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Allocation of innovative solutions to future scenarios

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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
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12	UKF	FAKULTA PRÍRODNÝCH VIED - UNIVERZITA KONŠTANTÍNA FILOZOFA V NITRE	Slovak Republic
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14	AMPHI	AMPHI CONSULT	Denmark
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20	ZARAND	ASSOCIATA ZARAND	Romania
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22	GDDKIA	GENERALNA DYREKCJA DROG KRJAOWYCH I AUTROSTRAD	Poland
23	STUBA	SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE	Slovak Republic
24	MINUARTIA	MINUARTIA	Spain
25	SLU	SVERIGES LANTBRUKSUNIVERSITET	Sweden
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
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TABLE OF ACRONYMS

AI	Artificial intelligence
CSA	Coordination and support action
EC	European commission
EIA	Environmental Impact Assessment
EU	European Union
HTI	Habitat related to Infrastructure
IENE	Infrastructure & Ecology Network Europe
IoT	Internet of Things
ITS	Intelligent Transport System
KPI	Key Performance Indicator
NGO	Non-profit Governmental organisation
ROW	Right of Way
SEA	Strategic Impact Assessment
SRDA	Strategic Research and Deployment Agenda
TI	Transport Infrastructure

EXECUTIVE SUMMARY

BISON project is the first CSA issued by the EC on the topic of transport, which is directly integrating biodiversity issues, particularly the ones related to pollution or climate change. Apart from assessing the current situation, there is also a need to prepare for the future by 1) considering emerging trends and uncertainties to develop plausible scenarios and 2) proposing research priorities by allocating to these scenarios the most suitable innovative solutions that would address the stakeholders' needs and requirements.

This deliverable is one outcome of task 5.3 "The future: plausible scenarios, relevant EU funding sources and proposals for future cross-thematic funding" that focuses on the identification of new emerging trends to be addressed in the future scenarios of climate change and its effects on biodiversity and transport.

Task 5.3, titled "The future: plausible scenarios, relevant EU funding sources, and proposals for future cross-thematic funding," aims to generate valuable insights regarding emerging trends in the areas of climate change, biodiversity, and transport. The deliverable produced as a result of this task serves is an outcome that provides a comprehensive elaboration on these identified trends and their implications.

The primary objective of this deliverable is to present plausible scenarios that depict potential future developments in the context of climate change and its impact on biodiversity and transport. These scenarios are based on thorough research and analysis of current trends, scientific projections, and expert opinions. By exploring multiple scenarios, the deliverable offers a range of possible futures, helping stakeholders to anticipate and prepare for various outcomes.

In the context of this task, a participatory approach was employed to define four future scenarios. This approach involved engaging various stakeholders and taking into account their needs and requirements, as outlined in Work Package 4 (WP4). These stakeholders include experts, policymakers, industry representatives, and members of the community who are directly or indirectly affected by the issues at hand. The participatory approach ensured that a diverse range of perspectives and insights were incorporated into the process of scenario development. By involving stakeholders, the aim was to enhance the relevance and applicability of the scenarios to real-world situations and challenges.

To define these future scenarios, the project utilized the Prospective process through Scenarios methodology. This methodology is an approach for strategic thinking and planning, particularly when dealing with complex and uncertain situations. It involves systematically exploring and analyzing various factors, trends, and uncertainties to construct multiple plausible futures. By employing a participatory approach and utilizing the Prospective process through Scenarios methodology, the project ensured that the future scenarios developed are grounded in stakeholder perspectives, supported by research and analysis, and can serve as valuable tools for strategic thinking, planning, and decision-making in the context of climate change, biodiversity, and transport.

The initial step involved identifying key variables related to the project's nine specific thematic fields. A total of 29 key variables were selected, with each variable mapped to a specific thematic field. These variables likely encompassed a wide range of factors relevant to the project's focus areas, such as climate data, biodiversity indicators, transportation patterns, policy frameworks,

and socio-economic factors. Next, specific hypotheses were formulated based on these key variables. These hypotheses likely represented key factors or assumptions that would shape the future scenarios. These factors could be related to technological advancements, regulatory changes, societal behavior, or other influential aspects within each thematic field. Building upon these key factors and hypotheses, mini scenarios were defined. These mini scenarios explored different combinations and permutations of the identified factors, creating plausible storylines for the future. These mini scenarios served as building blocks or starting points for the formulation of the final prospect scenarios of BISON.

To ensure the robustness and validity of the prospect scenarios, they were validated by a set of external experts. These experts likely possessed specialized knowledge and insights in the fields of climate change, biodiversity, and transport, providing valuable input and feedback on the formulated scenarios. This validation process helped to refine and enhance the scenarios, ensuring they accurately reflected the potential future developments in the relevant domains.

By formulating and validating these prospect scenarios, the BISON project team was able to establish a foundation for the research part of the Strategic Research and Development Agenda (SRDA). The scenarios provided a framework for guiding and structuring the research activities within the project, enabling a targeted and focused approach towards addressing the identified challenges and opportunities.

Overall, the process of identifying key variables, formulating hypotheses, defining mini scenarios, and validating the prospect scenarios served as a crucial preparatory step for the research phase of the BISON project. These scenarios provided a strategic direction and roadmap, facilitating effective research planning and decision-making to address the complex issues related to climate change, biodiversity, and transport.

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1. Introduction

The BISON project focuses on the future relationship between infrastructure development and biodiversity, in order to achieve enhanced "mainstreaming of biodiversity with infrastructure". One part of the project wants to address the future, by defining scenarios that present a "symbiotic" relationship between biodiversity and infrastructures whereby 1) biodiversity could be beneficial to infrastructure and 2) infrastructure development beneficial to biodiversity could emerge and in which conditions.

To study this issue, in BISON project, we used **the Prospective process through Scenarios, which is an approach for strategic thinking**. It provides the methods and techniques needed to explore the future and to approach complex issues of a long-term nature in a creative way. The process encourages unconventional thinking and influences the mindsets of people taking part to embrace the concepts of "pre-activity" (understanding) and "pro-activity" (influencing) (Godet, 2001). The Prospective Process through Scenarios does not attempt to predict or forecast the actual future, but rather it allows people to "think, talk, plan and act" creatively about the future (Ratcliffe, 2002).

The process involves the creation of a single preferred future vision, the 'prospective', that is reached following the creation and examination of a number of 'scenarios'. Scenarios are well-worked, internally consistent and evocative stories or images of the future. There is a strong focus on the communicative value of the scenarios and the participatory approach. They do not represent the future; instead, they portray a range of possible futures (Ogilvy and Schwartz, 1998).

The main advantage of the Prospective Process through Scenarios is that it is an interactive process that encourages participation at a wide-range of levels to produce a common, shared vision for the future.

The Prospective Process through Scenarios, follows 3 logical stages that explore the current knowledge on the past and future trends, then builds hypothesis and scenarios and finally transforms this prospective into a strategic action plan (Figure 1). The process adopts an iterative approach, and data collected at any stage can be continually recycled and integrated back into other stages, as necessary.

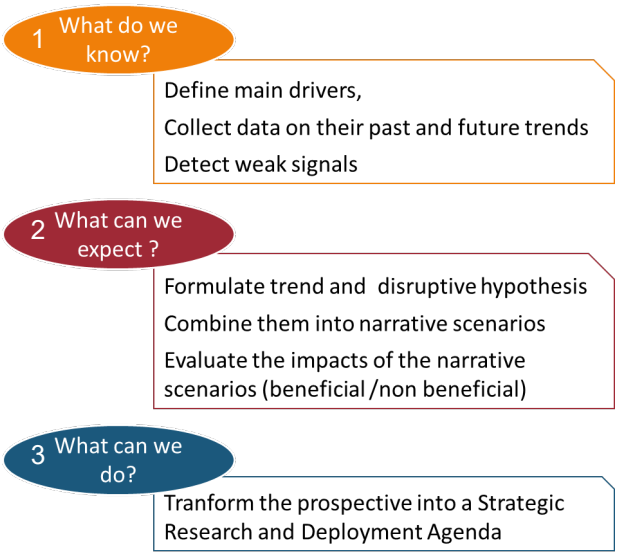


Figure 1 : The framework of the "Prospective Process through Scenarios"

2. Methodology towards BISON prospective scenarios

2.1. Overview of the methodology

Creating prospective scenarios involves a systematic process that includes several key steps, as they are depicted in Figure 2. The first step is to identify and categorize the drivers or variables that are considered significant in shaping the future. These drivers can be diverse, encompassing political, social, environmental, economic, and technological aspects. They serve as the fundamental building blocks for constructing the scenarios.

Once the drivers are identified, the next step involves formulating hypotheses for each variable. These hypotheses describe the potential changes or developments that could occur in the future. They are crafted based on the knowledge and expertise of the consortium experts or relevant stakeholders. These hypotheses provide a basis for understanding the potential trajectories of the variables and their interactions.

The next stage focuses on creating mini-scenarios within each thematic area. These mini-scenarios are developed by combining the formulated hypotheses for each variable in a specific theme. By exploring different combinations of hypotheses, multiple plausible storylines or pathways for the future are generated within each thematic field.

Finally, the mini-scenarios from various themes are integrated to form global scenarios. These global scenarios represent comprehensive and holistic visions of the future, capturing the interdependencies and interactions across different thematic areas. The combination of mini-scenarios allows for a broader perspective on the potential outcomes and implications of the identified drivers and their respective hypotheses.

The creation of prospective scenarios is an iterative and collaborative process that often involves validation and refinement through the input and feedback of external experts or stakeholders. This iterative approach helps ensure the robustness, credibility, and relevance of the final scenarios. Ultimately, these scenarios provide valuable insights and strategic directions for the research and planning activities undertaken within the project or organization.

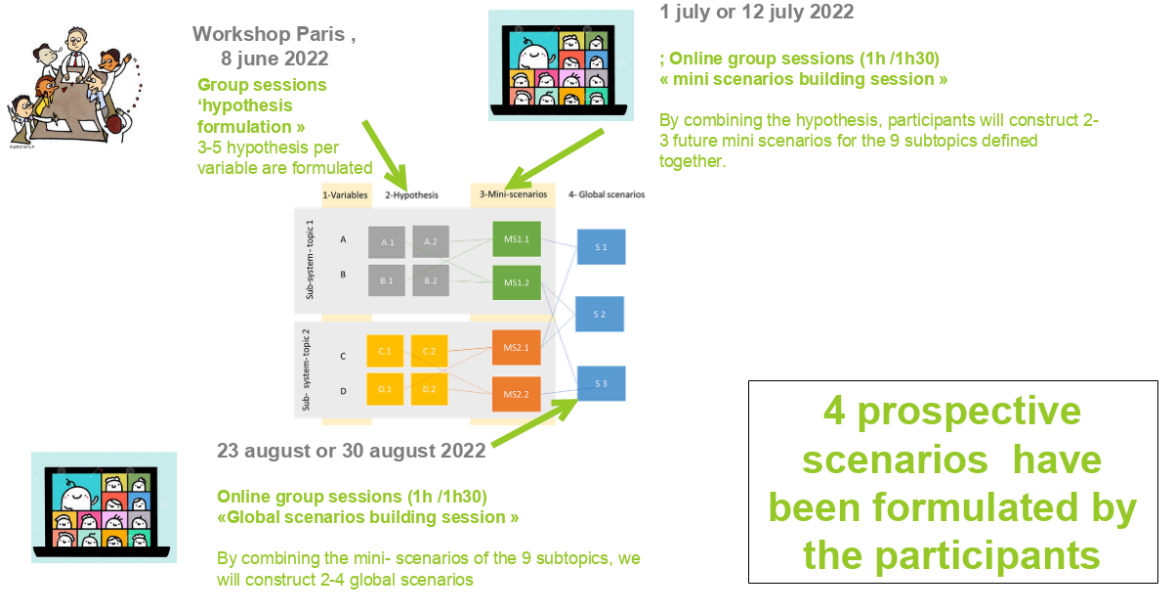


Figure 2: Expert panel sessions within the BISON project for the construction of prospective scenario

Indeed, the three-stage process of formulating hypotheses, developing mini-scenarios, and creating global scenarios is a classical and well-established methodology for prospective approaches. This methodology is designed to effectively handle the complexity inherent in studying and analysing various drivers and their potential impacts on the future.

2.2. Identification and selection of variables

In the BISON project, the identification of emerging trends for prospective scenarios in the context of climate change and its associated effects encompasses all transport modes, including rail, road, airports, ports, and the electrification of transportation, at the European scale. The time horizon for these scenarios is set at 2050, aligning with the European agendas and long-term planning goals.

The future of the "infrastructure and biodiversity" system is influenced by a multitude of factors, such as political will, societal resistance, environmental drivers, and economic considerations. Recognizing the complexity of this system, the BISON partners conducted a working session called "identification of prospective variables" to handle these diverse influences.

During the working session, the main drivers or variables for the prospective scenarios were selected. The primary criterion for the selection of these variables was their ability to equally influence both infrastructure and biodiversity on a European scale. The aim was to identify factors that have a significant impact on both aspects and are representative of the project's thematic dimensions.

The table below presents the 9 thematic dimensions related to the BISON project and the specific variables proposed by the partners. These variables were grounded in previous research and expertise, ensuring their relevance and applicability to the project's goals and objectives.

Table 1 : Thematic dimensions and their prospective variable defining the system "Infrastructure and Biodiversity"

Thematic Dimension	Title	Definition
European transport and biodiversity policies and regulations	Strategic Environmental Assessment	Systematic process for evaluating the environmental implications of a proposed policy, plan or program (only for public organs)
	Environmental Impact assessment	Systematic process for evaluating the environmental implications of a proposed project
	Invasive species regulations	EU policies and regulations on invasive species and their integration into national transport policies and regulations
Funding	European funding tools and taxes	Funding programs and taxes for infrastructure and biodiversity and their transversality & Private-public partnerships
	National funding tools and taxes	Funding programs and taxes for infrastructure and biodiversity and their transversality & Private-public partnerships
Intelligent Transport Systems (ITS)	Data acquisition technologies	New technologies for infrastructure and biodiversity monitoring: IoT, remote sensing
	New mobility schemes	Mobility sectors and infrastructures implemented for autonomous vehicles
	New data technologies	Use of new data technologies for Infrastructures development and maintenance (digital twins, Big data, AI)
Climate change & adaptation	Climatic adaptation of verges & drainage systems	Solutions and management of verges to deal with climate change
	Climatic adaptation drainage systems	Solutions and management of drainage system to deal with climate change
	Risk management	Topic and frequency of the risk monitoring and management schemes
TI induced pressions on biodiversity	Conflict between wildlife and infrastructure and/or traffic	Importance and risk management of wildlife mortality and ecological traps
	Anthropogenic pollutions	Importance and technical solutions for chemical, noise, artificial Lighting and atmospheric pollutions
Uses	Transport mode balance	Infrastructure use and repartition between Freight and Human transport , and Diurnal and nocturnal traffic
	Infrastructure loading	Traffic volume and need for new infrastructure
Right of way (ROW)	Habitat related to Transport Infrastructure	Evolution of natural or semi-natural area within infrastructures
	Ecological connectivity	Technical solutions and practices to enhance infrastructure impact on habitat fragmentation
Spatial organisation of networks	Multimodal platforms	Development of multimodal platform
	Spatial mesh	Spatial Infrastructure mesh within the urban-rural balance

Thematic Dimension	Title	Definition
		Infrastructure entering urban areas
	Urban area penetration	Spatial Infrastructure mesh within the urban-rural balance
Political, social and societal perception	Awareness of biodiversity conservation issues	The political and societal awareness of biodiversity conservation issues
	Infrastructure acceptability by local population	Consultation frameworks and their acceptance by local population.
	Mobility preference and demand	Transport preference & demand for the populations and goods.
	Biodiversity labels	Labels that aim to emphasise extra-regulatory biodiversity protection

By defining these variables, the BISON project aims to capture and address the crucial aspects that shape the relationship between infrastructure and biodiversity. These variables serve as key elements in constructing the prospective scenarios, enabling a comprehensive exploration of the potential future trajectories and their implications for the sustainable development of transport infrastructure while considering biodiversity conservation at a European level.

During the workshop, the BISON project partners put forward specific prospective variables for each thematic dimension. These variables were carefully considered and discussed, leading to the selection of the final variables, presented at the figure below.

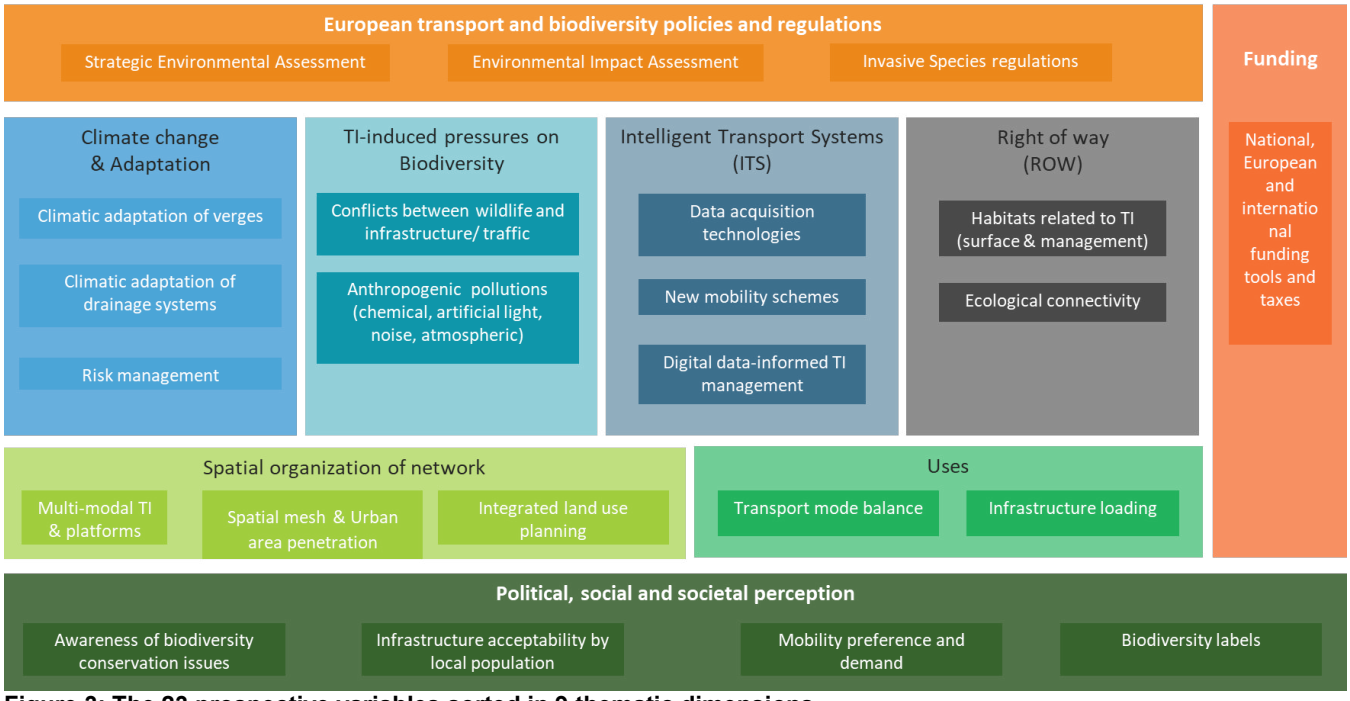


Figure 3: The 23 prospective variables sorted in 9 thematic dimensions

Information on the Past and future trends regarding each variable have been analysed by the BISON partners in a 2-10 pages report for each one. At this stage, only established future scenarios or prediction models were collected, using various sources.

2.3. Co-creation process for the construction of the scenarios

Following the definition and selection of prospective scenario variables, the BISON partners proceeded to formulate the scenarios themselves. This process took place through expert panels, following the three-stage methodology. Four prospective scenarios were developed as a result of these collaborative efforts. The first session, focused on hypothesis formulation, was conducted during a General Assembly meeting held in Paris in June 2022. The meeting involved both physical and virtual participation from the partners. This session allowed for the initial articulation of hypotheses regarding the evolution of the identified variables, taking into account the expertise and insights of the participants.

The second session, dedicated to building mini scenarios, took place in July 2022 and was conducted as an online workshop. During this workshop, the hypotheses formulated in the previous session were combined to create a set of mini scenarios within each thematic dimension. This step involved exploring different combinations and permutations of the hypotheses to generate plausible storylines for the future.

The final session, focusing on building global scenarios, occurred in August 2022 and was also conducted as an online workshop. In this session, the mini scenarios developed in the previous step were integrated and combined to form comprehensive global scenarios. The interactions and interdependencies between different thematic dimensions were considered to generate a holistic understanding of the potential future trajectories.

While the first session had a physical component in Paris, the subsequent sessions were conducted entirely online, allowing for virtual participation and collaboration among the BISON partners. This approach facilitated the involvement of experts regardless of their geographical location and ensured the efficient and inclusive development of the prospective scenarios.

Through these collaborative sessions, the BISON project partners were able to create four distinct prospective scenarios, providing valuable insights into the potential future of climate change, biodiversity, and transportation. The diverse expertise and perspectives of the participants contributed to a comprehensive exploration of the plausible paths and outcomes, setting the stage for further research and analysis in the SRDA (Strategic Research and Development Agenda) phase of the project.

At the following sections we will see in details how each step of the process was conducted in detail.

2.3.1. Hypothesis formulation

The formulation of hypotheses within each variable is considered the most creative part of the process. Experts from the BISON consortium (project partners) were responsible for formulating 3-5 hypotheses for each variable. These hypotheses outline the envisioned final situation by the year 2050, while also considering potential developments that may occur between 2025 and 2050.

To ensure diverse perspectives and generate multiple hypotheses, groups consisting of 4-5 participants were formed. Each group was assigned specific variables to work on, with the aim of achieving redundancy. This means that hypotheses were generated independently by three different groups of actors for each variable.

By distributing variables among multiple groups, the BISON project sought to foster a broader range of ideas and perspectives. This approach allowed for a more comprehensive exploration of potential future scenarios, taking into account the expertise and insights of various stakeholders within the consortium.

Through this collaborative process, the BISON project aimed to tap into the collective knowledge and creativity of the participants, enhancing the robustness and richness of the prospective scenarios. By considering a diverse set of hypotheses, the project could capture a wider range of possibilities and contribute to a more comprehensive understanding of the potential future impacts of climate change, biodiversity, and transportation.

2.3.2. Mini scenarios formulation

During the mini scenarios formulation phase, participants collaborated in small groups to combine the previously formulated hypotheses into thematic "mini-scenarios." Each group was assigned two or three themes to work on, ensuring that there was redundancy between groups. This redundancy involved multiple groups addressing the same thematic area to promote diverse perspectives and robust scenario development.

In a narrative format, the prospective team partners crafted 2-3 mini scenarios for each theme. These mini scenarios were written to depict plausible storylines that captured the potential future outcomes resulting from the combination of hypotheses within each thematic dimension. By presenting the scenarios in a narrative manner, the BISON project aimed to create vivid and engaging descriptions that allowed stakeholders to envision and understand the implications of the various thematic factors on the future of climate change, biodiversity, and transportation.

The mini scenarios served as valuable building blocks for the subsequent phase of scenario development, enabling a deeper exploration of the interdependencies and interactions between different themes and variables. By incorporating multiple perspectives and narratives, the BISON project aimed to create a comprehensive and diverse set of mini scenarios that would inform the development of the final global scenarios.

2.3.3. Global scenarios formulation

During the global scenarios formulation phase, participants collaborated in small groups to engage in discussions and merge the narrative mini-scenarios into cohesive global scenarios. Through a process of deliberation and synthesis, the participants aimed to distil the key elements and storyline components from the mini-scenarios to create a smaller set of comprehensive scenarios that encompassed the broader implications of climate change, biodiversity, and transportation.

Throughout this process, participants critically evaluated and refined the hypotheses and mini-scenarios, allowing for the discarding of less relevant or inconsistent elements. This iterative approach ensured that only the most relevant and coherent components were incorporated into the global scenarios. By the end

of the session, the participants collectively determined four distinct global scenarios that represented different possible visions of the future. These scenarios captured the potential trajectories and impacts of climate change, biodiversity, and transportation, taking into account various factors and their interactions.

Following the collaborative discussions, the prospective team partners took the lead in articulating the four global scenarios in a narrative format. Each scenario was elaborated in a comprehensive manner, with a dedicated narrative spanning 2-3 pages. This narrative approach aimed to provide a rich and detailed description of each scenario, allowing readers to immerse themselves in the envisioned future and understand the dynamics and implications within the context of climate change, biodiversity, and transportation.

Through the process of discarding and refining hypotheses and mini-scenarios, the participants and prospective team partners created a set of four robust global scenarios that served as valuable tools for envisioning and exploring the potential future landscapes. The narrative descriptions of these scenarios facilitated a deeper understanding of the diverse possibilities and helped stakeholders grasp the potential implications and challenges that may arise in relation to infrastructure, ecosystems, and society.

2.4. Evaluation of the prospective scenarios

During the IENE 2022 workshop held in September 2022, the impact of the four prospective scenarios on stakeholders' activities and the path to action was thoroughly discussed (Figure 4). The workshop brought together a diverse panel of participants, including researchers, infrastructure and institution operators, and representatives from environmental NGOs or consultancies. These professionals were selected based on their involvement in activities that could be affected by the scenarios and their potential role as actors in driving future changes.

To gain insights into how the participants could contribute to the different scenarios, three key questions were posed:

What do you find desirable in this scenario?
Participants were encouraged to identify and highlight the aspects of each scenario that they perceived as positive or desirable. This could include elements such as sustainable infrastructure development, improved biodiversity conservation, enhanced stakeholder collaboration, or innovative approaches to transportation and mobility. By pinpointing the desirable aspects, participants could envision the positive outcomes they would like to see in the future.

What do you find undesirable?
The participants were also asked to identify the aspects of each scenario that they found undesirable or challenging. This could encompass factors such as negative environmental impacts, social inequalities, policy constraints, or disruptions to their respective sectors. Recognizing the undesirable aspects helped to bring attention to potential risks and areas that require mitigation or alternative approaches.

What can I do as an administration/ NGO/ study office/ TI manager/ etc. to make this future more sustainable?

In this question, participants were encouraged to reflect on their own roles and responsibilities within their respective organizations or sectors. They were invited to consider actionable steps they could take to contribute to a more sustainable future within the context of each scenario. This could involve adopting environmentally-friendly practices, advocating for policy changes, fostering collaboration and knowledge sharing, or implementing innovative solutions.

By addressing these questions, the workshop participants engaged in a comprehensive exploration of their preferences, concerns, and potential contributions within each scenario. The discussions aimed to facilitate a deeper understanding of the implications and potential actions needed to shape a more sustainable future in alignment with the desired outcomes.

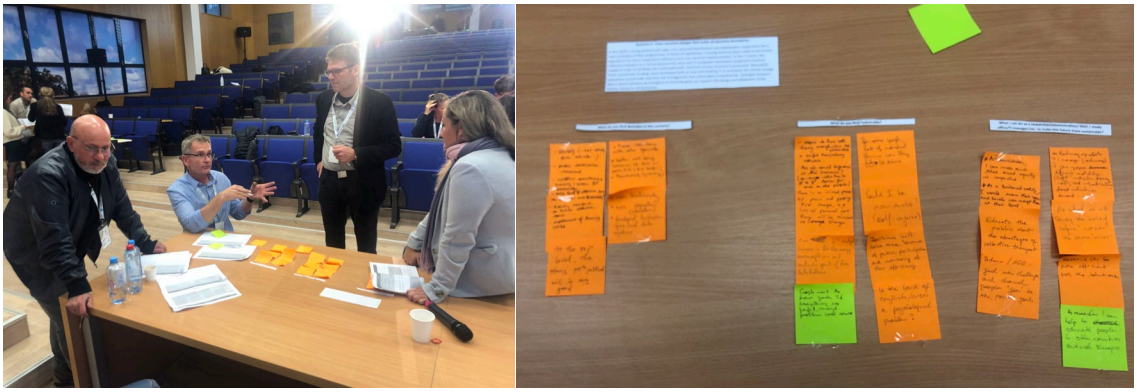


Figure 4 : Workshop on the impact of the prospective scenarios during the 2022 IENE conference in Romania

3. The prospective scenarios for biodiversity and infrastructure

3.1. Results of the hypothesis formulation

During the evaluation of the hypotheses in relation to their relevance based on geography, participants were specifically asked to assess whether a hypothesis would be more or less applicable depending on the region within Europe (North, West, East, or South). The objective was to determine if there were any spatial disparities or variations in the relevance of the hypotheses across different geographical areas.

The results of this evaluation, however, did not indicate any significant spatial disparities. The findings suggested that the formulated hypotheses were predominantly considered equally relevant for all European countries, irrespective of their location within the North, West, East, or South regions. This implies that the identified factors and potential future developments associated with climate change, biodiversity, and transportation were perceived to have a broad applicability and significance across the entire European continent.

The absence of spatial disparities in the relevance of the hypotheses highlights the consensus among the participants regarding the pan-European nature of the challenges and opportunities related to infrastructure, biodiversity, and climate change. It indicates that the potential implications and considerations outlined in the hypotheses were perceived to be pertinent and applicable across diverse geographical contexts within Europe.

This finding contributes to a comprehensive understanding of the scenarios and supports the notion that the identified drivers and variables are broadly significant in shaping the future of climate change, biodiversity, and transportation across the entire European region. It underscores the need for a collective and coordinated approach in addressing these challenges and leveraging opportunities for sustainable development on a pan-European scale.

Participants were also invited to describe each hypothesis depending on their relation to the future:

- Business as usual: the hypothesis describes a future that follows the current trends
- Plausible change: the hypothesis describes a future that corresponds to a significant acceleration or deceleration of current trends
- Weak signal: the hypothesis describes a future based on current minority trends
- Disruptive: the hypothesis describes a future that emerges from a new, unpredictable situation

The results of the hypothesis formulation for each variable are presented at the table below.

Table 2 : Hypothesis for the future formulated by the participants

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
1 – Strategic Environmental Assessment	1A- SEA instruction committee must present Biodiversity experts within transport programs.				X
	1B- «Sustainable mobility» strategies effectively integrates biodiversity concerns and public participation.		X		
	1C- SEA exist but are implemented without using common methodology and standardisation. there are differences in implementation	X			
	1D- SEA is part of the decision making process and it's efficiency monitored		X		
2- Environmental Impact Assessment	2A- EIA directive has been modified in order to include a better control of the EIA measures success			X	
	2B- There is not enough biodiversity left in 2045 that is worth to protect. All countries disentangled their legislation regarding biodiversity protection and EIA				X
	2C- Thanks to major changes in the procedures / evaluation tools, time of assessment has been reduced.		X		
	2D- Environmental Impact Assessment includes public participation in a properly way and all the biodiversity issues especially protected areas and their connectivity.		X		
	2E- Offset banking is developed and usable all across Europe but still controversial			X	
	2F- Thanks to close work (SEA-EIA tiering) between TI constructors, urban planners and environmental agencies, EIA efficiency and monitoring improve.			X	

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
3 - Invasive species regulations	3A- Despite invasive alien species regulation, the lack of investment in controlling already established invasive populations and increasing niche availability due to climate change result in the devastation of native biodiversity	X			
	3B- All EU countries have developed harmonised regulation and their implementation have improved. Invasive alien species populations are now stable and their effects on native species controlled.		X		
	3C- Efficient invasive alien species control is only on species that have economic impacts.			X	
4 – National, European & International funding tools and taxes	In 2045, there will be a common funding about biodiversity and climate change for infrastructure				X
	In 2045, there will be no funding because of the war and catastrophes (climate change)	X			
	No more funding of biodiversity projects	X			X
	Companies and innovations are more involved in funding in biodiversity projects		X	X	
5 - Data acquisition technologies	5A- In 2045, citizen are the major vector of collecting data: There is a very early educational program about ecology (biodiversity) in schools / kindergarten. So people can « feed » citizen science programs or collect data			X	
	5B- There will be a lot of available data but not enough harmonisation and sharing of data	X			
	5C- In 2045, harmonisation and improved access to data has been implemented. TI companies invest in collecting data on biodiversity.		X		

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	5D- A global & multi-topic (water, sound, etc.) a global earth monitoring network is developed based on different technologies (remote sensing, etc.).				X
6 – New mobility schemes	6A - In 2045, thanks to the emergence of climate friendly solutions, people use alternative energy sources that lead to a higher individual car traffic, a huge degradation of natural habitats and wildlife mortality		X		
	6B – Collective & alternative mobility options (e.g. car-pooling, public transportation) are the norm.		X		
	6C – In 2045, Collective & alternative mobility options are the norm only in Cities. Rural areas are depopulated and suffer from outdated & exhausted mobility means		X		
7 - Data informed TI	7A In 2045, I.T. collapses because of the collective awareness of its impact on biodiversity.				X
	7 B – In 2045 I.T. solutions that support the biodiversity and TI life cycle information needs exists but are not implemented.			X	
	7C- Multiple data systems exist but the effectiveness of data sharing is low due to a lack of inter communication between these data systems	X			
	7D- In 2045 I.T. solutions are well spread within the operators. Standardised systems make it possible to exchange data of biodiversity & eco-connectivity, on a real time basis. They are usable by the decision makers,		X		
8- Climatic adaptation of verges	8A- Major part of the road verges will be converted for renewable energy (with solar panels for instance)			X	
	8B- All vegetation is cut to prevent fire risks			X	

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	8C- Verges are temporary flooded from time to time creating attractive habitats for amphibians		X		
	8D- Verges are not properly managed and inhabited by invasive and adapted species, causing biodiversity loss. Their expansion through verges cause an impact on other areas.			X	
9 - Climatic adaptation of drainage systems	9A – No real mitigation measures have been undertaken, the lack of water leads to more frequent droughts or floods. These events severely degrade the TI provoking many political conflicts (massive people migration). Basic life products costs & biodiversity loss explode.	X			
	9B- Nature based solutions are generalised getting to less drought, floods (e.g. end of drainage system). Desartificialisation (decaling of the soil). Farther development of drainage infrastructure will be not necessary. This leads to an increase biodiversity		X		
	9C- Thanks to the shift from grey solutions (construction of the technical infrastructure…) towards nature based solutions including boarder development / support use of ecosystem services farther development of drainage infrastructure will be not necessary		X		
	9D- Large investment programs on climate change mitigation were developed and constructors will build drainage systems that can resist to 100 years flood	X	x		
	9E- Drainage systems will become one of the main source of freshwater for wetland biodiversity to reproduce			X	
10 – TI Risk management	10A -Extreme weather event has triggered the development and implantation of multi- use analysis. Because of the frequency of events, the path of analysis is on an almost real-time basis.		X		

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	10B- Biodiversity is not integrated in the TI risk management	X			
	10C- Biodiversity is fully integrated in the TI risk management.			X	
	10D- TI risk management is mainly worked during the design of TI	X			
11 - Conflicts between wildlife and infrastructure/ traffic	11A- Wildlife mortality is not a real concern except for species that can generate economic losses.	X			
	11B- New TI design, and / or technical solutions and/or traffic solutions have succeed to reach the « no mortality» objective.		X		
	11C- Reducing wildlife mortality is no more a priority. Roadkill's are in high numbers impacting wildlife populations			X	
12- Anthropogenic pollutions (chemical, noise, artificial light, atmospheric)	12A- Noise pollution underwater will be much more important than today (associated to boat and ports activities, offshore wind parks also)		X		
	12B- TI design /technical solutions make it possible to reduce anthropogenic pollutions.		X		
	12C- Anthropogenic pollutions have gradually increased and are known to be a major environmental & health problem. It causes ~ 1,5 billions of premature deaths in Europe.			X	
13-Transport mode balance	13A- In cities and suburban areas, rail & bikes (equivalent) are the main transport of goods and persons for distances < à 50 km.		X		
	13B- Thanks to a European directive, high speed rail is the only collective long distance mode in Europe for persons. Air transport is only permitted for transcontinental travel.			X	

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	13C- Road transports for freight and persons are the main transport mode for distances <500 km. Rail and air transport are mainly used for longer distances.	X			
	13D- Individual air transport becomes the be norm but only in richer regions of Europe				X
14 - Infrastructure loading	14A- In 2045, the traffic load will decrease because of energy cost		X		
	14B- Private ownership of new built infrastructure	X	X		
	14C- Enhanced increased local production lead to reduced freight transportation	X	X	X	
	14D- Smart transportation, car sharing and multimodal transportation lead to fewer vehicles		X		
15 - Habitat related to Transport Infrastructure	15A -Due to a need of new TI (or Renewable Energy plants) and the difficulty to find new locations, new TI are cumulated with existing ones. Surfaces of HTI have been reduced a lot.				X
	15B- Partial ecologically efficient management of HTI in different EU countries	X			
	15 C- HTI is managed properly as habitats and trap from relevant species combined to support mitigation compensation measure		X		
16 - Ecological connectivity	15D- Ecological connectivity is fully integrated in SEA and EAI with appropriated indicators			X	
	16A- Ecological Connectivity is still decreasing because of new infrastructures without ecological concerns. It leads to isolated populations and extinction species	X			

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	16B- Defragmentation strategies will be applied in 75% of the European countries. Actions will be undertaken to enhance permeability of linear TI will be applied based on the analyses of current bottlenecks / new infrastructure		x		
	16D- Defragmentation actions are in conflicts with other issues such as renewable energies production, or densification (houses + tunnel) cumulative infrastructures			X	
	16E- Nature based solution are developed in a comprehensive large scale, ensuring benefits for ecological connectivity			x	
17 - Multimodal platforms	In 2045, there will still be a competition between freight and railway because of energy cost rise and freight will be done on electric truck (or hydrogen). As a consequence, many trucks / rail are half empty.		X		
	17A- In 2045, Cooperation within transport modes has been found the main solution to eco-friendly and cheap transport solutions. Companies of rail, airplanes etc. merges in a global multimodal companies.				X
	17B -Mobility as a service is the norm. No private vehicles.				X
	17C- Digitalisation of supply chain and shared autonomous vehicles enhance the freight effectiveness		X		
	17D- If epidemic goes up, we stay more at home air plane collapse				X
	17E- No significant change or shift in transport of goods and passengers i.e. The dominance of roads and air will increase and the decrease of rail	X			
18 - Spatial mesh	18A- Due to a change of demand, the decommissioning of roads conducts to a decrease of 20 % of the European network.				X

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	18B- Railway networks have considerably been (re) developed especially for local and rural transport (low speed) and transnational transport (high speed).		X		
	18C- Road networks has increased from 10 to 20 % in European countries during the last 20 years	X			
	18D- Transport networks (except electricity) stay mainly unchanged because of the lack of money leading to prioritise and the soil protection policies.		X		
19 - Landscape planning	19A- Heterogeneity in landscape planning in EU members state will continue	X			
	19B-Weak harmonisation in the planning process between countries which will lead to insufficient coordination at EU Level. There is contradicting between types of planning e.g. green, grey infrastructure	X			
	19C- The European spatial development perspective in enforced in all EU member states. This leads to harmonisation of planning systems. This harmonisation will solve trans-boundary issues e.g. in the planning of green-grey infrastructure				X
	19D- Holistic approach of the landscape planning is getting of importance. Biodiversity conservation goals (no more project by project mitigation measures) are clearly defined during the process which helps to coordinate actors including the TI sector.			X	
20- Awareness of biodiversity conservation issues	20A- Biodiversity awareness is only partially included in policy and actions staying in the same trajectory with differentiation on geographical scale	X			
	20B- Economic pressure (climate change) softens both environmental regulations and public interest in biodiversity as countries and companies		X		

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	increasingly depend on foreign investments. Political rule will be replaced by corporate interests.				
	20C- Under the massive migrations of human population and despite more achieved level of awareness, new kind of competition and conflicts with biodiversity have emerged				X
	20D- Awareness has been growing up and affecting people and decisions. Biodiversity needs are effectively included in policies mainstreaming biodiversity in transport development		X		
21 - Infrastructure acceptability by local population	21A- In 2045, less public consultation by the governments and people will accept more because of their diminution of quality of life			X	
	21B- Opposition of people will increased and permanent will have to integrate more democratic consultation				X
	21C- Scenario technique and visualisation (BIM) for a better communication and participation of the public during the planning processes			X	
22 - Mobility preference and demand	22A- Regional production will be combine with the development of local and regional cycle economy lowering transaction costs and transport demands …. Local and regional transport performance will be straighter on the costs of transcontinental transport.		X		
	22B- Less transport demands due to more local production & accessibility (food stores, work, essential infrastructure (schools, hospitals)			X	
	22C- Scarcity of petrol cause a reduction of long distance mobility, This leads to an increase of new energy technology, a decrease of consummation, a more regional production, a stronger border and more nationalism		X		
	22D- The physical internet concept will become increasingly developed which will reduce the volume and kms of inland freight transport		X		

Variable N°	Hypothesis (1-3 sentences)	Category			
		Business as usual	Plausible change	Weak signal	Disruptive
	22E- There is an increase in the volume of freight and passengers even if efficiency is improving i.e. increase in GDP	X			
	22F- Use of autonomous vehicles becomes more common leading to an explosion of mobility demand (passengers & freight)			X	
23 - Biodiversity labels	23A- Multiplication of labels leads to unpreparedness, green washing, lack of coordination and saturation of people	X			
	23B- Standardisation inspire different labels. Stakeholder from all organisations from all countries		X		
	23C- Labels are not emerging because of EU, national frameworks whose biodiversity protection goals and public awareness are sufficient for TI sector.		X		
	23D- Companies will try to differentiate themselves and more and more labels will be created	X			

3.2. Results of the mini-scenarios formulation

The results of the mini scenarios Workshop for the 9 thematic dimensions (see Figure 3) are the following.

1. European transport and biodiversity policies and regulations

1-A- Harmonisation in regulations, efficient, cooperative and cross-sectorial implementation

To face biodiversity loss, EU countries have initiated in the 2020s, an extended work in terms of harmonisation of their national regulation (EIA and SEA) and their implementation. They introduced more transparency (public participation and monitoring of their efficiency) in the SEA end EIA. In 2045, public participation is made mandatory for any programmes or project. Cross-scale (tiering) and sectorial frameworks (transport, urbanism, environment, energy, etc.) are now well defined and used by practitioners. Moreover, cooperation between countries has been reinforced. It has made it possible to control most of the invasive alien species and protect the native species against them.

1B- The EU fails to disseminate its ambition at national level.

Even though EU Directives & policies have been modified for more ambition in terms of biodiversity protection (better control of mitigation measures, of invasive alien species, etc.), differences of implementation among EU countries are still important. National implementation of these regulations & policies lacks budgets and controls.

Weak signals: Loss of biodiversity progress during the period. At the beginning of the 2040s, some countries start to pledge for disentangling the legislation regarding biodiversity protection: « There is not enough biodiversity left to spare money and time to protect it. »

1-C – Economical deficit introduces Green washing in policies & regulations

An economic crisis has touched the EU during the period and has put pressure on the biodiversity regulations and policies. In 2045, their implementation is mainly driven by economic efficiency and differs considerably between countries. For example, invasive alien species control focuses only on species that have economic impacts, time & budget allocated to impact assessment have been considerably reduced. Offset banking has been found to be more economically efficient but is still controversial in terms of their ecological benefits.

Weak signals: Loss of biodiversity progress during the period. At the beginning of the 2040s, some countries start to pledge for disentangling the legislation regarding biodiversity protection: « There is not enough biodiversity left to spare money and time to protect it.»

2. Intelligent transport system

2A – Large amount of data collected by environment & transport stakeholders but poorly exploited

During the 2025-2045, transport companies have invested in collecting a large amount of data on biodiversity. IT solutions that support the biodiversity and TI life cycle information needs exists but are heterogeneous among EU countries. This lack of harmonisation and data sharing impedes their exploitation for informing EU policies.

2B- Large amount of data collected by citizens but poorly exploited

In 2045, citizens are the major vector of collecting data, thanks to very early educational programs about ecology in schools (could also be a low-cost solution for data collection). So people are used to « feed » citizen science programs or collect data. Some programs are dedicated to wildlife and transport infrastructure through the development of smartphone applications, for example. But the effectiveness of data sharing is low due to a lack of inter communication between these data systems. As a result, these data are effectively exploited to influence national & EU policies.

2C- EU-level data system - Harmonisation & cooperation -

During the 2025-2045 period, harmonisation and improved access to data has been implemented in order to develop a global & multi-topic (water, sound, etc.) earth monitoring network based on different technologies (remote sensing, etc.). TI companies invest at their scale on these technologies and data systems.

In 2045 IT solutions are well spread within the operators. Standardised systems make it possible to exchange data of biodiversity & eco-connectivity, on a real-time basis. They are usable by the decision makers.

3. Biodiversity induced and pollution risk management

3A- Devastation

Both in terrestrial & marine ecosystems are highly polluted by transport. Anthropogenic pollution has gradually increased and are known to be a major environmental & health problem. As biodiversity is not integrated in the TI risk management, reducing wildlife mortality & disturbance is no more a priority. As an example, roadkill is in high numbers impacting wildlife populations.

3B- Anticipation in adaptation & real-time risk management

1 During the 2020s-Extreme weather event has triggered the need for the development and implementation of multi-use analysis. Because of the frequency of events, the path of analysis is on an almost real-time basis, and biodiversity is fully integrated into the TI risk management. During the 2030-

2045 period, new TI design, and / or technical solutions and/or traffic solutions have succeeded in reaching the « no mortality» objective on biodiversity and to considerably reduce anthropogenic pollution

3C-Partial integration of biodiversity for design and adaptation

TI risk management is mainly worked during the design & adaptation of TI. Wildlife mortality is not a real concern except for species that can generate economic losses. Moreover, the impact of pollutions on biodiversity are not treated equally based on the cost-benefit analysis with other impacts (human). As a result some of them have been underestimated.

During the period 2025-2045, anthropogenic pollutions have gradually increased and have become a major environmental & health problem (cocktail effect is getting of importance) even though technical/design solutions have helped to reduce the transportation effect zones.

4. National, European & International funding tools and taxes

4A- Supranational investment banks dealing with both new and existing TI

In the 2020s, the investment banks engaged in sustainable infrastructure funding and definition of KPI related to biodiversity. A common fund of biodiversity and climate change for new and existing infrastructure became effective in the beginning of the 2030s.

4B- Private Funding through Social and environmental responsibility

In the 2020s, the companies get more involved in funding biodiversity projects, especially to avoid legal issues. As a consequence, the funding differs considerably between regions and/or countries.

4C -Lack of money - maintenance becomes the main factor to fund

In 2045, there will be no funding because of the war and catastrophes. Climate change adaptation is the priority, and there is no more funding of biodiversity measures.

5. Uses

5A- Green energy that sustains the actual mobility uses.

In 2045, thanks to the emergence of climate-friendly solutions, people use alternative energy sources. Road transports for freight and persons are the main transport mode for distances <500 km. Rail and air transport are mainly used for longer distances. In cities and suburban areas, rail & bikes (equivalent) tend to be the main transport of goods and persons for distances < 50 km.

Two possible changes:

1. If the cost of the green energy is high

Individual mobility is actually possible for the richer persons & regions. As an example, individual air transport becomes the norm but only in richer regions of Europe.

2. If the cost of the green energy is low

This situation led to a higher individual car traffic, a huge degradation of natural habitats and wildlife mortality.

5B- Energy prices are increasing, less mobility.

During the 2025-2045 period, the traffic load has decreased by 50% compared to 2025 level because of the increase of energy costs. In 2045, Collective & alternative mobility options are the norm only in Cities. Individual air transport has been developed for a minority of richer regions /populations. Rural areas are depopulated and suffer from outdated & exhausted mobility means. This situation has promoted the local production and the reduction of freight transportation.

5C -Collective Transport Is the Norm

In 2045, collective & alternative mobility options (e.g. carpooling, public transportation) are the norm (this change may be promoted by private ownership of new built infrastructure). Transportation, car sharing and multimodal transportation lead to fewer vehicles especially in urban areas. Thanks to a European directive, high-speed rail is the only collective long-distance mode in Europe for persons. Air transport is only permitted for transcontinental travels.

Possible divergence in rural areas: thanks to the emergence of climate-friendly solutions, people use alternative energy sources for individual transport in rural areas.

6. Climate change and adaptation

6A- Degradation of verges & drainage system as connectivity & refugee provider role, towards low risk & energy providers.

During the 2030s, the biodiversity conservation role of verges and drainage systems has been shifted to other ecosystem services (regulation / production). All vegetation is cut to prevent fire risks. Major part of the road verges will be converted for renewable energy (with solar panels for instance). Large investment programs on climate change adaptation were developed and constructors will build drainage systems that can resist to 100-year flood. In 2045, this degradation of verges and drainage systems as connectivity & refugee provider has been documented to increase biodiversity loss

6B- No environmental management.

Verges are not properly managed (or totally abandoned) and inhabited by invasive and adapted species. Their expansion through verges causes an impact on surroundings areas. No real adaptation measures have been undertaken, the lack of water leads to more frequent droughts or floods. These events

severely degrade the TI provoking many political conflicts (massive people migration). Basic life products cost & biodiversity loss explodes.

6C- Verges and drainage adaptation are managed for biodiversity conservation purposes.

Management is locally adapted to the local conditions (traffic, surrounded landscape, etc.). As an example, verges can be temporarily flooded from time to time creating attractive habitats for amphibians. Thanks to the shift from grey solutions (construction of the technical infrastructure...) towards nature-based solutions including boarder development / support use of ecosystem services father development of drainage infrastructure will not be necessary. These Nature based solutions have resulted in less drought, floods (e.g. end of the drainage system) & Desartificialisation (dealing of the soil). Increases in biodiversity diversity and abundance have been documented.

7. Right of way

7A- Relative integration of biodiversity conservation needs in the habitat related to infrastructure

During the 2025-2045 period, the ecological management of HTI is partially efficient and differs between EU countries.

Two possible results

1. The negative trend: Defragmentation actions are in conflicts with other issues such as renewable-energy production, urban densification & cumulative infrastructure.

2. The positive trend: defragmentation strategies have been applied in 75% of the European countries. Actions will be undertaken to enhance permeability of linear TI will be applied.

7B- Synergies between NBS & ecological connectivity goals found in the design and adaptation of Habitat related to infrastructure. From 2030, ecological connectivity is fully integrated in SEA and EIA with appropriated indicators. As a result, HTI are designed & managed in order to provide 1) habitats and traps to relevant species combined to support mitigation measure, 2) Nature based solution ensuring benefits for ecological connectivity

7C- Dense & Cumulative TI implantation

Due to a need for new TI (or Renewable Energy plants) and the difficulty to find new locations, new TI is cumulated with existing ones. Surfaces of HTI have been reduced a lot. During the period 2025-2045, because defragmentation actions were in conflicts with other issues such as renewable-energy production, urban densification & cumulative infrastructure, new infrastructure were designed without ecological concerns. Ecological Connectivity was still decreasing & lead to isolated populations and extinction of species.

8. Spatial organisation of networks

8A- Cooperative business model -cooperative planning

In 2045, mobility as a service is the norm. Cooperation within transport modes has been found the main solution to eco-friendly and cheap transport solutions. Companies of rail, aeroplanes & other transport merges in a global multimodal company. Railway networks have considerably been (re) developed especially for local and rural transport (low speed) and transnational transport (high speed). Due to a change of demand, the decommissioning of road conducts to a decrease of 20% of the European network.

To achieve this reorganisation, the European spatial development perspective has been reinforced in all EU member states in the beginning of the 2030s. Holistic approach of the landscape planning is getting importance. Biodiversity conservation goals (no more project by project mitigation measures) are clearly defined during the process which helps to coordinate actors including the TI sector. It has led to harmonisation of the planning systems. This harmonisation has then solved trans-boundary issues e.g. the planning of green-grey infrastructure

8B-Modal shift.

During the 2025-2045, digitalisation of the supply chain and shared autonomous vehicles enhance the freight effectiveness. This digitalisation solved trans-boundary issues. But the coordination has been mainly focused on freight. Transport networks (except electricity) stay mainly unchanged in 2045 and the weak harmonisation in the planning process between countries leads to insufficient coordination at EU Level. There is contradicting between types of planning e.g. green, grey infrastructure

8C- Network densification without planning harmonisation.

No significant change or shift in transport of goods and passengers has been observed during the 2025-2045 period. The dominance of roads and air has increased at the expense of rail. Road networks have increased from 10 to 20 % in European countries during the last 20 years.

Heterogeneity in landscape planning in EU members states due to insufficient coordination at EU level results in contradiction between landscape uses & risk management.

8D - Extreme shift to lower mobility

During the 2025-2045 period, epidemics or other events have made populations to stay home. Mobility has been considerably reduced, airports and roads have been abandoned. The decommissioning of road conducts to a decrease of 20 % of the European network. But these changes were not planned to restore quality of life or biodiversity because there were no time / resources to plan landscape anymore.

9. Political, social and societal perception

9A -Environmental & biodiversity is partially tackled by the society

Biodiversity awareness was only partially included in policy and actions staying in the same trajectory with differentiation among EU countries. But in 2030, economic pressure (climate change) softens both environmental regulations and public interest in biodiversity as countries and companies increasingly depend on foreign investments & the increase in the explosion of mobility demand (passengers & freight) thanks to the emergence use of autonomous vehicles

Political rule has been replaced by corporate interests. A part of the population that wants to keep environmental protection as a priority reinforced their opposition with protestations.

Biodiversity concerns become a marketing issue. Companies will try to differentiate themselves and more and more labels will be created. Multiplication of labels leads to unpreparedness, green washing, and lack of coordination and saturation of people.

9B- Collapse scenario, urgency first

Under the massive migrations of human populations, the scarcity of petrol and despite more achieved level of awareness of biodiversity issues, new kind of competition and conflicts with biodiversity have emerged (food & energy supply). People were worried by their quality of life (day-to-day product shortages became more frequent in 2030) and left their governments more freedom to act towards more nationalism & less public consultation: stronger boarders, promoting regional products, etc.

9C- Biodiversity & environmental needs fully integrated by our society

Since 2025, awareness has been growing up and affecting people and decisions. Biodiversity needs are effectively included in policies mainstreaming biodiversity in transport development. The virtuous cycle is found in public consultation processes: Scenario technic and visualisation (BIM) for a better communication and participation of the public during the planning process is broadly used. For instance, by combining the advantages of the physical internet that reduces the volume and klms of inland freight transport and the development of local and regional cycle economy that promotes the reuse of resources, regional products become economically performant. As a result, the transport demand decreased.

Labels are not emerging because of EU, national frameworks whose biodiversity protection goals and public awareness are sufficient for TI sector.

3.3. Results of the global scenarios formulation

3.3.1. Scenario 1 : Transport System collapse

Abstract:
This scenario mainly deals with emergencies.
During the 2020's, there was no real anticipation of the strong effects of global changes (extreme weathers, etc.). As a result, TI maintenance became problematic. Combined with more frequent crisis (epidemics, primary resources shortages, etc.) and/ or energy price rising, the mobility has considerably decreased during the 2030's. To face, economic & emergency challenges, environmental management standards & regulations disentangle during the period. In 2050, some existing TI are extremely deteriorated (maintenance is difficult), or abandoned & the rare new TI do not support any role for biodiversity.

In 2050, EU faces a collapse scenario.

Economic shutdowns & natural disasters cause deregulation

During the 2030-2040 period, EU has been the theatre of war, frequent natural disasters and a prolonged downturn in economic activity. Basic life product costs have risen and scientists have documented a high increase in biodiversity loss. Despite raising awareness about biodiversity issues, the scarcity of food, water access, energy supplies of oil and gas and the large-scale human migrations have brought new kinds of competitions and conflicts with biodiversity. The economic crisis has left little to no funding for EU biodiversity regulations and policies. Climate change adaptation and the maintenance of previous legislation are the main governments' priorities. The marginal implementation of new biodiversity measures is exclusively driven by economic efficiency and green-washing opportunities, with large discrepancies between countries. Some countries may even start to pledge to disentangle the legislation regarding biodiversity protection, arguing that: «There is not enough biodiversity left to spare money and time to protect it». Without proportionate political action, trust in governments' ability to provide lasting solutions has been severely affected, leading to citizens' uprisings and direct actions. Reactionary calls for authoritarian and nationalist measures have led countries to pressingly act in their own regional interests, with a lack of planning, no public consultation and no international cooperation.

In average, lower mobility but greater social and geographical inequalities are the reality.

Even though new and low-carbon emitting technologies have emerged, the high green-energy prices, the frequent outbreaks and epidemics, managed by strict lockdowns, resulted to less mobility. With a large part of the population staying home, the traffic load has decreased up to 50% compared to 2025 levels. Airports and roads have been abandoned and road decommissioning has reached 20% of the European network. Due to a lack of time and planning, this decommissioning has not been followed by restorative actions and the habitats quality for biodiversity may have not improved. Remaining road transportation is slow and mainly used for freight and passengers for short distances under 500 km. Railways and airlines are used for longer routes. In cities and suburban areas, traffic is mainly made of collective modes of public transportation and ecomobility options, which include cycling, scooting and walking. Individual mobility and technologies such as autonomous vehicles or individual air transport are only accessible to the wealthiest people and regions. Rural areas are isolated and do not have access

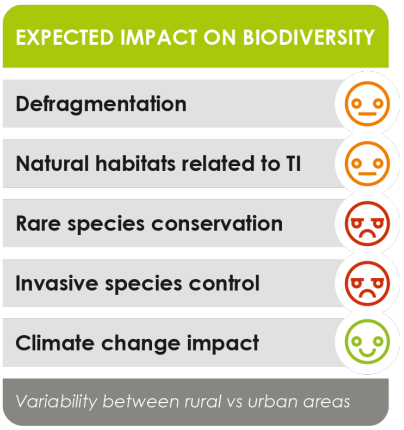
to widespread collective transportation. This situation promotes local production and the decline of freight transportation. For regions with low green-energy prices, higher individual traffic leads to a huge degradation of natural habitats and wildlife mortality.

Failure of biodiversity to influence policies and new transport infrastructures due to lack of data monitoring

During the 2025-2035 decade, even though transport companies invested in Information Technologies solutions for collecting large amounts of data on biodiversity and citizens became large vector of collecting ecological data due to the development of low-cost and easy-to-use digital platforms, the effectiveness of this large amount of data collection is low due to high maintenance costs and the lack of harmonization, data sharing and communication between international agencies. As a result, data was not effectively exploited to inform and influence national and EU policies.

New transport infrastructure projects went in competition to get land access, cumulating with existing ones and no landscape planning. Defragmentation actions are impeded by cumulative infrastructures, renewable energy plants and urban densification. Moreover, anthropogenic pollution and cocktail effects became a devastating environmental and health problem. Biodiversity were not integrated in the transport industry risk management, leading both terrestrial and marine ecosystems to be highly polluted by transport. Reducing wildlife mortality and disturbance is far from being a priority and roadkill is a main driver affecting wildlife populations. Verges and drainage systems are mostly abandoned, not properly managed or reassigned to renewable energy projects. Their biodiversity conservation role as shelters and ecological corridors for connectivity has shifted to serve other goals.

All vegetation may be cut off to prevent fire or inhabited by invasive alien species, which has a negative impact on surrounding ecosystems. Invasive alien species assessments and control may only focus on species that have high economic consequences. Offset banking may be widely implemented because of its economic efficiency but without conclusive ecological benefits. As no real adaptation measures have been undertaken, the lack of water has led to more frequent floods and drought, damaging the transport infrastructures and worsening national and international emergency response, logistics and capacity.



In 2050, Biodiversity loss has been drastic in urban and suburban areas. Rural areas are split in extremely intensive areas with low biodiversity levels and extensive farming where biodiversity stays at the 2000's levels. Endangered species extinction path has increased during the period.

Weak signal: In 2050, biodiversity starts to recover from abandoned TI & depopulated rural areas

During the 2025-2050 period, TI sector has contributed to isolate wildlife populations and to deteriorate the habitats quality. By 2050, the economic shutdowns, the less or slower mobility especially in rural areas and the frequent natural disasters makes it possible to get more and more TI that are abandoned because of a maintenance price that is too expensive. These decommissioned TI can be expected to be beneficial as pioneer habitats. Biodiversity may start to recover in some areas particularly depopulated by this process.

Source: ageheureux.centerblog.net

3.3.2. Scenario 2 : Sustainability remains wishful thinking

Abstract:

This scenario follows the business as usual trends. *Even though biodiversity issues took more and more importance within the European populations, EU failed to implement really ambitious policies in terms of biodiversity restoration. During the period, freight found digital solutions to support its multimodal shift with some advantages in terms of lowering carbon emissions, but this trend does not apply for personal mobility, which remains similar to the 2020's situation. In the TI sector, this situation results in partial integration of biodiversity in the practices (focusing only on the design phase, data is collected but poorly exploited for improving biodiversity management, biodiversity is sometimes in competition with grey solutions or Renewable energy solutions, private funding exist but is limited). Anthropogenic pollutions have increased in 2045 causing environmental and health problems.*

In 2050, EU conducts business as usual.

EU fails to disseminate its ambitions to face private and public inaction.

During the 2020's, citizens' awareness of biodiversity raised slowly and has been partially included into policies and actions. EU directives have been modified to include ambitions of biodiversity protection such as mitigation measures or better control of invasive alien species. However, economic pressure due to climate change and reliance on foreign investments has led some countries to overrule these environmental regulations, motivated by their own regional interests. EU fails to disseminate its ambitions at national level. High discrepancies between countries exists as national implementation lacks budget and control. Corporate interests have supplanted political rule and will towards change. Large corporation investments in biodiversity projects are typically done to avoid legal issues or motivated by green-washing opportunities. Biodiversity concern has mainly become a marketing topic. Companies have created lots of labels and trademarks to stand out from the competition, leading to inaction, confusion and public indifference. Citizen organisations invested in environmental protection have intensified their opposition with large protests and frequent civil disobedience actions.

Steady demand in high-speed and/ or individual transport modes impacts more natural habitats & causes wildlife mortality

Technologies such as autonomous and low-carbon emitting vehicles have increased the mobility demand for passenger and freight transport, without a significant change in people's habits. The dominance of motorways and airlines has increased at the expense of railways. Road networks have increased from 10 to 20%, but the lack of planning, coordination and harmonisation between countries have led to contradicting landscape uses and risk management. In cities and suburban areas, traffic is mainly made of individual modes of transportation which include carpooling, cycling and scooting. Individual air transport has been developed but is only accessible to the wealthiest people and regions. The intensification of individual car traffic in rural areas has led to an important degradation of natural habitats and wildlife mortality.

Biodiversity loss mitigation actions are partially developed in some regions and countries

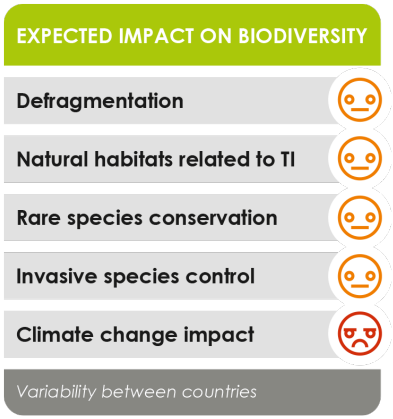
Transport companies have invested in IT solutions for collecting large amounts of data on biodiversity and for monitoring the transport infrastructure needs towards an intelligent transport system. Some programs are dedicated to the development of smartphone applications and people often contribute to data collection. Nevertheless, the lack of harmonisation and data sharing between countries impedes the practical use of the data to inform EU policies. New transport projects have partially included the ecological management of habitats related to infrastructure (HTI). In some countries, defragmentation actions have been in conflict with the growing need for renewable energy plants, urban densification and cumulative infrastructures, while in others, defragmentations actions are widespread and designed hand to hand with actions to enhance the permeability of linear transport infrastructures.

Technical grey solutions are invented to minimise pollutions and climate change disturbances

In the field, anthropogenic pollution and cocktail effects have gradually become a major environmental and health concern, even though technical and design solutions have helped to reduce the transportation effect zones. Biodiversity is partially integrated in the transport infrastructure risk management, primarily during the design and adaptation of new projects. The impact of transport pollution on biodiversity is underestimated and improperly included in cost-benefit analysis. Wildlife mortality is only cared for species that can generate economic losses. Verges and drainage systems are not properly managed, sometimes abandoned or reassigned to renewable energy projects. Their biodiversity conservation role as shelters and ecological corridors for connectivity has shifted to serve other goals. Either all vegetation may be cut off to prevent fire or inhabited by invasive alien species, which has a negative impact on surrounding ecosystems. Large investment programs in climate change adaptation have been developed and constructors have built drainage systems that can resist 100-year floods. These adaptation measures prevent some of the

damage to the transport infrastructure, thus mitigating negative impacts on national and international emergency response, logistics and capacity.

In 2050, biodiversity loss is about 50% in abundance compared to the baseline of 2000 and causes concrete failures in the provision of ecosystem services. As the TI sector is not directly affected by this situation, no real modification of their business as usual is considered and biodiversity remains wishful thinking.



3.3.3. Scenario 3: Decarbonisation & climate change adaptation First

Abstract:
This scenario focuses on solutions for carbon emissions
During the 2020's, thanks to a strong political support, a green energy alternative is found to sustain the current mobility uses at a good price. Individual mobility remains the norm. The EU has the ambition to restore biodiversity but fails to disseminate its goals at national level. New transport infrastructures are developed in a cumulative way and without concrete harmonisation and planning. Public TI funding exists but biodiversity management is not part of the Key Performance Indicators. As a result, the impact of TI on biodiversity increases during the period.

In 2050, EU actions are only focused on climate change.

Decarbonisation is the priority, biodiversity remains a sub-topic of climate-change

During the 2025-2040 period, biodiversity awareness is low and has only occasionally been included in policies and actions. The main focus of recent legislation has been lowering carbon emissions at all costs. EU efforts on biodiversity legislation, harmonised frameworks, and regulations are mainly focused on improving carbon storage and helping the construction of energy or carbon storage facilities. Therefore, simplification of EIA and SEA procedures is voted for these related economic sectors. The marginal implementation of biodiversity measures is exclusively driven by economic efficiency and green-washing opportunities, with large discrepancies between countries. Global biodiversity conservation goals have not been clearly defined and project-by-project mitigation measures are still the norm. Some countries have acted single-handedly, according to their own regional interests, and may even start to pledge to disentangle the legislation regarding biodiversity protection, arguing that: «There is not enough biodiversity left to spare money and time to protect it».

Investment banks have committed early on to sustainable infrastructure funding at a supranational level, defining key performance indicators (KPI) related to carbon emissions. Offset banking may be widely implemented because of its economic efficiency but without conclusive ecological benefits. Large corporation investments are typically made to avoid legal issues and their marketing campaigns for climate change have overshadowed biodiversity concerns. Citizen organisations invested in biodiversity protection struggle to get their message across, as resistance against new projects is seen as slowing down the path towards net-zero carbon emissions.

Low-carbon emitting technologies have boosted the transport demand

In the early 2030s, the emergence of new and low-carbon emitting technologies has essentially solved the mobility restrictions. Due to an EU directive on low-carbon emissions, conventional vehicles powered by combustion engines have been banned and must be replaced by alternative energy and autonomous vehicles. Without mobility restrictions, the demand for freight transport and individual mobility has surged, strengthening the dominance of motorways and airlines at the expense of railways. Road networks have increased up to 30% and the EU spatial development perspective has pushed the option to open newly built infrastructures to private ownership. Individual air transport has been developed and is becoming more commonly available, further increasing the need for new infrastructures. This uncoordinated and fast development has led to large discrepancies between countries, regions, and populations. In cities and suburban areas, mobility as a service and individual modes of transportation, including the multiplication of smaller vehicles and the automation of traffic, have become the norm. Rural areas have yet to replace their car fleet and the implementation of individual air transport and autonomous traffic is uneven and slow.

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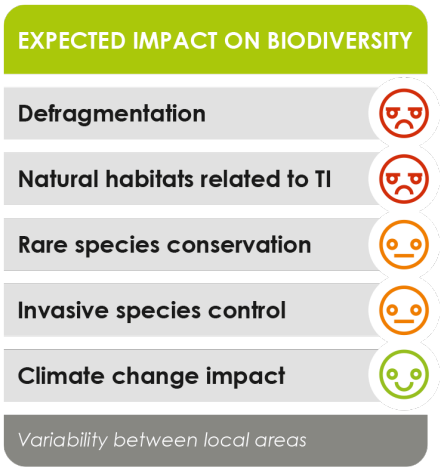
Collecting data on the environment to protect human health and TI assets

Transport companies have invested in IT solutions for collecting large amounts of data along the transport infrastructure life-cycle and towards an intelligent transport system. Citizens are also a large vector of collecting data, due to the development of low-cost and easy-to-use digital platforms. But the effectiveness of this large amount of data collection is low as it has not been primarily focused on monitoring ecological indicators and biodiversity. The lack of harmonisation, data sharing and communication between international agencies also impedes the practical use of data to inform EU policies. New transport projects have not included the ecological management of habitats related to infrastructure (HTI). Defragmentation actions have been in conflict with the growing need for renewable energy plants, land use changes, and new infrastructures. This has led to the extinction of isolated populations and to a high increase in biodiversity loss.

In the field, anthropogenic pollution and cocktail effects are a devastating environmental problem. Biodiversity is not integrated in the transport industry risk management, leading both terrestrial and marine ecosystems to be highly polluted by transport. Even though new designs and technical solutions have been implemented to reduce the individual impact of transportation infrastructures, their surging development has increased the total-effect zones. Wildlife mortality and disturbance have not been made a priority and roadkill is a main driver affecting wildlife populations. Verges have mostly been reassigned to renewable energy projects and no longer serve their biodiversity conservation role as shelters and ecological corridors for connectivity. Large investment programs in climate change adaptation have been developed and constructors have built drainage systems that can resist 100-year floods. These adaptation measures may prevent some of the damage to the transport infrastructure, but have a negative impact on surrounding ecosystems.



In 2050, biodiversity loss is about 50% in abundance compared to the baseline of 2000. Ecosystem provision services are altered by this loss. The detrimental effects of carbon storage actions on the provision of ecosystem services and the water cycle are emerging as the next challenge for the next 50 years.

3.3.4. Scenario 4 : Cross-sectoral changes that tackle all planetary boundaries

Abstract:
This scenario relies on systematic search of solutions for every challenges
In the 2020's, strong political will make cross-sectoral planning and stakeholders cooperation the two main principles of their programs. In terms of regulations, a strong work has been made to harmonise regulations for more cooperation efficiency and cross-sectoral implementation. In the TI sector, the collective transport as a service becomes the norm and TI companies develop cooperative business models in order to facilitate the multimodal shift. Local and circular economy is promoted. Meanwhile, public and private funding are allocated both on new and existing TI and sustain a real-time risk management that anticipates the climate change

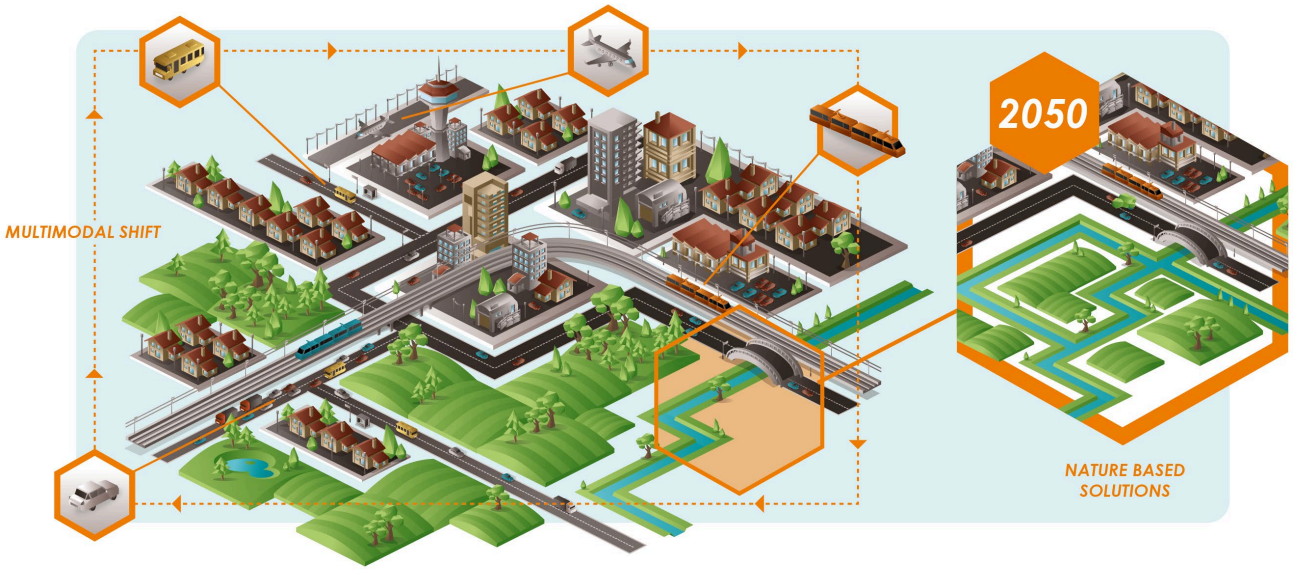
adaptations and the needs of biodiversity protection. Synergies between Nature-Based Solutions and ecological connectivity goals are found in the design and adaptation of the habitat related to infrastructure.

In 2050, EU goes through a transformative change.

Early and strong political actions and cooperation to stay within the planetary boundaries

In the 2025-2030 period, biodiversity awareness campaigns focus on encouraging politicians to pledge for actions. Even though they are not very popular at that time among the population, politicians decide to prioritise biodiversity conservation into policies, which provide mutual benefits for both ecosystems and society (One Health). To minimise biodiversity loss, EU has initiated an extended work focused on long term planning and the harmonisation of national regulations, such as the Environmental Impact Assessment (EIA) and the Strategic Environmental Assessment (SEA). Cooperation between countries has been reinforced and has achieved more transparency and better monitoring, as public participation is now a mandatory part of any program or project. Scenario techniques and visualisations (BIM) for better communication and participation of the public during the construction planning process is broadly used. Civil society organisations and citizens cooperate with governments, stakeholders and corporations to integrate the results of science into the design of the new frameworks. In 2040, biodiversity impacts are now seamlessly included in people's life choices and corporate decisions.

Investment banks have committed early on to sustainable infrastructure funding at a supranational level, defining key performance indicators (KPI) related to biodiversity. A common fund for biodiversity and climate change related to new and existing infrastructure has been in place since the beginning of the 2030s. Companies have followed the trend by becoming more involved in funding biodiversity projects, as it also opens marketing opportunities and circumvents legal issues. The holistic approach for landscape planning is getting more traction. Global biodiversity conservation goals have been set, clearly defined, and no longer allow project-by-project mitigation measures. Sectoral and cross-scale frameworks are implemented by practitioners which help coordinate all actors and sectors, including urbanism, environment, energy and transport. This harmonisation has solved trans-boundary issues, such as the planning of Green-Grey infrastructures.



Mobility as a service thanks to a large cooperation within TI companies

Mobility as a service, collective transportation and Eco mobility options, including car sharing, carpooling, biking, scooting, and walking, have become the norm. These options may have been pushed by the opening of newly built infrastructures to private ownership or strong political will. Multimodal transportation has led to fewer vehicles, especially in urban areas. Road decommissioning has been planned to reach 20% of the European network. The EU spatial development perspective has been reinforced early on in order to achieve this reorganisation in all countries. Due to an EU directive, high-speed railways are the only collective mean of long-distance transportation. Railway networks have been considerably redesigned to accommodate effective low-speed local transport and high-speed transnational transport. Airlines are only allowed for transcontinental travel. Railways, airlines and other transport companies have all merged into global multimodal companies. This cooperation between transport modes has been found to be the most sustainable and cheapest transport solution. By combining the benefits of the physical internet that reduces the volume and distance of national freight transport and the development of local circular economy, regional manufacturing has become economically attractive. Rural areas are fully integrated into the collective transport network and benefit from the emergence of low-carbon emitting technologies.

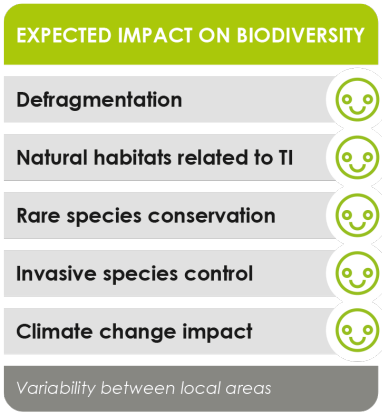
Anticipation and real-time TI management thanks to digital twins

Transport companies have each invested their best in complementary technologies in order to collect data across all media, including remote sensing, sound monitoring, and AI recognition. Harmonisation and improved access to these data have been implemented in order to develop a global, land and water, monitoring network. IT solutions are well spread within the operators and standardised systems make it possible to exchange data on biodiversity and ecosystem connectivity on a real-time basis. Such data systems may be used to inform decision makers and EU policies. As ecological connectivity is fully

integrated in EIA and SEA policies with appropriate indicators, habitats related to infrastructure (HTI) are designed and managed in order to support both mitigation measures and nature-based solutions.

Nature-Based solutions are widespread for their co-benefice in maintenance cost and biodiversity protection

In the field, anthropogenic pollution has been considerably reduced by new transport infrastructure designs and technical and traffic solutions, which have also made possible to reach the «no mortality» objective on biodiversity. Early extreme weather events have triggered the need for anticipatory measures and for the development and implementation of multi-use analysis. Because of the frequency of these events, the path of analysis is almost on a real-time basis and biodiversity is fully integrated in the transport infrastructure risk management. Infrastructure management is locally adapted to the local conditions, surrounding landscapes, traffic intensity, and biodiversity needs. Verges can be temporarily flooded to create attractive habitats for amphibians. Most of the invasive alien species have been controlled and native species have been protected against them. Thanks to the shift from Grey solutions, related to the construction of technical infrastructures, to nature-based solutions, which includes broader development and support of ecosystem services, the development of new drainage infrastructures is no longer needed. The implementation of nature-based solutions has resulted in fewer droughts and floods, through the decommissioning of waterproof structures. Increases in biodiversity diversity and abundance have been documented.



In 2050, the TI sector has reached its “biodiversity net gain” objective within steady maintenance costs and improved resilience indicators to climate change adaptation. Biodiversity has started to recover and its abundance is now similar to the baseline of 2000.

4. DRIVERS HYPOTHESIS UNDER THE 4 SCENARIOS

The table on the next page provides the list of the hypothesis used to construct the four scenarios by the expert panel. This synthetic presentation enables the direct comparison of the 4 scenarios and highlights the convergences between scenarios.

It appears that the scenarios 2 -“Sustainability remains wishful thinking” and 3 -“Decarbonisation & climate change adaptation First” are found to be very similar for many thematic dimensions except for funding and spatial organisation of networks. Even though the outcomes in terms of transport demand and TI are quite different, their impact on biodiversity was close. The expert panel wanted to explore the fact that decarbonisation and biodiversity loss can be dissociated in such a way that one challenge can be solved while the other is worsened.

Table 3: Details of the hypothesis selected to build the 4 prospective scenarios

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 101006661

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
European transport & biodiversity policies & regulations	Biodiversity regulations and policies implementation are mainly driven by economic efficiency and differ considerably between countries. Only on species that have economic impacts, some countries start to pledge for disentangling the legislation regarding biodiversity protection: «There is not enough biodiversity left to spare money and time to protect it.»	More ambitious EU Directives & policies but differences of implementation among EU countries (lacks budgets and controls).	More ambitious EU Directives & policies but differences of implementation among EU countries (lacks budgets and controls).	EU countries engaged an extended work in terms of harmonisation of their national regulation (EIA and SEA) and their implementation. More transparency (public participation and monitoring of their efficiency) Cross-scale (tiering) and sectorial frameworks (transport, urbanism, environment, energy, etc.) Cooperation between countries
Climate change & adaptation	No environmental management that causes problematic situation in surrounding areas (invasive species etc.) Lack of water leads to more severe degradations of TI (frequent droughts or floods) provoking many political conflicts (massive people migration). Basic life products cost explodes.	Degradation of verges & drainage system as connectivity & refugee provider role Vegetation is cut to prevent fire risks. Major part of the road verges converted for renewable energy (with solar panels for instance). Investment in drainage systems that can resist to 100-year flood	Degradation of verges & drainage system as connectivity & refugee provider role Vegetation is cut to prevent fire risks. Major part of the road verges converted for renewable energy (with solar panels for instance). Investment in drainage systems that can resist to 100-year flood	Management is locally adapted to the local conditions (traffic, surrounded landscape, etc.). shift from grey solutions (construction of the technical infrastructure...) to nature-based solutions These Nature-based solutions achieve less drought, floods (e.g. end of the drainage system) & Desartificialisation (dealing of the soil).

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
TI induced pressures on biodiversity	Terrestrial & marine ecosystems highly polluted by transport. Anthropogenic pollutions are a major environmental & health problem (cocktail effect) Reducing wildlife mortality & disturbance is no more a priority.	TI risk management mainly worked during the design & adaptation of TI. Wildlife mortality not a real concern except for species that can generate economic losses. Impact of pollutions on underestimated. Anthropogenic pollutions are a major environmental & health problem (cocktail effect)	TI risk management mainly worked during the design & adaptation of TI. Wildlife mortality not a real concern except for species that can generate economic losses. Impact of pollutions on underestimated. Anthropogenic pollutions are a major environmental & health problem (cocktail effect)	Extreme weather events trigger the need for the development and implementation of multi-use analysis. Real-time basis, and biodiversity fully integrated into the TI risk management. New TI design, and/or technical solutions and/or traffic solutions have succeeded in reaching the «no mortality» objective on biodiversity and to considerably reduce anthropogenic pollutions.
Intelligent transport system	Large amount of data collected by citizens (citizen science) The effectiveness of data sharing is low due to a lack of inter communication between these data systems. These data not exploited to influence national & EU policies.	Large amount of data collected by environment & transport stakeholders Data systems are heterogeneous among EU countries. Lack of harmonisation and data sharing impedes their exploitation for informing EU policies.	Large amount of data collected by environment & transport stakeholders Data systems are heterogeneous among EU countries. Lack of harmonisation and data sharing impede their exploitation for informing EU policies.	Harmonisation and improved access to data in order to develop a global & multi-topic (water, sound, etc.) earth monitoring network based on different technologies (remote sensing, etc.). TI companies invest on these technologies and data systems. Standardised systems make it possible to exchange data of biodiversity & eco-connectivity, on a real-time basis. They are usable by the decision makers.

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
Right of way	Surfaces of HTI have been reduced a lot. Defragmentation actions are in conflicts with other issues such as renewable-energy production, urban densification Ecological Connectivity is still decreasing	The ecological management of HTI is partially efficient and differs between EU countries. Defragmentation actions are in conflicts with other issues such as renewable-energy production, urban densification & cumulative infrastructure.	The ecological management of HTI is partially efficient and differs between EU countries. Defragmentation strategies applied in 75% of the European countries. Actions will be undertaken to enhance permeability of linear TI will be applied	**E**cological connectivity fully integrated in SEA and EIA HTI are designed & managed in order to provide 1) habitats and traps to relevant species combined to support mitigation measure, 2) Nature-based solution ensuring benefits for ecological connectivity
Funding	Lack of money/maintenance becomes the main factor to fund Climate change adaptation is the priority, and there is no more funding of biodiversity measures.	Limited Private Funding through Social and environmental responsibility The funding differs considerably between regions and/or countries.	Supranational investment banks defined Key Project Indicators related to climate change.	Private Funding through Social and environmental responsibility + Supranational investment banks defined Key Project Indicators related to biodiversity. A common fund of biodiversity and climate change for new and existing infrastructure became effective in the beginning of the 2030s
Spatial organisation of networks	Extreme shift to lower mobility. Epidemics or other events have made populations to stay home A decrease of 20 % of the European network because of the decommissioning of roads & airports	Digitalisation of the supply chain and shared autonomous vehicles enhance the freight effectiveness. Digitalisation solved trans-boundary issues.	No significant change or shift in transport of goods and passengers The dominance of roads and air increased at the expense of rail.	Mobility as a service is the norm. Cooperation within transport modes has been found the main solution to eco-friendly and cheap transport solutions. Railway networks developed especially for local and rural transport

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
	No time / resources to plan landscape anymore.	Transport networks (except electricity) stay mainly unchanged in 2045. Weak harmonisation in the planning process between countries	+ 20% of Road networks in European countries during in 2045 Insufficient coordination of the landscape planning at EU level results in contradiction between landscape uses & risk management.	(low speed) and transnational transport (high speed). - 20 % of the European road network. Holistic approach of the landscape planning & harmonisation of the planning systems among EU member states.
Uses	Traffic load has decreased by 50% compared to 2025 level because of the increase of energy costs Collective & alternative mobility options are the norm only in Cities. Rural areas are depopulated and suffer from outdated & exhausted mobility means. This situation has promoted the local production and the reduction of freight transportation.	Collective & alternative mobility options are the norm only in Cities. Because of the energy price, rural areas shift to less mobility. Individual mobility is actually possible for the richer persons & regions. (ex. Individual air transport)	Thanks to the emergence of climate-friendly solutions, people use alternative energy sources -> Higher traffic loads. Road transports for freight and persons are the main transport mode for distances <500 km. Rail and air transport are mainly used for longer distances. In cities and suburban areas, rail & bikes (equivalent) tend to be the main transport of goods and persons for distances < à 50 km. Higher individual car traffic, a huge degradation of natural habitats and wildlife mortality.	Collective & alternative mobility options (e.g. carpooling, public transportation) are the norm (this change may be promoted by private ownership of new built infrastructure). Fewer vehicles especially in urban areas. High-speed rail is the only collective long-distance mode in Europe for persons. Air transport is only permitted for transcontinental travels.
Political, social & societal perception	Under the massive migrations of human populations, the scarcity of petrol and despite more achieved level of awareness of biodiversity issues, new kind of competition and conflicts with biodiversity have	Biodiversity awareness was only partially included in policy and actions staying in the same trajectory with differentiation among EU countries. But in 2030, economic pressure (climate change) softens both	Biodiversity awareness was only partially included in policy and actions staying in the same trajectory with differentiation among EU countries. But in 2030, economic pressure (climate change) softens both	Since 2025, awareness has been growing up and affecting people and decisions. Biodiversity needs are effectively included in policies mainstreaming biodiversity in transport development. The virtuous

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
	emerged (food & energy supply). People were worried by their quality of life (day-to-day product shortages became more frequent in 2030) and left their governments more freedom to act towards more nationalism & less public consultation : stronger boarders, promoting regional products, etc.	environmental regulations and public interest in biodiversity. Political rule has been replaced by corporate interests. A part of the population that wants to keep environmental protection as a priority reinforced their opposition with protestations. Biodiversity concerns become a marketing issue. Companies will try to differentiate themselves and more and more labels will be created. Multiplication of labels leads to unpreparedness, green washing, and lack of coordination and saturation of people.	environmental regulations and public interest in biodiversity. Political rule has been replaced by corporate interests. A part of the population that wants to keep environmental protection as a priority reinforced their opposition with protestations. Biodiversity concerns become a marketing issue. Companies will try to differentiate themselves and more and more labels will be created. Multiplication of labels leads to unpreparedness, green washing, and lack of coordination and saturation of people.	cycle is found in public consultation processes: a better communication and participation of the public during the planning process is broadly used. For instance, by combining the advantages of the physical internet that reduces the volume and klms of inland freight transport and the development of local and regional cycle economy that promotes the reuse of resources, regional products become economically performant. As a result, the transport demand decreased. Labels are not emerging because of EU, national frameworks whose biodiversity protection goals and public awareness are sufficient for TI sector.

5. Stakeholders evaluation of the 4 future scenarios

5.1. Desirable features of the 4 scenarios

The top 5 desirable features of the majority of the scenarios are the following.

- Environmental pollution and climate change
- Society engagement
- Transport Infrastructures and mobility
- Society well-being & other economic sectors
- Biodiversity

The table below provides in detail how each desirable feature is described by the TI & ecology sectors professionals each one of the 4 scenarios.

Table 4: Desirable features of the 4 prospective scenarios formulated by the BISON panel of TI and ecology experts

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
Environmental pollution and climate change	The drastic reduction of mobility There are less CO2 emissions There is a drastic reduction in energy and resource consumption		Carbon emissions are slowing down, (climate change mitigation) By acting for climate change we change our energy system.	There is a holistic approach to tackle pollution issues
Society engagement	The call for action will be easier once we touch the bottom. It is easier to mobilise people to survive and act.	Strong recommendations of EU.	It's a first step toward change (scenario 4)	The involvement of the financial sector, for both climate change and biodiversity. There is strong political will at the top level. Cooperation is supported new

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
				technologies and data systems.
Transport Infrastructures and mobility	Less infrastructure development. The maintenance of green infrastructures is lower	Freight support multimodal shift. Alternative mobility options in cities.		Sobriety (-20% of the network, fewer vehicles), public participation is increased, real time monitoring
Society well-being & other economic sectors	Rethink our way of life, work at home. Local economies (agriculture, health, services, etc.).	Less trucks on the road means less accidents and a better quality of individual travels.	I am free to do what I want I want it (self-centred interests). There are fewer restrictions in goods access and energy.	Better well-being because of less air pollution (less traffic) and more biodiversity (green energy).
Biodiversity	Less impacts on wildlife caused by lowered traffic Better wildlife connectivity Biodiversity will come by itself and we do not have to manage it (spontaneous).	Renewable energies on verges are better to reduce animal collisions. Data collection on biodiversity. Biodiversity is taken into account in the design phase.	Reducing carbon emissions is part of the wider impact of TI on biodiversity, even if we did not address directs impacts on biodiversity	There is more biodiversity, There are more interactions with other species and better well-being because of less air pollution (less traffic) and more biodiversity (green energy). Assessing and actions for biodiversity and some level of attention towards green energy.
Conclusions	Local economy & the reduced daily mobility is the main features that found desirable in this scenario.	The role of EU as a key player for mainstreaming biodiversity into TI sector through legislation is stressed in this scenario. The trend to get a better integration of biodiversity in	The scenario 3 highlights that reducing climate change is still beneficial for biodiversity. It is a first step towards the scenario 4. The participants think that people can be proactive	The scenario 4 emphasises that planning and cooperation are strong drivers for an efficient sobriety in terms of the use per capita of the natural resources (in mobility, in TI design and

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
		the design of TI is reaffirmed by the participants.	to get a future that assure freedom of actions (instead of scenario 1).	maintenance, in the landscape management, etc.) It also points out them as main drivers for effective biodiversity protection. The participants highlight the necessity of a top-down process with first political decisions & specific funding. Public is involved in the decision-making through science-based indicators.

5.2. Undesirable features of the 4 scenarios

This table provides the details the undesirable features described by the TI & ecology sectors professionals for the 4 scenarios.

Table 5: Undesirable features of the 4 prospective scenarios formulated by the BISON panel of TI and ecology experts

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
Environmental pollution and climate change	The increased vulnerability of cities to extreme climatic events (e.g. worse emergency response in case of famine).	The increase in pollutions leading to heath problem. Acting and planning have failed to overcome the growing pressure from economy and population (implementation fails).	Individual mobility means that more space is needed for less people.	
Society engagement	The social protests due to the lack of public transportation. The social discontent due to the lack of anticipation: "I told you so".	Developing renewable energy without taking biodiversity into account (it becomes less important than CO2 emissions). The failure of EU to implement real ambitions in terms of biodiversity protection.	It's the reign of the economic and corporate interests. International collaboration is strong and could be used for biodiversity. The ability to adapt to climate change makes people look away from biodiversity degradation. There is planning and no cooperation between infrastructures	Common funding for climate change and biodiversity is a risk (allocating all the budget for climate change). Such decision will take time, because of the public participation and the monitoring of their efficiency.
Transport Infrastructures and mobility			There is no significant change in transport of goods and passengers.	It's a utopia to have both enough automated cars and a perfect train/railway network.
Society well-being & other economic sectors	Some goods and services are less accessible and more expensive due to the lack of freight and transportation. The lack of access to some heath	The increase in efficiency will probably lead to increases in absolute impact even if impact per unit of goods is less (profit driven logic – rebound effect).	The quality of human life will decline due to the decrease in ecosystem services and functions. There is no change in people's behaviours, no awareness about	I cannot be individualist (self-centred). Are all social differences included in this scenario? (Ex: nurse who has to go to different

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
	goods, medications and exotic food. The loss of freedom due to more constraint. The rise of violence and possibility of wars. The loss of resilience of urban life, which is dependent on the transportation of passenger, food and resources. We will be more vulnerable.	Passenger and individual mobility remains the same.	nature's contribution to our quality of life. There is no insight. If we find a new energy we will not change our behaviours.	homes for sick and old people). The loss of individual thermal cars some people like to drive. Many will be reluctant to change. There is an initial process of pain getting over change (e.g. the loss of personal cars).
Biodiversity		The lack of cooperation in international initiatives (counter-productive, sometimes conflicting) may lead to conflicts between climate change adaptation and mitigation measures and biodiversity	In such a world, there is no biodiversity protection without biodiversity monetarisation There is more habitat fragmentation Cumulative impacts are not taken into account	
Conclusions	This scenario is not judged utopic by participants who unsurprisingly fear the vulnerability of populations and the risk of not fulfilling basic needs.	The lack of sobriety in mobility and natural resources (land conversion) is pointed out. The lack of international cooperation is also problematic. The participants correlate biodiversity protection with a deep change of behaviours towards collective mobility.	The lack of sobriety in mobility and natural resources (land conversion) is pointed out. The lack of international cooperation is also problematic. The participants correlate biodiversity protection with a deep change of behaviours towards collective mobility &	The resistance to change is a main sticking point. As a result, strong political willingness is compulsory. Features of this scenario appear utopic to some participants as it is supported by radical changes in mobility, in society, etc.

	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
			sustainable business models.	

5.3. Paths to actions

This table provides the paths to actions described by the TI & ecology sectors professionals for the 4 scenarios.

Table 6: Paths to actions formulated by the BISON panel of TI and ecology experts

Type of stakeholder	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
Administration, Policy makers	I can encourage home office, so that the rural areas don't get depopulated. I can support the development of local markets and businesses to reduce the need for transport.	I can look for and promote solutions from projects like BISON. I can involve researchers and other experts in decision finding.	I can engage stakeholders at the national level. I can ensure funding dedicated to biodiversity. I can raise awareness for the need of more holistic change and realise that with individual transportation, we may have addressed carbon emissions, but our comfort means that extensive road and car use still threatens biodiversity. i can get citizens and local community involved. We could have created "biodiversity services" obligations with awareness program and actions for the country. Regional administrations and	I can make sure that social equity is respected. I can find new challenges and channel people's fears towards new positive goals. I would ensure that regions and local people can adapt at their level.

Type of stakeholder	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
			stakeholders must come up with a masterplan for defragmentation.	
NGO		I can spread visions about a sustainable future.	I can raise awareness. i can get citizens and local community involved. I can produce visions to the general public and change behaviours.	I can find new challenges and channel people's fears towards new positive goals.
Consultant		I can promote good practices, transfer knowledge from research to operators (about TI and biodiversity).	I can try to make biodiversity as important of a fight as climate change for companies and public institutions.	
TI operator		Use developments in information and data availability currently used to improve efficiency of business and freight, to improve biodiversity monitoring,mitigation and avoidance instead. I can integrate biodiversity preservation in all steps (including maintenance). I can increase the corridor role of linear infrastructure. As a railway operator, I can double the number of people in trains and fight against individual mobility by car. As a company, I can try to develop cooperative projects (label, innovation, for biodiversity, data collection).		I can propose different mobilities (light vehicle sharing rail or road infrastructure, shared vehicle demand...)
Researcher	I can use data collected by citizen instead of collecting my own (after data quality check).	I can work more with applied science and operators.	I can strengthen the importance of biodiversity and ecosystem services and improve their understanding.	Research can be more efficient for the solutions i can help to educate people in

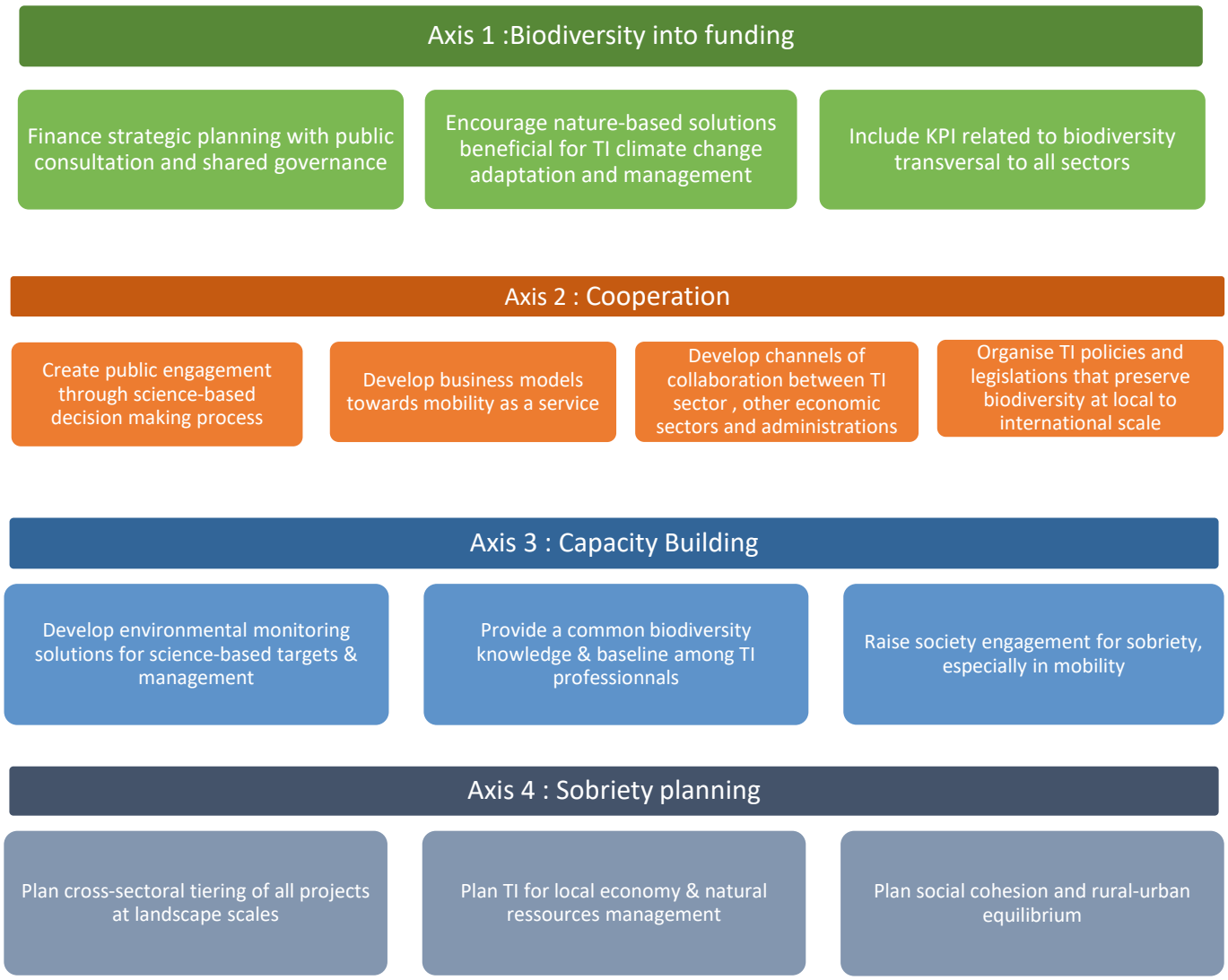
Type of stakeholder	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
	I can find new innovations and solutions that may emerge from the disastrous conditions.	I can work towards more implementation and operability.	Researchers need to provide scientific evidence of the importance of biodiversity for human well-being.	other countries outside Europe.
Other actors	I can raise awareness among peers, friends and family to change their mobility patterns and reduce the anthropic stress on transport infrastructure until we have a better maintenance strategy. I can raise awareness of the effects of global changes through education programs. As a cyclist, I can help my friends, neighbours, to learn tricks to drive safely by bike, help them repair their bikes and not feel isolated from the world. For older people, I can promote electric biking, explain how it works, safety measures and precautions. I can promote local productions in agriculture and energy. I can develop rules for distributing land and resources (rationing?). I can use and promote collective transportation, instead of individual transportation. I can	I can keep doing what we are doing in 2022 for biodiversity, keep fighting and hoping for the best. Through education, I can contribute to system-level change to change the root cause behaviours. As a citizen I can use my bike and choose better modes of transportation.	We need to rely on sobriety in order to reduce energy demands and the number of power plants infrastructures Citizen must demand mandatory rules, from EU level to local level, to invest in biodiversity conservation.	Educate the general public about the advantages of collective transportation At school, we can study the « world before » not to do the same errors. As an individual, I can raise awareness about biodiversity and nature's contributions to people, amongst friends, peers and family.

Type of stakeholder	Scenario 1 Transport System collapse	Scenario 2 Sustainability remains a wishful thinking	Scenario 3 Climate change adaptation	Scenario 4 Cross-sectoral changes that tackle all planetary boundaries
	minimise waste from any source to remove problems with waste disposal and optimise the use of available resources.			

6. EMERGING STRATEGIC DIRECTIONS FROM THE PROSPECTIVE SCENARIOS

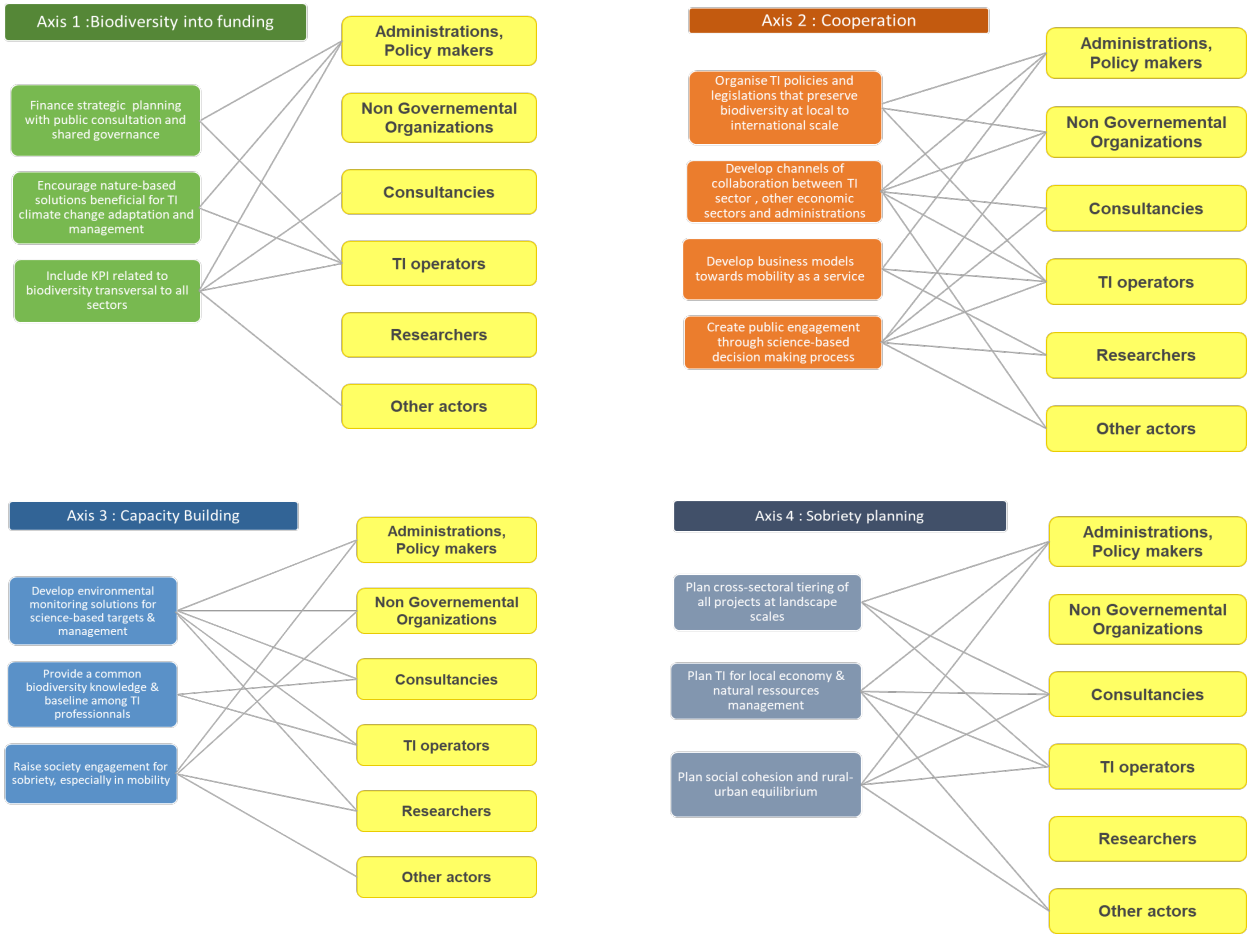
A result of the study of these 4 scenarios, it appears that mainstreaming biodiversity into transport infrastructures involves **transversality & inclusion** of a large set of actors (from TI actors to society), of human activities (mobility & productions). The scenarios have also highlighted the need of **multi-scale coordination & anticipation** (local to international, short and long term). Four axis of strategic directions emerge from the analysis of these scenarios: funding, cooperation, capacity building & sobriety planning.

Figure 5: Strategic directions informed by the prospective scenarios



Even though, TI sector is considered a strong player in building a desirable future, **the paths to actions rely on a large set of actors**. The first axis "biodiversity funding" mainly focuses on administrations, policy makers, and TI operators to influence private and public funding. The second axis "cooperation" needs the involvement of all actors. The same is true for the third the axis "capacity building". Especially, NGO and researchers are identified for the development of environmental monitoring solutions and the rise of society engagement. The fourth axis "sobriety planning" is more a top-down process where NGO and researchers could be indirectly involved as external reviewers. Consultancy firms could play the role of intermediary for knowledge, collaboration, monitoring solutions implementation and planning. Administrations and policy makers are expected to drive the path to actions.

Figure 6: Actors that can directly influence the paths to actions



7. CONCLUSIONS

In conclusion, the BISON project has successfully developed plausible scenarios for the future, focusing on the intersection of climate change, biodiversity, and transport. Through a participatory approach involving various stakeholders, the project identified key variables and formulated hypotheses that shaped the scenarios. The Prospective process through Scenarios methodology was employed to systematically explore and analyse factors, trends, and uncertainties, resulting in the creation of mini scenarios that served as building blocks for the final prospect scenarios.

These prospect scenarios were validated by external experts, ensuring their robustness and validity. They provide valuable insights into potential future developments in the relevant domains. By incorporating stakeholder perspectives and expert knowledge, the scenarios are grounded in real-world considerations and can serve as effective tools for strategic thinking, planning, and decision-making.

The formulated scenarios have not only contributed to the project's research activities but also provided a foundation for the Strategic Research and Development Agenda (SRDA). They guide and structure the research efforts within the project, enabling a targeted and focused approach to address the challenges and opportunities identified in the areas of climate change, biodiversity, and transport.

Overall, the process of scenario development conducted by the BISON project has paved the way for effective research planning and decision-making. The scenarios offer a roadmap for addressing complex issues and preparing for the future by considering emerging trends and uncertainties. By integrating biodiversity issues and considering the stakeholders' needs and requirements, the project has made significant contributions to the field of transport and its relationship with climate change and biodiversity.

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