IDES

Improving water quality in the Danube River and its tributaries by integrative floodplain management based on Ecosystem Services

DTP3-389-2.1 – IDES

1 July 2020 – 31 December 2022

From integrative floodplain management based on Ecosystem Services to better water quality

The IDES Strategy

Output O.T 3.2

Strategy for integrated water quality management in the Danube region

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Abbreviations

BG	Bulgaria
DPSIR	Drivers-Pressures-State-Impact-Response
DRB	Danube River Basin
DRBMP	Danube River Basin Management Plan
DTP	Danube Transnational Programme
ES	Ecosystem Services
EU	European Union
FCIM	Fuzzy Cognitive Mapping
HD	EU Habitats Directive
HR	Croatia
HU	Hungary
ICPDR	International Commission for the Protection of the Danube River
MONERIS	Modelling Nutrient Emissions in River Systems
N	Nitrogen
NBS	Nature-based Solution
P	Phosphorus
RO	Romania
SWMI	Significant Water Management Issues
SZIU	Széchenyi István University
TN	Total Nitrogen
TP	Total Phosphorus
UD	University of Debrecen, Hungary
UPS	University of Public Service, Hungary
WFD	Water Framework Directive

0. Output Factsheet O T3.2 “Strategy to implement the IDES approach”

Summary of the output
The Output OT3.2 IDES Strategy is based on all technical work packages of the IDES project and especially on the transnational stakeholder workshop (OT3.1). With this output, the strategy for an integrated water quality management in the Danube region was developed. The target groups are mainly decision-makers and planners both at the Danube region level and at national levels. The strategy first gives an overview of the IDES project, focusing on the challenges in the DRB and the IDES objectives. Starting from an analysis of the existing situation (potentials and deficits) for water quality, ecological status and provision of ecosystem services, the current pressures and possible measures for the Danube region were described. Best practice examples in the pilot areas how to implement the ES approach (selection of ES, assessment of ES, DPSIR framework, stakeholder involvement) were given. Necessary actions for water quality management are defined at different levels (local, national, Danube-wide). The strategy also includes an analysis of the national legal and political framework conditions and the integration of ES in the public planning processes (public involvement, cross-sectoral consultation) of the participating Danube countries. It ends with recommendations for actions in decision making and planning. The strategy was made available to all gathered stakeholders through the IDES website, a permanent DOI and in brief together with the IDES Manual as extended summary. It was promoted during all capitalization’s events and the final conference. This output will serve the SO 3, as it defines the strategic goals at the national levels, thus complementing the transnational picture.
Contribution to EUSDR actions and/or targets
Within the EUSDR this output addresses the two priority areas PA4 and PA6. It contributes to the PA 4 target "Reduce the nutrient levels in the Danube" by providing a strategic way of where and how potential nature-based solutions are able to retain nutrients. It promotes sustainable floodplain management both at the local/regional and national/Danube-wide level. The IDES strategy contributes to the PA6 target "ecosystems and their services" as it improves the so far developed way of the implementation of the ecosystem service approach valorising water related ecosystem services in the Danube region and demonstrates the way of its practical and legal implementation. Additionally, this output contributes to PA5, as integrative floodplain management is promoted and flood retention is a ubiquitous task along rivers, thus, flood prevention must be integrated in all sustainable planning and decision making in floodplains, too.

Integration and use of the output by the target group
The target group of this output are key actors in water management at the national and transnational level. The experience with this target group and their expertise was included in the development of the output during the transnational stakeholder workshop (O T3.1), the final conference and meetings of several icpdr expert and task groups. The target group was very interested in the topic and the provided methods which makes the uptake and use of the IDES strategy possible.
Geographical coverage and transferability
The IDES strategy covers the entire Danube region and focuses both on the basin and the national level. Potentials and deficits were described for several rivers (e.g. Danube, Tisza, Sava, Yantra, Mura), recommendations were made for three levels (additionally the local/regional level). Thus, the results were applicable in the entire Danube region. The methods are also transferable to other regions beyond the Danube region.
Durability
The aim of the IDES strategy was to synthesize the gained knowledge and sketch a way on how to implement the ES approach in the Danube region in the future. This should increase the transferability of the achieved results and finally their durability. Its publication with a permanent DOI provides an easy access to the IDES Strategy and makes the durability of the output even easier and will guarantee the visibility and foster the uptake of the IDES method by all interested parties. Furthermore, the durability and transferability will be assured by the exchange of experience between PPs, ASPs and the stakeholders. All Outputs are permanently available: https://www.interreg-danube.eu/approved-projects/ides/outputs , the IDES Strategy has additionally the DOI: https://doi.org/10.17904/ku.edoc.31281
Synergies with other projects/ initiatives and / or alignment with current EU policies/ directives/ regulations, if applicable
The Output contributes to the implementation of the EU Water Framework Directive in the Danube River Basin by demonstrating a strategy on how to establish integrative floodplain management to the benefits of society. The clear aim is to foster the implementation of the recently published ICPDR Danube River Basin Management Plan and to promote integrative water quality management. The Danube wide cooperation in the IDES project and the intensive discussion with stakeholders at several levels will initiate further transboundary cooperation in water management, and thus support the aims of ICPDR activities (esp. expert groups "River Basin Management", "Pressures and Measures", therein Task Groups “Nutrient” and “Hydromorphology”). The replication and harmonization of the method will enable water managers to figure out synergies between various sectors, e.g. flood risk management, nature conservation, tourism. Thus, the IDES approach will also support the implementation of the Floods Directive and of the Habitats and Birds Directive and will foster nature-based solutions and restoration measures in line with the EU biodiversity strategy including the EU Green Deal and the

target to restore 25,000 km of free-flowing rivers, among others by restoration of floodplains and wetlands.
Output integration in the current political/ economic/ social/ technological/ environmental/ legal/ regulatory framework
The aim of the output was to reflect on the IDES results and link them to the current political, legal, social and environmental framework. For this, the status quo (legal, political and ecological) as well as the needs and requirements of various stakeholders were precisely analysed. As final output of the IDES project, it describes the integration into the current political, environmental and regulatory framework. Certainly, the developed evaluation framework and the stakeholder integration is based on existing assessments such as the water frame work directive and meets the objectives of the EU 2030 Biodiversity strategy (restoration of floodplains and wetlands) as well as the EU Biodiversity strategy 2020 (map and assess the state of ecosystems and their services). The IDES strategy has the potential to foster cross-sectoral management of ecosystems in line with many EU (WFD, HD, BD, FD…) and national policies and the acceptance of nature-based solutions for water quality actions to reach the objective of 25,000 km restored rivers in the EU.

I. Introduction

Tim Borgs, Andreas Gericke, Bernd Cyffka, Barbara Stammel

I.1 Background of the IDES project

In order to achieve the water quality objectives defined in the EU Water Framework Directive (WFD), we must improve the water quality in the Danube and its tributaries, specifically by reducing the impact of primary nutrients, nitrogen (N) and phosphorus (P), transported through the Danube to the Black Sea. According to the current Danube River Basin Management Plan (DRBMP), these nutrients' sources and input pathways are diverse and complex (ICPDR 2021). Lessening their impact requires source reduction, establishing riparian buffer strips, and enhancing the retention potential in active floodplains. However, progress in implementing such nature-based attenuation solutions has been relatively slow so far.

One of the main reasons for the slow implementation is the multitude of divergent human interests focusing on river channels and floodplain areas, e.g. navigation, hydropower, agriculture, nature conservation, tourism, flood prevention and disposal of sewage. Integrative water management along rivers and floodplains aims to bring together disparate interests and find synergies from measures that improve the ecological conditions throughout the basin. The IDES project (https://www.interreg-danube.eu/ides), funded by the Danube Transnational Programme (DTP), pursues such an approach. It aims to improve water quality along the Danube and its tributaries by developing an approach that integrates all relevant interests. The concept of ecosystem services (ES) - the benefits people obtain from ecosystems (MEA 2005) - can depict the different interests by assessing them following a common framework. The IDES project developed an ES assessment for integrative floodplain management: the IDES Tool. The IDES Strategy describes how to implement this novel IDES Tool for water quality management at the Danube-wide and national levels and pilot studies at the local/regional level. It complements the application of the IDES Tool in the IDES Manual (https://www.interreg-danube.eu/approved-projects/ides/outputs).

I.2 Aim of the IDES project

The IDES project aims to improve existing conditions of nutrient pollution and hydrological alterations while accounting for other societal demands. It will facilitate water quality management in the Danube River Basin (DRB) by identifying optimum sites for nutrient retention via nature-based solutions, mitigating conflicts among stakeholders, and demonstrating synergies among different societal interests in floodplains. IDES supports the development and implementation of sustainable, efficient and integrative management concepts for the entire river course of the Danube using the newly-developed IDES Tool (Stäps et al., 2022).

The IDES Tool helps to demonstrate and visualise the synergies of nutrient retention through a wide range of ES provided by the Danube, its tributaries and floodplains (e.g. flood protection, recreational values, drinking water). Decision-makers can then identify the most effective and integrative options for suitable nature-based solutions at the transnational level. IDES thus facilitates the implementation of specific actions for improving water quality at a national level and the creation of synergies between different ES.

The main objective of IDES is to apply ES-based integrative floodplain management to improve water quality management along the Danube and its tributaries. Three work packages addressed the following specific objectives and outputs:

1. Enhancing synergies and impeding trade-offs in floodplain and water quality management in the DRB by employing a homogenous ES-based approach.

IDES developed a transnational and harmonised method to assess all ES related to water quality to inform stakeholders and decision-makers better. It will improve and accelerate the implementation of water quality measures with significant benefits to society. The IDES Tool is a unified evaluation scheme that adapts to the varying availability of regional data and leverages in-place valorisation schemes throughout the Danube countries. Its primary purpose is knowledge-based assistance for decision-makers to identify management options that create the most synergies between different sectors.

2. Providing best practice examples of the IDES Tool application and co-creating water quality management concepts for pilot areas.

We applied the IDES Tool to five pilot areas and the Yantra river in Bulgaria to demonstrate an ES-based integrative floodplain management approach. It supported the achievement of many policy implementations and socioeconomic development goals. We engaged the relevant local, regional and national stakeholders early, allowing us to implement the IDES approach mutually, thus creating win-win situations. The objective was to make decision-making more transparent to all stakeholders and foster the willingness to support the implementation of measures. In this case, the IDES Tool visually communicated the needs of stakeholders in each pilot area leading to a better understanding.

3. Accelerating a joint implementation of effective and sustainable water quality management along the Danube and its tributaries

Providing a joint strategy and producing a list of priority sites will support more efficient and effective water quality management actions along the Danube and its tributaries and provide enhanced, knowledge-based cooperation in the long run. By applying the IDES approach, the project defined national action plans then prioritised concrete actions, and finally, identified and defined a joint strategy for better water quality management in the DRB. Transnational stakeholders held a workshop to discuss and summarise their results as part of this strategy.

Readers may download the outputs of the IDES project at the following link:
https://www.interreg-danube.eu/approved-projects/ides/outputs

- T1.1: ES-based integrative floodplain management tool
- T1.2: National training courses for key actors in the water sector on IDES application
- T2.1: Stakeholder workshops in pilot areas focusing on water quality and ES
- T2.2: Water quality management concepts in five pilot areas
- T2.3: Pilot implementation of the IDES Tool in five pilot areas
- T2.4: IDES Manual, including best practice examples/recommendations
- T3.1: Transnational Stakeholder workshop
- T3.2: Strategy to implement the IDES approach (this document)

I.3 Danube River Basin: current challenges for water quality

The DRB is Europe's second largest river basin, with an area of about 800,000 km^2 or 10% of mainland Europe (Figure I.1). The basin stretches from central to south-eastern Europe with a maximum elevation above 4,000 m. The basin is part of 19 countries, the most international river basin in the world. The Danube River begins in southwest Germany and flows into the Black Sea, covering a distance of 2,857 km as it passes ten countries (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Moldova, and Ukraine). The mean discharge at the river mouth is about 6,500 m3 s^{-1} (ICPDR 2021).

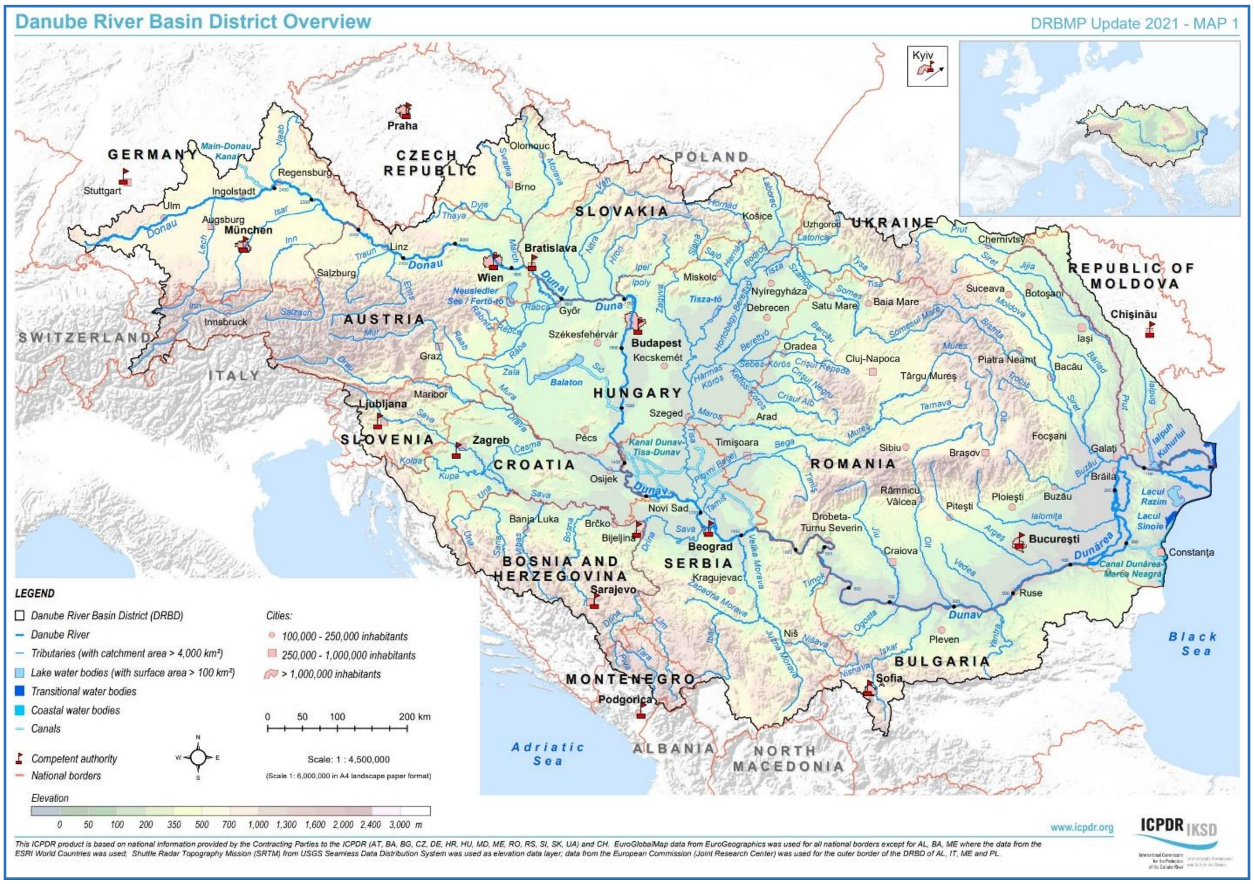

Figure I.1 Overview of the Danube River Basin District (ICPDR 2021)

In the DRB, around 79 million people depend on surface waters, groundwater and the fertile soils of floodplains to provide drinking water, energy production, agriculture, and transport. The extensive demand for water as a resource affects the Danube's ecological and chemical balance. The impacts of intensive land use, anthropogenic nutrient emissions and structural changes to the river systems have resulted in ecological degradation where only 15% of the 29,127 km river network (i.e. Danube River and tributaries with catchment areas over 4,000 km²) achieved a "good" status rating. The Water Framework Directive (WFD) rated the chemical status slightly higher, where 36% rated "good" (ICPDR 2021).

I.3.1 Hydromorphological Alterations

An undisturbed hydrological regime with longitudinal and lateral connectivity of channels and morphological dynamics is an ideal river environment. Such a network is conducive for the many species and habitats specific to rivers and floodplains and results in high biodiversity (Tockner et al., 2008).

Regarding the hydrological regime, the quantity and dynamics of runoff and the connection to groundwater bodies must remain certain (Ward et al., 1999). The groundwater-surface water interface also provides chemical, biological, and thermal exchanges beneficial to both (Environment Agency UK, 2009). Properly functioning longitudinal connectivity fosters the migration necessary for the reproduction of aquatic organisms and the transport of sediments. Regarding the morphological conditions (Figure I.2), the variability of river depth and width, the structure and substrate of the river bed, and the riparian zone structure are relevant parameters (ICPDR 2021). In addition to maintaining species-specific ecosystems,

Figure I.2 Morphological condition of rivers water bodies in the DRB (ICPDR 2021)

natural hydromorphological conditions favour in-stream nutrient retention and contribute to climate change resilience and drought reduction. However, the hydromorphological conditions of the Danube, as with most rivers in Europe, have been significantly altered for centuries. For navigation and hydropower purposes, channels were straightened and impounded. Farmers converted floodplains to fields and installed channelised drainage systems. Engineers built levee systems to protect towns from flooding, disconnecting the river channel from adjacent floodplains and exacerbating future flood events downstream (Nilsson et al., 2005).

The morphological floodplains in the DRB cover an area of 41,605 km², with only 19% now connected to their rivers (ICPDR 2021). Despite the ongoing anthropogenic use of former floodplains, there is still a potential to reconnect them to the river system. The available area for floodplain restoration for the Danube totals about 8,100 km², with 75% showing a high restoration potential. The Danube Floodplain project (https://www.interreg-danube.eu/danube-floodplain) identified 2,395 km^2, where no significant restrictions for restoration (e.g. settlements) were apparent.

Within the WFD currently, 3,819 km of the rivers in the DRB are classified as natural to slightly altered, 4,851 km as moderately altered, and 3,407 km as extensively to severely altered. Romania, Bulgaria, and Serbia use a 2-class rating system where 7,760 km are near-natural, and 6,935 km are slight to severely altered. Assessments are unavailable for the remaining 2,354 km in the DRB (ICPDR 2021).

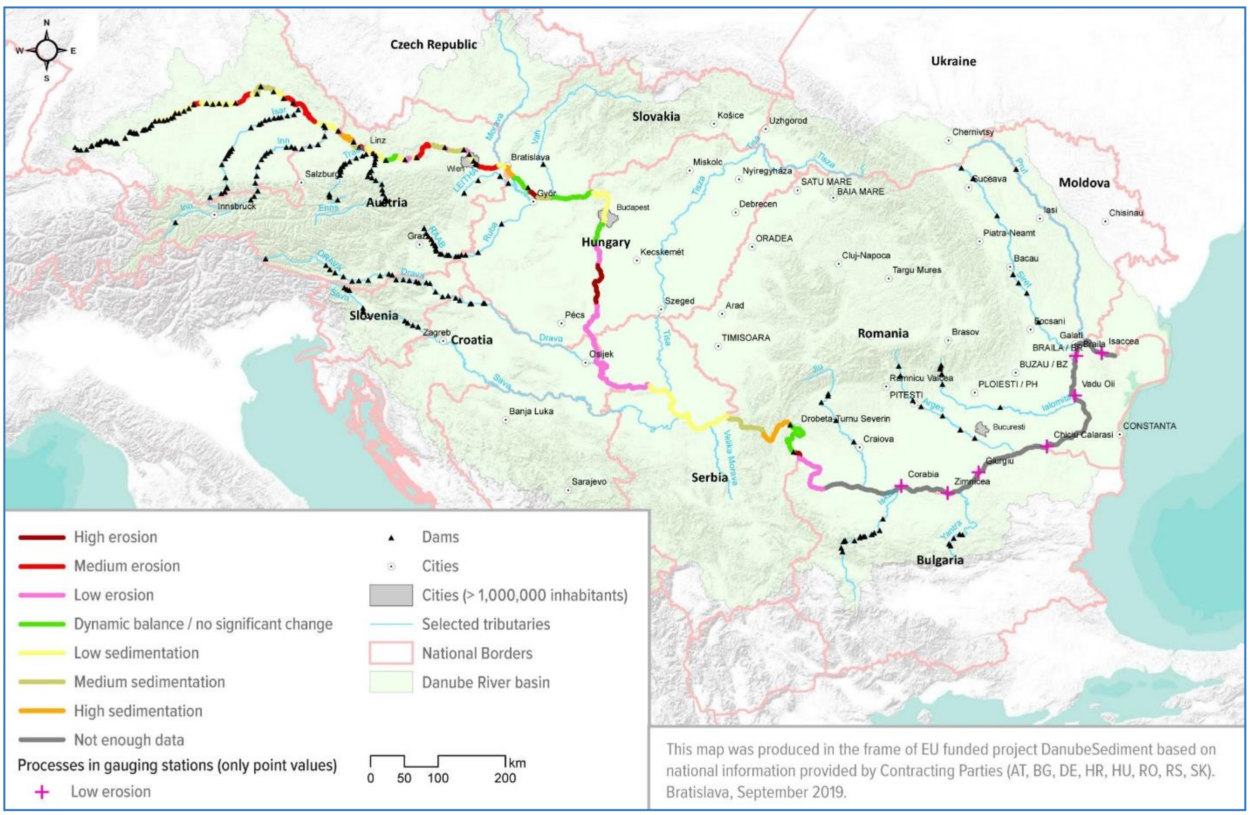

Figure I.3 Danube River sections under sedimentation and erosion (ICPDR 2021, Habersack et al. 2019)

Transverse structures in rivers disrupt longitudinal connectivity. They may consist of dams and weirs to serve hydropower, flood control, agriculture, water supply, navigation and other hydraulic engineering purposes. They are the most significant hydrological pressure in the DRB (ICPDR 2021), leading to impoundments, water abstraction, and hydropeaking. These pressures can hinder or prevent aquatic organisms' migration to their habitats and spawning grounds. In addition, these alterations interfere with natural sediment dynamics which can result in bed scour or aggradation. Nevertheless, many aquatic organisms depend on a natural sediment regime and the provision of species-specific habitats (ICPDR 2021).

In the Danube and its large tributaries, transverse structures interrupt longitudinal connectivity at 965 locations, where 66% are dams or weirs, 23% are ramps or bottom sills, and 11% are other types. Most structures help to generate power, control floods, and supply water, with 20% multifunctional, e.g. hydropower generation and navigation. Interruptions restrict fish migration in 357 water bodies in the DRBD. Of those, 93 allow fish passage, and 264 do not. Along the Danube River, 27 water bodies contain 81 significant interruptions, mainly in the Upper Danube. Fish and other aquatic organisms can only pass 35 of these interruptions.

There are currently 422 significant impoundments in the DRB affecting 269 water bodies, 19 more than reported in 2015. Regarding flow length, impoundments affect 15% of the river system (4,502 km of the 29,127 km of River Danube and tributaries > 4000 km2 catchment area). Twenty-six dams impound 1,069 km (37%) within the Danube River. The Iron Gate 1 dam creates the largest impoundment at the border of Serbia and Romania, with a length of about 500 km, corresponding to 18% of the Danube's length. This massive anthropogenic intervention has impacted the hydrological regime up to Novi Sad in Serbia. The cascading hydropower plants in Germany and Austria cause another significant impoundment. It extends about 540 km or 19% of the entire length of the Danube (ICPDR 2021). Loss of floodplain area, impoundments, and alterations to the natural flow regime of the Danube system have also disrupted its natural sediment balance. Impoundments remove sediments that contribute to a continuous dynamic balance needed for habitats downstream. Only 241 km (10%) of the Danube is in dynamic sediment equilibrium (Figure I.3).

I.3.2 Pollution by Nutrients

The effects of anthropogenic N and P emissions are multifaceted and can significantly affect the conditions of sensitive natural aquatic ecosystems (Lemm et al., 2021). Nutrient accumulation can accelerate the growth of algae and aquatic macrophytes, leading to a possible overgrowth of certain species. Overgrowth may lead to eutrophication, an associated degradation of water quality, and changes in ecosystem functions. The algal overgrowth in the DRB significantly affects surface waters, especially during summertime. Consequently, this generates oxygen deficiency, toxicity, pH fluctuations, and accumulation of organic and toxic substances, resulting in changes in species diversity and numbers of individuals. In addition to the ecological damage, eutrophication can also limit or even hinder the supply of ES, such as drinking water or recreational activities (ICPDR 2021).

Recently, nutrient loads from rivers in the DRB to the Black Sea declined significantly. The measured loads in the last 5-10 years are relatively low and close to the Black Sea's target values, indicating a significant improvement in the water quality. However, compared to the early 1960s, the river load of approx. 300,000 t a^{-1} total N (TN) and approx. 20,000 t a^{-1} total P (TP) is still too high. There is further potential for reduction (approx. N: 30%, P: 15%) and the definite aim to reduce loads to improve the ecological and chemical status of the river itself and the Black Sea (Kovacs & Zavadsky 2021, ICPDR 2021).

I.3.2.1 Nitrogen Emissions

According to the MONERIS application, a semi-empirical, robust model to quantify N and P fluxes at the meso- to macro-scales, the annual TN emissions in the DRB amount to approx. 500,000 t a^{-1}, or 6.2 kg ha^{-1} (Venohr et al. 2011, Lemm et al. 2021). The emissions vary significantly between the countries in the DRB. Germany, Bosnia and Herzegovina, and Slovenia have the most area-specific N emissions in the basin due to the natural site conditions, the intensity of agriculture, population density, and the efficiency of wastewater collection and treatment. The most significant pathways are subsurface runoff (baseflow and interflow), with 57% of all N emissions in the DRB, followed by urban runoff, with 12%. The contribution of the other diffuse pathways is low (Figure I.4: left). Only 13% of total N emissions in the Danube catchment originate from point sources like wastewater treatment plants. Diffuse sources, such as agricultural land (44%), urban areas (30%) and natural land (23%), are significant contributors, especially upstream in Germany and the Czech Republic, where the agricultural N surplus is high (Figure I.4: right, ICPDR 2021).

A significant amount of the nitrogen entering the river system is retained in the river network through denitrification. Therefore, the observed river load of 340,000 t a^{-1} TN is much lower than the TN emissions.

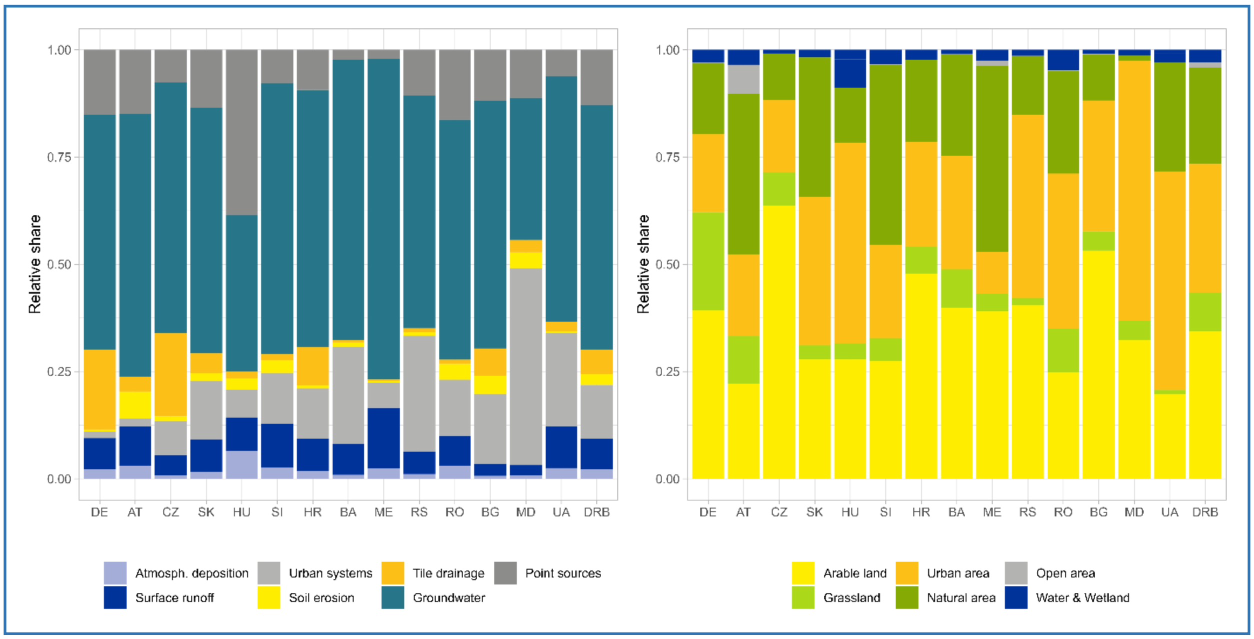

Figure I.4 Relative share of the pathways (left) and sources (right) on the overall TN emissions in the Danube countries for the reference period (2015–2018) as modelled with MONERIS

I.3.2.2 Phosphorus Emissions

MONERIS estimated that 31,000 t a^{-1} TP or 0.4 kg ha^{-1} enter the rivers in the DRB every year. Similar to TN, the emissions vary widely within the DRB in terms of absolute numbers and pathways depending, e.g., on the soil erosion risk, population density, wastewater collection and treatment. In contrast to TN, the most critical pathway is soil erosion and sediment transport, with 28% of all basin-wide emissions. Nonetheless, subsurface runoff (22%) and runoff from urban areas (19%) are also relevant (Figure I.5: left). The dominance of diffuse emissions is less pronounced, as 22% of the emissions originate from point sources. Emissions from urban areas (43%) are greater than agricultural land (37%) and natural land (20%, Figure I.5: right). The "open areas" contribution in Austria and Montenegro reflects the high soil erosion risk in mountainous areas (ICPDR 2021).

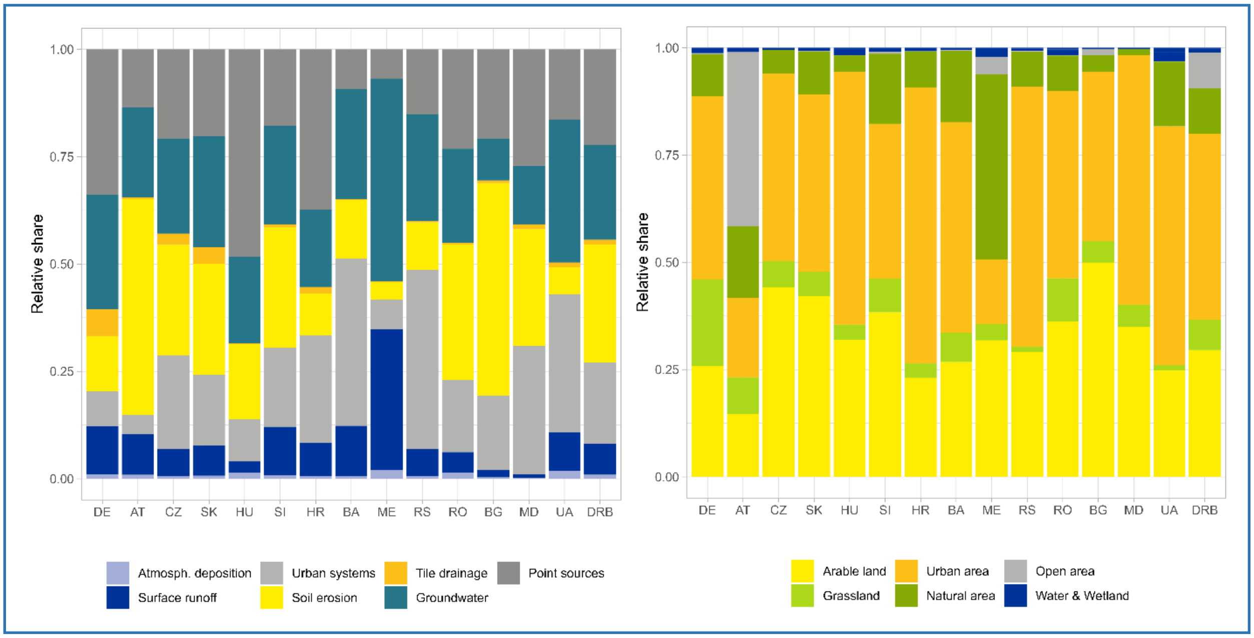

Figure I.5 Relative share of the pathways (left) and sources (right) in the overall TP emissions in the Danube countries for the reference period (2015–2018) as modelled with MONERIS

Similar to N, a significant amount of P, which enters the river system, is retained before it reaches the Black Sea. Accordingly, the observed river load of 18,000 t a^{-1} TP is lower than the emissions of 31,000 t a^{-1} TP.

II. Principles, uses, and functions of floodplain areas

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A morphological floodplain is a low plain adjacent to a river composed mainly of sediment and is subject to flooding. It extends from the banks of the river to the high banks or the edge of the valley (Figure II.1).

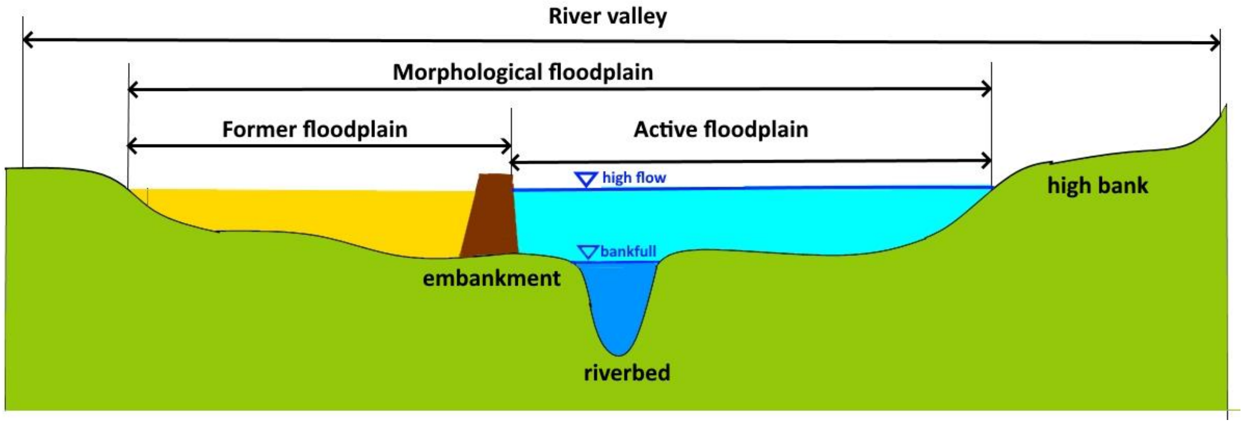

Figure II.1 Cross-section of a river valley

In technical terms, an active floodplain is the active part of the morphological floodplain that extends between the embankments or the edge of the high bank where there are no embankments.

For thousands of years, humans used river floodplains for hunting, fishing, agriculture and settlement. While these uses somewhat altered floodplain ecological communities, they only moderately affected the basic hydrological and morphological processes that sustain floodplain ecosystems. Following the industrial revolution, major engineering projects transformed river ecosystems and their processes. These interventions also induced the disconnection and conversion of river floodplains directly by the construction of flood control levees and indirectly by the alteration of the hydrology and hydraulics of the river itself. These anthropogenic changes in the riverine and floodplain landscape contribute significantly to the decline of crucial ecological functions, including the loss of native species (Williams et al., 2019).

Floodplain management and flood control involve different natural conditions such as soil moisture gradient, climate, topography, and soil types. They may apply alternative structural measures, including levees, dikes, retention basins, channel modifications or non-structural such as flood warnings and land uses. Other factors such as natural conditions (climate), socioeconomic interests and various preferences may influence management decisions. (Ganoulis, 2003).

Ever-changing water levels characterise the natural dynamics of river-floodplain ecosystems. Floodplains experience bank overflow and deposition during floods, cycles of erosion and sedimentation, varying groundwater levels, and repeated channel cutting. From an ecological perspective, the particular importance of floodplains lies in their structural richness and enormous diversity of species. Floodplains function as supra-regional axes in a habitat patch connectivity (SUMAD Manual, 2006).

A significant part of the ecosystem only exists under dynamic circumstances. The last shelter of typical floodplain ecosystems is the active floodplain. Natural floodplains are essential habitats, bird nesting places, feeding places, and spawning areas for amphibians, certain types of fish (phytophilic fish), and other animal and plant communities.

The changes in the hydrological regime of rivers are particularly significant in assessing their ecological conditions because river flow variability is considered a fundamental characteristic of river systems and their ecological functioning. Spatio-temporal flow variations exert direct and indirect control on the structure and dynamics of biotic communities and influence ecosystem processes, such as nutrient uptake and transformation, organic matter processing, and ecosystem metabolism. Based on research on the impact of the hydrological regime on river ecosystems, natural flow regimes exhibit variability at different timescales, from seasonal to inter-annual, and native aquatic and riparian biota are adapted to this variability (Tadić et al., 2022). Therefore, the magnitude, frequency, duration, timing, and rate of change of the natural flow regime are considered critical elements for sustaining and conserving native species and ecological integrity.

Floodplain forests are among the most vital communities and vulnerable habitats (softwood and hardwood) (Hughes et al., 2012). Floodplain forests are longitudinal features occupying the lower areas extending along the river valley. Their boundaries correspond to the areas periodically disturbed by river flooding, and they generally have shallow water tables. Like other habitat types, floodplain forests evolve from the dynamic physical processes in the river channels. They are at the receiving end of a catchment's physical, biological, and human activities. They, therefore, reflect the patterns of water, sediment, and nutrient delivery via flood events to the floodplain.

Studies have shown that in small stream systems, riparian vegetation can create effective buffer zones against the transported dissolved nutrients carried in the runoff from agricultural land. In the broader and more complex areas occupied by floodplain forests in large river systems, the exact mechanisms for nutrient retention are harder to assess and are highly variable over small distances but appear to be related to characteristics such as water residence time, sediment size and the nature of the contact between plant roots and soils. Floodplain forests also have an essential role in flood retention as they reduce flow velocities during floods, reduce the peak of the hydrograph, and decrease flooding in downstream areas. The longer retention time for flood water on a floodplain also contributes to groundwater recharge. Floodplain forests' well-watered and high nutrient status makes them highly productive and often provide valuable timber. In addition to traditional forestry products, floodplain forests increasingly provide tree seeds for the forestry industry (Hughes et al., 2012).

River management practices in Europe have led to severing connections between river channels and their floodplains, primarily through river engineering practices such as building embankments. These practices have led to the deterioration and disappearance of most floodplain forests, as they depend on fluvial processes to regenerate. In addition, clearing natural floodplain forests for agriculture or forestry has made them very rare in Europe, with about 10% of the original amount remaining, mainly in the larger river systems of Eastern Europe. However, along embanked floodplains, the levees require the flood-related management of floodplain forests to cooperate; otherwise, the reduction of velocities can cause a higher load for the levees.

Floodplain forests usually consist of mosaics of different aged forests and regenerating patches of tree seedlings associated with geomorphological features. The floodplain comprises a patchwork of sedimentary features resulting from erosion and deposition during flood events. In geomorphologically active river systems, these sediments ' turnover rate is high, and many parts of the floodplain forest are in the early stages of succession. The opposite is true in lower energy (lowland) river systems where parts of a floodplain forest may attain a great age, and a small proportion of the forest is in early successional stages.

Floodplain meadows evolved over hundreds of years through the need to store the summer grass crop as hay to sustain cattle, sheep and horses over the winter months. Allowing the vegetation to grow in the spring, taking a hay crop in midsummer, and then grazing the re-growth prevented taller, coarser species from becoming dominant and created the diverse flower-rich sward we see today. Floodplain meadows could be found on a wide moisture gradient from very wet to moist and even dry grasslands on gravel banks or sand bars. Once valued primarily for their crucial role in commercial agriculture, the few remaining species-rich floodplain meadows now contribute to a diverse range of species. Floodplain meadows functions include the generation of a sustainable hay crop, the provision of an important nectar source for pollinating insects such as bumblebees and hoverflies, and the support of rare plant communities are as well vital sources of seed for the restoration of meadows. They provide feeding areas and breeding places for animals, such as amphibians, reptiles, birds and mammal species. Apart from this, they provide flood-storage areas, trap sediment and store carbon, and increase ecological value as the climate changes. Floodplain meadows also provide aesthetic values and, on steep slopes, protection against soil erosion. They are a living link with the past, a reminder of the traditional, rural landscapes and the ways of life that created them.

In some river landscapes, environmental protection attempts to conserve and develop meadow landscapes of historical origin with their biocoenosis and species. In many river landscapes, however, neophytes are widespread and, in most cases, are irreversible (SUMAD Manual) due to altered conditions and water regimes. Extensive stands of Solidago gigantea, Asclepias syriaca and Amorpha fruticosa have now replaced many of the former meadows in The Middle and Lower Danube.

Floodplains often contain permanent water bodies (lakes and channels) and permanent or seasonal wetlands. Floodplain wetlands are one of the world's most extensive wetland types. Floodplains often host a vast diversity of wetland ecosystems that reflects underlying geomorphological diversity, water regime variability and inundation patterns. Plants and animals adapt to seasonal flooding, varying water levels and dissolved oxygen availability (Hamilton, 2009).

Floodplain wetlands are among the most degraded ecosystems in the world. Under natural conditions, these ecosystems harbour an enormous diversity of plants and animals because of the seasonal fluctuation in river discharge which generates a moving ecotone and creates a variety of habitats (van den Brink et al., 2013).

Floodplain waterbodies may have differing lateral hydrological connectivity that determines their classification. Eupotamon channels have permanent inflow and outflow. Parapotamon channels connect permanently to the main channel only at their downstream ends. Plesiopotamon channels do not connect but remain close to the main channel receiving water during high flood waves. Paleopotamon channels have less contact with the main channel due to their greater separation distance and often represent abandoned meanders. (Amoros et al., 1987). Both surface and subsurface hydrological connectivity play a vital role in the structure and functioning of large river-floodplain ecosystems.

Like other freshwater wetlands, river floodplains are among the most threatened ecosystems, and, over the past 30 years, species diversity has declined faster here than in terrestrial or marine ecosystems. Alteration of the flow regime is one of the most serious and continuing human threats to the ecological integrity of these ecosystems. It harms biodiversity in floodplain wetlands by disrupting the periodic river-floodplain connection (Kuiper et al., 2014). Consequently, floodplain wetlands' abundance, productivity, and biodiversity have decreased. Over 60% of global river systems have been affected by altered stream flows, which will increase.

The existence of floodplains with natural flood regimes enhances the overall productivity of the river-floodplain system. For example, among riverine fish species, some migrate seasonally between main river channels and floodplain wetlands (especially during the spawning season), and others are confined mainly to floodplain waters. When floodplains are no longer naturally inundated or isolated entirely from the river, riverine fish recruitment, productivity, and diversity diminish.

Over the past two centuries, human development has seriously damaged floodplains and their ecosystems. The most critical impacts are:

- channelisation and straightening of the river for transport and flood protection, confining and shortening the river;
- the interruption of lateral connectivity;
- blocking the flow and altering the sediment regime by dams;
- blocked morphodynamics;
- land use alterations, including the draining of wetlands and changing the natural vegetation, especially in the former floodplain;
- different point and diffuse sources of pollution (nutrient, chemical and heat emissions) changed water quality;
- the self-purification ability of the river and its floodplain is reduced.

All these impacts reduced the naturalness and hence the vitality and life-supporting potential of the rivers.

A recent study found that over 80% of the original floodplain area in the Danube River Basin alone has been lost since the turn of the 19th – 20th centuries (Hein et al., 2016). The loss of floodplains is not only significant because of the loss of biodiversity. Floodplains serve essential functions in nature, such as the purification of water, storage of flood volumes, and groundwater recharge. The loss of floodplains has meant not only the loss of biodiversity but also the loss of these functions, which have enormous consequences (Bachmann & Wurzer, 2000).

The most common purposes of river regulation are the improvement of flood and eventual ice conveyance, the creation of new spaces for urbanisation or agriculture, the maintenance or improvement of navigation, the stabilisation of the riverbed, and the reduction of bank erosion. In the past few decades, a new goal for river management appeared: saving and conserving water-dependent ecosystems and restoring floodplain wetlands.

River regulation frequently seriously impacts aquatic and riparian ecosystems but has far-reaching effects extending into the floodplain. Both flora and fauna along the river are affected by changes induced by channelisation. They include morphological, sedimentological, and hydrological changes. Floodplain ecosystems may be affected since connectivity between the river and its floodplain may dramatically change. Agricultural activities require draining wetland environments and are frequently affected by channelisation (Encyclopedia of Water Science).

Water management in floodplains, or river management, provides essential services for humanity, such as navigation possibilities, irrigation supply, drinking water, electric power generation and recreation. However, it often degrades ecosystem services and natural resources and conflicts with the natural ecosystem.

More than 70% of the large rivers of Europe, North America and the former Soviet Union are regulated (Nilsson et al., 2005), and there are more than 800.000 dams worldwide affecting two-thirds of the freshwater. Most large rivers in densely populated areas have been modified to prevent floods and to obtain new land for development. In many cases, hydrological engineering structures change river courses and channels considerably, with meanders and branches being straightened and redirected (Manual on Danube Navigation).

River regulation (training or channelisation) includes engineering methods (resectioning, straightening, bank stabilisation, construction of levees, diversions, etc.) that modify existing river channels or create new channels, often changing the relationship between river channels and floodplains (Figure II.2).

River regulation is carried out on very large rivers and small streams, widespread in lowland rivers. However, many upland (mountainous) rivers have also experienced this human intervention. Europe has channelised most of its alluvial rivers during the last 200 years. Early regulation activities appeared in the Danube River Basin with the start of the economic and industrial development; however, the most significant interventions were carried out between 1840-1880.

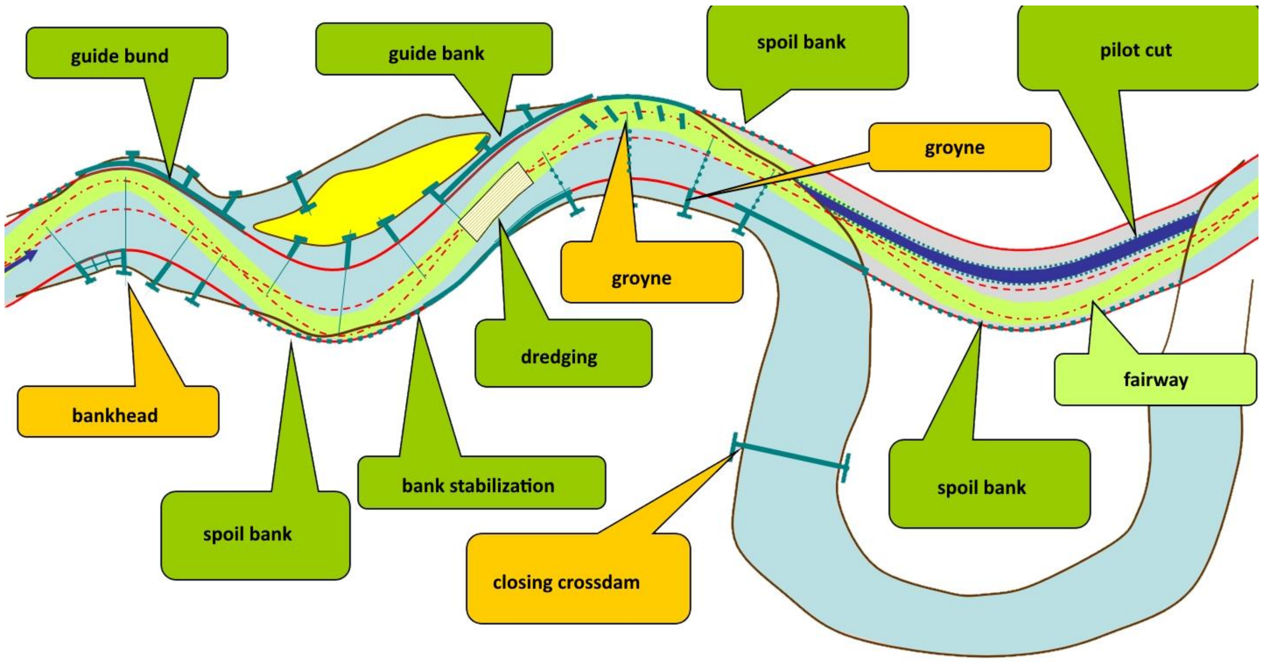

Figure II.2 River regulation structures used in the Danube River Basin

There are several types of regulation worldwide, all of which share the same elements of methodology and regulation structures. The most commonly used regulation principles in the 19th and 20th centuries are called the "French" principles of river regulation because they are based on the findings of H. Girardon on the Rhône and M. Fargue on the Garonne (Fargue, 1882; Girardon, 1894).

Embankments or levees aim to increase channel capacity so that flood flows are confined and do not inundate the areas adjacent to the channels (floodplains). Levees can be built close to the river channel (in this case, levees must be quite high) or farther apart (for instance, including the "shifting belt" or the "erodible corridor" of the river). This type of intervention, used in rural and urban areas for flood control, requires extensive maintenance of the structure itself (geotechnical properties of materials may decay through time) and the river channel.

Several studies have documented that channelisation may affect channel morphology, hydrology, riparian and floodplain ecology, human infrastructure, etc. (Goda et al., 2007; Tamás et al., 2021). Such effects regard not only the channelised reaches of a river but, quite often, also the upstream and downstream reaches (e.g., increased flood discharges in the downstream reaches). Early channelisation projects required little or no consideration of sediment transport and river dynamics, causing dramatic changes in the river (Tamás & Tadić, 2021).

Regulation works affect river and floodplain hydrology. During floods, channelisation produces higher velocity in the channelised reach (lower water stage). However, it can induce increased discharge in the downstream reaches due to floodplain storage reduction (or elimination). Deepening the channel or incision induced by channelisation may strongly affect the interconnection between the river and its floodplain. In the case of unconfined aquifers, lowering the water table is likely to occur, whereas, in the case of confined aquifers, an increase in stream flows may occur. In very low-gradient rivers, overbank flow, which under natural conditions is due to backwater effects and is fundamental from an ecological point of view, can be significantly reduced or eliminated. (Best, 2019; Goda et al. 2007; Tamás et al. 2021). In addition, there are several examples of the effects of channelisation on water quality (Encyclopedia of Water Science). In terms of, e.g., the reduction of the nutrient content of the rivers, the role of floodplain wetlands in retaining plant nutrients is significant.

The main water supply of the existing floodplain wetlands and oxbows originates from river flooding. Consequently, the water arriving from the river is one of the essential maintenance elements of floodplain ecology in terms of both water volume and nutrient supply.

III. ES selection and the DPSIR framework

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Any ES evaluation needs a precise aim and a selection of relevant ES from an abundance of existing ES. This chapter is about how to consider and select relevant ES for evaluations on the basin-scale and stakeholder opinions on a local scale.

Generally, the broadest possible range of ES will provide the best opportunity for evaluation and mapping the current status. It will also allow for a more resilient basis to detect (unforeseen) changes due to, e.g. management interventions (Podschun et al., 2018). The selected ES should represent all ES main types: provisioning, regulating, and cultural. (Haines-Young & Potschin, 2012). Such a broad range of ES supports a less-biased assessment of trade-offs and synergies in different scenarios.

III.1 Selection criteria for ES assessments

When applying ES evaluations in floodplains on larger scales, the selection of ES depends on the following criteria, among others:

- Floodplain purpose

The purpose might include: producing fish or timber, providing floodwater retention, or offering an immersive experience in a biodiverse riverine landscape.

- Aim and relevant scale

When experts evaluate the status of ES on a large scale (river section, river basin), they must differentiate between ES that is relevant on large scales versus those on local features. Secondly, the sensitivity of ES to specific interventions or changes (restoration or management measures, climate change) will vary depending on the spatiotemporal scale of the hazard (restoration or management measures, climate change). For example, if the aim is to mitigate disasters with the support of floodplain ES, the large-scale assessment of flood or nutrient retention and drought regulation would have national or international relevance. Local needs require more direct and specific action on a smaller spatial scale (see III.2).

- Evaluation method

Large-scale ES assessments require a suitable set of ES evaluation methods that are as simple as possible yet as detailed as necessary. They must also reflect sensitivity to anticipated measures and the local stakeholders. In the case of floodplains, the IDES Tool presents a collection of helpful methods that support a wide range of users to realise ES evaluations. For all ES, large-scale evaluation methods are rare and can only illustrate the *potential* ES rather than the *delivered* ES. Cultural ES present unique challenges due to its subjective nature (Thiele et al., 2020). Current research and technological advances provide an ever-growing amount of evaluation methods which, in turn, contribute to increasing the number of evaluated ES and reducing their uncertainty in the future (e.g. Bagstad et al. 2013, Hooftman et al. 2022).

- Available data for the ES evaluation

In many cases, the main methodological constraints are the availability of data, their resolution, and the harmonisation of administrative borders. The quantity and quality of data are equally critical parameters for a successful and comprehensive ES evaluation. Therefore, evaluators often compromise between the amount and the quality of ES data. Fortunately, the assessments for the DRB benefit from the vastly improved monitoring and data collection in the EU member and candidate states, supporting more detailed assessments of an increasing number of ES.

One aim of the IDES Tool was to address the criteria mentioned above in the DRB. Balancing data quality and quantity resulted in a harmonised methodological framework to evaluate a selection of 26 different ES (Table III.1). The IDES Tool (and other approaches operating on a large spatial scale) depicts the potential provision of ES. Stakeholders' actual provision of ES depends on their preferences and local floodplain characteristics. .

Table III.1 Selected ES for the basin-wide evaluation by the IDES Tool

Type	Ecosystem Service	Abbr.	Description
Provisioning	**Arable crop production**	API	Used arable crops (e.g. cereals, root crops, vegetables, fruit)
	Plant biomass grassland	PBI	Plant biomass used for agricultural purposes (yield of meadows and pastures)
	Commercial fishing	CFI	Catches of the commercial fishing activity
	Timber production	TPI	Yield of forests managed for timber production (used as material or for energy)
	Commercial hunting	CHI	Yield of the commercial hunting activity
	Freshwater provision	FW	Water withdrawal for drinking water purposes, irrigation or cooling purposes
	Wild foods	WF	Food resources that can be foraged in the wild
	Abiotic energy sources	AES	Energy generated by hydropower plants, wind etc.
	Mineral resources	MR	e.g. sand / gravel quarries
Regulation & Maintenance	**N retention**	NRI	Permanent elimination of nitrogen (N) by denitrification (conversion to N2) or temporary retention by incorporation into stationary biomass (e.g. mussels, floodplain vegetation) or in river sediments (sedimentation)
	P retention	PRI	Temporary or permanent retention of phosphorus (P) by incorporation into stationary biomass (e.g. bivalves, macrophytes, floodplain vegetation) or by uptake into sediments (deposition, sorption)
	Greenhouse gas regulation and carbon sequestration	GHG	Emissions and sequestration of the greenhouse gases (GHG) carbon dioxide, methane, and nitrous oxide (CO_2 equivalents)
	Flood risk regulation	FRI	Reduction of the flood discharge and lowering of the flood peak: wave flattening (retention volume captures overflow/flooding, river/floodplain morphology influences roughness)
	Low flow regulation	LFI	Low flow regulation by hydrological self-regulation due to macrophyte growth and morphology (reduction of water level), if applicable, also compensation by strong groundwater inflow (expert assessment)
	Sediment regulation	SRI	Evaluation of the internal sediment balance of the river by the naturalness of morphological structures and effects of transverse structures on sediment consistency / morphological effects

Type	Ecosystem Service	Abbr.	Description
	Soil formation in floodplains	SFI	Evaluation of natural fen formation (peat accumulation) and anthropogenically caused fen degradation (lowering of the water body and groundwater level, changes in flood dynamics) and floodplain soil formation
	Local climate regulation/ cooling	LCR	Cooling potential of different land cover/land use types
	Habitat provision/simplified assessment (Danube-wide)	HPI_{simple}	Habitat provision describes the functional and structural quality of typical floodplain habitats, communities, and species that serve as a basis for many human uses. The habitats with their typical diversity of animal and plant communities of the natural and cultural landscape are an expression of the characteristic site conditions of floodplain landscapes
	Habitat provisioning / detailed assessment (pilot area)	HPI_{detail}	See "Habitat provision /simplified assessment"
	Habitat provision/river	HPI_{river}	Evaluation of water quality as well as the functional and structural quality of biologically relevant water body structures in the river and the directly adjacent river bank
Cultural	**Opportunities for non-water-related activities**	NWA	Experiencing animals, plants, and landscapes (e.g. nature observation, cycling, walking) for recreation
	Opportunities for water-related activities	WRA	Specific water-related activities for recreational purposes (recreational fishing, swimming, boating)
	Landscape aesthetic quality	LAQ	Diversity, uniqueness, and perceived naturalness characterise the aesthetics of the landscape
	Natural Heritage	NH	Natural features, geological and physiographical formations and delineated areas constituting the habitat of threatened species and natural sites of value from the point of view of science, conservation or natural beauty.
	Cultural Heritage	CH	The entity of mental and cultural reflection of material natural assets by man and living cultural expressions which are not tangible
	Knowledge systems	KS	Value of the landscape for research projects, educational activities, etc. in the floodplain areas

III.2 Selection of significant ES by stakeholders in five pilot areas

Experts applied the ES concept to five specific pilot areas. Since different actors assessed each area, the ES evaluations are relative rather than absolute. The range of services recognised socially and their value varied depending on the system of attitudes of the actors. Thus, any ES evaluation must first recognise that such services are socially defined. The stakeholders define what represents a benefit, as well as the relevance or the value of such a benefit. Thus, ES and its values vary in time and space according to stakeholders' social norms. The same ecosystem resources could have a specific value to the local community but a very different value to the scientific community or people from outside the local communities. The IDES Tool accounted for this using two spatial scales: the basin-wide and the pilot site. The pilot areas represent different (natural) site conditions and different groups of stakeholders, as one would expect the natural and social variability throughout the DRB.

Identification and ES evaluation change over time as people gain information, change attitudes and values and rethink their perspectives about the benefits of ecosystem services. Three basic methodological approaches can assess the social dimension of ES:

1. **Participative approach**: accounts for the diversity of ES at the level of local communities and captures the views of all stakeholders rather than the views of experts only.
2. **Inclusive approach**: mobilises and involves the representatives of all stakeholder groups by initially segmenting the stakeholders (from local to regional and national).
3. **Deliberative approach**: focuses on public/group debates and generates multiple effects at an individual and group level. It contributes to the following:
    - generating awareness of the different perceptions regarding the number and relevance of ES, pressures and measures
    - deeper individual understanding of the multitude of ES and their relevance
    - building shared, negotiated understanding of the most relevant ES, pressures and measures.

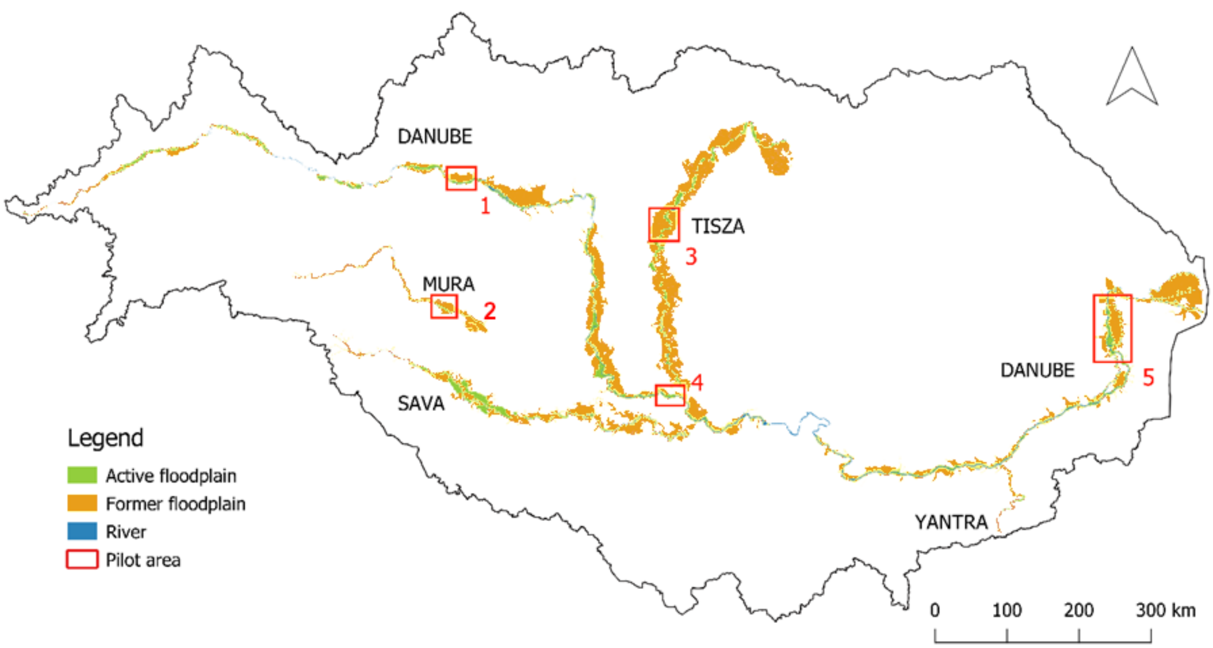


Figure III.1 The five pilot areas and their location in the DRB. The pilot areas mainly cover active floodplains and parts of the former floodplain. 1-Donau-Auen national park, Austria; 2-Mura river, Slovenia; 3-Floodplain of the Tisza River near Szolnok, Hungary; 4-Special Nature Reserve Koviljsko-petrovaradinski rit, Serbia; 5-Brăila Islands, Romania

Participative processes helped to identify potential ES, pressures and measures in the pilot areas (Figure III.1). Actors consisted of stakeholders and user groups of the natural and semi-natural ecosystems. The process integrated the stakeholders' perceptions regarding the capacity of ecosystems to supply various services, the pressures on different ES and the measures needed to reduce their impact. We identified different stakeholder types: local, regional and national stakeholders.

Identification and assessment of the services supplied by natural and semi-natural ecosystems rely on the "hierarchical model" (Potschin and Haines-Young 2011). The model integrates stakeholders' perceptions regarding ecosystems' capacity to supply various goods and services. The typology used for ES is specific to the "Common International Classification of Ecosystem Services" (CICES, http://cices.eu), according to the recommendations of the European Working Group of Mapping and Assessment of Ecosystem Services. (MAES 2014).

The approach proposed for identifying and assessing the ES, pressures, and measures includes two distinct stages:

STAGE 1: Identification and preselection of ES, pressures and measures relevant to water quality management in floodplains

- S1.1. Identification of all relevant ES, pressures and measures in all pilot areas.
- S1.2. Development of a questionnaire to identify and rank the relevant ES, pressures and measures in the pilot areas

The *questionnaires* used the CICES ES classification typology. They evaluated the stakeholders' understanding of ES in general and specific ecological pressures and measures in their area from a given list of potential ES. With this method, we could reach a large number of stakeholders.

STAGE 2: Stakeholder involvement: Assessing and ranking the social relevance/significance of the selected ES, pressures and measures

- S2.1. Completion of questionnaire translated into their respective language
- S2.2. Stakeholder workshop: Group debates and voting to generate a shortlist of the most significant/relevant ES, pressures and measures for each pilot area

In this stage, the questionnaire was filled out individually by the stakeholders. After identifying the ES, pressures and measures present in the pilot area, the stakeholders ranked them from 1 (low) to 5 (high importance) according to their perception, which they did intuitively. However, we can expect that assessments given by a large number of respondents would lead to a correct identification of the most important ES, pressures and measures. For each IDES pilot area, stakeholders identified 10 ES, five pressures and five measures. They could add more if needed, so additional ES were analysed.

Not all services have the same relevance for the stakeholders, depending on their social values, personal interests and pursuits. For instance, a forest can hold widely different values between owners of processing facilities and hotel managers. While the owners would be interested in exploiting it, the managers would be interested in conserving it. Determining the level of the social importance of the ES is a critical task in enabling their correct capitalisation. Determining a social ranking of ES is necessary, especially where services are conflictual. For instance, exploiting wood in a natural area diminishes the ecosystem's capacity to supply other services, such as protection against landslides, protection against winds, blizzards and, snow drifts, water quality.

Brăila Islands stakeholders employed the *debate and voting* method to gain a more profound social understanding of the ES in the pilot area. The process led to a more informed ranking of ES, pressures, and measures. The respondents had different/subjective criteria for defining priorities. Attendees indicated the ES that are most important from their perception using a five-value ranking. They used the same method to rank the pressures. In the next step, stakeholders used *fuzzy cognitive maps (FCM)* to identify connections between ES, pressures and measures. The FCM connected the ten highest-ranked ES, five pressures and five measures.

We combined questionnaire results from all the pilot areas and could identify the most important ES. Services focused on culture ranked first, and regulation ranked second. The ten most important ES contain five cultural, four regulating, and one provisioning services. Figure III.2 presents the rank order of ES selected by the participants in the first workshop from the highest to the lowest score.

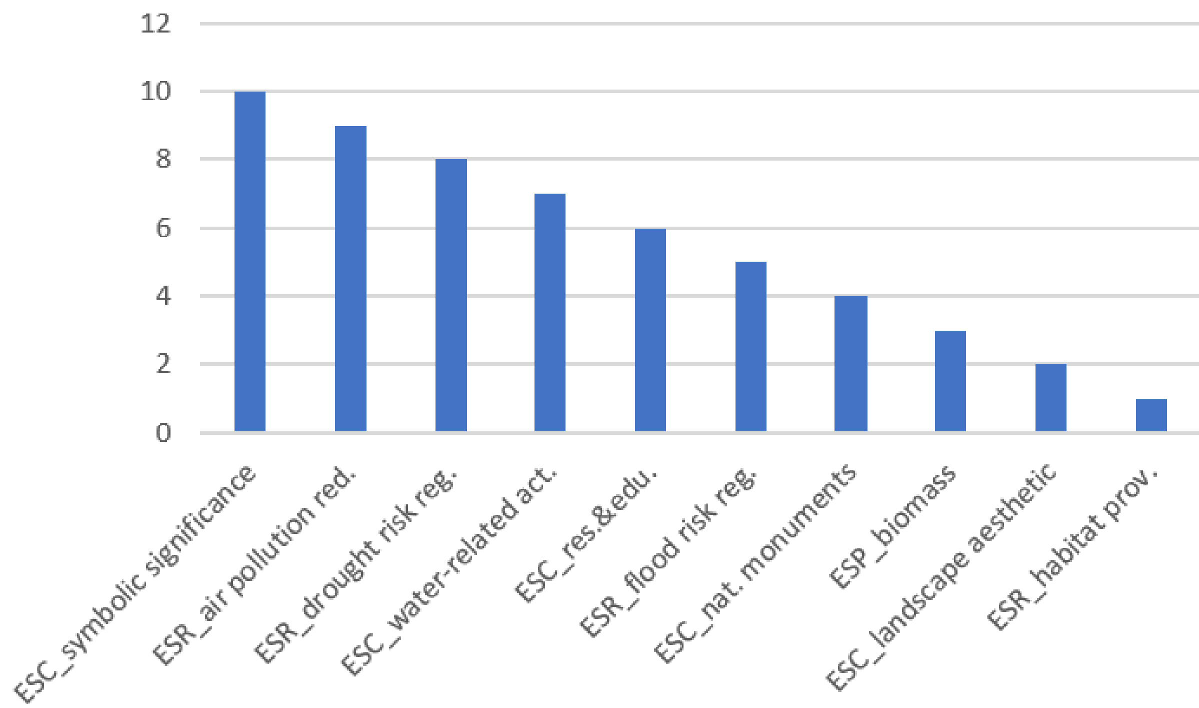


Figure III.2 The most important ES based on the data obtained from questionnaires in all five pilot areas (ESR: regulating services; ESC: cultural services, ESP: provisioning services)

III.3 ES potential and use

By comparing the ES evaluated by the IDES Tool and the evaluation by the stakeholders in the five pilot areas, the progression from the potential ES provision to their actual demand becomes visible. Table III.1 and Figure III.2 show the progress from the definition by the IDES Tool to the decision by the stakeholders. The results of the IDES Tool will depend on spatial resolution and input data (more detailed for pilot areas compared to basin-wide); therefore, the following basin-wide results can differ from pilot areas. The IDES

Manual, chapter III.2, describes the implementation of the IDES Tool in each of the five pilot areas in more detail (Stäps et al., 2022).

III.3.1 Flood risk regulation

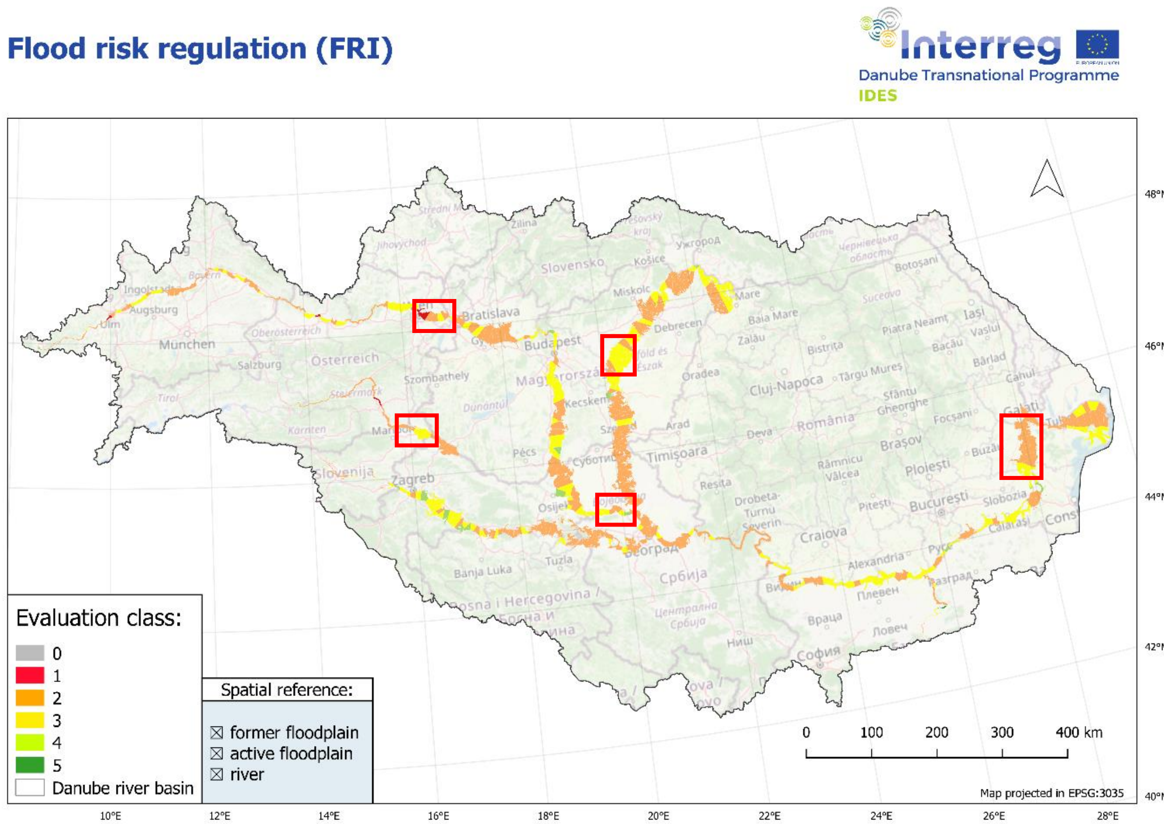


Figure III.3 Map of flood risk regulation as evaluated by the IDES Tool

In the Serbian pilot area, the IDES Tool evaluated the flood risk ES as a medium-high value (3-4), whereas other pilot areas evaluated it as low-medium (2-3). Only the urban Viennese part of the Austrian pilot area evaluated it as very low (1). Regarding flood risk regulation (Figure III.3), the high demands of the stakeholders are currently just sufficiently met by the respective pilot areas from a basin-wide perspective. However, based on the local assessments, this ES is higher in some pilot areas and agree with the stakeholder’s perceptions (e.g. in Serbia and Romania) (IDES Manual, chapter 3.2, Stäps et al. 2022).

III.3.2 Landscape aesthetics

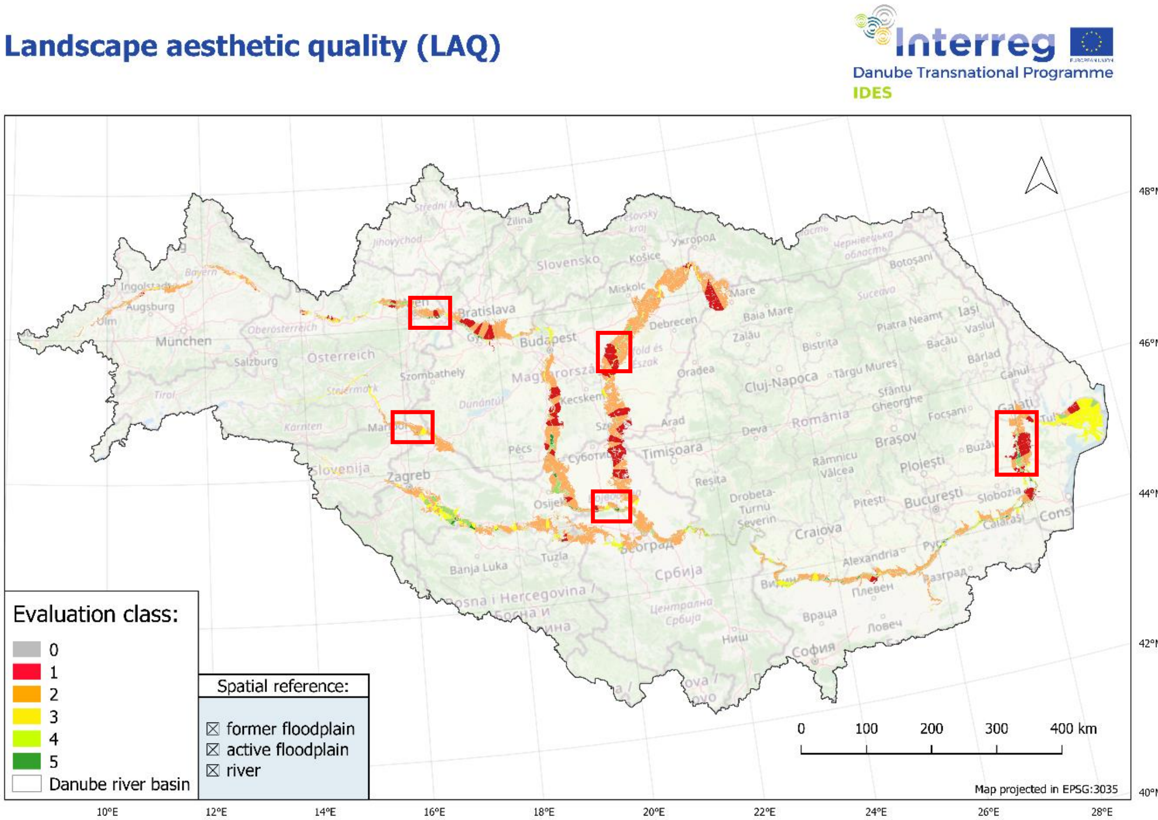


Figure III.4 Map of landscape aesthetic quality as evaluated by the IDES Tool

Stakeholders consider an aesthetic landscape as important for recreational activities (Figure III.4). The potential provision of this ES is good to very good (4-5) in the rivers and active floodplains of all pilot areas and matches the stakeholders' evaluations. In contrast, it has been evaluated as very low to low (1-2) in the former floodplains.

III.3.3 Plant biomass of grasslands for agricultural purposes

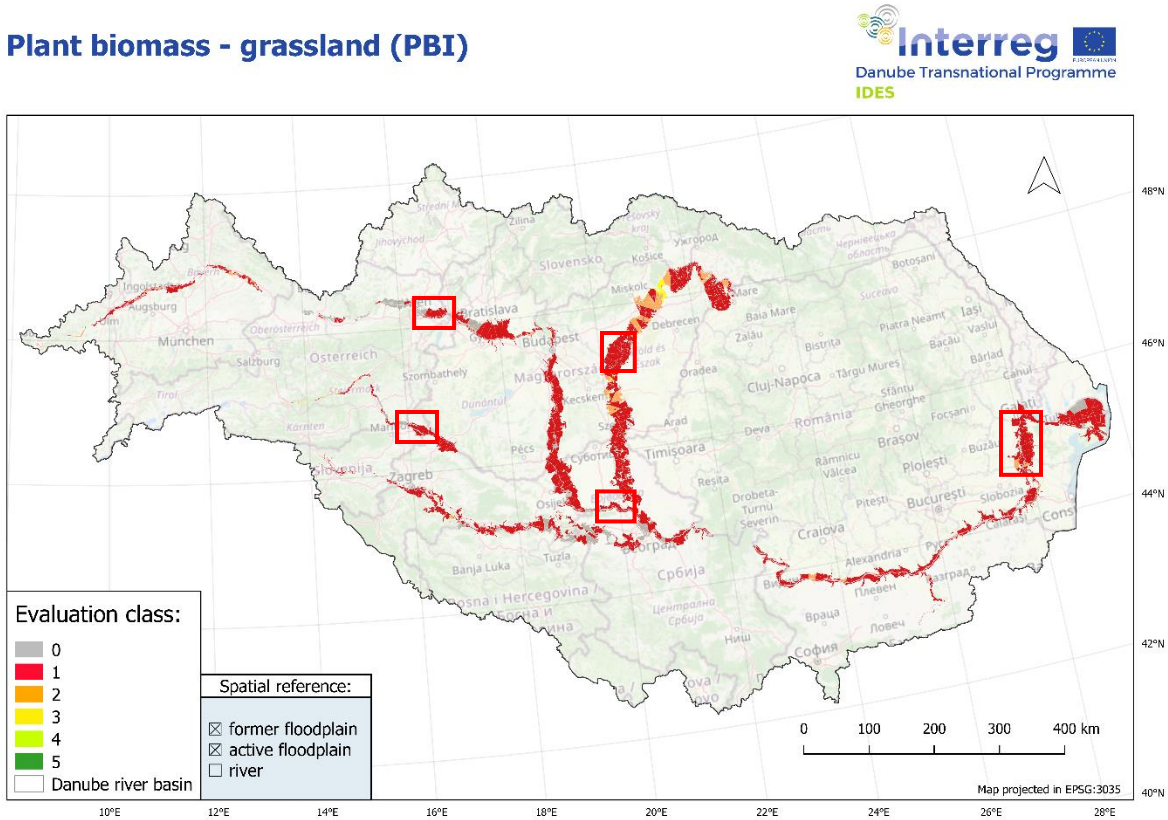


Figure III.5 Map showing the provision of plant biomass as evaluated by the IDES Tool

Stakeholders ranked plant biomass in all five pilot areas with a high value (Figure III.5). However, the IDES Tool evaluated the provision of biomass as very low (1) or low (2). This pattern is due to a low share of productive grasslands and is similar on the basin-scale and the local scale (IDES Manual, Chapter III.2, Stäps et al. 2022), as well as in all investigated active and former floodplains of the DRB.

III.3.4 Habitat provision

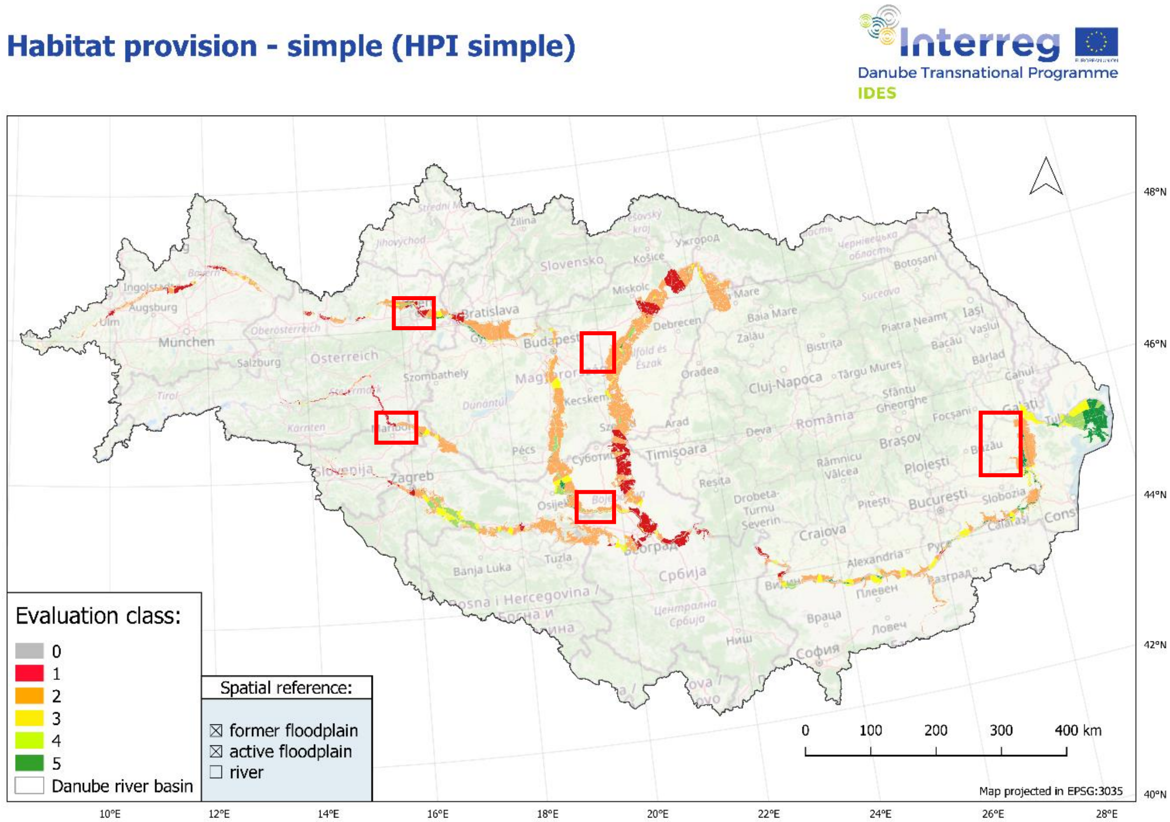


Figure III.6 Simple representation of habitat provisioning in floodplains as evaluated by the IDES Tool

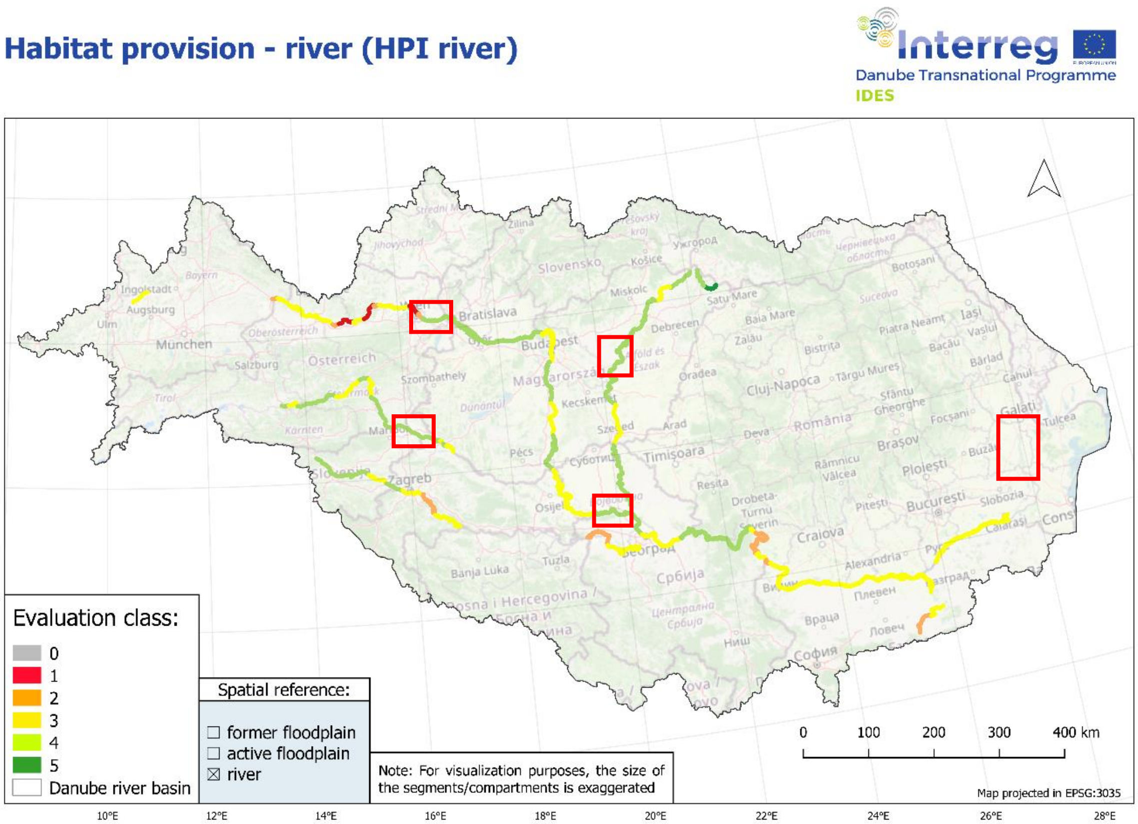


Figure III.7 Map of habitat provisioning in rivers as evaluated by the IDES Tool

For habitat provision, the IDES Tool differentiated between the provision in the river and the active and former floodplains. All river sections provide good (4) habitat quality in the investigated pilot areas. In the active floodplain sections of the pilot areas, the habitat provision is high to very high (4-5) in Austria, Slovenia and Romania but medium to high (3-4) in Hungary and Serbia. Former floodplain sections provide low to medium (1-3) quality for habitats. Hence, the high expectations of the stakeholders are met mainly by the river and active floodplain parts of the pilot areas but not by the former floodplain parts. Also, the local habitat assessments revealed a similar pattern, with even higher ranks in the active floodplain in the Serbian pilot area (IDES Manual, Chapter III.2, Stäps et al. 2022).

III.3.5 Drought risk / low flow regulation

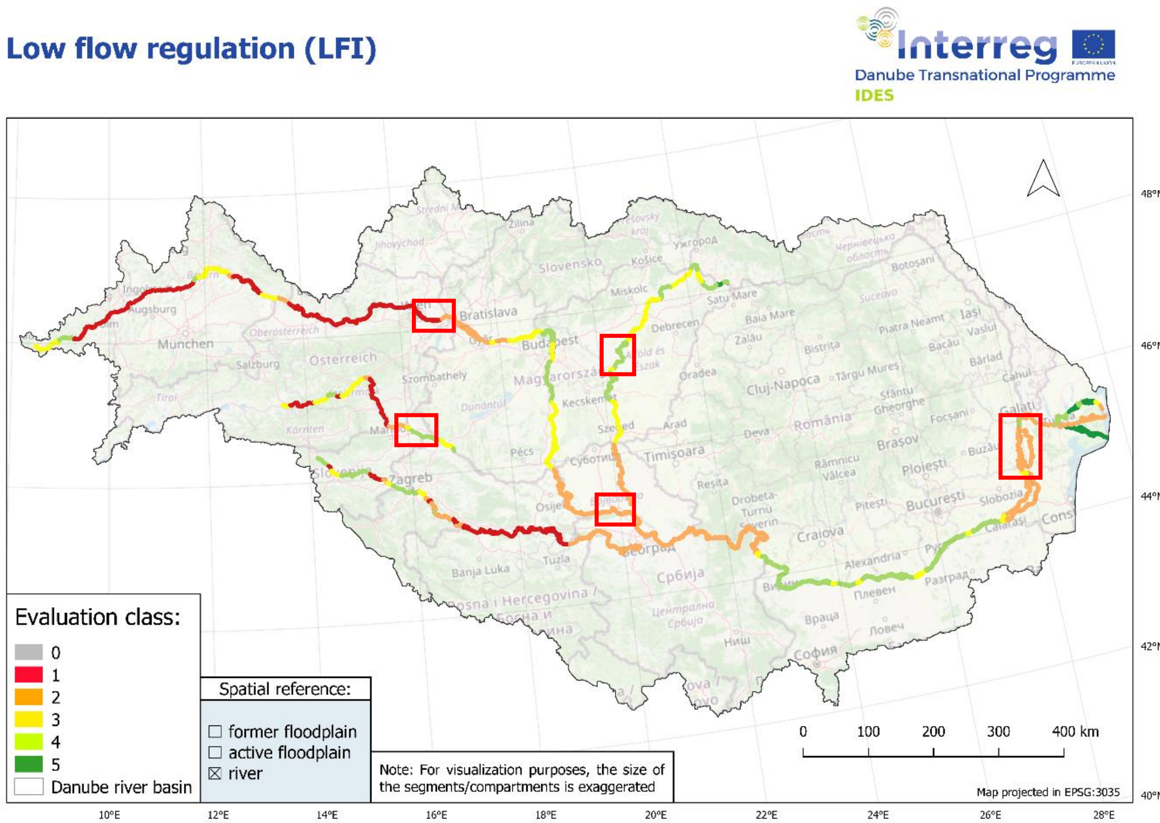


Figure III.8 Map of low flow regulation as evaluated by the IDES Tool

The stakeholders gave drought risk or low flow regulation a high value. The basin-wide evaluations of the IDES Tool resulted in very low to low (1-2) values in the pilot areas of Austria, Serbia and Romania but medium to high (3-4) values in Slovenia and Hungary. Hence, only in the latter two pilot areas, the regulation of low flow to counteract drought risk is similarly high as valued by the stakeholders. However, in pilot areas where finer and more detailed hydro-morphological assessments were available, the local evaluation classes of low flow regulation improved (e.g. in Austria) (IDES Manual, Chapter 3..2, Stäps et al. 2022).

III.3.6 Conclusion

Not all of the ES considered valuable by the local stakeholders are considered by the IDES Tool (e.g. symbolic significance, reduction of air pollution). Hence, the importance of ES, as perceived by stakeholders, should be considered before selecting ES for the IDES Tool evaluations. In contrast, the a-priori selection might highlight the significance of other ES, which the stakeholders were unaware of or consider worthy.

The potential ES provision generally matched the valuation of the stakeholders on the basin-scale, and locally, they agreed even more. However, potential ES provisions and actual use sometimes did not match on each spatial scale. Therefore, it is necessary to point out these areas on both scales (e.g. plant biomass of grasslands, landscape aesthetics and habitat provision in former floodplains) to envisage and tailor actions to improve the well-being of both local and international stakeholders.

III.4 Integration into the DPSIR framework

ES serve to connect human well-being to properly functioning ecosystems. Socio-ecological systems interact via multiple connections and cause-and-effect relations. Multiple attempts have addressed this complexity, and the most common organising approach seems to be the DPSIR framework (Drivers, Pressures, State, Impact, Response) (Müller & Burkhard 2012, Figure III.9).

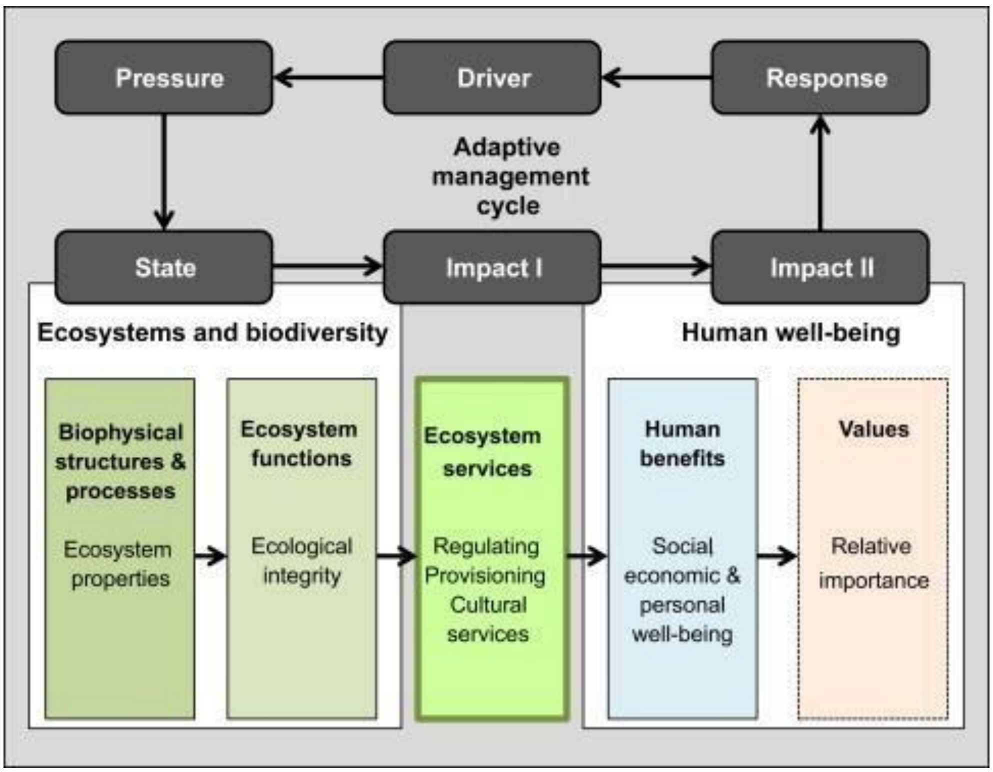


Figure III.9: ES as part of the adaptive management cycle for human-environmental systems, following the ES cascade of Haines-Young and Potschin (2010). While the traditional field of environmental indication mainly occupies the left side of the sketch, the anthropocentric components of the management cycle reside on the right. © Müller and Burkhard (2012), https://doi.org/10.1016/j.ecoser.2012.06.001, licensed under Creative Commons CC-BY-NC-ND (https://creativecommons.org/licenses/by/4.0/legalcode).

According to the DPSIR framework, social and economic developments exert pressures on the environment, causing state changes, such as the provision of ES. Finally, this leads to impacts on human well-being and ecosystems that may elicit a societal response that feeds back to the drivers or the state or impacts directly through adaptation or curative action. The real world is far more complex than can be expressed in simple causal relations. There is arbitrariness in the distinction between the environmental and human systems. Moreover, many human and environmental systems relationships are not sufficiently understood or difficult to capture in a simple framework (European Environmental Agency).

When working with the stakeholders in the pilot areas, the approach was simplified, working with only two parts/factors: **pressures** (with a negative impact on the ES) and **measures** (as a response of the society to reduce the negative impact on ES that the pressures exert). The drivers may have impacted at the global/regional level yet could not be easily identified by the local stakeholders.

By merging the networks of all pilot areas, we created a complex network that includes the concepts and relationships between concepts (Figure III.10-11). The aim of this was to create an overall view of how the stakeholders perceive the ES, pressures and the measures to reduce the impact at the basin scale. The idea was that an overall model would allow upscaling from the local problems (identified at each pilot area) to a model that could be applied to understand the systems functioning at larger scales (basin-wide).

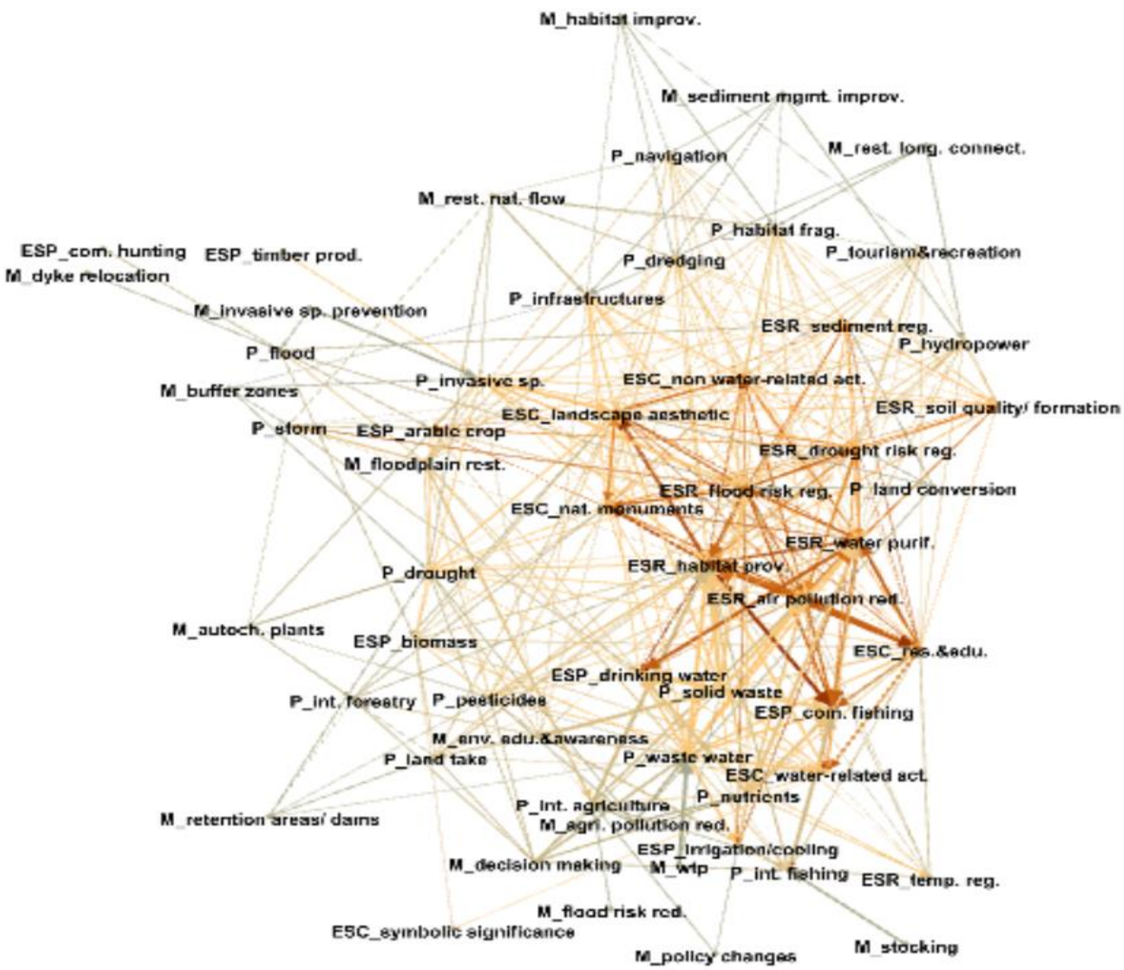


Figure III.10: Merged network for all sites showing complex relationships (trade-offs and synergies) between different ES as well as the most important measures (M) and pressures (P). The intensity is directly proportional to the concepts' centrality (centrality = the measure of prominence or importance of a concept within a network).

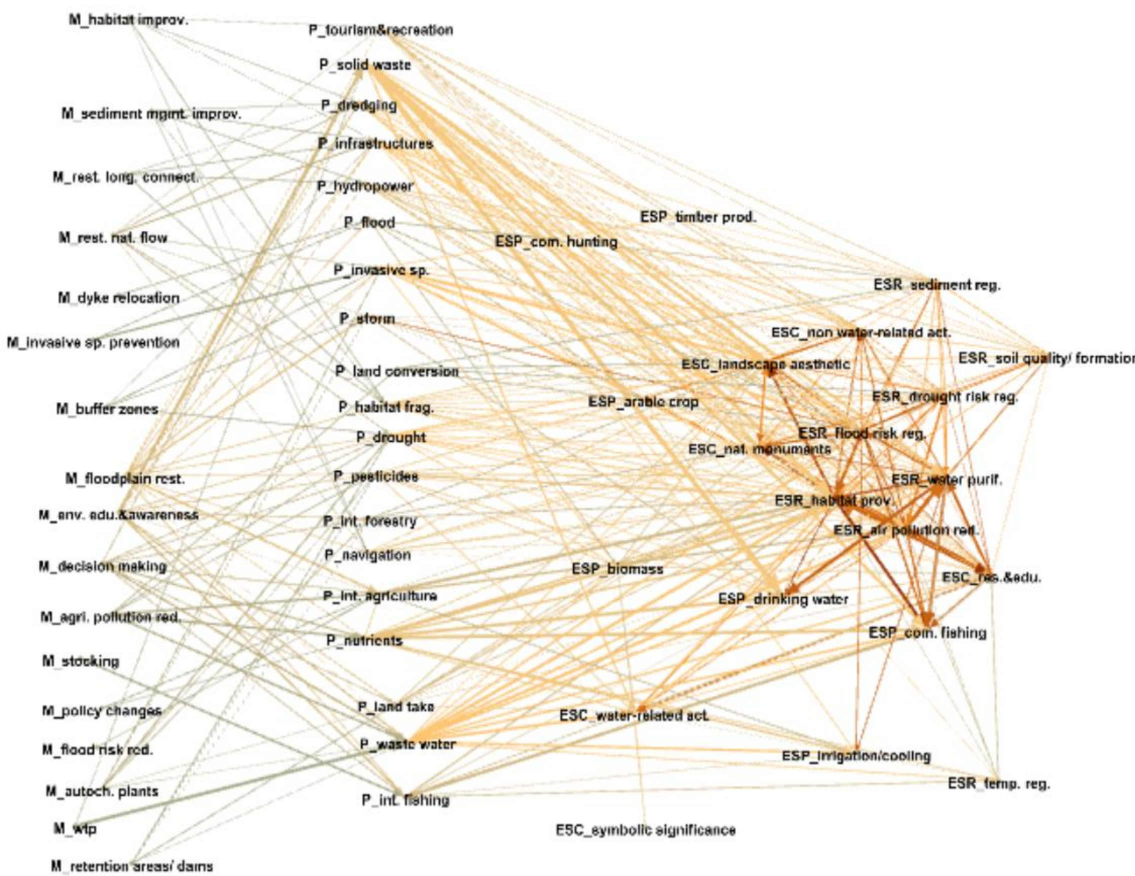


Figure III.11: Linkages between measures (M), pressures (P) and ecosystem services (ES) for all pilot areas

Reducing the dimensionality of the network based on the centrality, we are observing the following (Figure III.12):

Even if pressures appear to be present in all the pilot areas, the measures (besides floodplain restoration) appear site-specific (they have a lower degree of centrality;). The importance for site-specific measures are the following:

- specificity of local conditions in selecting measures to address general pressures,
- insufficient knowledge, and missing generalisation of measures across pilot areas and stakeholders.

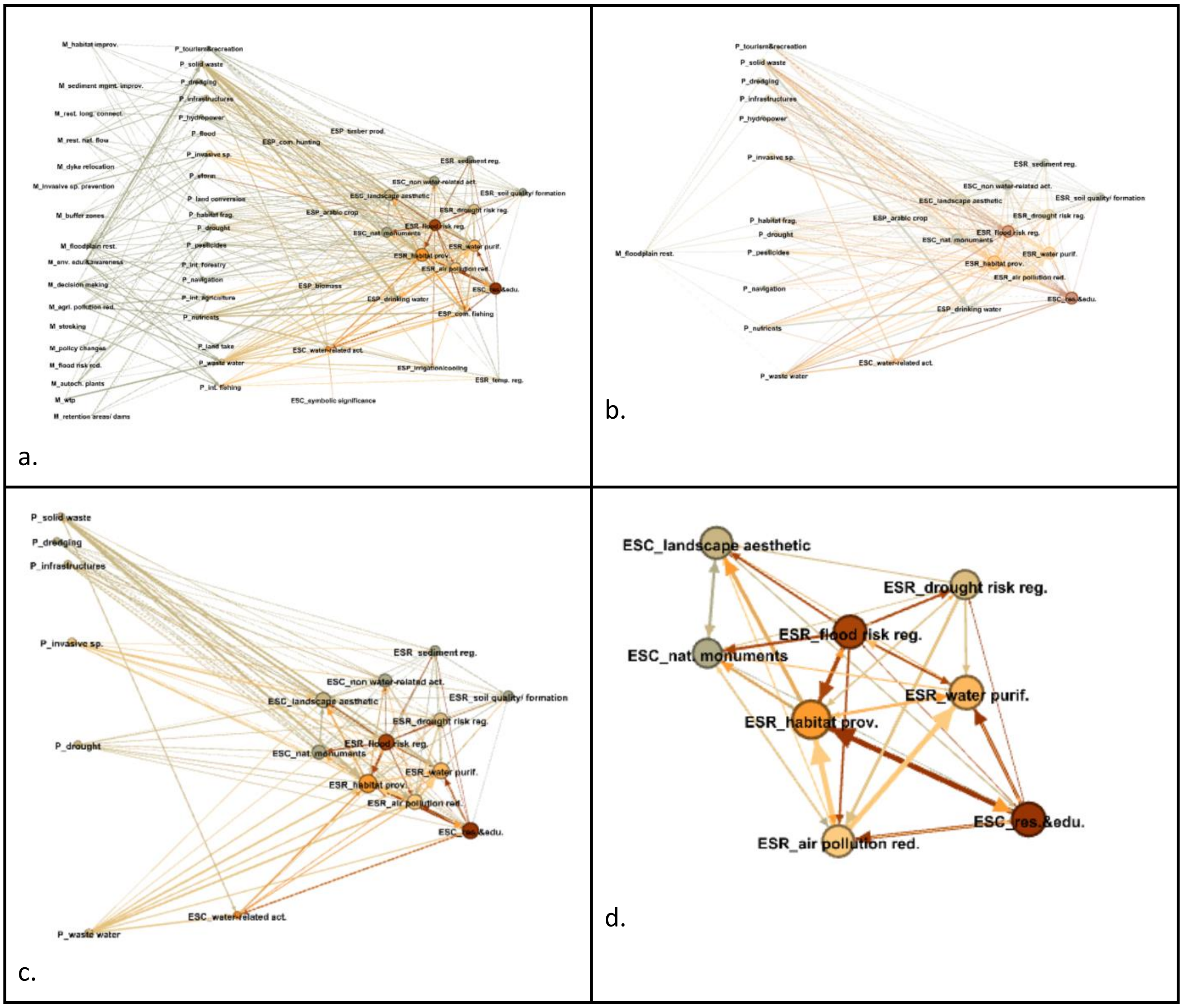


Figure III.12: Reducing the dimensionality of the network using centrality (a: <2; b: <13; c: <25; d: <28)

These results demonstrate that developing strategies to improve the water quality and related ES need to consider the local specificity. Even if the problems and needs are similar in all pilot areas, the solutions tend to be site-specific. Consequently, there is a need to integrate local stakeholders in developing action plans that will affect the use of ES and the well-being of different communities. Although a limited number of individual measures (as well as pressures) could increase the water quality, their combinations (or the concrete scenarios) should come from local knowledge. Tools like FCM could help identify and justify (in terms of local perceptions) the most important measures to improve water quality, manage multiple ES, and harmonise different interests among stakeholders at different spatial scales.

The valuation of ES for any ecosystem type or complex of ecosystems should be co-constructed with the stakeholders in steps. The different perceptions of ES, but also of pressures and measures that various stakeholders have, could allow or hinder (depending on many factors) the development and implementation of plans to improve, e.g., the water quality in complex river floodplains. Decision-makers, researchers, and planners should consider the system's complexity and unravel new ways to foster the stakeholders' views in decision-making. A future DRB Management plan based on ES should have multiple socio-ecological benefits for multiple users.

IV. IDES tool

Martin Tschikof, Elisabeth Bondar-Kunze

The following chapter represents a summary of the rationale, innovation, contents and fields of application of the IDES Tool. For a detailed technical step-by-step guide, please refer to the IDES Manual, chapter 2.2 (Stäps et al. 2022).

Rationale

Floodplains are critically threatened, yet among the world's most diverse and productive ecosystems, providing a plethora of vital ecosystem services (ES). Consequently, the EU Strategy on Adaptation to Climate Change (EU COM 2021) states (under no. 11) that '*Blue-green (as opposed to grey) infrastructures are multipurpose, "no regret" solutions and simultaneously provide environmental, social and economic benefits and help build climate resilience. For example, protecting and restoring wetlands, peatlands, … will help adapt to climate change in a cost-effective way. It is vital to better quantify their benefits, and to better communicate them to decision-makers and practitioners at all levels to improve take-up*. *… Nature-based solutions are essential for sustaining healthy water, oceans and soils. They must play a bigger role in land-use management and infrastructure planning to reduce costs, provide climate-resilient services, and improve compliance with Water Framework Directive requirements for good ecological status.*' However, successful implementation of nature-based solutions, e.g. blue-green infrastructure, depends on the reconciliation of the multiple stakeholder interests usually linked to rivers and floodplains. Ecosystem Services constitute a competent tool for inter-sectoral communication and multivariate, integrative decision support at the interface of natural and socioeconomic systems. The IDES program chose this Tool to address complex interdisciplinary questions in ecosystem management with human involvement.

Innovation

- Harmonised ES evaluations across spatial scales

Among the many existing ES evaluation approaches, the IDES Tool has selected methodological approaches that allow a harmonised, data-based, and objective evaluation and visualisation of the whole range of ES provided by rivers and floodplains on local, national, and basin scales. Thereby, the IDES Tool accounts for the spatial variability of ES in the very diverse and international Danube River Basin (DRB), where data and their availability are heterogeneous and transnational management is particularly challenging.

- Promoting communication between sectors and individual stakeholders by demonstrating the diversity of ES and co-creating scenarios

The overall target of the IDES Tool is the sustainable management of floodplains as multi-functional socioecological systems and the demonstration of the manifold ES they provide. However, the values of ES, their underlying pressures, and mitigation measures are perceived differently by stakeholders and in different areas. The IDES Tool creates a shared, comprehensible ground based on ES to promote a more inclusive discussion. By sharing objective and harmonised ES evaluations and exchanging various stakeholder perceptions, awareness about the diversity of ES and hence, the multifunctionality of floodplains is co-created. Further, the Tool promotes the elaboration of scenarios through joint stakeholder discussions about the pressures and mitigation measures affecting ES. Thus, the synergies and trade-offs of the considered measures can be demonstrated and further discussed.

- Raising awareness about water quality issues as an international concern

In many rivers of the DRB, nutrient concentrations have reached undesirable levels. As upgrades to wastewater treatment plants will only provide marginal improvement (as grey infrastructures), the IDES project has aimed at improving water quality by supporting the natural retention of nutrients in floodplains. Here, the IDES Tool provides a new method to prioritise floodplains based on their water quality functions and the degree of nutrient pollution on the basin-wide and national levels. The method focuses on the synergies between these water quality functions and ES.

- Accelerating decision-making for a (more) integrated floodplain management

The objective ES evaluations by the IDES Tool, together with the inclusion of stakeholders, and the co-creation of scenarios, promote the identification of multi-functional nature-based solutions. Further, its application on different scales encourages the placing of local needs within a national or basin-wide context. The ability to adjust spatial scales allows more diverse sectors to become involved and coordinates local ES toward better floodplain management.

Content

The IDES Tool involves the following working steps as explained in the IDES Manual (Stäps et al. 2022):

- Spatial delineation of rivers as well as active and former floodplains (IDES Manual, chapter 2.2.3)
- Scale-dependent segmentation into equally sized and comparable units to reflect the spatial variability within extensive floodplains (IDES Manual, chapter 2.2.3)
- Selection of an appropriate range of ES reflecting stakeholders' interests and legal goals (IDES Manual, chapter 2.2.4)
- GIS-based evaluation of ES availability in 5 classes, either based on a matrix of land uses (capacity matrix) or more complex algorithms (indicator-based approach) (IDES Manual, chapter 2.2.5)
- Prioritisation of floodplains for water quality improvement (IDES Manual, chapter 2.2.6)
- Comparison and aggregation of ES to demonstrate benefits across many sectors and to visualise the results (IDES Manual, chapter 2.4)
- Co-creation of management scenarios with stakeholders (IDES Manual, chapter 2.3 and 2.4.2)

Implementation of integrated floodplain and water quality management

Integrated floodplain management

The IDES Tool provides a familiar and objective communication platform for stakeholders from various societal sectors. By showing the quantity and quality of ES and their changes in (management) scenarios, the possible synergies and trade-offs between ES can be presented and discussed beforehand, and possible concessions agreed upon among stakeholders. This way, stakeholders can find joint solutions and compromises and mitigate conflicts of interest. The Tool enables environmental managers to justify better the sometimes costly restoration measures by demonstrating the multiple benefits (synergies) created by these measures. The IDES Tool does not support direct economic evaluation of ES, though, to avoid ethical and methodological biases of monetisation.

Water quality management

Water purification is one of the regulating ES that the IDES Tool assesses. In the DRB, nutrient retention in floodplains should complement the technical treatment of point-source pollutants but cannot counteract the excessive nutrient inputs from diffuse and point sources (Tschikof et al., 2022). Therefore, the IDES Tool *supports* water quality improvement by prioritising critical areas and through measures jointly improving other ES. It facilitates identifying the best compromise between local needs (e.g. crop production, recreation), regional development (e.g. drinking water supply, tourism), and river basin management goals (e.g. improving water quality).

The IDES Tool in river basin management and international policies

River basin management

The IDES Tool enabled the first harmonised overview of the ES provided by the floodplains of the DRB. These ES evaluations underpin essential prerequisites to successfully address the complex questions in river basin management, which require a trans-disciplinary approach. Decision makers can confront pressing challenges in the DRB of climate change (and extreme events), biodiversity loss and invasive species, pollution, hydro-morphological alterations, agriculture, navigation, and energy production. The IDES Tool could provide a more integrated strategy in future Danube River Basin Management Plans. Planners can apply the IDES Tool on a large spatial scale to identify floodplain areas most suitable for promising management actions and refine strategic plans.

Coordination of sectoral and international policies

Application of the IDES Tool in river basin management planning may facilitate the identification of common targets set by several EU directives which apply to floodplains, e.g. the Water Framework, Floods, Habitat, Marine Strategy Framework, and Nitrates Directives. The IDES tool may improve the effectiveness and coordination of implementing those policies. Moreover, the application of the IDES Tool in the international context, e.g. the DRB can assess the availability of ES with a uniform methodology acceptable to all involved countries. Applying such a harmonised approach will contribute to better integration of ES into international policies and to a better-aligned analysis of action needs and planning of management measures among the involved countries.

V. Status of the ES in the Danube River Basin

Martin Tschikof, Elisabeth Bondar-Kunze

In this chapter, the IDES Tool uses the detailed indicator approach to produce and map an aggregated overview of ES in the DRB. Individual ES in the DRB appears in the IDES Manual, chapter 3.1 (Stäps et al. 2022). The following maps show 4 to 6 simple metrics to visualise the multifunctionality of regulating and provisioning ES and the overall status of ES. Each metric depicts a specific perspective on ES evaluations' quantity and/or quality. The IDES Manual describes further details about the metrics used and visualisation options in chapter 2.4 (Stäps et al. 2022).

Multifunctionality metrics applied in this chapter:

A) Number of ES [0 to n]: The total number of ES evaluated per 10 km segment with the indicator-based approach

B) ES Sum Index [0 to n]: The total sum of ES evaluation classes (including ES evaluated for different compartments)

C) ES Mean Index [0 to 5]: The mean value of ES evaluation classes (including ES evaluated for different compartments)

D) ES Multifunctionality Index [0 to n]: The quotient of the number of ES with an evaluation class above 4 and ES with a class below 4 (including ES evaluated for different compartments). The higher the index, the higher the multifunctionality of the segment. Index values below 1 show that low-scored ES dominate, a value of 1 means a trade-off between low- and high-scored ES, and at values above 1, high-scored ES dominate.

E) Floodplain Specificity Index [0 to n]: This index relates to the overall ES assessment. It gives the quotient of ES, provided exclusively by rivers and floodplains (e.g. flood risk-, low flow-, and sediment regulation), and ES provided elsewhere (e.g. arable crop and biomass production, non-water-related recreational activities). The higher the value of the index, the higher the floodplain specificity of the provided ES. The further interpretation is similar to the ES Multifunctionality index (D).

F) Simpson's Diversity Index *D* [0 to 1]: A commonly used species diversity index that can be adapted to assess the diversity of the overall ES supply. In this case, ES evaluations replace the species abundance values in the original index when calculating *p.* The higher the value, the more diverse the ES per segment.

$$D = 1 - \sum p_i^2$$

$$p = \frac{\text{total sum of ES evaluation classes}}{\text{ES evaluation class of each ES i}}$$

V.1 Status of regulating ES

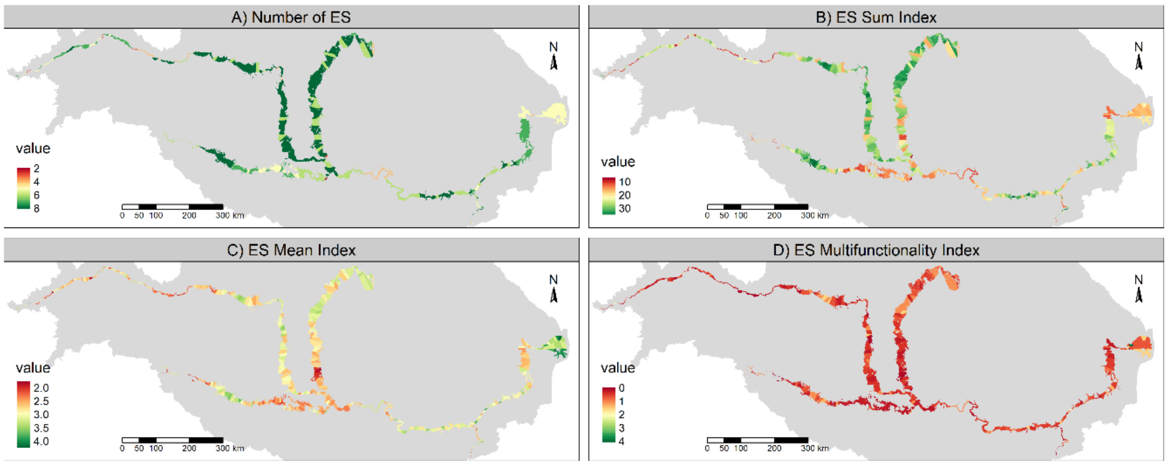


Figure V.1 Status of regulating ES

Regulating ES represented the dominant ES type evaluated in floodplains (Figure V.1). This is because diverse ecosystem processes occur in floodplains, translating into regulating ES. The eight included ES in the maps are: habitat provision in the floodplain (1) and river (2), nitrogen (3)- and phosphorus (4) retention, sediment (5)-, greenhouse gas (6)-, low flow (7)- and flood risk (8) regulation (details in Table III.1).

A) Number of ES: Fewer regulating ES evaluations occurred in river stretches without floodplains (cf. Figure III.1) and in the Danube Delta. The Danube Delta was excluded from many ES evaluations due to its distinct hydrology and limited data availability.
B) ES Sum Index: The middle Danube, Sava and Mura, and the upper Tisza provided the most ES. Stretches with active floodplains (cf. Figure III.1) provided particularly many regulating ES.
C) ES Mean Index: The Danube Delta produced the highest mean ES values with the lower and middle Danube, and the middle Sava and Mura also with high values.
D) ES Multifunctionality Index: Segments of proportionally high ES scores were located in areas similar to the map created with the ES Mean Index (C). However, in most segments, ES with low scores dominate.

V.2 Status of provisioning ES

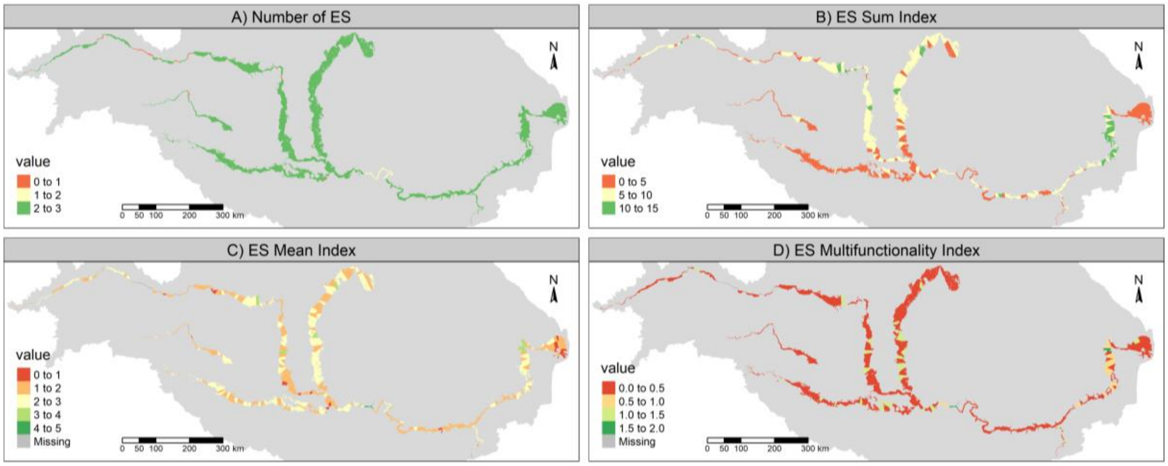


Figure V.2 Status of provisioning ES

Provisioning ES represented the second most frequently evaluated ES type (Figure V.2). Arable crop (API) and plant biomass (PBI) production occurred in all areas with active and potential floodplains. Commercial fisheries (CF) were only evaluated in the Romanian Danube (and its border regions) because of their economic importance and available data.

A) Number of ES: The number of provisioning ES was generally low (ref. Table III.1), with the lowest values in river stretches without floodplains.
B) ES Sum Index: The middle and lower Danube and Tisza provided the most ES. The Brăila Islands were prominent by providing both agriculture and commercial fisheries. Generally, former floodplains are more relevant for agricultural production, and active floodplains do not substantially affect the distribution of provisioning ES.
C) ES Mean Index: The mean ES provision is low to average, and the spatial patterns are similar to the map created with the ES Sum Index (B).
D) ES Multifunctionality Index: Generally, provisioning ES with low scores dominates the DRB.

V.3 Status of cultural ES

Cultural ES were least covered by the indicator approach since human perception and subjectivity strongly influence its provision (Chapter 3). In this particular case, non-water-related activities (NWA) were the only cultural ES evaluated using the indicator approach (map in chapter 3.1 of the IDES Manual (Stäps et al. 2022)). Hence, an aggregated visualisation of cultural ES was not meaningful.

V.4 Overall status of ES

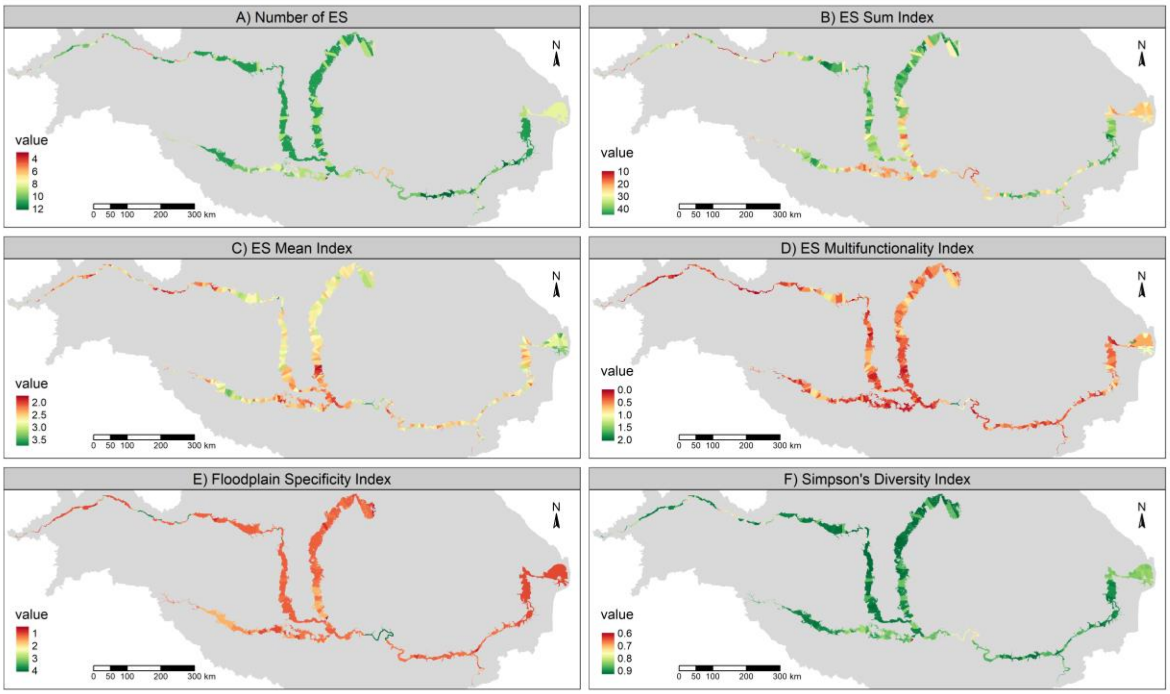


Figure V.3 The maps of overall ES status (including NWA) give a spatial overview of the multifunctionality of floodplains across the DRB with up to 12 different ES per segment.

A) Number of ES: Stretches without active floodplains contained the lowest provision of ES. The Danube Delta has distinct features that hindered ES evaluation.

B) ES Sum Index: The sum of ES evaluations shows a similar but more differentiated spatial pattern than the map showing the number of ES (A).

C) ES Mean Index: The highest mean ES evaluations occurred in the Danube Delta, the upper Tisza and the middle Danube, the Sava, and the lower Danube and the Mura.

D) ES Multifunctionality Index: Overall, low-scored ES dominate throughout the DRB or balance with high-scored ES. There are a few hotspots of high-scored ES, but these segments contain few ES in absolute terms.

E) Floodplain Specificity Index: ES's floodplain and river specificity are very high in areas with exclusively riverine ES. Except for a few segments in dark red (FSI < 1), floodplain-specific ES dominate in the DRB.

F) Simpson's Diversity Index: The index is highest in segments with all 3 compartments (river, active- and former floodplains) and hence, where most ES were found (A).

V.5 Conclusion

Aggregated visualisations of the status of ES help to gain a general overview of the distribution of the ES quantity and their quality and to identify “hotspots” of ES provision as well as potential priority areas to improve ES (cf. prioritisation approach for water quality functions, IDES Manual, chapter 2.2.6 (Stäps et al. 2022)). However, when evaluating the status of ES by aggregating them, it is essential to differentiate between the different metrics or indices of ES quantity and ES quality. The number of ES (A) is a simple metric to assess the overall quantity. The ES Sum Index (B) integrates the number of ES and their qualitative assessment, which is particularly useful to analyse spatial patterns but less valuable for comparing different types of ES (e.g. regulating vs provisioning ES). It requires interpretation alongside the number of evaluated ES. The ES Mean Index (C), a qualitative metric, averages the total ES evaluations between 1 and 5. It is less sensitive to the number of ES, as compared to the total sum, but averages out the distribution of their evaluations, resulting in frequent values around the mean (=3). Therefore, using a threshold like in the ES Multifunctionality Index (D) gives a more nuanced overview of the distribution of ES evaluations. The index of floodplain specificity (E) highlights the ES provision of the areas of interest for IDES. More complex diversity indices provide additional information but are more challenging to interpret. Even though Simpson’s diversity index (F) is less sensitive to the number of ES than other indices (e.g. Shannon index), the number of ES still needs to be considered for a correct interpretation. When assessing ecosystem multifunctionality or ES diversity, good practice suggests working with different metrics in parallel, as no single one can provide a comprehensive answer to a complex issue.

VI. Selection of the most important measures for improving the status of the ecosystem services

Dávid Béla Vizi; Gergely Szabolcs Gál

An essential step in developing an ES approach to floodplain management is identifying relevant measures for their performance. On a national level, this may involve establishing a specific list of measures that characterise the priorities, resources and stakeholder perceptions in that country. The measures should share standard evaluation criteria to ensure global harmony in the evaluation process. The suitable set of ES evaluation methods should be as simple as possible and as detailed as necessary. The methods should have flexibility in their data collection and evaluation to account for the broadest possible scenarios. This section focuses on ES for water quality measures applied at the national and DRB-wide levels.

Government agency documents provide most water quality measures. The agencies may regulate national, regional or global systems e.g. River Basin Management Plans and Flood Risk Management Plans. Water quality managers adopt ES measures that work toward achieving a rating of “good condition” or “good status” as defined by the ruling directive. Critical aspects of the evaluation include expected performance level and input from stakeholders (i.e. their perceptions). While managers may implement measures at the sub-basin level, local impacts still play a significant role in the decision process.

River floodplain systems in the DRB contribute 26 ecosystem services from three main groups (regulation, provisioning, and cultural). Flood risk regulation, nutrient retention, and habitat provision are the most significant measures to improve ecosystem services. The IDES Tool (Chapter IV) evaluates the potential effectiveness of a measure. In order to gauge performance, evaluators must examine conditions before and after implementing the measure. The FCM (Chapter III) methodology can quantify changes in ecosystem services by evaluating interrelationships between pressures, measures and ES in a specific area. Pressures affect ES negatively, whereas measures can attenuate pressures. The IDES has compiled the following standardised list of pressures on the floodplain ecosystem and its water quality:

- Pollution: organic or hazardous pollution, and by nutrients or plastic waste,
- River connectivity: interruption of river continuity and morphological alterations, disconnection of adjacent wetlands/floodplains,
- Hydrology: hydrological alteration, altered quality and quantity of groundwater and surface waters,
- Hydrological extreme events (partly induced by climate change): flood and excess water, drought and water scarcity.

The measures were categorised based on their type and status. The following types were defined:

- A **general recommendation** that could lead to improving the river segment’s status (not used concretely).
- An **implemented**, previously used measure which has a good impact.
- A **program** that improves ecosystem services.
- A **law** regulating activity in the country generates a good impact.

- A form of **financing** that improves ecosystem services and water quality.

The Table VI.1. contains the collected measures with the directly targeted ES. A table with a more detailed assessment is part of Deliverable D 3.1.1.

Table VI.1 Summary list of measures to improve the status of the ES

Significant ES	**Measure Type**	**Directly targeted ES**
Flood Risk Regulation alimentation	Development of appropriate long-term compensation schemes for restoration and enlargement of floodplains by land-use change	Flood risk regulation
	Dike/levee relocation	Flood risk regulation
	Identification, establishment and conservation of floodplains	Flood risk regulation
	Improve water supply to floodplain (reconnection, water alimentation regulation)	Flood risk regulation
	Maintenance of rivers and lakes to gradually reduce the flood risk and create good ecosystem conditions or potential	Flood risk regulation
	Measures to adjust and raise riverbed levels by ribs and sills, as well as aggradation (deposition of sediment)	Sediment regulation
	Measures to mitigate scouring of a riverbed, and the effect of lowering of water level	Sediment regulation
	Removal of accumulated sediment and overgrown vegetation from rivers and lakes	Sediment regulation
	Restoration of small retention reservoirs	Flood risk regulation
	Restoration or establishment of appropriate or native vegetation in the floodplain	Flood risk regulation

Continued on the next page.

Significant ES	Measure Type	Directly targeted ES
Habitat Provision	Adaptation of navigation by considering the characteristics of rivers and lakes	Water-related activities
	Compensatory reforestation on the floodplain in lateral flow dead regions	Plant biomass
	Demolition of insufficient river regulation structures if they are not needed to achieve a good status or potential	Opportunities for water-related activities
	Measures to reconcile natural bed profile and meandering with satisfying societal needs	Habitat provision
	Measures to restore the connection between the main branch and cut bend, backwaters and tributaries or provide regular flooding to floodplain	Habitat provision
	Removal of inorganic waste in rivers and lakes	Landscape aesthetic quality
	Reconstruction and maintenance of facilities in the river bed, including the application of natural solutions and materials	Natural heritage
	Rehabilitation of the water type-specific zonation in the riparian zone of the rivers and lakes	Habitat provision
	Restriction of dredging to increase channel cross-section and disposal of dredged material to avoid sensitive ecological and water resource locations	Low water regulation
Nutrients Retention	Creation of riparian zones without agricultural or horticultural land use (buffer strips)	Nutrient retention
	Measures to meet the unique needs of nature conservation with the other water quality protection measures	Nitrogen retention
	Specific hydro-morphological measures to improve the status of nature-protected areas, including special regulation of abstractions, impoundments and water supply to meet the needs of nature conservation	Water resources supply

VI.1 Proposed measures in pilot areas

Stakeholder Workshops promoted discussing the possible measures in the pilot areas (Chapter III). The participants had the opportunity to construct an optimal scenario, which could most likely improve ecosystem services and water quality.

The basis of this Chapter is the deliverable “D T2.1.2: Identification of ES and proposed measures in pilot areas”.

VI.1.1 Donau-Auen National Park (Austria)

Table VI.2 The measures selected to reduce the pressures in the Austrian pilot area

Pressure	Selected measure for the Water Management Concept
Navigation	- reduce speed or increase the distance to shore; - ban/quota on Twin City liners; - significantly reduce emissions; - continue to reduce/improve treatment of waste entering the Danube; - reduce negative impacts of river regulations; - research on fish fauna, habitat quality, and migration information; - create more spawning habitats for fish fauna; - promote more eco-friendly ships ; - more efficient capacity utilisation with improved conditions in the waterway.
Invasive alien species	- encourage higher riparian dynamics; - remove rip-raps where not appropriate.
Human infrastructure	- shorten footpaths for easier access; - reduce and consolidate paths; -dismantle paths in the lower Lobau (partially complete) ; - maintain/monitor the number of visitors.
Habitat fragmentation	- reconnect all major side arms to the Danube; - manage bed load.
Tourism and recreation	- promote efficient visitor guidance; - relocate more intensive public use outside the NP; - measures aimed at keeping the numbers at the current level.
Hydropower	- fish ladders; - adding 215,000 m^3/year of bedload.
River regulation	- major deconstruction programme; - river regulation for navigation will be rebuilt to reduce negative ecological impacts; - everything that does not add value will be removed.

VI.1.2 Special Nature Reserve “Koviljsko-petrovaradinski rit” (Serbia)

In the nearby settlement Kovilj, 95% of households connect to the wastewater treatment plant (WWTP) and sewage system. However, the remaining 5% would benefit from the connection as well. Moreover, plans for developing a new industrial zone must include planning a sewer network and accompanying WWTP.

Protective belts/buffer zones composed of natural vegetation would mitigate agricultural pollution along drainage canals.

Wetland areas represent the core of biodiversity; therefore, its preservation has absolute priority.

While stakeholders have opposing opinions about the importance of restoration of longitudinal connectivity, all believe that renewing old bypasses is required. Water-related fauna (fishes, turtles, lizards etc.) would benefit the most.

Future measures could focus on maintaining a habitat already in good condition.

Native biodiversity requires preservation. Additionally, hybrid poplars should remain under controlled management. All other allochthonous and invasive species require removal.

In case of initiatives in tourism and recreation expansion – authorities should provide extensive planning and assessment of the number of people and specify recreational activities. The planning will allow for more efficient and beneficial implementation.

Table VI.3 The measures selected to reduce the pressure in the Serbian pilot

Selected measures for the WMC
Constructing or upgrading wastewater treatment plants
Reducing pollution from agriculture
Establishing buffer zones
Restoring floodplains
Restoring longitudinal connectivity
Improving habitat
Preventing or controlling adverse impacts of invasive species
Preventing or controlling adverse impacts of recreation
Reducing flood risk on agricultural land
Campaigning for environmental education & awareness
Changing policies
Streamlining the decision-making process

VI.1.3 Brăila Islands (Romania)

Discussions with stakeholders have focused on reducing nutrient use related to water quality and evaluating a future increase in intensive agriculture. The stakeholders proposed some detailed measures such as:

- Subsidising/stimulating nitrogen-fixing crops (soybeans, peas, beans, lucerne), crop rotation, cover crops to reduce synthetic nutrient use, using bio-fertilisers, bio-herbicides (with N and P fixing bacteria), new technologies.
- Updating courses in universities and practical schools to promote using new technologies, bio-fertilisers and permaculture.
- Changing consumption habits. Consumers choose eco-products that have less impact on the environment.

Simple compliance with legislation would lead to a reduction in the impact of waste and wastewater. Compliance should go hand in hand with institutional strengthening and reduction of corruption in the system. Upgrading the existing WWTP will also improve water quality.

Table VI.4 The measures selected to reduce the pressure in the Romanian pilot

Selected measures for the WMC
Cultivation of optimal types of crops
Reducing agricultural pollution
Constructing or upgrading wastewater treatment plants

VI.1.4 Middle Tisza (Hungary)

Stakeholders considered drought and flood the most significant pressures in the region. Szechenyi organised the regulation of the Tisza (*a Tisza szabályozása*) from 1848 to ~1880. The regulation shortened the Tisza's main channel from 1419 km to 966km, creating ~590km of dead channels and disconnecting/eliminating floodplains. The weather in the region has increased in severity, causing water shortages followed by floods. Invasive species reduce the water conveyance capacity of the active floodplains, which could also increase the flood risk.

The selected measures should reduce both flood risk and water scarcity/drought. Climate change effects also require consideration. According to the participants of the Hungarian Stakeholder Workshops, expanding the floodplain by selective levee removal offers the best solution. It will increase the floodplain's water retention capacity and attenuate the impact of flooding. For this, it is necessary to assess the areas where levee relocation is possible and water retention and infiltration will readily occur during a flood.

Similar measures in the region have contributed to a positive long-term impact. For example, in Bivalytó, restoring wetlands and restarting grazing have benefitted the floodplain (Figure VI.1). The restoration also brought many advantages from the nature conservation point of view and grazing reduced the level of pollution from agriculture.

Figure VI.1 The restored floodplain area near Szolnok

Table VI.5 The measures selected to reduce the pressure in the Hungarian pilot

Selected measures for the WMC
Creating water retention
Restoring floodplain
Relocating levees
Reducing agricultural pollution

VI.1.5 Mura River Kučnica Mura Petajnci – Gibina (Slovenia)

Stakeholders agreed upon the importance of restoring indigenous plants and trees. In doing so, they could reduce the influence of alien plant species (one of the most significant pressures in the Mura pilot area). Local plants are better adapted to local climate and conditions and therefore have positive connectivity with improving biodiversity. Slovenian legislators have mandated the use of indigenous plants.

Revitalising riparian areas with indigenous plants will help retain runoff, flood waters, and filter minerals. These buffer zones enhance indigenous plants' resilience and limit alien species' propagation. The zone also moderates water temperature.

Mura River stakeholders recognised restoring the natural flow as a vital measure for the pilot area. They argued that restoring the natural flow regime would increase flow quantity and decrease impacts from extreme events. The process would also increase the self-cleaning capabilities of the Mura River. They could also increase farmland area and ensure a higher level of food self-sufficiency.

Stakeholders did not identify floodplain restoration solely as an essential measure. They did agree that floodplain restoration enhances the removal and limitation of alien plant species. Floodplain restoration would also decrease the area available for farmland and pesticide use, positively affecting water quality.

Table VI.6 The measures selected to reduce the pressure in the Slovenian pilot

Selected measures for the WMC
Using indigenous plants and trees (in the case of forests)
Preventing or controlling adverse impacts of invasive species
Establishing buffer zones
Restoring the natural flow regime
Restoring floodplains

VII. Legal framework

Corina Gheorghiu, Camelia Ionescu, Martin Push, Martin Tschikof, Peter Suhadolnik, Zorica Srdjevic, Galia Bardarska, David Bela Vizi

VII.1 Introduction

EU sectoral policies address and influence ES and the use of natural resources. Different policy sectors affect ES in different ways. Some policy sectors regulate economic activities that negatively impact biodiversity, ecosystems and their services (e.g. agriculture, energy production, transport and tourism). Other EU policy instruments support the conservation and sustainable use of ES and natural resources. First and foremost, the Birds and Habitats Directives protect the biodiversity underlying all ES. Furthermore, a range of sector-specific instruments – policies shared within the EU for:

- agriculture and fisheries (CAP and CFP),
- managing inland, coastal and marine areas (Water Framework Directive, WFD, Marine Strategy Framework Directive, MSFD),
- supporting EU-wide cohesion and regional development (European Regional and Development Fund, ERDF, Cohesion Fund, CF, European Agricultural Fund for Rural Development, EAFRD, European Maritime and Fisheries Fund, EMFF)

provide measures relevant to maintaining and sustainably using ES (Kettunen 2014).

The Ecosystem Approach serves as the primary framework for action under the Convention on Biological Diversity (CBD). The Convention defines it as "…a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way" (Secretariat of the Convention on Biological Diversity, 2004). Policies must include ES to minimise the pressures on ecosystems and maintain their functioning, so they provide essential services for human well-being. To achieve this goal, all levels of governance (regional, national, local) must integrate ES into and across various policy sectors.

VII.2 The implementation of the Ecosystem Approach

VII.2.1 Methodology

Maintaining the good status of the ecosystems in the DRB, particularly its water quality, depends on the successful design and implementation of associated public policies.

The IDES project has used the analytical framework developed under the OPERAs project to address the conceptual and operational integration of the Ecosystem Approach into the national policies of the following countries: Austria, Germany, Hungary, Bulgaria, Romania, Serbia and Slovenia. We complemented OPERA's analyses of the EU policies with policies from new sectors such as territorial planning and tourism.

According to OPERAs, there are two different levels of how ES and natural capital integrate into public policies (Kettunen et al. 2014):

- **Conceptual integration** - refers to their integration into the overall premises and objectives of different policy areas; it is assessed based on the critical strategic policy documents setting out the scope and objectives for sectoral policies.
- **Operational integration** - refers to their integration into practical policy implementation; it is assessed based on the availability of concrete policy tools and instruments that take up and implement the concepts.

Table VII.1 Categorisation of the level of policy integration in the context of this assessment (Kettunen et al. 2014)

Integration level	Conceptual integration	Operational integration
Explicit and comprehensive	Explicit recognition of all ES, combined with natural capital as underpinning elements of human well-being.	Dedicated instruments exist for fully addressing ES and natural capital within a policy sector.
Explicit but not comprehensive	Some explicit integration (e.g. specific ES), including some recognition of ES and natural capital as underpinning elements of human well-being.	Some instruments exist that proactively address/build on the understanding of ES and natural capital within a policy sector.
Implicit and comprehensive	Implicit and indirect integration with a focus on preventing negative impacts from a policy sector on ES and natural capital.	No dedicated instruments exist for directly addressing ES and natural capital. Some aspects – mainly focusing on avoiding negative impacts on (some) ES - integrated into sectoral instruments.
Without specific integration	No recognition (direct/indirect) of ES and natural capital.	No instruments exist that would in any way address ES and natural capital.

VII.2.2 The implementation of the Ecosystem Approach in EU policies

Building on the work already done in OPERAs, we updated the policy analyses with two more strategies at the EU level, on territorial planning and tourism as common ground when compared with the national policy analysis.

Table VII.2 Current level of the integration of ecosystem services and natural capital into EU policy areas (Kettunen et al. 2014, adapted)

Policy sector	Key references	Conceptual integration	Operational integration
Water	Blueprint to Safeguard Europe's Water Resources (COM/2012/673) Water Framework Directive (Directive 2000/60/EC) Floods Directive (Directive 2007/60/EC) Common Implementation Strategy for WFD and Floods Directive - Work Programme 2013-2015 (EC 2013d)	The EU's current policy framework for water - outlined in the Blueprint to Safeguard Europe's Water Resources recognises and addresses ecosystem services explicitly. It recognises the current threats to water ecosystems and the services they provide and highlights the importance of green infrastructure in cost-effective water management. The Blueprint also recognises water as valuable natural capital and provides numerous valuable provisioning ecosystem services. It highlights the value of water to humans, nature and the economy and proposes to develop water accounts further. It also states that there is a need to include the value of water in pricing better and to develop new economic incentives	Some indirect proactive elements (e.g. restoring fish migration routes under the Water Framework Directive (WFD) and recognising the role of natural flood retention areas under the Flood Directive) and provisions on preventing negative impacts on the functioning of water ecosystems None of the existing instruments explicitly recognise the role of ES in maintaining water quality or maintaining groundwater resources. Nor do they explicitly avoid negative impacts on water-related ES. However, indirectly, aiming to secure the excellent quality of water ecosystems (including their functioning) supports the maintenance of ES. Likewise, preventing adverse impacts on water ecosystems help to protect water-related ES. Moreover, various elements of guidance and work programmes produced under the WFD Common Implementation Strategy support ES-based approaches, e.g. develop and promote ecosystem-based approaches for mitigating and adapting to climate change.
Agriculture and rural develop-ment	CAP financing, management and monitoring, including cross-compliance rules (Regulation (EU) No 1306/2013) CAP rules for direct payments to farmers (Regulation (EU) No 1307/2013) European Agricultural Fund for Rural Development (EAFRD) (Regulation (EU) No 1305/2013)	Both Pillars of the EU Common Agriculture Policy (CAP) promote some ES. All area-based payments are conditional upon cross-compliance, including standards for water, soil and retention of landscape features (GAEC 7). Pillar 1 funding: direct payments to farmers (including a greening payment linked to retention of permanent pasture and Ecological Focus Areas); conservation of genetic resources in agriculture; and agricultural surveys.	Some proactive elements (mainly agri-environment-climate, support to Natura 2000 areas, and non-productive investment measures in Member States' RDPs) and preventing adverse impacts on ecosystems/ecosystem services. Such as CAP cross-compliance standards for soil, water and landscape, and greening requirements for permanent pastures.

	Habitats Directive (Directive 92/43/EEC) and Birds Directive (Directive 2009/147/EC) establishing the Natura 2000 network	EAFRD fund (Pillar 2): allocated by Member States to at least four of six general EU priorities. One priority is 'restoring, preserving and enhancing ecosystems related to agriculture and forestry' with three specific focus areas: biodiversity (including Natura 2000, high nature value farming and "the state of" European landscapes); water management; and soil. Although the agri-environment climate measure is compulsory for all Rural Development Programmes, the extent to which Member States prioritise these three focus areas may differ. Limited coverage of some ES, e.g. attractive landscapes and cultural heritage.	
Forest	EU Forest Strategy (COM/2013/659) European Agricultural Fund for Regional Development (EAFRD) (Regulation (EU) No 1305/2013) EU Land Use, Land Use Change and Forestry (LULUCF) accounting rules (Decision No 529/2013/EU) Habitats Directive (Directive 92/43/EEC) and Birds Directive (Directive 2009/147/EC) establishing the Natura 2000 network Water Framework Directive (Directive 2000/60/EC) LIFE 2014-2020 (Regulation (EC) No 1293/2013)	The current EU Forest Strategy includes explicit reference to ES, where one key objective for 2020 is 'contributing to balancing various forest functions, meeting demands, and delivering vital ecosystem services'. The Strategy also recognises ES as natural capital: the Commission asks Member States to develop, with the assistance of the Commission, a conceptual framework for the valuation of ES, promoting their integration in accounting systems at EU and national levels by 2020.	No separate/dedicated instruments for forest ecosystem services and some elements are integrated into different EU instruments. Although the EU Forest Strategy is a policy doc-ument - not a legislative act - it has explicit links to other EU policy instruments and funding. Instruments include the EAFRD rural development funds (the primary source of EU funding for the forest sector), Natura 2000 legislation, LIFE+ funding for climate action, Water Framework Directive (WFD); and Land Use, Land Use Change and Forestry (LULUCF) reporting under climate policy. Note: The Treaty on the Functioning of the EU includes no specific provisions for an EU forest policy. Consequently, the EU has limited competence in developing common forest policy / adopting dedicated standard forest policy instruments for the EU.

Climate	EU Strategy on adaptation to climate change (COM/2013/216)	Climate change adaptation: The EU Strategy on Adaptation to Climate Change recognises that ecosystems and their services suffer from climate change. Green infrastructure and ecosystem-based approaches (building on ES) can provide cost-effective solutions for adaptation (e.g. help to achieve reduced flood risk, less soil erosion, improved water and air quality and reduced heat island effect).	Adaptation: They are mainly indirect, preventing adverse impacts on ecosystems / ES. The only explicit instrument is support for ecosystem-based approaches to climate change adaptation under EU funds.
Energy/ Bioenergy	Renewable Energy Directive (Directive 2009/28/EC) Fuel Quality Directive (2009/30/EC) EU Energy Efficiency Plan (COM/2011/109)	The Renewable Energy Directive refers directly to ES in the preamble (e.g. watershed protection and erosion control) and concerns sustainability criteria. However, this integration mainly refers to the sustainable production of biofuels and not extending to the use of solid biomass, e.g. there currently exists no sustainability criteria for the latter. In addition to the above, concerning biofuels, the EU bioenergy policy includes reference to existing requirements (e.g. cross-compliance) set out under the CAP direct payment regulation. Finally, the EU's Energy Efficiency Plan also mentions green infrastructure, directly linked to ES by definition.	Indirect, preventing adverse impacts on ecosystems / ES. The Renewable Energy Directive and Fuel Quality Directive sustainability criteria cover land with high biodiversity value and carbon stock for biofuels. There are no EU-level sustainability criteria for solid biomass.

Transport	Union guidelines for developing the trans-European transport network (Regulation EU/1315/2013) Funding to support TEN-T implementation (Regulation EU/670/2012). SEA Directive (2001/42/EC) EIA Directive (current 2011/92/EU and proposed COM/2012/628)	EU guidelines for the development of the trans-European transport network (TEN-T) represent the main piece of legislation on this issue, alongside an EU Regulation outlining dedicated funding to support TEN-T implementation. In addition, EU policy for cohesion and regional development (i.e. ERDF and CP) provides transport and other infrastructure support. The above vital documents do not make specific, direct links to possible negative impacts of transport on ES and natural capital. Implicit links are created through provisions to avoid negative impacts on nature and the environment (i.e. the impact assessment procedure).	Indirect, preventing adverse impacts on ecosystems. EU transport framework builds on assessing negative environmental impacts on the environment. It also foresees the use of Strategic Environmental Assessments for policies and planning and Environmental Impact Assessments for projects to minimise impacts on ecosystems. These processes reduce impacts on the environment and biodiversity and indirectly on ES. There are currently no specific requirements to cover ES in the SEA and EIA directives; however, the official guidance documents supporting the implementation of the directives cover different aspects of ES.
Territorial planning	The Territorial Agenda 2030	Agenda explicit references to ecosystems, ES, ecosystem-based approach and nature-based solutions. Recognises that the loss of biodiversity and land consumption pose severe risks to ecosystems, impacting the functioning of ecosystems and the provisioning of ES. Promotes integration beyond borders to address common challenges, to find synergies and to diminish economic and environmental fragmentation (including ecosystems) and negative externalities. Ecosystems, including agricultural, forest, grassland, freshwater and marine ecosystems, are fundamental to human existence and essential for long-term sustainable development.	Possible mitigating and adaptive actions include promoting sustainable land use, open spaces and public green areas, restoring degraded land and coastal areas, combatting deforestation and preserving oceans and water bodies. Other actions can involve preventing urban sprawl and urban heat islands, implementing green infrastructure, improving air quality, ensuring no net land take by 2050, strengthening the delivery of ES and improving the integration of terrestrial and maritime spatial planning.

Tourism	Europe, the world's No one tourist destination – a new political framework for tourism in Europe	There is no direct reference to ecosystems or ES. The sustainability of tourism covers several aspects: the responsible use of natural resources, taking account of the environmental impact of activities (production of waste, pressure on water, land and biodiversity, etc.), the use of 'clean' energy, protection of the heritage and preservation of the natural and cultural integrity of destinations, the quality and sustainability of jobs created, local economic fallout or customer care.	

VII.2.3 The implementation of the Ecosystem Approach in national policies

Starting from the need to integrate the Ecosystem Approach into all relevant sectors for the IDES project, the partner countries analysed the integration of the Ecosystem Approach into their national policies (from strategies to action plans).

This assessment refers to the most recently approved policies related to the EU programming period 2014-2020. It covers the following policy sectors: biodiversity, water, forestry, agriculture, fisheries & aquaculture, climate change, energy, transport, territorial planning and tourism.

Using the above-presented methodology, the partner countries of the IDES project have carried out policy analysis to address both conceptual and operational levels of integration of the Ecosystem Approach into their national policies as follows: Austria (Table VII.3), Germany (Table VII. 4), Hungary (Table VII. 5), Bulgaria (Table VII. 6), Romania (Table VII. 7), Serbia (Table VII. 8) and Slovenia (Table VII. 9).

Table VII.3 The implementation of the Ecosystem Approach in national policies / Austria

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Environment	Environmental control report		
Water	National water management plan / LIFE IRIS		
	Action programme for the Danube (navigation, ecology, flood risk management)		
	Water legislation 1959 (last modified 2018)		
	National flood risk management plan		
Forestry	Forestry strategy 2020+		
Agriculture	Rural Development Programme 2014-2020		
	Common Agriculture Policy 2023-2027		
	Nitrates Actions Program		
Climate Change	Climate change adaptation strategies per federal state		
	Burgenland 2050		
	Kärnten		
	Niederösterreich 2020-2030		
	Oberösterreich		

	Salzburg 2050		
	Steiermark		
	Tirol		
	Vorarlberg		
	Wien		
Energy	Energy strategy 2050		

Table VII.4. The implementation of the Ecosystem Approach in national policies/ Germany

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	National Strategy and Action Plan for Biodiversity Conservation		
Water	National Water Law (Wasserhaushaltsgesetz, WHG)		
	National Water Strategy		
	WFD River Basin Management Plans 2022-2077 for Rhine and Danube rivers		
Forestry	National Forest Strategy		
Climate Change	Climate protection programme 2030		
	National Strategy on Climate Adaptation		
Territorial planning	Spatial Planning: Guiding principles and action strategies		
Tourism	Master Plan Recreational Navigation		

Table VII.5. The implementation of the Ecosystem Approach in national policies/ Hungary

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	National Biodiversity Strategy		
Water	National Water Strategy 2015		
	River management planning 1999-2003		
	Further development of the Vásárhelyi Plan (VTT) and The concept of flood protection development of the Tisza valley 2015		
	SUMAD project INTERREG IIIB – PHARE, SUMAD "Sustainable use of the wave field between embankments of alluvial plains" 2004		
	National Water Utilities Public Service Strategy		
	National Urban Wastewater Drainage and Cleaning Program		
Forestry	National Forest Strategy		
	Natura 2000 maintenance plans		
Fisheries and aquaculture	National Aquaculture Strategy		
Territorial planning	Integrated Spatial Development, Rural Development and Environmental Management Concept of the Tisza 2004		

Table VII.6 The implementation of the Ecosystem Approach in national policies/ Bulgaria

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	Biodiversity Law		
Water	Water Act		

	National Strategy for Management and Development of the Water Sector		
	River Basins Management Plans 2016–2021		
	Flood Risk Management Plans		
	General Strategy for Management and Development of hydro melioration and protection from the harmful impact of water.		
Fisheries and aquaculture	Fisheries and Aquaculture law		
Climate Change	National strategy for adaptation to climate change		
	Climate Change Mitigation law		
Energy	Energy law		
	Strategy for sustainable development of the Republic of Bulgaria until 2030 with a horizon until 2050 and draft Integrated National Energy and Climate Plan of the Republic of Bulgaria until 2030		
Territorial planning	Territory Development law		

Table VII.7 The implementation of the Ecosystem Approach in national policies/ Romania

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	National Strategy and Action Plan for the conservation of biodiversity 2013-2020 Member State Implementation Report		
Water	Water Law (Legea Apelor, 107/ 1996) National River Basins Management Plans & Member State Implementation Report National Strategy for the management of flood risk National Plan for the prevention, protection and		

	reduction of flood consequences		
Forestry	Forestry Law National Rural Development Program 2014-2020		
Agriculture	National Rural Development Program 2014-2020 Common Agricultural Policy (Pillar I)		
Fisheries and aquaculture	National Strategy on Fisheries and Aquaculture National Program on Fisheries and Maritime Affairs		
Climate Change	Romania National Strategy on Climate Change 2013-2020 & Action Plan		
Energy	Romania Energy Strategy 2011-2020 (updated) National Action Plan on renewable energy sources		
Transport	Romania General Master Plan on Transport		
Territorial planning	National Strategy for Territorial Development horizon 2035 National Strategy SEA Environmental Report		
Tourism	Strategy for the development of Balneo-tourism, 2019. Tourism investment plan. Masterplan for tourism investments, eligibility criteria for investment projects, 2017		

Table VII.8 The implementation of the Ecosystem Approach in national policies/ Serbia

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	Law on Nature Protection		
	National Strategy for Sustainable Use of Natural Assets and Resources		
	Nature protection Programme of the Republic of Serbia for 2021 - 2023		
Water	National Strategy for Water Management till 2034		
Forestry	National Strategy for Sustainable Development		
	Spatial plan of the Republic of Serbia from 2021-2035 (draft version)		
Agriculture	Spatial plan of the Republic of Serbia from 2021-2035 (draft version)		
	National Strategy for Sustainable Development of Urban Areas till 2030		
Fisheries and aquaculture	National Strategy for Sustainable Development		

Table VII.9 The implementation of the Ecosystem Approach in national policies/ Slovenia

Policy sector	National legislation/strategy or action plan	Conceptual integration	Operational integration
Biodiversity	Natura 2000 Management Programme (2015-2020)		
Water	River Basin Management Plan for Danube River Basin (2016-2021)		
Water	River Basin Management Plan for Adriatic River Basin (2016-2021), Flood Risk Management Plan (2017-2021)		
Forestry	Forest management plans		
Agriculture	Common Agricultural Policy Strategic Plan 2023-2027 for Slovenia		
Fisheries and aquaculture	Program for the Management of Fish 2010-2021		
Climate Change	Integrated National Energy and Climate Plan of the Republic of Slovenia		
Energy	Integrated National Energy and Climate Plan of the Republic of Slovenia		
Transport	Resolution on the National Programme for the Development of Transport of the Republic of Slovenia until 2030		
Territorial planning	Spatial Planning Strategy of Slovenia 2050 – draft, in progress		
Tourism	2022 - 2028 Slovenian Tourism Strategy		

VII.3 Conclusions

Analysing documents covering the EU, the implementation of the Ecosystem Approach is stronger at the conceptual level compared to the operational level.

When analysing documents covering the national level, the integration of the Ecosystem Approach is still a work in progress for all countries, but keeping the same trend of better integration at the conceptual level compared to the operational level.

Although the policy analyses look very heterogeneous between the different countries, sectors like biodiversity, water, and forestry have better integrated the Ecosystem Approach in their respective policies. However, for one country, Serbia, the integration is poor for the biodiversity, waters and forestry sectors. On the other end, sectors like tourism, territorial planning and energy have implicit or no integration of the Ecosystem Approach in their respective policies.

The diverse EU policy sectors can seamlessly incorporate ES and biodiversity into pursuing their objectives. They can achieve it at the conceptual and operational levels by proactively supporting ES and biodiversity while achieving their respective goals.

VIII. Public involvement and consultation across sectors

Camelia Ionescu, Corina Gheorghiu

VIII.1 Background

Scientists acknowledge that human well-being connects directly to the status of ecosystems and the services they provide. They concluded that ES delivered at the global level – from crop pollination and water purification to flood protection and carbon sequestration – are worth an estimated € 102 trillion (i.e. 102 million-million, Costanza et al. 2014). Not only scientific publications espouse the financial benefits of ecosystem services (ES), but also the official European institutions. The benefits generated by the Natura 2000 network of protected areas are estimated to be €200 - 300 billion annually. The Natura 2000 network estimates there are 1.2 - 2.2 billion visitor days to their sites each year, generating annual recreational benefits worth €5 - 9 billion. In the European Union, around 4.4 million jobs, and €405 billion in yearly turnover, directly depend on maintaining healthy ecosystems, of which a significant proportion is located within Natura 2000 (EC DG Env 2011).

Despite the enormous monetary value of ecosystems, the well-being of humans is beyond material measure. Managers explore the relationships between ES and human well-being to understand the mechanisms behind decision-making processes that lead towards sustainable floodplains as a landscape. By this, an economy, including the ES, may contribute to an equitable distribution of resources for supporting local communities to manage their natural resources and enhance local economies (Sangha et al. 2021).

Informing citizens about the ES benefits and changing societal attitudes to understand the urgent need to manage the ecosystems and their services properly is essential (Costanza et al. 2014). Along with changes in policies, modern societies must act quickly to address the changing climate and the degradation of natural resources and to mitigate wide-ranging impacts on human populations (MEA 2005; IPEBS Services 2019). Community-based scenario planning meetings can help inform people about human actions' impact on human-nature systems. They can help people realise their dependence on natural resources, improve their attitudes towards nature, and develop a collective plan for a desirable future which is sustainable, equitable, and enhances people's well-being.

VIII.2 Attitude of European citizens towards water and biodiversity

To understand the citizens' opinion on societal challenges, the Directorate-General for Environment commissioned a public survey to measure their opinions, attitudes and behaviour towards the environment. The special Eurobarometer "Attitudes of European citizens towards the environment" was carried out triennially in the Member States between 2005 and 2020, addressing:

- General attitudes towards the environment: first associations and main concerns;
- People's relationship with the environment: attitudes and behaviour;
- Opinions on environment policies: acceptability of sustainable development approaches, preferred policies, support for a European environmental policy and the role of the EU as its executor;

- Information on the environment: impression about being informed, topics for which there is a lack of information, sources of information.

The most relevant questions in the case of water and floodplain management are related to the environmental issues that European citizens are worried about, choosing from the following list:

- Water pollution (seas, rivers, lakes, underground sources, etc.);
- Climate change;
- Air pollution;
- The health impacts of chemicals used in everyday products;
- Escalating waste;
- Agricultural pollution (use of pesticides, fertilisers, etc.);
- Depletion of natural resources;
- The use of genetically modified organisms in farming;
- Loss in biodiversity (extinction of animal species, flora and fauna, etc.);
- Urban problems (traffic jams, pollution, lack of green spaces, etc.);
- Our consumption habits;
- Shortage of drinking water;
- Frequent droughts or floods.

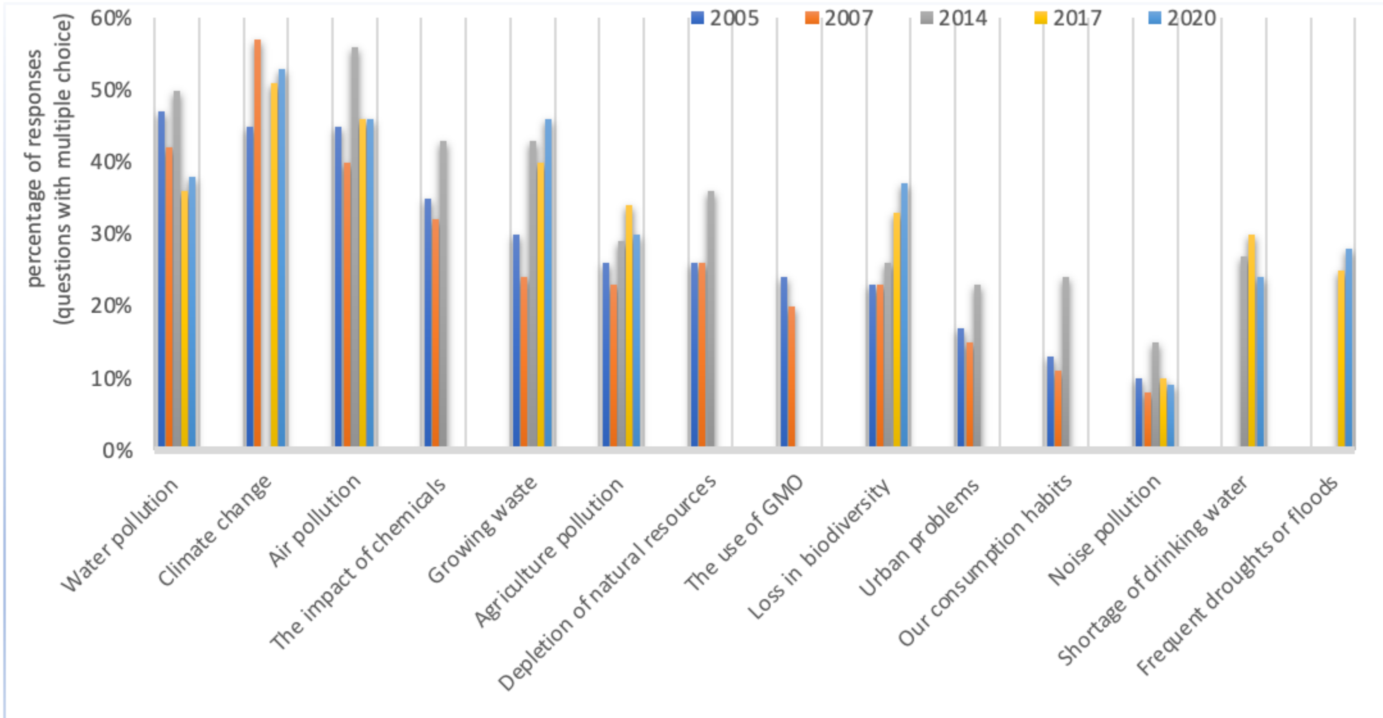


Figure VIII.1 Evolution of how European citizens perceive the main environmental issues based on results of the special Eurobarometer "Attitudes of European citizens towards the environment"

From the results of the surveys (Figure VIII.1), water pollution has been one of the most significant worries of European citizens since 2005, together with climate change and air pollution. In later years, three major water-related issues came to the fore: a shortage of drinking water, frequent droughts and floods and increased biodiversity loss. In contrast, the water-related actions of European citizens analysed during the surveys are more related to reducing the water used in households. The reasons that link to the results include:

1. Level of knowledge and understanding by the citizens of the impacts of human habits on the river status through reducing the spilling of different households' polluters (i.e. pharmaceuticals);
2. The citizens expect the authorities to act more efficiently in improving the water quality by properly regulating industrial pollution.

VIII.3 Stakeholders' engagement in assessing the ecosystem services in the context of the IDES project

The citizens, authorities, and other stakeholders are essential for the ecosystem services provided by floodplains and are assessed using the IDES Tool. In the IDES project, the stakeholders have actively assessed ecosystem services. The involvement should reduce the risk of non-implementation of measures identified to improve the Danube water quality. Stakeholder engagement in the assessment of ecosystem services has allowed each stakeholder to share their values where "…trust and knowledge are generated and circulated to provide a foundation of social and intellectual capital upon which collaboration can build…" (Healey, 1997). According to Healey, three pillars support the collaborative process:

- Design of arenas accessible to all who have a stake in an issue;
- Transferring powers to make decisions close to those stakeholders who will be affected by them;
- Promoting engagement methods which allow exploration of diverse viewpoints.

At the beginning of the assessment of the floodplain ES, different levels of stakeholder engagement have been identified, depending on the ultimate aims of engagement activities. From a general perspective, stakeholder engagement involves, to varying degrees, the following elements:

- Stakeholder analysis and planning;
- Disclosure and dissemination of information;
- Consultation and meaningful participation.

The entire ecosystem services assessment architecture and implementation plan in the IDES project integrated the work with stakeholders from different spatial scales: basin-wide, national and local / pilot area (additional information appears in section III.2).

A more thorough analysis and action plan for meaningful stakeholder engagement, including a dedicated toolkit, has been designed covering the entire DRB, each involved country and the pilot sites. We adapted the method to develop the stakeholder engagement tools from the BiodivERsA toolkit and based it on the experience of project partners (Figure VIII.2). The method used entails five stages in the stakeholder engagement process:

1. *Identify* the stakeholders;
2. *Analyse* the stakeholders;
3. *Plan* the engagement process;
4. *Act* – implement the engagement actions;
5. *Review* – monitor the actions and review for improving the engagement.

Figure VIII.2 The stages used in the stakeholder engagement process

In the first stage ("*Identify*"), we have analysed a preliminary understanding of the stakeholders' interests regarding the ES. Figures VIII.3 and VIII.4 show the grouping and analysis of stakeholders. , Stakeholder types encompass a wide range of spatial scales and backgrounds. Figure VIII.4 presents the number of stakeholders at each incremental level of involvement. The number of participants from each country subdivides the involvement level categories. Combining this information with knowledge about the area and topic and seeking out less obvious stakeholders and marginal groups requires substantial time and effort.

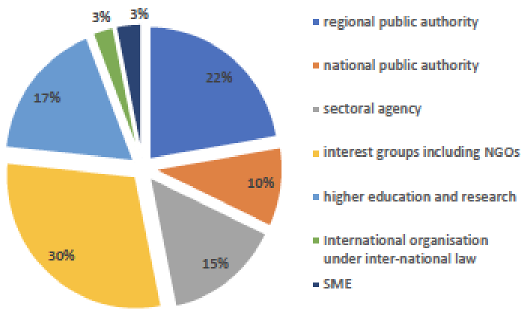


Figure VIII.3 The percentages of stakeholder types from the total of 202 stakeholders identified

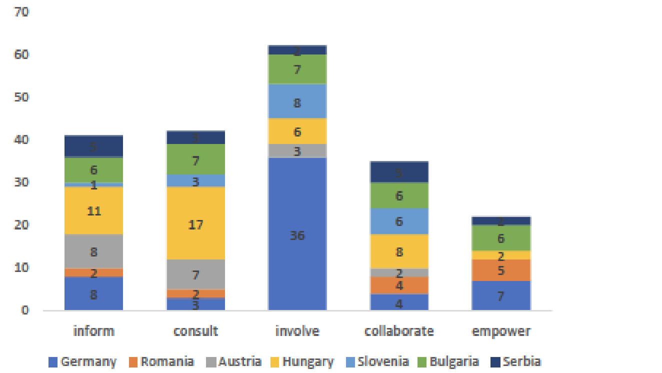
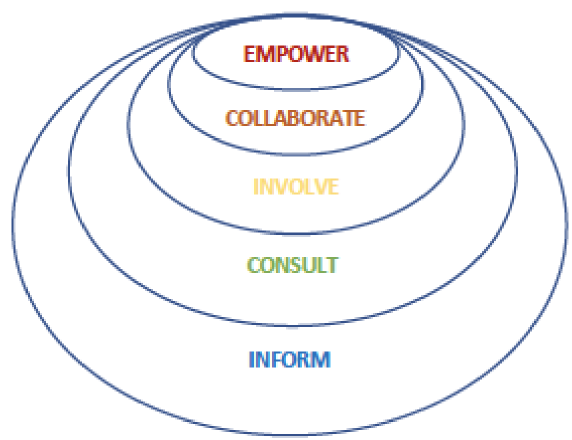


Figure VIII.4 The level of stakeholder's engagement for IDES tool in all project countries

The IDES project's second stage ("*Analyse*") contains the following types/levels of engagement (BiodivERsA, 2013):

1. INFORM – The project partners provided interested stakeholders with balanced and objective information to assist them in understanding the IDES project and ES concept. They tailored the information to the stakeholder profile.
2. CONSULT – project partners received opinions (unidirectionally) from interested stakeholders on relevant aspects of the IDES Tool.
3. INVOLVE – partners engage directly (bi-directionally) with interested stakeholders to ensure that their concerns and ideas are understood, considered, and, when appropriate, incorporated into the IDES Tool.
4. COLLABORATE – project partners working with interested stakeholders on relevant aspects of the IDES Tool, including developing alternative methods and identifying preferred solutions.
5. EMPOWER – stakeholders accept the responsibility to implement the IDES Tool during and after the project's lifetime.



Based on the conclusions from the "*Identify*" stage, the "*Analyse*" stage projects the ideal role and level of engagement of each stakeholder, and the steps (INFORM, CONSULT, INVOLVE, COLLABORATE, EMPOWER) have to be defined. Additionally, the tool defines one engagement objective for each stakeholder. Figure VIII.4 shows the result of this stage (desired level of engagement) and the breakdown for each country within the IDES project.

After the identification of relevant stakeholders and a process of deep analysis concerning the type of necessary engagement, the identification and planning of activities required to achieve stakeholder engagement objectives (stage 3: "*Plan*") precedes its implementation *"Act*" (stage 4).

Figure VIII.5 presents a synthesis of the planning. Stakeholder engagement and actions form a ladder representing levels of engagement. The ladder starts from the "inform" level, targeting the general public, up to the "empower" level, focused on stakeholders who will actively implement the results and promote the activity. In the case of the IDES project, the number of stakeholders (persons) reached for engagement level appears for each category.

VIII.4 Greater public involvement consultation across sectors to improve water quality in the Danube River

Developing the ecosystem services assessment tool for the Danube floodplain has been a living laboratory. Stakeholders were not only involved in testing the already applied ecosystem assessment methods, which was valuable from the scientific perspective but could bring in their experience at the local level in co-developing the water management concepts in the pilot areas. The IDES project included stakeholder engagement at the basin, national, and local/ regional levels. The basin level incorporated transnational stakeholder workshops with national

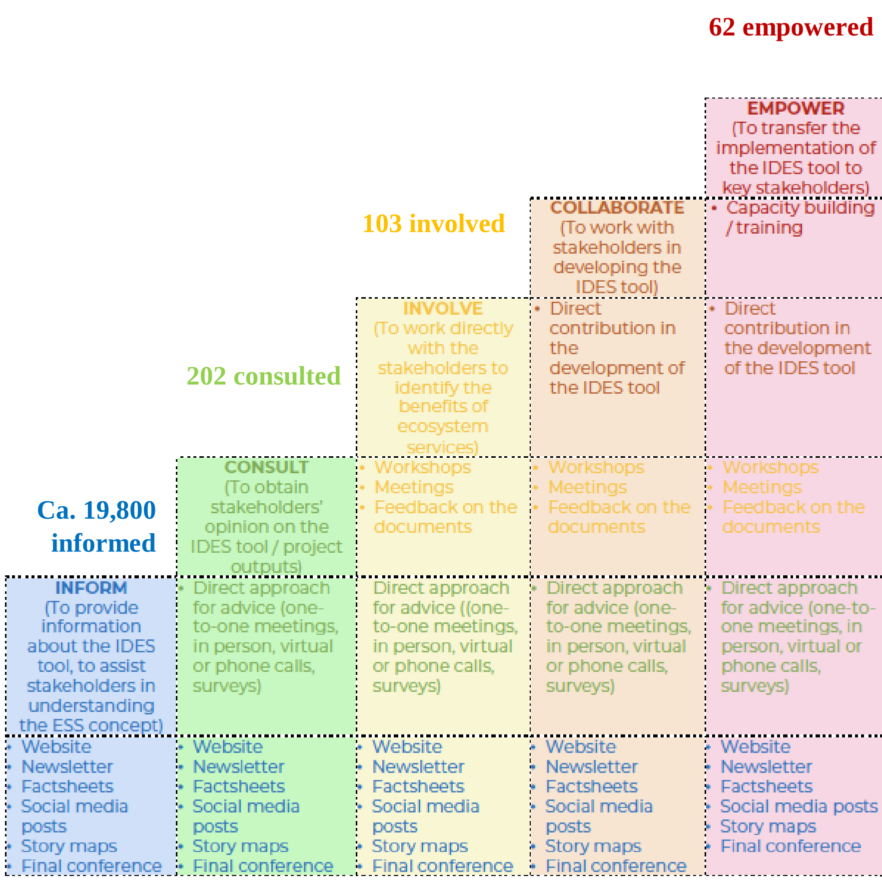


Figure VIII.5 Ladder representation of engagement levels showing the steps and tools for each type of engagement stakeholders who consulted to achieve a harmonised evaluation. The national level engaged key actors in water management and empowered them through training on the new IDES Tool. The local/regional level encompassed all relevant stakeholders who collaborated and shared knowledge to improve conditions in their area. Furthermore, the context of the IDES Tool gives an excellent opportunity to define the strategic recommendations in further using the ecosystem services assessment in conjunction with engaging the stakeholders for more efficient floodplain management, as follows:

1. *A national awareness campaign highlighting the interdependence of human well-being and healthy river ecosystems.* Although freshwater ecosystems have degraded globally, and a healthy ecosystem provides many ecosystem services (including social and economic benefits), public opinion perceives river improvement solely as limiting the pollutants discharged from agriculture and other industries. The public must embrace a greater awareness of the multiple benefits of robust river ecosystem functions and the need to restore them and their floodplains.
2. *Incorporate stakeholder engagement at all levels to help direct funding and decision-making in river management.* Usually, expert judgement and science drive the decision-making process. However, this neglects the valuable contribution of local knowledge and support. Public authorities' decisions and the outcomes of projects directly impact locals. Using their specialised knowledge of the local communities and evidence-based approaches in projects and policies will increase the likelihood of immediate success and long-term sustainability of river improvement projects.
3. *Improve the public consultation legal and procedural requirements regarding stakeholder engagement in managing the river basins.* While water management and nature conservation policies promote public consultation, legal and procedural requirements necessitate codification to guarantee a fair and equitable process. Thus, improving legislation by including how public consultations should proceed during the decision-making process will provide a consistent and equitable process for stakeholders.

IX. Recommendation for action in decision-making and planning processes

Barbara Stammel, Martin Pusch

IX.1 Framework and challenges in River–Floodplain Management

With its integrative approach, the EU Water Framework Directive (WFD) has brought a breakthrough in the management of surface waters in Europe. Through the standardised monitoring of the status of surface waters, the WFD has enabled a comprehensive pan-European overview of their ecological status revealing that 60% of riverine water bodies are not in a 'good' ecological status (EEA 2018). Moreover, the WFD has facilitated identifying the main human pressures that prevent surface waters from attaining 'good' ecological status. River basin management plans show that pollution from diffuse sources is the most frequent dominant human pressure in EU surface waters (dominant in 22% of surface waters). In addition, 10% of the EU's surface water bodies are affected by the loss of lateral connectivity to the river by physical alterations of the channel bed or riparian area due to river training, flood protection and agriculture (EEA 2021a). The situation is similar for the floodplains protected under the Habitats Directive (HD), as more than 70% of the original floodplain area has been separated from the river and degraded. Although around 30% of the floodplains are protected Natura 2000 sites, only 17% achieve a good conservation status (EEA 2019). Again, we have identified hydromorphological pressures, land use, and pollution by nutrients, organic and hazardous substances as the main pressures (Chapter I).

As for the DRB, the management plan (DRBMP) has revealed that ca. 70% of water bodies are not in a good ecological status or do not have good ecological potential. Less than 20% of the morphological floodplains still connect hydrologically to their rivers (Chapter I, ICPDR 2021) due to channel straightening, levee construction and intensified land use in former floodplains. Most floodplain forests have disappeared, with only a few tree rows and narrow riparian buffer strips remaining. In fact, in several countries of the DRB (HR, HU, BG, RO), the fraction of croplands in the morphological floodplains is nearly 50% or higher (http://www.eea.europa.eu/data-and-maps/data/data-viewers/floodplain-areas), since obtaining agricultural land was one of the main goals for the regulation of rivers and flood protection systems. In order to respond to these human pressures, the DRBMP Update 2021 (ICPDR 2021) focuses on five Significant Water Management Issues (SWMI), including pollution by nutrients and hydromorphological alterations (Chapter I).

While human impacts on river floodplains often originate from societal sectors such as agriculture, flood protection and navigation, they often cannot solely be resolved by employing water management (WFD) or nature conservation (HD). Agriculture is commonly interested in using the excellent quality of floodplain soils. Flood protection required by the Floods Directive still aims in many places to keep grey infrastructure (e.g. levees, control structures) not only to protect settlements and infrastructure but also agricultural areas near rivers. Therefore, water management aiming to improve the ecological status often conflicts and competes with strong interests from these other societal sectors. In practice, this often results in the changeable willingness of land owners in floodplains to sell land for purposes of river restoration.

In order to support solving the conflicts between various sectoral policies and private interests, the European Commission has defined the goal of establishing a multifunctional green and blue infrastructure across the EU. Such nature-based solutions (NBS) should secure the provisioning of ecosystem services that support water management goals and a variety of sustainable socio-economic activities (Rozkošný et al. 2014, Faivre et al. 2017, Kooijman et al. 2021). This goal has now been implemented into many policies by the EU and its member states (Davis et al. 2018) (Chapter VII). Meanwhile, the economic benefits provided by NBS have been analysed systematically (EU COM 2022). The European commission has developed criteria and indicators for implementing NBS (EU COM 2021).

In addition to supporting a sustainable economy, NBS seem indispensable in simultaneously undertaking the various challenges of climate change (EEA 2021b, Seddon 2022). Climate change profoundly impacts water availability and, thus, its quality in the EU (Elmhirst et al. 2020). As for the DRB, the DRBMP Update 2021 includes the effects of climate change (drought, water scarcity, extreme hydrological phenomena, and other impacts) as one of its five SWMI (ICPDR 2021).

IX.2 Lessons learned from the IDES project

The improvement of the Danube's water quality in recent years has shown that it is possible to reverse (under certain limits) the negative impacts of human activities. Thereby, emissions of pollutants from point sources can be reduced mainly through technical solutions (wastewater treatment) but still result in residual pollutant loads that enter the river system. Loading often occurs during rainy periods that exceed the sewer's flow capacities. Hence, natural processes resulting in the retention of pollutants entering a given river section either from upstream or through the riparian area represent a second important tool to improve water quality. Natural retention of plant nutrients and organic matter may be increased by restoring a diverse river channel morphology (Fischer et al. 2005, Gücker & Pusch 2006), reconnecting floodplains, or more sustainable land use of areas adjacent to the water (Chapter I, Tschikof et al. 2022). Such NBS offer the opportunity to address particular issues, i.e. water quality, and to look holistically for solutions integrating several societal demands. NBS improves the ecological status of rivers and floodplains and enhances the ecosystem's many services (Stammel et al. 2020, Thiele et al. 2020).

The IDES project's primary goal was to promote a holistic solution-oriented, multifunctional management of floodplains, including the rivers, instead of sectoral or technical approaches related to water management problems. Numerous potential floodplains exist throughout the DRB, with a total area of more than 100,000 ha (ICPDR 2021). However, the reactivation of former floodplains at local or regional levels is often very slow, as the reconciliation of the many interests of the different stakeholders is always a challenge. At this point, IDES has shown that the functional approach of ES assessment helps integrate the various interests in a multidimensional view. Stakeholders can better understand and appreciate the perception of others and jointly develop site-specific integrative concepts (Chapter III; IDES Manual). The balance of stakeholder interests and restoration goals may vary among countries and landscapes, as each area has its peculiarities and restrictions, which especially applies to the vast DRB. However, the methodological approach of the IDES project to support the solution of water-related issues still applies at the site-specific and basin-wide levels. For this purpose, we have developed a common framework of ES evaluation and stakeholder involvement within the IDES project, which may accelerate the implementation of water quality improvement and floodplain restoration projects in all countries

(Chapter IV; IDES Manual). However, an aggravating factor for the Danube-wide assessment of ES within the IDES project was that monitoring data or other parameters required for the ES assessment were missing or incomplete in several countries. For the entire DRB, they were not harmonised at all except for the data available across Europe. In addition, access to the national data is sometimes not open or only available upon request. In most cases, it took a very long time to collect the necessary data from the administrations or the provision was not even made possible.

In general, decision-making and planning work at three levels (basin-wide, national, and local) in the DRB. When applying the IDES Tool with EU-wide available data at the DRB scale, we identified deficits in ES provision, i.e. areas with a low value of specific ES (Chapters III and V). Although we observed no clear correlations between specific ES and nutrient retention at this large scale, this information can now identify geographical focuses in national action plans (national level). This first comprehensive overview of the ES assessment of river sections and floodplains has highlighted the significant differences between countries concerning the awareness and use of the ES concept so far. Especially the extent of considering ES in spatial planning differs significantly, as in some countries, discussions on ES have not spread much from the scientific community to societal decision-making (Chapters VII and VIII?). Incorporating the ES concept into spatial and socio-economic planning and decision-making will be aided by the new availability of a common assessment procedure described by IDES that consider many relevant ES. Water managers and planners trained to design ES-based, non-monetary, integrative and transparent decision-making processes will foster this approach. Results will produce multi-purpose and sustainable solutions.

In comparison, the monetary valuation of ES, which at first sight seems easy to understand and generates impressive numbers, exhibits several biases that prevent its use in integrative landscape planning. First, monetary value is not an appropriate or meaningful benchmark for all ES. Second, market prices are often unavailable, so several poorly comparable methods are applied to estimate 'costs' such as restoration costs, damage costs, or willingness to pay. The resulting monetary values defy comparison. Water managers realise projects at the local and regional levels. Land owners, users, and other stakeholders would understand and favour solutions created through a detailed assessment of ES based on the available local data. They may allow measures to increase ES availability in their floodplain territories. Chances for successful implementation of restoration projects improve when stakeholders participate in the planning process. This requires interactive planning and co-development, where the links between human pressures, management measures and ES in the respective region are discussed and demonstrated, and possible scenarios are developed. The two stakeholder workshops in the five IDES pilot areas and Bulgaria demonstrated that such events could foster the idea of bringing various benefits through floodplain restoration to local communities.

IX.3 New understanding of decision-making in water/floodplain management

The IDES pilot areas developed novel water management concepts to test a new avenue in decision-making on floodplain management: the IDES Tool. This integrative approach that considers all relevant stakeholders' interests in a given planning area to increase the chances for the implementation of floodplain restoration projects aims to improve water quality and other goals of the WFD and HD. This approach analyses synergies of stakeholder interests and then promotes them during subsequent planning processes, thereby avoiding negative interactions or trade-offs. It aims to

i) facilitate communication on complex management issues with various stakeholders and the public (Chapter VIII);

ii) support a complex social learning process to harmonise multiple competing local interests as a prerequisite for subsequent co-creation processes;

iii) provide a decision support tool that enables simple assessment of complex management scenarios. In IDES, fuzzy cognitive mapping (FCM, chapter III) enabled the joint development of sustainable water management concepts to respond to the current state.

By co-creating restoration projects with stakeholders from the beginning, their perception of the local ES and their understanding of the system can, on one side, be better used. On the other side, their different understandings of how the system functions will provide opportunities for societal learning. Through a common understanding of the interrelationships and processes in their specific region, the stakeholders can develop shared goals and identify ways to achieve them in the most sustainable manner. The basis for this co-creation derives from the Drivers-Pressures-State-Impact-Response (DPSIR) Framework (Figure III.9, chapter III). The DPSIR framework acknowledges the dependence of human society on the natural system and its services as the life-supporting unit for humans (van Rees et al. 2021). It identifies the nexus between the ecosystem and the societal systems and introduces options to initiate self-regulatory actions that support the approximation of both systems to common management goals. Thus, society can continuously respond to insufficient states of the ecosystems by mitigating pressures and adapting management measures. In particular, actions deemed nature-based solutions that support an intact ecosystem and, thus, most ES for society are meaningful in response to these undesirable drivers, pressures, states and impacts.

Nature-based solutions (NBS) refer to solutions to environmental and societal challenges that are "… *inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience*" (EEA 2021b). Such solutions bring more diverse nature and natural features and processes into cities, landscapes, and seascapes through locally adapted, resource-efficient, and systemic interventions. The NBS approach, which thus aims to improve ecosystem functions and ES even in strongly modified environments, is different from the traditional restoration approach that aims to restore only natural structures and biota (Cohen-Shacham et al. 2019). Hence, the effectiveness of NBS may increase by the provision of an array of ES plus social (stakeholder participation) and economic (new 'green' economic opportunities) indicators (EEA 2021b). Thereby it is assumed that ecosystems that humans only impact to a low extent provide the highest values of ES needed by most members of society and show the greatest synergies.

The IDES approach focuses on selecting the ES that are relevant for society in a given region, then objectively evaluates them and demonstrates the relationships that support their evaluation. Stakeholders can choose from several management scenarios regarding their expected well-balanced ES values. By this, stakeholders can examine the positive and negative effects of the different scenarios on their interests and legal management goals (e.g. water quality, flood prevention, agriculture, recreation, and nature protection). They can discuss among themselves to obtain a realistic and holistic picture of their needs and those of the broader society. The decision-making process must be well-balanced, accept democratic rules and represent all important groups of society. We regularly observed that initial stakeholders' perceptions differed significantly from those later mutually agreed upon (Chapter III) due to the social learning process where stakeholders share their knowledge. Taking a step back, giving priority to a holistic view of the system, and understanding the concerns of others is necessary to optimise the management of complex floodplain systems with many goals, such as flood risk reduction, water quality improvement or water-related recreation development. Effective planning and decision-making mean reaching a common understanding of the needs of citizens but also of a healthy ecosystem, resulting in much faster implementation of measures. The ES approach can serve as a common language among the various sectoral interests and goals.

IX.4 Future application of project results

The IDES Tool supports the implementation of NBS in river-floodplain systems aiming at holistic, multifunctional, and sustainable management and, simultaneously, strengthening resilience against climate change. It thus undertakes water quality improvement and the many management challenges of complex socio-ecological systems. It provides an inter-sector framework to support stakeholder involvement and integration of existing monitoring data into landscape planning and decision-making. The IDES Tool may effectively adapt formerly modified river-floodplain systems that maximised one or a few societal benefits to create a more sustainable solution and meet diverse societal requests and legal requirements of the 21st century. We recommend applying the IDES Tool at Danube-wide and national levels. For the local level, recommendations for its application follow directly from experience in the pilot areas.

<u>DRB-wide level</u>

• **Spatial analysis of the whole course of the major rivers and their floodplains** with the IDES Tool for single and multiple ES: Identification of deficits and potentials to improve the availability of specific ES in certain areas to meet societal needs or legal goals.

• **Identification of hot spots of ES availability**: the IDES Tool may distinguish areas with high scores for one or multiple ES and of specific ES only provided in certain areas that require protection due to their extraordinary functional benefits to society.

• **Integration of deficits and potential of ES and their management needs into the DRBMP and its regular updates**: The IDES Tool enables users to integrate results on ES availability and ES development needs into the DRBMP, thus fulfilling goals on ES assessment and NBS implementation, as stipulated by the EU Biodiversity 2030 Strategy. Primarily the ES assessment may be used to demonstrate and visualise the multiple benefits of restoration projects conducted in the DRB and the benefits of NBS implementation that also increase resilience against climate change.

• **Demonstration of synergies and trade-offs of different EU regulatory frameworks and comparison of management scenarios based on ES**: We recommend using the IDES Tool as a basin-wide framework for a standardised indicator-based approach to analyse the impacts and conflicts of different EU regulatory frameworks (WFD, HD, FD) and compare the effects of large-scale management measures in floodplains on ES availability in the DRB.

<u>National level</u>

• **Development of national floodplain atlases** with indications of the available ES (based on the IDES analysis) and national road maps to improve the availability of key ES.

• **Integration of ES evaluation into regional planning protocols**, thus **promoting NBS** to be better adapted against the upcoming challenges in water management (incl. water quality, climate change, and increased frequency of floods and droughts).

• **Fostering the development of joint water management planning documents** based on ES assessment, including all relevant sectors, such as drinking water supply, flood management, water quality management, nature protection, local economy, and tourism.

• **Establishing the ES approach as a tool for assessment of cost-benefit analyses** of measures and adjustment payments/compensation of land owners in floodplains.

• **National educational programmes on ES provided by floodplains** and their integrative management, incl. capacity building and education of interested stakeholders on the IDES Tool.

• **Co-creation and transparent decision-making on water management concepts at the regional/local scale**: Involvement of interested citizens and stakeholders in planning processes from the beginning to increase the quality, acceptance and sustainability of projects that have implications on surface waters and floodplains. The IDES Tool may facilitate the visualisation and comparison of different scenarios and thus support a joint agreement on the most effective scenarios for society with the greatest synergies and the lowest trade-offs.

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