MERLIN

Navigation Sectoral Strategy: Greening the European inland waterway network by mainstreaming Nature-based Solutions

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MERLIN

Imprint

The MERLIN project (https://project-merlin.eu) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036337.

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Due date of deliverable: 31 January 2025

Actual submission date: 25 February 2025

To be cited as: Buijse, T., A, Kosters, T. Gruber, A. Bérczi-Siket, E. Fuchs, M. Gerisch, K. Blackstock, R. Tögel (2025) MERLIN deliverable 4.5 navigation sectoral strategy: Greening the European inland waterway network by mainstreaming Nature-based Solutions. 52 p.

Acknowledgements: The basis for this strategy has been laid during the three MERLIN round tables in 2022, 2023 and 2024. We thank the colleagues and stakeholders who actively took part in these online meetings. The draft strategy has been sent out for feedback. We would like to thank the following people and organisations for taking the time to read and comment: Francisco-de-Asis Sanchez-Crespo (DG ENV), Theresia Hacksteiner (Inland Water Transport), Dejan Trifunovic (Danube Commission), Karin de Schepper (Inland Navigation), Duško Isaković (International Sava River Basin Commission), Guus Meijer (Rijkswaterstaat), Savu Codruta (WWF Romania), Tibor Erös (Balaton Limnological Research Institute), Rolien van der Mark (Deltares), Eva Hernandez Herrero (WWF-CEE), Iris Kempter (viadonau), Gert-Jan Muilerman (viadonau). We hope they are satisfied with the way these sometimes conflicting comments were handled.

MERLIN Key messages

1. The EU Green Deal ambitions for the inland waterways sector focus on multiple issues, including the shift of transport to inland waterways, zero-emission, digitalisation, employment, financing the transition and governance. The Strategy aligns with the NAIADES III Action Plan by exploring Nature-based Solutions (NbS) for greener waterways.
2. Sustainable transport and biodiversity conservation must be harmonised through a balanced, pragmatic approach.
3. The Trans-European Transport Network policy and the EU Water Framework Directive offer space to balance different – and possibly opposing – interests through exemptions in the requirements for Good Navigation Status and Good Ecological Potential.
4. Variations in inland water transport intensity require careful trade-offs between navigation and ecosystem conservation.
5. Studies suggest reducing engineering structures does not hinder navigation, supporting more nature-friendly river engineering.
6. Climate change will bring extreme discharge conditions, requiring adaptable vessel, logistics, and waterway designs that benefit both nature and navigation.
7. Greater awareness and expertise on NbS in navigable waterways are needed to overcome knowledge gaps and misconceptions.
8. High level policy and management ambitions need to be linked to on-the-ground experiences to build confidence and mainstream the application of NbS in inland waterways.
9. Pilot projects have shown that NbS can reduce environmental impact while maintaining navigability. The total length of these projects together is only a very small fraction of Europe's 41,000 km long network of inland waterways, but they offer inspiration for upscaling.
10. Both, public and private stakeholders can contribute to greener navigation. National waterway management and navigation authorities should take the lead in implementing NbS, ensuring early and continuous stakeholder participation to avoid unnecessary conflicts.
11. It is not yet known if NbS can reduce the need for inland waterway maintenance and thus become a cost reduction for waterway management, and this process is likely to be highly context dependent. There is the need to collect and analyse maintenance and cost information, both for existing and upcoming pilots.
12. Funding for current NbS pilots in inland waterways has so far come mainly from public sources. A joint effort from both public and private sectors is essential for long-term ecological improvements and safe navigation.

MERLIN Executive Summary

MERLIN's focus is on mainstreaming freshwater restoration through Nature-based Solutions (NbS), aiming to address the needs of nature, society, and the economy. The goal of this Strategy is to serve the European Union's Green Deal ambitions to both promote environmentally friendly inland navigation and improve the ecological functioning and biodiversity of inland waterways. To reach these ambitions, this Strategy advocates for the exploration and implementation of NbS. The Strategy is relevant for all stakeholders in the inland Navigation Sector as well as the environmental sector, both public and private and both on high policy levels and on the ground.

Inland waterways play an important role in the transport of goods in Europe. Around 41,000 kilometers of waterways connect hundreds of cities and industrial regions. Making European rivers suitable for inland water transport has required enormous modifications with critical ecological consequences. Freshwater habitats and species are under severe threat, with significant losses occurring over the past 50–60 years. Climate change is expected to create more extreme discharge conditions affecting both the navigability and the ecological status of inland waterways.

To transition inland waterway transport the EU Action plan NAIADES III, aimed at future-proofing European inland waterway transport, cites the importance of **greening inland waterway infrastructure and ports** stating: ***"An integrated approach is [...] essential when considering future inland waterway transport infrastructure developments, taking into account transport needs but also environmental and societal concerns, as well as the multiple functions of waterways and ports in terms of regional economic development, water supply, energy generation and biodiversity."*** (EC 2021) NbS can be an excellent means to realise such an integrated approach, but experiences with their use in inland waterways are still in an early phase. This Strategy specifically emphasises the potential to mainstream NbS based on pilot experiences in several EU countries for greening European inland waterways.

This Strategy has been developed through three online round tables in 2022, 2023 and 2024. In total 16 organisations participated, of which eight were external organisations, and eight partners in the MERLIN project. In addition to the round tables, websites and literature about environmentally-friendly initiatives for inland waterways and the application of NbS in inland waterways were consulted. The collected information is compiled in an overview of top-down perspectives on environmentally-friendly waterways, and of bottom-up initiatives for integrated river management and projects with NbS in large navigable rivers. Together, the three round tables and this literature review helped to focus the proposed MERLIN strategy for mainstreaming NbS in the inland waterway network and to propose a set of actions.

The Navigation Sector is complex and comprises a diverse group of both public and private bodies and stakeholders. At the international level there are umbrella organisations which represent their constituents. Here policy development, experience sharing and awareness raising are key components. It is the national level where concrete activities take place. Decisions are taken aat this level on how to engineer, maintain and use waterways. This is the scale where NbS are implemented by waterway management and navigation authorities, protected area managers or other organisations and where the consequences are experienced by those navigating their ships or using the land adjacent to the rivers.

MERLIN's vision with regard to the Navigation Sector is to mainstream the implementation of NbS in inland waterways by developing an action plan at the EU level, and facilitating implementation of this plan by allowing stakeholders to build on each other's knowledge and experiences.

The EU Green Deal ambitions for the inland waterway sector focus on multiple issues, including the shift of transport to inland waterways, zero-emission, digitalisation, employment, financing the transition and governance. This Strategy addresses these ambitions by focusing on the opportunities to apply NbS with the purpose of greening inland waterways.

This Strategy proposes a set of five actions (A–E) that are needed for greening the European inland waterway network by mainstreaming NbS:

A. **Develop an action plan for greening inland waterways** to facilitate the application of NbS in inland waterways on a much larger scale, and to provide the necessary regulatory basis.

B. **Build confidence by installing Communities of Practice** that facilitate collaboration and the sharing of knowledge and experiences.

C. **Share experiences with NbS in inland waterways** to create a common understanding of the problems and the way forward.

D. **Minimise engineering of inland waterways** by promoting an integrated approach.

E. **Prioritise inland waterways based on their ecological status and role for navigation,** so that management measures contribute to a shared vision that balances reliable and sustainable inland water transport and well-functioning ecosystems.

Content

The MERLIN project (https://project-merlin.eu) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036337.

Abbreviations and acronyms

- BfG - Federal Institute of Hydrology (Germany)
- DC - Danube Commission
- CCNR - Central Commission for the Navigation of the Rhine
- CoP Community of Practice
- EBA - European Boating association
- FCS Favourable Conservation Status
- GEP Good Ecological Potential
- GNS Good Navigation Status
- HD Habitats Directive
- ICM - International Meuse Commission
- ICPDR - International Commission for Protection of the Danube River
- ICPER - International Commission for Protection of the Elbe River
- ICPR - International Commission for Protection of the Rhine
- INE - Inland Navigation Europe
- IWT Inland Water Transport
- METEET Mixed Environment Transport External Expert Team
- MERLIN - Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: INnovation, upscaling and transformation
- NAIADES III - European Action plan aimed at Future-proofing European inland waterway transport
- NAVIDIV - Project titled: Inland navigation infrastructures and biodiversity: impacts and opportunities for waterwayscape management
- NbS Nature-based Solution(s)
- NRL - Nature Restoration Law
- PIANC - The World Association for Waterborne Transport Infrastructure
- PLATINA - PLATform for the Implementation of NAiades
- TEN-T - Trans-European Transport Network
- UN United Nations
- UNECE - United Nations Economic Commission for Europe
- UNEP - United Nations Environment Programme
- WFD - Water Framework Directive

1 Introducing MERLIN's role for a navigation strategy

1.1 MERLIN project, and its overall objectives

The H2020 MERLIN project (Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: INnovation, upscaling and transformation) aims to contribute to delivering the EU Green Deal goals through a focus on freshwater restoration measures throughout the EU. These measures include wetland and peatland restoration as well as instream, riparian and floodplain restoration in small streams and large rivers. MERLIN's focus is on mainstreaming freshwater restoration through Nature-based Solutions (NbS), aiming to address the needs of nature, society, and the economy. This is done through learning from existing good practice in 18 case studies and upscaling and mainstreaming these practices across the EU.
Mainstreaming means normalising ideas considered common in one domain into other domains, to build shared understandings and concerted actions (Scott et al. 2022). The MERLIN "Transformations" Work Package considers how to move beyond using these restoration measures for solely conservation goals, to measures that act as NbS to societal challenges. A key part of the mainstreaming is to embed the use of NbS, where appropriate, within society and economic sectors. MERLIN aims to outline a strategy that enables compliance with and contribution to the EU Green Deal goals and that facilitates the sector's beneficial adaptation in the face of change

1.2 Purpose of a navigation strategy

Making European rivers suitable for inland water transport has required enormous modifications with severe ecological consequences (Jeliazkov et al. 2024; Sexton et al. 2024). These large-scale modifications started in the 19th century and are ongoing until the present day (see Chapter 1.2.1). At the same time the Green Deal requests a modal shift in transport from the congested roads to rail or water (European Commission 2020). The challenge is to reduce the environmental impacts of waterway infrastructure and navigation while at the same time safeguarding a reliable mode of transport on inland waterways (PIANC 2008; European Commission 2021).

Freshwater habitats and species are under severe threat, with significant losses occurring over the past 50-60 years. Freshwater species populations compared to marine and terrestrial populations have suffered the heaviest declines, falling by 85% on average since 1970 (WWF 2024). For these species and habitats to persist there is an urgent need to improve the ecological state of rivers and adjacent floodplains which are the goals of the EU Water Framework Directive (2000), Habitats Directive (1992) and recently adopted Nature Restoration Law (2024).

Climate change is expected to create more extreme discharge conditions affecting both the navigability and ecological status of inland waterways. This asks for adjustments in ship design, waterway design and management to better cope with both flood and drought conditions.

The goal of this strategy is to serve the European Union Green Deal ambitions to both promote environmentally friendly inland navigation and improve the ecological functioning and biodiversity of inland waterways. To reach these ambitions, this strategy advocates for the exploration and implementation of NbS. To transition inland waterway transport the NAIADES III action plan 'Boosting future-proof European inland waterway transport' (see Annex 9.3) names amongst others greening inland waterways infrastructure and ports stating "***An integrated approach is therefore essential when considering future inland waterway transport infrastructure developments, taking into account transport needs but also environmental and societal concerns, as well as the multiple functions of waterways and ports in terms of regional economic development, water supply, energy generation and biodiversity***" (EC 2021). NbS (see text box 'NbS in inland waterways') can be an excellent means to realise such an integrated approach, but the experience with NbS in inland waterways is still in an early phase. The proposed strategy is also in line with the position of PIANC, The World Association for Waterborne Transport Infrastructure (e.g. PIANC 2008, 2018, see Annex 9.5) and the "Joint Statement for the Danube River" of the International Commission for the Protection of the Danube River, the Danube Commission and the International Sava River Basin Commission (ICPDR, DC & SRBC 2007, see Annex 10.1)[1]. As such, the strategy emphasises to proceed along with those propositions and initiatives. The contribution of the MERLIN strategy for navigation is that it specifically emphasises the potential to mainstream NbS based on pilot experiences in several EU countries for greening European inland waterways.

[1] A second, updated version of the Joint Statement is currently under development. The new version is expected to appear in 2025.

Nature-based Solutions in inland waterways

The UN defines NbS as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits" (UNEP 2022). The essence is that NbS serve multiple goals. For this strategy on inland navigation the scope of NbS is therefore delineated to measures which can serve the navigability of inland waterways while simultaneously improving their ecological status i.e. implementing NbS to improve the hydromorphological conditions in the rivers. This includes measures that mitigate the effects of climate change on inland waterways. Due to climate and land use changes, a generally increasing variation in river discharges is expected. This development affects both the navigability and the ecological functioning of the rivers and their adjacent floodplains. We also include measures that reduce the impact of navigation on riverine ecosystems.

Besides NbS there are numerous other measures such as a zero-emissions fleet which may benefit the environment, but these are not further addressed in this strategy. Rivers have been heavily modified to accommodate inland transport over water with severe ecological consequences. The challenge is to replace such grey infrastructure by NbS without significant consequences for the safety and reliability of inland waterways. There are promising pilot experiences in Europe with removing bank protection, adapting groynes and longitudinal training walls to reduce the environmental impact of navigation without hampering the navigability. These measures may be replicated elsewhere to transform or adapt the current practices of engineering rivers. The total length of such projects together is at present only a small fraction of Europe's 41,000 km long network of inland waterways. Whether NbS can reduce the need for fairway maintenance and thus become a cost reduction for water managers is, as of yet, insufficiently known.

Figure 1 Examples of NbS for greening inland waterways. Top left bank protection removed (Danube, AT), top right adapted groynes (Danube, AT), bottom left bank removal protection (Meuse, NL), bottom right side channel reconnection (Rhine, NL)

1.2.1 Environmental impact of inland navigation

Navigation serves our society and economy but making freshwater bodies suitable for navigation comes with various kinds of environmental impacts (Zajicek et al. 2018; Jeliazkov et al. 2024; Sexton et al. 2024; Figure 3). As this strategy is about NbS, it focuses on the physical environmental impacts of inland navigation (red encircled in Figure 4). The causes of these impacts can be divided in three domains: the presence of infrastructure to improve the navigability, the intensity of navigational use and the maintenance of the fairways (Jeliazkov et al. 2024, Sexton et al. 2024).

Rivers have been modified to make them suitable, safe and reliable for inland transport over water. These modifications aim at creating a uniform and standardised waterway width and depth (depending on the waterway class[2]), and include protecting banks against erosion, shortening main channels, constructing weirs with shipping locks and disconnecting side channels and floodplains. Large-scale application of such measures has led to heavily modified river ecosystems and has initiated a decline and shift in biodiversity. For example, shortening river stretches leads to an increase in flow velocities, causing river beds to incise and floodplains to desiccate and terrestrialise. Constructing weirs creates impoundments, disrupting river connectivity and free-flowing conditions, while their operation can lead to unnatural fluctuations in water levels and flow velocities. Furthermore, the inland waterway network contains canals (e.g. Rhine-Maine-Danube canal, Figure 2) that connect river basins. These artificial connections facilitate the spread of invasive alien species (e.g. Bij de Vaate et al. 2002, Leuven et al. 2009).

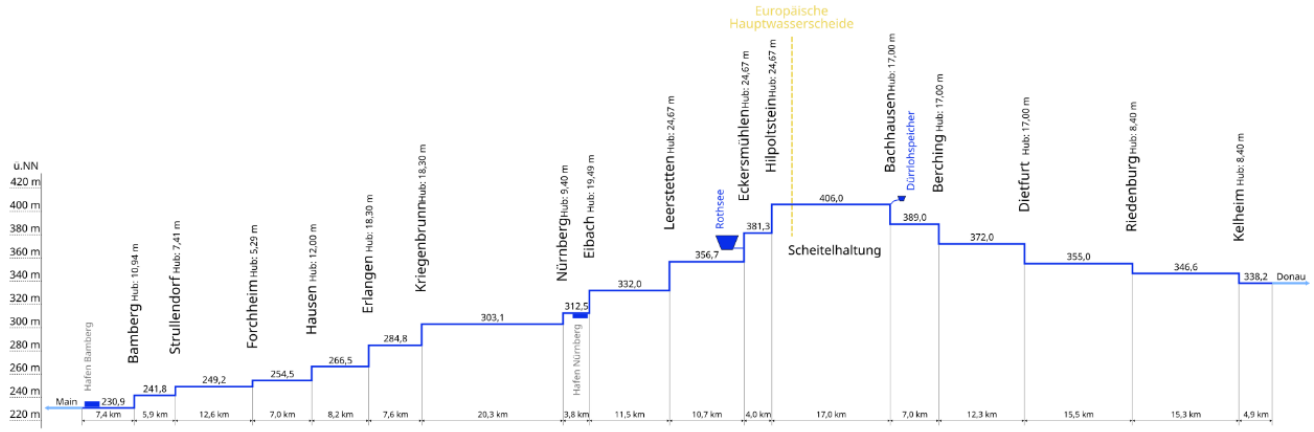

Figure 2 The Rhine (through the Main, left) and Danube (right) are connected through a canal consisting of a chain of impoundments. The canal, completed in 1992, facilitates the spread of numerous alien species. The figure shows a side view, indicating the water level in each section, the names of the locks and their water level difference, the two large water reservoirs (Dürrlochspeicher and Rothsee) and the ports of Bamberg and Nürnberg.

Navigation intensity creates another set of environmental pressures. Passing ships create waves, displace water and affect river beds (PIANC 2008; Gabel et al. 2017). This negatively impacts native taxa (Jeliazkov et al. 2024) as well as fish density and diversity in rivers (Zajicek & Wolter 2019). They also function as means of transport for invasive alien species through fouling or in ballast tanks (Wonham et al. 2000; Minchin & Gollasch 2003).

Finally, maintenance and renovation of aging infrastructure is required and inland waterways are regularly dredged to meet the required navigable channel depth (mostly at least 2,50 m, European Union 2024a).

1.2.2 Effects of climate change on inland navigation and river ecosystems

Climate change is expected to lead to significant changes in river discharge regimes. For example, the discharge regime of the Rhine is expected to become more variable, with larger discharge peaks and low flow extremes (Stahl et al. 2022). Prolonged periods of low discharge combined with an expected increase in water temperature pose severe threats to existing ecosystems (Sabater et al. 2023).

Inland navigation benefits from a stable and sufficiently large water depth throughout the year and is therefore affected by changes in discharge regimes as well. During high-discharge conditions, navigation may be

[2] https://en.wikipedia.org/wiki/Classification_of_European_Inland_Waterways

hampered by large flow velocities and limited clearance under bridges. During periods of low flow, water depths may be insufficient for navigation and structures can pose obstacles such that canals and ports become inaccessible.

Hence, with regard to climate change the challenge is to increase the resilience of both river ecosystems and inland water transport.

Figure 3 Environmental impacts of inland water transport. Top: standardising width and depth with groynes (left) and bank protection against erosion (right) modify habitats; Middle: weirs and sluices to regulate water depth disrupt connectivity and free-flow conditions; Bottom: waves and water displacement (left) and dredging (right) impact biota.

1.3 Stakeholders for a navigation strategy

Developing a strategy for the navigation sector raises the question which organisations should or could be considered to belong to the sector. There is no single or simple answer. Two spatial scales appear to be relevant: the international or EU scale and the national ones (Figure 4). At the international level there are umbrella organisations which represent their constituents. Here policy development, sharing experiences and raising awareness are the dominant components. It is the national level where concrete activities take place. On this level decisions are taken on how to engineer, maintain and use waterways. This is the scale where NbS are implemented by water management authorities, protected area managers or other organisations and where the consequences are experienced by those navigating their ships or using the land adjacent to the rivers. Also, national umbrella organisations may represent their constituents at this level.

The focus of the MERLIN project is to upscale freshwater ecosystem restoration by advocating the mutual benefits of NbS. This scope of MERLIN should be considered when identifying for whom this strategy is meant to be. We conclude that the strategy must connect the international and EU top-down aspect with the bottom-up national experiences. This is presented in Figure 4 without the pretension to be exhaustive.

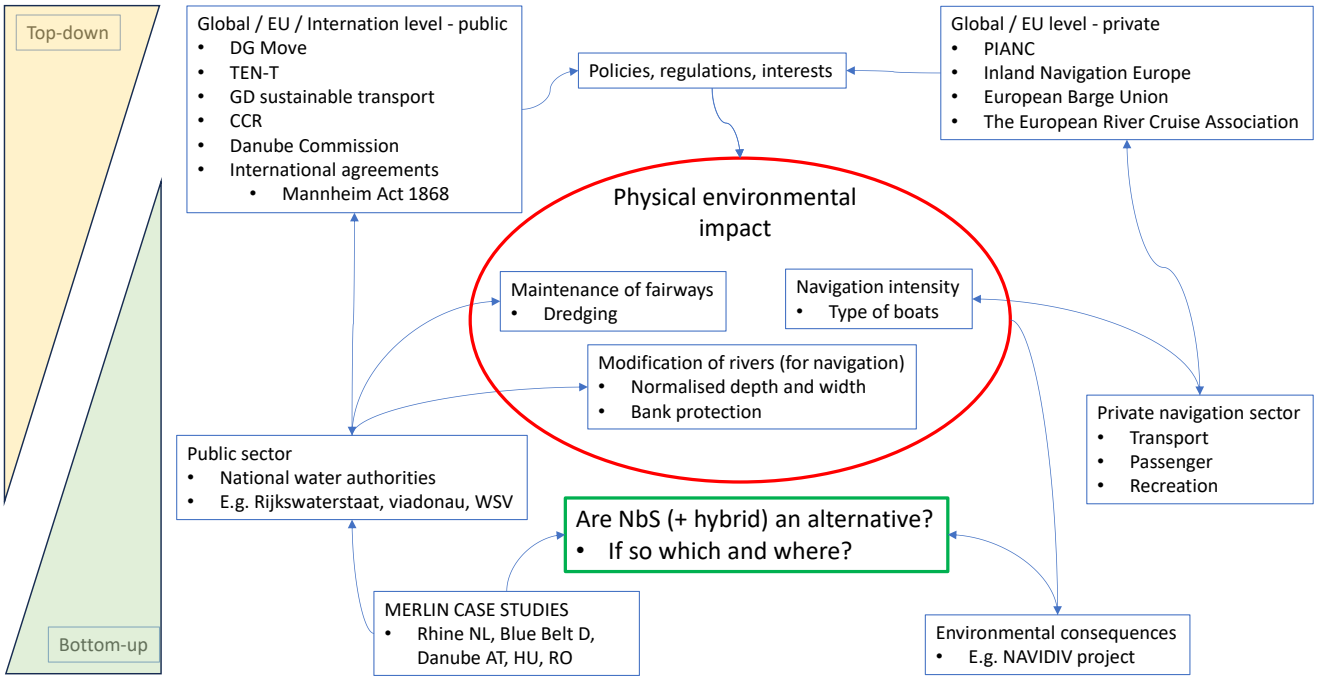

Figure 4 A sketch of elements considered relevant for a sectoral navigation strategy to be better balanced with environmental protection by mainstreaming NbS in inland waterways. For abbreviations see Abbreviations and Acronyms.

Relevant stakeholders can be arranged by their top-down or bottom-up roles and their specific relation to inland navigation and waterways (Figure 4). At the global / EU level there are organisations such as PIANC, the Central Commission for Navigation of the Rhine and the European Commission's Directorate-General for Mobility and Transport (DG Move) as well as the Directorate-General for Environment (DG ENV). Relevant policies at this level are e.g. environmental legislation (Nature Restoration Law, Water Framework Directive, Birds and Habitats Directives), the regulation for the development of the Trans-European Transport Network (TEN-T), the European Green Deal ambitions for sustainable transport[3] and international agreements such as the Mannheim Act (1868). At the national level there are water management and navigation authorities such as Rijkswaterstaat in the Netherlands, viadonau in Austria or the Federal Waterways & Shipping Administration (WSV) in Germany. The public sector has the responsibility to manage and maintain the waterways while the private sector (transport, passenger ships, recreation) utilises the inland waterway network. Next to representatives of the navigation sector are environmental and nature organisations, either public or private.

The navigation sector is complex and comprises a diverse group of both public and private bodies and stakeholders. Within the private navigation sector, we can for example distinguish between skippers, ship owners, the companies whose products are transported (ranging from small enterprises to heavy industry) and intermediaries. All stakeholders within the navigation sector can contribute to environmentally friendly

[3] https://transport.ec.europa.eu/transport-themes/sustainable-transport_en

navigation and sustainable management of the inland waterway network. For NbS the lead and initiative should logically be with the national waterway management and navigation authorities whereby early and continuous stakeholder participation is crucial to avoid unnecessary conflicts.

We consider this strategy relevant to the entire European network of waterways (Figure 6; see Annex 9.2 on UNECE). The strategy concentrates on commercial navigation but is equally useful for waterways used mainly or exclusively by motorised recreational navigation. Within the MERLIN project, the inland navigation strategy is relevant to the case studies of the Rhine (CS04), the Danube (CS07a) and the German Blue Belt programme (CS10) and, to a lesser extent, to the case study of the Tisza River (CS09), which is almost exclusively used for recreational navigation (see the MERLIN Case Study portal and their Regional Scalability Plans).

Concluding, we consider abovementioned stakeholders, both public and private, both at high policy levels and on the ground, those who manage, maintain and use inland waterways on the one hand and those involved to improve the environmental and ecological status of rivers on the other the core audience for this strategy.

1.3.1 A network of Communities of Practice

Stakeholders that feel committed to implement this strategy for greening inland waterways should ideally organise themselves in Communities of Practice (CoP) to enable knowledge exchange and the collaborative advancement of best practices. An example is the network of parties that prepared the Joint Statement for the Danube River (Annex 10.1). Also, in several other river basins, parties already meet and greening inland waterways could or should become a recurrent agenda item in these meetings. At the EU or national level such CoP's do not exist yet.

There is an urgent need for a coherent CoP network that connects all of these different levels. Figure 5 proposes a structure for such a network.

When establishing Communities of Practice an international CoP would have other topics on its agenda than a national CoP. National CoP's are the most logical platform for sharing experiences with NbS. At the same time the number of locations and projects within which NbS have been realised to date is still rather limited. This calls for putting emphasis on presenting these rather rare pilots to an international audience.

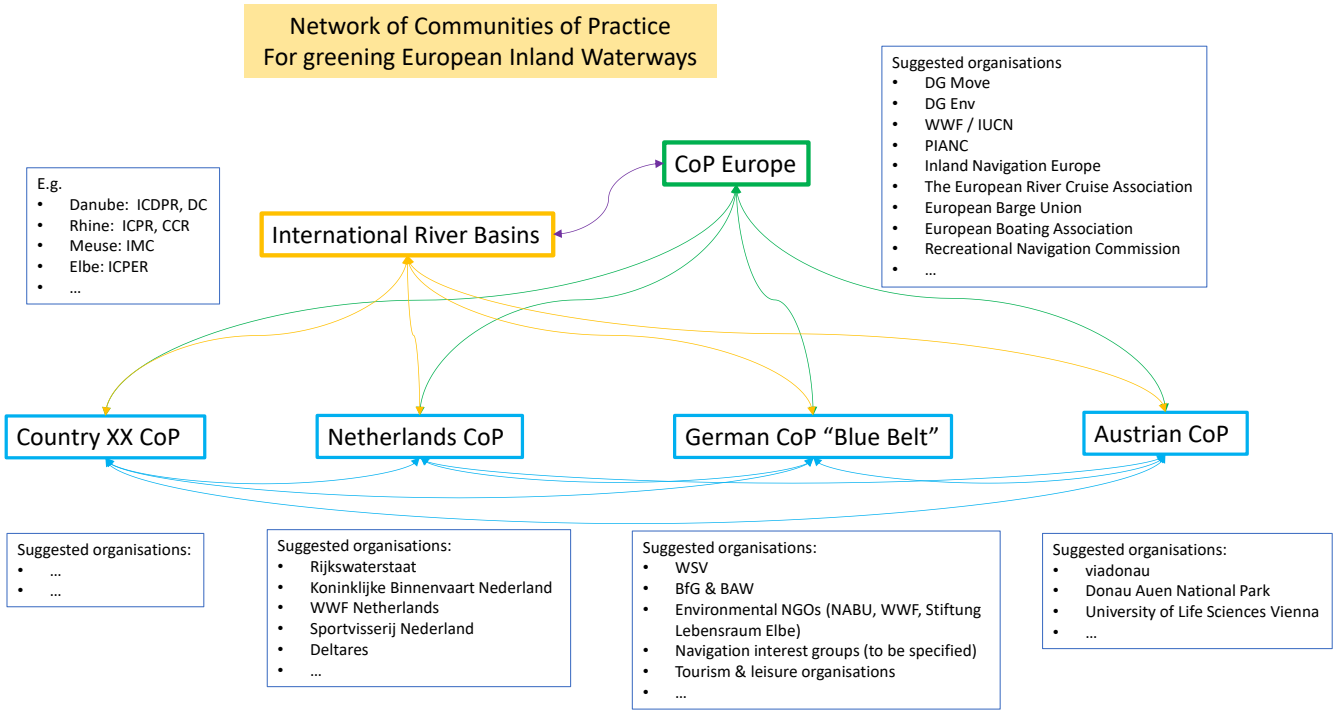

Figure 5 Proposal for a European network of CoP's for greening European inland waterways

2 MERLIN's navigation strategy development trajectory

The strategy has been developed through three online round tables in 2022, 2023 and 2024. In total 16 organisations participated of which eight were external organisations and eight partners in the MERLIN project (Table 1). The list of organisations invited to the round tables was compiled based on a stakeholder analysis. More organisations have been invited to the round tables than those who actually attended.

The 1st round table was focussed on collecting input from the participating organisations to understand the motivation and interest of the sector in NbS, and to understand the impact of restoration on the sector.

During the 2nd round table, the following topics and questions were discussed:

- What does the term NbS mean in the context of navigation?
- Who is the target audience and how to reach them?
- Which stakeholders are involved in different countries and on an international level?
- Which projects can be identified as representing best practices?

In the 3rd round table, the potential for NbS in navigable waterways was discussed. Furthermore, the key messages from the draft sectoral strategy were presented and feedback from the participants on these messages was collected.

Between the 1st and 2nd round tables a briefing for the navigation sector has been prepared (Gruber et al. 2023) indicating how the sector understands NbS and how NbS could support the sector e.g. by giving several good examples followed by listing challenges, opportunities and next steps.

In addition to the round tables, websites and literature about environmentally friendly initiatives for inland waterways and the application of NbS in inland waterways were consulted. The collected information is compiled in an overview of top-down perspectives on sustainable and environmentally friendly navigation (Chapter 3.1) and of bottom-up initiatives for integrated river management and projects with NbS in large navigable rivers (Chapter 3.2).

The three round tables and this compilation helped to focus the proposed MERLIN strategy for mainstreaming NbS in the inland waterway network and to propose a set of actions (Chapter 5).

Reflecting on the participation of the round tables (Table 1), it is concluded that most of the invited participants represent umbrella organisations that operate on a policy level and thus mostly have a top-down perspective on the relation between NbS and the navigation sector. The idea behind targeting these organisations was to have an international representation of the inland navigation sector, without having a large number of people present at the round tables (which limits interaction). A consequence of this approach however, is that the round table discussions and outcomes reflect this top-down perspective. In future endeavours, a wider range of stakeholders may be considered, representing more national and regional waterway authorities and shipping associations.

Two of the invited stakeholders from outside the MERLIN project participated in all three round tables (Table 1). Some participated twice, but the majority attended once. This limited interaction between stakeholders, and the fact that most participants were from MERLIN partner organisations in each round table may have created a certain imbalance in the discussions (see also Gray et al. 2024).

Table 1 Participating organisations in the MERLIN round tables on inland navigation. External organisations are shown in bold.

	RT1 March 2022	RT2 April 2023	RT3 June 2024
Deltares	X	X	X
European Barge Union		X	
European Boating Association	X		
European River Cruise Association	X	X	
Federal Institute of Hydrology (Germany)			X
Inland Navigation Europe		X	X
International Sava River Basin Commission	X	X	X
James Hutton Institute	X	X	X
PIANC - The World Association for Waterborne Transport Infrastructure	X	X	X
Recreational Navigation Commission	X		
Rijkswaterstaat	X		
University of Duisburg-Essen			X
University of Natural Resources and Life Sciences, Vienna			X
US Army Corps of Engineers	X		
Viadonau	X	X	X
WWF Hungary / Central Eastern Europe	X	X	X

3 Why do we need a strategy

As stated in Chapter 1 the aim of MERLIN is on mainstreaming freshwater restoration through NbS, aiming to address the needs of nature, society, and the economy. To give this strategy the appropriate focus and an added value, it is relevant to briefly sketch the present state of play from a top-down perspective (Section 3.1) and to name ongoing bottom-up initiatives (Section 3.2). Further details can be found in Annexes 9 (top-down perspectives) and 10 (bottom-up initiatives).

3.1 Global and European top-down perspectives

Inland waterway transport plays an important role in the transport of goods in Europe. Around 41,000 kilometres of waterways connect hundreds of cities and industrial regions (Figure 6). Thirteen of the EU Member States have an interconnected waterway network. The potential for increasing the modal share of inland waterway transport is significant. Compared to other modes of transport which are often confronted with congestion and capacity problems, inland waterway transport is characterised by its reliability, energy efficiency and major capacity for increased exploitation. The European Commission aims to promote and strengthen the competitive position of inland waterways in the transport system, and to facilitate its integration into the intermodal logistics chain (European Commission 2024).

Also, according to the United Nations Economic Commission for Europe (UNECE) "*Inland water transport is a viable alternative or addition to road and rail transport on European corridors. Though environmentally friendly and, frequently, the most economical mode of inland transport, it remains largely under-exploited in Europe*" (UNECE 2024) (Annex 9.2).

The EU's trans-European transport network policy, the TEN-T policy (2024), is a key instrument for the development of an efficient multimodal transport network across the EU (see also text box below). It comprises railways, inland waterways, short sea shipping routes and roads linking urban nodes, maritime and inland ports, airports and terminals (Annex 9.1). While the policy states that EU Member States must ensure Good Navigation Status (GNS) for their inland waterways by 2030, exemptions from this requirement are possible when the Member State concerned can show that negative impacts on environment, biodiversity or cultural heritage are significant (European Union 2024a). Furthermore, the TEN-T regulations state that measures to mitigate negative environmental impacts of inland water transport (IWT) should be developed and promoted. However, the TEN-T policy does not give specific guidelines or requirements related to this. Instead, it refers in a general sense to applicable environmental and biodiversity policies.

The guideline on achieving Good Navigation Status, published by the European Commission in 2018 (Muilerman et al. 2018), does explicitly mention the EU Water Framework Directive (WFD) and Habitats Directive as important policies to consider. Mentioned here is that the WFD requirements to reach Good Ecological Potential (GEP) by 2027 are less stringent in case a water body is designated as heavily modified or artificial (also see text box below). This designation is possible when the measures needed to reach Good Ecological Status (GES) would otherwise have significant negative effects on, amongst others, navigation. Hence, by making requirements for Good Navigation Status and Good Ecological Potential dependent on the specific characteristics and functions of each water body, different and possibly conflicting interests can be balanced (see text box 'balancing GNS and GES/GEP').

Furthermore, the guideline on GNS advocates the usage of the concepts of "Working with Nature" as described in the position paper by PIANC (2011), which puts emphasis on identifying win-win solutions, rather than minimising adverse effects on ecology. However, the guideline also has ample attention for measures that are focused on the latter. This shows that different perspectives on the importance of ecosystem functioning with respect to the navigation function exist.

Also published by the European Commission in 2018 is the "Guidance on Inland waterway transport and Natura 2000" (European Commission 2018). This document focuses in more detail on the implications of the EU Birds and Habitats Directives for inland waterway development. Next to highlighting the importance of rivers for both biodiversity and inland waterway transport and the need for integrated planning, the guidance document details how IWT developments can be assessed when they are likely to have a significant (negative) effect on Natura 2000 sites. Such an assessment is required through Article 6 of the Habitats Directive. Furthermore, the document explains the relation between the Birds and Habitats Directives and other EU environmental laws.

Balancing Good Navigation Status and Good Ecological Status / Potential

Many rivers that are part of the inland waterways network have been modified to such an extent that they have been designated as heavily modified water bodies. Below are the requirements posed by TEN-T regulation and the WFD that require balancing between Good Navigation Status (GNS) and Good Ecological Status / Potential (GES/GEP). The aim of Nature-based Solutions is – where possible – to serve both requirements.

TEN-T Article 23.2 Member States shall ensure that the inland waterway network, including connections referred to in Article 21(1), point (e), is maintained to enable efficient, reliable and safe navigation for users by ensuring minimum waterway requirements and minimum levels of service requirements laid down in paragraph 3 of this Article (Good Navigation Status). Member States shall prevent the deterioration of the Good Navigation Status, as well as prevent the deterioration of the current status of those parts of the network that already exceed those minimum requirements by ... [date of entry into force of this Regulation].

TEN-T Article 23.4 At the request of a Member State, in duly justified cases, the Commission shall adopt implementing acts granting exemptions from the requirements referred to in paragraphs 2 and 3 per waterway and where appropriate per waterway section, on the ground of specific geographical or significant physical constraints, negative result of socio-economic cost-benefit analysis, or significant negative impacts on environment, biodiversity or cultural heritage.

WFD Article 4.1 (i) Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water; (ii) Member States shall protect, enhance and restore all bodies of surface water, subject to the application of subparagraph (iii) for artificial and heavily modified bodies of water, with the aim of achieving good surface water status at the latest 15 years after the date of entry into force of this Directive; (iii) Member States shall protect and enhance all artificial and heavily modified bodies of water, with the aim of achieving Good Ecological Potential and good surface water chemical status.

WFD Article 4.7 Member States will not be in breach of this Directive when failure to achieve good groundwater status, Good Ecological Status or, where relevant, Good Ecological Potential or to prevent deterioration in the status of a body of surface water or groundwater is the result of new modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater, or failure to prevent deterioration from high status to good status of a body of surface water is the result of new sustainable human development activities and all the following conditions are met:

a) all practicable steps are taken to mitigate the adverse impact on the status of the body of water;
b) the reasons for those modifications or alterations are specifically set out and explained in the river basin management plan required under Article 13 and the objectives are reviewed every six years;
c) the reasons for those modifications or alterations are of overriding public interest and/or the benefits to the environment and to society of achieving the objectives set out in paragraph 1 are outweighed by the benefits of the new modifications or alterations to human health, to the maintenance of human safety or to sustainable development, and
d) the beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

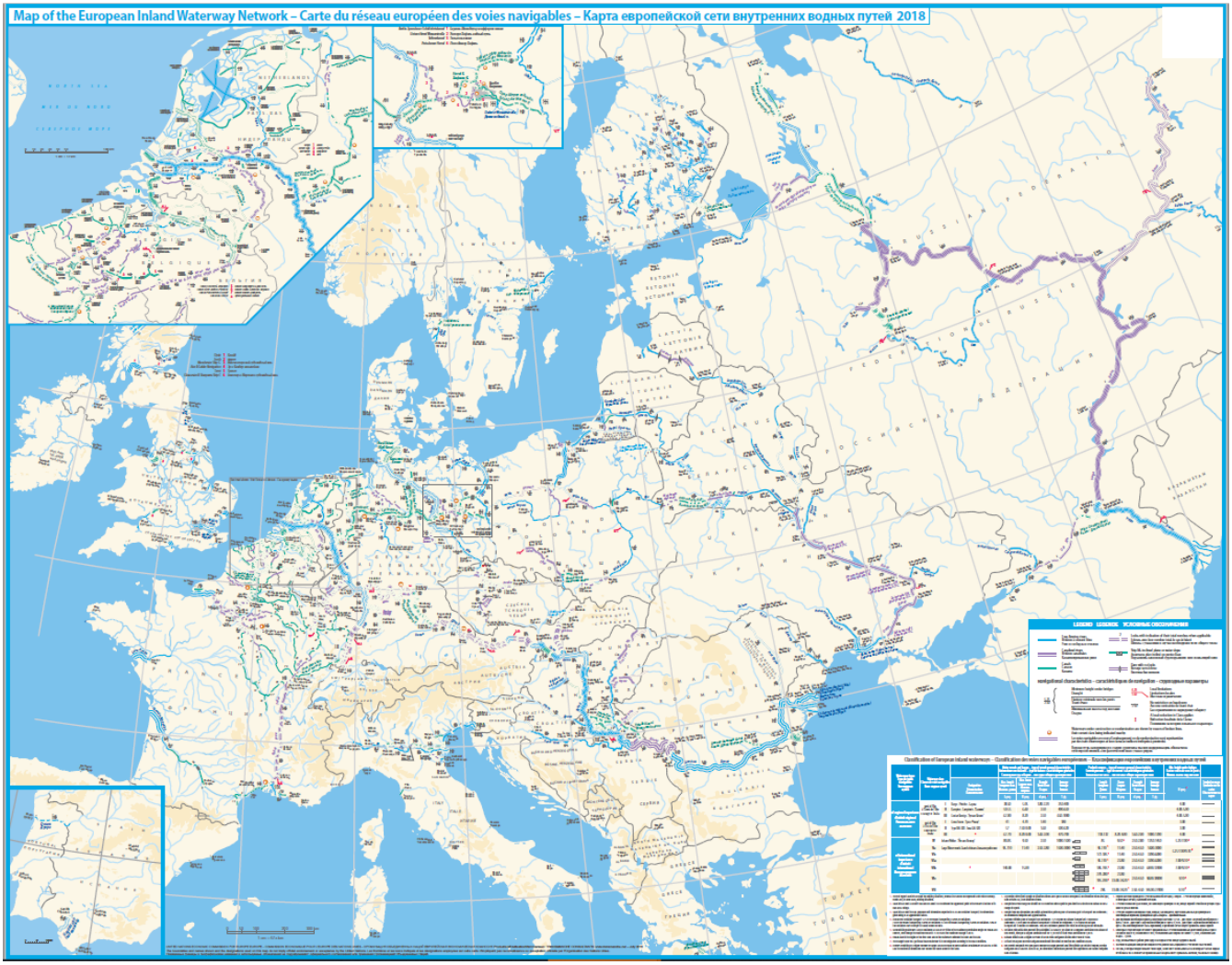

Figure 6 Within Europe there are 41,000 km of navigable waterways (Source UNECE 2018).

The policy of the European Commission to promote inland waterway transport is encapsulated in the NAIADES III Action Programme “Boosting future-proof European inland waterway transport”, which comprises numerous actions and measures (European Commission 2021) (Annex 9.3). Within the NAIADES III programme the relation to NbS in the inland waterway network is through the component “greening inland waterways infrastructure and ports” captured by a problem description and way forward. The action plan, however, concentrates on zero-emission and does not present NbS as one of the solutions in the form of a concrete action.

The EU PLATINA project and its successors PLATINA II, PLATINA3 and PLATINA4Action aim to promote inland waterway transport in Europe, by coordinating and supporting the implementation of the NAIADES action programme (Annex 9.4). Concerning waterway infrastructure, an integrated approach towards design, maintenance and management is recognised as the way forward to adapt to climate change. In terms of river engineering measures, a mix of 'green' (nature-based) and 'grey' (traditional engineering) solutions is thought to be most suitable to reach the objectives of different stakeholders (Schweighofer & Fraunhofer 2022).

PIANC is the World Association for Waterborne Transport Infrastructure (https://www.pianc.org/) (Annex 9.5). PIANC is a non-political and non-profit organisation that brings together international experts to issue technical reports covering a wide range of topics related to sustainable waterborne transport infrastructure. PIANC has four technical commissions of which the Environmental Commission (EnviCom) and the Inland Navigation Commission (INCOM) are most relevant for the MERLIN navigation sector strategy. The work of EnviCom is relevant to raise awareness for the environmental impacts of inland water transport. Furthermore, the commission develops and provides environmental guidance supporting the waterborne transport infrastructure sector to strive for sustainability. EnviCom is responsible for dealing with both broad and very specific issues related to navigation sustainability and environmental risk and has task groups on climate change, the EU Water Framework Directive and the topic “Working with Nature”, which has strong resemblances with NbS. The WFD navigation task group prepared a position paper on the proposed EU Nature

Restoration Law (NRL) to emphasise that both safe and environmentally friendly transport and restoring biodiversity are Green Deal ambitions. They state that a synergistic approach is therefore required, and the proposal must be balanced, proportionate and pragmatic in both its objectives and its implementation (PIANC WFD NAVI 2023).

Inland Navigation Europe (INE) is the platform of national and regional waterway authorities and bodies promoting waterway transport (Inland Navigation Europe). The mission of INE is to make transport by water clean and efficient, keeping in mind the multi-functionality of waterways. INE supports the Working with Nature initiative of PIANC, and is committed to 'develop Nature-based Solutions or green infrastructure where possible and grey infrastructure when necessary'. With respect to climate adaptation, INE believes stronger EU action is required to help increase climate preparedness. According to INE, climate adaptation of the waterway infrastructure should have the same priority as climate mitigation of the waterborne fleet, and more research is needed to develop effective NbS for inland waterways. They also urge to avoid silo thinking in climate funding, as inland waterways are (contrary to road and rail) multifunctional.

Summarising these top-down perspectives, the EU is putting a lot of effort into improving the multimodal transport network and increasing the share of IWT within this network. The EU has published guidance documents on how to achieve their goals for the inland waterway network, considering European environmental legislation, such as the Water Framework Directive and the Habitats Directive. However, in the implementation programmes a strong link with nature restoration and conservation in European inland waterways still seems to be missing, although both safe, environmentally friendly transport and restoring biodiversity are Green Deal ambitions. This policy gap is recognised by organisations like INE. They advocate for a synergistic approach and more attention for climate adaptation of inland waterways. The MERLIN sectoral strategy for navigation can help to further shape this approach and increase awareness for the link between IWT and ecology/biodiversity on a policy level, thereby eventually making sure it is embedded within the relevant EU policies.

3.2 River basin and national bottom-up initiatives

On the level of (trans-boundary) river basins, quite some experience has already been gained on balancing inland waterway development and nature conservation/restoration through pilot projects and collaborations between waterway authorities. This has resulted in an initial catalogue of NbS examples in inland waterways (see e.g. Annex 10.4, ICPDR 2010a; BMVI & BMU 2020), as well as several guidelines and practical manuals that can be used to develop integrated projects. Notable are (both for the Danube):

- The Joint Statement on “Development of Inland Navigation and Environmental Protection in the Danube River Basin”, aiming to provide guidance to decision makers dealing with inland waterway transport (IWT) and environmental sustainability as well as to water managers preparing relevant riverine environmental and navigation plans, programmes and projects. The process to develop the Joint Statement has been initiated by the International Commission for the Protection of the Danube River (ICPDR), the Danube Commission (DC) and the International Sava River Basin Commission (ISRBC) (ICPDR, DC & SRBC 2007; ICPDR 2010b). A second, updated version of the Joint Statement is currently under development. The new version is expected to appear in 2025.
- The practical manual on “Environmentally sound waterway management in the Danube River Basin”, that was developed as part of the Interreg project Danube STREAM. It contains a model for an integrated planning process, framework for practical application and examples of integrated planning from Austria, Germany, UK and Belgium (Muilerman & Kempter 2018). The manual focuses on the interface between waterway maintenance and rehabilitation activities on the one hand, and nature conservation, restoration and developments on the other. In terms of legislation, the aim is to create integrated projects that ideally allow the achievement of Good Navigation Status (GNS, TEN-T Regulation), Good Ecological Status (GES, Water Framework Directive) and (where applicable) Favourable Conservation Status (FCS, Habitats Directive) at the same time (Figure 7).

Despite the availability of these manuals and the considerable experience that has already been gained, it seems to be difficult to mainstream an integrated approach towards inland waterway management, making use of NbS. Here, MERLIN can contribute by enabling Communities of Practice from different river basins to share their experiences with one another, and by facilitating communication and collaboration with organisations operating on an EU or global level.

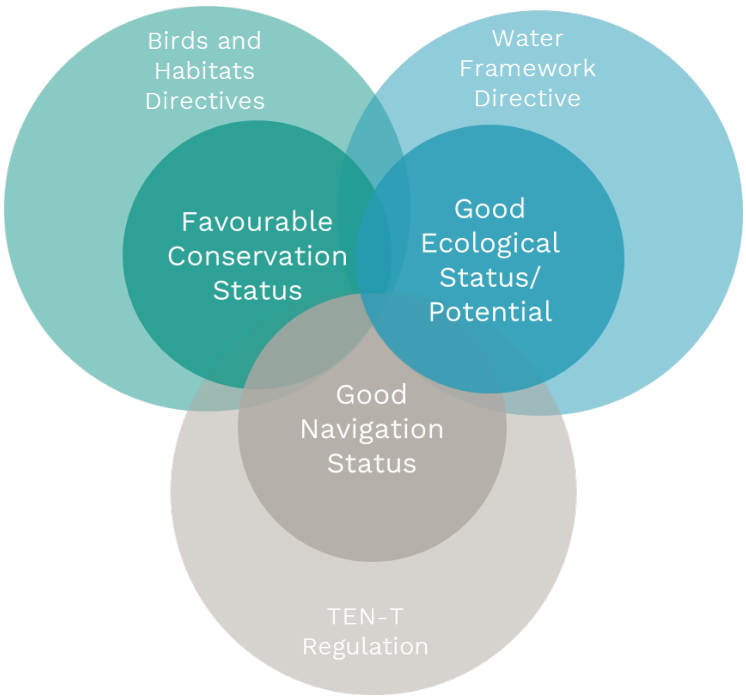

Figure 7 Interaction between FCS, GES and GNS. Source: adapted from Muilerman & Kempter (2018).

3.3 Ingredients for a strategy: how to resolve the problems?

An overarching vision is needed to better balance environmental protection and navigation. As Inland Navigation Europe stated, "*climate adaptation of the waterway infrastructure should have the same priority as climate mitigation of the waterborne fleet, and more research is needed to develop effective nature-based solutions for inland waterways*". The good initiatives by PIANC, ICPDR, DC and ISRBC need to become materialised in concrete actions. Based on the large differences in navigation intensity among European rivers it would seem reasonable to differentiate in balancing between priority for environmental status or navigability. This includes, amongst others, finding a balance between adapting the river for the type of ships and adapting the ships for the type of river.

The topic of greening inland waterways in NAIADES III has described the problem and the way forward which could or even better should take NbS into consideration but has not defined any concrete action for this. Additionally, during the 3rd round table it was mentioned that European financing instruments appear not to be sufficiently open for integrative projects addressing multiple goals in inland waterways, while serving multiple goals is at the heart of NbS.

There is quite a bit of hesitancy towards implementing NbS in inland waterways. The implementation of NbS in the European inland waterway network is very much a local or regional activity (see the examples given in Chapter 3.2). The experiences and lessons learned from pilot projects in countries such as Austria, Germany, and the Netherlands (Annex 11.4) should be shared and made accessible to a broader group of stakeholders, providing inspiration through these examples. Developing a strategy to disseminate knowledge and promote the use of NbS in inland waterways is essential.

Application of NbS in inland waterways can be considered a transformation from the traditional methods of engineering rivers to make them navigable. **Transformations** in society generally follow the path of the adoption lifecycle for innovations (Figure 8; Rogers 2003). We can conclude that the NbS application in inland waterways presently is in the innovator's and early adopter's phases. The challenge to mainstreaming is to make the majority aware of its potential to contribute to more environmentally friendly inland waterways and to dare take the step towards this novel form of river training and fairway maintenance. This should come with evidence collated in projects as presented in Chapter 3.2.

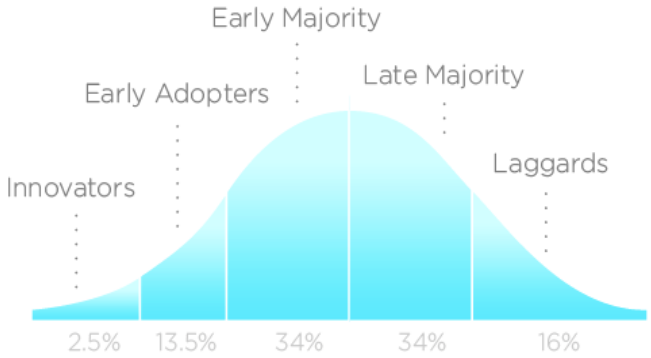

Figure 8 Innovation Adoption Lifecycle (Rogers 2003. Image source: Wikipedia (https://en.wikipedia.org/wiki/Early_adopter)

4 Vision: scaling out, up and deep

MERLIN's vision with regard to the navigation sector is to mainstream the implementation of NbS in inland waterways by developing an action plan on EU level, and facilitating implementation of this plan by allowing stakeholders to build on each other's knowledge and experiences.

Both sustainable transportation and biodiversity conservation are European Green Deal goals. A strategy requires a synergistic approach and must be balanced, proportional and pragmatic in both objectives and implementation.

The Green Deal ambitions for the inland waterways sector focus on multiple issues (shift of transport to inland waterways, zero-emission, digitalization, employment, financing the transition, governance). This strategy addresses a specific component by focusing on the opportunities to apply NbS with the purpose of greening inland waterways.

The navigation sector comprises both public and private bodies and stakeholders all of which can contribute to more environmentally friendly navigation and the sustainable management of inland waterways. For NbS the lead and initiative should logically be with the national waterway management and navigation authorities whereby early and continuous stakeholder participation is crucial to avoid unnecessary conflicts.

Awareness about the benefits and potential of NbS in navigable waterways needs to be raised, as scaling up is hindered by the perception that NbS only compromise navigability. To do this, high-level ambitions need to be linked to on-the-ground experience to build confidence and mainstream the application of NbS in inland waterways.

The intensity of navigation on European inland waterways varies by orders of magnitude. This means a tailored approach is required when planning and deciding the trade-offs between inland navigation and freshwater ecosystem conservation and restoration. The freedom of choice should be within the limits of the regulations (see the box on balancing GNS with GES/GEP). For ecology, high priority must be given to ecological hotspots and stretches of high conservation value, while at locations that can contribute most to the goal of shifting freight from road to inland waterway the priority may be to improve navigation conditions. Additionally, the needs and benefits of other water users, such as those in agriculture, fisheries, industry and tourism, must be carefully considered. Furthermore, there are substantial differences in the extent to which inland waterways are channelized and normalized for navigation. Recent experience that fewer engineering measures do not adversely affect navigability (see the examples in Annex 10.4) should encourage nature- and environment-friendly engineering practices in rivers that are still relatively natural.

To reach abovementioned Green Deal goals and the underlying MERLIN goal of freshwater restoration through NbS, we propose a strategy following the Scaling Out, Up and Deep framework first proposed by Moore et al. (2015). In the context of this strategy, we use the following definitions:

- Scaling out: replicating effective measures and actions on a larger scale.
- Scaling up: informing, adapting or strengthening the policy context to support implementation of measures and actions in the long term.
- Scaling deep: changing perspectives and introducing new ways of thinking that will help to reach the goals.

For the envisioned transformation to succeed, our strategy must address all these types of scaling. Table 2 shows the five core actions of the proposed strategy, and how these contribute to scaling out, scaling up and scaling deep. The actions are shortly explained below and further elaborated in Chapter 5.

A. An action plan for greening inland waterways is needed to facilitate application of NbS in inland waterways on a much larger scale (**scaling out**), and to provide the necessary regulatory basis (**scaling up**).

B. By installing Communities of Practice (CoP's), the relevant policy levels and stakeholders on the ground are brought together, to facilitate collaboration and sharing of knowledge and experiences. This action contributes to **scaling out** (facilitating sharing of experiences between responsible waterway authorities, and between stakeholders), **scaling up** (facilitating exchanges between high-level policymakers and implementers/stakeholders) and **scaling deep** (creating and strengthening the network of organisations involved in NbS in inland waterways).

C. Within the CoP's, experience with NbS in inland waterways can be shared. By learning from success stories, discussing points of view, sharing what works and what doesn't, this action contributes to **scaling out, scaling up** and **scaling deep**.

D. A change in thinking is needed to minimise engineering interventions (**scaling deep**): from mono-functional designs to win-win solutions where possible, from traditional grey engineering solutions to NbS or even omitting interventions to conserve existing ecosystems.

E. As part of the plan for greening inland waterways (action A), the importance of each waterway for navigation and for nature must be assessed. This balance determines which types of measures (if any at all) are fitting. This action thus mostly contributes to **scaling out**.

Table 2 Relation between proposed actions and the scaling out, scaling up and scaling deep framework.

Actions	Scaling out	Scaling up	Scaling deep
A: Develop an action plan for greening inland waterways	X	X	
B: Build confidence by installing Communities of Practice	X	X	X
C: Share experiences with NbS in inland waterways	X	X	X
D: Minimise engineering of inland waterways			X
E: Prioritise inland waterways based on their ecological status and role for navigation	X		

5 Strategic actions

Based on the need for a strategy which has been presented in Chapter 3 and the vision in Chapter 4, below a set of five actions (A-E) is proposed that are needed for greening the European inland waterway network by mainstreaming NbS. The actions are summarized in *Table 3* and visualised in Figure 9.

Table 3 Summary of actions.

Action	What	Who	When
A	Develop an action plan for greening inland waterways	DG Move, DG Env	2025 – 2027
B	Build confidence by installing Communities of Practice	DG Move, DG Env, international river basin commissions, national and regional waterway authorities	2025 – 2035
C	Share experiences with NbS in inland waterways	Stakeholders in NbS implementation projects	Continuous
D	Minimise engineering of inland waterways	Waterway authorities and nature organisations	Continuous
E	Prioritise inland waterways based on their ecological status and role for navigation	DG Move and DG Env with contributions from national authorities responsible for implementing TEN-T, WFD and NRL	2025 – 2027 (with possibility for updates later on)

5.1 Action A: Develop an action plan for greening inland waterways

The need for greening inland waterways is stated in NAIADES III, but no actions are identified yet to make a plan on how to do this. In our opinion the initiative for this should come from DG Move jointly with DG Env. There are already excellent regional initiatives, in particular the Joint Statement for the Danube and the Blue Belt programme in Germany, that can serve as an inspiration and source of experience. A plan for greening inland waterways could and should be developed as soon as possible, i.e. within a couple of years like other plans such as the Zero Pollution Action Plan and inland waterway transport action plan mentioned in NAIADES III (European Commission 2021). This can be done by taking two recent EU regulations as a basis: the Regulation of the European Parliament and of the Council on Union guidelines for the development of the trans-European transport network (European Union, 2024a) and Regulation (EU 2024/1991) of the European Parliament and of the Council of 4 June 2024 on nature restoration (European Union, 2024b). This clearly is a top-down action. As a minimum a check for cross-compliance is required, but much better would be exploring the potential for mutual benefits. The parties in the proposed EU CoP (Figure 9) should be involved in drafting this plan, followed by consultation of CoP's at lower levels. It is important to identify how achieving Good Navigation Status can be combined with the requirements implied by the Water Framework and Habitats Directives and the Nature Restoration Law.

The plan should also identify the potential sources to finance greening of inland waterways. The funding for current NbS pilots in inland waters has so far come mainly from public sources. Protecting and improving ecological status while maintaining safe and reliable shipping conditions involves a palette of actions for which the public and private sectors must take their share and responsibility.

An important notice in this respect is the transboundary nature of most of the important waterways which have to meet the requirements for waterway dimensions. A sole national approach is unlikely to be successful. So, an institutional improvement will be inevitable to cope with these challenges as well as cross-sectoral decision making, national as well as international.

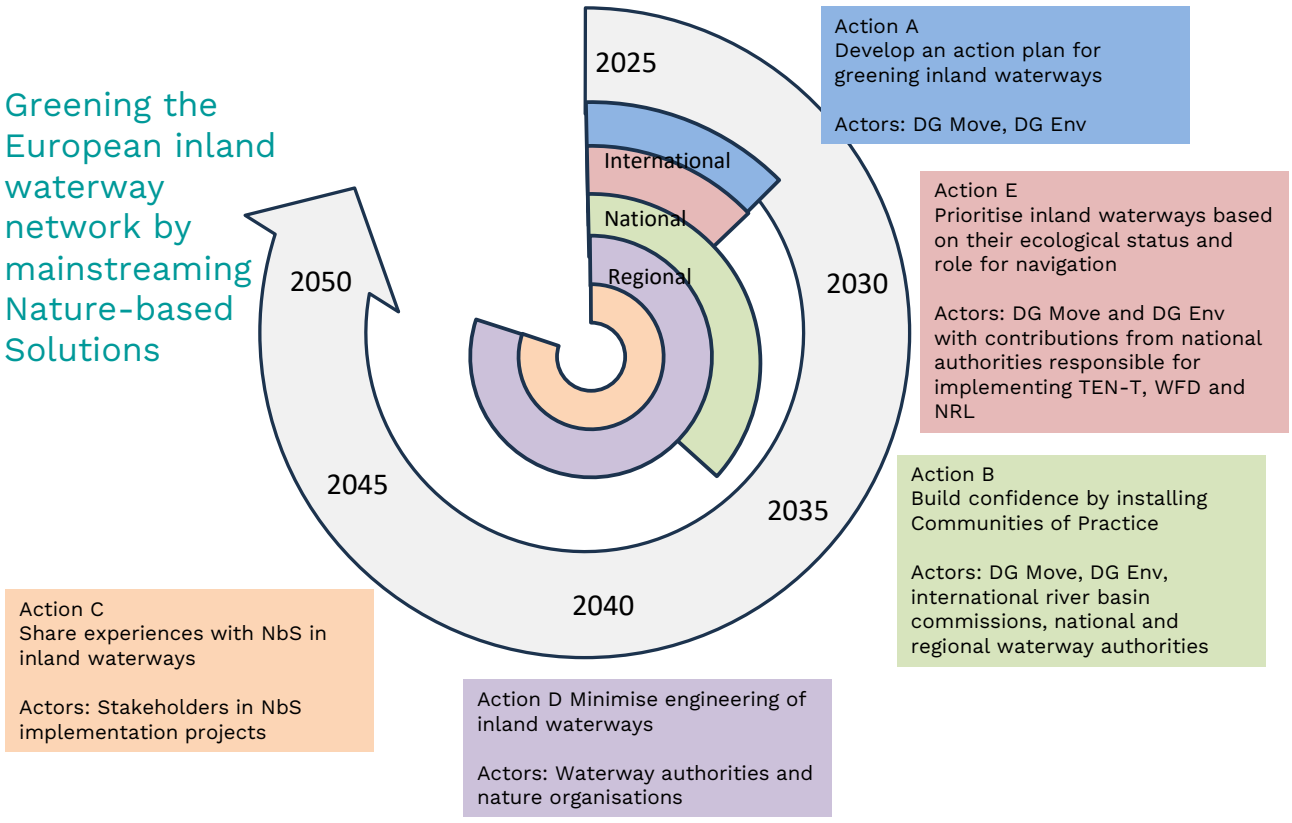

Figure 9 The actions of MERLIN's sectoral strategy for navigation

5.2 Action B: Build confidence by installing Communities of Practice

As described in Chapter 1.3.1, streamlining communication and collaboration between stakeholders at different levels is essential to achieve the dual goal of sustainable transport and ecological conservation and restoration. Figure 2 proposes a structure in which the relevant policy levels are organized in communities of practice (CoP's), which are again connected in an overarching network.

The CoP at EU level would be closely connected to the development of an overall plan for greening inland waterways (Action A). However, close consultation with CoP's at the national and river basin level should also be part of this process, to make sure that plans are fitting the relevant governance structures and can be implemented efficiently and timely.

The national CoP's and international river basin commissions allow for streamlining stakeholder consultation within implementation projects and building mutual trust. Between these national CoP's and basin commissions, experiences can be shared related to the implementation of NbS in inland waterways (Action C). Relevant parties to involve in these CoP's are waterway authorities responsible for the implementation of measures, universities and institutes involved in research related to NbS and inland waterways, and stakeholder organizations advocating for nature conservation, navigation, recreation, local residents, landowners, etc.

An example of such a network of CoP's is the European Center for River Restoration (ECRR). As there are no strict requirements for national CoP's to become part of the ECRR, the network leaves room for the CoP's to be organized in a way fitting to national/regional governance structures and policies. The same approach could be taken for the CoP network related to greening inland waterways, and ECRR members could become members of these CoP's as well.

Exchanges between CoP's could be funded by the EU as part of the plan for greening inland waterways. Setting up a CoP at the European level would be a responsibility of DG Move and DG Env as well. National and river basin CoP's will in many cases already exist in some form (Joint Danube statement follow-up meetings; METEET meetings), and with appropriate funding it is likely that these CoP's are willing to contribute to

exchanges with one another, as it is also in the interest of involved implementers/stakeholders to gain experiences, build a network and exert influence on higher-level decision-making.

As Good Navigation Status must be reached by 2030 and Good Ecological Status/Potential by 2027, there is ample reason and motivation to start forming these networks and organizing exchanges in the coming years. However, some time will be needed to properly establish the network, ensure continuation of the exchanges and embed the network in the existing playing field. An appropriate timeline could be:

- By 2030: Appointed CoP's for relevant EU member states, trans-boundary river basins and at the European level;
- By 2035: Recurring opportunities for exchanges between CoP's, fitting CoP needs.

5.3 Action C: Share experiences with NbS in inland waterways

In Chapters 3.1 and 3.2 it was shown that perspectives on the link between IWT and ecological conservation/restoration vary among stakeholders and policy levels. One of the goals of sharing experiences is to create a shared understanding of the problems and, more importantly, the way forward. A second and equally important goal is to learn from each other's experience with implementing NbS, to overcome the upscaling threshold and transform the way of thinking (see Chapter 3.3). Following the definitions of the adoption lifecycle for innovations (Figure 8; Rogers 2003), the Innovators and Early Adopters have an important role in this process by showing the way forward. However, existing doubts and criticism on NbS in inland waterways are equally important to consider to improve measures and processes and remove obstacles.

Important aspects to share and discuss within CoP's and the CoP network (Chapter 5.2) are:

- Effectiveness of different types of measures (including not intervening), considering the needs of different stakeholders;
- Funding opportunities/difficulties;
- Appropriate methods to assess costs and benefits of measures;
- The overall implementation process;
- Stakeholder involvement;
- Appropriate governance structures, division of responsibilities;
- Monitoring and evaluation plans;
- Trans-boundary aspects;
- Policy instruments, interpretation/implications of laws and regulations.

Annex 10.4 already gives an overview of the limited number of existing initiatives and covers several of these aspects. Available information on NbS in inland waterways, relating to all aspects mentioned above, should be easy to find, use and add to by anyone interested. To obtain an overview of new ways of reduced or environmentally friendly river engineering and maintenance, an initiative is needed to compile the experiences. One of the parties in the national CoP or an international river basin organization could take up this responsibility.

5.4 Action D: Minimise engineering of inland waterways

"Inland waterways in Europe are characterised by a heterogeneous hydro-morphology which hampers a coherent performance for all waterway stretches. Inland waterways, especially free flowing stretches, may be heavily impacted by climate and weather conditions. To ensure reliable international traffic, while respecting the hydro-morphology and applicable environmental legislation, trans-European transport network requirements should consider the specific hydro-morphology of each waterway (for example free-flowing or regulated rivers), as well as the objectives of environmental and biodiversity policies" (European Union, 2024a).

There are still initiatives to modify rivers for navigation without adequately taking the environmental consequences into consideration (IGB, 2020). Since experience and evidence is increasing that reliable navigation is possible with less grey infrastructure (see the examples with removal of bank protection, modified groynes and longitudinal training walls in Austria, the Netherlands and Germany in Chapter 10.4) current practices of river engineering should be reconsidered and where possible be adapted or transformed to

minimise their environmental impact (PIANC 2018). The initiative for this should be taken by the national waterway and navigation authorities in cooperation with nature management organisations. In Austria it has been viadonau, in the Netherlands Rijkswaterstaat and in Germany the Federal Waterway and Shipping Administration (WSV), that have taken initiatives to explore the potential for reduced or novel forms of engineering in concrete projects.

This action can start immediately by reconsidering whether the engineering interventions in current or planned projects can be reduced or be made more environmentally friendly. It is essential to involve a core group of stakeholders representing both navigation and nature interests and depending on the location other relevant stakeholders as well. To what extent engineering can be done without negative environmental impact or even omitted, of course, depends on local conditions and on the potential for other types of measures to increase the reliability and efficiency of IWT. Besides grey and green river engineering measures the inland water transport sector requires another suit of measures to become more climate resilient for example adapting the fleet (e.g. shallow-water vessels to cope with smaller navigable depths during droughts), improving water depth predictions and developing real-time information sharing systems (see e.g. Van der Mark & Lemans 2020).

Less river engineering may come with a reduced cost for construction and maintenance and may help to omit negative consequences of heavy modification of rivers that are currently experienced in many engineered rivers around the world. Examples of such consequences are riverbed erosion (leading among other things to bottlenecks for navigation and an increased risk of instability of structures) and decreased robustness to cope with high water levels (Opperman et al. 2009; De Vriend 2015). It is important that such cost – benefit information is collected and analysed.

5.5 Action E: Prioritise inland waterways based on their ecological status and role for navigation

Navigation intensity is highly variable across European inland waterways, as illustrated in Figure 10 by the amount of freight handled in 2023. The intention is to increase market share transport by inland waterways by 25% in 2030 and 50% by 2050 (European Union, 2024a). Inland waterways should therefore be ranked and prioritised on their ecological status and value and role for navigation i.e. in one river navigation may have preference overachieving a higher ecological ambition while in another navigation should be subordinate (see e.g. Némethy et al. 2022). This is thus not only about implementing NbS to improve the ecological status in environmentally degraded inland waterways, but equally or perhaps moreover to put a halt to or reconsider engineering rivers for navigation that will be of little socio-economic value now and in the coming decades. In some cases, the importance of a waterway for commercial navigation – that usually dictates required waterway dimensions – has decreased over time. In these cases, it may even be possible to remove structures that have been implemented in the past for navigation, as is done in e.g. the German Blue Belt programme (Annex 10.4.3). This also links to recent efforts to remove barriers in rivers and increase the length of free-flowing river stretches, e.g. through the EU Nature Restoration Law (2024) and the EU 2030 Biodiversity Strategy. In essence this boils down to balancing TEN-T requirements for Good Navigation Status with environmental legislation (WFD, NRL, HD).

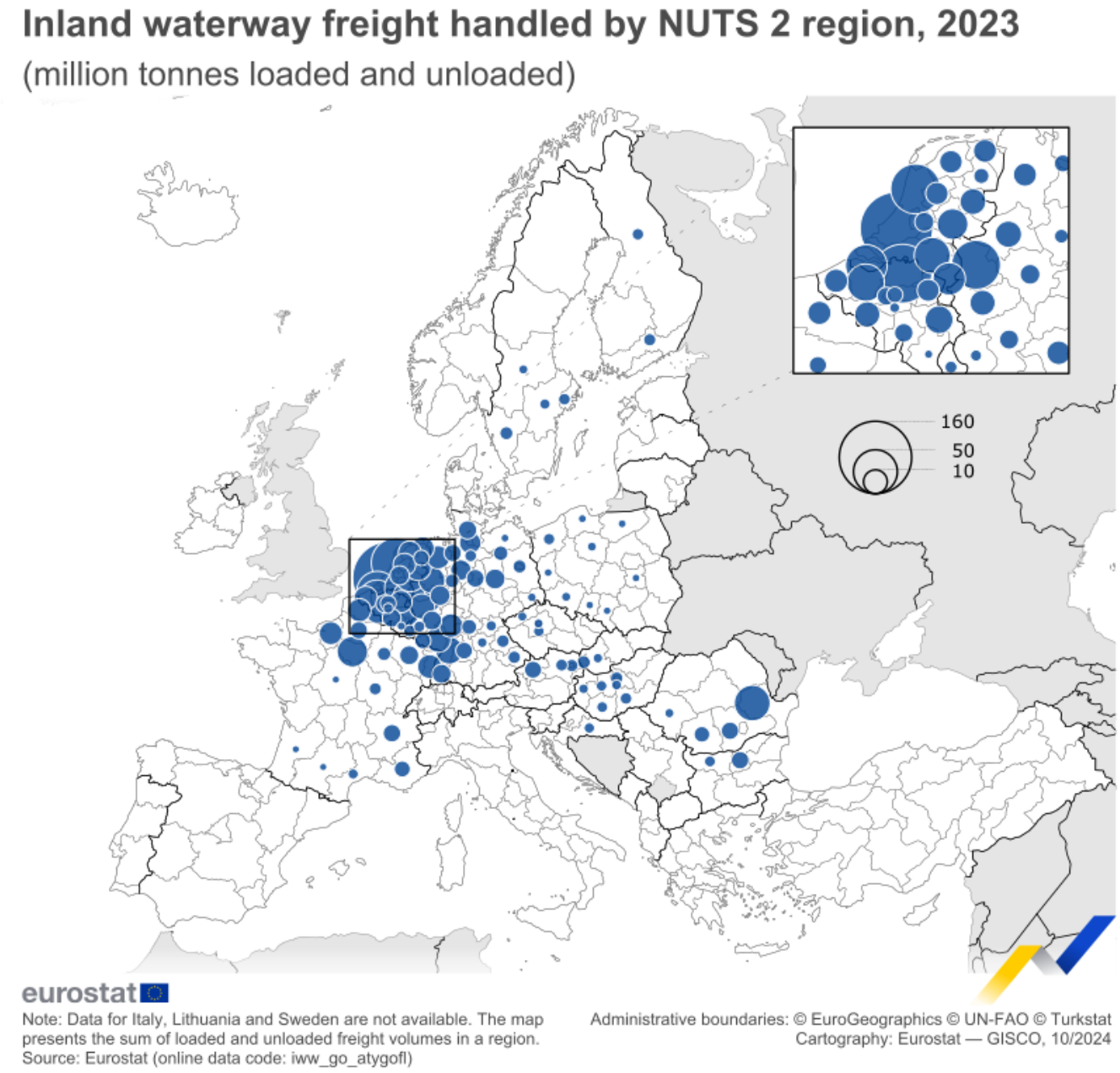

Figure 10 Navigation intensity differs substantially among European inland waterways illustrated by the freight transport volumes (Source: Eurostat)

As inland waterways are part of the trans-European network that must be safe and secure, this action requires top-down coordination that can be taken up jointly by DG Move and DG Env with contributions from national water and shipping management authorities responsible for implementing TEN-T, WFD and NRL.

This action should preferably start now to prevent further degradation of rivers in Europe for shipping without a sound socio-economic rationale, see for example the intentions for the river Oder (IGB, 2020).

6 Discussion

6.1 Cross-sectoral implications

How rivers are managed for floods, droughts, energy production, freshwater supply or navigation impacts each of these aspects as well as the ecological functioning and biodiversity of rivers. This asks for an integrated management strategy of rivers and their floodplains. This goes far beyond the scope of this navigation sector strategy, but the components - especially the cross-sectoral implications of the actions - mentioned in this strategy should serve as ingredients for an overarching integrated strategy.

6.2 Is the sector ready to transform?

As mentioned, greening inland waterways by means of NbS is still in an innovation and early adaptation phase. In other words, the urgent need is to learn from the pilot projects, collect evidence on the pros and cons of NbS, to involve stakeholders to get to know their perceptions and opinions and connect these to the projects' experiences. At the same time a parallel trajectory is needed to minimise engineering of inland waterways with undesirable environmental consequences.

Important to realise is that it will take time to build confidence within the Communities of Practice, and to collect further information on the effects of NbS in inland waterways. For proper analysis of these effects, extensive monitoring campaigns with a duration of at least several years are needed.

6.3 Financing the greening of inland waterways

Needless to say, significant funding is needed to green Europe's inland waterways. There is a need for cross-disciplinary EU co-funding for infrastructure covering transportation, climate, water and biodiversity in a synergistic approach. Connecting European Facility (CEF) has been co-funding such synergies to a certain extent, but not always coherently. Also, in the implementation of TEN-T, resources should be allocated for greening inland waterways to improve both navigability and environmental value. The German Blue Belt programme (Annex 10.4.3) is great initiative in this respect, being a long-term and nation-wide initiative to restore waterways and enhance their ecological connectivity, biodiversity, and recreational value.

Both public and private parties have responsibilities to protect and improve the environmental and ecological status of inland waterways, while maintaining safe and reliable shipping conditions. This responsibility includes a shared ambition for a future-proof and environmentally friendly mode of transport and a fair financial contribution to achieve it. This requires budgeting for the actions in Chapter 5 and scaling up the implementation of NbS in the coming decades.

Within MERLIN an initial attempt[4] has been made to identify the opportunities and barriers for the private sector to engage in restoration financing (*Table 4*) thereby addressing questions such as:

- How is the private navigation sector involved in the planning, financing, construction, and management of public waterway infrastructure?
- How does/could the sector overcome market failure (e.g. free riding) and contribute privately but collectively to the shared goods and services provided by ecological restoration and ecosystems?
- Leaving aside the aspects described under "Use of environment, natural resources, and ecosystem services", what Ecosystem Services Supply does this sector depend on if any?
- How can the sector display mutual benefits of restoration, e.g. by overall cost-benefit-analyses using (monetized) ecosystem services?

[4] The text is part of an unpublished MERLIN document prepared by Gerardo Anzaldua and Josselin Rouillard (Ecologic).

Table 4 Opportunities (O) and barriers (B) for the private sector to engage in restoration finance

Opportunities and Barriers	
It appears that inland navigation infrastructure is funded as a public good by the respective national ministries and the EU. Connecting Europe Facility 2 (CEF2) "is the EU funding instrument to achieve trans-European networks" with a budget of €25.81 billion, which is co-financing waterways (studies, works, bottlenecks, cross-border, Regional Innovation Scheme) of up to 50% of costs, or 85% for cohesion countries.	O
The sector does not seem to depend critically on functional ecosystems. Though, shared benefits between restoration and navigation can be identified and win-win outcomes can be created by means of thoughtful project design, navigation not seem to depend on riverine ecosystems to provide its essential service of passenger and cargo transport. One exception could be tourism-based passenger transport or marinas, which might depend on a pleasant landscape and wildlife.	B / O
In light of the above two points, it might be difficult to mobilize single private companies to contribute financially to restoration. In this case, asset investments with Return of Investment (RoI), might be less relevant for this sector.	B
However, port authorities may still have a strong interest in ecosystem restoration as part of green infrastructure or as part of a strategy to reduce greenhouse gases and pollution. Furthermore, a paradigm shift from conventional hydraulic engineering towards nature-based solutions can be observed.	O
The sector has an interest to prevent river incision and erosion, as these increase the need and cost for dredging. Hence, there is a financial incentive to pay for the prevention of erosion and river incision, which could be tied to restorations measures.	O
Currently major water ways (e.g. Danube and Rhine) are free of charge for inland navigation. The sector does also not contribute financially to achieve the principle of 'cost recovery' under the WFD. Tariffs or charges could help to raise money for restoration. The implementation of tariffs, however, would counter the objective to reduce transport over land (e.g. trucks, trains) while increasing water borne transport.	B
Certification schemes (e.g. for CSR) could demand payments for ecosystem restoration to certify the sustainability of inland navigation services. Current CSR/ESG commitments focus on GHG emissions without considering environmental impacts on the landscape level.	O
Enabling investment by the sector could be relevant, and is already happening to some extent through umbrella organizations (stakeholder engagements, crafting of guidelines, policy recommendations, lobby work, etc.). Stakeholder engagement and management is particularly important since local communities can object to restoration projects (e.g. fear of flooding from restored floodplains). The sector's network, knowledge, experience, etc. are potential enabling assets. For example, the sector could promote a mandatory percentage of all public project budget to fund restoration projects. Given the large budgets, this could yield substantial coverage.	O
Membership in an umbrella organization could require a fee (fixed, or relative to transport volumes/economic turnover), which is specifically used for restoration work with or without RoI. A fund with fix endowments (stocks/shares of the companies, other assets) could provide a stable and independent source of finance. This could be part of the sustainability profile that the sector is actively crafting. Umbrella organizations could also finance/enable the upscaling of restoration across the river system that they represent, or certain specialized elements thereof (usually physical elements of the river, e.g. river bank works, sediment work, etc.).	O
When damages to ecosystems cannot be fully avoided or mitigated, then the sector could pay for offsetting restoration projects. This could happen through established market places or through contractors.	O

6.4 Inland waterways for recreational navigation

Parts of the inland waterway network are predominantly or solely used for recreational purposes. This strategy can also be used for those waterways. Within the German Blue Belt programme differentiation is made regarding the importance and purpose of the waterways (commercial, recreation, use intensity) as an argument to decide on the scope for improving the ecological connectivity and biodiversity.

7 Conclusion and Next Steps

This strategy is the outcome of three round tables organised as part of the MERLIN project, followed by its drafting. The draft strategy has been commented on by representative organisations from the public and private navigation and environmental sectors. The cooperation of these sectors is required to implement the proposed strategy. The way forward has been specified in the form of five actions. It is the belief of the authors that the willingness is there. Sharing experiences is considered key to advance the application of NbS for safe and reliable inland navigation and improved ecological status.

The MERLIN project will end in March 2026 and will, in its final year, raise awareness of this strategy, organise a final round table and stimulate that the proposed actions are set into motion by the proposed target audience (see Table 4, column ‘who’).

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9 Annexes on global and European perspectives

9.1 Trans-European Transport Network (TEN-T)

The EU's trans-European transport network policy, the TEN-T policy, is a key instrument for the development of an efficient multimodal transport network across the EU. It comprises railways, inland waterways, short sea shipping routes and roads linking urban nodes, maritime and inland ports, airports and terminals.

The requirements for the TEN-T network are meant to ensure efficient and reliable transport, reduction of transport emissions and development of climate-resilient infrastructure, in line with the European Green Deal and the Sustainable and Smart Mobility Strategy.[5]

To coordinate the development of the network, nine core network corridors (CNC's) have been identified that connect member states through different modalities. The core and comprehensive inland waterway network is presented in Figure 11.

So far, studies on the environmental impact of the TEN-T policy are mainly focused on the effects on emissions (e.g. Schade et al. 2018). However, the European Commission is currently conducting a study to identify major climate resilience risks on the TEN-T. It will also identify the measures and investments needed to adapt to climate change (Bodewig & Secchi 2024).

The EU regulation on guidelines for the development of the Network (European Union 2024a) recognizes that inland waterways vary greatly in terms of hydro-morphological characteristics and suitability for navigation (through engineering measures). Therefore, requirements for inland waterways (e.g. in terms of reference water levels) are defined on a case-by-case basis, taking environmental and biodiversity policies into account as well. The regulation further states that "when building or upgrading inland waterway infrastructure, particular attention should be given to avoiding potential barriers to the connectivity of free-flowing rivers".

For this purpose, reference water levels should be established for each European Transport Corridor, waterway or section of waterway, while considering the impact of climate change. In the process of specifying reference water levels, the Commission should closely cooperate with Member States and the European Coordinators concerned and with the river navigation commissions concerned set up by international agreements to ensure a coherent approach regarding the requirements for inland waterway infrastructure with a view to promoting that mode of transport.

While the policy states that Member States must ensure Good Navigation Status for their inland waterways by 2030 (meaning a navigable depth of at least 2,5 m and a minimum height under non-openable bridges of at least 5,25 m at specified reference water levels), exemptions are possible when the Member State concerned can show that negative impacts on environment, biodiversity or cultural heritage are significant.

[5] https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en [accessed 30th October 2024]

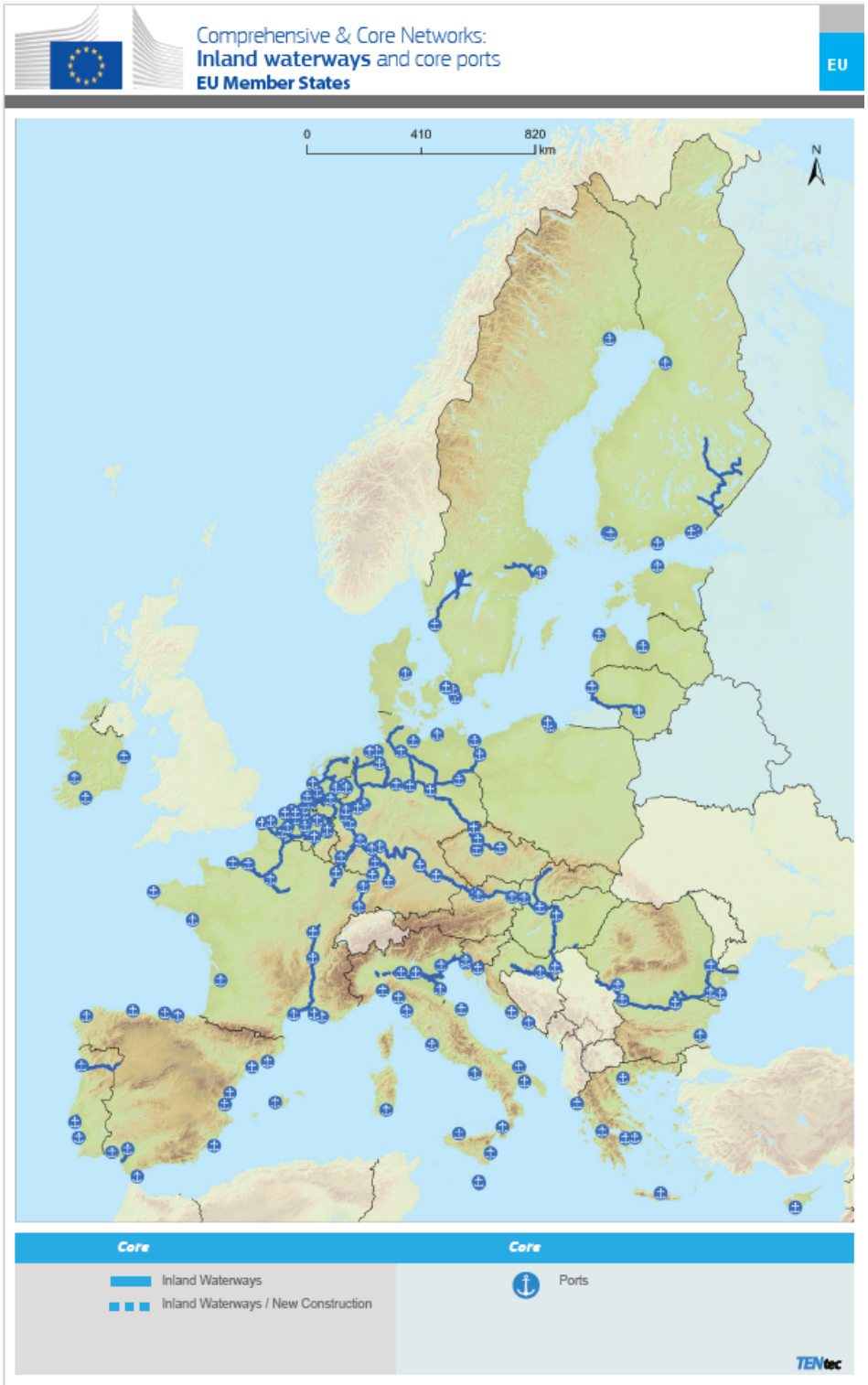

Figure 11 Comprehensive and core network of inland waterways and ports in EU member states (source: TEN-T-guidelines-2024-annex-1.pdf)

The regulation further states that “attention shall be given to promoting and developing measures to improve the environmental performance of inland waterway transport and transport infrastructure, including zero and low emission vessels and measures to mitigate impacts on water bodies and water-dependent biodiversity, in accordance with the applicable requirements under Union law or relevant international agreements.”

Reflecting on these regulations, there clearly is attention for the potential negative impacts of an increase in IWT on ecology. However, the policy does not stipulate specific requirements for measures to mitigate these negative impacts, but instead refers to applicable environmental and biodiversity policies.

9.2 UNECE

The United Nations Economic Commission for Europe (UNECE) is one of the five United Nations regional commissions. It was established in 1947 with the mandate to help rebuild post-war Europe, develop economic activity and strengthen economic relations among European countries, and between Europe and the rest of the world. Since the early 1990s the organization has focused on analyses of the transition process, using its harmonization experience to facilitate the integration of Central and Eastern European countries into the global markets. That cooperation concerns economics, statistics, environment, transport, trade, sustainable energy, timber and habitat.

"Inland water transport is a viable alternative or addition to road and rail transport on European corridors. Though environmentally-friendly and, frequently, the most economical mode of inland transport, it remains largely under-exploited in Europe."[6]

The UNECE "White Paper on the progress, accomplishment and future of sustainable inland water transport" is the third edition of a policy paper on the current situation, trends and challenges in inland water transport on European inland waterways of international importance in the region of the Economic Commission for Europe (UNECE 2020). The overall objective is to assess the current situation of inland water transport in Europe, review progress since 2011, identify current trends and challenges, and propose recommendations in key areas of pan-European cooperation to promote the development of the sector. Regarding our strategy section "Inland Water Transport and the United Nations Sustainable Development Goals" is most relevant: "Sustainable transport is safe, high-quality and accessible to all, ecologically sound, economically viable, and a positive contributor to local, national and international sustainable development. Economic, social and environmental sustainability can only be achieved through an integrated inland transport system", but focuses only reducing pollution and not on the physical environmental impacts.

9.3 NAIADES III Boosting future-proof European inland waterway transport

The policy of the European Commission to promote inland waterway transport is encapsulated in the NAIADES III Action Programme "Boosting future-proof European inland waterway transport", which comprises numerous actions and measures (European Commission 2021).

"Long recognised as one of the most CO2- efficient modes of transport (per tonnes of goods) carried along with rail, inland waterway transport (IWT) is clearly seen as central to the Union's efforts to decarbonise the transport system … The European Green called for decisive action to shift a substantial part of the freight transported by road (currently accounting for 75% of inland freight) to inland navigation and rail, namely through measures to increase the capacity of inland waterways from 2021 …. indicated that inland waterway transport and short-sea shipping should increase by 25% by 2030 and by 50% by 2050 … The already high modal share of inland waterway freight transport in some countries such as the Netherlands (42.7%), Romania (28.1%) or Bulgaria (31.8%) as well as the increasing use of inland waterway transport in urban logistics in some of the EU's most congested cities, highlight the great potential of the sector where the conditions are right … The sector also faces new challenges, such as the intensification of climate change and extreme weather events, which severely affect its ability to operate and the reliability of services, and which require adequate EU policy responses" (European Commission 2021).

Within the NAIADES III programme the relation to NbS in the inland waterway network is through the component "greening inland waterways infrastructure and ports" captured by a problem description and way forward.

- Problem: Inland waterway transport activities can exert pressure on aquatic ecosystems, mainly due to modifications in the hydro-morphology of rivers, fragmentation of ecosystems, disruption of ecological flows, or pollution of water and sediment.
- Way forward: an integrated approach is therefore essential when considering future inland waterway transport infrastructure developments, taking into account transport needs but also environmental and societal concerns, as well as the multiple functions of waterways and ports in terms of regional economic development, water supply, energy generation and biodiversity"

The action plan, however, concentrates on zero-emission and does not address this problem with NbS as an option in the form of a concrete action. So, this underpins the potential contribution this strategy can give.

[6] https://unece.org/transport/inland-water-transport [accessed 16th January 2024]

9.4 PLATINA

The EU PLATINA project and its successors PLATINA II, PLATINA3 and PLATINA4Action are aimed at promoting inland waterway transport in Europe, by coordinating and supporting the implementation of the NAIADES action programme.

Work packages are connected to the goals defined in the NAIADES action programme.[7]

1. Integration & digitalization of IWT in view of modal shift & synchromodality;
2. Zero-emission, automated & climate resilient fleet;
3. Skilled workforce anticipating to zero-emission & automation;
4. Smart & climate resilient waterway and port infrastructure with clean energy hubs.

Concerning waterway infrastructure (goal 4), an integrated approach toward design, maintenance and management is recognized as the way forward to adapt to climate change. This means (Schweighofer & Fraunhofer 2022):

- Identification of integrated project objectives incorporating inland navigation aims, environmental needs and the objectives of other uses of the river reach such as nature protection, flood management and fisheries;
- Integration of relevant stakeholders in the initial scoping phase of a project;
- Implementation of an integrated planning process to translate inland navigation and environmental objectives into concrete project measures thereby creating win-win results;
- Conduct of comprehensive environmental monitoring prior, during and after project works, thereby enabling an adaptive implementation of the project when necessary.

PLATINA aims to inform inland waterway and port infrastructure managers on best practices regarding this approach, by collecting existing guidelines and producing manuals, such as:

- Manual on Good Practices in Sustainable Waterway Planning (ICPDR 2010)
- Good Practice Manual on Inland Waterway Maintenance. Focus: Fairway maintenance on free-flowing rivers (viadonau 2016)

In terms of river engineering measures, a mix of 'green' (nature-based) and 'grey' (traditional engineering) solutions is thought to be most suitable to reach the objectives of different stakeholders (Schweighofer & Fraunhofer 2022).

9.5 PIANC

PIANC is the World Association for Waterborne Transport Infrastructure. PIANC is a non-political and non-profit organisation that brings together international experts to issue technical reports covering a wide range of topics related to sustainable waterborne transport infrastructure. PIANC has four technical commissions of which the Environmental Commission (EnviCom) and the Inland Navigation Commission (INCOM) are most relevant for the MERLIN navigation sector strategy. EnviCom is responsible for dealing with both broad and very specific navigation sustainability and environmental risk-related issues and has task groups on climate change and the EU Water Framework Directive and the topic Working with Nature, which has resemblances with NbS[8]. The work of EnviCom is relevant to raise awareness among the members of its association for the environmental impacts of inland water transport and developing and providing environmental guidance supporting the waterborne transport infrastructure sector to strive for sustainability.

The WFD navigation task group prepared a position paper on the proposed EU nature restoration law (NRL) to emphasize that both safe and environmentally friendly transport and restoring biodiversity are Green Deal ambitions. They state that a synergistic approach is therefore required, and the proposal must be balanced, proportionate and pragmatic in both its objectives and its implementation (PIANC WFD NAVI 2023).

EnviCom has produced several relevant reports: “Guidance on Applying Working with Nature to Navigation Infrastructure Projects” (PIANC 2018), “Climate Change Adaptation Planning for Ports and Inland Waterways” (PIANC 2020), “An introduction to applying ecosystem services for waterborne transport infrastructure

[7] https://platina3.eu/what-we-do/ [accessed 30th October 2024]

[8] https://www.pianc.org/commission/environmental-commission/ [accessed 30th October 2024]

projects" (PIANC 2021) and "Waterborne Transport, Ports and Waterways: A 2023 Update of Climate Change Drivers and Impacts" (PIANC 2023). Earlier INCOM published Considerations to Reduce Environmental Impacts of Vessels (PIANC 2008).

PIANC (2023) Waterborne Transport, Ports and Waterways: A 2023 Update of Climate Change Drivers and Impacts. EnviCom TG 3

This report, prepared by members of PIANC's Permanent Task Group on Climate Change, updates PIANC TG 3 (2008) with the improved climate change knowledge as of late 2022. The update presents an overview of the key messages regarding, the projected climate change impacts on maritime and inland navigation including from changes in air and water temperature, sea level rise, wind conditions, wave action, tidal and surge propagation and range, ocean circulation, storms, coastal hydrodynamics, ice conditions, icing, water supply and quality in inland rivers, extreme hydrological conditions, and coastal, estuarine and river morphology. Relevant chemical and biological changes and their potential implications for navigation are also discussed. The need for adaptation responses and measures to strengthen resilience is highlighted.

PIANC (2020) Climate Change Adaptation Planning for Ports and Inland Waterways. EnviCom WG 178

Ports and waterways around the world are experiencing air and water temperature increases, rising sea levels, and changes in parameters such as seasonal precipitation, wind and wave conditions. Many are also seeing more frequent and severe extreme events including storms, heatwaves and droughts. Climate change represents a significant risk to business, operations, safety and infrastructure – and hence to local, national and global economies. Waterborne transport infrastructure will be adversely affected. Port and waterway operators need to take urgent action to strengthen resilience and adapt.

The guidance, which has been prepared by the international experts on PIANC's Working Group 178, provides an introduction to the potential consequences of climate change and some of the challenges to be addressed if ports and waterways are to adapt effectively.

It then introduces a four-stage methodological framework to help port and waterway owners and operators plan for improved resilience:

- Stage 1 facilitates understanding of how assets, operations and systems could be impacted and who should be involved in identifying climate change adaptation requirements
- Stage 2 identifies the type of climate-related information needed to prepare an adaptation strategy, and explains how reference to climate change 'scenarios' can assist in understanding the range of possible future changes
- Stage 3 describes how the vulnerability of waterborne transport infrastructure assets, operations and systems can be assessed and a risk analysis undertaken
- Stage 4 presents a 'portfolio' of potential measures (structural, operational and institutional) to be considered when developing an adaptation pathway.
- Sixteen international good practice case studies are appended to the guidance, along with various templates to be used for data collection and record keeping.

This guidance also provides methodological support to the recent PIANC Declaration on Climate Change[2], enabling PIANC's members and the wider navigation infrastructure community to take timely action to strengthen resilience, and adapt port and waterway infrastructure and operations to the effects of climate change, and fulfils an action in the adaptation strand of the Navigating a Changing Climate[3] partnership's Action Plan, to develop and deliver technical guidance on climate change adaptation.

PIANC (2021) An introduction to applying ecosystem services for waterborne transport infrastructure projects. EnviCom WG Report 195 – 2021.

This report provides an introduction to the Ecosystem Services (ES) concept for people actively involved in Waterborne Transport Infrastructure (WTI) projects. Such projects interact with the natural environment in which they are developed, and thus they have a direct bearing and dependence on the capacity of the natural environment to supply ES. This report provides an understanding of the ES concept, elaborates its relationship to WTI projects, outlines its methodological basis, demonstrates the application of the ES concept in real-life WTI case studies, and makes recommendations for their implementation in ongoing and future WTI projects. The potential benefits of integrating ES in the deployment, planning, design and/or maintenance of WTI projects include the enhancement of positive effects on the surrounding natural and socio-economic environment, use of natural processes to obtain functional benefits, e.g. reduced maintenance dredging, and facilitation of the consent process and stakeholder dialogue. It introduces the ES cascade, linking biophysical

structure and function to ES, human benefits and values, and ecosystem use in decision making. It introduces an ES classification, emphasising the need to consider not only ES provided by living systems but also abiotic services essential to WTI. It defines the role of ES concepts within various types of decision making.

PIANC (2018) Guidance on Applying Working with Nature to Navigation Infrastructure Projects. EnviCom WG Report 176 – 2018.

Preparing guidance that raises awareness of natural ecosystems, inspires the navigation infrastructure community to embrace natural systems design and promotes expanded acceptance of the Working with Nature (WwN) approach by providing a selection of case studies to illustrate how WwN applies to navigation infrastructure projects and identifies associated tools, steps and practices. WwN offers a framework to design new infrastructure or rehabilitate existing infrastructure in a way that works with natural processes, such that the measures benefit both navigation and nature. This approach serves to enhance ecosystem viability and resilience and minimise negative anthropogenic impacts to the environment ... While it is possible to implement WwN at virtually all project phases, incorporating WwN during conception, design, and early implementation provides the most promising opportunities to affect positive outcomes for the environment. Greater effort is generally needed to introduce WwN concepts later in the design process. A holistic understanding of ecosystem structures and processes makes it possible to minimise ecosystem degradation and enhance ecosystem functions on a local, regional or watershed scale.

PIANC (2008) Considerations to Reduce Environmental Impacts of Vessels. InCom Working Group 27.

Balancing the needs of the natural waterway system with the development of inland navigation as a viable and environmentally friendly mode of transportation was the driving motivation to establish the Working Group 27. As traffic demands increase and the public interest in conserving natural systems grows, it is important to understand and quantify the effects of passing vessels and determine the relationship of these physical effects to the aquatic ecosystem. Several key drivers have brought this subject to the forefront of inland waterway transport, calling for the best practices in evaluation, design, and operation of safe, dependable and environmentally sustainable waterways.

9.6 Inland Navigation Europe

Inland Navigation Europe (INE) is the platform of national and regional waterway authorities and bodies promoting waterway transport. The mission of INE is to make transport by water clean and efficient, keeping in mind the multi-functionality of waterways.

INE supports the Working with Nature initiative of PIANC, and is committed to 'develop nature based solutions or green infrastructure where possible and grey infrastructure when necessary'[9].

With respect to climate adaptation, INE believes stronger EU action is required to help increase climate preparedness. According to INE, climate adaptation of the waterway infrastructure should have the same priority as climate mitigation of the waterborne fleet, and more research is needed to develop effective nature-based solutions for inland waterways. They also urge to avoid silo thinking in climate funding, as inland waterways are (contrary to road and rail) multifunctional.

[9] https://www.inlandnavigation.eu/eu-topic/climate-change/ [accessed 30th October 2024]

10 Annexes on river basin and national bottom-up initiatives

10.1 Joint statement "Development of Inland Navigation and Environmental Protection in the Danube River Basin"

This Joint Statement aims to provide guidance to decision makers dealing with inland waterway transport (IWT) and environmental sustainability as well as to water managers preparing relevant riverine environmental and navigation plans, programmes and projects. The process to develop the Joint Statement has been initiated by the International Commission for the Protection of the Danube River (ICPDR), Danube Commission (DC) and the International Sava River Basin Commission (ISRBC) (ICPDR, DC & SRBC 2007, ICPDR 2010b).

The intention of the Joint Statement was to address potential conflicts of interest and synergies between EU directives related to river ecosystems - in particular the EU Water Framework Directive - and EU directives in the transport sector. In particular the Trans-European Transport Networks (TEN-T) Directive provides for the expansion of inland waterway transport as a comparatively environmentally friendly mode of transport.

In 2007, an intensive cross-sectoral discussion process took place between ecology and navigation along the Danube. The results were summarised in the Joint Statement (Figure 12 left). This is a guiding document for the maintenance and development of the Danube waterway, taking ecological concerns into account. In this way, existing EU legal bases and interdisciplinary planning approaches, such as those already applied in Austria, were publicised in the Danube region.

Since the decision was taken by the three commissions, follow-up meetings have been held approximately every year. This should ensure that the established platform for dialogue between advocates for the environment and the navigation sector is not lost again.

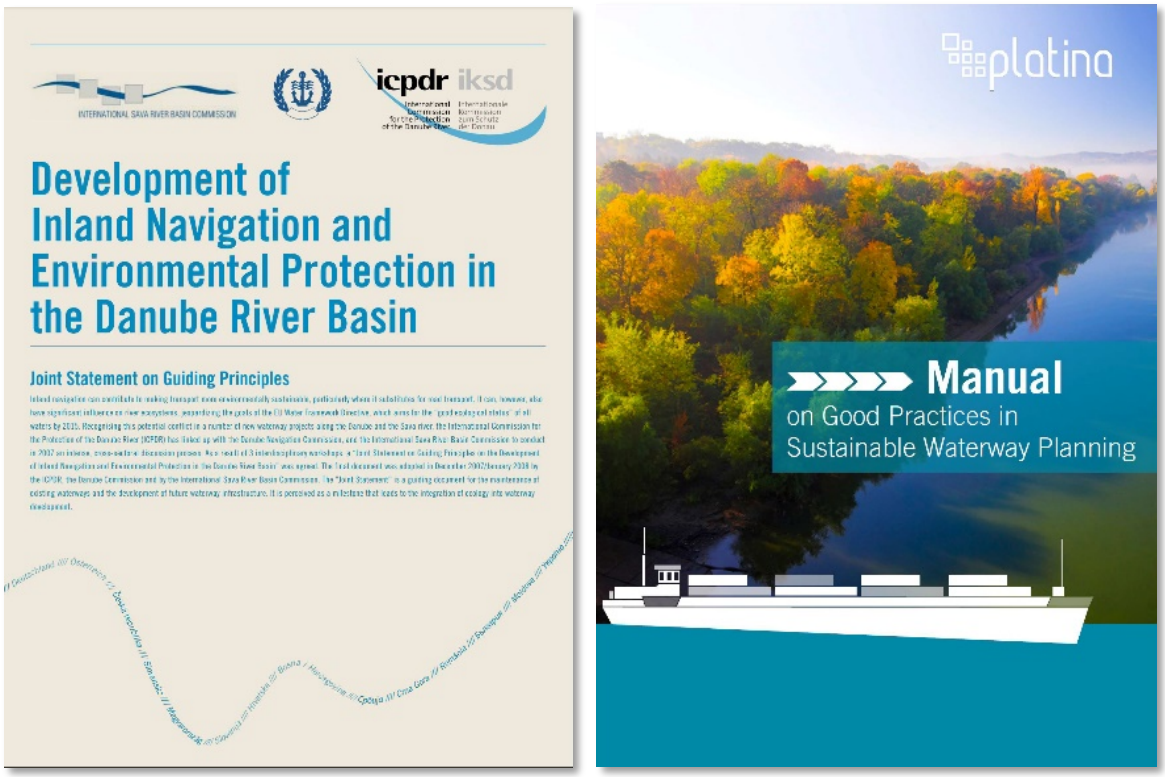

Figure 12 The covers of the Joint Statement (ICPDR, DC & SRBC, 2007) and the Manual on Good Practices in Sustainable Waterway Planning (ICPDR, 2010a)

The Joint Statement subsequently formed the basis for further cross-sectoral cooperation. As part of the PLATINA projects (realized under the FP7- Seventh Framework programme for Research and Technological Development 'TRANSPORT' 2007 – 2013, see Annex 9.4), it was possible to build on the preliminary work of the Joint Statement. The PLATINA projects served to implement the NAIADES action programme, with which the EU Commission aims to promote Inland Waterway Transport.

In PLATINA I, a manual for the integrative planning of hydraulic engineering projects was created (ICPDR, 2010a; Figure 12 right). In this process, the contents of the Joint Statement were updated and operationalised, making it directly applicable to waterway managers. Good practice projects were to inspire environmentally friendly or at least less harmful solutions. In PLATINA II, a similar manual was drawn up for maintenance activities on waterways that had not yet been focussed on to this extent (viadonau 2016).

Another follow-up activity of the Joint Statement is METEET (Section 10.2).

In 2024, the three river commissions initiated a process to fundamentally revise and update the original Joint Statement.

10.2 METEET

The purpose of the Mixed Environment Transport External Expert Team (METEET) is to assist and coordinate with regional inland waterway transport authorities, on a voluntary basis, and to develop and foster an integrated and environmentally friendly approach to infrastructural projects in the field of inland navigation. Key organisations are DG Move (also providing financial support), DG Env, DG REGIO, CINEA (Climate, Innovation and Networks Executive Agency; previous INEA), ICPDR and the Danube Commission. METEET organises workshops with changing topics relevant to environmental legislation requirements, climate resilience and inland navigation. Minutes of a number of the workshops can be found on the website of the Danube Commission.

- 2023 online workshop on the climate resilience of inland waterways and ports
- 2021 online workshop environmental legislation requirements and inland waterway navigation projects
- National workshops (Romania 2020, Bulgaria (2020), Ukraine (2021)
- Previous workshops were held in September 2017 in Vukovar (Croatia), June 2018 in Belgrade (Serbia), and April 2019 in Bratislava (Slovakia), November 2019 in Budapest (Hungary).

10.3 Danube Stream

Building on preceding projects NEWADA and NEWADA duo, the Interreg project Danube STREAM further improved transnational cooperation between waterway authorities and harmonized waterway management along the Danube corridor[10]. As part of the project a practical manual for environmentally sound waterway management has been made. It contains a model for an integrated planning process, framework for practical application and examples of integrated planning from Austria, Germany, UK and Belgium (Muilerman & Kempter 2018).

The manual focuses on the interface between waterway maintenance and rehabilitation activities on the one hand, and nature conservation, restoration and developments on the other. In terms of legislation, the aim is to create integrated projects that ideally allow the achievement of good navigation status (GNS, TEN-T Regulation), Good Ecological Status (GES, Water Framework Directive) and Favourable Conservation Status (FCS, Habitats Directive) at the same time (Figure 13).

[10] https://www.viadonau.org/en/company/project-database/aktiv/danube-stream-smart-integrated-and-harmonised-waterway-management [accessed 30th October 2024]

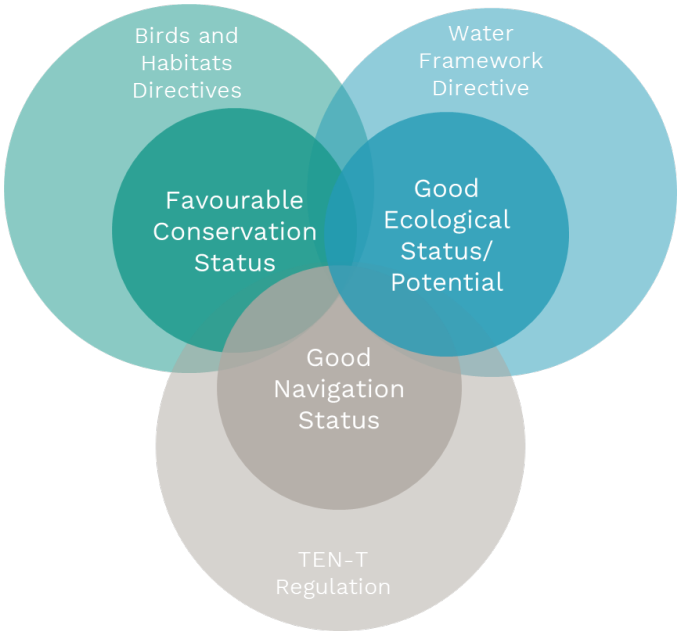

Figure 13 Interaction between FCS, GES and GNS. Source: Muilerman & Kempter (2018).

The manual states that waterway management in the Danube region has already shifted from a navigation-only perspective to a more integrated approach over the last decade, but that the application of the integrated approach as proposed by the Joint Statement (see Chapter 3.2.1) is varying between authorities. One of the objectives of the manual is therefore to share knowledge and experiences on integrated waterway maintenance.

The proposed model for an integrated planning process (Figure 14) can be used as a checklist for the required steps, but does not contain analyses or recommendations that are generally applicable, because the specifics of each site determine which measures and actions are appropriate.

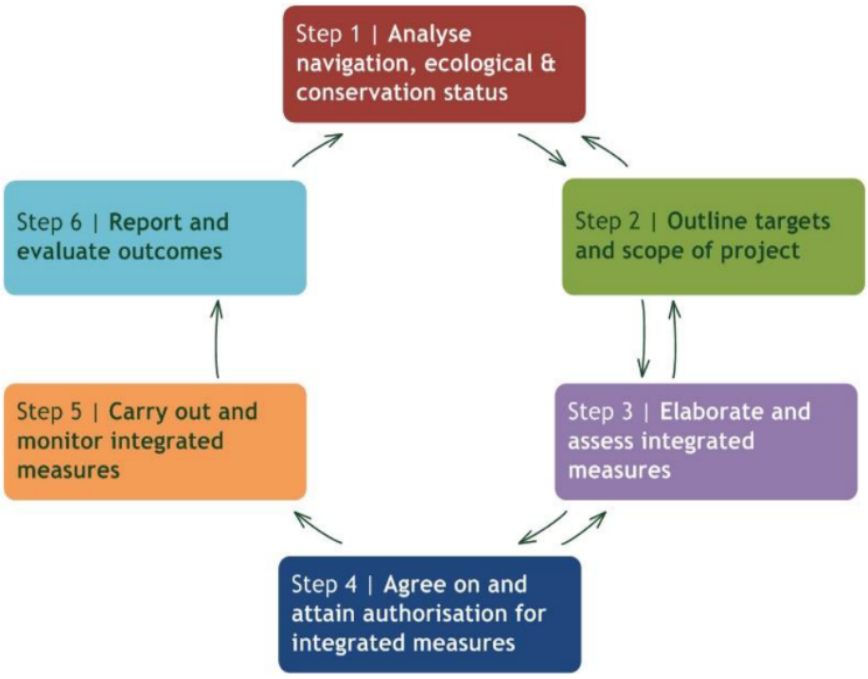

Figure 14 Model process to achieve GNS, GES and FCS. Source: Muilerman & Kempter (2018).

10.4 NbS examples in large navigable rivers

10.4.1 Danube (AT) : Integrated River Engineering Project

The Integrated River Engineering Project aims to achieve both Good Navigation Status according to the TEN-T Directive and Good Environmental Status according to the Water Framework Directive on the free-flowing section of the Danube east of Vienna. The approach by the Austrian waterway company viadonau covers a multitude of river engineering measures designed to stabilize the decrease in water levels, preserve the unique habitats of the Danube floodplains and create a waterway infrastructure that fulfils the requirements of safe and economic navigation.

These objectives are not being achieved through a single large-scale project, but through a Catalogue of Measures that has been implemented step by step since 2018 (viadonau 2018). The individual river-engineering and monitoring measures were previously developed in a concept and pilot project phase lasting several years.

Viadonau´s integrative approach started already when the objectives for the Danube section were defined and has accompanied the detailed planning and implementation of the individual measures to this day. Whereas at the beginning the focus was on the interdisciplinary development of solution strategies and guiding principles, today it is stakeholder participation through a specially established Stakeholder Forum. The forum agreed on a joint mission statement for the development of the Danube east of Vienna, which was negotiated between the shipping industry and the environment.

The following types of measures will be implemented:

- Integrative bedload management to counteract river bed erosion, which is mainly caused by the disturbed bed load balance caused by hydropower plants, but also by river regulation.
- Optimisation of regulating structures in order to create safe and reliable fairway conditions for shipping. However, it is also necessary to reduce excessive regulation from today's perspective in order to minimise its contribution to the erosion of the river bed. Innovative construction methods allow new or remodelled groynes to be better integrated into the river habitat (Figure 15).

Extensive renaturation measures are being implemented where there is the greatest need for action from an ecological point of view - in the hydro-morphological improvement of the river habitat and the floodplain:

- Side-arm reconnection to reconnect previously separated and gradually silting up side-arms to the main stream (Figure 16).
- Riverbank restoration in order to preserve natural bank structures again. The dismantling of the hard bank structures is taking place where the circumstances, such as the existence of infrastructure, allow it.

The widening of the course of the river and the division of the flow also contribute to the goal of stabilising the river bed and help to preserve the Danube floodplains as a retention area.

Figure 15 Instead of eight traditional groynes, only four innovative groynes regulate the Petronell-Witzelsdorf ford. They were combined with bank restoration. The picture shows the situation with low water. © viadonau/Zinner

Figure 16 The Spittelauer side-arm was reconnected 2021 in the framework of Dynamic LIFE Lines Danube project. © viadonau

The Catalogue of Measures is understood as a learning system. In addition to individual monitoring programmes at measure level, an overarching scientific support system has been set up. In this way, a high degree of impact-orientation is achieved and the findings from the implementation of measures contribute to

the improvement of follow-up implementation steps. In this context, the Christian Doppler research laboratories are particularly worth highlighting. CD SED deals with abiotics, CD MERI with biotics. Both research laboratories were set up at the University of Natural Resources and Life Sciences in Vienna and operated together with partner organizations.

The MERLIN Case Study CS7a is a measure for structuring the banks of the Danube and is both part of the implementation of the Catalogue of Measures and a contribution to the scientific support of the work on the Danube east of Vienna.

10.4.2 River Meuse (NL): large-scale removal of bank protection

In the Dutch stretch of the River Meuse Rijkswaterstaat already started to remove bank protection around 2008 as part of a measure to improve the ecological status for the Water Framework Directive. The removal of riprap depending on local conditions was either complete or partial. It comprises dozens of projects which had by 2019 together a total length of about 60 km. The ecological (both terrestrial and aquatic fauna and flora) and morphological development of a subset has been monitoring for a period of 10 years (Buijse et al. 2019; Chrzanowski et al. 2019). The following conclusions could be drawn:

- Regarding their morphological development: most sites in initial succession state of bank erosion had obtained an increased habitat diversity of riparian zone.
- The location of riverbank plays a crucial role for erosion rate, and it affected by water level fluctuation, bank height, intensity of navigation, flow velocity, channel width, inner/outer bend, and substrate.
- For ecology: both aquatic and terrestrial biota benefit. However, both impoundment and navigation constrain aquatic ecology (rheophiles, densities). Fish show a rapid response. For aquatic vegetation there is a time-lag, while substrate dictates for benthic invertebrates the species community. Also, terrestrial biota benefit e.g. the characteristic sand martin.
- 10 year monitoring may sound long, but many factors influence development (location, design)
- Before-After- Control-Impact (BACI) monitoring yielded improved understanding, but no hard statistical conclusions could be drawn due to the diversity in local conditions.

By the choice where and how to remove bank protection the anticipated consequences for navigation and excessive shoreline erosion are considered. The monitoring programme did not include collecting the effect on navigation. No significant complaints have been received from commercial shipping about the nature-friendly banks along the Meuse.

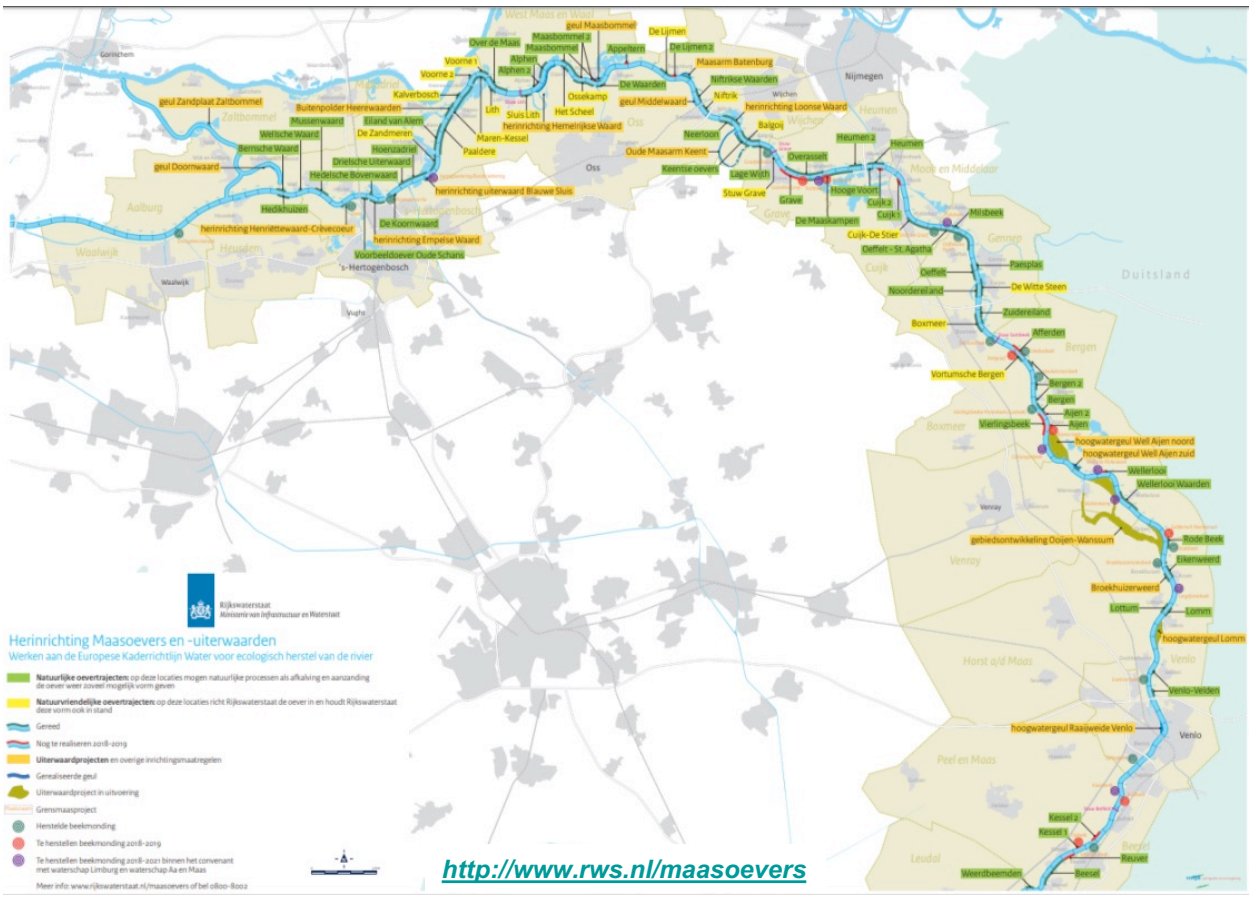

Figure 17 Locations along the Dutch stretch of the river Meuse where the rip-rap bank protection has been (partially) removed.

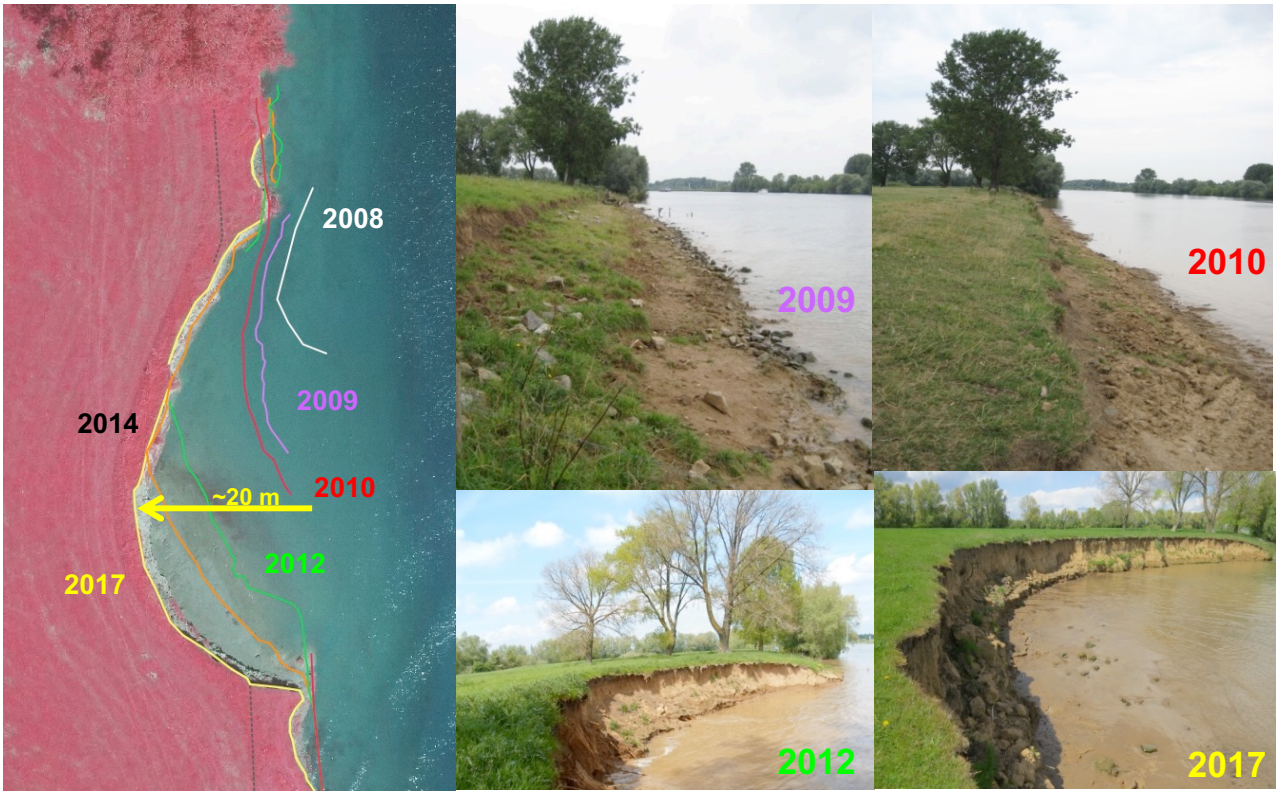

Figure 18 Shoreline erosion (2008 - 2017) following the removal of bank protection (Noordereiland, river Meuse)

Figure 19 There have been no serious complaints received from commercial shipping about the removal of bank protection in the river Meuse.

10.4.3 Germany's Blue Belt (D): restoration of federal waterways and floodplains

Germany's Blue Belt (Blaues Band Deutschland) programme is a joint initiative of the Federal Ministry for Digital and Transport (BMDV) and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection (BMUV). Its aim is to restore federal waterways and adjacent floodplains in Germany that are no longer required for commercial navigation. Since inland waterway transport in Germany is nowadays mainly concentrated on major rivers and canals, many secondary waterways are underused. By restoring these waterways, ecological connectivity, biodiversity, and recreational value can be significantly enhanced. Measures include the removal of obsolete infrastructure, the reconnection of floodplains and the creation of structural variability by implementing e.g. gravel bars and varied bank profiles.

On the waterways with high navigation intensity, restoration measures are implemented as well, but these are tailored to comply with navigation requirements. Examples are:

- removing bank protection, when there is sufficient distance between bank and navigation channel;
- replacing rip-rap with natural materials such as willow revetments, when wave action is too severe for complete removal of bank protection;
- reconnecting oxbow lakes and side channels, above mean water levels, such that sufficient navigable depth is maintained.

Through pilot projects, experience was gained on successfully balancing navigation requirements and ecological goals. One of the challenges during this phase was to clearly define the mandate, role and responsibility of each of the partners involved, especially the Federal Waterways and Shipping Administration (DE: Wasserstraßen- und Schifffahrtsverwaltung des Bundes, WSV), that was in charge of the implementation of the pilot projects. It was concluded that changes in the legal framework are needed to accommodate this.

The goal is to finish implementation of the programme largely by 2050.

Figure 20 The network of inland waterways: the "Blue Belt" in Germany; © WSV

10.4.4 Rhine (NL): Longitudinal training walls

The river Waal is the main branch of the river Rhine in the delta in the Netherlands. It has been trained with groynes in the 19th century to reduce flooding risk due to ice jams and to improve navigability. The resulting narrower main channel, however, has triggered bed erosion and lowered low-flow water levels at a rate of metres per century with increasing adverse effects. For instance, hydraulic structures become unstable, pipeline and cable crossings are exposed, obstacles appear for navigation, and inundation depths and frequencies of floodplain and wetland habitats are reduced.

Figure 21 Over a length of 10 km the river Waal is split in two parallel channels, separated by a longitudinal training wall (Photo: Rijkswaterstaat).

To mitigate the adverse effects while maintaining the benefits of river training, Rijkswaterstaat launched the idea of a new system of river training. It replaces the existing system of a single main channel between groynes by two parallel channels, separated by a longitudinal training wall (Figure 21; Figure 22). To test this new system, Rijkswaterstaat implemented a 10-km long pilot with three longitudinal training walls in the river Waal in the years 2014-16. Before, during and after implementation, an extensive monitoring and research programme was executed by the WaalSamen partnership consisting of Rijkswaterstaat, Koninklijke BLN-Schuttevaer, Sportvisserij Nederland, Hengelsportfederatie Midden-Nederland, Deltares, and the universities of Nijmegen, Wageningen, Delft and Twente (Mosselman et al. 2021).

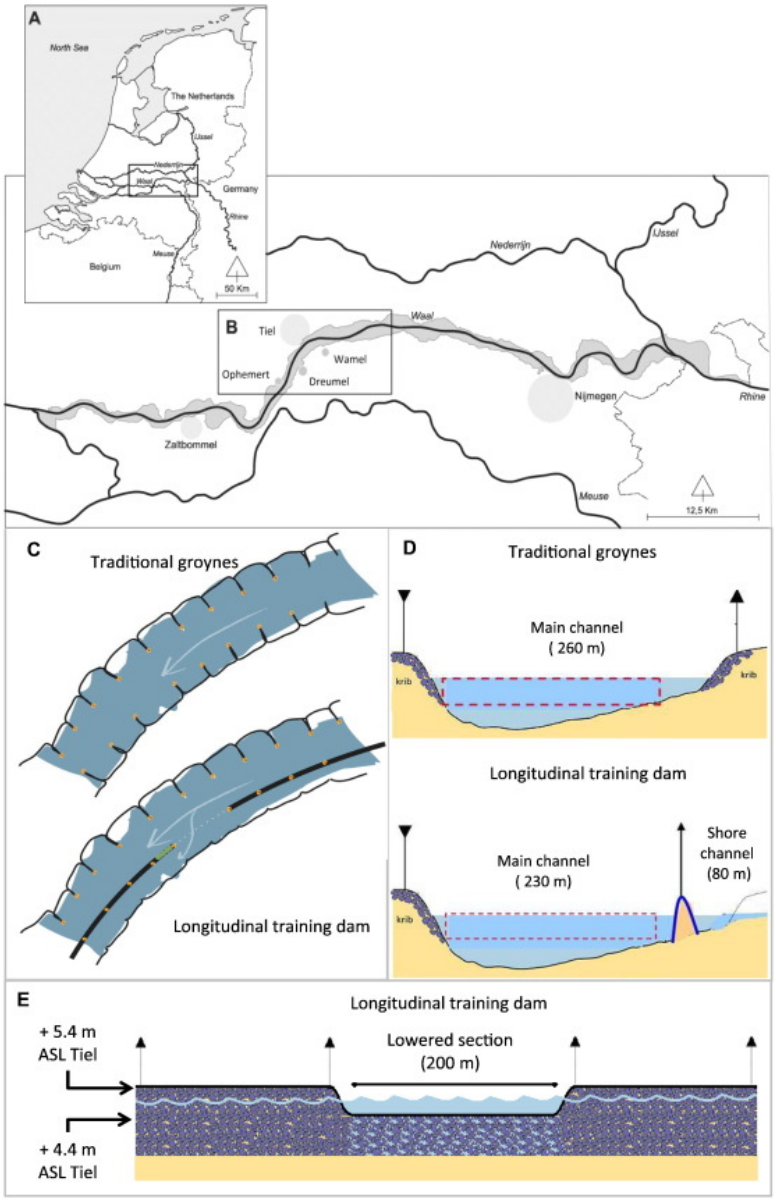

Figure 22 Schematic presentation of the replacement of traditional groynes by longitudinal training walls (Source: Collas et al. 2017)

The new system was found to improve navigability at low flows if applied in reaches of least available depth. Moreover, it was found to sustain long-term navigability by countering the ongoing overall incision of the river bed. After implementation of the pilot, the waterway continued satisfying the international navigability standards. The pilot substantially improved the quality of nature in the reach of the training walls (Collas et al. 2017). The walls lowered design flood water levels at least as much as the groyne lowering previously planned in this reach. A modestly positive effect was found on freshwater supply during droughts. Participation of stakeholders in the monitoring and research programme was found to have increased support and appreciation for the pilot.

The conclusion is that the system tested in the pilot opens perspectives for integral solution of several river problems. It performs better than the old system with groynes thanks to spatial diversification through separation of functions. No unforeseen negative impacts have surfaced. A longer pilot reach monitored over a longer period would be required for solid conclusions about the extent to which the new system solves all river problems, but at any rate it offers more space for further improvements in the future than the old system.