BISON
BIODIVERSITY AND INFRASTRUCTURE SYNERGIES AND OPPORTUNITIES FOR EUROPEAN TRANSPORT NETWORKS

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Effective transport infrastructure life cycle tools, processes and implementation barriers for Green and Grey Infrastructure and recommendations for adaptations and deployment to different transport modes and / or regional clusters

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CONSORTIUM - LIST OF PARTNERS

Partner no.	Short name	Name	Country
1	FEHRL	FORUM OF EUROPEAN NATIONAL HIGHWAY RESEARCH LABORATORIES	Belgium
2	MTES	MINISTERE DE LA TRANSITION ECOLOGIQUE ET SOLIDAIRE	France
3	CERTH/HIT	CENTER FOR RESEARCH AND TECHNOLOGY HELLAS	Greece
4	CDV	CENTRUM DOPRAVNÍHO VÝZKUMU- TRANSPORT RESEARCH CENTER	Czech Republic
5	UGE	UNIVERSITÉ GUSTAVE EIFFEL	France
6	SPW	SERVICE PUBLIC DE WALLONIE – DIVISION MOBILITE – INFRASTRUCTURES	Belgium
7	UPGE	UNION PROFESSIONNELLE DU GENIE ECOLOGIQUE	France
8	UIC	INTERNATIONAL UNION OF RAILWAYS	France
9	CEREMA	CENTRE D'ETUDES ET D'EXPERTISE SUR LES RISQUES, L'ENVIRONNEMENT, LA MOBILITE ET L'AMENAGEMENT	France
10	Agristudio	AGRISTUDIO	Italy
11	WWF RO	WWF ROMANIA	Romania
12	UKF	FAKULTA PRÍRODNÝCH VIED - UNIVERZITA KONŠTANTÍNA FILOZOFA V NITRE	Slovak Republic
13	BMK	BUNDESMINISTERIUM FUER VERKEHR, INNOVATION UND TECHNOLOGIE	Austria
14	AMPHI	AMPHI CONSULT	Denmark
14a	FPP	FPP - WITH AMPHI CONSULT	Poland
15	FRB	FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITE	France
16	UNILIM	CENTRE DE RECHERCHES INTERDISCIPLINAIRES EN DROIT DE L'ENVIRONNEMENT DE L'AMENAGEMENT ET DE L'URBANISME - EQUIPE THEMATIQUE DE L'OBSERVATOIRE DES MUTATIONS INSTITUTIONNELLES ET JURIDIQUES - UNIVERSITE DE LIMOGES	France
17	OFB	OFFICE FRANÇAIS DE LA BIODIVERSITE	France
18	BAST	BUNDESANSTALT FUER STRASSENWESEN	Germany
19	BMVI	BUNDESMINISTERIUM FUER VERKEHR UND DIGITALE INFRASTRUKTUR	Germany
20	ZARAND	ASSOCIATA ZARAND	Romania
21	UASVM-CN	UNIVERSITATEA DE STIINTE AGRICOLE SI MEDICINA VETERINARA CLUJ NAPOC	Romania
22	GDDKIA	GENERALNA DYREKCJA DROG KRJAOWYCH I AUTROSTRAD	Poland
23	STUBA	SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE	Slovak Republic
34	MINUARTIA	MINUARTIA	Spain
25	SLU	SVERIGES LANTBRUKSUNIVERSITET	Sweden

Partner no.	Short name	Name	Country
26	AWV	BRUSSELS AREA, BELGIUM - AGENTSCHAP WEGEN EN VERKEER	Belgium
27	CAU	UNIVERSITY OF KIEL	Germany
28	UNI KASSEL	UNIVERSITY OF KASSEL	Germany
29	BfN	BUNDESAMT FÜR NATURSCHUTZ	Germany
30	ARMSA	ARMSA	Poland
31	IP	INFRAESTRUTURAS DE PORTUGAL SA	Portugal
32	MDPAT	MINISTERSTVO DOPRAVY A VÝSTAVBY SLOVENSKEJ REPUBLIKY	Slovak Republic
33	ASTRA	FEDERAL DEPARTMENT OF THE ENVIRONMENT, TRANSPORT, ENERGY AND COMMUNICATIONS - FEDERAL ROADS OFFICE	Switzerland
34	NTIC	NETIVEI ISRAEL - NATIONAL TRANSPORT INFRASTRUCTURE COMPANY LTD	Israel
35	NCA	NATURE CONSERVATION AGENCY OF THE CZECH REPUBLIC	Czech Republic
36	RWS	MINISTERIE VAN INFRASTRUCTUUR EN WATERSTAAT - MINISTRY OF INFRASTRUCTURE AND WATER MANAGEMENT	Netherlands
37	TII	TRANSPORT INFRASTRUCTURE IRELAND	Ireland
38	Egis SE	EGIS ENVIRONNEMENT	France
39	TRV	SWEDISH TRANSPORT ADMINISTRATION – TRAFIKVERKET	Sweden
40	DTES.GEN CAT	DEPARTAMENT DE TERRITORI I SOSTENIBILITAT. GENERALITAT DE CATALUNYA	Spain
41	ANAS	ANAS	Italy

TABLE OF ACRONYMS

AA	Appropriate Assessment
DG ENV	Directorate - General for Environment (Commission department responsible for EU policy on the environment)
EIA	Environmental Impact Assessment
GI	Green infrastructure
IAS	Invasive Alien Species
IENE	Infra Eco Network Europe
IUCN	International Union for Conservation of Nature
N2k	Natura 2000 Network
SEA	Strategic Environmental Assessment
SRDA	Strategic Research and Deployment Agenda
TEN-G	Trans-European Network for Green Infrastructure
TEN-T	Trans-European Transport Network
TI	Transport Infrastructure
TIH	Transportation Infrastructure Habitats
UNEP - WCMC	The UN Environment Programme World Conservation Monitoring Centre
WFD	the Water Framework Directive
BS	Biological survey
FMS	Framework migration study
ICPDR	The International Commission for the Protection of the Danube River

SMS	Strategic migration study
EMFs	Electromagnetic fields
DMS	Detailed migration study
CBA	Cost-Benefit Analysis

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EXECUTIVE SUMMARY

This document provides an in-depth review of a tool that can be used to analyse the impacts of transportation infrastructure plans and projects. The checklist included in this tool is based in Excel format and is structured in three distinct sections, each of them with a dedicated Excel sheet: *Impacts*, *Mitigation measures*, and *Process and tools and barriers*[1].

The primary purpose of this tool is to ensure a consistent approach to the identification of impacts and potential mitigation measures. In addition, it aims to inform stakeholders of the existing processes, tools, and barriers that are relevant to the transportation sector they represent.

The first section of the tool entitled **"Impacts"** helps to identify different types of effects and impacts for different modes of transportation based on their specific characteristics. For a particular mode of transportation, the project can generate effects and impacts, which are marked by "X" in the annexed table. This section helps to identify the changes generated in the physical environment as a direct consequence of the causes generated by the analyzed project in all of its phases of implementation. The impacts can include changes at a structural level or at a functional level, changes on the sensitive analyzed environmental parameters (things such as Natura 2000 sites, water bodies, ecological corridors, habitats and species, or even human health and well-being).

The second section, **"Mitigation measures"**, lists the primary measures that are typically implemented for projects in each transport mode. It serves as a guide for project owners and other stakeholders to ensure that their projects adopt measures that are appropriate for that type of project. The measures presented in the table should address the impacts identified for that specific project, based on the environmental impact assessments performed. It is essential to note that the proposal of measures for a particular plan or project should be based on the mitigation hierarchy, with avoidance measures being the first option taken into consideration. Mitigation measures are those that work on reducing otherwise significant impacts to a non-significant level, and compensation measures refer to situations where the significant impact cannot be avoided or reduced, and there is a need to replace or restore the lost habitats or species.

The third section, **"Process, Tools & Barriers"**, has three main components: environmental processes applicable to each transport mode, the primary tools that can be used for different project stages, and the primary barriers identified for each project type. Its main aim is to showcase in a single place what is needed for the implementation of a project (from an impact assessment point of view), what are the primary tools that can be used for developing the assessments, and what are the main barriers related to each transport sector. In addition, the tool includes a list of barriers identified as the most important ones in the process of developing adequate green infrastructure and ensuring the development of more sustainable projects.

The proposed tool focuses on transport infrastructure and builds mostly on the experience of Europe, but can be applied to other countries as well.

In conclusion, the tool is a comprehensive and useful resource for stakeholders involved in transportation plans and projects. It provides a framework for identifying potential impacts and mitigation measures, as

[1] https://wwf.ro/wp-content/uploads/2023/06/Annex_D5.4_1.Impacts-2.-Mitigation-measures-3.Processes-tools-barriers.pdf

well as guiding users through the necessary environmental processes and tools required for the implementation of a project. The tool's emphasis on ensuring adequate green infrastructure and sustainable projects is particularly crucial in the current climate, where environmental concerns are at the forefront of public attention.

The current deliverable (D5.4), as well the tool itself will feed into the Strategic Research and Deployment Agenda (SRDA).

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1. INTRODUCTION

The BISON project (**B**iodiversity and **I**nfrastructure **S**ynergies and **O**pportunities for European Transport **N**etworks) is a European-level project, funded through HORIZON 2020, which aims at contributing to Europe's need to adapt its existing infrastructure to new climatic conditions (floods, droughts etc.), as well as the need to find innovative and sustainable solutions to reduce the impact of invasive species and address the decline of native species and ecosystem fragmentation. An important component is also related to transport infrastructure, which has seen a sharp rise in development, especially in Eastern Europe, and the need to support this development while paying particular attention to the local biodiversity, which is often endemic.

The project has several main objectives:

- Identify research and innovation needs for biodiversity mainstreaming in transport infrastructure.
- Detect the methods and materials that can be used by different transport modes to mitigate pressure on biodiversity.
- Make infrastructure more performant and reliable.
- Support European Member States to fulfil their regional and international commitments for sustainable development.
- Develop collaboration among European Member States to become political leaders on jointly addressing biodiversity and infrastructure challenges.

The project has a 3 million € budget and involves work from 44 partners and 6 third parties, from 16 countries. It has a duration of 30 months, with the finalisation expected at the end of June 2023.

This deliverable is part of Task 5.2 within the project. The task focuses on the identification of tools for avoiding further fragmentation and lead to efficient defragmentation on the base of an improved and applicable EU defragmentation map. The life-cycle approach for transport infrastructure can help to develop a sustainable, eco-friendly transport network that supports biodiversity.

The scope of this deliverable is to offer an overview of the available life cycle tools, processes and implementation barriers for green and grey infrastructure, and to identify recommendations for adaptations and deployment to other transport modes and / or regional clusters.

For fulfilling this scope, the deliverables set the following objectives:

- To establish a working framework for the tool, in order to ensure appropriate identification of the tools, processes and barriers;
- To identify the main types of impacts associated with infrastructure project development;
- To identify the usual mitigation measures included in the development of infrastructure projects;
- To identify the processes, tools and barriers associated with the development of infrastructure projects;

- To establish the addressability of each type of impact, measure, process, tool and barrier in different types of infrastructure projects, in accordance to their particular characteristics.

The tool addresses several modes of transport, considered to be the most important for the development process of infrastructure in Europe. It is important to note that while most knowledge and experience has been established in infrastructure projects, this report intends to aid in extending this knowledge to other domains, such as inland waterways, ports, airports and powerlines.

2. DEFINITIONS AND GLOSSARY OF TERMS

This chapter of the report is aimed at detailing the most important concepts included in the tool, for ensuring a better understanding by its users, of the aspects included.

2.1. The effects, impacts and opportunities section (sheet)

2.1.1. Direct effects

Definitive / **long term vegetation removal** = refers to the permanent removal of vegetation from a particular area, often through processes like land clearing, deforestation, or urbanization.

Soil artificialisation = occurs when natural soil processes are disrupted or destroyed by human activities, such as the removal of topsoil or compaction caused by heavy machinery.

Occupying the land with constructions = refers to the building of infrastructure or structures on land that was previously undeveloped or used for other purposes.

Nests / **roosts destruction** = refers to the permanent removal or destruction of habitats used by birds or other animals for nesting, roosting, or breeding.

Changes in groundwater level (e.g., aridification) = reduction in groundwater levels, which can lead to the loss of wetland habitats and changes in plant communities.

Artificialisation of aquatic substrate = the addition of artificial substrates (e.g., concrete, plastic) to aquatic environments, which can lead to habitat loss and changes in aquatic ecosystems' physical and chemical properties.

The introduction/dispersal of IAS (Invasive Alien Species) = it represents the introduction of non-native species to an ecosystem, which can have significant impacts on native biodiversity by outcompeting native species for resources, altering habitats, transmitting diseases, and negatively impacting ecosystem functions and services.

Selective removal of vegetation = the removal of specific plants from an area, which can lead to changes in plant communities, negatively impact biodiversity and ecosystem functions, and alter soil properties, hydrology, and wildlife distribution.

Soil erosion = the loss of soil due to natural (e.g., wind, water) or human-made (e.g., agriculture, deforestation) causes, which can lead to the loss of soil organic matter, nutrient depletion, and changes in soil structure, negatively impacting plant growth, carbon sequestration, water regulation, and aquatic biodiversity.

Soil / **sediment contamination** = the presence of pollutants in soil or sediment, which can lead to changes in microbial communities, nutrient cycling, and plant growth, negatively impacting wildlife health, food safety, and ecosystem functions.

Air quality deterioration = reduction in the quality of air, with potential impacts on human health, wildlife health, and ecosystem functions.

Water quality deterioration = negative changes in the quality of water, potentially affecting human health, wildlife health, and ecosystem functions.

Hydrogeomorphological alterations = changes in the physical features of water bodies, which can negatively impact biodiversity and ecosystem functions. Hydromorphological alterations are presented in the Water Framework Directive guidance documents.

Alterations in micro-climate = changes in the local climate (e.g., temperature, humidity, wind), which can negatively impact biodiversity and ecosystem functions.

Changes in physical features of the area = changes in the physical features of an area (e.g., land use change, urbanization, infrastructure development), which can negatively impact biodiversity and ecosystem functions.

Physical terrestrial barriers (Interruption of terrestrial corridors) = physical structures or landscape features that impede the movement of terrestrial wildlife between habitats, potentially leading to habitat fragmentation and a negative impact on biodiversity.

Physical aerial barriers (for birds / bats) = physical structures that impede the flight of wildlife (especially birds and bats) between favourable habitats and can contribute to a bottleneck effect on species through limiting genetic exchange within the population.

Interruption of aquatic longitudinal connectivity = physical or behavioural barriers that impede the movement of aquatic wildlife along a river, stream, or other watercourse.

Interruption of aquatic lateral connectivity = barriers that impede the movement of water and of aquatic wildlife between a watercourse and its floodplain.

Behavioural barriers = barriers that impede the movement of wildlife due to changes on their behaviour, such as human presence, noise pollution, or artificial lighting.

Edge effect = the changes in environmental conditions and dynamics that occur at the boundary between two different ecosystems, which can lead to changes in plant and animal communities and negatively impact biodiversity.

Population isolation = the separation of a population of organisms from other members of the same species, which can lead to genetic drift, reduced genetic diversity, and reduced adaptability to changing environmental conditions.

Noise & vibrations = excessive noise and vibrations caused by human activities (e.g., traffic on a new motorway or new railway, construction activities) can negatively impact wildlife by disrupting communication, causing stress, and leading to behavioral changes.

Electromagnetic fields = electromagnetic fields (EMFs) from power lines, communication towers, and other sources can negatively impact wildlife by disrupting navigation, migration, and other behavioral patterns.

Attractant / deterrent odours = odors that attract or deter wildlife (e.g., predator urine, food scents) can be used to manage wildlife populations, but they can also negatively impact non-target species and alter natural behavior patterns.

Burial of plant and slow / sedentary animal species = it represents the burial of plants and slow-moving or sedentary animals (such as snails, freshwater bivalves) by human activities, such as dredging or construction activities.

Chemical poisoning = exposure to toxic chemicals (e.g., pesticides, heavy metals), which can have a negative impact on wildlife or non-toxic chemicals, which can alter physiological or behavioural processes.

Lethal level of aquatic turbidity = increased turbidity can affect aquatic organisms either through a disruption of their biological processes or through changing the abiotic conditions of the water body (such as reducing the amount of light that can reach the habitat).

Stranding of aquatic fauna (larval / juvenile / adult stages) = stranding of aquatic animals (e.g., fish, crustaceans, bivalves) can occur due to sudden changes in water level, for instance through the operation of a dam.

Eggs destruction / nest abandonment = destruction of eggs or abandonment of nests can occur due to human activities (e.g., construction, recreation) or changes in environmental conditions (e.g., flooding) and can lead to reduced reproductive success and population declines.

Reduced capacity for rearing offspring = changes in environmental conditions (e.g., pollution, increased levels of noise, apparition of certain behavioural barriers) can negatively impact the ability of parents to rear offspring.

Increased predation = an increase in predation can occur due to changes in environmental conditions (for instance an increase in water turbidity can be advantageous for predatory fish species, as it can improve hunting success).

Wildlife electrocution = electrocution of wildlife (e.g., birds, bats) can occur due to contact with power lines or other electrical infrastructure and can lead to mortality and overall changes of the population structure.

Traffic mortality = it is represented by mortality of wildlife due to collisions with vehicles on roads, railways or other transportation infrastructure.

Mortality due to dredging = dredging activities can lead to the mortality of aquatic organisms (e.g., fish, benthic invertebrates) due to the physical disturbance of sediments and disruption of habitat.

Transport infrastructure habitats (TIH) as ecological traps and sink habitats = transportation infrastructure (e.g., roads, railways) can create ecological traps and sink habitats by providing attractive habitat for wildlife (e.g., nesting sites, food sources) that ultimately lead to mortality due to collisions with vehicles or other infrastructure.

2.1.2. Secondary / indirect effects

Increase the interest of industrialization = promotion and extension of industrial activities, which can lead to habitat loss, pollution, and other negative impacts on biodiversity and ecosystem functions.

Increase the interest of urbanization = promotion and extension of urbanised areas, occupying new areas of habitats and leading to a potential loss and fragmentation of habitats.

Climate change contributions (drought, flooding, fires, landslides etc.) = it represents the cumulative contribution of climate change on biodiversity. Together with the analysed project, it can lead to a continuous and cumulative reduction of the habitats' surface.

Change the landscape perspectives in irreversible way and in a broader time and geographical scales = the alteration of natural landscapes due to human activities, such as land use change, that can lead to irreversible changes in ecosystems and biodiversity loss.

Landscape fragmentation = the division of continuous natural habitats into smaller, isolated fragments due to human activities. In time, fragmentation can lead to habitat loss, altered ecological processes, and reduced biodiversity.

Changes in the downstream transport network (e.g. maintenance road, farming roads, secondary roads, other transport modes) = refers to at-distance impacts generated by certain infrastructure, such as the risk of displacement of species on secondary roads due to increased traffic levels.

Increase of human access (poaching, hunting, fishing) = refers to the facilitation of human access through infrastructure development. This can also facilitate access for poachers, hunters and fishermen.

Increase the tourism activity especially in critical habitats areas = it is also related to the facilitation of human access, leading to an increase in tourism activity in potentially sensitive areas.

Cumulative contribution of the above-mentioned effects & impacts = it represents the combined and ongoing impacts of all of the above-mentioned effects and impacts, which can overcome significance thresholds and lead to a significant impact.

2.1.3. Impacts

Habitat loss = the process of losing natural habitats due to human activities such as deforestation, urbanization, and agriculture that result in a reduction in the size of natural habitats or the complete loss of habitats. Habitat loss can negatively impact biodiversity and ecosystem functions.

Habitat alteration / degradation = the process of changing natural habitats due to human activities such as pollution, soil erosion, spread of Invasive Alien Species (IAS), that result in changes in the physical and chemical properties of natural habitats.

Habitat fragmentation = the process of dividing continuous natural habitats into smaller, isolated fragments due to human activities such as land use change, infrastructure development, and urbanization.

Disturbance and displacement = it is a type of impact related to certain effects (such as noise or illumination levels) that affects the population size of fauna species, especially in relation to key biological stages, such as breeding, nesting or feeding. Displacement refers to the movement of certain individuals from certain areas due to significant changes in the abiotic conditions of their environment (for instance, too high of an increase in noise levels can affect the distribution of bird nesting areas in a certain site).

Direct wildlife mortality (main cause for the reduction of population size) = the process of wildlife death due to human activities, which can include traffic mortality or electrocution, as mentioned above.

Continuous and cumulative reduction of natural habitats' surface = the ongoing and cumulative process of losing natural habitats due to human activities such the increase of industrialisation and urbanisation, climate change and changes in the landscape that result in a reduction in the size of natural habitats or the complete loss of habitats.

Landscape fragmentation = refers to the fragmentation of habitats at the level of the landscape, taking into consideration all of the existing barriers which might impede free movement of wildlife (including the existence of urban areas and other human made barriers.

Reduction of population size = the process of reducing the size of wildlife populations for any reason, including an increase in human presence and tourism.

2.1.4. Opportunities

Transport infrastructure habitats (TIH) as wildlife habitats = refer to habitats created by transportation infrastructure, such as roads or railways. They can serve as important habitats for wildlife, providing a potentially important shelter area in an otherwise unfavourable habitat.

Transport infrastructure habitats (TIH) as wildlife corridors = transport infrastructure habitats can also serve as wildlife corridors, providing a means for wildlife to move between habitats and promoting genetic diversity and population resilience. These are usually habitats such as road verges, shelterbelts or other green areas that can act as habitats for wildlife.

2.2. The Types of mitigation measures section (sheet)

2.2.1. Strategic planning stage

- **Avoidance:**
  - Null alternative (no project at all) = the option of not implementing a certain project, which would result in no changes to the environment or impacts on biodiversity and ecosystem functions.
  - Alternative transportation mode or alternative project location / corridor (entire project or components) = it represents the analysis of a different type of transportation instead of the initially proposed project, or of an alternative project location / corridor. It is a type of analysis that is specific to the strategic planning stage, where analysis of different alternatives (including alternatives between different types of transportation) can be easily done.
- **Mitigation** – Guidance for design phase:
  - Proposing methodological approaches for conducting EIA / AA = refers to the need, during the SEA procedure and the development of the Environmental Report, for including methodological requirements, to be taken into consideration at the project level, when the EIA is developed.

These can be related to requirements for including certain analyses (such as an analysis on landscape fragmentation), or for analysing different project alternatives etc.

- Define Key performance indicators for the EIA / AA and for the project = refers to the need to establish key performance indicators during the strategic assessment, to be taken into consideration at the project level. The indicators can refer to specific requirements for the EIA and AA, such as the need to assess all types of impact, the need to provide quantifications for the analysed parameters, the need to provide specific measures etc.
- Define the follow-up process (e.g., clear reporting mechanisms, open data) = refers to the need for establishing the necessary reporting mechanisms for the data obtained during the monitoring process of the plan or, if it is the case, of the projects included in the plan.
- Identify relevant stakeholders and adequate/innovative tools to engage them = refers to the need to identify the relevant stakeholders early, at the strategic environmental assessment stage, to ensure their cooperation throughout the project development period. An early engagement with stakeholders can prevent subsequent delays and unnecessary additional costs later, at the project design stage.

2.2.2. Design stage

- **Avoidance:**
  - Define no go areas for the components of the project (restriction areas) = implies the need to establish areas where it is forbidden to set any project components. These areas can be represented by zones of particular importance, such as wilderness areas, protected areas, areas of high natural value etc.
  - Define restriction periods during construction = refers to the necessity to establish certain periods (either during the year, or during the day), when construction should not occur, due to the presence of sensitive species or a particularly important biological process. For instance, construction work should not be done in a bird nesting area during the nesting period of bird species, as this could lead to a potential displacement due to increased noise and human presence.
  - Make changes in the project technical solutions / locations for implementation of project components = it represents an avoidance measure which involves the implementation of changes to the project's technical solutions or locations, in order to avoid the apparition of a significant impact on a certain sensitive receptor (e.g., a protected area, a settlement etc.).
- **Mitigation:**
  - Fauna overpasses = overpasses or bridges designed to allow wildlife to cross over transportation infrastructure without coming into contact with vehicles. These should comply with the best practice guidelines available.
  - Fauna underpasses = underpasses designed to allow wildlife to pass under transportation infrastructure. They can be specifically made for wildlife, or can be represented by adapted existing structures, such as viaducts, bridges, culverts etc.
  - Level crossings = crossings designed to allow wildlife to safely cross transportation infrastructure at the same level as vehicles. Usually used for railway infrastructure.

- Changing traffic flow and speed = implies changes to traffic flow and speed to reduce the risk of wildlife-vehicle collisions.
- Active warning signs for alerting drivers = signs that alert drivers to the presence of wildlife and encourage them to slow down and exercise caution. These signs should be active, with flashing lights, animations or other means of highlighting the presence of the sign.
- Fauna warning and detection systems = refers to systems for warning fauna of incoming traffic, leading to a possible removal of individuals from the risk areas.
- Increasing visibility for drivers = clearing vegetation or other obstructions to increase visibility for drivers and reduce the risk of wildlife-vehicle collisions.
- Public awareness = educational campaigns and outreach efforts to increase public awareness of the risks of wildlife-vehicle collisions and encourage safe driving practices.
- Temporary / permanent fences = fences designed to prevent wildlife from accessing transportation infrastructure or guide them towards safe crossing locations.
- Screens = refers to screens installed on infrastructure to prevent wildlife from accessing the risk areas.
- Escape facilities (e.g., exit ramps) = ramps or other facilities designed to allow wildlife to safely exit transportation infrastructure.
- Cattle grids and gates = grids and gates designed to prevent wildlife (as well as livestock) from accessing transportation infrastructure.
- Visual deterrents (e.g., drones, dogs, lights, falconry, reflectors, lasers, virtual fences) = systems to prevent wildlife from accessing the transport infrastructure by discouraging the presence of individuals in the risk area through visual means.
- Acoustic deterrents (Devices with recordings of disturbing noises) = systems to prevent wildlife from accessing the transport infrastructure by discouraging the presence of individuals in the risk area through acoustic means.
- Olfactory deterrents = systems to prevent wildlife from accessing the transport infrastructure by discouraging the presence of individuals in the risk area through the use of scent.
- Verges management as green corridors Including plant species selection and prevention of IAS spread) = managing the vegetation along the sides of transportation infrastructure to promote good habitat conditions for wildlife. It involves the selection of the plant species to be planted, as well as invasive alien species management.
- Drainage management as blue corridors = management of the drainage system of the infrastructure as a blue corridor, through maintenance of the system free of barriers, without impeding free movement of species.
- Tree removal = the removal of vegetation, including trees, to improve habitat conditions in the verges of infrastructure.
- Embankment design = designing the embankment of the infrastructure with consideration of the wildlife in the area and ensuring the use of plant species that are adequate for the wildlife of the area.

- Habitat attractiveness management = managing the embankments and other components of the project in a manner which allows an improvement in habitat attractiveness.
- Maintenance adaptation especially close to wildlife crossings = refers to the need to maintain the habitat areas of the TIH, especially in areas close to wildlife crossings. This maintenance is crucial for ensuring the functionality of the wildlife crossings.
- Biological control methods = using natural predators or other biological controls to manage wildlife populations in and around transportation infrastructure.
- Adapting kerbs and drains = modifying kerbs and drainage systems to be friendly to fauna. This can mean for instance changes in the drainage system so as not to constitute traps for fauna (for example through the installation of screens above the actual drains).
- Carcasses removal = removing animal carcasses from transportation infrastructure in order to reduce the risk of wildlife-vehicle collisions with scavenging species.
- Visibility markers for screens = markers or signs placed on screens to increase their visibility and reduce the risk of collision.
- Visibility markers for powerlines = markers or signs placed on powerlines to increase their visibility and reduce the risk of collisions, especially of bird species.
- Electric wire/ catenary insulation = insulating electric wires or catenaries to reduce the risk of electrocution by flying fauna species.
- Adapting the lighting system = modifying lighting systems to reduce the risk of disturbance and eventual displacement of individuals. Adaptation of the lighting system can also contribute to decreasing the risk for collision, by not attracting fauna to risk areas.
- Light deflectors = devices designed to deflect light from incoming traffic and to reduce the amount of light in the surrounding areas to the infrastructure.
- Artificial walls = walls or barriers designed to reduce the amount of light, noise and air pollutants that leaves the transport infrastructure.
- Tree windbreaks = planting trees or other vegetation to act as windbreaks and reduce the amount of light, noise and air pollutants in the surrounding area of the infrastructure.
- Noise absorbing panels = structures that aid in the control of noise pollution and also can help in reducing the incidence of wildlife – vehicle collisions.
- Speed reduction = measures of reducing the movement speed of vehicles in order to contribute to noise reduction.
- Waste management = system of managing waste in a manner that can reduce the risk to wildlife. This can be represented by the use of special garbage cans that are wildlife proof, as well as the implementation of a waste collection system that can collect garbage with a high frequency.
- Rainwater treatment = represents a system of treatment of rainwater, to ensure that no polluted rainwater is released in the environment. It can involve the use of hydrocarbon separators as well as other systems for water pre-treatment.
- Retention / infiltration ponds = constructing retention or infiltration ponds to manage stormwater and reduce the risk of pollution.

- Wetlands = creating or restoring wetlands to promote biodiversity and contribute to a reduction in the risk of water pollution.

2.2.3. Pre-construction stage – Natura 2000 Network Compensatory measures

- Designation of new N2k sites = a type of compensatory measure that involves the designation of new Natura 2000 sites to replace a site whose integrity has been compromised by a project. The new Natura 2000 sites should allow for the conservation of the same habitats and species from the compromised site and should ensure that their conservation status is a favourable one. **The success of the compensatory measures should be proven before the implementation of the project that has a significant impact on the integrity of the site.**
- N2k Habitats restoration, enhancement or recreation = a compensatory measure that addresses habitat restoration, enhancement or recreation, after being compromised by a certain project. The measures should include a higher ratio of restored, enhanced or recreated habitat to destroyed habitat (a 1:1 ratio is not sufficient) and should be implemented successfully before the commencement of the project.
- N2k Species reintroduction and re-stocking = refers to compensatory measures addressed to species, necessary for compensating significant impacts on their population. Similar to the compensatory measures for habitats, these measures' efficiency should be proven before implementing the project that generates the significant impact.

2.2.4. Construction stage

- **Avoidance**
  - Translocation = measure aimed at removing individuals or favourable habitat components (such as host trees for certain species) from a risk area and relocating them to a safe habitat.
  - Management of construction site traffic = involves measures to avoid potential collisions with wildlife, through rerouting of construction traffic or through a reduction of the movement speed of construction vehicles.
  - Management of execution works = involves measures such as stopping or adapting the construction works in order to avoid certain impacts.
- **Mitigation**
  - Pollution control = any type of measure which can contribute to reducing the potential pollution of abiotic components.
  - Invasive Alien Species (IAS) Control = specific measures addressing the process of removing IAS and preventing further spread of IAS.
  - Rehabilitation works = represents activities aimed at rehabilitating a certain temporarily affected area, such as a borrow pit, with adequate vegetation.

2.2.5. Operation stage

- **Mitigation:**
  - IAS Control = refers to the control of invasive alien species during the operation stage, in order to prevent their spread along the infrastructure.
  - Measures maintenance = involves the maintenance of the proposed measures during the operation stage, to ensure their continued efficacy in the project.

2.2.6. Decommissioning stage

- **Restoration:**
  - Removal of infrastructure = it represents a measure to remove the existing pressure related to infrastructure through its removal, during the decommissioning stage.
  - Habitat restoration = after infrastructure removal, habitat restoration should be implemented, in order to ensure an improvement of the overall landscape in the area of the decommissioned project.

2.2.7. Repurposing stage

- **Restoration:**
  - Reshaping and transforming the infrastructure = it represents the process of reshaping the infrastructure and/or repurposing the area. It can also include activities aiming at defragmenting an already fragmented landscape.
  - Transport infrastructure habitat (TIH) restoration = it represents the restoration of the habitats associated with transport infrastructure, such as road verges, to ensure better habitat conditions for wildlife.

2.3. The Processes & Tools & Barriers section (sheet)

2.3.1. Environmental processes

- Strategic Environmental Assessment (SEA) = it is a systematic process for evaluating the environmental implications of policies, plans, and programs. It aims to identify and mitigate potential negative impacts on the environment and to promote sustainable development. SEA is a legal requirement in all EU Member States, including those in the European Union, and is an important tool for ensuring that environmental considerations are integrated into decision-making processes.
- **Design stage:**
  - Environmental Monitoring Programs = the environmental monitoring programs are essential for assessing the impacts of human activities on the environment and for developing effective management strategies to mitigate these impacts. These programs typically involve the collection and analysis of data on key environmental parameters, including water quality, air quality, soil quality, and biodiversity. The Monitoring Programme is the basis for the assessments necessary for the different project stages.

- Environmental Impact Assessment = the Environmental Impact Assessment Report is the document prepared by a project owner that presents the output of the assessment. It contains information regarding the project, the likely significant effect of the project, the baseline scenario, the proposed alternatives, an assessment of potential impacts and their significance and the measures to mitigate adverse significant impacts.
- Appropriate Assessment = the purpose of the appropriate assessment is to assess the implications of the plan or project in respect to a Natura 2000 site's conservation objectives, either individually or in combination with other plans or projects. The conclusions should enable the competent authorities to ascertain whether the plan or project will adversely affect the integrity of the site concerned. The focus of the appropriate assessment is therefore specifically on the species and/or the habitats for which the Natura 2000 site is designated.
- Water Framework Directive assessment = the Water Framework Directive (WFD) assessment can be used to identify pressures on aquatic ecosystems and develop measures to address these pressures. The WFD assessment includes the evaluation of ecological status, which considers the structure and function of aquatic ecosystems, as well as the evaluation of chemical status, which considers the presence of pollutants in water bodies.
- Planning the mitigation and compensation measures = this process involves a series of steps, following after the assessments of impacts. It involves the identification of adequate mitigation and compensation measures, and their evaluation from the point of view of their effectiveness and feasibility.

- **Construction:**
  - Environmental Monitoring Programs = contains tools for monitoring the environmental conditions in the area of the project during the construction stage. The purpose of the program should be to ensure adequate implementation and efficacy of the proposed impact avoidance and mitigation measures.
  - Environmental Management Plan (Implementation of Polluters pays principle) = it is an environmental process that aims at organising the environmental aspects necessary to be taken into consideration during the construction of the project. It should also include requirements for taking into account the polluter pays principle during construction, especially in the case of any accidental pollution.
- **Operation:**
  - Ecological asset maintenance = it is the process of maintaining the components of the project that are important for the environment, especially the measures which contribute to the avoidance and reduction of the identified impacts.
  - Monitoring / Evaluation = implies the process of monitoring and evaluation of the proposed impact mitigation measures, during the operational phase of the project. The evaluation should analyse the efficacy of the proposed measures and implement additional measures if they are deemed ineffective.

- **Upgrade and adaptation:**
  - Environmental Monitoring Programs = refers to environmental monitoring programme implemented during the upgrade and adaptation stage of the project. It should be similar to the monitoring programme from the construction stage.
  - EIA (Environmental Impact Assessment), AA (Appropriate Assessment), WFD assessment = environmental processes necessary for the decommissioning stage of the project, to be realised in a manner similar to the ones done during the construction stage.
  - Ecological asset maintenance = similar to the operation phase, in involves an assessment of the components proposed in the project for ensuring the avoidance or reduction of environmental impacts
- **Decommissioning:**
  - Restoration / Monitoring = a process to restore the project area to a natural state after the decommissioning of the project.

2.3.2. Tools

- **Strategic planning phase**:
  - (T1) Strategic migration study, map of protected areas, core areas and main migration corridors for target species, important and protected Species Action Plans and their distribution (SMS)= the aim of SMS is to prepare a resource material for the analysis of problems between the planned transport corridors/constructions (grey infrastructure) and natural areas (protected areas, Natura 2000 sites etc.) and long-distance migration corridors of some species (green infrastructure). SMS also known as analytical map is recommended to be part of the Strategic Environmental Assessment (SEA).
  - (T2) Biological survey (BS) = BS are used to find out the real occurrence, population state and migration routes of the target species, distribution of selected habitats and to work out an overall background material for selecting the final alignment, for proposals of mitigation measures and for proposal of follow-up monitoring. The whole survey should be done in a complex ecosystem approach (besides fauna also flora and ecosystems are assessed).
  - (T3) Framework migration study (FMS) = the FMS is carried out at the level of EIA process. The FMS assesses the overall permeability and acceptability of the proposed variants and set basic placement and types of fauna passages and other protective measures. It is designed in analogy to other environmental components (acoustic study, dispersion study, study of impacts on human health etc.). It is a complex material that summarizes the given issue from the initial analysis of starting state, all the way to the proposal of measures.
  - Ecosystem monetary valuation (based on ecosystem services) = ecosystem monetary valuation involves quantifying the economic value of ecosystem services provided by natural ecosystems. It is important to provide this analysis as early as possible in the project life cycle, to ensure an informed decision from the start of the project.

- Report on identification of Gaps and Barriers to expand replicability and application of good practice to mainstream biodiversity and transport (D3.3 Chapter 2) = it is a document developed within BISON project, intended to identify the gaps and barriers for different transport modes.
- Open data geoportals = these are tools that provide spatial data related to habitats and species location, as well as, in certain cases, locations of the other pressures existing in the area of a proposed project. There are many types of open data geoportals, either at an international or at a national level.
- Other guidelines (including EC) for SEA & AA = they can represent tools developed by different organisations, including the European Commission, for the process of SEA and AA. It includes manuals, guidelines, whitepapers or any other resources.
- Platina Manual on Good Practices in Sustainable Waterway Planning from ICPDR[2] = it is a document developed by ICPDR, intended to improve the implementation of waterway projects.

- **Design phase:**
  - (T4) Monitoring program = the purpose of this tool is to create a comprehensive concept of gaining relevant data regarding the impacts of implemented road/railway on fauna and landscape connectivity and regarding the effectiveness of fauna passages as a resource for feedback in the form of post-project analysis. The Monitoring program can be used also for the other types of transport mode (e.g. maritime ports, airports etc.).
  - (T5) Detailed migration study (DMS) = this study includes the final detailed technical solution of all measures to protect fauna and landscape connectivity and to check other parts of prepared construction from this point of view. DMS forms an overall background material for statements of administration authorities and for preparing the organization of the construction.
  - (T6) Incorporation of migration corridor(s) near fauna passage(s) into spatial plan = to ensure protection of migration corridors in the surroundings of fauna passages in spatial plans, to prevent changes in land use that would limit the access of animals to the fauna passages. Although the legislative support for this protection is in many cases very weak, it is necessary to have one separate comprehensive material set available to gradually work with. Additionally, there are many cases of effective mitigation measures taken on roads and railways, but insufficient spatial planning and land use of the surroundings, which of course negatively influences the overall ecological connectivity. Since the general spatial planning is not the responsibility of investor or the operator of the transport infrastructure, involvement of appropriate stakeholders and support of cross-sectoral cooperation on securing the functionality of the migration corridors is of vital importance.
  - (T7) Plan to protect biota during construction = to work out a detailed plan of technical and organizational measures for minimizing negative impacts of construction on natural habitats and wildlife. Plan to protect biota during construction is usually elaborated within

[2] Document is available here https://www.icpdr.org/main/resources/manual-good-practices-sustainable-waterway-planning

the EIA process, but sometimes also in later phases of preparation (e.g. documentation for building permit or detailed implementing documentation).

- (T8) Ecological supervision = ecological supervision is performed by a professionally qualified person who oversees the compliance with the interests of nature protection during the entire time of construction all the way to its final inspection. This person is responsible for the compliance with the conditions laid down by the nature conservation authority and is controlled by that authority. Main objective is to minimize negative impacts on the environment during construction.
- Asset management = a tool for analysing the assets associated with the project and ensuring the maintenance of these assets.
- Cost-Benefit Analysis (CBA) to include ecosystem valuation & assets = an analysis which integrates the valuation of ecosystem services as well as the asset management.
- Biological surveys & monitoring activities = refers to the implementation of biological surveys and monitoring during the design stage of the project. It can represent a support for the EIA and AA developed for the project.
- Other guidelines (including EC) for EIA & AA = they can represent tools developed by different organisations, including the European Commission, for the process of EIA and AA. It includes manuals, guidelines, whitepapers or any other resources.

- **Operation phase:**
  - (T9) Post-project analysis = the main purpose of the report/ analysis is to serve as background material for the investor, administration authorities, designers and public and to use the gained experience in other constructions. In case the post-project analysis reveals that some conditions set in the associated building permit have not been met (e.g. a non-functional spare habitat for amphibians or a green bridge not used by fauna), it should focus on searching for the reasons for this situation and when it is still possible to improve it, it should propose additional measures for such improvements.
  - Methodology for Standardised Monitoring of Ecological Connectivity[3] = it is a deliverable developed during the SaveGREEN project, aimed at providing a standardised monitoring methodology for field activities.
- **Update and adaptation phase:**
  - Defragmentation programmes = they can represent important tools for ensuring defragmentation of already fragmented landscapes. One tool that can be used, and that addresses the European level is the defragmentation map developed during the BISON project.
  - Asset management = the process of evaluating and managing the components of the project within the update and adaptation process, including decisions on component maintenance, reuse or removal.

[3] https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/56/dc86e1c6e3dac3299b3b411262b93dcd0210f85f.pdf

- **Decommisioning:**
  - Demolition plan = it is a tool for ensuring the demolition of the project without significant impact on the environment.
  - Habitat restoration plan = the plan for restoring the habitats affected by the infrastructure without significant impacts on the environment.

2.3.3. Barriers

- Lack of political will = this type of barrier refers to the lack of political willingness for project implementation.
- Lack of intermediate levels of planning (regional, sectorial). In some countries there is only national level followed by individual projects = in some countries there might not be an intermediate level between the national level plans and the projects themselves. Adequate implementation of measures might be more difficult if these regional and sectorial levels are missing.
- Lack of (biodiversity) standardisation - for green engineering = this barrier refers to the lack of standardisation in the application and implementation of green engineering practices, which can lead to inconsistency and uncertainty in the effectiveness of these practices in promoting biodiversity and ecosystem functions.
- Lack of awareness on the consequences = a lack of awareness among stakeholders about the potential negative consequences of infrastructure development on biodiversity and ecosystem functions has been highlighted. This can affect project implementation.
- Lack of money and optimisation of resources = infrastructure development projects may lack the necessary funding and resources to effectively incorporate biodiversity and ecosystem considerations into planning and implementation.
- Lack of administrative and scientific capacity = a lack of administrative and scientific capacity to effectively manage and mitigate the negative impacts of infrastructure development on biodiversity and ecosystem functions has been noted. This highlights the need for further capacity building activities.
- Lack of multidisciplinary and multisector cooperation on prioritisation = there can be a lack of cooperation between different sectors and disciplines in prioritizing biodiversity and ecosystem considerations in infrastructure development projects, leading to delays in the implementation of projects.
- Lack of baseline scientific knowledge on habitats and species distribution = refers to situations where there is a lack of scientific knowledge regarding the habitats and species distribution, in an area where a project can be implemented. It can lead to delays due to the necessity to complete field surveys to make up for the missing data.
- Time pressure (always in hurry) = infrastructure development projects are most often subject to time pressure for project implementation, potentially leading to inadequate consideration of biodiversity and ecosystem functions in planning and implementation.

- Lack of capacity of staff and methods to mainstream biodiversity = the staff involved in infrastructure development projects may lack the necessary capacity and methods to effectively mainstream biodiversity considerations into planning and implementation.
- Lack of engagement of the stakeholders = there may be a lack of engagement and participation of stakeholders, including local communities from the project level into the project development. This can lead to a more difficult implementation of the project.
- Lack in data availability = availability of data might not be sufficient for the project level, to ensure an adequate level of detail for the EIA and AA and for the proposal of impact avoidance or mitigation measures.
- Lack of long-time monitoring data for strategic level = in certain countries monitoring activities have not been done for a very long time, and there can be a lack of long-term monitoring information to inform the process of EIA.
- Lack of policies, standards and regulations about sustainable and biodiversity friendly transport infrastructure requirements = refers to situations where there is a lack of policies, standards and regulations indicating how transport infrastructure can be made more sustainable for wildlife.
- Many provisions on paper only = refers to situations where the established provisions are done only theoretically, but are not applied to the real-life situations in the field.
- Lobbying of industry = this barrier represents situations where industry representatives put pressure on governance bodies, consultants or other authorities for pushing a project which might have significant impacts due to various reasons, including economic and political reasons.
- Lack of will to implement green solutions = refers to the refusal to implement green solutions in infrastructure projects due to various reasons;
- Lack of awareness of the public = is linked to the necessity for early information of stakeholders. If they are not informed and do not participate in the project development, lack of public awareness can represent an important barrier.
- Lack of standardisation (linked to methods and applied research) = is represented by missing standards in the area of infrastructure development, in the context of environmental protection.
- Press of cost's reduction = usually is linked with the lack of political will barrier, and refers to the need to ensure a certain pre-determined budget for a project.
- Lack of innovation in methods = refers to the use of obsolete or old information and non-compliance with the latest requirements in methodologies.
- Lack of prioritisation with other sectors = refers to situations where there is no integrated assessment with other sectors at the strategic level, for the identification of the best available solution.
- Revision of mitigation measures without public consultation = refers to situations where the initially proposed impact mitigation measures, which went through a process of public consultation, are changed without repeating the same process of consultation.
- Market availability for mitigation solutions = is related to the lack of market availability for adequate solutions for the proposed mitigation measures. If these are not available, there can be delays in the project until new solutions are developed.

- Lack of knowledge / will of constructors = it is related to the inability of constructors to implement adequate impact avoidance and mitigation measures.
- Lack of multidisciplinary and multisector cooperation = refers to situations where there is a lack of cooperation between people representing different sectors. It can also refer to situations where ecologists don't cooperate enough with engineers to ensure implementation of adequate measures.
- Lack of environment supervision = refers to situations where monitoring the environment is inadequate or is lacking.
- Difficulties in changing unsuitable mitigation measures = refers to situations where there is a barrier in an eventual change necessary for some mitigation measures that might not be adequate or sufficient for addressing the evaluated impacts.
- Inadequate / lack of maintenance for mitigation measures = refers to situations where there is a lack of maintenance of mitigation measures, either during construction, or during the operation of the project.
- Lack of will of the project/infrastructure owners = this barrier is related to the lack of willingness for the project owners, either for performing an adequate EIA or AA, or for implementing the necessary measures or monitoring programme.

3. SHORT PRESENTATION OF THE TOOL

The main purpose of the tool[4] is to ensure a common approach to the identification of impacts and possible mitigation measures and to inform stakeholders of the existing processes, tools and barriers relevant to the transport sector they represent.

The tool is based in Excel (and also attached as an annex to this document) and can easily be used by anyone to analyse any relevant transportation project.

For the use of this tool, it is important to differentiate the concepts of "causes", "effects" and "impacts". In the understanding of this tool **effects** refer to **changes generated in the physical environment**, as a direct consequence of the **causes** (project interventions) generated by the analysed project, in all of its phases of implementation. **Impacts** can include, either at a structural level, or at a functional level, **changes on the sensitive analysed environmental parameters** (things such as Natura 2000 sites, ecological corridors, habitats and species or even human health and well-being).

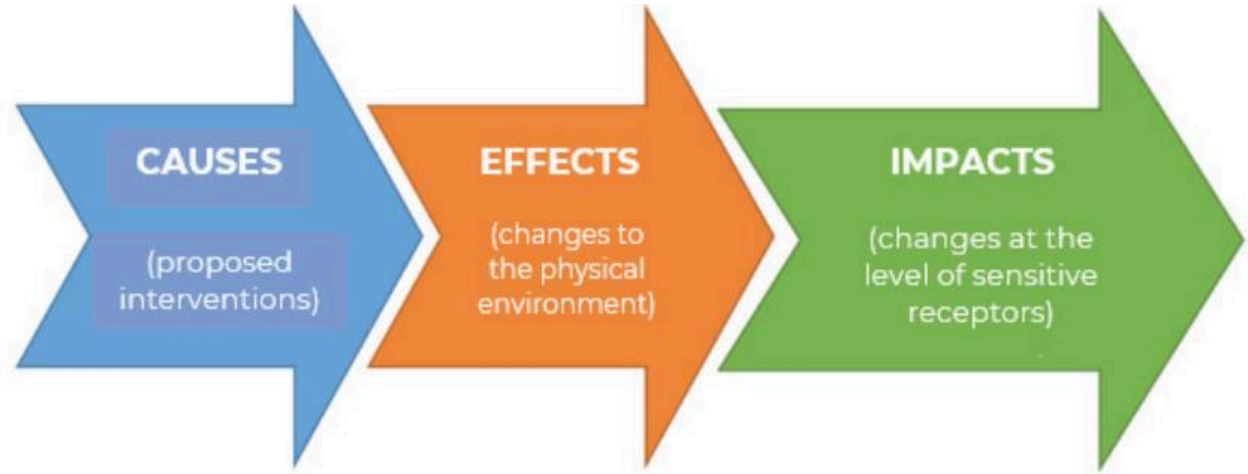

Figure 3-1: The relationship between causes, effects and impacts, as they are understood in this Report, provided by EPC.

The proposed tool is structured in three separate sections (Excel sheets). The application of the information included in each section/ sheet is applicable to different transport sectors to varying degrees. The contents of each component of the tool are described in detail below:

- **The Impacts Section**

The first section (Excel sheet) identifies different types of effects and impacts for different modes of transportation, based on the specific characteristics of each of them. For a certain mode of transportation (e.g., roads), the project can generate de effects and impacts marked by "X" from columns A and B. The following figure shows **the *Impacts*** *section/* sheet and its contents (*Figure 3-2*).

[4] https://wwf.ro/wp-content/uploads/2023/06/Annex_D5.4_1.Impacts-2.-Mitigation-measures-3.Processes-tools-barriers.pdf

IMPACTS	Causes/ effects leading to impacts	TRANSPORT MODE					
Direct effects		Road	Rail	Inland waterways	Ports	Airports	Powerline
Habitat loss	*Definitive / long term vegetation removal*	X	X	X	X	X	X
	Soil artificialisation	X	X	X	X	X	X
	Occupying the land with constructions	X	X	X	X	X	X
	Nests / roosts destruction	X	X	X	X	X	X
	Changes in groundwater level (e.g., aridification)	X	X	X	X		
	Artificialisation of aquatic substrate	X	X	X	X		
Habitat alteration / degradation	*The introduction/dispersal of IAS (Invasive Alien Species)*	X	X	X	X	X	X
	Selective removal of vegetation	X	X	X	X	X	X
	Soil erosion	X	X	X	X	X	
	Soil / sediment contamination	X	X	X	X	X	
	Air quality deterioration	X	X	X	X	X	
	Water quality deterioration	X	X	X	X	X	
	Hydrogeomorphological alterations	X	X	X	X	X	
	Alterations in micro-climate	X	X	X	X	X	
	Changes in physical features of the area	X	X	X	X	X	
Habitat fragmentation	*Physical terrestrial barriers (Interruption of terrestrial corridors)*	X	X	X	X	X	X
	Physical aerial barriers (for birds / bats)	X*	X			X	X
	Interruption of aquatic longitudinal connectivity	X	X	X		X	
	Interruption of aquatic lateral connectivity	X	X	X	X	X	
	Behavioural barriers	X	X	X	X	X	X
	Edge effect	X	X	X	X	X	X
	Population isolation	X	X	X	X	X	
Disturbance and displacement	*Human presence and activity*	X	X	X	X	X	
	Noise & vibrations	X	X	X	X	X	
	Electromagnetic fields		X				X
	Artificial light / loss of darkness condition	X	X	X	X	X	
	Attractant / deterrent odours	X	X		X	X	
Direct wildlife mortality (main cause for the reduction of population size)	*Burial of plant and slow / sedentary animal species*	X	X	X	X	X	
	Chemical poisoning	X	X	X	X	X	
	Lethal level of aquatic turbidity	X	X	X	X		
	Stranding of aquatic fauna (larval / juvenile / adult stages)	X	X	X	X		
	Eggs destruction / nest abandonment	X	X	X	X	X	X
	Reduced capacity for rearing offspring	X	X	X	X	X	
	Increased predation	X	X	X	X		
	Traffic mortality	X	X	X	X	X	
	Wildlife electrocution	X*	X				X
	Mortality due to dredging	X	X	X	X		
	TIH as ecological traps and sink habitats	X	X	X		X	
Secondary / indirect effects							
Continuous and cumulative reduction of natural habitats' surface	*Increase the interest of industrialization*	X	X	X	X	X	X
	Increase the interest of urbanization	X	X	X	X	X	X
	Climate change contributions (drought, flooding, fires, landslides etc.)	X	X	X	X	X	X
	Change the landscape perspectives in irreversible way and in a broader time and geographical scales	X	X	X	X	X	
Landscape fragmentation	*Caused by interplay of multiple infrastructure barriers and other human made barriers (urban areas) as well as natural barriers*	X	X	X	X	X	X
Reduction of population size	*Changes in the downstream transport network (e.g. maintenance road, farming roads, secondary roads, other transport modes)*	X	X	X	X	X	
	Increase of human access (poaching, hunting, fishing)	X	X	X	X		X
	Increase the tourism activity especially in critical habitats areas	X	X	X	X	X	
	Cummulative contribution of the above mentioned effects & impacts	X	X	X	X	X	X
OPPORTUNITIES							
Transport infrastructure habitats (TIH)	*TIH as wildlife habitats*	X	X	X	X	X	X
	TIH as wildlife corridors	X	X	X			X

Figure 3-2: The Impacts section/ sheet in the annexed Excel tool

- **Mitigation measures Section**

This section/ sheet lists the main measures which are usually implemented for projects in each transport mode. It serves the purpose of guiding project owners and other stakeholders in ensuring that their projects adopt measures that are appropriate for that type of project. The measures presented in this table should address the impacts identified for that particular project, based on the environmental impact assessments performed.

It is important in this context to take into consideration that proposal of measures for a certain plan or project should be based on the measure mitigation hierarchy. In the context of addressing identified impacts, the proposed measures should be prioritised as follows:

1. **Avoidance measures** should be prioritised. They can help in preventing the occurrence of an impact, or to avoid the appearance of a significant impact. Avoidance measures can be aspects such as: changing a project component (for instance moving an interchange from inside a Natura 2000 site to another location, outside of the site), changing a certain technical solution of the project etc.

   Avoidance measures must ensure a non-significant level of impact on the relevant parameters analysed and must maintain the same level of effectiveness through the whole life cycle of the project.

2. **Mitigation measures** are those that work on reducing otherwise significant impacts to a non-significant level. They require maintenance, modernisation and improvement throughout the life cycle of the project. In the context of transport infrastructure, mitigation measures can be those related to the reduction of pollutant emissions and pollution dispersal, maintenance of ecological connectivity, reduction of the mortality risk etc.

3. **Compensation measures** refer to situations where the significant impact cannot be avoided or mitigated, but is compensated by special actions such as habitat restoration, habitat recreation or other measures aimed at replacing the lost elements. They should aim to balance residual impacts to achieve No Net Loss or a Net Gain for the site in question. Compensatory measures are a type of compensation measures, which address Natura 2000 sites.

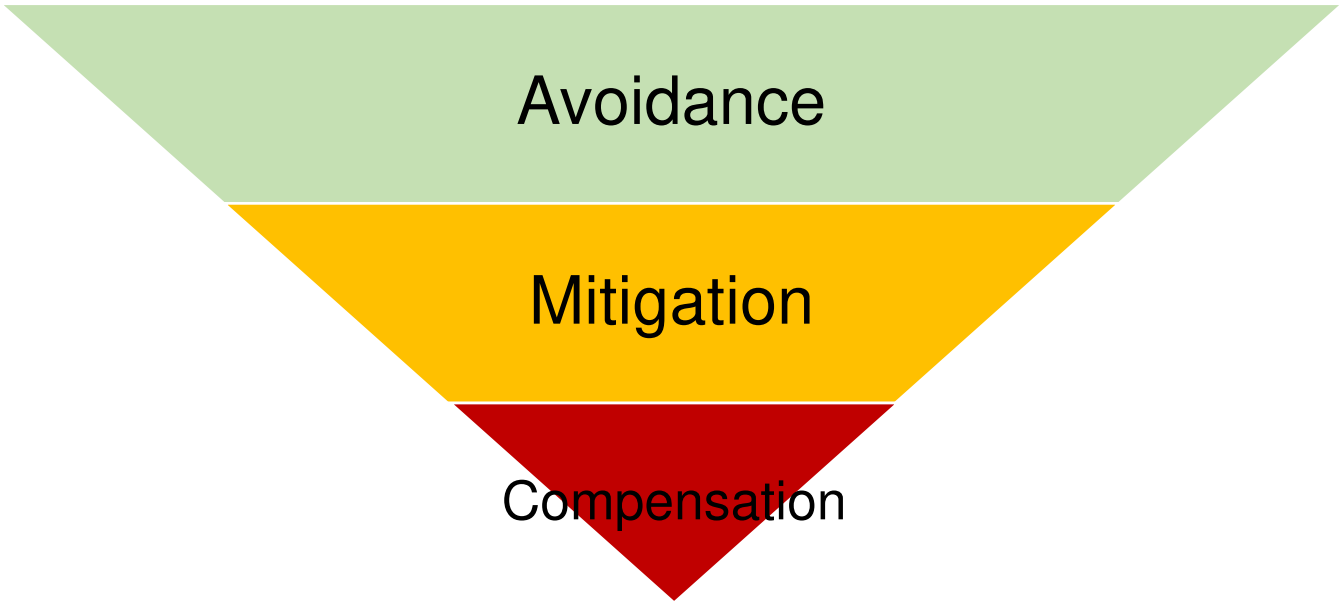

Figure 3-3: The mitigation hierarchy which should be taken into consideration when establishing measures for plans or projects

The following figure (Figure 3-4) shows a sample of the ***Mitigation measures*** *section/* sheet and its contents.

Mitigation hierarchy implemented on the all lifecycle steps											
TI LIFECYLCLE	Mitigation Measures					TRANSPORT MODE					
	Mitigation Hierarchy Measures	Measures type	Specific measures			Roads	Rail	Inland waterways	Ports	Airports	Powerlines
STRATEGIC PLANNING	Prevention & Avoidance	Change / reject the proposed solution	Null alternative (no project at all)			X	X	X	X	X	X
			Proposing an alternative transportation mode			X	X	X		X	X
			Proposing an alternative project location / corridor (entire project or components)			X	X	X	X	X	X
	Mitigation	Guidance for design phase	Proposing a framework for establishing baseline for all phases of the project			X	X	X	X	X	X
			Proposing methodological approaches for conducting EIA/AA			X	X	X	X	X	X
			Define Key performance indicators for the EIA / AA and for the project			X	X	X	X	X	X
			Define the follow-up process (e.g. clear reporting mechanisms, open data)			X	X	X	X	X	X
			Identify relevant stakeholders and adequate/inovative tools to engage them			X	X	X	X	X	X
DESIGN	Prevention & Avoidance	Change / reject the proposed solution	Define no go areas for the components of the project (restriction areas)			X	X	X	X	X	X
			Define restriction periods during construction			X	X	X	X	X	X
			Make changes in the project technical solutions / locations for implementation of project components			X	X	X	X	X	X
	Mitigation	Fauna passages	Overpasses	Wildlife overpasses		X	X	X			
				Multiuse overpasses		X	X	X			
				Tree-top overpasses (Canopy bridges)		X	X	X			
				Other - Bat gantries		X	X				
				Tunnels (bored & cut and cover tunnels)		X	X				
			Underpasses	Adapted structures allowing for mixed use by wildlife and humans (e.g. viaducts, bridges, culverts etc.)		X	X	X			
				Wildlife underpasses		X	X				
				Passages for fishes & other aquatic organisms		X	X	X			
				Special passages (amphibian / reptile tunnels)		X	X				
			Level crossings			X	X				
		Traffic management	Changing traffic flow and speed	Speed reduction		X	X	X			
				Traffic calming/ rerouting		X	X			X	
			Active warning signs for alerting drivers			X	X	X			
			Fauna warning and detection systems			X	X				
			Increasing visibility for drivers			X	X				
			Public awareness			X	X	X	X	X	X
		Fencing	Temporary / permanent fences			X	X			X	
			Screens			X	X				
			Escape facilities (e.g. exit ramps)			X		X		X	
			Cattle grids and gates			X	X			X	
		Wildlife deterrents	Visual deterrents (e.g. drones, dogs, lights, falconry, reflectors, lasers, virtual fences)			X	X			X	X
			Acoustic deterrents (Devices with recordings of disturbing noises)							X	
			Olfactory deterrents			X	X			X	
			Other biological deterrents			X	X			X	
		TIH (Transport Infrastructure Habitat) management	Verges management as green corridors including plant species selection and prevention of IAS spread)			X	X	X	X	X	X
			Drainage management as blue corridors			X	X	X	X	X	X
			Tree removal			X	X	X	X	X	X
			Embankment design			X	X	X	X		
			Habitat attractiveness management			X	X	X	X	X	X
			Maintenance adaptation especially close to wildlife crossings			X	X	X			
			Biological control methods			X	X	X	X	X	X
		Other measures to reduce animal vehicle	Adapting kerbs and drains			X	X			X	
			Carcasses removal			X	X			X	
		Visibility markers	Visibility markers for screens			X	X				
			Visibility markers for powerlines			X	X				X
		Avoiding electrocution	Electric wire/ catenary insulation			X*	X				X
		Light pollution control	Adapting the lighting system			X	X	X	X	X	
			Light deflectors			X	X		X	X	
			Artificial walls			X	X				
			Tree windbreaks			X	X				
		Noise pollution control	Noise absorbing panels			X	X			X	
			Speed reduction			X	X				
			Tree windbreaks			X	X			X	
		Air / odour pollution control	Speed reduction			X	X				
			Artificial walls			X	X				
			Tree windbreaks			X	X				
			Waste management			X	X		X	X	
		Water pollution control	Rainwater treatement			X	X		X	X	
			Retention / infiltration ponds			X	X		X	X	
			Wetlands			X	X		X	X	
PRE - CONSTRUCTION	Natura 2000 Network (N2k) Compensatory measures	New N2k sites	Designation of new N2k sites			X	X	X	X	X	X
		Maintaining / increasing the area of N2k Habitats	N2k Habitats restoration			X	X	X	X	X	X
			N2k Habitats enhancement			X	X	X	X	X	X
			N2k Habitats recreation			X	X	X	X	X	X
		Maintaining / increasing the population of N2k	N2k Species reintroduction			X	X	X	X	X	X
			N2k Species re-stocking			X	X	X	X	X	X
CONSTRUCTION	Avoidance	Translocation	Translocation of individuals			X	X	X	X	X	X
		Management of construction site traffic	Rerouting the construction site traffic			X	X	X	X	X	X
			Speed reduction for the construction site trafic			X	X	X	X	X	X
		Management of execution works	Stop of works			X	X	X	X	X	X
			Adaptation of works (including strict maintenance of construction works limits)			X	X	X	X	X	X
	Mitigation	Pollution control	Silt screens			X	X	X	X		
			other measures (already mentioned in design phase)			X	X	X	X	X	X
		Invasive Alien Species (IAS) Control	IAS removal			X	X	X	X	X	X
			other measures (already mentioned in design phase)			X	X	X	X	X	X
		Rehabilitation works	Land rehabilitation			X	X	X	X	X	X
			Management of vegetation			X	X	X	X	X	X
OPERATION	Mitigation	IAS Control	IAS removal			X	X	X	X	X	X
		Measures maintenance	Measures maintenance			X	X	X	X	X	X
			Measures improvement			X	X	X	X	X	X
DECOMMISIONING	Restoration	Removal of infrastructure				X	X	X	X	X	X
		Habitat restoration				X	X	X	X	X	X
REPURPOSING	Restoration	Reshaping and transforming the infrastructure				X	X	X	X	X	X
		TIH restoration				X	X	X	X	X	X

Figure 3-4: A sample of the Mitigation measures section/ sheet in the annexed Excel tool

- **Process,Tools & Barriers Section**

This section/ sheet has three main components: **environmental processes** applicable to each transport mode, the main **tools** which can be used and the main **barriers** identified for each project type. Its main aim is to showcase in a single place what is needed for the implementation of a project (from an impact assessment point of view), what are the main tools that can be used for developing the assessments and what are the main barriers related to each transport sector.

The section related to tools from this sheet includes several references to other existing tools developed within different projects, such as TRANSGREEN[5], ConnectGREEN[6] and SAVEGREEN[7], as well as other tools developed within BISON project. It is important therefore to take into consideration this tool in the overall context of the project, and to also analyse and verify the other products of the BISON project. The figure below (Figure 3-5, Figure 3-6, Figure 3-7) shows samples of the **Process, Tools & Barriers section**.

LIFECYCLE	PROCESSES, TOOLS & BARIERS	TRANSPORT MODE					
		Roads	Rail	Inland waterways	Ports	Airports	Powerlines
	ENVIRONMENTAL PROCESSES*						
Strategic planning	SEA (Strategic Environmental Assessment)	X	X	X	X	X	X
Design	Environmental Monitoring Programs	X	X	X	X	X	X
	EIA (Environmental Impact Assessment)	X	X	X	X	X	X
	AA (Appropriate Assessment)	X	X	X	X	X	X
	WFD (Water Framework Directive) assessment	X	X	X	X	X	X
	Planning the mitigation and compensation measures	X	X	X	X	X	X
Construction	Environmental Monitoring Programs	X	X	X	X	X	X
	Environmental Management Plan (Implementation of Polluters pays principle)	X	X	X	X	X	X
Operation	Ecological asset maintenance	X	X	X	X	X	X
	Monitoring/ Evaluation	X	X	X	X	X	X
Upgrade and adaptation	Environmental Monitoring Programs	X	X	X	X	X	X
	EIA (Environmental Impact Assessment)	X	X	X	X	X	X
	AA (Appropriate Assessment)	X	X	X	X	X	X
	WFD assessment	X	X	X	X	X	X
	Ecological asset maintenance	X	X	X	X	X	X
Decommisioning	Restoration/Monitoring	X	X	X	X	X	X

Figure 3-5: A sample of the Process section

[5] TRANSGREEN - Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature, https://www.interreg-danube.eu/approved-projects/transgreen

[6] CONNECTGREEN- Restoring and managing ecological corridors in mountains as the green infrastructure in the Danube basin, https://www.interreg-danube.eu/approved-projects/connectgreen

[7] SAVEGREEN - Safeguarding the functionality of transnationally important ecological corridors in the Danube basin, https://www.interreg-danube.eu/approved-projects/savegreen

LIFECYCLE	PROCESSES, TOOLS & BARIERS	TRANSPORT MODE					
		Roads	Rail	Inland waterways	Ports	Airports	Powerlines
	TOOLS*						
Strategic planning	(T1) Strategic migration study, map of protected areas, core areas, main migration corridors for target species important and protected Species Action Plans and their distribution	X	X	X	X	X	X
	(T2) Biological survey	X	X	X	X	X	X
	(T3) Framework migration study	X	X	X	X	X	X
	Ecosystem monetary valuation (based on ecosystem services)	X	X	X	X	X	X
	WP2 - Integrative planning, education of stakeholders	X	X	X	X	X	X
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Open data geoportals	X	X	X	X	X	X
	Other guidelines (including EC) for SEA & AA	X	X	X			X
	Platina Manual on Good Practices in Sustainable Waterway Planning from ICPDR			X			
Design	(T4) Monitoring program	X	X	X			
	(T5) Detailed migration study	X	X	X			
	(T6) Incorporation of migration corridor(s) near fauna passage(s) into spatial plan	X	X	X			
	(T7) Plan to protect biota during construction	X	X	X	X	X	X
	(T8) Ecological supervision	X	X	X	X	X	
	Asset management	X	X	X	X	X	X
	Cost-Benefit Analysis (CBA) to include ecosystem valuation & assests	X	X	X	X	X	X
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Biological surveys & monitoring activities	X	X	X	X	X	X
	Other guidelines (including EC) for EIA & AA	X	X	X			X
Construction	(T4) Monitoring program	X	X	X	X	X	
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
Operation	(T4) Monitoring after construction, monitoring the impacts of operation (including maintenance) on fauna	X	X	X	X	X	X
	(T9) Post-project analysis	X	X				
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Methodology for Standardised Monitoring of Ecological Connectivity (SaveGreen project)*	X	X				
Upgrade and adaptation	Defragmentation programmes	X	X	X			
	Asset management	X	X	X	X	X	
Decommisioning	Demolition plan	X	X	X	X	X	X
	Habitat restoration plan	X	X	X	X	X	X

Figure 3-6: A sample of the Tools section

LIFECYCLE	PROCESSES, TOOLS & BARIERS	TRANSPORT MODE					
		Roads	Rail	Inland waterways	Ports	Airports	Powerlines
	BARRIERS*						
Strategic planning	Lack of political will	X	X	X	X	X	X
	Lack of intermediate levels of planning (regional, sectorial). In some contries there is only national level followed by individual projects.	X	X	X	X	X	X
	Lack of (biodiversity) standardisation - for green engineering	X	X	X	X	X	X
	Lack of awareness on the consequences	X	X	X	X	X	X
	Lack of money and optimisation of resources	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation on prioritisation	X	X	X	X	X	X
	Lack of baseline scientific knowledge on habitats and species distribution	X	X	X	X	X	X
	Time pressure (always in hurry)	X	X	X	X	X	X
	Lack of capacity of staff and methods to mainstrem biodiversity	X	X	X	X	X	X
	Lack of engagement of the stakeholders	X	X	X	X	X	X
	Lack in data availability	X	X	X	X	X	X
	Lack of long-time monitoring data for strategic level	X	X	X	X	X	X
	Lack of policies, standards and regulations about sustainable and biodiversity friendly transport infrastructure requirements	X	X	X	X	X	X
	Many provisions on paper only	X	X	X	X	X	X
	Lobbying of industry	X	X	X	X	X	X
	Gaps & barriers analysis deliverable (D3.2, BISON project)	X	X	X	X	X	X
Design	Lack of political will	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of will to implement green solutions	X	X	X	X	X	X
	Lack of awareness of the public	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation on prioritisation	X	X	X	X	X	X
	Lack of baseline scientific knowledge (appropriate this knowledge for decisions) on habitats and species distribution (collecting data earlier - see also ecosystem valuation)	X	X	X	X	X	X
	Press of time	X	X	X	X	X	X
	Lack of engagement of the stakeholders	X	X	X	X	X	X
	Lack of standardisation (linked to methods and applied research)	X	X	X	X	X	X
	Press of cost's reduction	X	X	X	X	X	X
	Lack of inovation in methods	X	X	X	X	X	X
	Lack of prioritisation with other sectors	X	X	X	X	X	X
	Gaps & barriers analysis deliverable (D3.2, BISON project)	X	X	X	X	X	X
Construction	Press of time	X	X	X	X	X	X
	Press of cost reduction	X	X	X	X	X	X
	Revision of mitigation measures without public consultation	X	X	X	X	X	X
	Market availability for mitigation solutions	X	X	X	X	X	X
	Lack of knowledge / will of costructors	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Public availability of data	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Difficulties to change unsuitable mitigation measures	X	X	X	X	X	X
Operation	Press of cost reduction	X	X	X	X	X	X
	Lack of knowledge of costructors	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Inadequate / lack of maintenance for mitigation measures	X	X	X	X	X	X
	Difficulties to change unsuitable mitigation measures	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Lack of will of the project/infrastructure owners	X	X	X	X	X	X
Upgrade & Adaptation	Press of cost reduction	X	X	X	X	X	X
	Lack of knowledge of costructors	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
Decommisioning	Lack of political will	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Lack of baseline scientific knowledge on habitats and species distribution	X	X	X	X	X	X
	Press of cost's reduction	X	X	X	X	X	X

Figure 3-7: A sample of the Barriers section/ sheet from the annexed Excel tool

The use of the tool involves a series of steps, such as the following:

1. Identification and analysis of the proposed plan or project, including the domain for each one.
2. Based on the domain established for each plan or project, the tool allows the used to identify first the main effects and impacts caused by the plan or project under analysis. This identification can be done through the use of the first section/ sheet (1. Impacts) in the attached Excel tool.

   This general identification can also be important for plan or project owners or other stakeholders in the process of verifying the Strategic Environmental Assessments and Environmental Impact Assessments developed by experts. For each of the domains included in the tool, the SEA or EIA should address all of the effects and impacts deemed relevant for that domain.
3. After establishing the effects and impacts relevant for the analysed plan or project, the second section/ sheet in the Excel file (2. Mitigation measures) can be used to establish the appropriate measures to be implemented for each plan or project. The measures should be appropriate for the life cycle of the analysed project. The tool can provide information on the appropriate measures corresponding to each of the life cycle stages.

   The third section/ sheet of the Excel file (3.Process, Tools & Barriers section) can aid in identifying the types of environmental processes associated with each transport mode, as well as the main tools that should be used for implementing the environmental processes mentioned.

   The tool also includes a list of barriers, identified after discussions with the Project partners and other stakeholders, as the most important ones in the process of development of adequate green infrastructure and in ensuring the development of more sustainable projects.

4. METHODOLOGY FOR THE DEVELOPMENT OF THE TOOL

The development of the tool presented in this Report (D5.4) involved consultations with the Project Partners and other stakeholders as well. The initial idea was discussed and a first draft of the Excel file was developed in 2022. A workshop, which involved multiple brainstorming sessions, was organised at the beginning of 2023.

The second draft of the Excel tool included the results of the workshop and was finalised in April 2023. This version was sent to the Project Partners and stakeholders for further feedback on the content.

In May of 2023, the provided feedback was integrated, and the Excel tool was finalised. The final version was discussed with the participants to the BISON Project Final Conference in Strasbourg, at the beginning of June 2023. The feedback provided by the participants was integrated, to develop the final version of the Excel tool, annexed to this Report.

5. REQUIREMENTS FOR THE IMPLEMENTATION OF PROPOSED PLANNING TOOLS TO DIFFERENT TRANSPORTATION MODES AND REGIONS

The proposed tool focuses on transport infrastructure and builds mostly on the experience of linear transportation in Europe but it can be used in any country and geographical context. The application of the tool to different modes of transport is possible, taking into consideration the similarities they have with the domains included in the tool.

In regards to impacts, the types of impacts can be similar for all other kinds of transport infrastructure. They are based on effects which can also be similar in other types of transport infrastructure. For instance, any type of project which involves building permanent constructions will also lead to habitat loss due to land occupation, as well as changes in the parameters of the environment (such as air quality, soils, water quality etc.).

In terms of measures, the measures proposed at the strategic level can also be applied to different types of projects. The prevention and avoidance measures from the design stage presented in the tool are also applicable to other types of projects (either infrastructure or, in some cases, other categories of projects), regardless of their similarity to the transport modes presented in the tool.

Regarding the environmental processes, the steps presented in the tool are applicable to different types of transport infrastructure. It should be noted however that the Appropriate Assessment and the Water Framework Directive assessment are based on the EU legislation and are thus applicable at the level of the European Union.

For the proposed tools, many of them can be applied to other types of projects (infrastructure and other domains) as well, especially the tools related to resources, such as open data portals or guidelines for Cost Benefit Analyses or monitoring requirements.

In the case of transport infrastructure plans and projects proposed outside of Europe, the types of impacts are applicable in a similar manner. One tool that can aid in the identification of impacts for different types of projects is the ENCORE project developed by the UNEP-WCMC[8]. This can highlight the main effects and impacts generated by different types of projects, from different sectors of industry. It should be noted however, that the tool does not include aspects related to the quantification of these effects and impacts and should be used in correlation with more detailed analyses, modelling instructions or guidelines.

[8] The ENCORE project is available here https://encore.naturalcapital.finance/en

6. TECHNICAL AND PUBLIC POLICIES RECOMMENDATIONS

The recommendations regarding technical aspects are related mostly to the need to consider best practice guidelines in the process of impact assessment and in the process of identifying optimal impact prevention, avoidance, mitigation and compensation measures.

On the topic of impact assessment and the identification of adequate measures, the main recommendations related to best practices can be the following:

- Establishment of a clear baseline for the project area, including from the point of view of landscape connectivity. This should also include field surveys, with a lengthy duration, preferably of one year or more.
- At the strategic level, it is preferable to identify, analyse and decide upon alternatives to the analysed project. These alternatives can be either related to the project itself, or an alternative between different types of projects (for instance an alternative can be the implementation of a railway project instead of a new motorway project).
- Usage of historical data and existing data, in addition to field collected data, for aggregating the whole picture of the potentially sensitive receptors.
- Identifying a clear, replicable and adequate impact assessment methodology, that also takes into consideration the existing level of pressures and threats of the area. The application of this methodology should represent an assessment of the potentially cumulative impacts generated by the proposed project, with the existing pressures and threats.
- The impact analysis should take into consideration the interdependencies between the biotic and abiotic components, such as the relationships between groundwater and certain habitats or between air quality and the health of the vegetation in the area. Such an analysis ensures the assessment of the potential impacts on ecosystem functions and can aid in the identification of measures that ensure the maintenance of the ecosystem integrity.
- Establishing the appropriate measures for addressing habitat fragmentation (such as the implementation of green bridges or ecoducts) with special consideration of the landscape level connectivity and the measures proposed or required for other projects or for the existing infrastructure.
- Proposing SMART[9] measures, that specifically address a certain type of impact that was identified.
- Proposing measures that do not necessarily address the project under analysis, but another existing pressure, that would be aggravated by the proposed project or that would deem the measures proposed for the project as inadequate. Such an example can be the proposal of certain measures for the defragmentation of existing infrastructure, in the context of the construction of a new, permeable, motorway.

[9] Specific, Measurable, Achievable, Relevant, and Time-bound

- It is preferable for the measures proposed for the project to be discussed with stakeholders (including stakeholders from the local level) from the start of the project, to ensure that the most adequate solutions are proposed for the project.
- The project should include an adaptative management programme for the proposed measures. The effectiveness of the proposed measures should be monitored and any inadequate situations or potential unforeseen impacts should be addressed through further measures.

In regards to policy recommendations, Deliverable D 5.2 from BISON project exploring the policy/ strategy alignment and implementation maturity in reconciliation with the European Union Strategy for Green Infrastructure (EU SGI) for ensuring ecological connectivity in infrastructure development, and the proposed recommendations for addressing the different levels of maturity, already offers a comprehensive approach.

The content of Deliverable 5.2 has been based upon the outcomes of D5.1, and more specifically the initial recommendations on improving policies and legislation status from both EU level and Member States (national) level for their implementation at local/regional level and what specific processes are foreseen towards ecological connectivity.

However, referring specifically to the proposed tools, the following can be mentioned:

- The development of an international Technical Guide that integrates such tool as an example of good practice (UNEP, IUCN etc.).
- Creating a standard for biodiversity proofed transport infrastructure based on such a transferability tool for different transport modes (ISO, EU level standardization bodies).

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ANNEX

IMPACTS	Causes/ effects leading to impacts	TRANSPORT MODE					
Direct effects		**Road**	**Rail**	**Inland waterways**	**Ports**	**Airports**	**Powerline**
Habitat loss	*Definitive / long term vegetation removal*	X	X	X	X	X	X
	Soil artificialisation	X	X	X	X	X	X
	Occupying the land with constructions	X	X	X	X	X	X
	Nests / roosts destruction	X	X	X	X	X	X
	Changes in groundwater level (e.g., aridification)	X	X	X	X		
	Artificialisation of aquatic substrate	X	X	X	X		
Habitat alteration / degradation	*The introduction/dispersal of IAS (Invasive Alien Species)*	X	X	X	X	X	X
	Selective removal of vegetation	X	X	X	X	X	X
	Soil erosion	X	X	X	X	X	
	Soil / sediment contamination	X	X	X	X	X	
	Air quality deterioration	X	X	X	X	X	
	Water quality deterioration	X	X	X	X	X	
	Hydrogeomorphological alterations	X	X	X	X	X	
	Alterations in micro-climate	X	X	X	X	X	
	Changes in physical features of the area	X	X	X	X	X	
Habitat fragmentation	*Physical terrestrial barriers (Interruption of terrestrial corridors)*	X	X	X	X	X	X
	Physical aerial barriers (for birds / bats)	X*	X			X	X
	Interruption of aquatic longitudinal connectivity	X	X	X		X	
	Interruption of aquatic lateral connectivity	X	X	X	X	X	
	Behavioural barriers	X	X	X	X	X	X
	Edge effect	X	X	X	X	X	X
	Population isolation	X	X	X	X	X	
Disturbance and displacement	*Human presence and activity*	X	X	X	X	X	
	Noise & vibrations	X	X	X	X	X	
	Electromagnetic fields		X				X
	Artificial light / loss of darkness condition	X	X	X	X	X	
	Attractant / deterrent odours	X	X		X	X	
Direct wildlife mortality (main cause for the reduction of population size)	*Burial of plant and slow / sedentary animal species*	X	X	X	X	X	
	Chemical poisoning	X	X	X	X	X	
	Lethal level of aquatic turbidity	X	X	X	X		
	Stranding of aquatic fauna (larval / juvenile / adult stages)	X	X	X	X		
	Eggs destruction / nest abandonment	X	X	X	X	X	X
	Reduced capacity for rearing offspring	X	X	X	X	X	
	Increased predation	X	X	X	X		
	Traffic mortality	X	X	X	X	X	
	Wildlife electrocution	X*	X				X
	Mortality due to dredging	X	X	X	X		
	TIH as ecological traps and sink habitats	X	X	X		X	
Secondary / indirect effects							
Continuous and cumulative reduction of natural habitats' surface	*Increase the interest of industrialization*	X	X	X	X	X	X
	Increase the interest of urbanization	X	X	X	X	X	X
	Climate change contributions (drought, flooding, fires, landslides etc.)	X	X	X	X	X	X
	Change the landscape perspectives in irreversible way and in a broader time and geographical scales	X	X	X	X	X	
Landscape fragmentation	*Caused by interplay of multiple infrastructure barriers and other human made barriers (urban areas) as well as natural barriers*	X	X	X	X	X	X
Reduction of population size	*Changes in the downstream transport network (e.g. maintenance road, farming roads, secondary roads, other transport modes)*	X	X	X	X	X	
	Increase of human access (poaching, hunting, fishing)	X	X	X	X		X
	Increase the tourism activity especially in critical habitats areas	X	X	X	X	X	
	Cummulative contribution of the above mentioned effects & impacts	X	X	X	X	X	X
OPPORTUNITIES							
Transport infrastructure habitats (TIH)	*TIH as wildlife habitats*	X	X	X	X	X	X
	TIH as wildlife corridors	X	X	X			X

Mitigation hierarchy implemented on the all lifecycle steps											
TI LIFECYLCLE	Mitigation Measures				TRANSPORT MODE						
	Mitigation Hierarchy Measures	Measures type	Specific measures		Roads	Rail	Inland waterways	Ports	Airports	Powerlines
STRATEGIC PLANNING	Prevention & Avoidance	Change / reject the proposed solution	Null alternative (no project at all)		X	X	X	X	X	X
			Proposing an alternative transportation mode		X	X	X		X	X
			Proposing an alternative project location / corridor (entire project or components)		X	X	X	X	X	X
	Mitigation	Guidance for design phase	Proposing a framework for establishing baseline for all phases of the project		X	X	X	X	X	X
			Proposing methodological approaches for conducting EIA/AA		X	X	X	X	X	X
			Define Key performance indicators for the EIA / AA and for the project		X	X	X	X	X	X
			Define the follow-up process (e.g. clear reporting mechanisms, open data)		X	X	X	X	X	X
			Identify relevant stakeholders and adequate/inovative tools to engage them		X	X	X	X	X	X
DESIGN	Prevention & Avoidance	Change / reject the proposed solution	Define no go areas for the components of the project (restriction areas)		X	X	X	X	X	X
			Define restriction periods during construction		X	X	X	X	X	X
			Make changes in the project technical solutions / locations for implementation of project components		X	X	X	X	X	X
	Mitigation	Fauna passages	Overpasses	Wildlife overpasses	X	X	X			
				Multiuse overpasses	X	X	X			
				Tree-top overpasses (Canopy bridges)	X	X	X			
				Other - Bat pantries	X	X				
				Tunnels (bored & cut and cover tunnels)	X	X				
			Underpasses	Adapted structures allowing for mixed use by wildlife and humans (e.g. viaducts, bridges, culverts etc.)	X	X	X			
				Wildlife underpasses	X	X				
				Passages for fishes & other aquatic organisms	X	X	X			
				Special passages (amphibian / reptile tunnels)	X	X				
			Level crossings		X	X				
		Traffic management	Changing traffic flow and speed	Speed reduction	X	X	X			
				Traffic calming/ rerouting	X	X			X	
			Active warning signs for alerting drivers		X	X	X			
			Fauna warning and detection systems		X	X				
			Increasing visibility for drivers		X	X				
			Public awareness		X	X	X	X	X	X
		Fencing	Temporary / permanent fences		X	X			X	
			Screens		X	X				
			Escape facilities (e.g. exit ramps)		X		X		X	
			Cattle grids and gates		X	X			X	
		Wildlife deterrents	Visual deterrents (e.g. drones, dogs, lights, falconry, reflectors, lasers, virtual fences)		X	X			X	X
			Acoustic deterrents (Devices with recordings of disturbing noises)						X	
			Olfactory deterrents		X	X			X	
			Other biological deterrents		X	X			X	
		TIH (Transport Infrastructure Habitat) management	Verges management as green corridors Including plant species selection and prevention of IAS spread)		X	X	X	X	X	X
			Drainage management as blue corridors		X	X	X	X	X	X
			Tree removal		X	X	X	X	X	X
			Embankment design		X	X	X	X		
			Habitat attractiveness management		X	X	X	X	X	X
			Maintenance adaptation especially close to wildlife crossings		X	X	X			
			Biological control methods		X	X	X	X	X	X
		Other measures to reduce animal vehicle collisions	Adapting kerbs and drains		X	X			X	
			Carcasses removal		X	X			X	
		Visibility markers	Visibility markers for screens		X	X				
			Visibility markers for powerlines		X	X				X
		Avoiding electrocution	Electric wire/ catenary insulation		X*	X				X
		Light pollution control	Adapting the lighting system		X	X	X	X	X	
			Light deflectors		X	X		X	X	
			Artificial walls		X	X				
			Tree windbreaks		X	X				
		Noise pollution control	Noise absorbing panels		X	X			X	
			Speed reduction		X	X				
			Tree windbreaks		X	X			X	
		Air / odour pollution control	Speed reduction		X	X				
			Artificial walls		X	X				
			Tree windbreaks		X	X				
		Water pollution control	Waste management		X	X		X	X	
			Rainwater treatement		X	X		X	X	
			Retention / infiltration ponds		X	X		X	X	
			Wetlands		X	X		X	X	
PRE - CONSTRUCTION	Natura 2000 Network (N2k) Compensatory measures	New N2k sites	Designation of new N2k sites		X	X	X	X	X	X
		Maintaining / increasing the area of N2k Habitats	N2k Habitats restoration		X	X	X	X	X	X
			N2k Habitats enhancement		X	X	X	X	X	X
			N2k Habitats recreation		X	X	X	X	X	X
		Maintaining / increasing the population of N2k	N2k Species reintroduction		X	X	X	X	X	X
			N2k Species re-stocking		X	X	X	X	X	X
CONSTRUCTION	Avoidance	Translocation	Translocation of individuals		X	X	X	X	X	X
		Management of construction site traffic	Rerouting the construction site traffic		X	X	X	X	X	X
			Speed reduction for the construction site trafic		X	X	X	X	X	X
		Management of execution works	Stop of works		X	X	X	X	X	X
			Adaptation of works (including strict maintenance of construction works limits)		X	X	X	X	X	X
	Mitigation	Pollution control	Silt screens		X	X	X	X		
			other measures (already mentioned in design phase)		X	X	X	X	X	X
		Invasive Alien Species (IAS) Control	IAS removal		X	X	X	X	X	X
			other measures (already mentioned in design phase)		X	X	X	X	X	X
		Rehabilitation works	Land rehabilitation		X	X	X	X	X	X
			Management of vegetation		X	X	X	X	X	X
OPERATION	Mitigation	IAS Control	IAS removal		X	X	X	X	X	X
		Measures maintenance	Measures maintenance		X	X	X	X	X	X
			Measures improvement		X	X	X	X	X	X
DECOMMISIONING	Restoration	Removal of infrastructure			X	X	X	X	X	X
		Habitat restoration			X	X	X	X	X	X
REPURPOSING	Restoration	Reshaping and transforming the infrastructure			X	X	X	X	X	X
		TIH restoration			X	X	X	X	X	X

LIFECYCLE	PROCESSES, TOOLS & BARIERS	TRANSPORT MODE					
		Roads	Rail	Inland waterways	Ports	Airports	Powerlines
	ENVIRONMENTAL PROCESSES*						
Strategic planning	SEA (Strateoic Environmental Assessment)	X	X	X	X	X	X
Design	Environmental Monitoring Programs	X	X	X	X	X	X
	EIA (Environmental Impact Assessment)	X	X	X	X	X	X
	AA (Appropriate Assessment)	X	X	X	X	X	X
	WFD (Water Framework Directive) assessment	X	X	X	X	X	X
	Planning the mitigation and compensation measures	X	X	X	X	X	X
Construction	Environmental Monitoring Programs	X	X	X	X	X	X
	Environmental Management Plan (Implementation of Polluters pays principle)	X	X	X	X	X	X
Operation	Ecological asset maintenance	X	X	X	X	X	X
	Monitoring/ Evaluation	X	X	X	X	X	X
Upgrade and adaptation	Environmental Monitoring Programs	X	X	X	X	X	X
	EIA (Environmental Impact Assessment)	X	X	X	X	X	X
	AA (Appropriate Assessment)	X	X	X	X	X	X
	WFD assessment	X	X	X	X	X	X
	Ecological asset maintenance	X	X	X	X	X	X
Decommisioning	Restoration/Monitoring	X	X	X	X	X	X
	TOOLS*						
Strategic planning	(T1) Strategic migration study, map of protected areas, core areas, main migration corridors for target species important and protected Species Action Plans and their distribution	X	X	X	X	X	X
	(T2) Biological survey	X	X	X	X	X	X
	(T3) Framework migration study	X	X	X	X	X	X
	Ecosystem monetary valuation (based on ecosystem services)	X	X	X	X	X	X
	WP2 - Integrative planning, education of stakeholders	X	X	X	X	X	X
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Open data geoportals	X	X	X	X	X	X
	Other guidelines (including EC) for SEA & AA	X	X	X			X
	Platina Manual on Good Practices in Sustainable Waterway Planning from ICPDR			X			
Design	(T4) Monitoring program	X	X	X			
	(T5) Detailed migration study	X	X	X			
	(T6) Incorporation of migration corridor(s) near fauna passage(s) into spatial plan	X	X	X			
	(T7) Plan to protect biota during construction	X	X	X	X	X	X
	(T8) Ecological supervision	X	X	X	X	X	
	Asset management	X	X	X	X	X	X
	Cost-Benefit Analysis (CBA) to include ecosystem valuation & assests	X	X	X	X	X	X
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Biological surveys & monitoring activities	X	X	X	X	X	X
	Other guidelines (including EC) for EIA & AA	X	X	X			X
Construction	(T4) Monitoring program	X	X	X	X	X	
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
Operation	(T4) Monitoring after construction, monitoring the impacts of operation (including maintenance) on fauna	X	X	X	X	X	X
	(T9) Post-project analysis	X	X				
	Deliverable - D3.2 (Chapter 2, BISON project)	X	X				
	Methodology for Standardised Monitoring of Ecological Connectivity (SaveGreen project)*	X	X				
Upgrade and adaptation	Defragmentation programmes	X	X	X			
	Asset management	X	X	X	X	X	
Decommisioning	Demolition plan	X	X	X	X	X	X
	Habitat restoration plan	X	X	X	X	X	X
	BARRIERS*						
Strategic planning	Lack of political will	X	X	X	X	X	X
	Lack of intermediate levels of planning (regional, sectorial). In some contries there is only national level followed by individual projects.	X	X	X	X	X	X
	Lack of (biodiversity) standardisation - for green engineering	X	X	X	X	X	X
	Lack of awareness on the consequences	X	X	X	X	X	X
	Lack of money and optimisation of resources	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation on prioritisation	X	X	X	X	X	X
	Lack of baseline scientific knowledge on habitats and species distribution	X	X	X	X	X	X
	Time pressure (always in hurry)	X	X	X	X	X	X
	Lack of capacity of staff and methods to mainstrem biodiversity	X	X	X	X	X	X
	Lack of engagement of the stakeholders	X	X	X	X	X	X
	Lack in data availability	X	X	X	X	X	X
	Lack of long-time monitorino data for strategic level	X	X	X	X	X	X
	Lack of policies, standards and regulations about sustainable and biodiversity friendly transport infrastructure requirements	X	X	X	X	X	X
	Many provisions on paper only	X	X	X	X	X	X
	Lobbying of industry	X	X	X	X	X	X
	Gaps & barriers analysis deliverable (D3.2, BISON project)	X	X	X	X	X	X
Design	Lack of political will	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of will to implement green solutions	X	X	X	X	X	X
	Lack of awareness of the public	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation on prioritisation	X	X	X	X	X	X
	Lack of baseline scientific knowledge (appropriate this knowledge for decisions) on habitats and species distribution (collecting data earlier - see also ecosystem valuation)	X	X	X	X	X	X
	Press of time	X	X	X	X	X	X
	Lack of engagement of the stakeholders	X	X	X	X	X	X
	Lack of standardisation (linked to methods and applied research)	X	X	X	X	X	X
	Press of cost's reduction	X	X	X	X	X	X
	Lack of inovation in methods	X	X	X	X	X	X
	Lack of prioritisation with other sectors	X	X	X	X	X	X
	Gaps & barriers analysis deliverable (D3.2, BISON project)	X	X	X	X	X	X
Construction	Press of time	X	X	X	X	X	X
	Press of cost reduction	X	X	X	X	X	X
	Revision of mitigation measures without public consultation	X	X	X	X	X	X
	Market availability for mitigation solutions	X	X	X	X	X	X
	Lack of knowledge / will of costructors	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Public availability of data	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Difficulties to change unsuitable mitigation measures	X	X	X	X	X	X
Operation	Press of cost reduction	X	X	X	X	X	X
	Lack of knowledge of costructors	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Inadequate / lack of maintenance for mitigation measures	X	X	X	X	X	X
	Difficulties to change unsuitable mitigation measures	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Lack of will of the project/infrastructure owners	X	X	X	X	X	X
Upgrade & Adaptation	Press of cost reduction	X	X	X	X	X	X
	Lack of knowledge of costructors	X	X	X	X	X	X
	Lack of environment supervision	X	X	X	X	X	X
	Lack of innovation	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
Decommisioning	Lack of political will	X	X	X	X	X	X
	Lack of administrative and scientific capacity	X	X	X	X	X	X
	Lack of multidisciplinary and multisector cooperation	X	X	X	X	X	X
	Lack of baseline scientific knowledge on habitats and species distribution	X	X	X	X	X	X
	Press of cost's reduction	X	X	X	X	X	X

LEGEND*

1. Impacts

Row 19 - Physical aerial barriers (for birds / bats) - applies for roads in the case of eHighways.

Row 38 - Wildlife electrocution - applies for roads in the case of eHighways.

2. Mitigation measures

Row 50 - Avoiding electrocution, Electric wire/ catenary insulation - applies for roads in the case of eHighways.

3. Processes, Tools & Bariers

Row 3 - Environmental processes* = evaluation of potential harm or negative impacts of the certain stages from the life cycle of various transport modes (from planning to decommissioning) on the environment and its components (including on ecosystem services).
Row 20 - Tools* = instrument that allows to effectively avoid, mitigate or ultimately compensate for the impact of various transport modes on the environment and its components (including on ecosystem services).
Row 45 - A Methodology for Standardised Monitoring of Ecological Connectivity – Guidelines for the Analysis of Structural and Functional Connectivity, Danube Transnational Programme DTP3-314-2.3 SaveGREEN project, 2022.

https://www.interreg-danube.eu/uploads/media/approved_project_output/0001/56/dc86e1c6e3dac3299b3b411262b93dcd0210f85f.pdf

Row 50 - Barriers* = any kind of impediment (such as a rule, practice, law, policy, knowledge gaps) towards the effective application/implementation of dedicated tools for reducing the impact of various transport modes on environment and its components (including ecosystem services).

General definitions	Definition according to BISON materials
Environmental assessment = is a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. Environmental assessment can be undertaken for individual projects, such as a dam, motorway, airport or factory, on the basis of Directive 2011/92/EU (known as 'Environmental Impact Assessment' – EIA Directive) or for public plans or programmes on the basis of Directive 2001/42/EC (known as 'Strategic Environmental Assessment' – SEA Directive).	
SEA (Strategic Environmental Assessment) = is a process governed in the European Union by Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (SEA Directive). According to the Directive, its goal "is to provide for a high level of protection of the environment and contribute to the integration of environmental considerations into the preparation and adoption of plans and programs with a view to promoting sustainable development, by ensuring that, in accordance with this Directive, an environmental assessment is carried out of certain plans and programs which are likely to have significant effects on the environment".	SEA = description and evaluation of expected direct and indirect effects of the transport development concept in order to reduce impact on the environment
EIA (Environmental Impact Assessment) = is a process that focus on assessing the environmental impacts of projects of a certain kind and scope. The Environmental Impact Assessment (EIA) Directive (2014/52/EU) applies to a wide rang of defined public and private projects, which are defined in Annexes I and II. Mandatory EIA refers to all projects listed in Annex I, having been considered to have significant effects on the environment and require an EIA (e.g. long-distance railway lines, motorways and express roads, airports with a basic runway length ≥ 2100 m, etc.). For projects listed in Annex II, the national authorities must decide whether an EIA is needed. EIA shall identify, describe and assess in an appropriate manner, in the light of each individual case, the direct and indirect significant effects of a project on the following factors: (a) population and human health; (b) biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC; (c) land, soil, water, air and climate; (d) material assets, cultural heritage and the landscape; (e) the interaction between the factors referred to in points (a) to (d).	EIA = evaluation of impact of the proposed project or development on the environment and evaluation as to whether it is possible to implement it, or under what conditions the implementation is acceptable
AA (Appropriate Assessment) = is an assessment of the potential adverse effects of a plan or project (in combination with other plans or projects) on Special Areas of Conservation and Special Protection Areas. These sites are protected by National and European Law.	