to be built in their vicinity

© Ministerio de Transporte

must avoid becoming barriers that hinder or prevent their normal transit.

Taking advantage of the implementation of road intervention projects (improvement, rehabilitation, or maintenance), and to restore the mobility of wildlife where it has been affected, some of the most common drainage structures that should be evaluated and eventually adapted include:

- Bridges
- Pontoons
- Box culverts
- Culverts

Broadly speaking, the purpose of the adaptation of structures is to enlarge their section to ensure that they do not invade the flood zones of water bodies and their buffer zone. This must happen in such a way that these structures, particularly bridges and pontoons, do not occupy the water body buffer zone beyond what is necessary for the installation of their corresponding supports, and in particular, without affecting their functionality as a mobility corridor. In the case of box culverts and culverts, the purpose of their design, size, and characteristics is to ensure that they maintain permanent dry passages at both of their lateral ends and that the bottom surface is conducive to the mobility of aquatic and terrestrial wildlife typical of the area.

However, to make an appropriate decision on what type of structure is best suited to the particular characteristics of a water body (as well as its dimensions and other characteristics), it is necessary to take into account, among other aspects, scenarios of climate variability. The evaluation of the conditions associated with drainage structures, which guides the adjustments to be made to each type of structure, should include an analysis of hydrometeorological information contemplating different return periods. The following periods are recommended, depending on the type of structure:

- Bridges: 100 years.
- Pontoons: 50 years.
- Box culverts: 30 years.
- Culverts: 20 years.

In road infrastructure improvement projects, a general recommendation is to replace round culverts with square or rectangular ones that have greater capacity (Figure 10). These projects should also contemplate the removal of any type of physical barrier that obstructs the mobility of aquatic or terrestrial wildlife, seeking to re-establish the natural riverbed.

There are a number of considerations that will determine which species of wildlife will use a structure as a route to pass to the opposite side of the road. These include the type of structure to be built (bridge, box culvert, or culvert) and its dimensions, as well as other conditions such as natural lighting, floor substrate, and complementary structures (channelling barriers, vegetation cover, availability of shelter, etc.).

To determine the dimensions that a wildlife underpass structure must have, the opening coefficient must be determined according to the species for which the structure is being designed or adapted (Donaldson, 2005; Mata Estacio, 2007). This can be calculated as the result of dividing the section area of the structure by the length (from the entrance to the exit) (Figure 10).

As an example:

A 2m high and 3m wide box culvert that crosses a single carriageway (7.65m of carriageway + 2m of roadside = 9.65m long), would have an opening coefficient of 0.6. This same type of structure with the same section, but which crosses a dual carriageway (15.3m of the two carriageways + 1m of separator + 2m of roadside = 18.3m long), would have an opening coefficient of 0.3.

The passage of large mammals requires the structure to have a minimum opening coefficient of 0.75, while for the passage of medium-sized mammals it is required to have an opening coefficient of no less than 0.4.

Figure 10. Opening index in a quadrangular structure and in a circular section structure

Source: Mata Estacio (2007).

6.4 Identify potential ecological connectivity corridors prior to intervention

The functionality of ecological connectivity corridors is essential for maintaining genetic exchange, the dispersion of wild flora and fauna species, and other ecological flows. For this reason, both their conservation and the incorporation of strategies to favour such connectivity are part of the actions that must be taken at the intervention stage (improvement, rehabilitation, or maintenance) in green road infrastructure.

Although the most opportune moment to identify the presence of ecological connectivity corridors associated with road infrastructure projects is in the early stages of planning, many of them are nevertheless already in operation without having been subject to measures that contribute to preserve and consolidate this important conservation figure.
For this reason, the intervention stage represents a good opportunity to meet this requirement.

The identification of potential ecological connectivity corridors before beginning road intervention can be carried out using biological studies. In this way, actions oriented toward their preservation can be incorporated in the intervention project in a timely manner, some of which include the following:

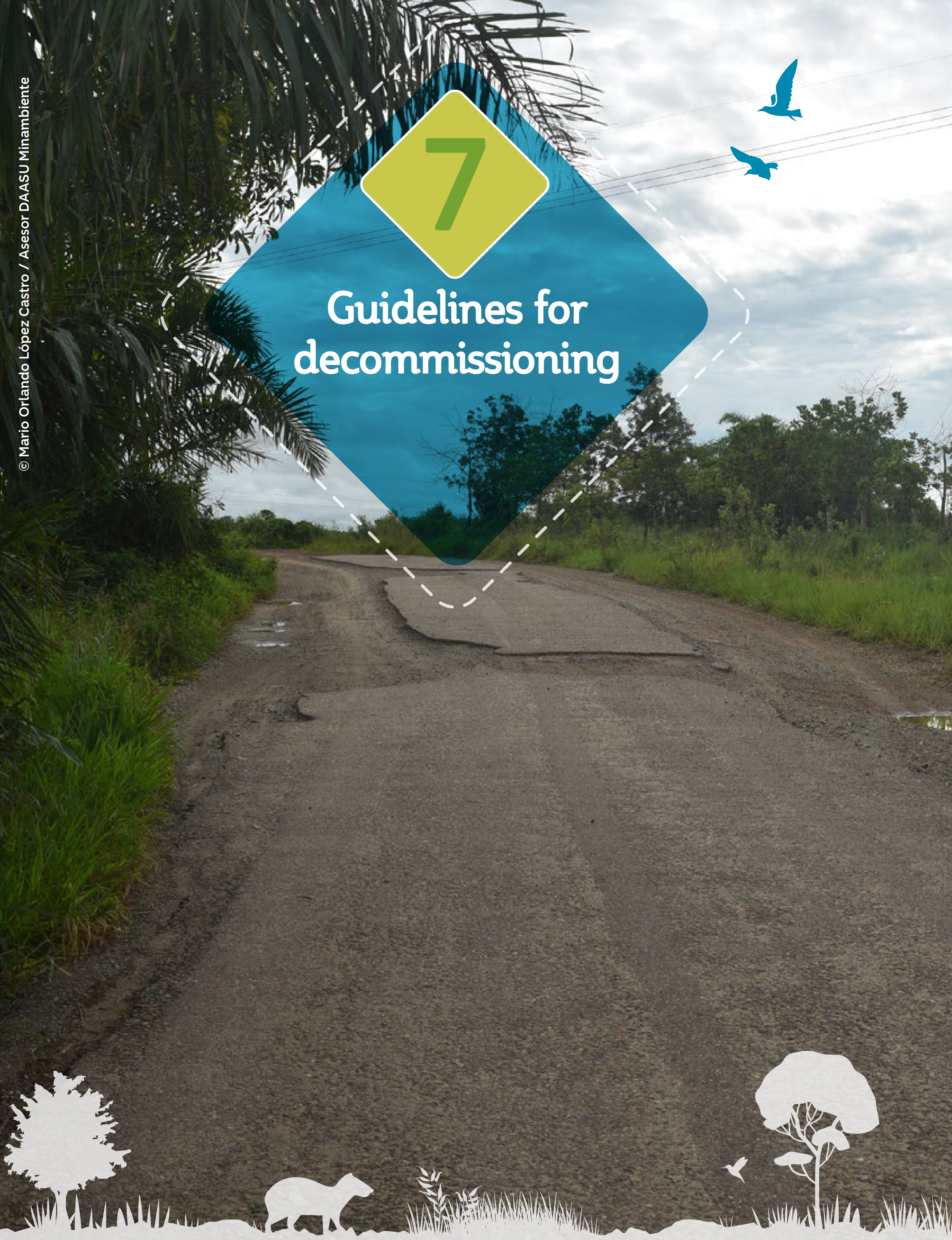
- Evaluate alternatives for the relocation, layout, engineering, technology, and design of projects that prevent the infrastructure from overlapping or affecting ecological connectivity corridors.
- Avoid carrying out interventions that negatively affect existing vegetation cover in the area of influence of the road.

© Ministerio de Transporte

- Enrich the strips located on both sides of the road with native plant species, preferably trees, minimizing the barrier effect caused by the road.

Most of the country's road infrastructure has been built without considering the impact it has on ecological connectivity, which is why it is necessary to compensate for the impact this has had on the country.

7 Guidelines for decommissioning

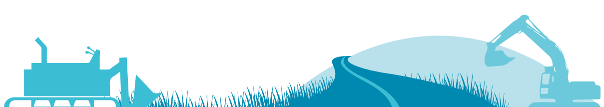


© Mario Orlando López Castro / Asesor DAASU Minambiente

7.1 Identification of road infrastructure that needs to be decommissioned

The execution of road construction or improvement projects may have contemplated the replacement of some road sections that must be decommissioned as part of the actions to be implemented, in order to correct the environmental impacts generated in other stages of the project cycle. Similarly, road sections that have lost their functionality must undergo the same process, so that the areas affected by that road infrastructure can be recuperated. Likewise, illegal roads that are not part of the national road network that were built without complying with sectoral or environmental regulations, and which have been disabled, must be decommissioned.

In Article 2.2.2.3.1.1 of Decree 1076 of 2015, the Single Environmental Regulatory Decree, the dismantling of the infrastructure associated with the development of projects, works, or activities that require environmental licensing is established as part of their scope. Further, this is established as being an additional stage to those considered in the project cycle, such as planning, siting, installation, construction, assembly, operation, and maintenance.



The execution of road construction or improvement projects may have contemplated the replacement of some road sections that must be decommissioned as part of the actions to be implemented, in order to correct the environmental impacts generated in other stages of the project cycle.

In order to be able to undertake a decommissioning project or undertake the decommissioning stage of a project, Decree 1076 of 2015, in its article 2.2.2.3.9.2, states that a study must be submitted to the relevant environmental authority. This study must contain, among other aspects, the identification of the environmental impacts present at the time of initiating this phase, the decommissioning and abandonment plan with the final restoration activities, and the costs of the activities for the implementation of the decommissioning and abandonment phase.

In the case of road sections that have been replaced or have lost their functionality, the infrastructure managers will conduct a technical reconnaissance tour in order to identify those to be decommissioned.

In the case of illegal road sections, the process of identifying the infrastructure to be decommissioned begins with the application of the methodology of technical environmental criteria for the prioritization of roads for intervention, by means of which their illegal status is corroborated, which, in turn, supports the decision to order their disabling by the relevant environmental authority. These sections of road must be dismantled.

7.2 Removal of existing infrastructure for decommissioning

The decommissioning of roads requires the incorporation of environmental, social, technological, and engineering considerations to decommission and remove the existing infrastructure and restore the area occupied by the infrastructure. This allows for the recovery of pre-existing conditions in the area, and particularly the carrying out of actions to fulfil the following purposes:

- Restore natural cover.
- Restore ecological connectivity.
- Restore the structure of the buffer zones of water bodies.
- Restore the structure of natural watercourses.
- Restore the mobility conditions of the fauna.

Additionally, actions must be taken to generate positive environmental impacts in the area of influence of the corridor through which the infrastructure to be dismantled runs, such as:

- Generate areas whose coverage allows for the establishment of ecological connectivity corridors.
- Connect areas that have the presence of critically endangered, threatened or vulnerable, endemic, or migratory fauna species.
- Build nurseries for natural restoration and recovery of affected or eroded areas.
- Generate actions for the enrichment of water courses.
- Plant vegetation which is aimed at favouring wildlife habitats and food supply.

The removal of the infrastructure must be undertaken by taking into account the formulation of the decommissioning plan. This includes the management measures to avoid, prevent, mitigate, and correct the environmental impacts of the activity. Some of the actions to be considered are:

- Removal of all structures.
- Avoiding contributing sediment to water bodies.
- Recovering material used for construction (recycling of concrete, base material, sub-base, and milling material).
- Disposal of non-recycled waste material in an area authorized by the relevant environmental authority.

© Mario Orlando López Castro / Asesor DAASU Minambiente

7.3 Restoration of the affected area

One of the impacts generated by the construction of a road is the definitive change in the land use of the area of its construction, which affects the natural cover, ecosystems, ecological connectivity, and soil. Therefore, it is necessary to remove the road structure as well as other existing structures such as bridges, pontoons, and drainage works in order to prepare the ground for restoration.

Once the decommissioned road infrastructure has been removed, it is necessary to recover the soil structure, its vegetation cover, and the functionality of the landscape.

From the point of view of the physical component, it is important to recover the morphology of the natural landscape by carrying out landscape restoration processes. These processes involve the removal of embankments, improving the gradient of cuts and slopes to contribute to the re-establishment of the interrupted connectivity, and using organic soil and vegetation of the area to restore all the affected areas.

Moreover, from the biotic component viewpoint, restoration actions should be focused on recovering the natural conditions of the area in which the road construction took place, for which soil studies should be conducted and actions aimed at its recovery carried out. The restoration of natural cover should be carried out by using only species native to the affected area, selecting soil-forming vegetation as well as species that encourage the re-establishment of ecological connectivity processes. Importantly, these native species represent refuge, habitat, and food supply for fauna.

Glossary

- **Area of influence:** area in which the significant environmental impacts caused by the implementation of a project, work, or activity on the abiotic, biotic, and socioeconomic environments are objectively and, as far as possible, quantifiably evident (Minambiente, 2018a).
- **Box culvert:** square section culvert (INVÍAS, 2006).
- **Bridge:** a drainage structure whose main span, measured parallel to the axis of the road, is greater than ten meters (10 m) (INVÍAS, 2008).
- **Buffer zone of water bodies:** In Colombian regulation, the buffer zone of water bodies refers to a strip parallel to the maximum tidal line or to that of the permanent channel of rivers and lakes of no less than 30 meters wide (Decreto–Ley 2811/1974, art. 83). These are unseizable, inalienable, and imprescriptible. Additionally, it is stated by law that environmental authorities must establish the size of the stripe for every water body under their jurisdictions based on studies and technical criteria (Ley 1450/11, Decreto 2245/17)
- **Capillarity strategy:** maintenance of the functional connectivity of ecosystems in water bodies. The group of surface drainages (streams, rivers, creeks, meanders, lagoons, flood terraces, among others) is called the "capillarity structure". This denomination is used to make the analogy with the blood vessels in peripheral areas of the body where small vessels allow the flow of blood and the maintenance of the organs without depending on large vessels. In the case of infrastructure, the distribution of connectivity "loads" – through which species, genetic flows, and matter pass – in the greatest number of zones possible, and by using the bodies of water that cross a road layout (projected or existing), reduces the vulnerability of ecological connectivity corridors to fragmentation.
- **Clearance gauge:** the height between the bottom of the beam and the bottom of the bed in the case of crossings over rivers or estuaries. In road overpasses, it is the distance between the lowest point of the beam and the highest level of the pavement of the road over which it crosses.
- **Climate change:** change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is, in addition to natural climate variability, observed over comparable time periods (United Nations, 1992).
- **Compensation measures:** actions aimed at compensating and reimbursing communities, regions, localities, and the natural environment for the negative impacts or effects generated by a project, work, or activity that cannot be avoided, corrected, or mitigated (Minambiente, 2018a).
- **Concession contract:** a type of contract entered into by state entities for the purpose of granting to a legal entity identified as the concessionaire the total or partial provision, operation, exploitation, organization, or management of a public service, or the total or partial construction, exploitation, or conservation of a work or asset intended for public service or use, as well as all those activities necessary for the adequate provision or operation of the work or service on behalf and at the risk of the concessionaire and under the

supervision and control of the granting entity, in exchange for remuneration that may consist of fees, tariffs, rates, valuation, or in the participation granted in the exploitation of the asset, or in a periodic, single, or percentage sum and, in general, in any other form of consideration agreed upon by the parties (Congress of the Republic, 1993a).

- **Construction:** in the context of the present document, this constitutes action aimed at generating new works (Congreso de la República, 2013).
- **Corrective measures:** actions aimed at recovering, restoring, or repairing the environmental conditions affected by a project, work, or activity (Minambiente, 2018a).
- **Culvert:** work belonging to the surface drainage system, through which water crosses under the road transversally to the axis of its structure (INVÍAS, 2006).
- **Cumulative impact:** environmental impact resulting from successive, incremental, and/or combined effects of projects, works, or activities when added to other existing, planned, and/or reasonably anticipated future impacts. For practical purposes, the identification, analysis, and management of cumulative impacts should be oriented to those that are recognized as significant, which manifest themselves at diverse spatiotemporal scales (Minambiente, 2018a)
- **Direct environmental impact:** any alteration of the environment that is adverse or beneficial, total or partial, that can be attributed to the development of a project, work, or activity, whose effect is produced as a direct result of its activities during the stages of prefeasibility, feasibility, studies, designs, construction, operation, and decommissioning and abandonment (Minambiente, 2018a).
- **Drainage works:** works planned to eliminate excess surface water on the road strip and restore the natural drainage network which may be affected by the layout (INVÍAS, 2008).
- **Early intervention approach:** conceptual, analytical, and practical approach that highlights the benefits of incorporating in each of the instances of project conception, planning, and implementation, the concepts, instruments, and the best available information to support opportune decision making.
- **Ecological connectivity corridor:** A strip of territory within which the movement and dispersal of species of wild flora and fauna, genetic exchange, and other ecological flows (matter and energy) are maintained, which are part of natural landscapes in which such connectivity has been affected.
- **Emergency maintenance:** intervention in the infrastructure which comes from events originating from climatic emergencies, earthquakes, terrorism, among others, which in light of current legislation may be considered events of *force majeure* or a fortuitous event (Congreso de la República, 2013).
- **Environment:** fraction of the globe comprised of both physical and biological natural elements, as well as artificial, social, and cultural elements, and their interactions with each other (Minambiente, 2018a).
- **Environmental conflict:** clashes of interests or values that may arise between two or more persons (natural or legal) who intend to make a different and incompatible use of the territory or of the same natural resource (Minambiente, 2018a).
- **Environmental impact:** any alteration of the environment that is adverse or beneficial, total or partial, that can be attributed to the development of a project, work, or activity (Minambiente, 2018a).

- **Environmental zoning:** process of establishing homogeneous sectors according to the classification of the environmental sensitivity of the components of the abiotic, biotic, and socioeconomic environments, land uses or other criteria (Minambiente, 2018a).
- **Feasibility:** the phase of the execution of infrastructure projects in which the project must be designed and the final economic evaluation carried out through simulation with the model approved by the contracting entities. The purpose is to establish whether or not the project is feasible to be executed by considering all aspects related to it (Congreso de la República, 2013).
- **Governability:** the expression of the capacity of the State to achieve the fulfilment of its purposes in an effective and efficient manner. This capacity should emerge as a product of interinstitutional action and the participation of the communities in the decision-making levels of government policies, plans, programs, and projects that concern and are applied and executed in their territory.
- **Green road infrastructure:** road infrastructure that integrates environmental, social, technological, and engineering considerations throughout all stages of its development. This includes from the strategic planning stage and during its planning, construction, operation, intervention, and decommissioning, in order to avoid, prevent, mitigate, and correct the potential negative environmental impacts generated by this type of project, whether direct, indirect, synergistic, or cumulative, resulting in a positive net environmental balance.
- **Improvement:** changes in transportation infrastructure with the purpose of improving its initial technical specifications (Congreso de la República, 2013).
- **Indirect environmental impact:** any alteration in the biotic, abiotic, and socioeconomic environment which is adverse or beneficial, total or partial, and that can be attributed to the development of a project, work, or activity whose effect occurs as a result of its activities during the stages of prefeasibility, feasibility, studies, designs, construction, operation, and decommissioning and abandonment, and whose cause corresponds to effects related to environmental aspects that transcend the sphere of direct impacts (Minambiente, 2018a).
- **Mitigation hierarchy:** this concept was developed so that infrastructure projects which may potentially affect environmental components, plan, and implement effective measures to avoid, minimize, and correct or compensate for their impact.
- **Mitigation measures:** actions aimed at minimizing the negative impacts and effects of a project, work, or activity on the environment (Minambiente, 2018a).
- **Periodic maintenance:** a set of conservation activities at variable intervals, primarily aimed at recovering the deterioration caused by use or by natural phenomena or external agents (Congreso de la República, 2013).
- **Permeability:** In the context of this document, it refers to the ease with which a road allows the free and safe passage of individuals or groups of a species of wildlife from one side of the road to the other.
- **Pontoon:** a drainage structure, whose span measured parallel to the road axis, is less than or equal to ten meters (10 m) (INVÍAS, 2008).
- **Prefeasibility:** the phase of the execution of infrastructure projects in which the approximate pre-design of the project must be carried out. During this phase, alternatives are presented, and the

preliminary economic evaluation is performed using costs obtained in projects with similar conditions, as well as by using simulation models duly approved by the requesting entities (Congreso de la República, 2013).

- **Prevention measures:** actions aimed at avoiding negative impacts and effects that a project, work or activity may generate on the environment (Minambiente, 2018a).
- **Public–private partnership:** instrument for linking private capital, which materializes in a contract between a public entity and a natural or legal entity under private law, for the provision of public goods and related services, involving the retention and transfer of risks between the parties and payment mechanisms related to the availability and level of service of the infrastructure and/or service (Congreso de la República, 2012).
- **Rehabilitation:** reconstruction of transportation infrastructure to return it to the initial state for which it was built (Congreso de la República, 2013).
- **Road cluster:** group comprised of road infrastructure, occupation centres, and their articulation nodes in terms of the social dynamics of the territory.
- **Road intervention:** In the context of this document, this refers to infrastructure projects aimed at improving, rehabilitating, or maintaining roads.
- **Routine maintenance:** intervention for continuous conservation (at intervals of less than one year), in order to maintain optimal conditions for transit and proper use of transportation infrastructure (Congreso de la República, 2013).
- **Scope of the project, work, or activity:** includes the planning, siting, installation, construction, assembly, operation, maintenance, dismantling, completion, and/or termination of all actions, activities and infrastructure related to and associated with the development stages (Minambiente, 2015).
- **Studies and designs:** the phase of the execution of infrastructure projects in which detailed geometric designs must be prepared, as well as those of all the structures and works required, so that a builder can carry out the project. The objective of this phase is to materialize the final project in the field and design all its components in such a way that construction can begin (Congreso de la República, 2013).
- **Sustainable development:** type of development that meets the needs of the present generation, and which promotes economic growth, social equity, constructive modification of ecosystems, and maintenance of the natural resource base, without deteriorating the environment and without affecting the right of future generations to use it to meet their own needs (Minambiente, 2018a).
- **Synergistic impact:** impact that originates from complex interactions between other impacts, whether generated by the same project or by several projects. A synergistic impact can be evidenced when the combined effect of two impacts is greater than their sum or when they cause the appearance of a third impact (Minambiente, 2018a).
- **Vegetation clearing:** a routine maintenance activity aimed at keeping vegetation low on the sides of the road (INVÍAS, 2008).
- **Viaduct:** a long bridge that has intermediate supports due to a depression in the terrain, the presence of wetlands, drainage, an area of geological instability, a corridor of ecological connectivity, or an environmentally sensitive area that overlaps with the alignment or layout of a road.

Works cited

Abra, F. D., Huijser, M. P., Pereira, C. S., & Ferraz, K. M. (2018). How reliable are your data? Verifying species identification of road-killed mammals recorded by road maintenance personnel in São Paulo State, Brazil. Biological Conservation, 225, 42–52.

Alagmir, M., Campbell, M. J., Sloan, S., Goosem, M., Clements, G. R., Mahmoud, M. I., & Laurance, W. F. (2017). Economic, Socio-Political and Environmental Risks of Road Development in the Tropics. *Current Biology, 27*, 1130–1140.

Barber, C. P., Cochrane, M. A., Souza Jr., C. M., & Laurance, W. F. (2014). Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation, 177*, 203–209.

Broxtowe Borough Council. (2016). Green Infrastructure. Recovered from https://www.broxtowe.gov.uk/for-you/parks-and-nature-conservation/nature-conservation/green-infrastructure/

Business and Biodiversity Offsets Programme. (2009). Biodiversity Offset CostBenefit Handbook. BBOP, Washington, D.C. Available at: http://www.foresttrends.org/documents/files/doc_3094.pdf

Cardinale, P., & Greig, L. (2013). *Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. Corporación Financiera Internacional.* Washington, DC: World Bank.

Colombia. Congreso de la República. (1993a). Ley 80. Por la cual se expide el Estatuto General de Contratación de la Administración Pública. Bogotá, Diario Oficial 41.094, de 28 de octubre de 1993.

Colombia. Congreso de la República. (1993b). Por la cual se crea el Ministerio del Medio Ambiente, se reordena el Sector Público encargado de la gestión y conservación del medio ambiente y los recursos naturales renovables, se organiza el Sistema Nacional Ambiental, SINA y se dictan otras disposiciones. Ley 99 de 1993. Bogotá, Diario Oficial 41.146, de 22 de diciembre de 1993.

Colombia. Congreso de la República. (1997). Ley 388. Por la cual se modifica la Ley 9ª de 1989, y la Ley 3ª de 1991 y se dictan otras disposiciones. Bogotá, Diario Oficial 43.127, de 12 de septiembre de 1997.

Colombia. Congreso de la República. (2012). Ley 1508. Por la cual se establece el régimen jurídico de las Asociaciones Público Privadas, se dictan normas orgánicas de presupuesto y se dictan otras disposiciones. Bogotá, Diario Oficial 48308, de enero 10 de 2012.

Colombia. Congreso de la República. (2013). Ley 1682. Por la cual se adoptan medidas y disposiciones para los proyectos de infraestructura de transporte y se conceden facultades extraordinarias. Bogotá, Diario Oficial 48.987, de 27 de noviembre de 2013.

Colombia. Congreso De La República. (2013). Decreto 1076 de 2015. Por medio del cual se expide el Decreto Único Reglamentario del Sector Ambiente y Desarrollo Sostenible. Bogotá, Congreso de la República.

Colombia. Ministerio de Agricultura y Desarrollo Rural. (2018). Resolución 261. Por medio de la cual se define la frontera agrícola nacional y se adopta la metodología para la identificación general. Bogotá, Diario Oficial 50632, de junio 22 de 2018.

Colombia. Ministerio de Ambiente y Desarrollo Sostenible [Minambiente]. (2015). Decreto 1076. Por medio del cual se expide el Decreto Único Reglamentario del Sector Ambiente y Desarrollo Sostenible. Bogotá, 26 de mayo de 2015.

Colombia. Ministerio de Ambiente y Desarrollo Sostenible [Minambiente]. (2018a). Resolución 1402. Metodología general para la elaboración y presentación de estudios ambientales. Bogotá, Diario Oficial 50.673, de 2 de agosto de 2018.

Colombia. Ministerio de Ambiente y Desarrollo Sostenible [Minambiente]. (2018b). *Criterios ambientales para la priorización de vías de tercer orden.* Bogotá, D. C.

Colombia. Ministerio de Ambiente y Desarrollo Sostenible [Minambiente]. (s.f.). Convención Marco de las Naciones Unidas sobre el Cambio Climático. Recuperado de https://www.minambiente.gov.co/index.php/convencion-marco-de-naciones-unidas-para-el-cambio-climatico-cmnucc/convencion-marco-de-naciones-unidas

Colombia. Ministerio de Justicia y del Derecho. (2015). Decreto 1606. Por el cual se establece la conformación, organización y funcionamiento de la Comisión de Seguimiento a las Condiciones de Reclusión del Sistema Penitenciario y Carcelario creada por los artículos 93 y 94 de la Ley 1709 de 2014. Bogotá, Diario Oficial 49600, 10 de agosto de 2015.

Comisión Centroamericana de Ambiente y Desarrollo: https://www.sica.int/ccad/

Comisión Económica para América Latina y el Caribe [CEPAL]. Estudio económico de América Latina y el Caribe 2010–2011, documento informativo. Santiago de Chile, julio.

Conesa, V. (2010). *Guía metodológica para la evaluación del impacto ambiental*. (4.ª ed.). Madrid, España: Mundi–Prensa.

Consejo Nacional de Política Económica y Social República de Colombia – Departamento Nacional de Planeación (2016). *Conpes 3857. Lineamientos de política para la gestión de la red terciaria*. Bogotá, D. C.

Departamento Nacional de Planeación [DNP]. (2013). Consejo Nacional de Política Económica Y Social – Conpes 3760. Bogotá. También citado en Inversión en infraestructura vial y su impacto en el desarrollo económico: Un análisis al caso Colombia (1993–2014). Universidad Nacional. Ramírez Muriel, Andrés Felipe, 2015.

Donaldson, B. M. (2005). The use of highway underpasses by large mammals in Virginia and factors influencing their effectiveness. Richmond, Virginia, Estados Unidos.: Virginia Department of Transportation.

Echeverry C., D. (2017). Nivel de influencia sobre los costos de un proyecto. Notas de clase. Uniandes.

EFE. (2015). 'A. Latina debe invertir más en infraestructura': BID y CAF. *Portafolio*. Recuperado de http://www.portafolio.co/internacional/latina–debe–invertir–infraestructura–bid–caf–26900

Fedesarrollo. (2015). Plan Maestro de Transporte Intermodal (PMTI) 2015–2035. Bogotá.

Fundación para la Conservación y el Desarrollo Sostenible [FCDS] y Departamento de Interior de los Estados Unidos [DOI]. (2017). Plan Regional de Gestión Social y Ambiental en el área de influencia del proyecto vial Marginal de la Selva en los tramos entre La Macarena (Meta) y El Cruce La Leona (Guaviare). Iniciativa Ambiental para la Paz en Colombia, EPIC (USAID).

Fundación para la Conservación y el Desarrollo Sostenible. (2019). Guía técnica. Enfoque de intervención temprana (EIT). Botero García, Rodrigo.

Gómez, D. (2002). *Evaluación de impacto ambiental: un instrumento preventivo para la gestión ambiental* (2.ª ed.). Madrid, España: Mundi–Prensa.

Herrera, R. J. y Bonilla, M. (2009). *Guía de evaluación ambiental estratégica*. Santiago de Chile: Cepal y Minambiente.

Instituto Nacional De Vías [INVÍAS]. (2006). *Manual para la inspección visual de obras de drenaje*. p, 59.

Instituto Nacional de Vías [INVÍAS]. (2008). *Manual de Diseño Geométrico*. Colombia. p. 276.

Keller, G., & Sherar, J. (2004). *Ingeniería de caminos rurales: Guía de campo para las mejores prácticas de administración de caminos rurales*. México: Instituto Mexicano del Transporte.

Laurance, William F., Campbell, Mason J., Alamgir, Mohammed, and Mahmoud, Mahmoud I. (2017). *Road expansion and the fate of Africa's tropical forests*. Frontiers in Ecology and Evolution, 5. 75. pp. 1–7.

Laurance, William F., Mahmoud, Mahmoud I., and Kleinschroth, Fritz. (2017). *Infrastructure expansion and the fate of Central African forests*. In: Brouwer, Meindert, (ed.) Central African Forests Forever. Central African Forests Commission, Bunnik, The Netherlands, pp. 88–95.

Malky, A., Reid, J., Barr, R. y Ledezma, J. C. (2013). Filtro de carreteras. Identificando proyectos viales de alto riesgo en la cuenca amazónica. Conservation Strategy Fund. *Políticas de Conservación en Síntese* (14).

Mata Estacio, C. (2007). Utilización por vetebrados terrestres de los pasos de fauna y otras estructuras transversales de dos autovías del Centro-Noroeste peninsular. Madrid, España: Universidad Autónoma de Madrid.

Naciones Unidas. (1992). Convención Marco de las Naciones Unidas sobre el Cambio Climático. P. 27.

Naciones Unidas. (1993). Convenio de Diversidad Biológica (CDB).

Organización para la Cooperación y el Desarrollo Económicos [OCDE]. (2016). Hacia Infraestructuras Exitosas. Diez retos clave para la gobernanza y opciones de política. Marco de la OCDE para La Gobernanza de las Infraestructuras.

Price Waterhouse y Coopers. (2010). Invirtiendo y construyendo para el futuro Soluciones integrales en infraestructura, APP's y proyectos de capital. Price Waterhouse y Coopers.

Price waterhouse Coopers, S.C. (2015). El Futuro de la Alianza del Pacífico: Integración para un crecimiento productivo.

Quintero, J. D. (2012). *Principles, practices and challenges for green infrastructure in Latin America.* Discussion paper. No. IDB-DP250. Washington D.C.: Inter-American Development Bank (IDB).

Quintero, J. D. y López, D. (2015). Compensaciones de biodiversidad en Latinoamérica y aplicación en el contexto colombiano. *Gest. Ambient., 18*(1), 159-177.

Raiter, K., Possingham, P., Prober, S., & Hobbs, R. (2014). Under the radar: mitigating enigmatic ecological impacts. *Trends in Ecology and Evolution, 29*(11), 635-644.

Smith, D. J., Van Der Ree, R., & Rosell, C. (2015). Wildlife crossing structures: an effective strategy to restore or maintain wildlife connectivity across roads. Handbook of road ecology, 172-183.

Teixeira, F. Z., Coelho, I. P., Esperandio, I. B., da Rosa Oliveira, N., Peter, F. P., Dornelles, S. S., ... & Kindel, A. (2013). Are road-kill hotspots coincident among different vertebrate groups?. Oecologia Australis, 17(1), 36-47.

The New Climate Economy. (2016). The sustainable infrastructure imperative. Washington, DC.

United States Environmental Protection Agency [EPA]. (2016). Best Practices for Green Infrastructure O&M. Recovered from https://www.epa.gov/green-infrastructure/best-practices-green-infrastructure-om

World Economic Forum. Annual Report 2015-2016.

The Green Road Infrastructure Guidelines are a set of directives which have been formulated with the aim of being incorporated into road infrastructure projects. Specifically, the objective is to include environmental, social, technological, and engineering elements within these projects in order to avoid, prevent, mitigate, and correct any potential negative environmental impacts that they may cause, with a net positive environmental balance being the desired outcome.

El futuro es de todos Gobierno de Colombia

WWF

FCDS Conservación y Desarrollo