DANUBE RIVER BASIN MANAGEMENT PLAN

UPDATE 2021

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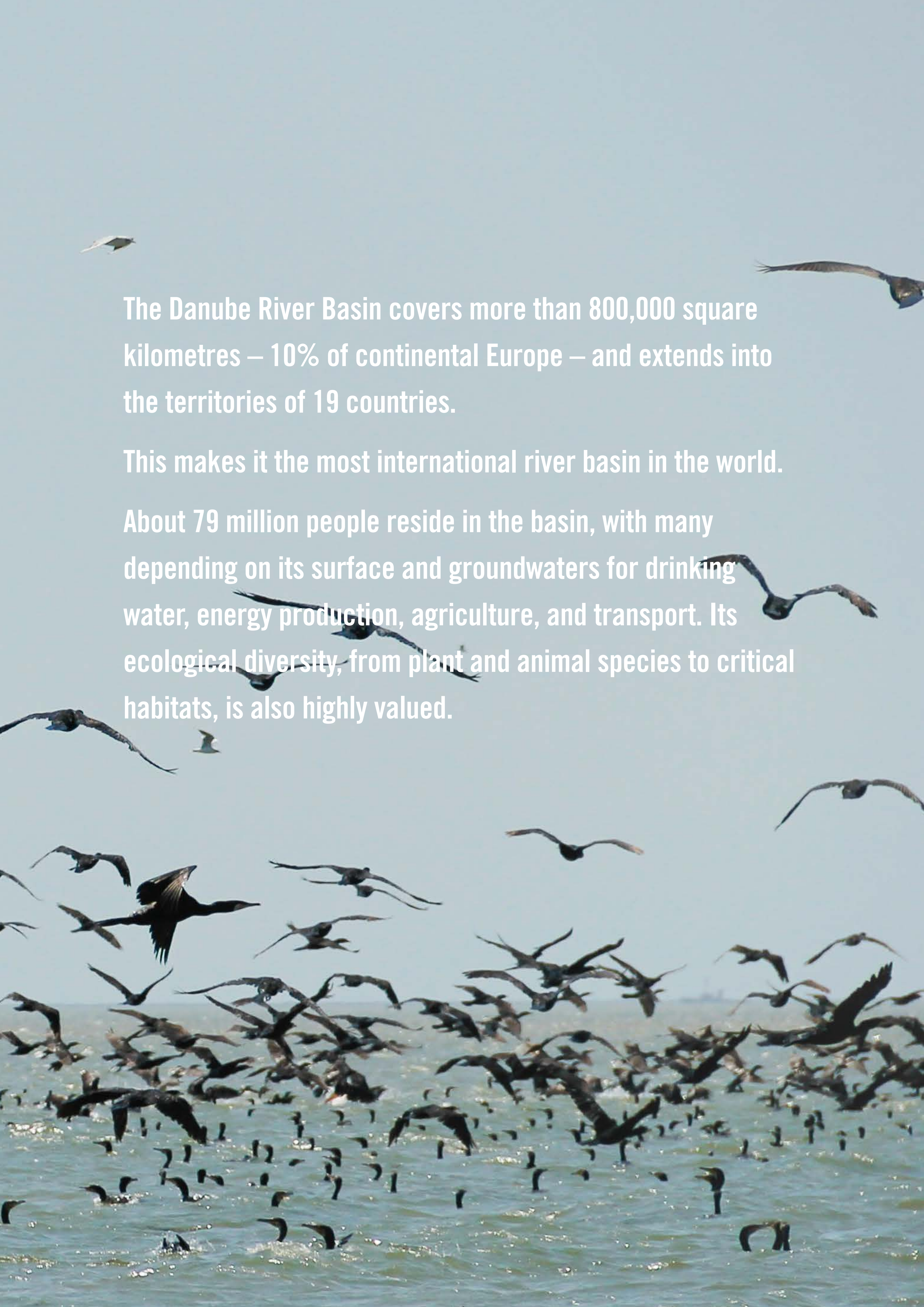
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

800,000 square kilometres



The Danube River Basin covers more than 800,000 square kilometres – 10% of continental Europe – and extends into the territories of 19 countries.

This makes it the most international river basin in the world.

About 79 million people reside in the basin, with many depending on its surface and groundwaters for drinking water, energy production, agriculture, and transport. Its ecological diversity, from plant and animal species to critical habitats, is also highly valued.

DISCLAIMER

The River Basin Management Plan for the Danube River Basin District, further referred to as Danube River Basin Management Plan (DRBMP), Update 2021 is based on data provided by Danube countries as of 5th November 2021.

Sources other than the competent authorities have been clearly identified in the Plan.

A more detailed level of information is presented in the national RBM Plans. Hence, the DRBMP Update 2021 should be read and interpreted in conjunction with the national RBM Plans.

The data in this report has been dealt with, and is presented, to the best of our knowledge. Nevertheless, inconsistencies cannot be ruled out.

IMPRINT

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EXECUTIVE SUMMARY

Shared Waters – Joint Responsibilities

Rivers, lakes, transitional and coastal waters, as well as groundwater, are vital natural resources. A significant proportion of water resources are exposed to environmental pollution or other potentially damaging pressures. Protecting and improving the waters of the Danube River Basin is therefore essential for the natural environment, the sustainable development of the region and the long-term health, well-being, and prosperity of the population.

The Danube River Basin (DRB) covers more than 800,000 square kilometres – 10% of continental Europe – and extends into the territories of 19 countries. This makes it the most international river basin in the world. About 79 million people live in this basin. They depend on its surface and groundwaters for drinking water, energy production, agriculture, and transport. Its ecological diversity, from plant and animal species to critical habitats, is also highly valued.

To mark their commitment to transboundary cooperation for the protection and sustainable use of the Danube River, the main Danube countries signed the Danube River Protection Convention (DRPC) in 1994. Today, 14 Danube Basin countries and the European Union are "contracting parties" of the International Commission for the Danube River (ICPDR). They work jointly towards the sustainable management of the Danube Basin`s waters. The ICPDR has a global reputation as a pioneer of successful transnational water management.

In 2000, the EU Water Framework Directive (WFD) came into force, establishing a legal framework to protect and enhance the status of aquatic ecosystems, prevent their deterioration, and ensure the long-term, sustainable use of water resources throughout the EU. In response, the ICPDR countries, including non-EU Member States (MS), agreed to implement the WFD throughout the entire basin. The contracting parties made the ICPDR the facilitating platform to coordinate WFD-related work.

The objectives of the WFD are to achieve "good chemical and ecological status (or potential)" for all inland surface waters, transitional and coastal waters – and for all groundwater to achieve "good chemical" and "quantitative status".

For a set of substances that present a significant risk to or via the aquatic environment, environmental quality standards were set at the European level, which define "good chemical status". And whilst "clean water", free from pollution by organic substances, nutrients and dangerous substances is essential, it is not always enough. For example, when the natural ecosystem, including its flora and fauna, is significantly damaged or dysfunctional. This is why a holistic approach also requires that surface waters have "good ecological status". Riverbeds and riverbanks have to provide suitable habitats for native aquatic species. Sufficient water to sustain these habitats, including access to migration routes and breeding grounds, has to be ensured.

To meet these objectives, the ICPDR developed its first "Danube River Basin Management Plan" (DRBMP) in 2009, including status assessments and measures towards the achievement of "good status" by 2015. Aware of the fact that not all waters would meet the target in six years and that river basins are dynamic systems that require an adaptive management approach, the WFD foresees an update of the River Basin Management Plans (RBMPs) in 2015, 2021 and subsequent cycles.

This DRBMP Update 2021 includes updated assessments of the main pressures impacting the Danube basin's waters, updated information on water status and progress achieved, as well as the joint further actions agreed by the Danube countries to be undertaken until 2027. The key issues requiring joint actions on the basin-wide level (Level A[1]) are addressed, underpinned by more detailed River Basin Management Plans at the national level (Level B).

Significant Water Management Issues – Progress Achieved and Remaining Pressures

The DRBMP Update 2021 focuses on five Significant Water Management Issues (SWMI), which are the main pressures and effects that affect water status. These are:

- Pollution by organic substances
- Pollution by nutrients
- Pollution by hazardous substances
- Hydromorphological alterations
- Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)

These issues all relate to the impacts on the ecological and chemical status of surface waters. For transboundary groundwater bodies, both, qualitative and quantitative issues are addressed.

Important changes with respect to the two previous DRBMPs are the addition of

- "Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)" as a fifth SWMI and
- a new sub-item "alteration of the sediment balance" under the existing SWMI "Hydromorphological alterations" to highlight the pressures to the balanced sediment regime and an undisturbed sediment continuity as well as related measures.

In addition to these SWMIs, the ICPDR is working on other relevant key issues like sediment quality management, invasive alien species and activities related to Danube sturgeon conservation in order to improve the data basis for these issues with the aim to determine their relevance on the basin-wide level and to propose and support the implementation of appropriate measures.

Pollution by Organic Substances

At the river basin scale, the urban wastewater sector generates about 190,000 tons per year of Biochemical Oxygen Demand (BOD) and 440,000 tons per year of Chemical Oxygen Demand (COD) discharges into the surface water bodies of the DRB (reference year: 2018). The direct industrial emissions of organic substances total up to ca. 65,000 tons per year of COD for the reference year (2018). Since the reference year of the DRBMP 2009 (2005/2006) and the DRBMP Update 2015 (2011/2012) DRBMP a remarkable reduction of the BOD emissions via urban wastewater can be recognized. The recent figures are about 61% and 27% less than those of the DRBMP 2009 and the DRBMP Update 2015 thanks to the substantial development of the wastewater infrastructure in the last decades. In the last fifteen years, Danube countries have invested more than €28 billion in wastewater infrastructure in line with the requirements of the EU Urban Waste Water Treatment Directive (UWWTD) and the WFD. Since 2006, ca 6,000 municipality projects have been implemented

1 The investigations, analyses and findings for Level A focus on rivers with catchment areas >4,000 km^2, lakes >100 km^2, transitional and coastal waters as well as transboundary groundwater bodies of basin-wide importance.

and around 45 million PE have had collecting and treatment facilities constructed or upgraded, with almost 2,800 more planned or currently in progress to improve the services for 26 million people. In addition, almost 180 operating industrial facilities with direct surface water emissions are certified with updated technology standards according to the provisions of the EU Industrial Emission Directive (IED). During the same time period, the percentage of municipalities and industrial facilities (bigger than 2,000 PE) connected to a sewer system and urban wastewater treatment plants (UWWTP) or adequate individual treatment facilities also increased substantially (to almost 80% at the DRB level), demonstrating a significant improvement of waste-water services in the DRB.

Pollution by Nutrients

The estimated recent, basin-wide nutrient emissions for the reference period (2015-2018) are 500,000 tons per year total nitrogen (N) and 31,000 tons per year total phosphorus (P). Similarly to the organic pollution, remarkable decrease is visible regarding the nutrient point source emissions in the Danube basin. The recently reported point source nutrient emissions are significantly lower in comparison to those of the DRBMP 2009 and the DRBMP Update 2015, the N emissions declined by 44% and 18%, the P discharges dropped by 56% and 22%, respectively. Diffuse emissions also dropped due to both, the low agricultural intensity in many countries and the measures implemented. The total N emissions decreased by 17% in comparison to the DRBMP Update 2015, whilst P emissions dropped by 19%. Diffuse emissions are dominating the total emission pattern (N: 87%, P: 78%), transporting nutrients from agricultural and urban areas into the water bodies. For N, subsurface flow (base flow and interflow) is the most important diffuse pathway with a proportion of 57%. For P, soil erosion (28%) generates the highest emissions. Regarding the sources, agriculture (N: 44%, P: 37%) and urban water management (N: 30%, P: 43%) are responsible for the majority of nutrient emissions indicating the necessity of appropriate measures to be implemented in these sectors. Historical trend analysis of nutrient river loads over the past decades shows a significant reduction in the transported nutrient fluxes to the Black Sea. However, the current long-term fluxes are still considerably higher than those of the early 1960ies which represent river loads under low pressures, indicating a further load reduction potential that might be exploited for the benefit of the Black Sea (N: 30%, P: 15%). This would require further reductions of both, point source and diffuse emissions generated in the DRB, with particular focus on pollution hot-spots. Nevertheless, in the last 5-10 years the measured loads are rather low and close to the Black Sea targets indicating significant water quality improvement.

Since 2006, over 1,700 municipalities and more than 35 million PE have had treatment plants with nutrient removal technology either constructed or extended in compliance with the UWWTD and WFD requirements. About €12 billion have been invested for these projects. Besides this, almost 500 more are planned or in progress by the end of 2021 to serve an additional 13 million PE. During the same time period, the percentage of people connected to nutrient removal in mid-sized and big settlements has reached 75%. Nitrates Action Programmes according to the obligations of the EU Nitrates Directive (ND) with mandatory rules on manure and fertilizer application are being implemented for more than 60% of the DRB. For agricultural areas in EU MS across the DRB, 70% are determined for direct support linked to cross-compliance and about 20% receive additional subsidies for implementing environmentally-friendly measures. In the last decade, more than €95 billion has been spent in the DRB countries to support farmers and finance best management practices. These financial mechanisms have been linked to the EU Common Agricultural Policy (CAP) and similar national programs in the non-EU MS.

Pollution by Hazardous Substances

Danube countries have taken important steps to fill the existing data gaps in the field of hazardous substances pollution by developing pollution inventories, organising specific UWWTP sampling campaigns and supporting modelling activities. Point source emission data are available for 180 major industrial facilities with recorded surface water releases of 32 compounds. The UWWTP monitoring campaigns carried out in the framework of the SOLUTIONS Project and the Joint Danube Survey 4 (JDS4) provided essential information on the point source emissions of emerging substances and the treatment efficiency of the UWWTPs for these chemicals. A priority list of substances associated with high risk and a wastewater related sub-list of the Danube River Basin Specific Pollutants have been elaborated. The ICPDR is actively supporting the Danube Hazard m^{3}c Project that has developed an emission model for basin-wide assessments of 17 representative chemicals, providing an insight into the pathway distribution of the analysed compounds. Moreover, policy recommendations and capacity building are also provided for effectively managing hazardous substances pollution in the DRB. Since 2006, at about 30 UWWTPs targeted technologies have been added to remove hazardous pollutants from wastewater. In addition, at more than 100 UWWTPs specific disinfection technologies are used that are partly able to remove organic micropollutants.

Danube countries made significant efforts to complete and update the basin-wide inventories on Accident Hazard Sites and Tailings Management Facilities and to carry out consistent hazard and risk assessment of these sites. At the basin-wide level, a few hundred of operating industrial facilities and active or non-active tailings ponds associated with significant hazard of accident pollution can be identified.

Hydromorphological Alterations

Impoundments, water abstractions, hydropeaking, continuity interruptions, morphological alterations and disconnections of wetlands/floodplains are recognized as significant pressures on water bodies within the Danube River Basin. Most of those types of significant pressures were already identified in previous planning cycles (DRBMP 2009 and DRBMP Update 2015) and were further on analysed in the DRBMP Update 2021. Additionally, sediment balance alteration is identified as significant water management issue in the DRBMP Update 2021. The sediment problematic, together with other listed significant hydromorphological pressures, are still hindering the achievement of environmental objectives in the Danube River Basin. Besides already existing pressures, also new hydromorphological pressures will arise in the future due to implementation of new infrastructure projects, mainly related to flood protection, navigation and hydropower production.

More than half of water bodies in the DRB are still under (at least one) significant hydromorphological pressure. There are 422 impoundments, 69 water abstractions and 42 cases of hydropeaking that are causing significant pressure in the DRB. Additionally, 624 river continuity interruptions are not passable for fish migration, while more than half of water bodies have altered morphological conditions.

Numerous hydromorphological measures have been implemented in the period between 2009 and 2021. The main aim of those measures was the mitigation of hydrological alterations like impoundments, water abstractions and hydropeaking, improvement of river continuity (building of fish passes), reconnection of wetlands/floodplains and improvement of morphological conditions (river restoration projects). 66 implemented measures were related to the improvement of hydrological alterations, mainly to impoundments and water abstractions. As of the year 2021, additional 5 measures addressing hydrological alterations are in the construction phase. 127 fish migration aids were completed; as for 8 fish migration aids the construction is on-going as of the end of 2021. 58 river restoration projects have been implemented, while additional 21 river restoration projects are in the construction phase as of the year 2021. There were also 61,745 ha of wetlands/floodplains partly or totally reconnected; for additional 4,526 ha the construction of reconnection is still ongoing as of the end of 2021. Furthermore, numerous fish migration aids and river restoration projects are currently in the planning phase. While within the DRBMP only measures on rivers with a catchment area larger than 4,000 km^2 are presented, it is important to emphasize that Danube countries are implementing hydromorphological measures also on other (smaller) rivers, where diverse hydromorphological pressures were assessed.

Besides implementation of listed technical measures, there were also many other research projects implemented in the WFD planning cycle until 2021, i.a. the Danube Floodplain Project, the Danube Sediment Project, the MEASURES Project and others, that are bringing new developments also related to hydromorphology and serve as a basis for preparation of further research and also technical measures. Investigations are performed on the possibilities of establishing fish migration at the Iron Gate dams for the migration of sturgeons and other migratory fish species, which are continued towards a full feasibility study. First investigations are also performed for the Gabčíkovo Dam.

In the period between 2015 and 2021 there were realized various ICPDR activities, supporting further developments in the field of hydromorphology and better implementation of hydromorphological measures in the DRB. In collaboration with Danube countries there were prepared i) analysis and recommendations on significant criteria for hydromorphological pressure assessment in the DRB, ii) analysis of relationship between hydromorphological alterations and response of biological quality elements in rivers in DRB, iii) catalogue of mitigation/restoration measures, iv) recommendations on implementation of hydromorphological measures focusing on the financial sources availability, v) a discussion paper on coordinating the implementation of the WFD and FD, vi) catalogue of lighthouse projects related to hydromorphology, vii) ecological prioritisation of barriers in the DRB and others. All these documents serve as a good basis for further improvements in the field of hydromorphology and implementation of hydromorphological measures, which are necessary for achievement of environmental objectives in the DRB.

Groundwater

The ICPDR has agreed to address at the basin-wide level the transboundary groundwater bodies (GWBs) of basin-wide importance. This approach aims to avoid the duplicity with the national plans, which provide information on all groundwater bodies, but it enables providing methodological guidance on groundwater management, which is applicable to all GWBs in the DRB. Transboundary GWBs of basin-wide importance were defined as follows: (i) important due to the size of the groundwater body i.e. an area >4,000 km^2 or (ii) important due to various criteria e.g. socio-economic importance, uses, impacts or pressures interaction with aquatic eco-system. Over the years, the ICPDR and Danube countries have identified 12 transboundary groundwater bodies of basin-wide importance (the last one, GWB-12 on Ipel/Ipoly, was added in 2019), which are addressed by this plan. The list of transboundary GWBs of basin-wide importance is open for further nominations.

The types of pressures on groundwater bodies of basin-wide importance are similar to those in 2015. Pollution by nutrients (ammonium, nitrates, phosphates and sulphates) from diffuse sources is the key factor posing significant pressure on the chemical status while the over-abstraction is the key pressure affecting quantitative status of groundwater bodies.

Effects of Climate Change (Drought, Water Scarcity, Extreme Hydrological Phenomena and other Impacts)

The impacts of climate change generally come on top of the impacts of other anthropogenic pressures affecting the water environment, such as pollution, water abstraction or hydromorphological alterations. The science is clear that meteorological extremes are on the increase and with them the pressures will increase overall. This is already becoming apparent in some waterbodies and is assumed by many experts to be a contributing factor in the slow progress in achieving the objectives of the WFD, i.e. good ecological, chemical and quantitative status.

Water Status – The Results of the Monitoring Programs

Surface Waters

According to the WFD, good ecological and chemical status has to be ensured and achieved for all surface water bodies. For those water bodies identified as heavily modified or artificial, good ecological potential and chemical status has to be achieved and ensured.

Monitoring results according to the WFD serve the validation of the pressure analysis. An overview of the impacts on water status is required in order to initiate measures.

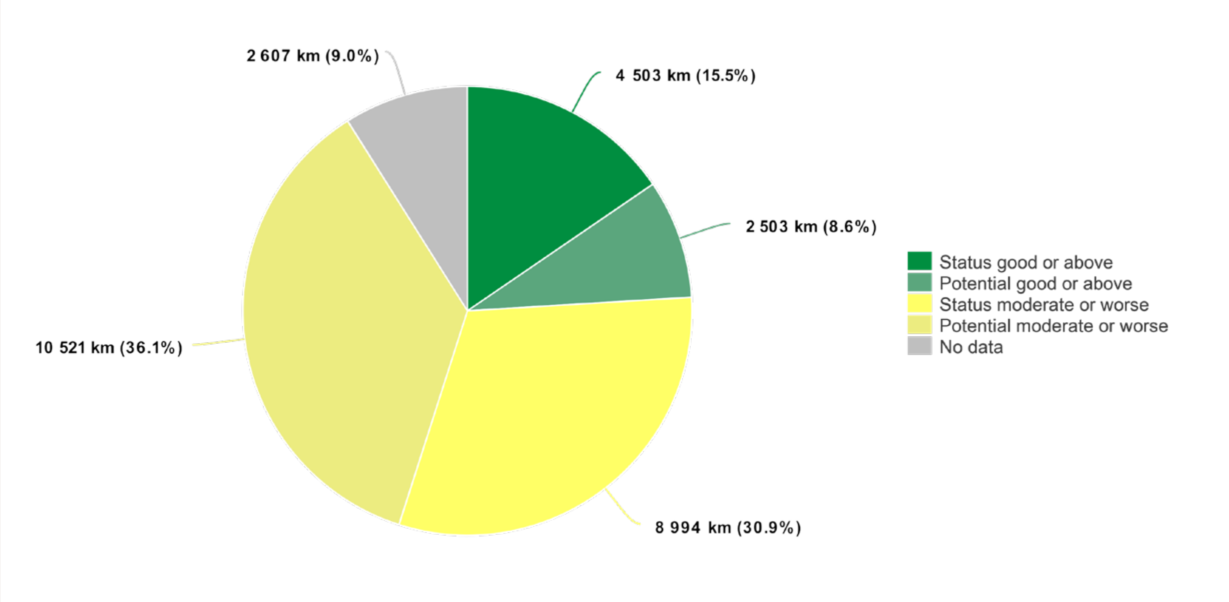
The ICPDR Transnational Monitoring Network (TNMN) has been in operation since 1996 and its major objective is to provide an overview of the overall status and long-term changes of surface water and, where necessary, groundwater status in a basin-wide context (with particular attention paid to the transboundary pollution load). There is a special activity in the frame of TNMN – Joint Danube Surveys (JDS) - which provide an extensive homogeneous dataset which is mainly based on WFD compliant methods jointly used by the Danube experts. JDS results provide an excellent reference database serving for harmonisation of existing monitoring methodologies; filling information gaps in WFD monitoring networks; testing new methods; or checking the impact of "new" chemical substances in different matrices.

Ecological and Chemical Status

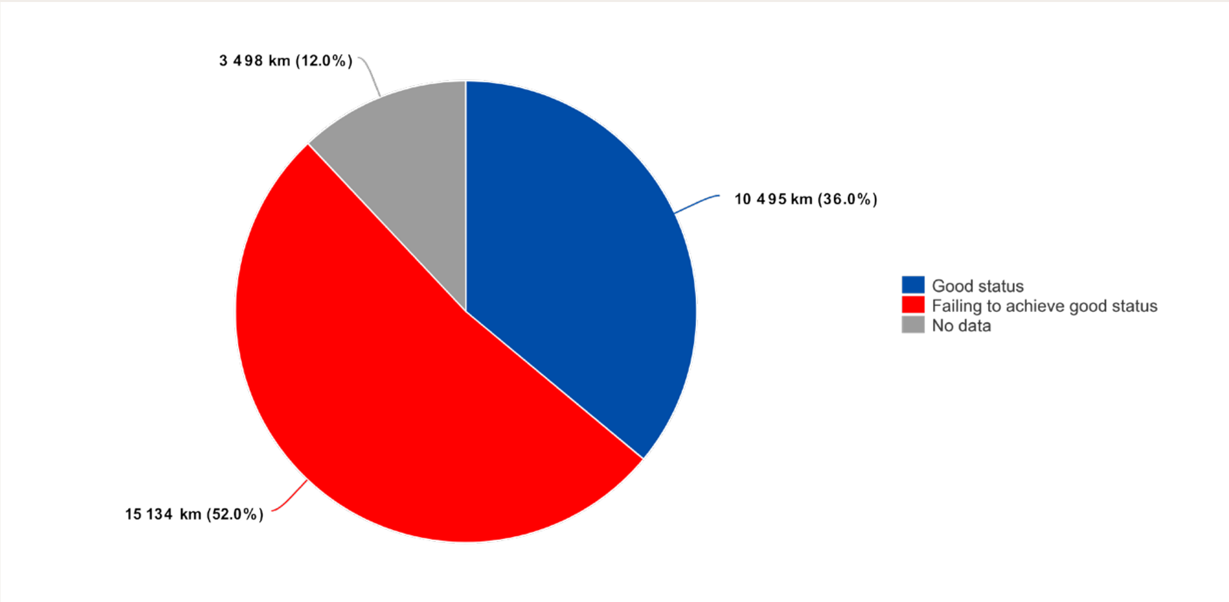
Out of a 29,127 rkm network in the DRBD, *good ecological status* or *ecological potential* is achieved for 7,006 rkm (24.1%) and good chemical status for 10,495 rkm (36.0%).

For priority substances in water, good chemical status was achieved at 19,725 rkm (67.7%). After neglecting the ubiquitous substances, the percentage of good chemical status was slightly increased to 73.8% but a significant portion of data is still missing. For priority substances in biota, good chemical status was not achieved in any water body, and despite a great portion of data for biota is still missing, the impact of ubiquitous substances on the chemical status in biota is significant: without brominated diphenyl ethers and mercury the *good chemical status* was achieved at 8,227 rkm (28.2%).

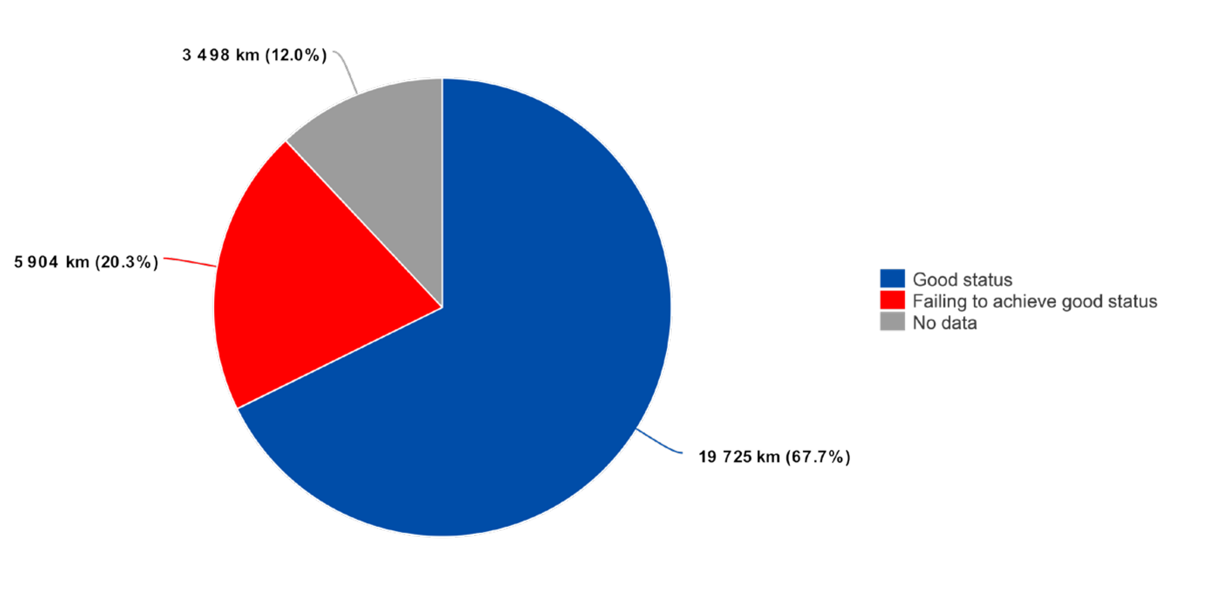
Ecological status and ecological potential for river water bodies in the DRBD in 2021 (indicated in length in km)



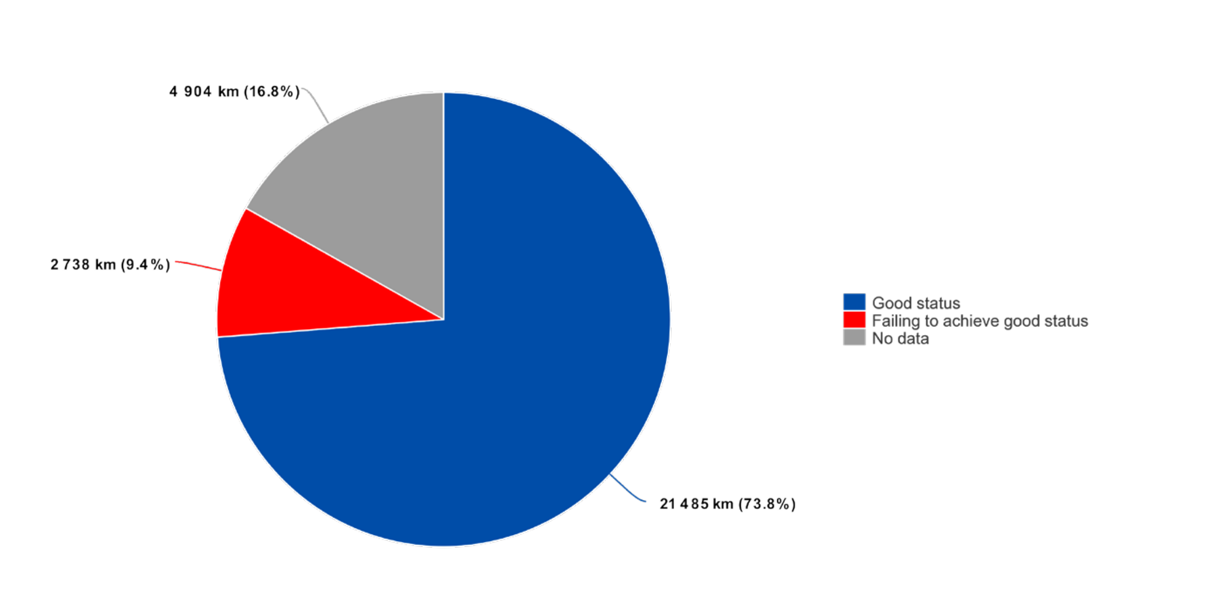
Chemical status of river water bodies in the DRBD in 2021, based on priority substances in water and biota (indicated in length in km)



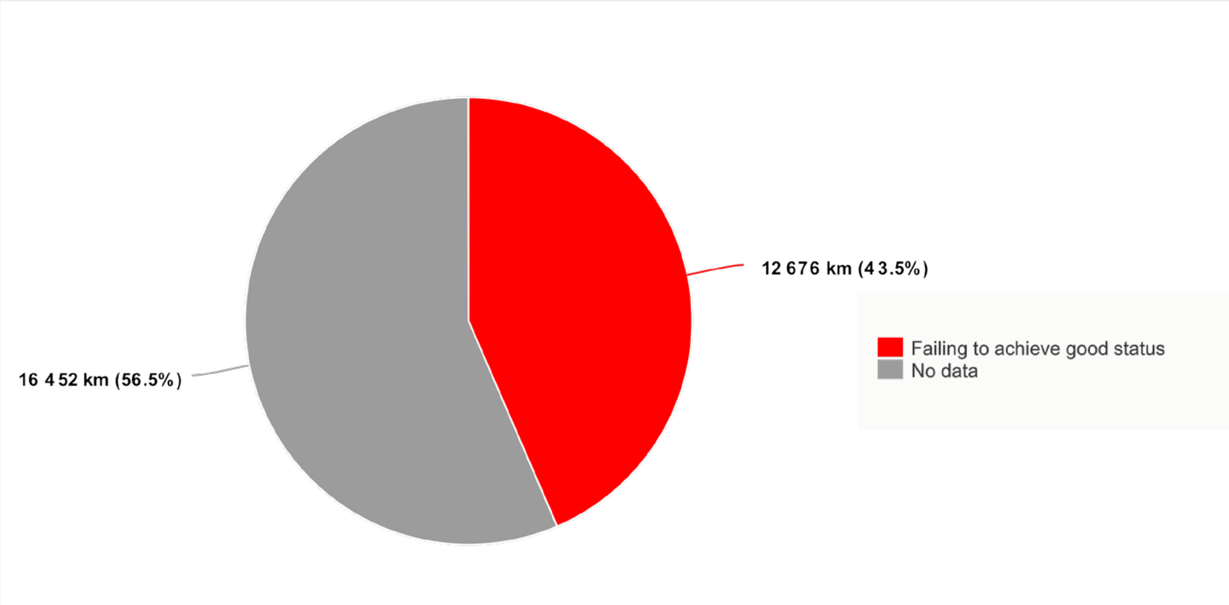
Chemical status of river water bodies in the DRBD in 2021, based on priority substances in water (indicated in length in km)



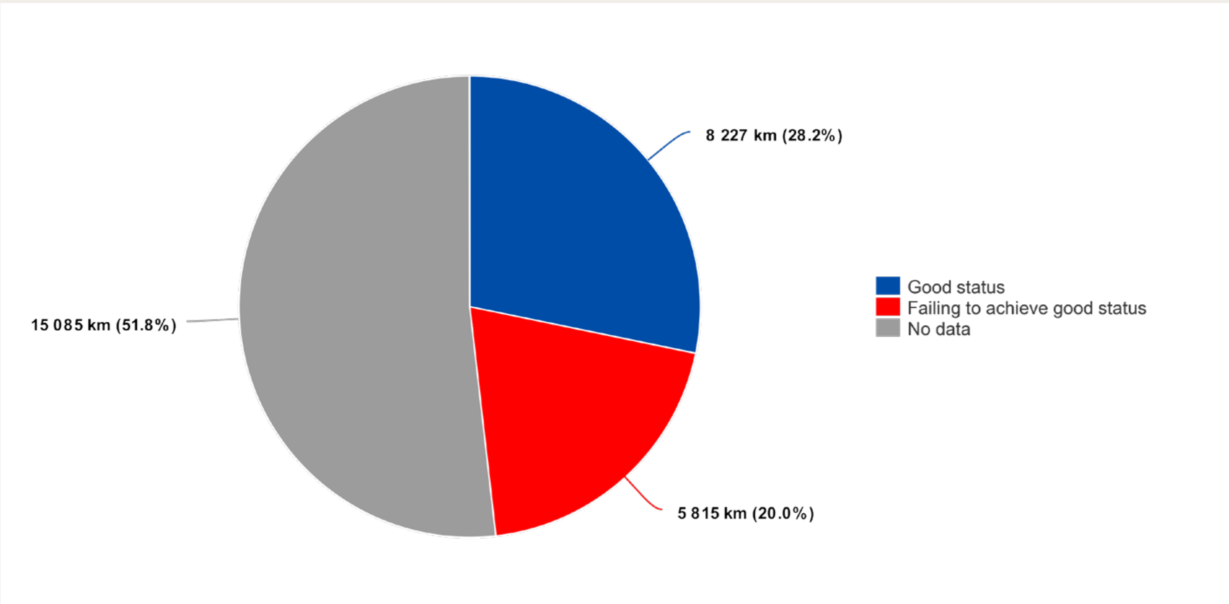
Chemical Status of river water bodies in the DRBD in 2021 based on priority substances in water without ubiquitous substances according to Directive 2013/39/EU (indicated in length in km)



Chemical status for river water bodies in the DRBD in 2021 based on priority substances in biota (indicated in length in rkm)



Chemical status for river water bodies in the DRBD in 2021 based on priority substances in biota without brominated diphenyl ethers and mercury (indicated in length in rkm)



Groundwater

Monitoring of the 12 transboundary GWBs of basin-wide importance has been integrated into the TNMN of the ICPDR. For groundwater monitoring under the TNMN (GW TNMN) a 6-year reporting cycle has been set, which is in line with reporting requirements under the WFD. GW TNMN includes both quantitative and chemical (quality) monitoring.

Groundwater Quality (Chemical Status)

Altogether, good chemical status was identified in 19 out of 25 national shares of the 12 transboundary GWBs and six are in poor chemical status. Four national shares were already in a poor status in 2015 and for two national shares, the chemical status deteriorated from good to poor status. One national share which was of unknown status in 2015 is now identified as of good status. All six national shares in poor status and also three national shares in good status are at risk of not achieving good status in 2027. Diffuse and point source pollution by nitrates, ammonium, phosphates, sulphates and chlorides is the cause of the poor classification.

Groundwater Quantity

Out of 12 transboundary GWBs (all 25 national shares evaluated), *good quantitative status* was observed in nine GWBs (with 18 national shares) and three transboundary GWBs (with 7 national shares) are in poor quantitative status. Within these three GWBs failing to achieve good status, three national shares are in good status and four are in poor status. Altogether, *good quantitative status* was identified in 21 out of 25 national shares of the 12 transboundary GWBs and four national shares are in *poor quantitative status.*

Compared to the status assessment in 2015, three national shares, which were in poor status, still remain at the same status, one national share that was in poor status in 2015 is now identified as of good status and one national share that was in good status in 2015 is now in poor status.

Five national shares (four currently at poor status and one at good status) are at risk of failing good quantitative status by 2027.

The *poor quantitative status* is caused in three cases by the exceeding of available groundwater resources; in two cases by significant damage to groundwater dependent terrestrial ecosystems and in one case by affected legitimated uses of groundwater.

Working with Water-Related Sectors: Integration Issues

As water is a cross-cutting issue and relevant for different sectors and industries, the integration with other sector policies is an important issue in the Danube River Basin in order to create synergies and avoid potential conflicts. Activities are ongoing to continuously implement and further intensify the exchange with different sectors such as nature protection including sturgeon conservation activities, inland navigation, sustainable hydropower and agriculture. Platforms for stakeholder exchange have been established within different projects in the DRB (e.g. Migratory Fish Networks within the MEASURES Project) and should be used for further stakeholder activities in the future. Considerable efforts are also being made towards the coordination of water management with the sustainable management of floods according to the FD. The elaboration and implementation of the Danube Flood Risk Management Plan according to the FD provides the opportunity of river basin and flood risk managers working closely together for the sustainable protection of the Danube basin's population and economies environment and the Black Sea, taking into account the MSFD.

Economic Analysis

There are considerable differences in the Danube countries socio-economic data like GDP and GDP per capita, highlighting significant differences between Danube countries´ economic activity. This fact is also reflected in terms of the heterogeneity in levels of investments which were possible in the past for basic water services like water supply and wastewater treatment, leading to different levels of infrastructure development (e.g., regarding the levels of UWWT). Closing this gap remains one of the key challenges for the DRB and the WFD planning period 2021-2027. Sustaining cost-recovery is a key tool for ensuring the financial sustainability of utilities, whereas socio-economic circumstances and affordability issues have to be taken into consideration. Efforts will be required in order to close remaining knowledge gaps and further work remains regarding methodologies and joint efforts towards the harmonisation of approaches e.g. on tools like cost recovery, including environmental and resource costs, in order to make best use of economic instruments offered by the WFD for water management planning, at the national level as well as in a transboundary context. Cost-effectiveness or cost-benefits analyses and affordability assessments are approaches for determining disproportionality of costs. These can be relevant for justifying possible exemptions. Consequently, best possible harmonisation of approaches would be especially beneficial in the transboundary context.

With regard to trends, the overall population in the DRB can be expected to decline slightly, while economies are mostly expected to grow – however, the COVID-19 pandemic is significantly increasing uncertainty and is already having a negative effect on economic growth. Sectors with significant consequences for water quality and quantity related aspects, such as agriculture, hydropower and production of energy from biomass, are also expected to grow, but less than foreseen in the DRBMP Update 2015.

The Joint Programme of Measures 2021-2027

Reducing Pollution by Organic Substances

Despite the huge investments already made in the wastewater infrastructure, additional measures should be taken in the future. In total, 20 million PE (24%) need basic infrastructural development; connection to public sewer systems and biological treatment needs to be ensured for 9 million PE, whereas 11 million PE need to access to collection system and tertiary treatment. More than 50% of the BOD surface water emissions via urban wastewater still stem from agglomerations with existing sewer systems but without treatment. Taking into account that these agglomerations represent only 6% of the total PE in the basin, implementation of measures for a relatively small proportion of the municipalities can result in substantial progress. Thus, these agglomerations should be prioritized. In the next management cycle, about 8 million PE will be provided with sewer system or IAS to appropriately collect wastewater and to convey it to treatment plants or to treat it locally. On the basin-wide level, 13% decrease in the BOD surface water discharges is expected, whereas soil BOD emissions via urban wastewater discharges will drop by about 60%.

Further efforts should be made to foster the development of investment projects in the wastewater sector. Supporting non-EU MS to find appropriate financial sources and to achieve progress is still a challenge in the DRB and should be further facilitated. Capacity building is necessary for both, the national/local administration and the utility operators to strengthen their management and technical skills and to improve financing, operational, and technological aspects of the wastewater infrastructure and services. The ICPDR in cooperation with the World Bank launched an initiative to support Danube countries in this respect by organising and facilitating knowledge exchange programs and events related to wastewater management, particularly on critical aspects like sustainable financing, rural wastewater management and sewage sludge management. Moreover, the ICPDR published the Recommendation Paper on Wastewater Management, that communicates the overall challenges, specific needs and potential solutions related to wastewater management in the DRB and provides several recommendations and potential actions for national policy making to improve wastewater management.

Reducing Pollution by Nutrients

The measures under implementation have been substantially contributing to the reduction of nutrient inputs into surface waters and groundwater in the DRBD but further efforts are still needed. Wastewater treatment for 16.5 million PE at agglomerations above 10,000 PE needs further improvement by introducing nutrient removal technology, out of which about 5.5 million concern treatment upgrades, whereas the rest (11 million PE) requires collection system and/or treatment plant construction. Diffuse pathways have a dominant share in the total nutrient emissions, therefore implementation of measures addressing land management has a high importance. Efforts are needed to ensure available financial instruments and to appropriately finance agricultural measures. In the next management cycle, about 8 million PE will be additionally connected to tertiary treatment ensuring high nutrient elimination rates. In addition, ca 2 million PE will be connected to secondary treatment and 1 million PE to IAS. Surface water nutrient emissions from point sources are expected to be increased because of the higher wastewater load reaching the UWWTPs in comparison to the reference status. For N, 14% emission increase is expected, whereas P surface water emissions will slightly rise by 4%. Nevertheless, soil emissions via urban wastewater discharges are expected to decline by 53% (N) and 56% (P). The baseline scenario in agriculture would lead to a slight decrease of the current nutrient emissions by 2027 (N: 9%, P: 5%). The baseline scenario estimates a slight decrease for the overall N and P emissions by 6% and 8%, respectively. River loads to the Black Sea are expected to drop by ca 5% for both N and P. According to the simulated vision scenarios, the river loads transported to the Black Sea can be significantly reduced towards or even below the level of around the 1960ies if nutrients are properly managed in the basin.

At the policy-making level, the agricultural sector needs to be addressed as significant amounts of nutrients stem from agricultural fields. The ICPDR Guidance Document on Sustainable Agriculture provides support for Danube countries to align water and agricultural policies, to seek synergies between CAP Strategic Plans and River Basin Management Plans and to decouple agricultural development from nutrient pollution and drought. The guidance paper recommends sound policy instruments, financial programs and cost-efficient agricultural measures to protect water bodies for decision makers in the agri-environmental policy field.

Reducing Pollution by Hazardous Substances

Despite the substantial progress achieved in many aspects of the hazardous substances pollution the state-of-the-art knowledge needs to be improved and the implementation of measures should proceed in the future to appropriately manage the problem. Further efforts are needed to identify which priority substances and other emerging chemicals are of basin-wide relevance. In particular, the lack of high-quality monitoring data on emerging chemicals of high importance in wastewater effluents have to be addressed. In addition, diffuse emissions should be further assessed by regionalized pathway and transport modelling adapted to the DRB to get a better understanding on inputs and fluxes of hazardous substances in the DRB. The Danube Hazard m³c Project delivered preliminary policy recommendations focusing on both, knowledge base establishment and measure implementation in various sectors, controlling sources and pathways of hazardous substances emissions.

Regular update of a basin-wide catalogue of hazardous industrial, abandoned and mining sites should be further accomplished, and implementation of safety measures should be promoted and reinforced to minimize the occurrence and adverse impacts of accident events. The ICPDR provides a platform for information exchange and know-how transfer for the countries to recommend practical hazard and risk assessment tools and preventive measures to be implemented. One highly relevant issue is the accident risk related to the tailings management facilities (TMF), where capacity building programs with regular training events at national or regional level need to be organized for facility operators and authority inspectors to strengthen their knowledge and skills in the field of accident prevention and contingency management. The ICPDR in cooperation with the German Environment Agency implemented the Danube TMF Project to improve the safety conditions of the tailings ponds, providing Danube countries with practical tools to assess safety conditions of individual TMFs and to identify potential measures to be implemented to improve safety.

Improving the Hydromorphological Conditions

In terms of hydromorphological pressures, further restoration measures are planned for 222 water bodies in respect of river morphology until 2027.

In 204 cases, measures are planned to reduce the impacts of impoundments like for instance by improving river morphology in the head sections of reservoirs. Measures towards establishing ecological flows are envisaged for 46 water abstractions and measures to reduce the impacts of hydropeaking are planned in 32 cases. In total 424 restoration measures on river continuity for fish migration are planned to be implemented by 2027. Further 23,399 ha of wetlands and floodplains will be reconnected by 2027. In total, 144,659 ha of wetlands and floodplains have been identified for a reconnection potential in the DRB.

Further implementation of hydromorphological measures is of special importance also in relation to climate change problematic, due to the fact, that it was recognized that hydromorphological measures can play an important role in mitigation of negative effects of climate change. Implementation is also crucial for reaching the targets of the EU Biodiversity Strategy 2030, mainly focusing on the guarantee of environmental flow and restoration of at least 25,000 km of EU rivers to a free-flowing state.

Improving Groundwater

Groundwater Quality

Taking into account that contamination by ammonium and nitrates is a key factor against achieving *good chemical status* of a significant portion of the GWBs of basin-wide importance it is essential to eliminate or reduce the amount of ammonium and nitrates entering groundwater bodies in the DRBD. Prevention of deterioration of groundwater quality and any significant and sustained upward trend in concentrations of ammonium and nitrates in groundwater has to be achieved primarily through the implementation of the EU Nitrates Directive and also the UWWTD.

To prevent pollution of GWBs by hazardous substances from point source discharges liable to cause pollution, the following measures are needed: an effective regulatory framework ensuring prohibition of direct discharge of pollutants into groundwater; setting of all necessary measures required to prevent significant losses of pollutants from technical installations; and the prevention and/or reduction of the impact of accidental pollution incidents.

It is essential to stress that the progress in implementation of measures described in this plan to tackle pollution by organic substances, nutrients and hazardous substances in surface water bodies has consequently a positive effect on the improvement of the chemical status of groundwaters.

Groundwater Quantity

The over-abstraction of GWBs should be avoided by effective groundwater and surface water management. Therefore, appropriate controls regarding abstraction of fresh surface water and groundwater and impoundment of fresh surface waters (including a register or registers of water abstractions) must be put in place as well as the requirements for prior authorisation of such abstraction and impoundment. In line with the WFD, it must be ensured that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction.

To prevent deterioration of groundwater quantity as well as the deterioration of dependent terrestrial ecosystems, solutions for the rehabilitation (e.g. natural water retention) have to be explored. These should include restoration of wetland areas, which are in direct contact with aquifers.

Effects of Climate Change (Drought, Water Scarcity, Extreme Hydrological Phenomena and other Impacts)

Climate change is changing the water cycle, which in turn exacerbates the impacts of other human induced pressures such as pollution or hydromorphological alterations. The best way to protect the DRB and its rivers, lakes and streams as well as groundwater against the consequences of climate change, is to increase the resilience of the natural environment in the whole river basin, this includes, for example, improving water retention by establishing green infrastructure, improving connectivity between habitats, improving sediment transport and minimising pollution. Climate change adaptation measures are therefore ultimately always a no-regret contribution towards achieving the objectives of WFD.

Financing the Joint Programme of Measures

For successfully implementing the JPM and reaching "good status" in the DRB, it is necessary to mobilize adequate ways of financing the planned measures. A number of EU-supported funding programs are available for some of the measures, but in general, the funding of measures in non-EU MS is more challenging than for those countries which have the legal obligation to fulfil the WFD. However, a number of financing sources and funding instruments exists, for different SWMIs and/or cross-cutting issues.

Time for the People of the Danube to #HaveYourSay

The ICPDR is committed to active public participation in its decision-making with the aim of achieving broader support for policies and increasing the efficiency of implementation efforts. The ICPDR therefore consults stakeholders in the entire cycle of its activities: from conceptualising policies, to implementing measures and evaluating impacts. The ICPDR has also taken the opportunity of this 2021 Public Consultation to further open the doors of the ICPDR, and to invite the public to participate in a new variety of ways – and the public is growing increasingly engaged as a result.

This is a vital shift, considering that environmental policy and management only succeed if key stakeholders feel engaged, and buy into the design of all the actions concerned. With an increased awareness of environmental issues, a growing appreciation for the ways in which the environment affects public health, plus the more direct contact of social media, public participation in processes like these is very much on the rise.

Today, a 'bottom-up' approach means that people can share information and responsibilities; they can partake in the design of programmes; monitor and evaluate progress; and all without central management. Key forms of participation and the dissemination of information assist environmental decision-makers in identifying the concerns of the general public. A recent shift towards such decentralized strategies encourages the active participation of organized groups, communities, and citizens at a more local level.

To expand the potential target groups of public consultation beyond merely expert stakeholders, the ICPDR developed a simple and easily accessible online questionnaire designed for both stakeholders and the general public. Available in 10 Danubian languages in addition to English, this questionnaire has helped the ICPDR to identify knowledge gaps amongst the general public, which the ICPDR will focus on filling in over the course of the next 6 years.

The flagship event of the process was the Stakeholder Consultation Workshop, which was held online for the first time (due to the COVID-19 pandemic): "Our Opinion – Our Danube". The event was hailed as a resounding success, bringing in 200 participants to discuss the key Thematic Areas from both the DRBMP and DFRMP. Additionally, the Danubian stakeholders and public, as ever, had the opportunity to comment on the plans in writing, by either emailing to a dedicated address (wfd-fd@icpdr.org), or even by post. Finally, the ICPDR's social media channels formed a new connection in addition to pre-existing online and offline content, such as Danube Watch magazine, or a user-friendly Public Participation section on the *ICPDR home page*.

All the issues raised, and comments made across all of these platforms, were taken into account by the relevant Expert and Task Groups during the finalisation process of the DRBMP Update 2021.

LIST OF ABBREVIATIONS

AAA	4-acetylaminoantipyrine
AEWS	Accident Emergency Warning System
AGR	Agriculture
AHS	Accident Hazard Sites
AL	Albania
AMPA	Aminomethylphosphonic Acid
AQC	Analytical Quality Control
AT	Austria
AWB	Artificial Water Body
BA	Bosnia and Herzegovina
BAT	Best Available Techniques
BDI	Biological Diatom Index
BEP	Best Environmental Practice
BMP	Best Management Practices
BG	Bulgaria
BLS	Baseline Scenario
BOD	Biochemical Oxygen Demand
CAL	Caloric Energy
CAP	Common Agricultural Policy
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CEN	European Committee for Standardisation
CF	Cohesion Fund
CIS	Common Implementation Strategy
CH	Switzerland
COD	Chemical Oxygen Demand
CP	Contracting Party
CR	Cost Recovery
CZ	Czech Republic
CZI	Czech multimetric index
DBA	Danube Basin Analysis
DDT	Dichloro-Diphenyl-Trichloroethane
DE	Germany
DEHP	Di (2-ethylhexyl) phthalate
DHSM	Danube Hazardous Substances Model
DFRMP	Danube Flood Risk Management Plan
D-LeaP	Danube Learning Partnership
DMCSEE	Drought Management Centre for South-eastern Europe
DPSIR	Drivers-Pressures-State-Impact-Response
DRB	Danube River Basin
DRBD	Danube River Basin District
DRBMP	Danube River Basin Management Plan
DRW	Drinking Water
DRPC	Danube River Protection Convention
DSTF	Danube Sturgeon Task Force
DWS	Deep Water Sampling
EAFRD	European Agricultural Fund for Rural Development
EBRD	European Bank for Reconstruction and Development
EEA	European Environment Agency
EFI	European Fish Index
EIA	Environmental Impact Assessments
EIB	European Investment Bank
EMFF	European Maritime and Fisheries Fund
ENI	European Neighbourhood Instrument
EoE	Extent of PNEC Exceedance
E-PRTR	European Pollutant Release and Transfer Register
ERC	Environmental and Resource Costs
ERDF	European Regional Development Fund
ETC	European Territorial Cooperation
EQS	Environmental Quality Standard
EQSD	Directive on Priority Substances
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union
EU MS	EU Member States
EUSDR	EU Strategy for the Danube Region
FAA	4-Formylaminoantipyrine

FIA	Fish Index Austria
FIP	Future Infrastructure Projects
FIS	Fish Index Slovakia
FD	EU Floods Directive 2007/60/EC
FoA	Frequency of Appearance
FoE	Frequency of PNEC Exceedance
FRMP	Flood Risk Management Plan
GAEC	Good Agricultural and Environment Conditions
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEP	Good Ecological Potential
GES	Good Environment Status
GLC	Global Land Cover
GNI	Gross National Income
GW	Ground Water
GWB	Ground Water Body
GWP	Global Water Partnership
ha	Hectare
HBCDD	Hexabromocyclododecane
HMWB	Heavily Modified Water Body
HR	Croatia
HU	Hungary
HYMO	Hydromorphology
IDMP	Integrated Drought Management Programme
IAD	International Association for Danube Research
IAS	Individual and other Appropriate Systems
IAWD	International Association of Water Service Companies in the Danube River Catchment Area
IBRD	International Bank for Reconstruction and Development
ICPBS	International Commission for the Protection of the Black Sea
ICPDR	International Commission for the Protection of the Danube River
IDA	International Development Association
IED	Industrial Emissions Directive
IND	Industry
IPA	Instrument for Pre-Accession Assistance
IPM	Integrated Pest Management
IRR	Irrigation
IT	Italy
IUCN	International Union for Conservation of Nature
IWT	Inland Waterway Transport
JDS	Joint Danube Survey
JPM	Joint Programme of Measures
JRC	Joint Research Centre
kg	kilogram
km	kilometre
LDM	Long Distance Migrants
LOD	Limit of Detection
LOQ	Limit of Quantitation
LS	Local Systems
MD	Republic of Moldova
MDM	Medium Distance Migrants
ME	Montenegro
MEC	Maximum Environmental Concentration
MK	North Macedonia
mm	Millimetre
MMI	Multimetric index
MONERIS	Modelling Nutrient Emissions in River Systems
MS	Member State
MoU	Memorandum of Understanding
MSFD	Marine Strategy Framework Directive
MZB	Macrozoobenthos
N	Nitrogen
ND	Nitrates Directive
NDICI	Neighbourhood, Development and International Cooperation Instrument
NGO	Non-Governmental Organization
NVZ	Nitrate Vulnerable Zone
NWRM	Natural Water Retention Measures
NWB	Natural Water Body

O&M	Operation & Maintenance
P	Phosphorus
PA	Priority Area
PAH	Polycyclic Aromatic Hydrocarbons
PE	Population Equivalent
PCDD	Polychlorinated Dibenzo-p-Dioxins
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctansulfonic Acid
PFRA	Preliminary Flood Risk Assessment
PL	Poland
PM EG	Pressures and Measures Expert Group
PNEC	Predicted No-Effect Concentration
PPP	Purchase Power Parities
RBM	River Basin Management
RBMP	River Basin Management Plan
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RI	Reference index
rkm	River kilometre
RO	Romania
RS	Serbia
SBC	Site-specific Biocontamination Index
SEA	Strategic Environmental Assessment
SK	Slovakia
SI	Slovenia (or Saprobic Index)
SMR	Statutory Management Requirements
SPD	Sustainable Use of Pesticides Directive
SPM	Suspended Particulate Matter
SSD	Sewage Sludge Directive
SWB	Surface Water Body
SWMI	Significant Water Management Issues
TCPP	Tris (1-chloro-2-propyl) Phosphate
TEN-T	Trans-European Transport Network
THI	Tailings Hazard Index
TMF	Tailings Management Facility
TN	Total Nitrogen
TNMN	Trans-National Monitoring Network
TOC	Total Organic Carbon
TP	Total Phosphorus
TRI	Tailings Risk Index
UBA	German Environmental Agency
UA	Ukraine
UNECE	United Nations Economic Commission for Europe
UWWTD	Urban Waste Water Treatment Directive
UWWTP	Urban Waste Water Treatment Plant
WFD	EU Water Framework Directive 2000/60/EC
WWF	World Wide Fund for Nature
WISE	Water Information System for Europe
WHI	Water Hazard Index

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http://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/drbmp_update_2021_final_annexes.pdf

1 INTRODUCTION AND BACKGROUND

1.1 Introduction

Rivers, lakes, transitional and coastal waters, as well as groundwater, are a vital natural resource of the Danube River Basin: they provide drinking water, crucial habitats for many different types of wildlife, and are an important resource for industry, agriculture, transport, energy production and recreation.

A significant proportion of water resources are exposed to environmental pollution or other potentially damaging pressures. Protecting and improving the waters and environment of the Danube River Basin is therefore essential for the natural environment, the sustainable development of the region and the long-term health, well-being and prosperity of the population of the Danube region.

Against this backdrop and in the light of the fact that the sustainable management of water resources requires transboundary cooperation, the countries sharing the Danube River Basin agreed to jointly work towards the achievement of this objective. The *Danube River Protection Convention*[2] (DRPC), signed in 1994, provides the legal framework for cooperation on water issues within the Danube Basin, which is the most international river basin in the world. All Danube countries with territories > 2,000 km^2 in the Danube River Basin are Contracting Parties to the DRPC: Austria (AT), Bosnia and Herzegovina (BA), Bulgaria (BG), Croatia (HR), the Czech Republic (CZ), Germany (DE), Hungary (HU), Republic of Moldova (MD), Montenegro (ME), Romania (RO), Serbia (RS), Slovakia (SK), Slovenia (SI) and Ukraine (UA). In addition, the European Union (EU) is also a Contracting Party to the DRPC. The *International Commission for the Protection of the Danube River* (ICPDR) is the organisation which was established by the DRPC Contracting Parties to facilitate multilateral cooperation and for implementing the DRPC.

In October 2000 the *EU Water Framework Directive*[3] (WFD) was adopted and came into force in December 2000. The purpose of the Directive is to establish a framework for the protection and enhancement of the status of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater, and to ensure a sustainable use of water resources. It aims to ensure that all waters meet 'good status' and to avoid their deterioration, which are the central objectives of the WFD.

EU Member States (EU MS) should aim to achieve "good status/potential" in all bodies of surface water and groundwater initially by 2015. Currently not all Danube countries are EU MS and therefore not legally obliged to fulfil the WFD requirements. Five countries (BA, MD, ME, RS and UA) are non-EU Member States (non-EU MS). Out of these non-EU MS, two countries (ME and RS) carry the status of candidate countries. However, when the WFD was adopted in the year 2000, all countries cooperating under the DRPC decided to make all efforts to implement the Directive throughout the whole basin.

The WFD establishes several integrative principles for water management, including public participation in planning and the integration of economic approaches, as well as aiming to integrate water management into other policy areas. It envisages a cyclical process where river basin management plans are prepared, implemented and reviewed every six years. There are four distinct elements to the river basin planning cycle: characterisation and assessment of impacts on river basin districts; water status monitoring; the setting of environmental objectives; and the design and implementation of the programme of measures needed to

2 *Convention on Cooperation for the Protection and Sustainable Use of the Danube River (Sofia, 1994).*

3 *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.*

achieve the objectives. These tasks were accomplished for the Danube River Basin in 2009 for the first time and are now updated according to the WFD cyclical approach, thus providing the framework for adaptive river basin management.

1.2 EU Water Framework Directive and Development of the DRBMP Update 2021

River basins, which are defined by their natural geographical and hydrological borders, are the logical units for the management of waters. This integrated approach for water management is also followed by the WFD. If a river basin covers the territory of more than one country within the EU, an international river basin district has to be created for the coordination of work in this district.

The Danube and its tributaries, transitional waters, lakes, coastal waters and groundwater form the Danube River Basin District (DRBD), which is shown in Map 1. The DRBD covers the Danube River Basin (DRB), the Black Sea coastal catchments in Romanian territory and the Black Sea coastal waters along the Romanian and partly Ukrainian coasts.

For reasons of efficiency, proportionality and in line with the principle of subsidiarity, the management of the DRBD is based on the following three levels of coordination (see Figure 1):

- **Part A:** International, basin-wide level – the Roof Level;
- **Part B:** National level (managed through the competent authorities[4]) and/or the international coordinated sub-basin level for selected sub-basins (Tisza, Sava, Prut, and Danube Delta);
- **Part C:** Sub-unit level, defined as management units within the national territory.

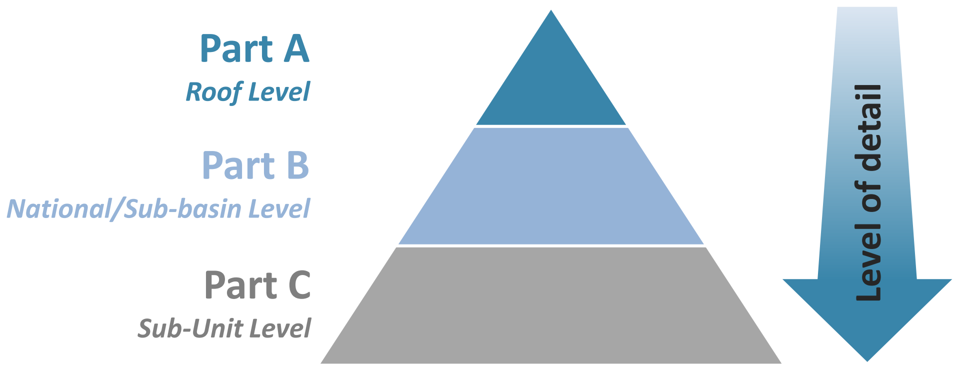


Figure 1: Three levels of management for WFD implementation in the DRBD showing the increase of the level of detail from Part A to Part B and C

The investigations, analyses and findings for the basin-wide scale (Part A) focus on:

- rivers with catchment areas >4,000 km²;[5]
- lakes >100 km²;
- transitional and coastal waters;
- transboundary groundwater bodies of basin-wide importance.

4 A list of competent authorities can be found in Annex 1.

5 The scale for measures related to point source pollution is smaller and therefore more detailed.

The ICPDR serves as the coordinating platform to compile multilateral and basin-wide issues at Part A ("Roof Level"[6]) of the DRBD. The information increases in detail from Part A to Parts B and C. Waters with smaller catchment and surface areas are subject to planning at sub-basin/national (Part B), respectively sub-unit level (Part C). All plans together provide the full set of information for the whole DRBD, covering all waters (surface as well as groundwater), irrespective of their size. The different planning levels allow for more detailed planning where necessary while ensuring overall coordination.

Since 2000 the following major milestones were achieved in managing the DRBD and in line with the principles as set by the WFD:

- 2004 Accomplishment of the first Danube Basin Analysis Report, compiling relevant information inter alia on the main pressures and impacts on water
- 2006 Summary report on the monitoring programmes in the DRBD
- 2007 Interim overview on the Significant Water Management Issues (SWMI) in the DRBD which are the main pressures on water requiring to be addressed on the Danube basin-wide level
- 2009 Adoption of the 1st Danube River Basin District Management Plan (DRBMP)
- 2012 Interim report on the progress in the implementation of the Joint Programme of Measures (JPM)
- 2013 Interim overview on the Significant Water Management Issues in the DRBD
- 2015 Adoption of the DRBMP Update 2015, providing an updated analysis on the main pressures water status information stemming from the monitoring programmes, and including the JPM towards the improvement of water status in the basin until 2021
- 2018 Interim report on the progress in the implementation of the JPM
- 2019 Interim overview on the Significant Water Management Issues in the DRBD

As a first step in the preparation of the third WFD management cycle (2021-2027), a timetable, work programme and statement on consultation measures for the development of the DRBMP Update 2021 was adopted by the ICPDR in December 2018. Following, an updated Interim Overview on the Significant Water Management Issues in the DRBD was developed by the end of 2019 and therefore two years before the deadline for the finalisation of the DRBMP Update 2021. Both documents were made available to the public, allowing for six months to comment in writing in order to allow for active involvement and consultation. The feedback provided was taken into account for the elaboration of the DRBMP Update 2021.

6 *At the roof level (Part A), the ICPDR agreed on common criteria for analysis related to the DRBMP as the basis to address transboundary water management issues. The level of detail of the roof level (Part A) is lower than that used in the national Part B Plans of each EU MS.*

1.3 River Basin Analysis and Risk Assessment

The Danube River Basin is the "most international" river basin in the world covering territories of 19 countries. Those 14 countries with territories greater than 2,000 km² in the DRB cooperate in the framework of the ICPDR. With an area of 803,260 km², the DRB is the second largest river basin in Europe.

Table 1 provides information on the basic characteristics of the DRBD.

Table 1: Basic characteristics of the Danube River Basin District

DRBD area	804,087 km²
DRB area	803,260 km²
Danube countries with catchment areas >2,000 km²	EU Member States (9): Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Slovakia, Slovenia, Romania Non-EU Member States (5): Bosnia and Herzegovina, Republic of Moldova, Montenegro, Serbia and Ukraine
Danube countries with catchment areas <2,000 km²	EU Member States (2): Italy, Poland Non-EU Member States (3): Albania, North Macedonia, Switzerland
Inhabitants	approx. 79 Mio.
Length of Danube River	2,857 km
Average discharge	approx. 6,500 m³/s (at the Danube mouth)
Important lakes >100 km²	Neusiedler See/Fertö-tó, Lake Balaton, Tisza-tó, Lake Ialpuh, Lake Kuhurlui, Lake Razim
Important groundwater bodies	12 transboundary groundwater bodies of basin-wide importance are identified in the DRBD
Important water uses and services	Water abstraction (industry, irrigation, household supply), drinking water supply, wastewater discharge (municipalities, industry), hydropower generation, navigation, dredging and gravel exploitation, recreation, various ecosystem services

The DRBD is not only characterized by its size and large number of countries but also by its diverse landscapes and the major socio-economic differences that exist. Table 2 provides an overview on the shares of countries of the Danube River Basin and the population within the DRB.

Table 2: Shares and population of countries in the DRB

Country	Code	Coverage in DRB (km²)	Share of DRB (%)	Percentage of land territory within the DRB (%)	Population within the DRB (Mio.)
Albania	AL	126	0.02	0.4	< 0.01
Austria*	AT	80,593	10.03	96.1	8.40
Bosnia and Herzegovina*	BA	38,289	4.77	74.9	3.20
Bulgaria*	BG	47,235	5.88	42.6	3.57
Croatia*	HR	35,111	4.37	62.1	2.90
Czech Republic*	CZ	21,681	2.70	27.5	2.70
Germany*	DE	56,250	7.00	15.7	10.07
Hungary*	HU	93,000	11.58	100.0	9.80
Italy	IT	565	0.07	0.2	0.02
Republic of Moldova*	MD	12,505	1.56	36.9	1.10
Montenegro*	ME	7,260	0.90	52.5	0.18
North Macedonia	MK	109	0.01	0.4	< 0.01

Country	Code	Coverage in DRB (km²)	Share of DRB (%)	Percentage of land territory within the DRB (%)	Population within the DRB (Mio.)
Poland	PL	430	0.05	0.1	0.04
Romania*	RO	232,193	28.91	97.4	19.50
Serbia*	RS	81,974	10.21	92.6	7.007
Slovakia*	SK	47,084	5.86	96.0	5.20
Slovenia*	SI	16,420	2.04	81.0	1.80
Switzerland	CH	1,809	0.23	4.4	0.02
Ukraine*	UA	30,626	3.81	5.1	3.03
Total		**803,260**	**100.00**	-	**78.53**

**) Contracting Party to the ICPDR*

The Danube River Basin shows a tremendous diversity of habitats through which rivers and stream flow. The richness in landscape include glaciated high-gradient mountains, forested midland mountains and hills, upland plateaus as well as plains and wet lowlands, as the Danube Delta, near sea level.

Fauna and flora show different geographical distributions depending on the natural characteristics of the environment. To account for these differences, the WFD requires the definition of surface water types and the development of type-specific ecological classification systems to assess the status of water bodies. Ecoregions are regions of similar geographical distribution of flora and fauna species. A detailed description of the ecoregions in the Danube River Basin District is provided in the DBA 2004 (see also Map 2).

The typology of the Danube River was developed in a joint activity by the countries sharing the Danube River for the first DBA in 2004. The Danube typology therefore constitutes a harmonized system used by all these countries. The Danube typology was based on a combination of abiotic factors of System A and System B. The most important factors are ecoregion, mean water slope, substratum composition, geomorphology and water temperature.

Ten Danube section types were identified. The morphological and habitat characteristics are outlined for each section type. In order to ensure that the Danube section types are biologically meaningful, these were validated with biological data collected during the first Joint Danube Survey in 2001.

As for the definition of the upper, middle and lower part of the Danube, this report refers to Upper Danube River (from source to rkm 1790), Middle Danube River (from rkm 1790 to 943) and Lower Danube River (from rkm 943 to mouth).

Water bodies are the basic management units according to the WFD. Therefore, all WFD assessments and activities (i.e. water status, final heavily modified water body designation, measures to improve status etc.) are linked to the unit of water bodies. Surface water bodies are discrete and significant elements of surface water (WFD Article 2(10)).

Between 2015 and 2021, minor changes in water body delineation still allowing comparison of the water body status were reported by Austria, Czech Republic, Hungary, Slovakia, Bosnia and Herzegovina, Republic of Moldova and Bulgaria. Since 2015, no changes in water body delineation were made in Germany and Slovenia. Romania performed some changes in water body delineation and in the assessment systems for BQEs, however a comparison of the water status between 2015 and 2021 has been made. Croatia performed

7 The data from Serbia do not include any data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

such changes in water body delineation and in the assessment systems for BQEs, which do not allow any comparison of water status between 2015 and 2021. In Ukraine, delineation of the water bodies is in a final stage and new monitoring principles are being introduced. Therefore, a meaningful comparison of SWB status in 2015 and 2021 is not possible.

The water bodies described here refer to those relevant for the Danube basin-wide scale. All other water bodies are dealt with in detail in the National Reports (Part B). 63 water bodies have been identified on the Danube River, and 868 water bodies have been identified on the tributaries with catchments > 4,000 km^2. Further, seven lake water bodies have been delineated and overall, 3 transitional and 4 coastal water bodies have been reported.

The overall aim of the pressure/impact analysis was inter alia to establish the risk of failure to achieve by 2027 the WFD environmental objective for rivers, lakes, transitional waters and coastal waters. The risk analysis was performed at the national level taking into account the ongoing pressures persisting from the past and the pressures which may emerge in future due to long-term trends and new developments. The risk analysis was based on data from AT, BG (part of the data), CZ, DE, HR, SI, RO, RS, SK and UA (part of the data). Risk data from BA, HU, MD and ME is missing.

Figure 2 illustrates the length of the river water bodies having the risk of failure to achieve a good ecological status or potential and Figure 3 illustrates the length of the river water bodies having the risk of failure to achieve good chemical status by 2027.

Altogether, 29,127 km of river water bodies were considered for the risk analysis. 8,350 km of rivers are not at risk of failure to achieve good ecological status or ecological potential (28.7%), and 13,494 km of rivers are not at risk of failure to achieve good chemical status (46.3%). No data for the risk assessment for the ecological status is available from 6,374 km of rivers and for the chemical status from 6,349 km of rivers.

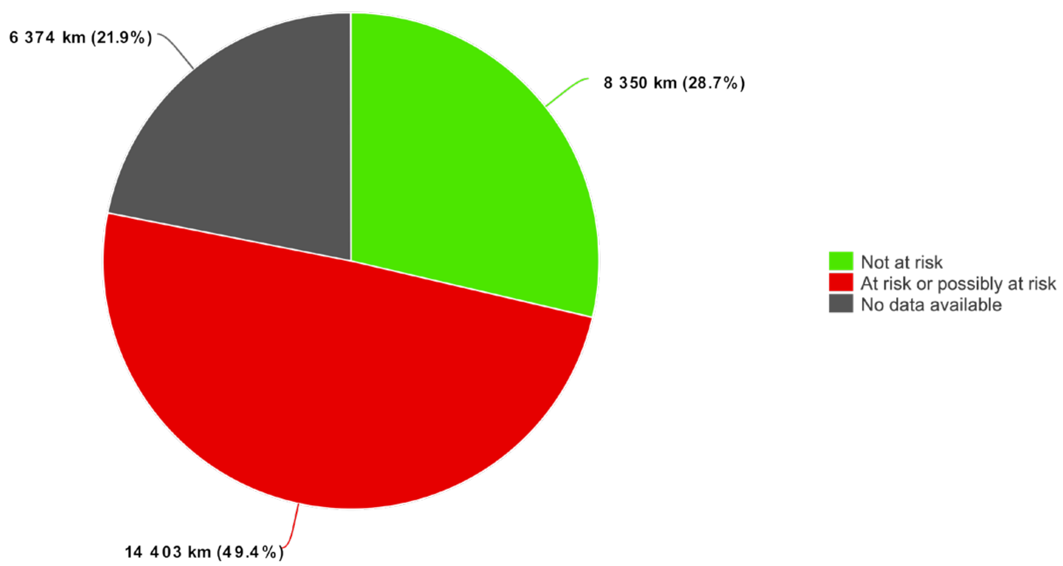


Figure 2: Risk Assessment Surface Waters (River WBs) – Risk of failure to achieve good ecological status by 2027 [8]

8 *In this graph, the length in kilometres of river water bodies reported for level A (rivers with catchment size larger than 4,000km²) is summed up, so the total (100%) includes duplicated river water bodies if they are located on border rivers.*

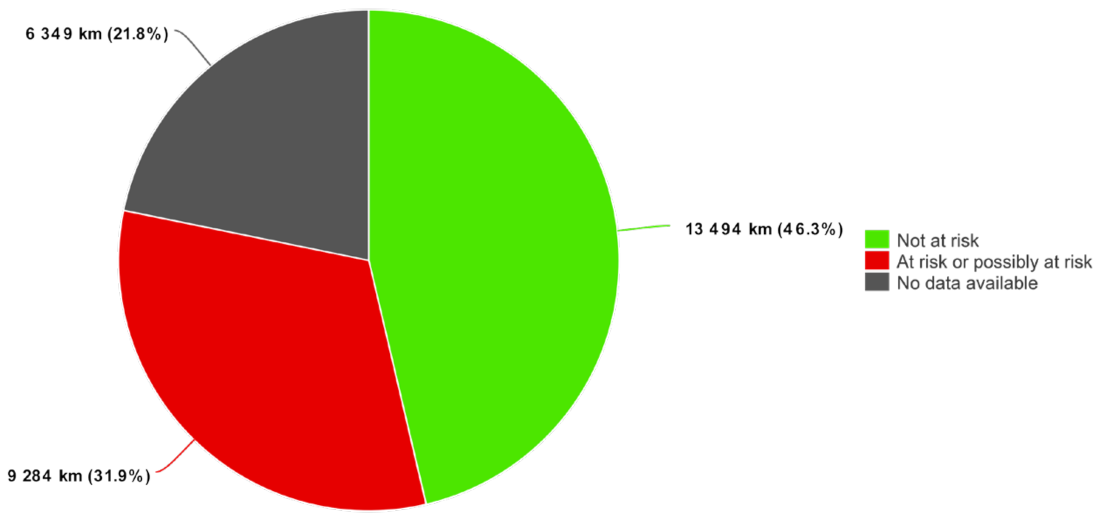


Figure 3: Risk Assessment Surface Waters (River WBs) – Risk of failure to achieve good chemical status by 2027 [9]

The reasons of the risk of failure to achieve a good ecological status / potential or good chemical status by 2027 expressed in terms of pressures by organic pollution, nutrient pollution, hazardous substances pollution and hydromorphological alterations are shown on Figure 4. This figure distinguishes between the ongoing pressures persisting from the past and the pressures, which may emerge in the future due to long-term trends and new developments. This information is crucial for the design of the JPM and for taking the necessary actions for achieving the environmental objectives by the year 2027.

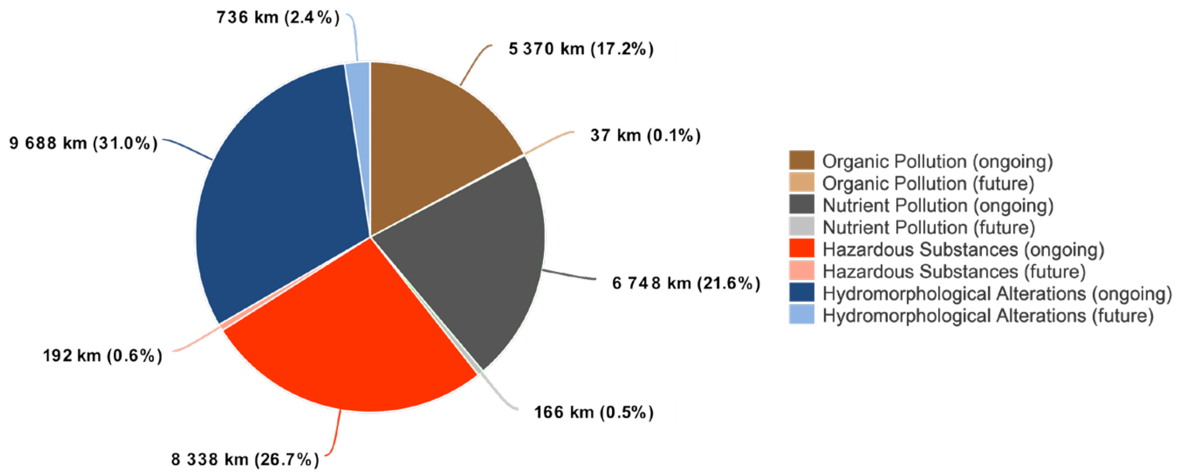


Figure 4: Surface Waters (River WBs) – Pressures leading to the risk of failure to achieve good surface water status by 2027 [10]

Out of 12 transboundary GWBs of basin-wide importance, which altogether consist of 25 national shares, a risk of failure to achieve good chemical status by 2027 was identified in nine national shares (located in seven different transboundary GWBs of basin wide importance). In five national shares the failing parameter is ammonium, in four national shares it is nitrates and sulphates. Phosphates and glyphosate were reported for

9 *In this graph, the length in kilometres of river water bodies reported for level A (rivers with catchment size larger than 4,000 km²) is summed up, so the total (100%) includes duplicated river water bodies if they are located on border rivers.*

10 *In this graph, the length in kilometres of river water bodies reported for level A (rivers with catchment size larger than 4,000 km²) affected by each pressure type are summed up, so the total (100%) includes duplicated river water bodies if they are located on border rivers or are affected by multiple pressures.*

two national shares and in one national share the failing parameters are chlorides, Trichloroethylene and electric conductivity. With regard to groundwater quantity, the risk of failure to achieve good quantitative status by 2027 was identified in five national shares (located in four transboundary GWBs). In conclusion, large parts of the DRBD are still subject to multiple pressures which need to be addressed in order to achieve the WFD environmental objectives.

1.4 Role of Significant Water Management Issues

According to WFD Article 14(1)(b), EU MS are required to prepare an interim overview of the Significant Water Management Issues identified in the river basin, at least two years before the beginning of the period to which the plan refers. The updated Interim Overview on the Significant Water Management Issues (SWMI) in the DRBD was elaborated by the end of 2019 as a step towards the development of this update of the DRBMP. Important changes with respect to the two previous DRBMPs are the addition of "Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)" as a SWMI and the definition of a new sub-item "alteration of the sediment balance" under the existing SWMI "Hydromorphological alterations".

Both the DRBMP Update 2021 and the Joint Programme Measures (JPM) focus on these SWMIs. In addition, the important transboundary groundwater bodies are dealt with as a separate item. Chapters 2 und 4 (significant pressures, water body status) and the JPM in Chapter 8 refer individually to each of the four pressure-specific SWMIs (organic, nutrient and hazardous substances pollution and hydromorphological alterations) and to groundwater. Contents relating to the effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts), as an overarching SWMI, are either presented in dedicated subchapters or integrated into the respective pressure-specific chapters, depending on the context.

For each SWMI and groundwater, visions have been agreed and the operational management objectives have been updated to guide the Danube countries and the DRBMP Update 2021. Visions and management objectives have been developed for each SWMI and groundwater. The visions are based on shared values and describe the principal objectives for the DRBD with a long-term perspective. The respective management objectives describe the steps towards the environmental objectives in the DRBD in a more explicit way. EU Member States are obliged to comply with the WFD which requires that environmental objectives are set and attained on a water body level. All other Contracting Parties to the DRPC have signed up to follow the WFD as well. The visions and management objectives serve the purpose to reflect this joint approach among all Danube countries and to support the achievement of the WFD objectives in this very large, unique and heterogeneous European river basin.

The visions as agreed in the frame of the DRBMP 2009 are again indicated in this document. Since the visions describe the principal objectives with a long-term perspective, no major updates of the visions were required for the preparation of the DRBMP Update 2021, with the exception of the new SWMI on "Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)" and a new sub-item "alteration of the sediment balance" under the existing SWMI "Hydromorphological alterations". However, updates of the management objectives have been performed with the perspective of 2027 (timeframe to which the DRBMP Update 2021 refers to). For the update, in particular the ongoing progress in the implementation of measures and other relevant information was taken into account.

Other important activities and emerging issues

Since the adoption of the DRBMP 2009, more intensive work has been done and additional topics were investigated, in order to identify their relevance and significance on the basin-wide scale. These include aspects of sediment quality, invasive alien species, and the sturgeon issue.

Furthermore, new activities were launched, and work has been continued to enhance inter-sectoral cooperation, especially with regard to inland navigation, sustainable hydropower and agriculture, as well as the linkages between the WFD, flood risk management under the EU Floods Directive 2007/60/EC (FD)[11] and the linkage to the marine environment via the EU Marine Strategy Framework Directive 2008/56/EC (MSFD)[12]. These sector policies are closely interlinked with the different Significant Water Management Issues. Infrastructure projects (i.e. navigation, hydropower and flood protection measures) are of specific relevance for the SWMI "Hydromorphological alterations", while agricultural activity is a specific issue for the SWMIs "Organic pollution", "Nutrient pollution" and "Hazardous substances pollution" and are addressed accordingly. Also, the measures applied at the basin-wide level for the reduction of nutrient pollution and hazardous substances pollution will contribute to the improvement of the Black Sea status.

A new initiative of particular strategic importance is the new EU Green Deal and the EU Biodiversity strategy where efforts in water management are/have to be multiplied to enhance synergies, halt the decline in European biodiversity and implement measures to restore it. To this end, and with a view to strengthening the resilience of aquatic ecosystems of the Danube Basin, the ICPDR and Contracting Parties will review how transboundary ecosystem connectivity and ecological corridors for aquatic species can be given a more prominent place in the next update of the ICPDR's SWMIs and how the ICPDR can help to ensure a coherent approach to maintaining and enhancing ecosystem connectivity across national borders.

1.5 Building on the Second Cycle – the DRBMP Update

The nine Chapters of the DRBMP Update 2021 follow the logic and requirements of the WFD; key findings and conclusions are summarized in Chapter 10. The structure is further determined through the SWMIs of the DRBD and related to the Drivers-Pressures-State-Impact-Response (DPSIR) Framework (see Figure 5) according to the European Environment Agency (EEA)[13].

The DPSIR Framework provides an overall mechanism for analysing environmental problems and responses with regards to sustainable development. 'Drivers' are human activities, often dictated by economic, social demands and technical developments as well as government policies. 'Pressures' are different factors through which the drivers can potentially affect the ecosystems and their components, e.g. emissions or structural alterations to natural conditions. These pressures can affect 'Status' of the environment, which then manifests itself in 'Impacts' upon ecosystems. Society has to 'Respond' with various measures, such as improvements in policy, enhanced regulations or mitigation measures; these can be directed at any other part of the system, though dealing with the "root causes" of the problems will typically require measures that focus on drivers and pressures.

11 *Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.*

12 *Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).*

13 *The DPSIR framework used by the EEA: https://www.eea.europa.eu/publications/92-9167-059-6-sum/page002.html (accessed 12 February 2021).*

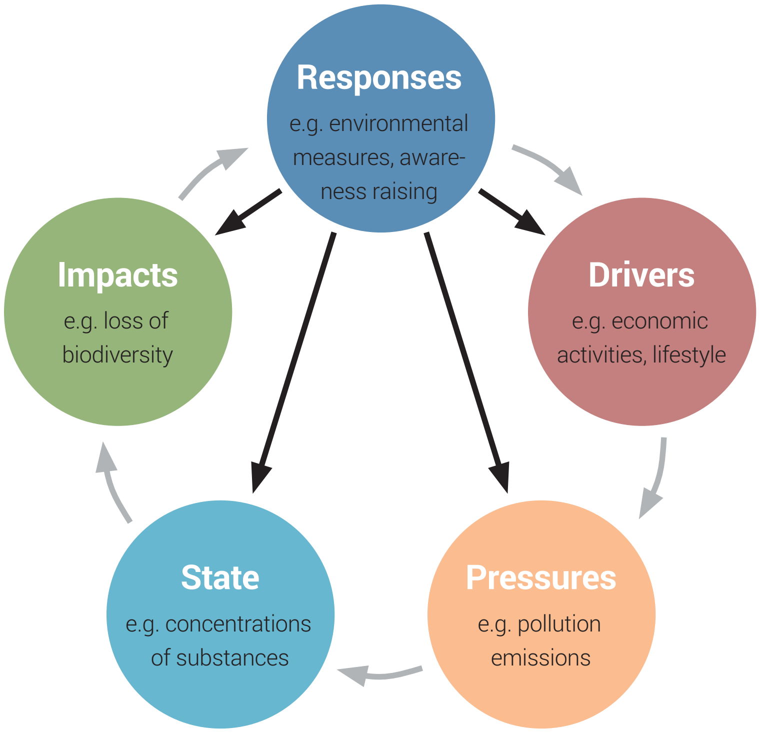


Figure 5: DPSIR approach according to the European Environment Agency (EEA)

Chapter 2 is dedicated to the existing 'Pressures' and their analyses for each SWMI, important transboundary groundwater bodies and other issues (i.e. sediment quality, invasive alien species). 'State' and 'Impacts', resulting from the existing 'Pressures', are addressed in Chapter 4, where information from the monitoring networks provides the basis for the status assessment for surface and groundwater bodies. The Chapter also includes information on the designation of Heavily Modified and Artificial Water Bodies.

This information, in combination with environmental objectives and exemptions according to WFD Articles 4(4) to 4(7), which are indicated in Chapter 5, leads to 'Responses' with respective measures to be implemented for each SWMI – the JPM which is outlined in Chapter 8. These are the actions, which are taken to improve water status in the DRBD. Actions can also be directed towards 'Drivers', which are inter alia addressed and assessed in Chapter 6 (Integration issues) and in Chapter 7 (Economic analysis).

Finally, the DRBMP Update 2021 includes an updated inventory of protected areas (see Chapter 3) and outlines the steps which are taken to ensure public information and consultation (see Chapter 9). The key findings and conclusions of the DRBMP Update 2021 are summarized in Chapter 10.

The close cooperation between the Danube countries at technical and strategic level provides water managers throughout the DRB with a framework within which to explore long term sustainable solutions to new and emerging water-related issues such as the impacts of climate change. In the light of the many challenges the Danube countries are currently facing and the growing complexity of environmental issues, there is a significant added value in sharing knowledge and expertise as well as demonstrating the necessity, efficacy and multiple advantages of a holistic and integrated approach to the transboundary water resources management. That is why the DRBMP Update 2021, in addition to WFD requirements, provides an overview of relevant projects and their results supporting ICPDR activities and providing the up-to-date scientific support and the ground for ICPDR activities (e.g. Joint Danube Surveys). Additionally, links to activities of related strategies (EUSDR) and initiatives (DSTF) cooperating with the ICPDR and supporting the work of the ICPDR as well as of WFD implementation are given.

A number of illustrative thematic maps accompany the Chapters of the DRBMP Update 2021; more detailed information is part of the Annexes.

Sturgeons – Flagship species and an example for the DPSIR approach

As “charismatic” flagship species, sturgeons serve as symbols for the sustainable management of the Danube River Basin. Located in the “upper floor” of the aquatic food chain and ecosystem, and as long-distance migratory species, their well-being relies on many aspects of river basin management. The basic concept of the DPSIR approach which forms the basis for the DRBMP is illustrated below, using the sturgeon as an example.

Key **DRIVERS** relevant for sturgeons comprise in principle economic and human activities like industrial development, transport, energy generation, agriculture or urban and rural settlements, leading to **PRESSURES** on sturgeon populations. These include for instance water pollution from untreated or not sufficiently treated wastewater, or the emissions of nutrients and pesticides from agriculture. Channelization and other physical modifications of the river system has led to a loss of habitats and interruption of migration routes from the Black Sea to spawning grounds in upstream regions.

Illegal fishing is another example for these pressures, which in sum change the **STATE** of the environment and **IMPACT** sturgeon populations. Until well into the 20th century, six sturgeon species lived in large parts of the Danube River Basin. Today, four out of the six species are critically endangered, one is considered vulnerable, and one is extinct. Observations have shown that the populations of all sturgeon species have declined in the past. However, populations still remain in many of the Danube basin countries, often with potential for recovery. This is particularly the case for the lower basin, but with regard to specific species also for the middle and upper part. Therefore, sturgeons are an issue of basin-wide concern.

As a **RESPONSE**, the complex nature of sturgeon conservation calls for manifold actions under the umbrella of basin-wide coordination. The DRBMP with its Joint Programme of Measures provides important contributions: Pollution reduction, the restoration of habitats, promoting the sustainability of future infrastructure like hydropower, inland navigation and flood protection, and the development of fish migration aids are elements of this program. For sturgeons, the Danube river itself was in the past the most important migration corridor within the basin. Opening this corridor by making dams passable is a fundamental issue.

These considerable efforts towards reaching and securing a healthy river system for current and future generations require an understanding of the issue and broad support. Therefore, sturgeons have become an important symbol for public information and awareness raising in the complex field of river basin management in the DRB.

Updates compared to the DRBMP 2009 and Update 2015 (WFD Annex VII B.1.)

The DRBMP Update 2021 builds on the structure and assessments, which were performed for the DRBMP 2009 and the DRBMP Update 2015. Relevant information has been updated, including e.g. the pressures assessment, designation of water bodies, monitoring networks and status assessment, as well as the results from the Joint Danube Survey 4 (JDS4). A fifth SWMI on the “Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)” and a new sub-item “alteration of the sediment balance” under the existing SWMI “Hydromorphological alterations” was added through the SWMI report

2019. Furthermore, the environmental objectives and exemptions have been updated and the management objectives and JPM have been revised, now addressing the period 2021 until 2027. Finally, the inventory of protected areas and the economic analysis have also been updated with latest data and information.

The DRBMP Update 2021 puts a strong emphasis on the topic of integration with other sectorial policies, taking into account that important steps were taken during recent years and that further steps are still to come. The integration with flood risk management, nature protection, inland navigation, sustainable hydropower and agriculture receives particular attention, as well as the inter-linkage with the marine environment.

Furthermore, the EU Strategy for the Danube Region (EUSDR) remains an important partner for the ICPDR, in particular in view of the relevance of the DRBMP for the implementation of EUSDR Priority Area 4 on Water Quality and Priority Area 6 on Biodiversity. As the DRBMP is of key importance for the implementation of the aims of the EUSDR, the ICPDR will continue the close cooperation with the EU Strategy for the Danube Region (EUSDR), enhance dialogue with ICPDR observers and other relevant stakeholders in the Danube Basin and seek to deepen the cooperation with the European Commission, EUSDR and all relevant stakeholders for the implementation of the DRBMP and initiatives of the ICPDR.

2 SIGNIFICANT PRESSURES

Human activities such as agriculture, transport, energy production or urban development exert pressures on the water environment. These pressures need to be assessed as part of sustainable river basin management and as a basis for taking decisions on appropriate measures to address and reduce these pressures. The WFD requires information on the type and magnitude of anthropogenic pressures to be collected and regularly updated. When addressing pressures on the DRB at the basin-wide scale, it is clear that cumulative effects may occur. Effects can occur both downstream (e.g. pollutant concentrations) and/upstream (e.g. river continuity) of a particular pressure. Addressing these issues effectively requires a basin-wide perspective and cooperation between countries.

This chapter addresses each of the significant pressures on surface waters, addresses groundwater issues and includes revised information since the DRBMP 2009 and the DRBMP Update 2015. Some activities with only local effects are not discussed in this plan as they are dealt within national RBMPs. Generally, the country specific emissions regarding organic, nutrient and hazardous substance pollution in this chapter should be seen in relation to the respective countries share in the DRBD.

2.1 Surface Waters: Rivers

2.1.1 Organic Pollution

Key findings and progress

At the river basin scale, the **urban wastewater** sector generates about **190,000 tons per year of BOD** and **440,000 tons per year of COD** discharges into the surface water bodies of the DRB (reference year: 2018). The direct **industrial** emissions of organic substances total up to ca. **65,000 tons per year of COD** for the reference year (2018). This means an overall COD emission of approximately 500,000 tons per year, of which ca. 87% are released by the urban wastewater sector. More than 50% of the BOD emissions into surface waters via urban wastewater stem from agglomerations with **existing sewer systems** but **without treatment**. Taking into account that these agglomerations represent only 6% of the total PE of the basin, implementation of measures for a relatively small proportion of the agglomerations can result in substantial progress. However, 36% of the agglomerations (representing 13% of the total PE) have no adequate collection systems. These should be constructed together with appropriate treatment in the future. Twenty-three percent of the total PE of the basin (20 million) need further **infrastructural development,** which should ensure access to sewer systems or appropriate local facilities to all and should achieve biological treatment for 9 million PE and tertiary treatment for 11 million PE.

Comparing the actual figures of the wastewater sector to those of the DRBMP 2009 and Update 2015, **a noticeable reduction** in organic pollution has occurred according to the reported data. The recently reported emissions are significantly lower than those of the DRBMP 2009 (2005/2006) and the DRBMP Update 2015 (2011/2012) thanks to the infrastructural development in the new and non-EU MS. The BOD discharges declined by 61% and 27%, the COD discharge reduction rates are 57% and 20%. The reduction rates correspond to those estimated in the DRBMP Update 2015 (BOD: 36%, COD: 25%).

The reported industrial emissions decreased by 51% and increased by 9% in comparison to the reference year of the DRBMP 2009 and Update 2015 (2006 and 2012). This is likely to be a consequence of the enhanced technologies installed at the operating industrial plants, the closure of some polluting facilities and the better knowledge and reporting resulting in more reliable emission figures.

Organic pollution refers to emissions of non-toxic organic substances that can be biologically decomposed by bacteria to a high extent. The key emitters of organic pollution are point sources. Collected but untreated municipal wastewaters from households and industrial plants are the most important contributors representing direct untreated wastewater discharges. Significant organic pollution can also be generated by the urban wastewater treatment plants (UWWTPs) that do not have appropriate treatment. Direct industrial dischargers and animal feeding and breeding lots can also constitute important point sources if their wastewater is insufficiently treated.

Diffuse organic pollution is less relevant in comparison to that of point sources. It is usually related to polluted surface run-off from agricultural fields (manure application and storage) and urban areas (e.g. litter scattering, gardens, animal wastes). A specific case of diffuse organic pollution is the emission from combined sewer overflows that represent a mixture of polluted run-off and untreated wastewater.

The primary impact of organic pollution on the aquatic environment is the influence on the dissolved oxygen balance of the water bodies. Significant oxygen depletion can be experienced downstream of pollution sources mainly due to biochemical decomposition of organic matter. Microorganisms use the oxygen available in the water bodies to break organic compounds down to simple molecules. However, dissolved oxygen concentrations increase again once the oxygen enrichment rate via diffusion from the atmosphere and photosynthesis ensured by algae and macrophytes exceeds the rate of consumption.

Due to the self-purification capacity of water bodies the water quality impacts of individual point sources are mostly local. The decrease in oxygen concentration and the length of the affected downstream river section depend on the amount of the organic matter received, the treatment degree of the wastewater, the dilution rate and the hydraulic conditions of the recipient. The affected river length usually ranges from several tens to hundreds of kilometres downstream of the source. Decreased oxygen content may seriously affect aquatic organisms especially sensitive species that can be damaged or killed even at low fluctuations in oxygen concentration. The pollution with organic substances can therefore cause changes in the natural composition of the aquatic ecosystems.

In the most severe cases of oxygen depletion anaerobic conditions might occur, which only some specific organism can tolerate. Additional impacts of anaerobic conditions could be the formation of methane and hydrogen sulphide gases and dissolution of some toxic compounds. Organic pollution can be associated with the health hazard due to possible microbiological contamination.

Usually, secondary (biological) wastewater treatment and runoff management practices provide adequate solutions to the organic pollution problem.

2.1.1.1 Organic Pollution from Urban Wastewater

According to the recent reporting[14] of the Danube countries on the status of wastewater treatment, there are about 5,600 agglomerations[15] with a generated load, expressed in population equivalent[16] (PE), more than 2,000 in the DRB (Table 3). Vast majority of the total population of the DRB live in these agglomerations and the most important industrial enterprises are also situated here. Almost 80% of these agglomerations are small settlements with a PE between 2,000 and 10,000, whilst only 2% have a PE higher than 100,000 (large cities). In total, a wastewater load of about 85 million PE is generated in the basin. Despite the high number of small agglomerations, they have the smallest contribution (21%) to the total loads, whilst medium-sized agglomerations produce about one-third of the loads. Almost half (42%) of the generated total wastewater load stems from large agglomerations indicating the necessity to use appropriate treatment technologies in these cities.

Table 3: Distribution of agglomerations and population equivalents in the DRB according to size classes (reference year: 2018)

Size classes (PE)	Agglomerations		Population Equivalents (PE)	
	number	%	number	%
2,000 – 10,000	4,381	78	17.62 Mio	21
10,000 – 100,000	1,142	20	31.23 Mio	37
≥ 100,000	113	2	36.32 Mio	42
Total	**5,636**		**85.17 Mio**	

The dominant level of wastewater collection and treatment in the agglomerations of the DRB shows a diverse picture (Table 4 and Map 5). The proportion of agglomerations where appropriate collection systems are completely missing or underdeveloped is still relatively high (36%). These are mainly small settlements between 2,000 and 10,000 PE. Four percent of the agglomerations have constructed public sewer systems but are not connected to UWWTPs. For an additional 4% of the agglomerations (in EU MS) wastewater collection is addressed by individual and other appropriate systems (IAS) where wastewater is collected in appropriate storage tanks and then transported to treatment plants or treated locally by standardized facilities[17]. In non-EU MS, local wastewater collection and treatment systems (LS) are in place in many agglomerations with local facilities having a wide range of technical quality and treatment performance (6% of the agglomerations). On the basin-wide level, at 50% of the agglomerations with more than 2,000 PE sewer systems with connection to operating UWWTPs is the dominant collection and treatment level. The majority (82%) of the medium-sized and large settlements discharges municipal wastewater into the recipient water bodies after (at least some form of) centralized treatment is applied. However, wastewater is only conveyed to treatment plants for 40% of small agglomerations in the DRB.

Regarding the treatment stages 1% of agglomerations are only served by primary (mechanical) treatment. The proportion of the secondary (biological) treatment is 9%. Wastewater at 40% of the settlements undergoes tertiary treatment that removes both, organic matter and nutrients. For small agglomerations, the share of the secondary and tertiary treatment is 9% and 31%, respectively. For agglomerations above 10,000 PE, where nutrient removal is either obligatory (EU MS) or recommended (non-EU MS) these respective figures are 8% and 73%. Twenty-two percent of the agglomerations have combined collection and treatment systems where

14 *For the EU MS this is in line with the obligatory data submission for the reference year 2018 to the European Commission under the Urban Wastewater Treatment Directive (UWWTD).*

15 *An area where the population and/or economic activities are sufficiently concentrated for urban wastewater to be collected and conducted to an urban wastewater treatment plant or to a final discharge point.*

16 *The ratio of the total daily amount of BOD produced in an agglomeration to the amount generated by one person per day (60 g per person per day).*

17 *https://circabc.europa.eu/sd/a/324828da-d6ea-4973-8b0b-af8434bd6522/2015_03_26_point_9_IAS.pdf (accessed 12 February 2021).*

the proportion of the dominant technological level of the total PE is less than 80%. In these agglomerations there is another significant treatment system besides the dominant one or more than two different systems are used simultaneously.

Table 4: Number of agglomerations and generated urban wastewater load in the Danube River Basin (reference year: 2018)

Collection and treatment system[1]	Generated load (PE)		Number of agglomerations	
	>80%[2]	<80%[3]	>80%	<80%
Tertiary treatment	50,733,867	7,219,693	1,878	376
Secondary treatment	5,423,859	2,854,184	314	188
Primary treatment	780,913	294,982	26	27
Collected but not treated	3,562,247	2,381,453	85	143
Addressed through IAS[4]	470,518	690,401	128	124
Addressed through LS[5]	1,142,239	649,592	260	61
Not collected	6,485,950	2,475,566	1,718	308
Total	**85,165,464**		**5,636**	

[1] Categorisation is based on the dominant collection and treatment system of the agglomeration (highest proportion).

[2] The proportion of the dominant collection and treatment system is higher than 80%.

[3] The proportion of the dominant collection and treatment system is less than 80%.

[4] IAS: Individual and other Appropriate Systems as defined by the UWWTD (standardized septic tanks with drain fields, small domestic wastewater treatment units, watertight tanks).

[5] LS: Local systems used for wastewater collection and local treatment (cesspools, septic tanks, small domestic wastewater treatment units, watertight tanks).

The distribution of the agglomerations according to their size and degree of connection to collecting systems and treatment plants clearly influences the distribution of the generated loads (Table 5 and Figure 6). Only 13% of the generated loads arise from households without connection to sewer systems or adequate individual local treatment facility (i.e. standardized[18] watertight storage tanks, septic tanks with infiltration fields, small domestic treatment plants, small treatment units). An additional 6% can be linked to collection systems without treatment, whilst 7% of the total loads are dealt with individual and local systems (IAS: 4%, LS: 3%). The majority (74%) of the total generated loads is conveyed via sewers to UWWTPs. Only one percent of the loads are subject to primary treatment, whilst quite a large proportion is transported to either secondary (9%) or tertiary (64%) phases. Seventy-seven percent of the overall PE of the basin are effectively treated with at least secondary treatment or addressed by IAS, whilst 23% (20 million PE) still need basic infrastructural development in order to provide appropriate wastewater collection and treatment services. In the small agglomerations, secondary treatment is required for about 9 million PE. At agglomerations above 10,000 PE, tertiary treatment is needed for ca. 11 million PE.

In total, almost 4,000 centralized collection and treatment facilities are in place, more than half of it is a treatment plant with nutrient removal technology and about 20% are equipped with biological treatment. However, another 20% is lacking an adequate treatment plant and having almost no or very limited pollutant removal capacity.

18 National standards in compliance with the European Standard EN 12566: Small wastewater treatment systems for up to 50 PT, European Committee for Standardization (CEN).

Table 5: Generated urban wastewater load and number of centralized collection and treatment systems in the Danube River Basin (reference year: 2018)

Type of collection and treatment system			Generated load (PE)	Number of centralized collection and treatment systems
Collected by sewer	Collected by sewer and treated in UWWTP	Tertiary treatment	54,345,005	2,220
		Secondary treatment	7,264,840	888
		Primary treatment	1,155,336	100
	Collected but not treated		5,492,920	751
Not collected by sewer	Individually collected and treated	IAS	3,487,062	-
		Local systems	2,750,534	-
	Not collected		10,669,765	-
Total			**85,165,464**	**3,959**

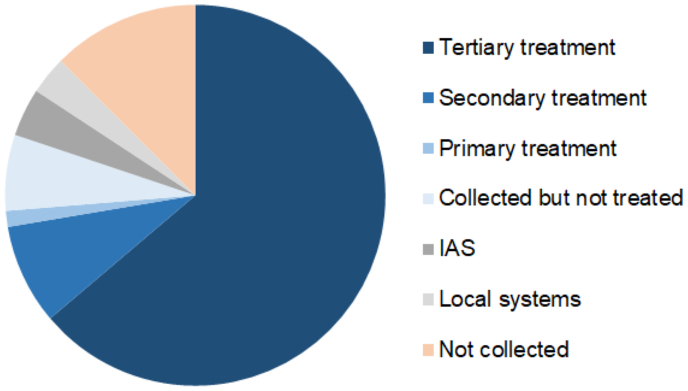


Figure 6: Share of the collection and treatment stages in the total population equivalents (PE) in the Danube River Basin (reference year: 2018)

Country contributions to the total load generated in the DRB and proportions of treatment and collection stages are presented in Figure 7 and Figure 8 (see also Annex 3 on urban wastewater emission inventory). Wastewater collection and treatment systems are generally very enhanced in the upstream countries, good in some countries in the middle-basin, whilst significant proportions of the generated loads are not collected or collected but not treated in the downstream states.

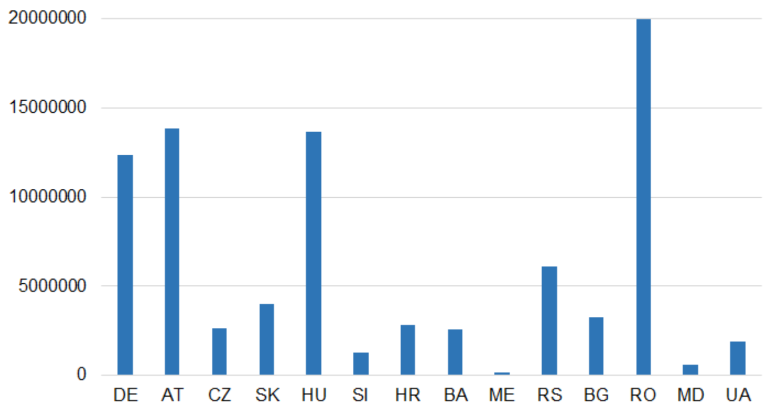


Figure 7: Generated wastewater load of the Danube countries (expressed in population equivalents, reference year: 2018)

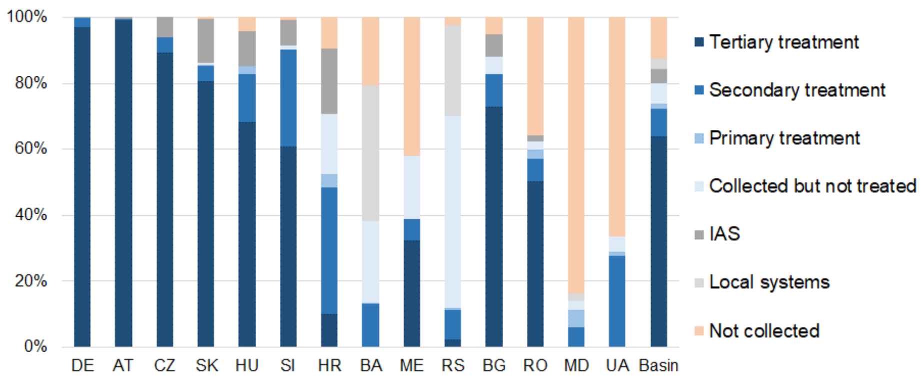


Figure 8: Share of the collection and treatment stages in the total population equivalents in the Danube countries (reference year: 2018)

Regarding the discharges of the organic substances into the river systems, about 190,000 tons per year of biochemical oxygen demand (BOD) and 440,000 tons per year of chemical oxygen demand (COD) are released from the agglomerations with more than 2,000 PE throughout the basin (Table 6). The ratio of COD to BOD of about 2.2 indicates that a considerable fraction of biodegradable organic matter is still being released. Significant proportions of the total discharges (BOD: 57%, COD: 45%) originate from collected but untreated wastewater volumes (Table 6 and Figure 9). Despite the fact that the share of wastewater volumes only subject to primary treatment is relatively low, the equivalent share in the discharges are relatively high (BOD: 4%, COD: 4%) due to the limited treatment efficiency. The secondary treatment plants produce 14% of the BOD and 13% of the COD discharges. Plants with tertiary treatment emit 25% (BOD) and 38% (COD) of the total releases due to their very high elimination rates (over 90%).

Table 6: BOD and COD discharges via urban wastewater in the Danube River Basin (reference year: 2018)

Type of treatment	Discharge	
	BOD (tons per year)	COD (tons per year)
Tertiary treatment	46,000	168,253
Secondary treatment	26,024	57,136
Primary treatment	8,050	18,859
Collected but not treated	106,166	199,319
Total	**186,241**	**443,567**

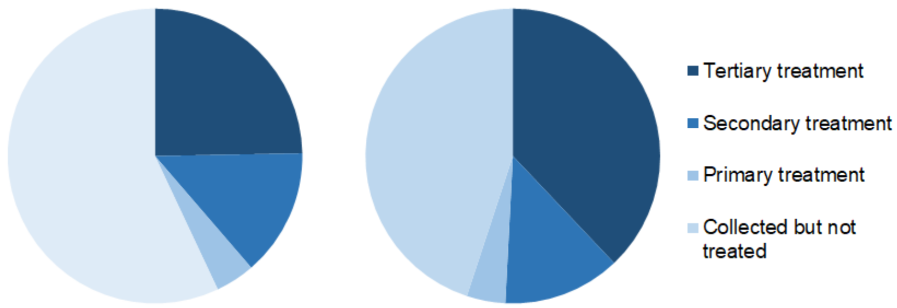


Figure 9: Share of the collection and treatment stages in the total organic pollution of surface waters via urban wastewater in the Danube River Basin (reference year: 2018); left: BOD discharge, right: COD discharge

BOD discharges per county are shown in Figure 10 and Figure 11 according to different collecting and treatment systems (see also Annex 3 on urban wastewater emission inventory). As a consequence of the less developed wastewater infrastructure in the middle and downstream countries, the BOD discharges of the new EU MS and the non-EU MS are substantially influenced by untreated wastewater releases. Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Romania and Bulgaria still have great potential to reduce organic pollution of their national surface water bodies by introducing at least biological treatment technology. In particular, Serbia, Bosnia and Herzegovina and Croatia can significantly cut organic pollution via wastewater since their PE-specific emissions are still high. Serbia and Romania have the highest absolute discharges indicating that further improvement in the wastewater sector in these countries would substantially reduce the basin-wide emissions. It has to be pointed out that the reference year of the assessment (2018) differs from the end of the recent management cycle (2021), therefore further improvements can be expected by 2021.

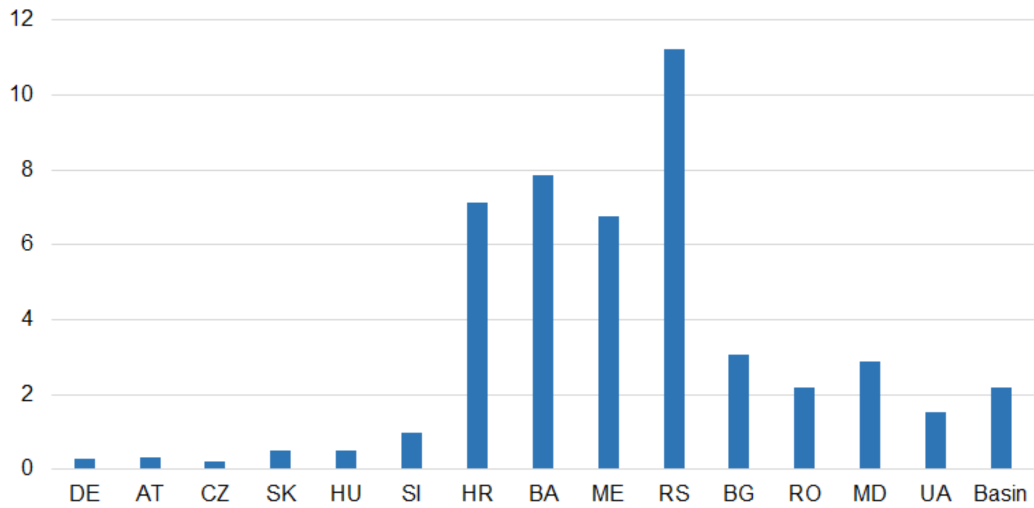


Figure 10: Specific organic substance emissions of the surface waters via urban wastewater in the Danube countries (expressed in kg BOD per PE and year, reference year: 2018)

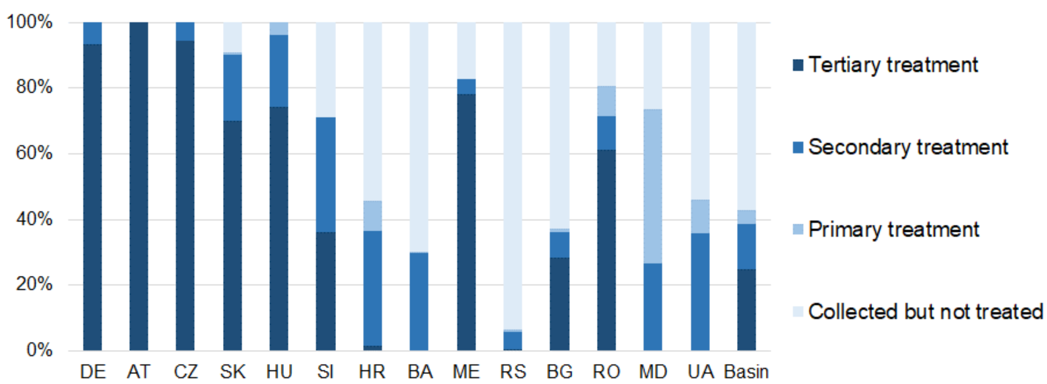


Figure 11: Share of the collection and treatment stages in the total organic pollution (BOD) of the surface waters via urban wastewater in the Danube countries (reference year: 2018)

2.1.1.2 Organic Pollution from Industry and Agricultural Point Sources

Data for industrial and agricultural direct dischargers were sourced from the European Pollutant Release and Transfer Register (E-PRTR)[19] database, which contains the main industrial facilities and their discharges above certain capacity and emission levels. In total, 51 installations from 8 main industrial sectors were reported by the countries which have significant direct organic substance discharges[20] (above a threshold of 50 tons of TOC per year, see Annex 4 on industrial emission inventory). Of these, paper and wood processing (39%), waste and industrial wastewater management sector (24%, mainly waste recycling and disposal sites and specific industrial wastewater treatment plants, excluding UWWTPs) and chemical industry (23%) are the most important fields in terms of organic pollution (Table 7 Figure 12, last column). In the reference year (2018) some 65,000 tons per year organic substances (expressed in COD) were released (Table 7). This release is only 15% of the discharges of the urban wastewater sector.

The relevant activities, their total releases and proportions differ from country to country. Austria, Romania, Germany and Hungary contribute the highest COD discharges via industrial activities (Figure 12 and Figure 13 as well as Annex 4 on industrial emission inventory). Czech Republic, Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Republic of Moldova and Ukraine have no facilities reported over the given release threshold.

Table 7: Organic pollution via direct industrial discharges in the Danube River Basin according to different industrial sectors (reference year: 2018)

Activities	Number of facilities	Release to water (tons COD per year)
Energy sector	8	5,141
Production and processing of metals	2	1,547
Mineral industry	1	210
Chemical industry	10	15,007
Waste and industrial wastewater management[1]	8	15,253
Paper and wood production processing	16	25,019
Intensive livestock production and aquaculture	2	2
Products from the food and beverage sector	4	2,045
Total	**51**	**64,224**

[1] excluding UWWTPs.

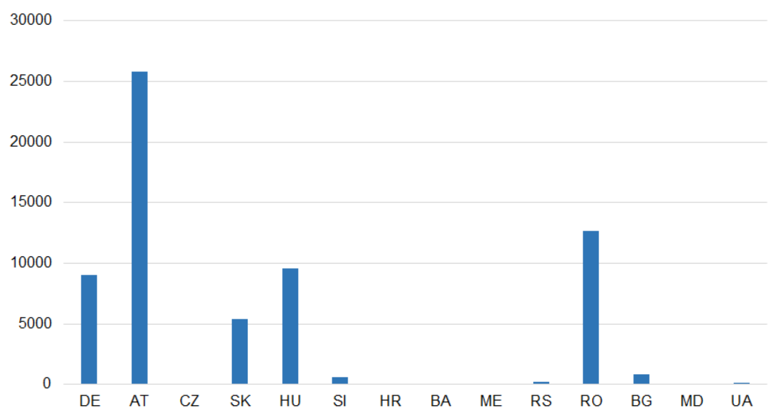


Figure 12: Organic pollution of the surface waters via direct industrial discharges in the Danube countries (expressed in tons COD per year, reference year: 2018)

19 https://www.eea.europa.eu/data-and-maps/data/industrial-reporting-under-the-industrial-3 (accessed 07 September 2021).

20 In E-PRTR organic pollution is reported as Total Organic Carbon (TOC), TOC ~ 0.33·COD.

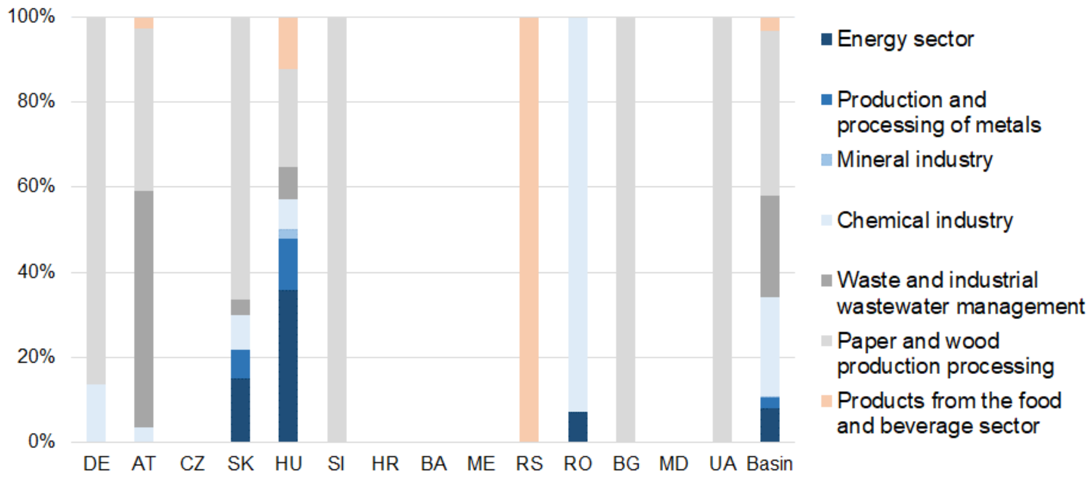


Figure 13: Share of the industrial sectors in the total organic pollution via direct industrial discharges in the Danube countries (reference year: 2018)

2.1.2 Nutrient Pollution

Key findings and progress

The estimated recent, basin-wide nutrient emissions for the reference period (2015-2018) are **500,000 tons per year TN** and **31,000 tons per year TP**. Diffuse pathways clearly dominate the overall emissions with a contribution of 87% (N) and 78% (P). For N, subsurface flow (base flow and interflow) is the most important diffuse pathway with a proportion of 57%. For P, soil erosion (28%) generates the highest emissions. Regarding the sources, agriculture (N: 44%, P: 37%) and urban water management (N: 30%, P: 43%) are responsible for the majority of nutrient emissions indicating the necessity of appropriate measures to be implemented in these sectors.

The current long-term average (2004-2018) observed river loads estimated from measured river discharge and nutrient concentration data at the river mouth (TNMN station Reni) are 440,000 tons TN per year and 24,000 tons TP per year. Annual (90 percentiles) concentration values in this period show a slightly decreasing or stagnant tendency. Historical trend analysis of nutrient river loads over the past decades shows a significant reduction in the transported nutrient fluxes to the Black Sea. However, the current long-term fluxes are still considerably higher than those of the early 1960ies which represent river loads under low pressures (TN: ca. 300,000 tons per year, TP: ca. 20,000 tons per year). This indicates a **further load reduction potential** that might be exploited for the benefit of the Black Sea (ca. N: 30%, P: 15%). This would require further reductions of both, point source and diffuse emissions generated in the DRB, with particular focus on the pollution hot-spots. Nevertheless, in the last 5-10 years the measured loads are rather low and close to the Black Sea targets indicating significant water quality improvement.

At the basin-wide level, **70,000 tons TN per year** and **9,500 tons TP per year** are emitted from urban wastewater collection and treatment systems into surface waters. Almost 75% of the generated load of agglomerations above 10,000 PE are treated appropriately.

However, wastewater services for 16.5 million PE needs to be further improved by introducing **nutrient removal technology** or equivalent individual solution where applicable, representing great potential to reduce nutrient emissions. Much like organic pollution, total point source emissions are significantly influenced by untreated wastewater discharges, which are responsible for 23% (N) and 33% (P) of the total point source emissions.

As with organic pollution, a significant **decrease** is apparent regarding the **nutrient point source emissions** in the DRB. The recently reported emissions from UWWTPs are significantly lower in comparison to those of the DRBMP 2009 and DRBMP Update 2015, the nutrient discharges decreased by 44% and 18% (N) and 56% and 22% (P), respectively. This is in line with the estimated future achievements of the DRBMP Update 2015 (N: 10%, P:17%). Besides this, the reported industrial direct emissions decreased by about 50% for N but increased by 50% for P in comparison to 2012. The latter is a consequence of the two times higher number of reported facilities releasing P in 2018.

Diffuse emissions also dropped due to both, the low agricultural intensity in many countries and the measures implemented. The total N emissions **decreased** by 17% in comparison to the DRBMP Update 2015 (a reduction of about 4% was foreseen), whilst P emissions dropped by 19% (a decrease of 8% was simulated).

Nutrient pollution is caused by significant releases of nitrogen (N) and phosphorus (P) into the aquatic environment. Nutrient emissions can originate from both point and diffuse sources. Point sources of nutrient discharges are highly interlinked to those of the organic pollution. UWWTPs with inappropriate technology, untreated wastewater, industrial enterprises and animal husbandry can discharge considerable amounts of nutrients into the surface waters. Diffuse pathways, however, may have higher importance regarding nutrients. Direct atmospheric deposition, overland flow, sediment transport, tile drainage flow and groundwater flow can contribute significantly to the emissions into rivers, conveying nutrients from agriculture, urban areas, atmosphere and even from naturally covered areas.

The importance of the pathways for diffuse pollution is not the same for N and P. For N, subsurface flow and urban run-off are the most relevant diffuse pathways. For P, sediment transport generated by soil erosion is the most relevant. Regarding the sources, agriculture can play a key role in nutrient pollution. Surface waters can receive significant nutrient emissions from agricultural fields due to high current nutrient surpluses of the cultivated soils, legacy nutrient surplus accumulated in the topsoil and unsaturated soil zone and/or inappropriate agricultural practices. Households without collection system, paved urban areas and combined sewer overflows are important urban diffuse sources. Deposition from the atmosphere is especially relevant for N as many combustion processes and agricultural activities produce N gases and aerosols that can be subject to deposition. The role of natural areas is often overlooked even though they can have significant regional contribution, especially in sparsely vegetated areas, mountainous catchments or glaciers. Moreover, riverbed sediments can also act as secondary source of nutrients and cause long-lasting pollution of surface waters.

Impacts on water status caused by nutrient pollution can be recognized through substantial changes in water ecosystems. The natural aquatic ecosystem is sensitive to the amount of the available nutrients which are limiting factors. In case of nutrient enrichment, the growth of algae and aquatic macrophytes can be accelerated and water bodies can be overpopulated by specific species. Many lakes and seas have been suffering from eutrophication that severely impairs water quality and ecosystem functioning (substantial algae growth and consequently oxygen depletion, toxicity, pH variations, accumulation of organic and toxic substances, change in species composition and in number of individuals). Eutrophication might limit or even hinder human water uses as well (drinking water supply, recreation, tourism, fisheries). Even though river systems, floodplains, wetlands and reservoirs can retain nutrients during their in-stream transport (e.g. denitrification, uptake, settling), significant amounts of them can reach lakes and even seas, transposing water quality impacts far downstream from the sources. Therefore, nutrient pollution is clearly a DRB-wide issue.

Minimising point source nutrient emissions requires nutrient removal at the UWWTPs. Management of diffuse nutrient emissions is more challenging task due to their temporal and spatial variability and strong relation to hydrology. Since diffuse emissions cannot be measured at source, catchment-scale assessments and water quality modelling are widely used to help in dealing with the issue. Management actions usually concern a wide range of agricultural best management practices and their combinations. The recovery of a eutrophic water body once measure are in place can take a longer time (even several decades) due to the time delay of the contributing pathways (e.g. N loads via groundwater) and the nutrients stored in the sediments that can re-enter water bodies (e.g. P internal loads of lakes).

2.1.2.1 Nutrient Pollution from Urban Wastewater

In total, about 2,250 agglomerations with a generated load of about 58 million PE have UWWTPs equipped (at least partially) with tertiary treatment aiming at nutrient removal in the basin (Map 5). A majority of them (87%) addresses the elimination of both nutrients. Out of the 1,255 agglomerations with a size over 10,000 PE, 912 agglomerations (73%) have tertiary technology already in place as dominant treatment. The overall load generation for agglomerations above 10,000 PE is about 67.5 million PE. 72% of this load (49 million PE) is effectively subject to tertiary treatment, whilst about 2 million PE are collected and/or treated in appropriate individual systems (IAS). These figures indicate that wastewater treatment for 16.5 million PE at agglomerations above 10,000 PE needs further improvement, out of which about 5.5 million concern treatment upgrades (secondary treatment to be enhanced to tertiary), whereas the rest (11 million PE) requires collection system, treatment plant construction or major extension (primary to tertiary).

At the basin-wide scale about 70,000 tons TN per year and 9,500 tons TP per year are emitted into the surface waters from the wastewater collection and treatment facilities (Table 8). 23% (N) and 33% (P) of the emissions can be linked to untreated wastewater discharged directly into the recipient water bodies (Figure 14). About 4% of the nutrient releases originate from plants with mechanical treatment, whilst the proportion of the UWWTPs with secondary treatment is 15% (N) and 26% (P). Some 58% and 37% of the nutrient emissions are discharged from plants with more advanced technologies. Regarding the medium-sized and large agglomerations (above 10,000 PE), 38% (N) and 58% (P) of the nutrient emissions are related to technologies less stringent than tertiary, indicating that further improvement of the treatment at these settlements would significantly reduce the nutrient discharges at the basin scale.

Table 8: Nutrient emissions of surface waters via urban wastewater in the Danube River Basin (reference year: 2018)

Type of treatment	Discharge	
	TN (tons per year)	TP (tons per year)
Tertiary treatment	42,318	3,594
Secondary treatment	10,876	2,516
Primary treatment	2,571	342
Collected but not treated	16,763	3,276
Total	**72,528**	**9,728**

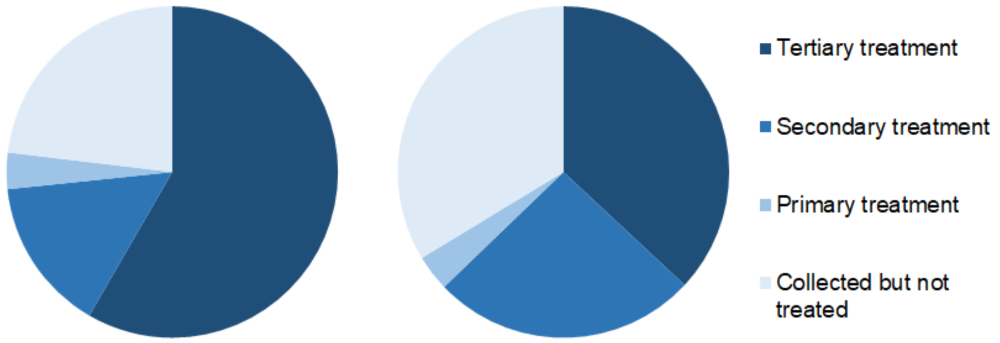


Figure 14: Share of the collection and treatment stages in the total nutrient pollution of surface waters via urban wastewater in the Danube River Basin (reference year: 2018); left: TN discharge, right: TP discharge

Country performances are presented in Figure 15 and Figure 16 (see also Annex 3 on urban wastewater emission inventory). The variation at the country level is similar to the situation of the organic pollution. Upstream countries have only limited possibilities, as they have already introduced nutrient removal at the vast majority of the agglomerations, even for smaller settlements. Middle and downstream countries, however, could significantly improve the overall treatment efficiency of the treatment plants, particularly for agglomerations over 10,000 PE, where progress is slow regarding the introduction of the tertiary treatment technologies.

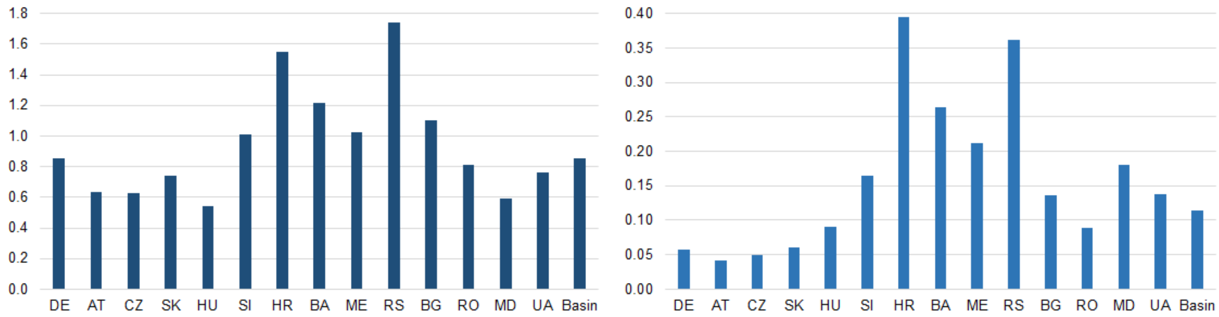


Figure 15: Specific nutrient emissions via urban wastewater in the Danube countries (reference year: 2018); on the left: TN, on the right: TP (expressed in kg TN/TP per PE and per year)

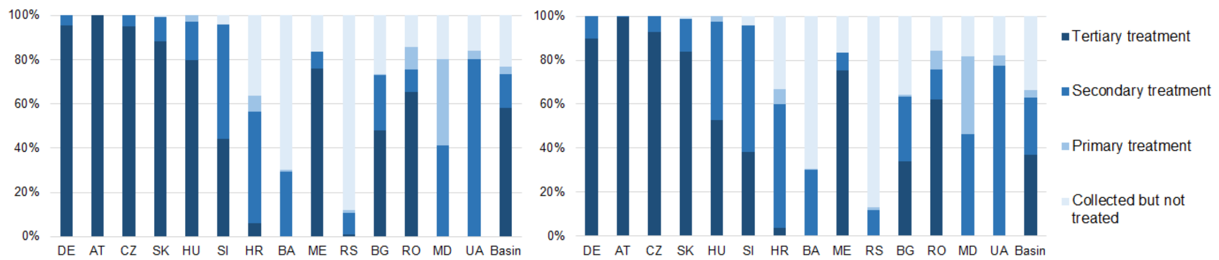


Figure 16: Share of the collection and treatment stages in the total nutrient pollution via urban wastewater in the Danube countries (reference year: 2018); on the left: TN, on the right: TP

2.1.2.2 Nutrient Pollution from Industry and Agricultural Point Sources

Regarding the industrial discharges, the main sectors reported by the countries that contribute to nutrient pollution are the same as those regarding the organic pollution (Annex 4 on industrial emission inventory), although fewer facilities have been reported for nutrient discharges (N: 34, P: 25). In total, 3,400 tons per year of TN and 320 tons per year of TP were released in the reference year 2018 (Table 9 and Table 10). For N, the chemical industry, the energy sector and the metal industry are the most significant contributors with 20-25% share. For P, intensive livestock farming has the highest share with 34%. The paper industry and chemical industry are further significant industrial fields that release P. The reported industrial emissions are relatively small in comparison to those from urban wastewater, only 6% (N) and 3% (P) of wastewater discharges are emitted from industrial facilities. Hungary and Romania (N) and Bulgaria and Serbia (P) have the highest direct industrial emissions (Figure 17). The industrial sector palette in the Danube countries is diverse for both nutrients (Figure 18).

Table 9: Nitrogen pollution of surface waters via direct industrial wastewater discharges in the Danube River Basin (reference year: 2018)

Activities	Number of facilities	Release to water (tons TN per year)
Energy sector	9	881
Production and processing of metals	3	737
Chemical industry	9	742
Waste and industrial wastewater management[1]	3	234
Paper and wood production processing	3	259
Intensive livestock production and aquaculture	3	218
Products from the food and beverage sector	4	290
Total	**34**	**3,360**

[1] excluding UWWTPs.

Table 10: Phosphorus pollution of surface waters via direct industrial wastewater discharges in the Danube River Basin (reference year: 2018)

Activities	Number of facilities	Release to water (tons TP per year)
Energy sector	6	38
Production and processing of metals	1	6
Chemical industry	2	46
Waste and industrial wastewater management[1]	2	36
Paper and wood production processing	6	68
Intensive livestock production and aquaculture	4	113
Products from the food and beverage sector	4	20
Total	**25**	**328**

[1] excluding UWWTPs.

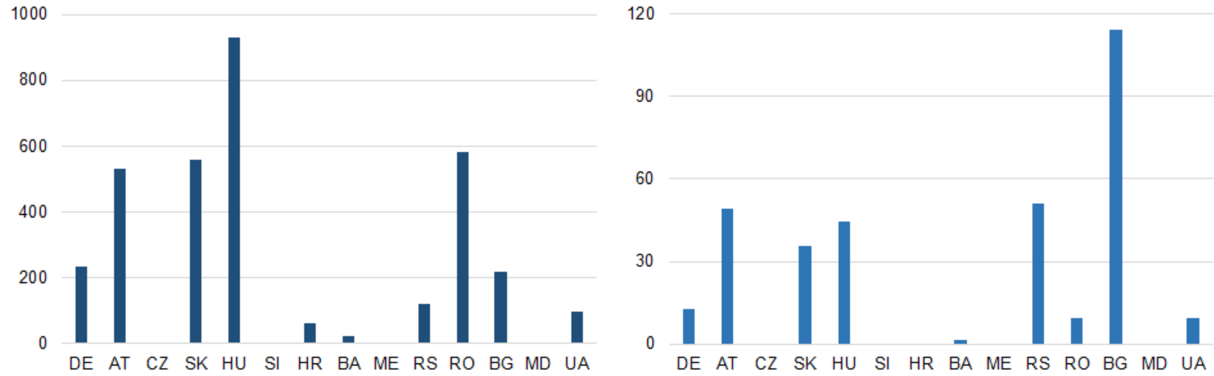


Figure 17: Nutrient pollution of the surface waters via direct industrial discharges in the Danube countries (expressed in tons TN/TP per year, reference year: 2018); on the left: TN, on the right: TP

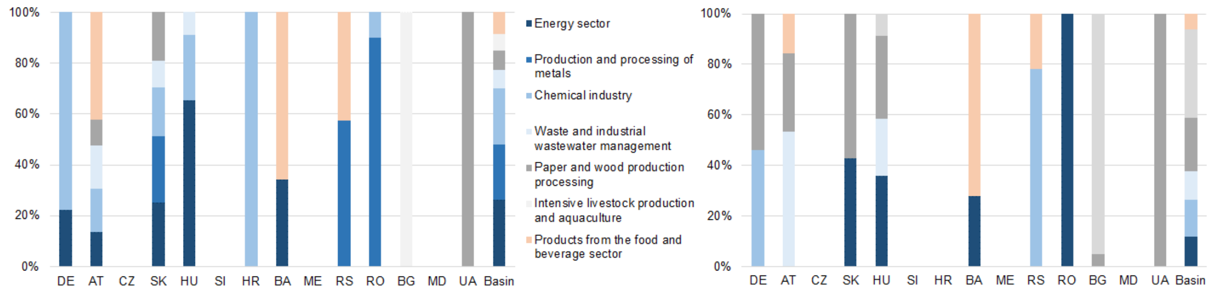


Figure 18: Share of the industrial activities in the total nutrient pollution via direct industrial wastewater discharges in the Danube countries (reference year: 2018); on the left: TN, on the right: TP

2.1.2.3 Point Source and Diffuse Nutrient Pollution

The Danube region is characterized by a wide variety of landscapes and soil-climate regions with essential influence on the situation of agriculture. About 50% of the DRB territory (about 45 million ha) is under agricultural cultivation. Farm structure, the number of farms, their size and their legal organisation are important elements as well. The average farm size varies from a couple of hectares (Slovenia, Romania, Moldova, Montenegro, Serbia), over several ten hectares (Hungary, Croatia, Bosnia and Herzegovina, Bulgaria, Austria, Germany) and up to the order of magnitude of hundred hectares or more (Slovakia, Czech Republic, Ukraine). Farm structure and economic performance in many Danube states are characterized by a large number of (very)small or middle-size farms on one side and a small number of large farms on the other. However, in many countries the relatively small amount of large holdings works on the majority of the agricultural land. In the Western DRB small and middle size family farms are the predominant form of farm organisation. Farms in Baden-Württemberg and Bavaria are relatively small compared to farms in other parts of Germany and comparable in size in Austria where commercial farms play almost no role. In the Czech Republic, Slovakia and the other countries along the Danube River, large farms run by a professional management are operating at a relatively large share of agricultural land. Moving to the East, the micro and (semi-)subsistence farming becomes more important. In all the regions to the East of Austria (except Ukraine), most farms are smaller than 5 hectares with a high number of farm owners. Many of them either do not produce for the market but use the resources of the farm to support the livelihood of the farm family or produce a little surplus output to be sold at the market. At present, the number of farms in the DRB is decreasing by about 2% per year (ca 25% in 10 years) and this trend will likely continue, while the total agricultural areas had a slight increase in the last decade.

Nutrient surplus in agricultural areas is considered to be one of the key agri-environmental indicators that represents excess nutrients available for mobilization from the soil towards ground and surface waters. With regard to the evolution of the area-specific nitrogen surplus (net nitrogen balance per unit agricultural area, taking into account gaseous losses and atmospheric deposition), a slowly decreasing trend can be recognized over the last two and a half decades in the Danube countries, starting in the early 1990s. The current nitrogen surplus over the DRB is relatively low (about 22 kg per hectare and year, estimated based on national surplus data or agricultural statistics reported by the Danube countries) compared to the EU average (27 kg per hectare and year[21]) but it shows high regional differences. In most of the Danube countries the average surplus is around or below the EU mean value except Germany, Austria, the Czech Republic and Croatia, and far from the EU maximum values.

Nutrient emissions to surface waters were assessed by using the MONERIS model. Recently, the input dataset has been updated and extended according to the latest available spatial information. Moreover, the model algorithm has been improved and the mode has been reapplied resulting in updated nutrient emission patterns for the DRB.

MONERIS – a catchment scale water quality model to quantify nutrient emissions and river loads

To estimate the spatial patterns of the nutrient emissions in the basin and to assess the different pathways contributing to the total emissions, the MONERIS model[22] was applied for the entire basin and for current multiannual average hydrological conditions (2015-2018). The model is an empirical, catchment-scale, lumped parameter and long-term average approach which can inform decision making and facilitate the elaboration of larger scale watershed management strategies. It can estimate the regional distribution of the nutrient emissions entering the surface waters within the basin at sub-catchment scale and determine their most important sources and pathways with reasonable accuracy. Moreover, by taking into account the main in-stream retention processes, river loads at the catchment outlets can be calculated which can then be used for model calibration and validation.

The application of the model has a long history in the Danube countries and at the basin scale as well in the field of river basin management and nutrient balancing. The model has been enhanced and adapted to specific ICPDR needs in several regional projects accomplished in the basin. The model is reliable and works with reasonable accuracy at regional scale. This has been proven by comparison of the results to observed river loads at several gauges for a long time period. It can be easily supported by available data, run for the entire basin and updated according to the actual conditions. The model is sensitive for some key management parameters, allowing the user to elaborate realistic future management scenarios of basin-wide relevance and assess their impacts on water quality.

According to current model calculations, the overall N emissions in the DRB are 500,000 tons per year (6.2 kg per hectare and year) for the reference period 2015-2018 (Table 11, left column, see also Annex 5 on the MONERIS model application). The subsurface flow (base flow and interflow) pathway accounts for 57% of all N emissions in the DRB and thus the most important pathway (Figure 19 left). The proportion of N inputs via urban runoff is 12%, whilst surface runoff, tile drainages, erosion and direct atmospheric deposition contribute with 7%, 6%, 3% and 2% respectively.

21 EUROSTAT, https://ec.europa.eu/eurostat (accessed 14 September 2021).

22 Venohr, M., Hirt, U., Hofmann, J., Opitz, D., Gericke, A., Wetzig, A., Natho, S., Neumann, S., Hürdler, J., Matranga, M., Mahnkopf, J., Gadegast, M. und Behrendt, H. (2011): Modelling of Nutrient Emissions in River Systems – MONERIS – Methods and Background. International Review of Hydrobiology, V. 96, Issue 5, pp. 435-483.

Diffuse pollution is the dominant form of N emissions, accounting for 87% of the basin-wide total. Emissions via point sources contribute the remaining 13% of the overall N emissions. Regarding the main sources (Figure 19 right), agricultural areas are the dominant source, accounting for 44%. In addition, both urban areas (wastewater discharges, runoff from paved surfaces and combined sewer overflows) and lands with natural vegetation are significant sources contributing with 30% and 23%, respectively. In all these areas there is significant N input from atmospheric deposition indicating that a part of the N emissions may originate from outside the basin, transported via atmospheric deposition that is difficult to control. Emissions from open areas and wetlands are less significant at the basin-wide scale. The regional distribution of the emissions is shown in Maps 7a-b. Regions with high agricultural surplus and shorter groundwater residence time and/or bedrock layers with lower denitrification capacity produce the highest area-specific emissions. Urban areas with significant point sources and urban runoff also generate significant local fluxes.

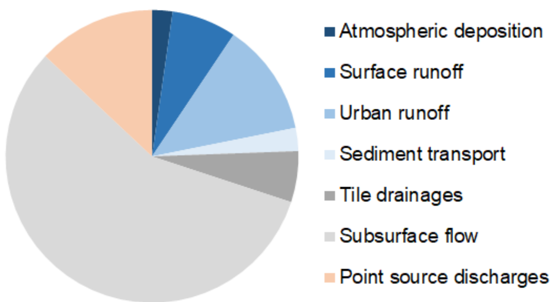
Table 11: Diffuse and point source nutrient emissions of the Danube basin according to different pathways for the reference period (2015-2018)

Pathway	Water emissions TN (tons per year)	Water emissions TP (tons per year)
Direct atmospheric deposition	11,284	292
Surface runoff	35,724	2,229
Urban runoff[1]	62,298	5,890
Sediment transport	12,760	8,555
Tile drainage flow	28,161	327
Subsurface flow[2]	284,669	6,837
Point sources[3]	64,983	6,931
Total	**499,879**	**31,060**

[1] cumulated emissions via urban runoff, combined sewer overflows, population connected to sewer systems without treatment plant and not connected population

[2] cumulated emissions via all subsurface flow components (base flow and interflow)

[3] cumulated emissions of UWWTPs and industrial direct dischargers



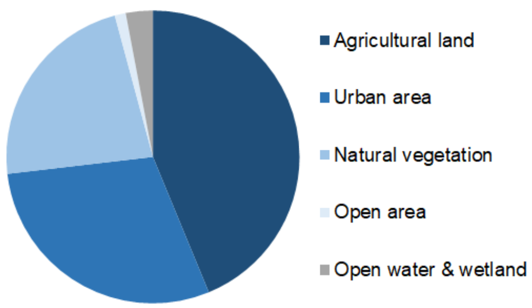


Figure 19: Share of pathways and sources in the overall TN emissions in the Danube Basin for the reference period (2015-2018); on the left: pathways, on the right: sources

Country contributions can be seen in Figure 20 and Figure 21. Germany, Bosnia and Herzegovina and Slovenia produce the highest area-specific N emissions in the basin. Subsurface flow (base flow and interflow) dominates the distribution of the pathways in most of the countries, particularly in the upper and middle basin. Point sources and urban runoff show significant relative contributions in the downstream countries. Regarding the sources, agricultural activities have a principal role in N emission generation. Urban water management is still an important source, especially in the new and non-EU MS. In countries with a significant proportion of natural landscapes (e.g. Austria, Slovenia, Montenegro) the relative emissions originating from these regions are comparatively high. Rural emission sources (sum of emissions from agriculture and natural land) have clear dominance in the overall emissions.

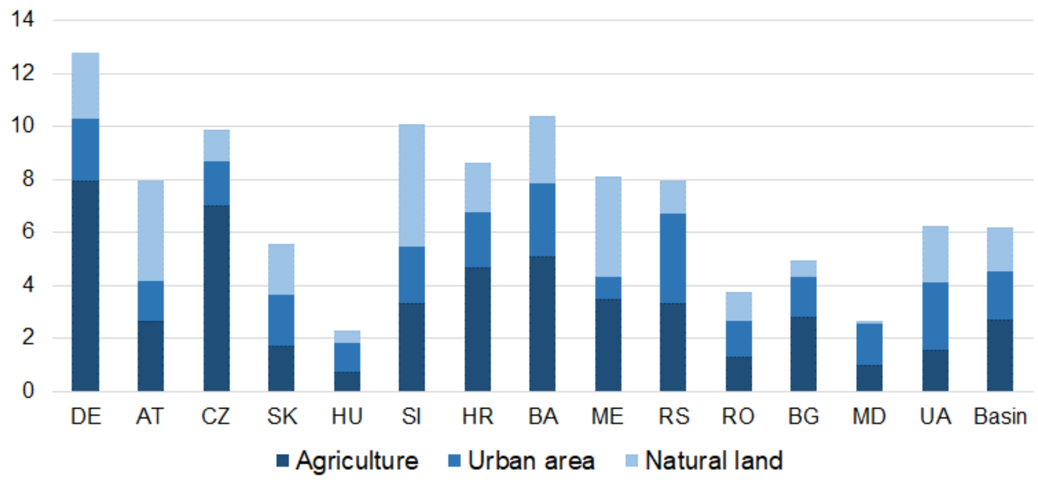


Figure 20: Specific total TN emissions and the contribution of source areas in the Danube countries for the reference period (2015-2018, expressed in kg N per hectare and year)

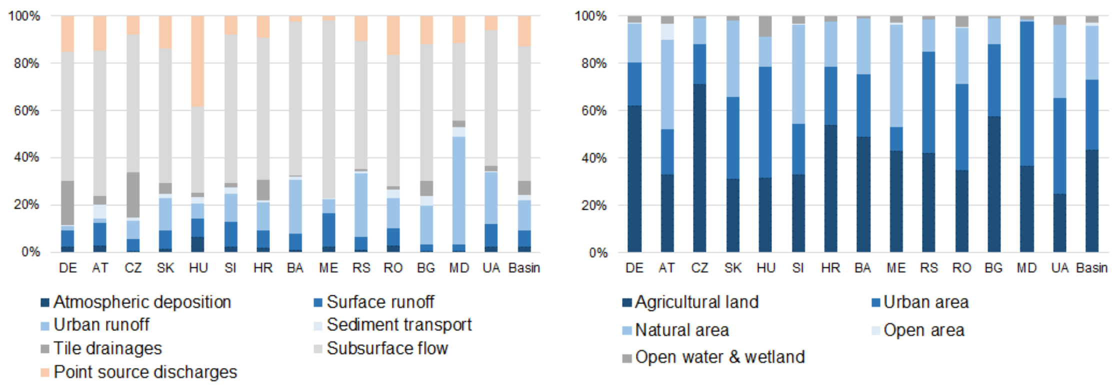


Figure 21: Share of the pathways and sources in the overall TN emissions in the Danube countries for the reference period (2015-2018); on the left: pathways, on the right: sources

Overall P emissions in the DRB are 31,000 tons per year (380 g per hectare per year) in the reference period (Table 11, right column, see also Annex 5). P emissions via the different pathways are presented in Figure 22 (left). The most important diffuse pathway in the DRB is soil erosion and sediment transport which is responsible for 28% of all P emissions. Emissions via subsurface flow contribute 22% to the overall P emissions, urban systems runoff accounts for 19%. Emissions via surface runoff, direct atmospheric deposition and tile drainages contribute 7%, 1% and 1% to the overall P emissions, respectively. All diffuse sources have a total share of 78%, whilst point sources pathway has a contribution of 22%. Source apportionment (Figure 22 right) shows the importance of the urban areas producing 43% of the emissions and agriculture that is responsible for 37% of the total emissions. The rest is equally shared between natural landscapes and open areas.

This confirms the high potential of measures that specifically address urban water management and agriculture to reduce nutrient pollution. Hilly regions with intensive agricultural activity or mountainous areas with high background emission rates generate the largest P inputs into surface waters (Maps 7c-d). As with N, point sources and paved urban surfaces also contribute significantly to the total emissions.

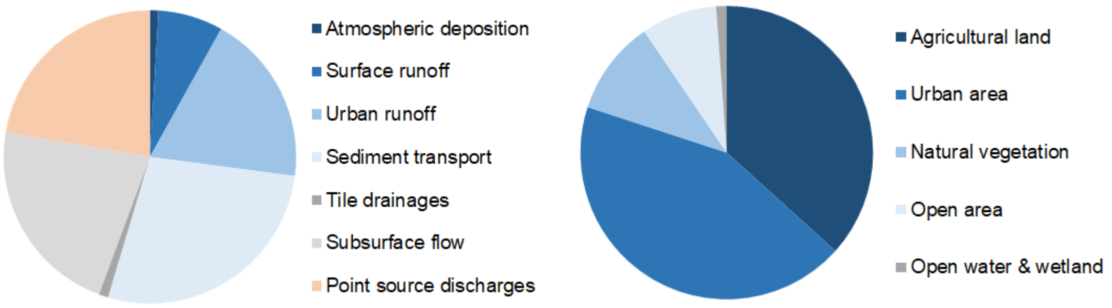


Figure 22: Share of the pathways and sources in the overall TP emissions in the Danube Basin for the reference period (2015-2018); on the left: pathways, on the right: sources

Pathway and source apportionments per country are presented in Figure 23 and Figure 24. Slovenia and Austria generate the highest area-specific P emission rates. Point sources, soil erosion and urban runoff are the most relevant emission components. Their proportion varies according to the national and regional development in the urban wastewater sector and the topographic and land use conditions. In upstream countries the contribution of the urban water management and agricultural sectors are at similar levels regarding P emissions. Moving downstream, urban areas become more dominant indicating the high potential to improve wastewater treatment by introducing P removal. Urban sources are particularly relevant in the middle basin.

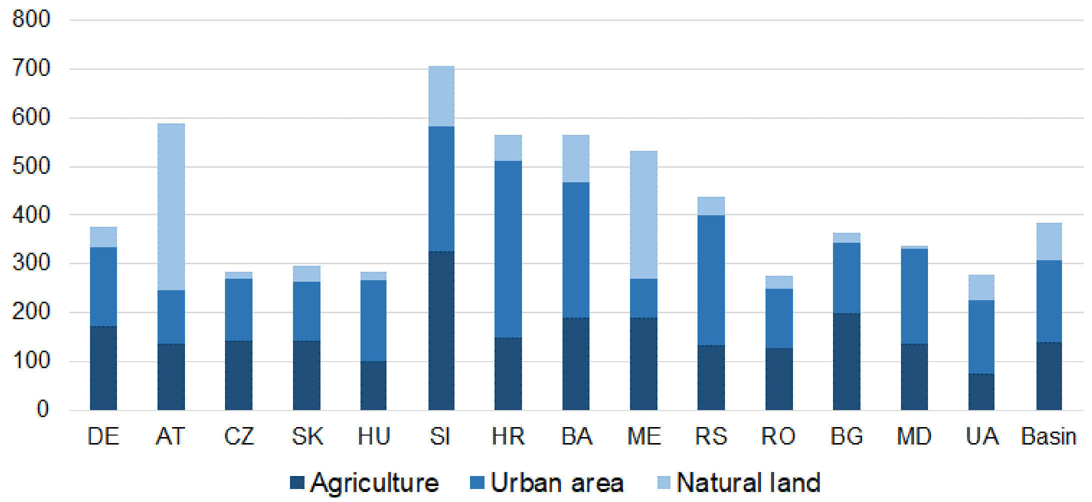


Figure 23: Specific total TP emissions and the contribution of source areas in the Danube countries for the reference period (2015-2018, expressed in g P per hectare and year)

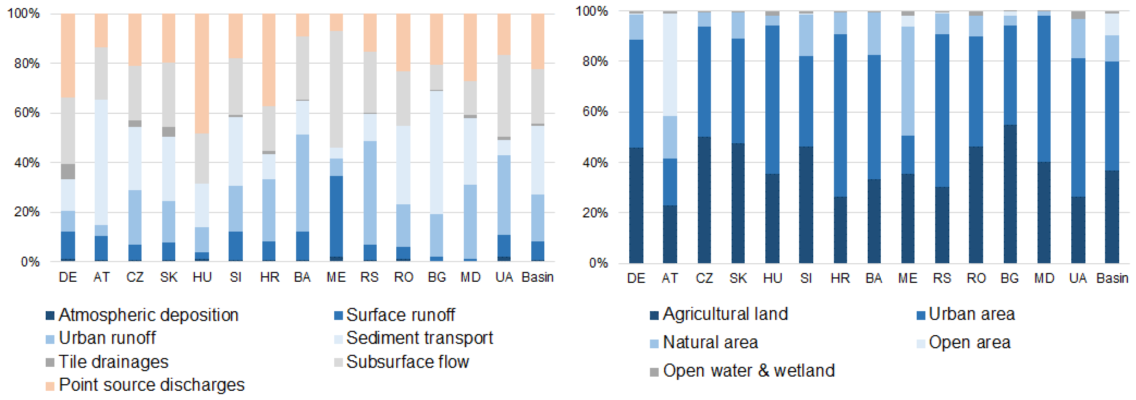


Figure 24: Share of the pathways and sources in the overall TP emissions in the Danube countries for the reference period (2015-2018); on the left: pathways, on the right: sources (absolute numbers on the top refer to g P per hectare and year)

The observed river loads are 340,000 tons TN per year and 18,000 tons TP per year for the reference period (2015-2018). These numbers indicate significant levels of retention in the river network compared with the total emission values. About 30% of the N emissions entering the river systems are retained during the in-stream transport mainly by denitrification. Some 40% of the P emissions do not reach the river mouth particularly due to settling in reservoirs and floodplains. Modelling results reasonably fit the observed river loads both, at the basin-wide and the regional scale.

2.1.3 Hazardous Substances Pollution

Key findings and progress

Danube countries have taken important steps **to fill the existing data gaps** in the field of hazardous substances pollution. The recent ICPDR investigations on the priority and other hazardous substances have provided essential information on the relevance of these substances resulting in a much clearer picture on the pollution problem (relevant substances and their magnitude) than ever before.

Point source emission data are available for 180 major industrial facilities with recorded surface water releases of 32 compounds. In addition, current investigations provided information on hazardous substance content of **UWWTP effluents** and oriented the scope of further activities to substances with high environmental risk. In the framework of two campaigns, more than 20 UWWTPs were sampled to analyse wastewater substance concentrations for a large number of chemicals. A priority list of substances associated with high risk and a wastewater related sub-list of the Danube River Basin Specific Pollutants have been elaborated.

Currently initiated basin-wide modelling activities delivered preliminary spatial information on **emissions of 17 selected hazardous substances** first time ever. The Danube Hazardous Substances Model (DHSM) water quality model has been developed to assess basin-wide emissions and fluxes of substances of high interest. Model results provide an insight into the pathway distribution of the analysed compounds.

Inventories on accident risk hot-spots and tailings management facilities and the related hazard and risk assessments discovered the most hazardous **industrial and mining facilities** in the DRB. Almost 500 industrial facilities and 200 tailings ponds have been identified with significant hazard of accidental pollution.

Hazardous substances pollution involves contamination with the priority substances laid down in WFD Annex X and other specific pollutants listed in WFD Annex VIII that might be toxic, heavily degradable or accumulative and have local/regional relevance. They include both inorganic and organic micro-pollutants such as heavy metals, arsenic, cyanides, oil and its compounds, trihalomethanes, polycyclic aromatic hydrocarbons, biphenyls, phenols, pesticides, haloalkanes, endocrine disruptors, pharmaceuticals, etc. Hazardous substances can be emitted from both point and diffuse sources. Industrial facilities that process, utilise, produce or store hazardous substances can release them with wastewater discharges. Indirect dischargers are connected to public sewer systems and can transport contaminated industrial wastewater to the treatment plants if their own treatment system is not sufficient. Households and public buildings connected to sewer systems can also contribute to water pollution by emitting chemicals used in the course of daily routine (e.g. personal care products, household chemicals, pharmaceuticals). Direct dischargers without specific removal technology for hazardous substances can potentially deteriorate water status.

Diffuse emission pathways are substance-specific. Surface run-off, sediment transport and groundwater flow are the main contributing routes. Urban systems, especially paved areas (deposited air pollutants, litter, roof and facade materials, particles from traffic), agriculture (pesticide and contaminated sludge application), contaminated sites (industrial areas, landfills, abandoned areas) and mining sites are the most important source sectors. Background geochemical loads can be considerable in specific regions where the parent rock layers naturally contain hazardous substances (e.g. metals). Hazardous substances contamination can occur through accidental pollutions as well. Industrial facilities, mining areas and contaminated sites that process or contain such substances in substantial amounts pose hazard (potential risk) to cause pollution even if they do not release substances into the environment in their regular operation. However, in case of emergency situations (natural disasters like flood or earthquake as well as operation failures) and without appropriate safety measures in place they might represent a real risk to human health and environment.

Due to the rapid development of the chemical industry that is continuously producing new chemicals, their different and complex environmental behaviour and the long-lasting chronic toxicity of many substances the whole mechanism of the hazardous substances pollution has not been fully clarified so far. Hazardous substances can pose a serious threat to the aquatic environment. Depending on their concentration and the actual environmental conditions, they can cause acute (immediate) or chronic (latent) toxicity. They usually attack one of the vital systems of the living organism, like nervous, enzymatic, immune, muscular systems or directly the cells.

Some of the hazardous substances are persistent, slowly degradable and can accumulate in the ecosystem (soil, unsaturated zone, river and lake sediments). They can deteriorate habitats and biodiversity and also endanger human health as many of these chemicals are carcinogenic, mutagenic or teratogen. They can also alter proteins and different organs, impair reproduction or disrupt endocrine systems. Many of the pollutants tend to attach to organic compounds, they may be taken up by the organisms during feeding and introduced in the food web through bioaccumulation and biomagnification processes. Moreover, some of the pollutants can attach themselves to soil and sediment particles and be subject to subsequent resuspension and dissolution. Therefore, hazardous substances pollution is considered as local/regional or even basin-wide water quality problem and its reduction may take some time. Reduction/elimination of these substances needs up to date technologies at the industrial sites, enhanced wastewater treatment, good agricultural practices to appropriately apply these substances and reduce their releases, cessation and replacement of the hazardous priority substances with others whenever possible and well-developed safety measures and crisis management system to address accidental events. Total and dissolved concentrations of the hazardous substances are used to describe water status. Additionally, concentrations in sediment and/or biota should be monitored especially for those priority substances which tend to accumulate in sediment and/or biota for long-term trend analysis of their concentrations in order to prevent further deterioration of water status.

2.1.3.1 Sources of Hazardous Substances Pollution

Towards a better understanding and a narrowed information gap on the sources of hazardous substances pollution the compilation of inventories on emissions, discharges and losses of priority substances and emerging chemicals provides a promising possibility. The current ICPDR activities on hazardous substances pollution are very much in line with the recommendations of the Common Implementation Strategy (CIS) Guidance No. 28[23] on preparing emission inventories of priority substances and other specific pollutants. Recently, a two-steps approach was applied to make use of the guideline. The first phase is a more general significance analysis of the priority substances and specific pollutants. The aim of this phase was to screen those substances which are clearly of higher relevance at present and in the foreseeable future and allow prioritisation of the resources and efforts necessary for the subsequent detailed investigations on the emission sources. It was based on the information available for the emissions from the E-PRTR database and specific sampling campaigns at UWWTPs embedded into the investigations of the SOLUTIONS Project[24] and the JDS4[25].

The second phase of the CIS Guidance No. 28 is a more detailed analysis focusing on the sources of the screened relevant substances. It aims to develop a detailed inventory for both, the point and diffuse source hazardous substances emissions. A comprehensive modelling activity on the emissions and transport of hazardous substances has been performed for the DRB in the framework of Danube Hazard m^{3}c Project[26], which helps better understand the links between sources and impacts of hazardous substances pollution.

2.1.3.1.1 Point Source Emissions

The outcome of the emission analysis is a preliminary set of relevant priority substances and other specific pollutants for which direct water emission data (Table 12 and Map 6) are available. In total, 179 facilities reported hazardous substances emissions directly released to water for the reference year 2018 in the E-PRTR, out of which 99 are industrial facilities and 80 are major UWWTPs (>100,000 PE). Chemical industry, energy production and metal processing are the most relevant sectors with the highest number of facilities. Based on the first screening 32 compounds were found with exceedance of the respective release threshold for at least one facility in the DRB (Table 12 and Annex 6 on hazardous substances pollution inventory). Out of these substances 7 organic pollutants, 8 metals, 3 pesticides, 11 chlorinated organic substances and 3 inorganic pollutants were identified. Heavy metals, Di-(2-ethyl hexyl) phthalate, nonylphenol, phenols, halogenated organic compounds and inorganic substances (chlorides, cyanides, fluorides) were reported by several countries, whilst information on other chemicals is only sparsely available. The highest number of compounds was reported for urban wastewater management, metal and chemical industries.

23 *Common Implementation Strategy for the Water Framework Directive (2000/60/EC) Guidance Document No. 28 Technical Guidance on the Preparation of an Inventory of Emissions, Discharges and Losses of Priority and Priority Hazardous Substances.*

24 *https://cordis.europa.eu/project/id/603437 (accessed 15 February 2021).*

25 *http://www.danubesurvey.org/jds4/ (accessed 12 February 2021).*

26 *http://www.interreg-danube.eu/approved-projects/danube-hazard-m3c (accessed 14 September 2021).*

Table 12: Number of facilities releasing direct hazardous substance discharges into water in the Danube River Basin (reference year: 2018)

Activities	Number of facilities	Number of compounds
Energy sector	21	15
Production and processing of metals	20	22
Mineral industry	16	10
Chemical industry	21	20
Waste and industrial wastewater management	80	13
Urban wastewater management	9	22
Paper and wood production processing	7	10
Products from the food and beverage sector	2	3
Other activities	3	2
Total	**179**	**32**

2.1.3.1.2 UWWTP Effluent Hazardous Substances Concentrations

In late summer 2017, samples from 12 UWWTPs were collected and analysed by the SOLUTIONS Project in cooperation with the ICPDR for a wide range of hazardous substances including organic compounds and metals. The objectives of the monitoring exercise were to evaluate the occurrence of chemicals using the state-of-the art wide-scope chemical screening techniques, to quantify the effluent concentrations of the chemicals, to prioritize the detected substances based on ecotoxicological thresholds and to assess the acute adverse effects of mixtures of pollutants on different indicator species.

In total, 280 different organic compounds have been detected at the 12 sampled UWWTPs (see Annex 6). 164 chemicals were found at least at half of the UWWTPs, whereas 53 chemicals were present at all UWWTPs. More than one third of the detected compounds are pharmaceuticals (36%). Pesticides (15%) and antipsychotic drugs (14%) are also important component groups, followed by industrial chemicals (12%) and antibiotics (11%). The groups of drugs of abuse, steroids and tobacco ingredients (9%) and the hypoglycaemic agents and artificial sweeteners (2%) are less relevant. Pharmaceuticals strongly dominate the cumulated concentration pattern with a proportion of 51%. Industrial chemicals, antipsychotic drugs, pesticides and antibiotics have a share around 10%, whereas drugs of abuse and artificial sweeteners have a minor share only (about 3%). Pharmaceuticals and industrial chemicals have the highest overall toxicity risk in terms of threshold exceedance. Antibiotics are also significant, but they show only one-third risk value in comparison the two dominant groups.

Risk assessment of the detected target compounds was done by the prioritization methodology developed by the NORMAN network[27]. The method is based primarily on comparing the measured concentrations of detected substances against their Predicted No-Effect Concentration (PNEC) or Environmental Quality Standard (EQS), which represent their ecotoxicological threshold values. The priority was evaluated based on three indicators, ranging from 0 to 1, determined for each compounds:

(i) Frequency of Appearance (FoA),

(ii) Frequency of PNEC Exceedance (FoE), and

(iii) Extent of PNEC Exceedance (EoE).

27 https://www.norman-network.com/nds/ecotox/ *(accessed 14 September 2021).*

Table 13 shows the results of the NORMAN-prioritization (chemicals above a Risk Score of 1.0). The industrial chemical PFOS (Perfluorooctanesulfonic acid, ingredient in repellents, foams) was ranked to the first place, which exceeded the PNEC/EQS in all samples and the cumulated extent of PNEC exceedance was also the highest for this compound. Very high-risk scores were calculated for the antibiotic Ofloxacin (against bacterial infection), the pharmaceuticals Telmisartan (to treat high blood pressure), Diclofenac (pain killer and to treat inflammatory diseases) and Carbamazepine (to treat epilepsy and neuropathic pain) and industrial chemicals PFHxS (Perfluorohexanesulfonic acid, used in surface treatment products, foams) and C12-LAS (Sodium dodecylbenzenesulfonate, used as detergent is personal and household care products). These compounds were detected at almost all UWWTPs and their PNEC exceedance is quite frequent and substantial. The top 25 high-risk compounds include 10 industrial chemicals (mainly perfluorinated substances), 6 pharmaceuticals (half of them non-steroidal anti-inflammatory drugs), 3 antibiotics, 3 antipsychotic drugs, 2 pesticides (insecticide and fungicide) and 1 drug for abuse.

Table 13: Prioritized high-risk compounds in UWWTP effluents

ID	Name	Compound group	LOD (ng/L)	PNEC (µg/l)	MEC (ng/L)	Risk Score
1	PFOS	Industrial Chemicals - Perfluorinated substances	0.100	0.001	49.542	3.000
2	Ofloxacin	Antibiotics - Quinolones	1.600	0.021	3,050.727	2.579
3	Telmisartan	Pharmaceuticals - Antihypertensive drugs	1.135	0.042	2,329.208	2.572
4	Diclofenac	Pharmaceuticals - NSAIDs	1.800	0.050	1,356.296	2.366
5	PFHxS	Industrial Chemicals - Perfluorinated substances	0.190	0.001	14.943	2.113
6	Dodecyl-benzenesulfonate (C12-LAS)	Industrial Chemicals - Surfactants	3.300	0.086	1,819.432	2.070
7	Carbamazepine	Pharmaceuticals - Antiepileptics	0.050	0.050	691.643	2.007
8	PFOA	Industrial Chemicals - Perfluorinated substances	0.120	0.001	4.121	1.976
9	Ibuprofen	Pharmaceuticals - NSAIDs	0.300	0.010	1,046.337	1.917
10	PFHxA	Industrial Chemicals - Perfluorinated substances	0.310	0.001	5.247	1.837
11	PFBuS	Industrial Chemicals - Perfluorinated substances	0.080	0.001	25.303	1.734
12	4-tert-Octylphenol	Industrial Chemicals - Phenols	3.287	0.100	305.479	1.722
13	Meclofenamic Acid	Pharmaceuticals - NSAIDs	2.840	0.097	317.674	1.720
14	Fipronil	Pesticides & Insecticides	1.052	0.023	396.346	1.711
15	Carbendazim	Pesticides & Insecticides	8.418	0.150	1,075.882	1.682
16	Venlafaxine	Antipsychotic drugs - SSRIs	2.000	0.038	97.915	1.629
17	PFDeA	Industrial Chemicals - Perfluorinated substances	0.070	0.001	3.276	1.550
18	Clarithromycin	Antibiotics - Macrolides	0.448	0.120	706.845	1.471
19	PFHpA	Industrial Chemicals - Perfluorinated substances	0.240	0.001	3.751	1.232
20	4-Hydroxy-Omeprazole	Pharmaceuticals - Antiulcer Drugs	0.600	0.263	8,477.977	1.129
21	PFNA	Industrial Chemicals - Perfluorinated substances	0.050	0.001	2.885	1.110
22	EDDP	Drugs of abuse, steroids and tobacco ingredients	0.020	0.137	215.085	1.099
23	Temazepam	Antipsychotic drugs - Benzodiazepines	1.300	0.071	248.035	1.024
24	Erythromycin	Antibiotics - Macrolides	1.700	0.200	764.083	1.015
25	Sertraline	Antipsychotic drugs - SSRIs	0.100	0.091	137.480	1.006

LOD: Limit of Detection; MEC: Maximum Environmental Concentration

Further analysis of the extent of PNEC exceedance at each UWWTP (Figure 25, UWWTPs ranked by PNEC exceedance) shows that risk related to chemical compounds in effluents can be detected at all UWWTPs and the level of cumulative risk (summed EoE of all compounds for each UWWTP) tends to relate to the population and the type of industrial activities that discharge wastewater into the municipal sewer systems. Pharmaceuticals have significant risk at almost all UWWTPs. Industrial chemicals also represent a high-risk group. Antibiotics have remarkable risk factor in several UWWTPs.

With regard to the overall risk of chemical groups (Figure 26), pharmaceuticals and industrial chemicals have clear dominance in terms of PNEC exceedance (summed EoE of all substances for each chemical group). Antibiotics are also significant, but they show only one-third risk value in comparison the two dominant groups. The remaining groups are rather negligible in terms of risk although their cumulative concentration is comparable to that of the other groups.

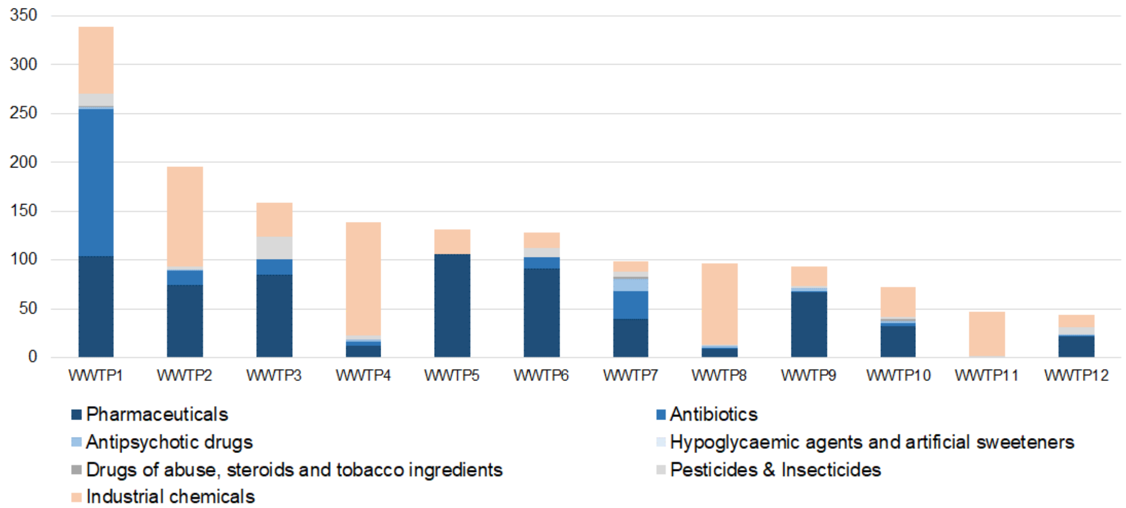


Figure 25: Cumulated PNEC exceedance of organic chemicals at the investigated UWWTPs

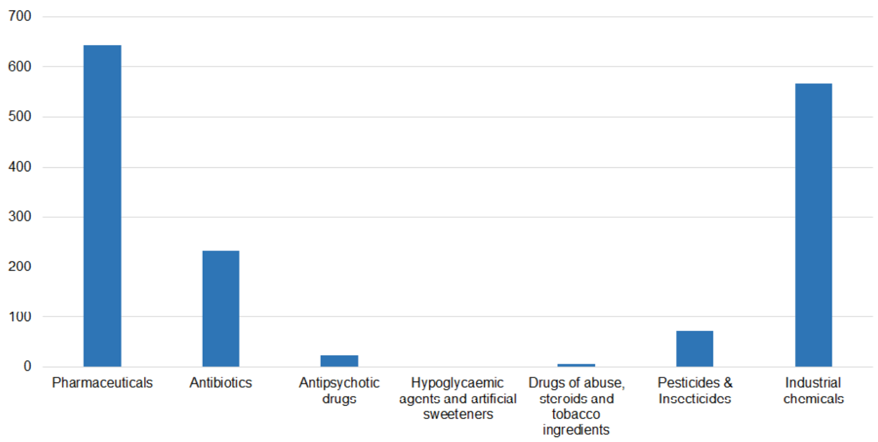


Figure 26: Cumulated PNEC exceedance of organic chemicals for chemical groups

All the 7 investigated metals have been detected at least at one UWWTP. Chromium, copper, nickel, lead and zinc were found at all UWWTPs. Cadmium was detected at 6 plants, whereas mercury was measured at one site only. Zinc has been ranked to the first place as the measured concentrations considerably exceeded the threshold value at almost all sites. Nickel, chromium and copper have also higher score because of threshold exceedance at one or more sites. At 10 of the 12 investigated UWWTPs, risks are associated with heavy metal PNEC exceedance in the effluent. (Figure 27, UWWTPs are ranked based on the PNEC exceedance).

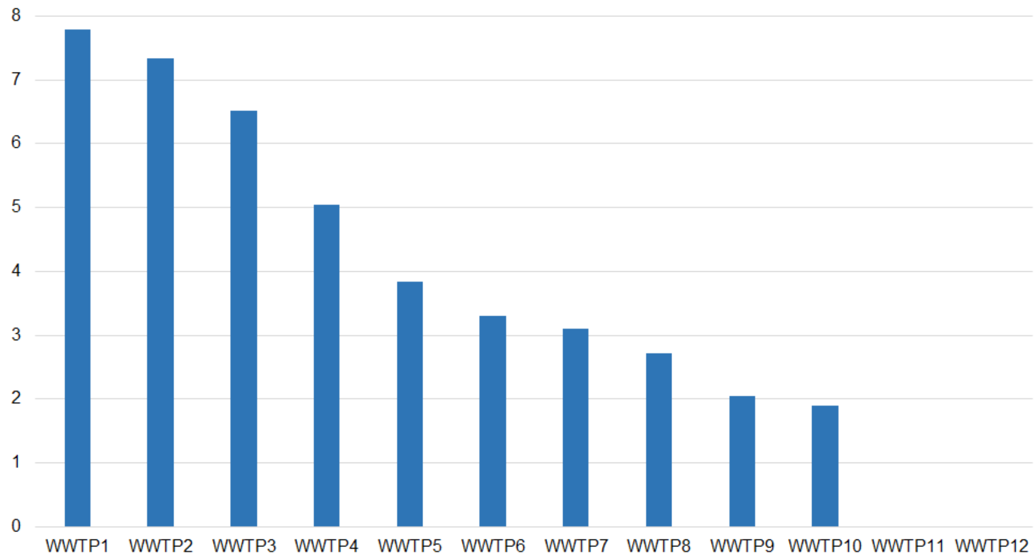


Figure 27: Cumulated heavy metal PNEC exceedance at the investigated UWWTPs

In the framework of the JDS4, daily composite wastewater influent and effluent samples from 11 UWWTPs were collected and analysed for a target list of more than 2,400 chemicals and their transformation products. Prioritisation of these chemicals based on the NORMAN-methodology resulted in a preliminary list of wastewater-related river basin specific pollutants that are obviously originating from UWWTPs and exceeding ecotoxicology threshold values in the river water at the basin scale. These substances represent carefully selected compounds, which are released from WWTPs in high concentrations causing adverse effects to environment, always present and easy to analyse. An initial list of 17 substances based strictly on the results of the JDS4 (no historical data) is shown in Table 14.

Table 14: Wastewater related potential river basin specific pollutants

ID	Compound	CAS No.	Lowest PNEC (ng/L)
1	Telmisartan	144701-48-4	0.00055
2	Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.00065
3	Benzododecinium	139-07-1	0.063
4	Candesartan	139481-59-7	0.0031
5	Carbamazepine	298-46-4	0.05
6	Imidacloprid	138261-41-3	0.0083
7	Hexa(methoxymethyl) melamine	68002-20-0	0.057
8	2-Ethylhexyl diphenyl phosphate (EHDP)	1241-94-7	0.018
9	Spinosyn A	131929-60-7	0.0027
10	17beta-Estradiol	50-28-2	0.0004
11	Fipronil	120068-37-3	0.00077
12	Diclofenac	15307-86-5	0.05
13	Ciprofloxacin	85721-33-1	0.089
14	Pethoxamid	106700-29-2	0.0005
15	Nicosulfuron	111991-09-4	0.009
16	Metazachlor	67129-08-2	0.02
17	4-((1,1-dimethylethyl) amino)-6-(ethylamino)-1,3,5-triazin-2(1H)-one	66753-07-9	0.0073

2.1.3.1.3 Basin-Wide Emission Assessment of Chemicals

DHSM – a catchment scale water quality model to quantify emissions and river loads for selected hazardous substances in the Danube River Basin

The Danube Hazardous Substances Model (DHSM) modelling approach is based on the methodology developed in the SOLUTIONS Project[28] and has been adapted to the DRB conditions and river basin management purposes. The model system that is applied for each of the of ca 3,500 analytical units (sub-catchments) of the DRB consists of two building blocks: (1) an emission model, and (2) a fate and transport model (Figure 28). The emission model is formulated in terms of mass flows and quantifies the emissions to surface waters and the emissions to the soil system by various pathways. The first step of the emission modelling is the estimation of the losses of target substances and the allocation of these losses to various receptors. These losses are then further routed through the wastewater and stormwater management systems by the emission model and transformed into total emissions to surface waters and the soil system.

The fate and transport model is a multimedia model based on the advection-diffusion equation. It simulates what happens to the emissions to the soil system: how much of these emissions reach the surface water by erosion, drainage and groundwater pathways, and how much stay there or degrade. The fate and transport model further simulates the instream transports and processes in surface waters. The concentrations of hazardous substances are calculated for various environmental compartments within the model analytical units, along with the fluxes of hazardous substances between the compartment as well as the fluxes in downstream direction between the analytical units, all driven by hydrological processes.

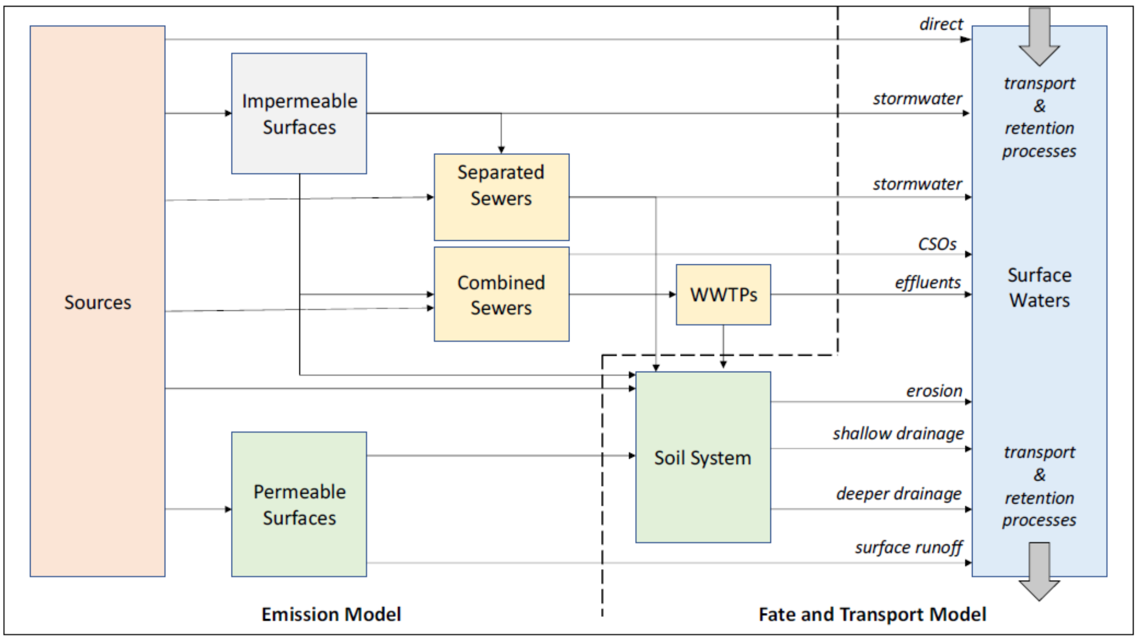


Figure 28: DHSM model scheme

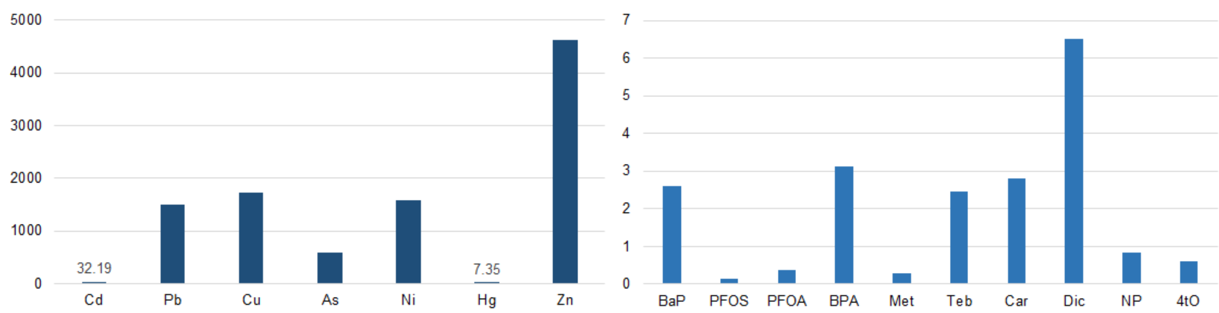
28 van Gils, J., Posthuma, L., Cousins, I. T., Brack, W., Altenburger, R., Baveco, H., van Wezel, A. (2020). Computational material flow analysis for thousands of chemicals of emerging concern in European waters. Journal of Hazardous Materials, 397(April), 122655, https://doi.org/10.1016/j.jhazmat.2020.122655 (accessed 14 September 2021).

The DHSM has been implemented for the following target chemicals, which represent relevant sources and pathways, are relevant for the ICPDR, national and regional authorities in the basin, and can be actually detected and measured:

- Metals: arsenic, cadmium, copper, nickel, lead, zinc and mercury.
- Polycyclic Aromatic Hydrocarbons or PAHs (16 so called "EPA PAHs"), among them benzo[a]pyrene.
- Pharmaceuticals: diclofenac and carbamazepine.
- Industrial chemicals with wide dispersive use: 4-tert-octylphenol, nonylphenol, bisphenol-A.
- Per- and polyfluoroalkyl substances (PFAS): perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), plus a range of short-chain PFAS.
- Pesticides: tebuconazole, a fungicide used for wood preservation, and metolachlor, a herbicide in agriculture (including metabolites metolachlor-ESA and metolachlor-OA).

The DHSM model was applied for 17 target compounds for the entire DRB in the framework of the Danube Hazard m^{3}c Project. The emission patterns presented in the followings are to be considered as preliminary results based on incomplete database and initial modelling structure. Efforts are on-going to improve the input data and system understanding based on specific pilot catchment investigations. The preliminary model results will be updated by the end of 2022. An overview of the investigated emission sources and their quantification quality is presented in Annex 6.

The basin-wide hazardous substances emissions show a relative high variation in their absolute values (Figure 29 and Annex 6). Metals range between 10 (mercury) and 4,000 (zinc) kg per km^2 and year, whereas organic compound emissions are much lower, having a range of 0.1-7 kg per km^2 and year. Spatial distribution of mercury, carbamazepine, nonylphenol and tebuconazole as examples for metals, pharmaceuticals, industrial chemicals and pesticides are shown in Maps 8a-d.



Cd: cadmium, Pb: lead, Cu: copper, As: arsenic, Ni: nickel, Hg: mercury, Zn: zinc, BaP: benzo[a]pyrene, PFOS: perfluorooctanesulfonic acid, PFOA: perfluorooctanoic acid, BPA: bisphenol-A, Met: metolachlor, Teb: tebuconazole, Car: carbamazepine, Dic: diclofenac, NP: nonylphenol, 4tO: 4-tert-octylphenol.

Figure 29: Total surface water emissions of metals and organic compounds (expressed in kg per km^2 and year)

The relative proportion of the main emission pathways are presented in Figure 30. The emissions are subdivided according to the pathways into direct emissions to surface waters (atmospheric deposition, the use of pesticides in agriculture, from households unconnected to centralized wastewater collection systems, industry and inland navigation), emissions by runoff from permeable surfaces (including agriculture and natural areas), emissions from mixed sewer systems (UWWTP effluents and combined sewer overflows) emissions from urban runoff (separated rainwater collection systems and uncollected runoff flowing into surface waters) and emissions via soil (erosion, drainage and groundwater flow).

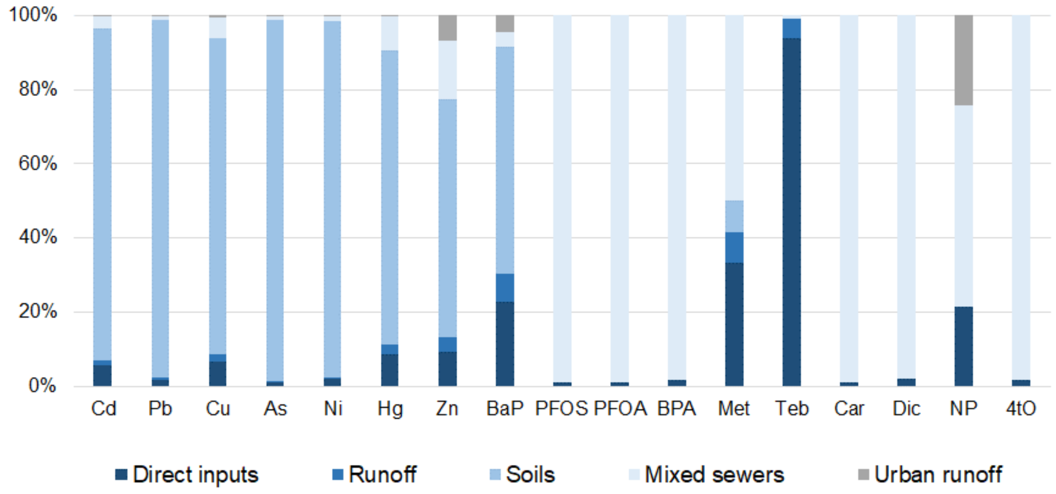
The metals show an almost complete spectrum of sources and pathways. This is partly because they are naturally occurring and non-decaying, but also because there is a relative abundance of information about them. The combined soils related pathways provide the largest contribution (60% or more). Contributions > 10% occur for direct (industry) discharges (copper, 29%) and mixed sewers (zinc, 16%). The spatial results for zinc show emission gradients probably controlled by hydrology gradients that drive the soil related pathways. It is noted that the background concentrations in soils of the metals are currently homogeneous. In most places the soil related pathways are dominant. Locally, direct sources are dominant (atmospheric deposition on large lakes, industrial point sources). In other places, the contribution from UWWTPs is dominant (from mixed sewers collecting wastewater and urban stormwater).

For benzo[a]pyrene, the largest contribution is from soils (61%, which is in turn largely determined by atmospheric deposition), with noticeable contributions from direct inputs, such as atmospheric deposition (14%) and navigation (9%), whereas runoff, UWWTPs and sewers are less relevant (all ≤ 10%). The spatial results for benzo[a]pyrene show high emissions in large lakes and larger rivers, in urban areas and in places with high local atmospheric deposition and high rainfall (e.g. in Slovenia). Often, the soil related pathways are dominant. In many places direct sources are dominant (atmospheric deposition on large lakes, inland navigation in larger rivers). Occasionally, separated sewers (urban runoff), mixed sewers/UWWTPs (urban runoff and wastewater) or surface runoff (atmospheric deposition) dominate.

For pharmaceuticals, only contributions from households are present, predominantly via mixed sewer systems (98% or more). The spatial results for carbamazepine show highest emissions to water in places with high population and a high connection rate to sewers. UWWTPs are the dominant pathway, except for areas with low connection rates, where direct sources from unconnected households may be dominant or soil-related pathways, again due to unconnected households.

For the industrial chemicals 4-tert-octylphenol, bisphenol-A, PFOS and PFOA, only households have been defined as a source. This may be due to a lack of information and the quantification of sources may still be partly incomplete. This was already observed during the model evaluation, for example for the perfluorochemicals. Consequently, for these chemicals the results are very similar to those for the pharmaceuticals. For one industrial chemical, nonylphenol, more sources could be quantified (road traffic, industry), which leads to contributions to the total emissions from mixed sewers, urban runoff and industry. The spatial distribution of the emission follows the population distribution and traffic intensity. In many places the urban runoff pathway is dominant. In other places, combined sewer systems are the dominant pathway. Locally, direct sources from industry dominate. Occasionally, the soil pathways dominate due to wastewater contributions from unconnected households.

For the pesticides a more diverse result is obtained. Tebuconazole emissions to water are dominated by direct losses, with a small contribution from runoff. For metolachlor, the current model indicates a very significant contribution via wastewater (mixed sewers, 50%), with a significant contribution also via soil-related pathways. This difference is caused partly by the current quantification of sources and partly by different sorption properties. The spatial results for metolachlor reflect that use volumes in agriculture are country specific, while a homogeneous concentration in wastewater has been assumed. In areas with high application rates in agriculture, direct emissions dominate except in areas with high runoff where soil related pathways tend to dominate. In areas with a high connection rate to sewers and low application in agriculture (e.g. Germany) the UWWTP pathway dominates.



As: arsenic, Cd: cadmium, Cu: copper, Ni: nickel, Pb: lead, Zn: zinc, Hg: mercury, BaP: benzo[a]pyrene, Dic: diclofenac, Car: carbamazepine, 4tO: 4-tert-octylphenol, NP: nonylphenol, BPA: bisphenol-A, PFOS: perfluorooctanesulfonic acid, PFOA: perfluorooctanoic acid, Teb: tebuconazole, Met: metolachlor.

Figure 30: Relative proportion of the emission pathways of the target compounds

2.1.3.2 Hazardous Substances Pollution from Accident Risk Spots

Assessment of hazardous substance pollution via accidents is based on hazard and risk assessment methods. Their main objectives are to raise awareness to the accidental pollution in the basin, to determine which priority industrial sectors need to be improved in different regions of the basin in order to minimize risk by implementing measures and to give advice for financing institutes and decision makers where financial and/or technical supporting projects should be targeted. The ICPDR has recently assessed the potential accident risk hot-spots and updated the inventory of hazardous industrial and mining sites of the DRB.

2.1.3.2.1 Accident Hazard Sites

The Accident Hazard Sites (AHS) represent mainly existing industrial and energy production facilities that process, store, produce or release hazardous substances. The AHS inventory evaluates the potential risk of the identified facilities based on the Water Hazard Index[29] (WHI) values. The WHI assesses the hazard of the industrial sites based on the hazard degree of the processed materials and their volume stored at the sites. The results provide support for the identification of the priority industrial sectors where accidental risk should be mitigated by implementing appropriate safety measures.

In total, more than 1,000 industrial facilities have been reported which store considerable amount of hazardous substances (Map 9a and Annex 6). Out of these, ca 470 facilities (47%) have been reported with a WHI value higher than 5.0 that is the threshold value considered for significant hazard. The number of installations is clearly decreasing as the WHI becomes higher defining particular high-risk facilities in the DRB (Figure 31, note that the WHI is on logarithmic scale, i.e. an increase of WHI by one unit means a rising danger by one order of magnitude in terms of mass). In total, almost 12 million tons hazardous substances are stored in the

29 *ICPDR (2001): Inventory of Potential Accidental Risk Spots in the Danube River Basin, Technical Report.*

basin which equals to a basin-wide WHI value of 10.1. More than 99% of the hazardous substances amount are stored in the high-risk facilities.

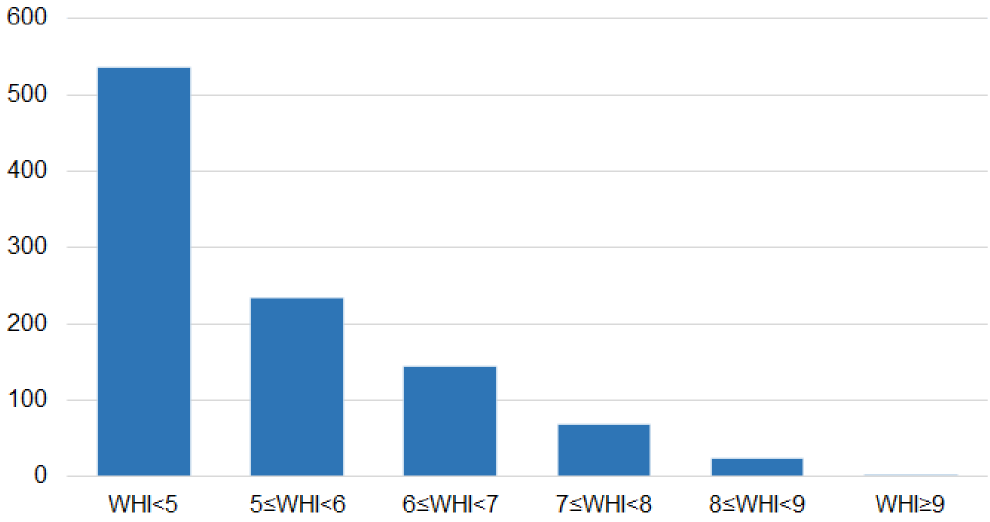


Figure 31: Distribution of the number of Accident Hazard Sites according to Water Hazard Index (WHI) classes

Country contributions are shown in Figure 32 (only for sites with WHI higher than 5.0). Romania reported the highest number of dangerous installations, followed by Germany, Hungary and Slovakia. The total WHI value (indicating the quantity of hazardous substances) at country level is the highest in Romania, Germany, Serbia and Slovakia (Figure 33). These countries also show the highest specific quantity of hazardous materials (mass per facility) indicating higher danger levels at the facilities in their national territory. However, it must be emphasized that the potential risk values presented here do not correspond to the actual risk, since for the assessment of the real risk the safety measures applied at the facilities and the potential impact receptors in the vicinity of the facilities that may be exposed would need to be also taken into account.

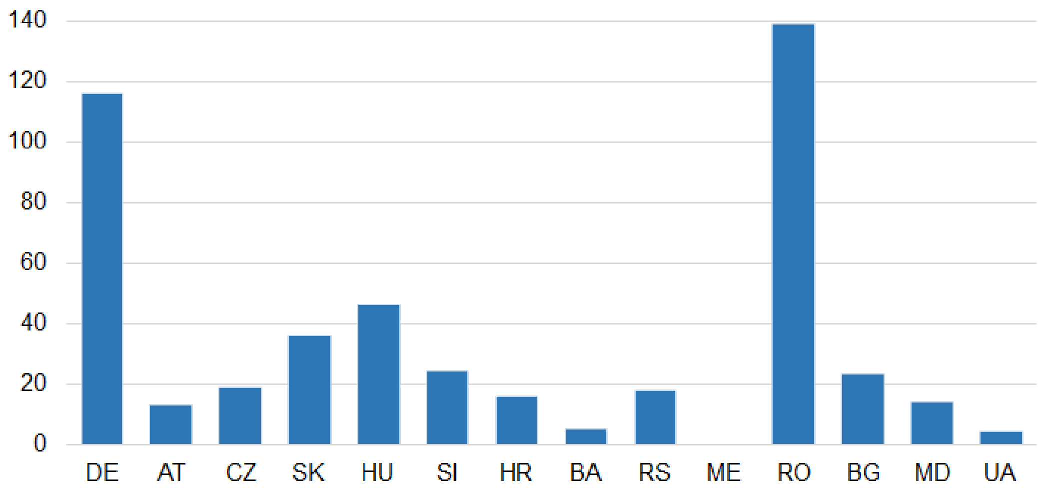


Figure 32: Number of dangerous facilities at national level (facilities with WHI≥5).

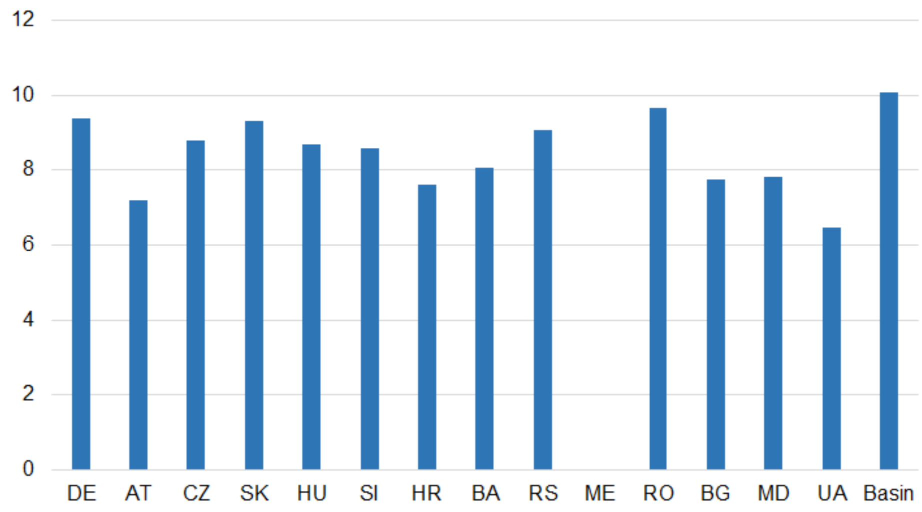


Figure 33: Total Water Hazard Index (WHI) values at country level (facilities with WHI≥5).

With regard to the main types of the industrial activities, the energy sector, the chemical industry, the storage facilities and the metal industry have the highest number of facilities operating in the DRB (Figure 34). Energy sector facilities that includes a large number of oil industry facilities (refineries, terminals, distribution facilities, etc.), chemical industry and storage facilities (oil tanks, storage houses for chemicals) clearly dominate the distribution with 45%, 23% and 13% share, respectively. Energy sector also shows the largest amount of the stored hazardous substances hence the highest overall WHI (Figure 35). Storage facilities, mineral and chemical industry sectors also pose a high potential risk to the aquatic environment. Comparing the specific amounts of hazardous substances, the energy industry and storage sites have the largest quantities per facility indicating higher specific hazardousness for these sectors.

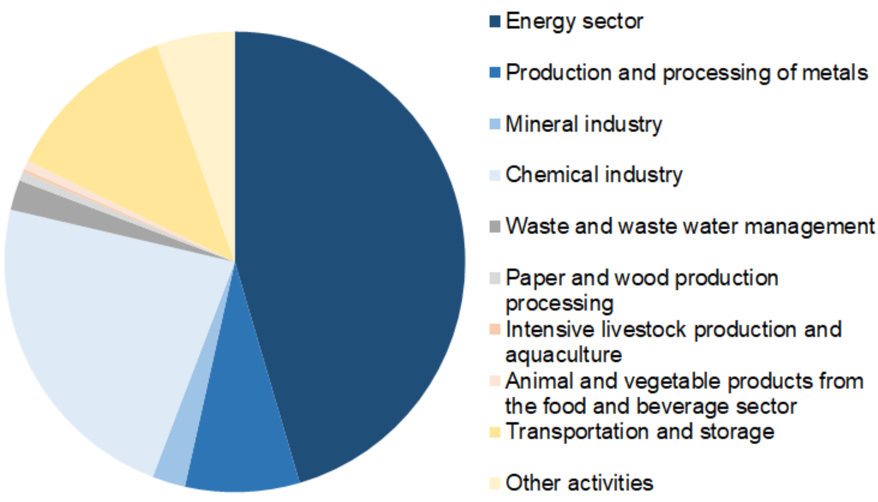


Figure 34: Distribution of Accident Hazard Sites with high risk (WHI≥5) according to industrial sectors

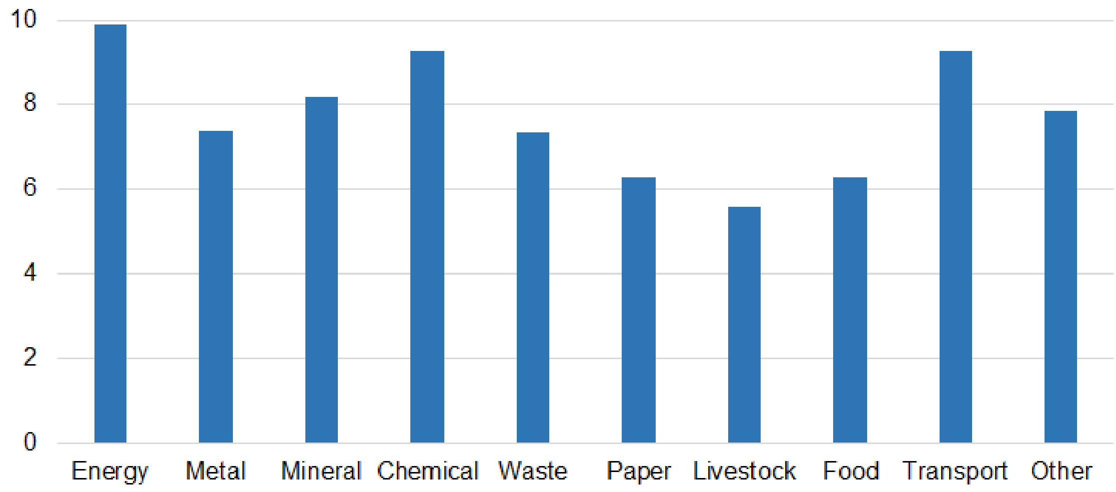


Figure 35: Total Water Hazard Index (WHI) values of the industrial sectors (facilities with WHI≥5)

At the national level, energy sector is strongly dominant in Austria, Germany, Croatia, Hungary, Romania and Serbia. Storage facilities have the highest WHI values in Slovenia, the Czech Republic and Bulgaria, whilst chemical industry is the most dangerous sector in Bosnia and Herzegovina and Slovakia.

In total, 94 installations have been reported for the upper hazard classes (WHI above 7), which store the vast majority (95%) of the total amount of hazardous substances processed in the DRB. Oil and gas industry sites (refineries, tanks, storages, pipelines), energy production facilities (power plants), storage sites, mining sites and several chemical factories can be found in the facility group associated with high potential danger.

2.1.3.2.2 Tailings Management Facilities

Mining is one of the most traditional and historically relevant industrial sectors in the world, providing valuable ores and minerals for further processing. Nowadays it is becoming even more important, as with the spread of smart and advanced technologies, a steep rise of connected mining activities is expected to supply the necessary battery storages with the specific metals needed. However, mining also represents a significant waste stream generated by its operations. One of the many types of the mining waste is the tailings, the fine-grained waste material derived from a mining processing plant and frequently transported by hydraulic methods to and deposited and handled at Tailings Management Facilities (TMFs). Ideally, TMFs should ensure the safe long-term storage of fine-grained mineral processing waste. However, TMFs can leak or collapse due to unfavourable natural conditions, design and construction deficiencies and inappropriate operation and management practices. Due to the physical characters and/or chemical nature of substances that can be found in the tailings, but also due to the significant amounts of stored mining waste, TMFs pose a risk to the environment and population.

Two index-based methods, the Tailings Hazard Index (THI) and Tailings Risk Index (TRI)[30] have been used to assess the accident hazard and risk of the TMFs located in the DRB. The THI allows assessing the hazard potential of a number of TMFs based on the volume and hazardousness of the stored substances and the management, natural and dam stability conditions of the TMFs, so that they can be sorted and prioritized according the calculated hazard potential. The TRI takes into account the hazard potential plus the population and water bodies downstream as potential receptors at risk of exposure in case of an accident.

30 UBA (2020): Safety of the Tailings Management Facilities in the Danube River Basin, Technical Report.

In total, 335 TMFs were identified in the DRB[31] (Map 9b and Annex 6). These sites do not include mine waste heaps that store mining waste without dam retention and drainage facilities. The TMFs are located in the territory of 9 Danube countries. The highest shares to the total TMF number in the DRB (Figure 36, left) belong to Romania (45%), Slovakia (18%) and Hungary (12%). The total volume of tailings materials in the 335 identified TMFs (including 96 active TMFs) is more almost 1600 million m3. Most of the identified TMFs (239 or 71%) are inactive, many of them were already rehabilitated or are currently under rehabilitation. The highest amount of tailings materials (Figure 36, right) was evaluated for Serbia (47%), Romania (29%) and Slovakia (8%).

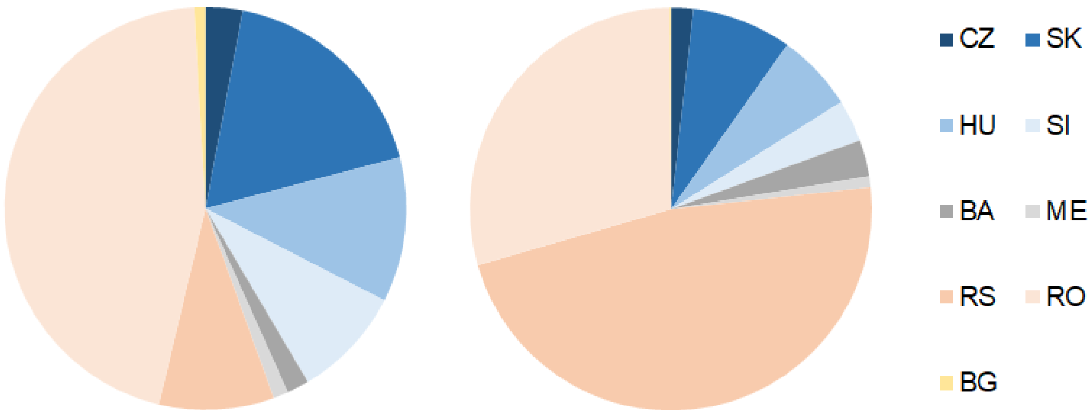


Figure 36: Distribution of the number of Tailings Management Facilities (left) and the total volume of tailings materials (right) over the DRB countries

Figure 37 demonstrates the distribution of the TMFs in the DRB according to THI ranges. In total, 144 TMFs have very low (THI≤8) or low (8<THI≤10) hazard. Additional 115 TMFs have medium hazard (10<THI≤12), whereas high (12<THI≤14) and very high (THI>14) hazard was determined for 82 TMFs. The country average values (Figure 38) are the highest in Serbia, Montenegro, Bosnia and Herzegovina and Slovakia. The difference of 5 between the highest (Serbia) and lowest (Hungary) average THI indicates 100,000 times higher hazard.

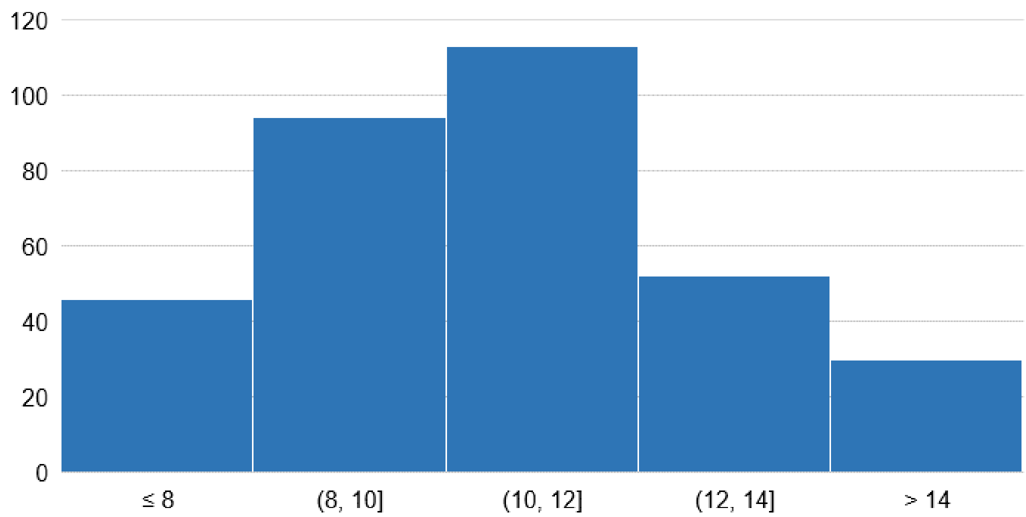


Figure 37: Distribution of the number of Tailings Management Facilities in the DRB according to the Tailings Hazard Index (THI)

31 *Preliminary database only, data have not been approved officially by RS and SI yet.*

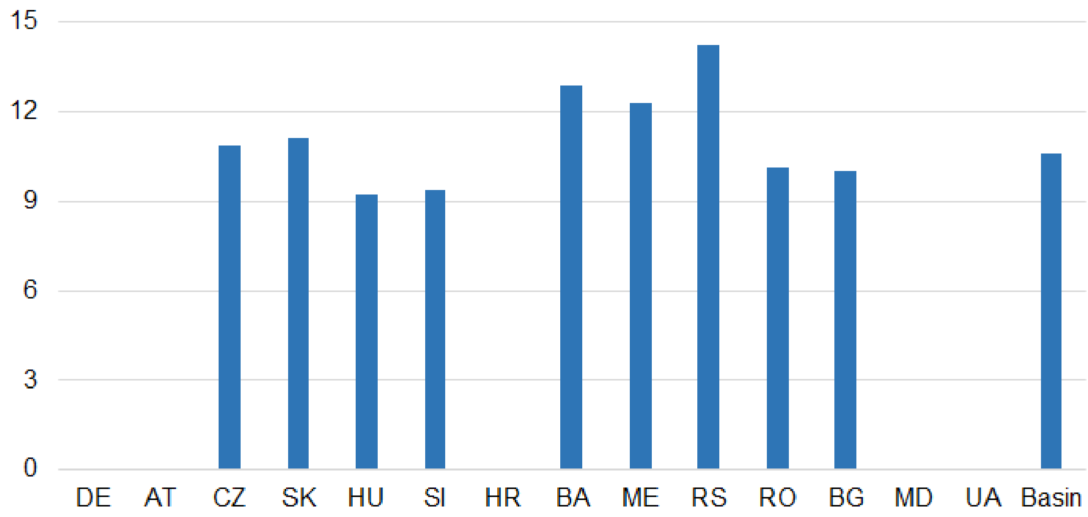


Figure 38: Average Tailings Hazard Index (THI) of the Danube countries

The number of TMFs and the amount of tailings materials in Bosnia and Herzegovina, Bulgaria, Czech Republic and Montenegro are relatively small. Nevertheless, there are also a few hazardous TMFs in these countries. Hungary and Slovenia have a significant number of TMFs, but of a lower hazard level due to lower toxicity of the waste, lower amount of tailings and closure and rehabilitation efforts. In contrast, the number, the amount of TMFs or the calculated hazard index in Romania, Serbia and Slovakia are much higher, these countries are of high concern regarding TMF safety and they should be in focus of future activities on safety improvement and capacity building. The TMF distribution according to TRI classes (Figure 39) is similar to that of based on the THI. Very low and low risk was calculated for 127 TMFs, 131 TMFs have medium risk and 83 facilities show high and very high risk. Similarly to the THI, the country average TRI value is the highest in Serbia and Montenegro, followed by Bosnia and Herzegovina, Czech Republic and Slovakia (Figure 40). The rest of the countries are below the DRB mean. The difference between the maximum (Serbia) and the minimum (Slovenia) is about 3.5, representing a risk 4,000 times higher.

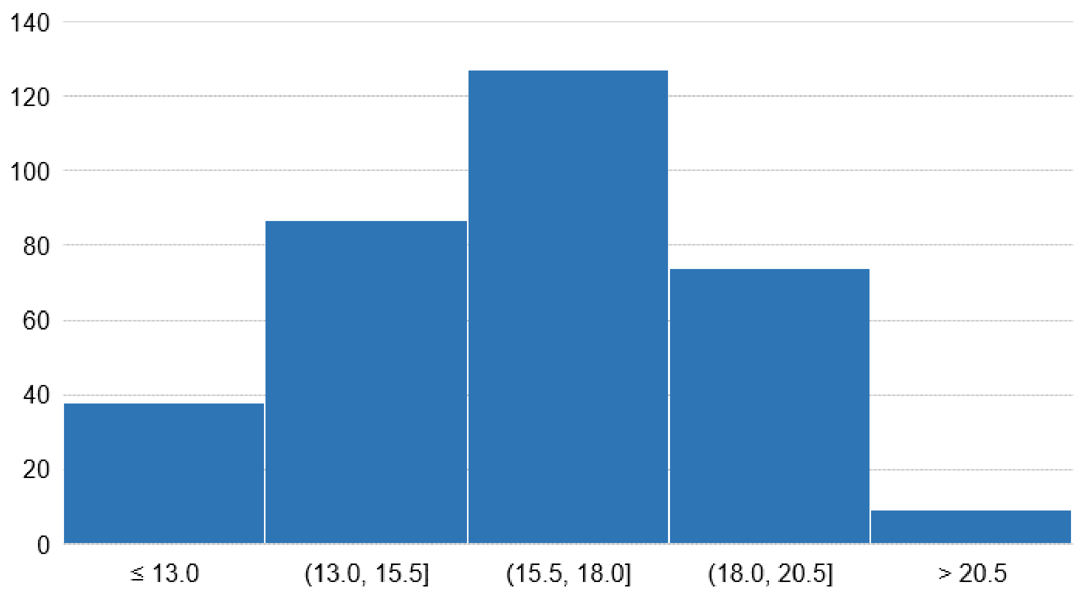


Figure 39: Distribution of the number of Tailings Management Facilities in the DRB according to the Tailings Risk Index (TRI)

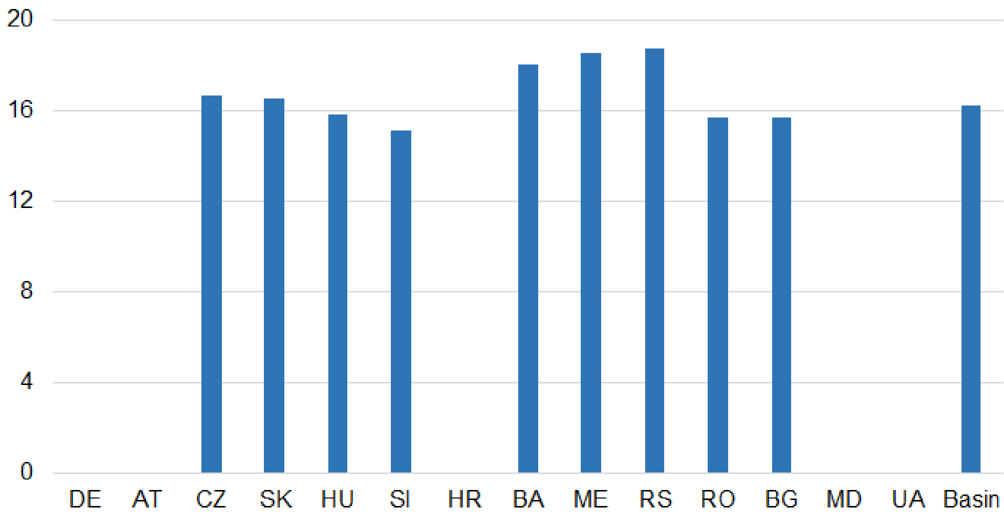


Figure 40: Average Tailings Risk Index (TRI) of the Danube countries

Ranking the TMFs based on the TRI and the THI values, for a high number of TMFs the ranks based on the two indexes are significantly different, indicating the necessity of considering land-use planning aspects at the point when TMFs are prioritized. This is very apparent for the top 10% TRI list (34 TMFs), where 16 TMFs posing high risk to population and environment would have much lower priority if only hazard was taken into account, i.e. only the remaining 18 TMFs are on both top 10% lists.

2.1.4 Gaps and Uncertainties of Pollution Assessment

Large part of the pollution data is obtained from the ICPDR pollution inventories that are regularly maintained and updated. Countries report official national data to these inventories, for most of the cases the data requirements are part of the reporting obligation to the EC, therefore the information reflects the best available data with high confidence. Nevertheless, some of the data are not reported consistently or have certain interpretation flexibility, resulting in data uncertainty and comparability issues. Further efforts need to be made to decrease these data inconsistencies to ensure fully coherent data assessment.

Basin-wide nutrient and hazardous substances emissions are assessed by water quality models. The modelling performance depends on the model structure and parameters, the appropriate temporal and spatial scale and the quality of model input data. Danube countries made significant efforts to provide the necessary input data for these models in close cooperation with the respective scientific institutions being in charge of the modelling task. Nevertheless, there is room for improvement, in particular for some critical input data whose spatial or temporal resolution is not sufficient and for those where the general data availability is poor. Input data harmonisation, database consistency and transparent data collection are key aspects towards reliable model performance and acceptance of the results. Moreover, the models need to be continuously updated to ensure sufficient system understanding and parametrization, proper linkages between drivers, pressures and impacts and ability to assess scenarios (climate change, management) and cost-efficiency of measures.

2.1.5 Climate Change Impacts on Pollution

Water quality of surface water bodies may have been negatively influenced by (summer) droughts. Water quality problems caused by point source effluents such as dissolved oxygen depletion, harmful pollutant concentrations and eutrophication may become more severe as response to high water temperatures, prolonged low flow periods and decreased flow rates (limited dilution capacity). Increased pollutant loads (sediment, nutrients and pesticides) may occur via heavy rainfall-runoff events, soil erosion and floods. Higher pollutants loads may also be expected from paved urban areas via runoff by stormwater sewers and combined sewer overflows.

Climate change effects may amplify the consequences of inappropriate land management practices, in particular the inputs of sediment, nutrients and hazardous substances to water bodies from agricultural areas without appropriate nutrient and soil management. Moreover, climate change may trigger higher demand for irrigation water, which may cause increased diffuse discharges of nutrients and pesticides via quick mobilization through preferential flow paths and subsequent leaching in case of improper irrigation management.

2.1.6 Hydromorphological Alterations

Hydromorphological conditions play an important role in the functioning of aquatic ecosystems and are therefore important elements with regard to water status. Undisturbed hydrological regime, river continuity and morphological conditions are a prerequisite for the formation of type-specific habitats for different species. Within the hydrological regime it is important to preserve quantity and dynamics of water flow and connection to groundwater bodies. Related to river continuity it is important to enable migration for aquatic organisms and transport of sediments and within morphological conditions to preserve river depth and width variation, structure and substrate of riverbed as well as structure of the riparian zone and connection between channel and floodplains/wetlands. Undisturbed hydromorphological conditions are not important only in relation to habitats, but also for reduction of nutrients, adaptation to climate change and water scarcity as well as for droughts prevention.

Key findings and progress

A significant number of surface water bodies in the DRBD are failing to achieve the WFD objectives due to hydromorphological alterations. Impoundments, water abstractions, hydropeaking, interruptions of river continuity, river morphological alterations, and disconnections of adjacent wetlands/floodplains may impact the water status now as well as alterations caused by future infrastructure projects may affect the water status in the future. Also, the disturbed or severely altered sediment balance is addressed within hydromorphological alterations, although it has not yet been analysed in depth in relation to WFD objectives. Thus, the sediment issue is currently addressed as an intrinsic part of hydromorphological alterations (e.g. within impoundments, morphological alterations). Hydromorphological alterations can also have an impact on quantitative and chemical status of groundwater bodies.

The main significant hydromorphological alteration on water bodies are morphological alterations (present on 552 water bodies), followed by continuity interruptions (357 water bodies), impoundments (269 water bodies), water abstractions (62 water bodies), hydropeaking (51 water bodies) and disconnected wetlands/floodplains (19 water bodies, where definite reconnection potential is recognized). Furthermore, there are 271 water bodies with at least one significant hydromorphological pressure, 148 water bodies with 2 different significant hydromorphological alterations, 188 water bodies with three and 43 water bodies with more than three different significant hydromorphological alterations. For 325 water bodies (33%), no significant hydromorphological pressure was reported.

There were several hydromorphological measures implemented between 2015 and 2021 for improving of hydromorphological conditions and achieving of environmental goals. 14 measures addressing hydrological alterations have been implemented in the DRBD since 2015; 422 cases of impoundments, 69 cases of water abstractions and 42 cases of hydropeaking are still causing significant hydrological alterations in 2021.

While 47 fish migration aids have been constructed between 2015 and 2021, 624 barriers still remain unpassable out of a total of 965 barriers reported in the DRBD. Also, first activities for enabling fish migration at Iron Gate I & II at the Romanian-Serbian border have been initiated (identified in the Terms of Reference for the Feasibility Study).

With regard to river morphological alterations, 28 river restoration projects were implemented between 2015 and 2021 in the DRDB. Approximately 16% of the river water bodies are still near natural and another 20% near natural to slightly altered. The remaining water bodies (nearly 60%) are morphologically altered while data are still missing for 7% of water bodies. Multiple measures to improve the connection of wetlands/floodplains in the period between 2015 and 2021 are still in planning (5,615 ha) or construction phase (4,526 ha). Nearly 10,000 ha of floodplains/wetlands have been partly or totally reconnected.

Besides already existing significant hydromorphological alterations, also 28 future infrastructure projects have been reported, of which 18 of them are located in the Danube River itself. In total, 17 are related to navigation, 6 to flood protection, and 2 to hydropower production. Three are classified with ”other purpose”. Targeted inter-sectoral cooperation activities have been launched by the ICPDR during the past years, helping to ensure the sustainability of these projects.

The progress in implementation of hydromorphological measures is shown in Annex 16 (Progress on Measures Addressing Hydromorphological Alterations) and in Annex 19, where the HYMO lighthouse projects are presented. While within the DRBMP only measures on rivers with a catchment area larger than 4,000 km^2 are presented, it is important to emphasize that Danube countries are implementing hydromorphological measures also on other (smaller) rivers, where diverse hydromorphological pressures were assessed.

Besides implemented hydromorphological measures, important progress in the field of hydromorphology in the Danube River Basin was made through the implementation of different projects supported by the ICPDR, mainly the DanubeSediment Project, the Danube Floodplain Project and the MEASURES Project (on restoring corridors for migratory fish species). The results of these projects are also presented in this document.

Additionally, also other important projects, supported by the ICPDR, were implemented, including projects Aquacross (hydromorphological restoration, mitigation and conservation), coopMDD (restoration of ecological connectivity), DANUBEparksCONNECTED and WILDislands initiative (Danube wild islands habitat corridor), DriDanube (management of drought related risks), FRAMWAT (small water retention measures) and MARS (managing of aquatic ecosystems) or are in implementation phase in the Danube River Basin, including projects Living Danube Partnership (rivers, floodplains and wetlands restoration), IDES (integrative floodplain management), and LIFELINE MDD (restoration of ecological connectivity).

More information about the projects, including a short description and weblinks, can be found in Annex 19. Several of these projects like DriDanube, FRAMWAT, MARS or IDES are also of pollution relevance and both support and are supported by the ICPDR.

Hydromorphological pressures resulting from various hydro-engineering projects can significantly alter the natural structure of surface waters. This structure is essential to provide adequate habitats and conditions for self-sustaining aquatic species. The alteration of natural hydromorphological conditions can have negative effects on aquatic populations, which might result in failing the WFD environmental objectives.

Hydromorphological alterations in the DRBD are mainly caused by flood protection measures, hydropower, navigation, agriculture and water supply. In some cases, development schemes that are causing hydromorphological alterations serve to multiple purposes.

The following three key hydromorphological alterations of basin-wide importance have been identified, considering sequence of hydromorphological quality elements in the WFD:

a) Hydrological alterations,
b) Interruptions of longitudinal river continuity and sediment balance alterations,
c) Morphological alterations.

Hydrological alterations include impounded river sections, water abstractions and hydropeaking. Interruption of longitudinal river continuity can block fish migration and sediment transport. Morphological alterations can either be related to river morphological alteration itself or to the disconnection of wetlands/floodplains. Information on the extent of the alterations was updated in order to gain a full picture on the current situation. In addition, potential pressures that may result from future infrastructure projects are also dealt with. In this regard, the list of planned hydro-engineering projects has been updated and supplemented with additional information in Annex 7.

This chapter reflects findings on hydromorphological alterations and their significance from ICPDR reporting, as well as from the most recent national data taking into account progress in the implementation of the JPM from the DRBMP Update 2015 that are presented in Annex 16.

This chapter is based on updated data provided by all ICPDR Contracting Parties except for Bosnia and Herzegovina (partly), and Republic of Moldova. In cases where countries share river stretches, bilateral harmonisation of hydromorphological data is currently ongoing in order to avoid a potential distorting of the overall assessment and discrepancies in the results.

Update of the assessment of hydromorphological alterations in the Danube River – Joint Danube Survey 4 (2019)

Prior to the most recent Joint Danube Survey (JDS) of 2019, three had already been conducted, in 2001, 2007, and 2013. While JDS1 in 2001 included only general hydromorphological site descriptions the JDS2 in 2007 delivered first comprehensive results on hydromorphological alterations for the Danube River (from Kelheim (rkm 2,416) to the Danube Delta). JDS3 in 2013, was performed based on enhanced methodology for hydromorphological assessment which was updated in JDS4 in 2019.

The JDS2 methodology, which was based on the guidance CEN standard (CEN 14614:2004), was further extended and applied during JDS3 to 10 rkm segments of the Danube River. Within JDS3, the second CEN standard (CEN 15843:2010) on the calculation of hydromorphological assessments was performed. This also includes the 3-digit approach, which was applied by selecting relevant parameters for the assessment of morphological, hydrological and continuity elements. The assessment was based on a concise methodology, applicable for the whole 2,400 rkm long Danube river stretch assessed during the survey supplementing, but not substituting, the national hydromorphological assessments as required by the WFD. Additional detailed in-situ measurements and assessment of river cross sections and sediment grain size distribution for all of the 68 JDS3 monitoring sites was performed within JDS3, underpinning the results of the continuous assessment.

For JDS 4, the results from JDS3 were updated, based on new information on river restoration projects and/or new hydro-engineering projects causing new hydromorphological alterations that were implemented in the period 2013-2019. The results of JDS 4 are illustrated below. Figure 41 provides results on the 3-digit parameter groups "Morphology", "Hydrology" and "Continuity" for particular 10 rkm segment. The longitudinal visualisation represents a comprehensive overview of assessment results of impounded reaches with the position of dams. The overall results for the entire Danube River are illustrated in Figure 42.

Compared with the results from JDS3, an estimated 3% of Danube River length have improved due to river restoration measures whilst for 1% of the Danube River length new hydro-engineering projects have resulted in degradations (3-digit assessment). There are 7 segments with improvements (including 4 fish bypasses in the Upper Danube) and 2 segments with degradations (Lower Danube).

Regarding the individual changes, most are related to riverbank development with in total 34 changes. The removal of rip-rap clearly prevails within 23 cases. Side channel connections are rather frequent (8 times), followed by channel changes, which are recorded in conjunction with side-channel connections on the Middle Danube (five times), but also as degradation (four times due to infrastructure and dredging activities in the Lower Danube). As already mentioned, all the recorded continuum improvements were realized in the Upper Danube. Changes in flow conditions and flow regime caused by structures (groynes, dams with impoundments) were not reported at all.

Finally, it is interesting to note that JDS4 revealed that riparian bird species, as indicators, show a significant relationship between presence and absence of aquatic indicator species and hydromorphological classification. More detailed information on the approach and results of JDS4 can be obtained from the JDS4 report.

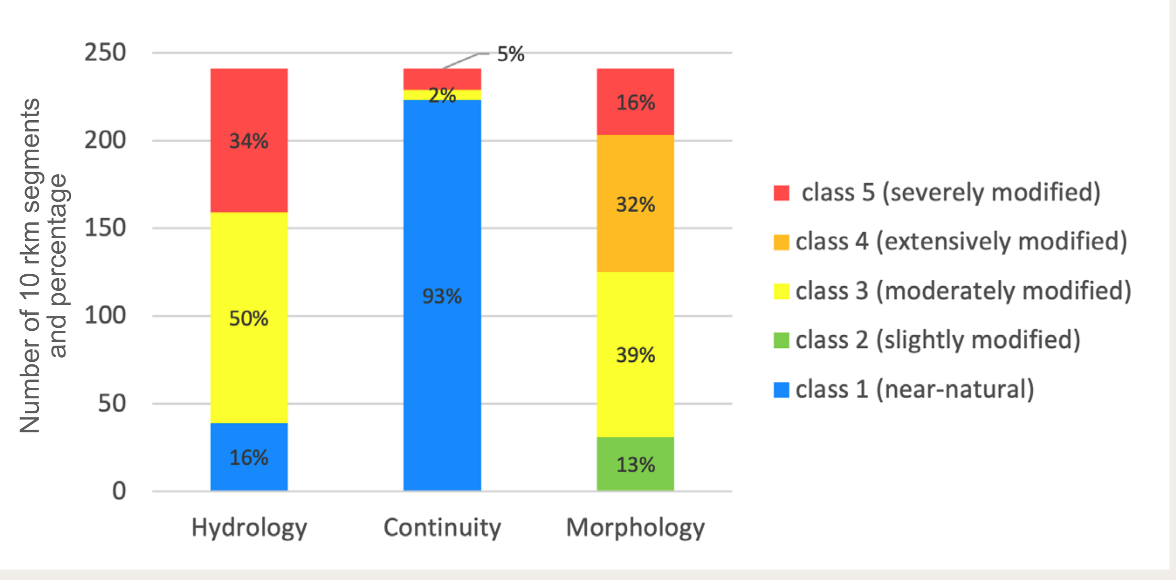


Figure 41: Overall results JDS4 3Digit assessment for the entire Danube

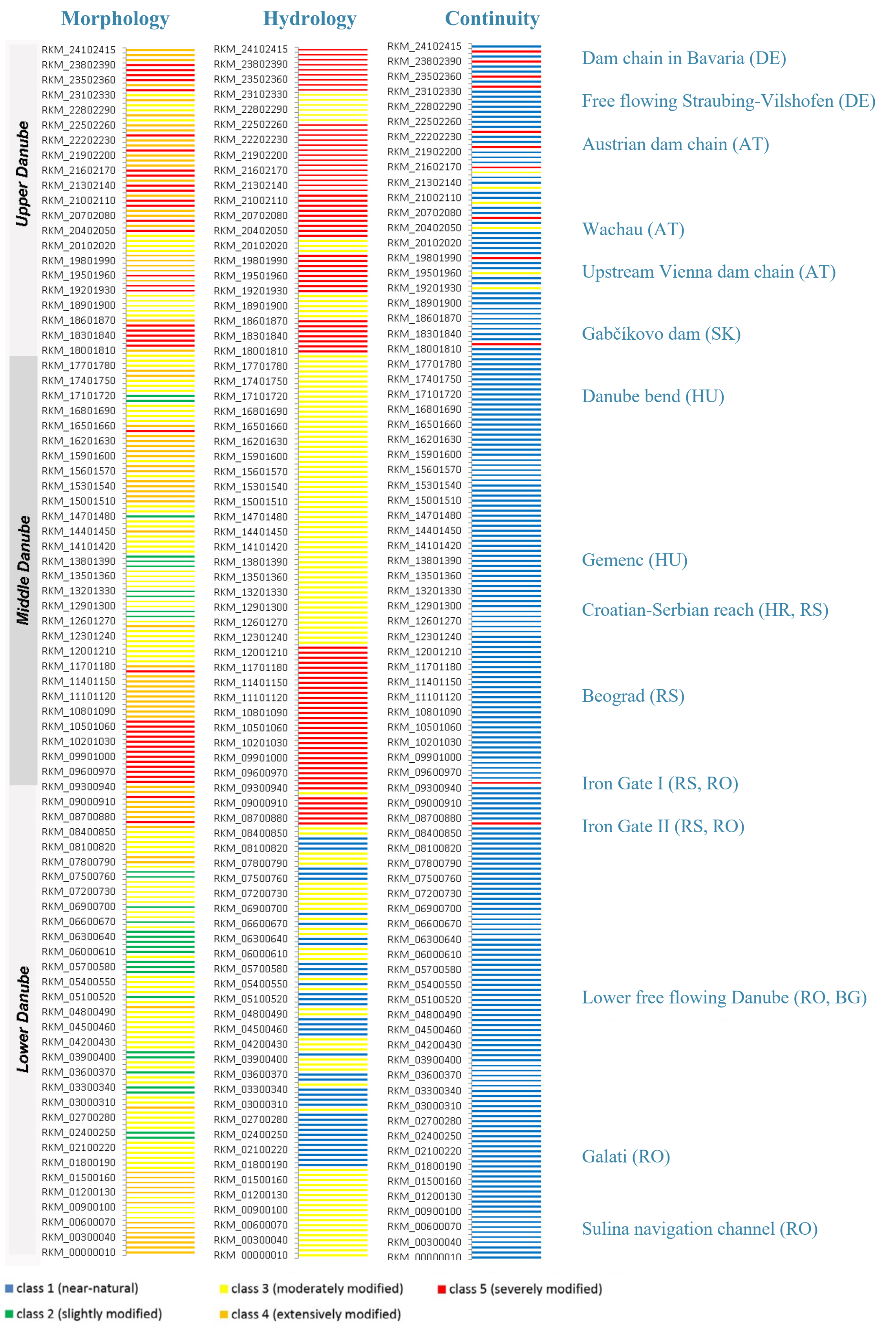


Figure 42: Longitudinal visualisation of the results of the 3Digit assessment

2.1.6.1 Hydrological Alterations

Hydrological alterations include pressures that are causing changes to the hydrological regime, i.e. quantity and dynamics of water flow and connection to groundwater bodies. Impoundments, water abstractions and hydropeaking were recognized as the main hydrological pressure types. An analysis of hydrological pressures was already performed for the DRBMP 2009, DRBMP Update 2015 and DRBMP Update 2021. This chapter provides a general overview on the current situation of hydrological alterations.

The main remaining hydrological pressures causing hydrological alterations are in numbers: 422 cases of significant impoundments, 69 cases of significant water abstractions and 42 cases of significant hydropeaking. The provoked alterations and applied criteria used for the assessment are shown in Table 15. Since monitoring of the effects of hydropeaking on biology needs to be improved, the actual number of significant cases might be higher compared to the currently known figures.

Table 15: Hydrological pressures, impacts and criteria for the significant pressure assessment

Hydrological pressure	Impacts	Criteria for significant pressure assessment
Impoundment	Alteration/reduction in flow velocity and flow regime of the river sections caused by artificial transversal structures, alteration of connection to groundwater bodies	Danube River: Impoundment length during low flow conditions >10 km Danube tributaries: Impoundment length during low flow conditions >1 km
Water abstraction /residual water	Alteration in quantity and dynamics of discharge/flow in water, alteration of connection to groundwater bodies	E-flow to achieve GES (according to CIS Guidance No. 31) is not guaranteed or flow below abstraction point <50% of mean annual minimum flow[32] in a specific time period (comparable with Q95)
Hydropeaking	Alteration of flow dynamics/discharge pattern in river and water quantity, alteration of connection to groundwater bodies	Water level fluctuation >1 m/day, the ratio of low flow to high flow is higher than 1:5, or less fluctuations in the case of known/observed negative effects on biology

The pressure analysis concludes that 326 water bodies located in the DRBD (33%) are impacted by significant hydrological pressures – 33 of them in the Danube River. Details on the distribution of hydrological pressures (impoundments, water abstractions and hydropeaking) and their significance according to the ICPDR criteria (Table 15) are outlined below as well as illustrated in Map 11, 12 and 13. Table 16 shows the number of DRBD water bodies affected by significant hydrological pressures (in absolute numbers and percentage).

Table 16: Number of river water bodies significantly impacted by hydrological pressures in relation to the overall water body number in the DRBD

	Danube River	DRBD tributaries	All DRBD rivers
Total number of WBs	63	912	975
impacted by impoundments	28 (29%)	241 (26%)	269 (28%)
impacted by water abstraction	5 (8%)	57 (6%)	62 (6%)
impacted by hydropeaking	1 (1%)	50 (5%)	51 (5%)
Total impacted	**33 (52%)**	**293 (32%)**	**326 (33%)**

32 *A pressure provoked by these uses is considered as significant when the remaining water flow below the water abstraction (e.g. below a hydropower dam) is too small to ensure the existence and development of self-sustaining aquatic populations and therefore hinders the achievement of the environmental objectives. Criteria for assessing the significance of alterations through water abstractions vary among EU countries. Respective definitions on minimum flows should be available in the national RBM Plans.*

2.1.6.1.1 Impoundments

Impoundments are caused by barriers that – in addition to interrupting river/habitat continuity – alter the upstream and downstream flow conditions of rivers. The character of the river is changed to lake-like conditions due to decrease of flow velocities and eventual alteration of flow discharge and sedimentation. Additionally, impoundments can also lead to severe changes to the river's sediment balance and to erosion and deepening processes downstream of the impounded section, inducing a decrease of the water table and consequently, dry out of the adjacent land and wetlands. However, impoundment can raise the level of the water table causing in some cases the salinification of soil/cultivated land.

The pressure analysis concludes that 422[33] significant impoundments are located in the DRBD (see Figure 43 and Map 11) affecting 269 water bodies. It can be concluded that out of 29,127 km of all river water bodies in the DRBD with catchment areas > 4,000 km^2 4,502 rkm are affected by impoundments. In total, 320 significant impoundments are present on HMWB or AWB, 96 significant impoundments on natural water bodies and 6 on both HMWB/AWB and natural water bodies. 95 significant impoundments are also decisive criteria for designation of 83 HMWB out of 377 HMWB (of which 52 are provisionally HMWB) in the DRBD.

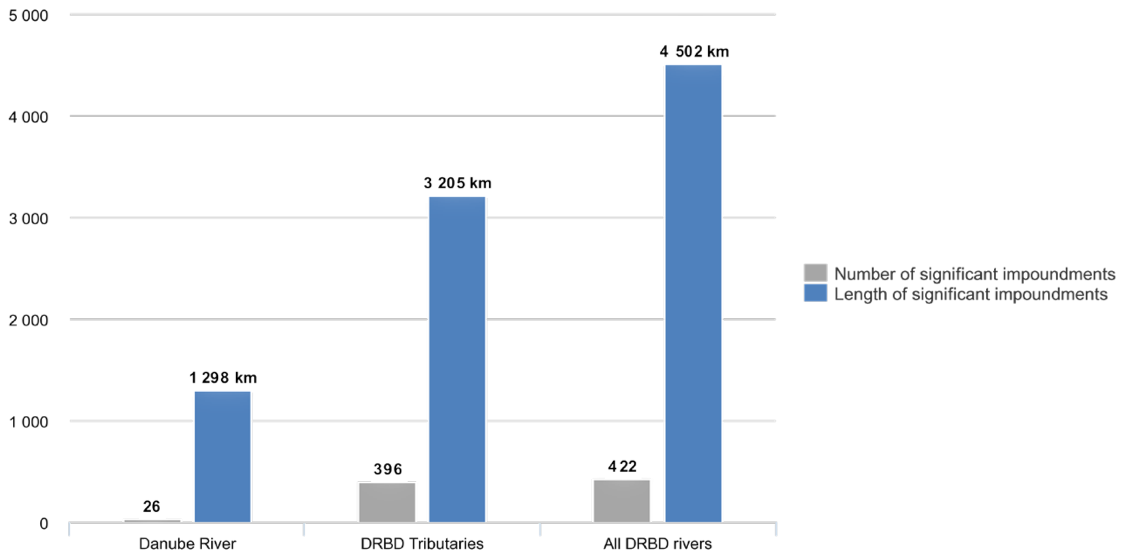


Figure 43: Number and length of significant impoundments in the Danube River and tributaries

The mean length of significant impoundmets in the Danube is 46 km while it is 8 km in the DRBD tributaries. Consequently, 29% of the impounded length is located in the Danube River, while this applies only to 6% of the number of significant impoundments.

For the Danube River, significant impoundments are the key hydrological pressure type causing significant alterations. Approximately, 1,069 km of its entire length (of 2,857 km) are impounded (representing 37% of the length) by 26 barriers.

The comparison of the number of significant impoundments between 2009 and 2015 show a decrease in significant impoundments from 448 to 403, mainly due to increased accuracy in reported data. Taking into account the comparison between 2015 and 2021, the number of significant impoundments slightly increased from 403 in 2015 to 422 in 2021 (i.e. an increase by 19 significant impoundments).

33 *Two impoundments are located on the national border between Romania and Serbia and are reported as transboundary object (thus these two impoundments are not double-counted in total number of impoundments).*

The impoundment upstream of the Iron Gate 1 Dam affects the flow of the Danube River over a length of around 500 km up to Novi Sad (18% of the entire length of the Danube River) and represents a significant pressure. In the middle Danube Basin, the Gabčíkovo Dam impounds around 25 km (less than 1% of the entire length) of the Danube River and the AT/DE chains of hydropower plants impound a major share of the upper Danube River (approx. 540 rkm or around 19%). However, significant free-flowing stretches are located upstream of Novi Sad to the Gabčíkovo Dam and downstream of the Iron Gate 2 Dam to the Black Sea. Number of significant impoundments in the Danube River and main Danube tributaries per Danube country is presented in Figure 44.

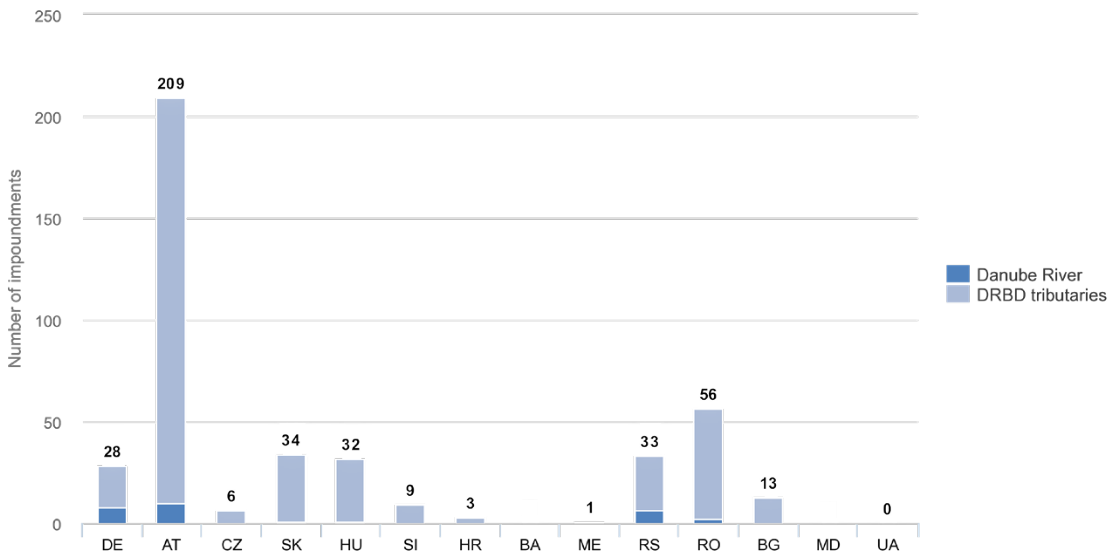


Figure 44: Number of significant impoundments in the Danube River and tributaries per country[34]

2.1.6.1.2 Water Abstractions

Water abstractions can significantly reduce the flow and quantity of water. They can also influence on sediment transport and morphological conditions and thus impact the water status in case where the ecological flow of rivers is not guaranteed. Addressing this important issue, a guidance on ecological parameters/ecological flows and hydrological parameters for assessing quantitative aspects and the link to GES was elaborated in the frame of the WFD CIS process[35].

In the DRBD, the key water uses causing significant alterations through water abstractions are mainly hydropower generation (96%), public water supply (1%), agriculture (1%) and others (1%). A share of 14% of water abstractions serve multiple purposes. The pressure analysis concludes that in total 69 significant water abstractions are causing alterations in water flow in DRBD rivers (see Map 12). In total, 62 water bodies are affected by these pressures. The Danube River itself is only impacted by alterations through water abstractions in Germany. There are 29 HMWB or AWB and 33 natural water bodies under significant water abstractions. Three significant water abstractions are also the decisive criteria for designation of 3 HMWB out of 377 HMWB (of which 52 are provisionally HMWB) in the DRBD.

34 Two impoundments are located on the national border between Romania and Serbia and are reported as transboundary object (thus these two impoundments are not double-counted in total number of impoundments).

35 EU Guidance Document No. 31 on "Ecological flows in the implementation of the Water Framework Directive".

The comparison of reported data on number of significant water abstractions between 2009, 2015 and 2021 shows that data are not comparable, mainly due to improved data accuracy and updated methodologies for defining significant water abstractions. Number of significant water abstractions in 2021 the Danube River and main Danube tributaries is presented in Figure 45.

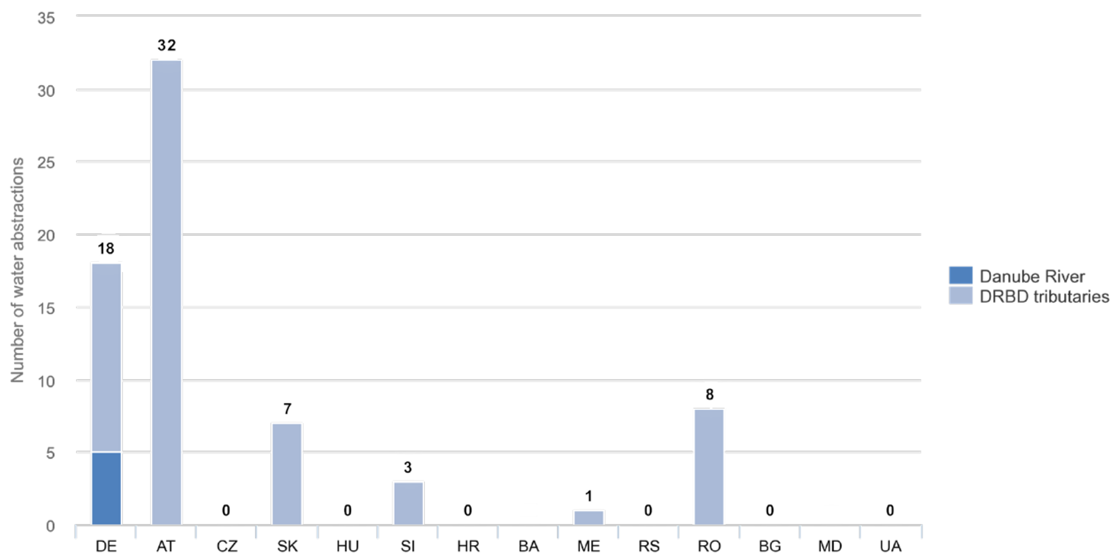


Figure 45: Number of significant water abstractions in the Danube River and tributaries per country

2.1.6.1.3 Hydropeaking

Hydropeaking is a pressure that occurs in the DRBD, stemming from hydropower generation for the provision of peak electricity supply resulting in artificial water level fluctuation. While hydropeaking is induced locally at the water outflow, hydropeaking waves can migrate far downstream. Consequently, is possible, that hydropeaking is induced by one (upstream) country, but the impacts are identified also in the downstream country.

Data was collected based on the ICPDR criterion (Table 15), whereas in total 42 cases of hydropeaking are causing significant water level fluctuations larger than 1 m/day below a hydropower plant or less in the case of known negative effects on water status (see Map 13). Overall, 51 water bodies are affected by significant hydropeaking, 1 of them located on the (Upper) Danube[36]. 31 HMWB and 20 natural water bodies are significantly impacted by hydropeaking. Three cases of hydropeaking are also the decisive criteria for designation of 3 HMWB out of 377 HMWB (of which 52 are provisionally HMWB) in the DRBD.

The comparison of number of significant hydropeaking between 2009 and 2015 shows a decrease of significant hydropeaking, mainly due to increased accuracy of reported data. Comparing data in 2015 and 2021, the number of significant hydropeaking slightly increased from 38 in 2015 to 42 in 2021. The number of significant hydropeaking cases in the Danube River and tributaries per country is presented in Figure 46.

36 RO and RS agreed that, considering ICPDR criteria for significant pressure assessment regarding hydropeaking (water level fluctuation >1 m/day or less in the case of knowns/observed negative effects on biology), and the data registered in the hydrometric stations downstream from the Iron Gates, hydropeaking below Iron Gate dams is not a significant pressure.

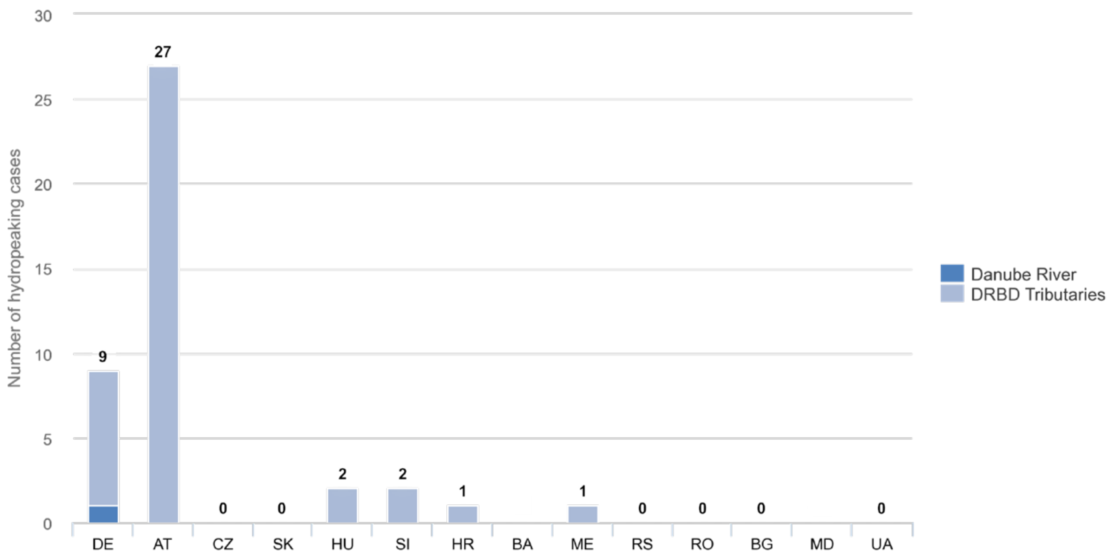


Figure 46: Number of significant hydropeaking cases in the Danube River and tributaries per country

2.1.6.2 Interruptions of River Continuity and Sediment Balance Alterations

Transversal structures in the rivers like dams[37] and weirs[38] are interrupting the longitudinal continuity and therefore could hinder fish from migration. Further effects of transversal structures are also changes in the natural sediment dynamics, reflecting as river bed incision/aggradation due to the interruption of sediment transport.

Analysis of interruptions of river continuity for fish migration was already performed for the DRBMP 2009, DRBMP Update 2015 and DRBMP Update 2021, while interruption of sediment transport is analysed in more detail only within DRBMP Update 2021. Since there is currently no ICPDR reporting on sediment pressures from Danube countries, data from the Interreg Project DanubeSediment are included in the DRBMP Update 2021. The project assessed the sediment budget of the Danube River, and identified reaches with surplus and deficit of sediment on the basis of presence of dams/weirs as well as other pressures influencing sediment transport (e.g. flood protection and navigation river regulation works).

2.1.6.2.1 Interruptions of River Continuity for Fish Migration

Transversal structures (such as dams and weirs) in rivers intended for flood protection, hydropower, agriculture, water supply, navigation and other hydro-engineering purposes act as barriers for the migration of fish (and other biota) and their access to relevant habitats and spawning grounds. This chapter provides a general overview on the current situation of interruptions of river continuity for fish migration. Table 17 provides information on the applied criteria for the significant pressure assessment on interruptions of river continuity for fish migration.

37 *According to International Glossary of Hydrology, UNESCO-OMM - 1992, Pierre Hubert, the term "dam" is defined as follows: "Barrier constructed across a valley to store water or to raise the water level".*

38 *According to International Glossary of Hydrology, UNESCO-OMM - 1992, Pierre Hubert, the term "weir" is defined as follows: "Overflow structure which may be used for controlling upstream water level or for measuring discharge or for both".*

Table 17: Interruptions of river continuity for fish migration, impacts and criteria for the significant pressure assessment

River continuity pressure	Impacts	Criteria for significant pressure assessment
Transversal structure (barrier)	Interruption of fish migration and access to habitats	Anthropogenic interruption, rhithral >0.7 m height, potamal >0.3 m height, or lower in case considered as relevant on the national level[39]

There are 965 interruptions located in DRBD rivers with catchment areas >4,000 km^2 (see Map 14). 640 of the interruptions are dams/weirs, 218 are ramps/sills and 107 are classed as other types of interruptions. The key driving forces causing interruption of river continuity are hydropower generation (56%), flood protection (19%) and water supply (15%). 20% of barriers are not linked to a single purpose due to their multifunctional characteristics (e.g. hydropower use and navigation). 528 significant interruptions are present on HMWB or AWB and 437 significant interruptions on natural water bodies. 186 significant interruptions are also decisive criteria for designation of 96 HMWB out of 377 HMWB (of which 52 are provisionally HMWB) in the DRBD.

A comparison of number of significant interruptions between 2009 and 2015 showed that data are not comparable, because data reported in 2009 did not meet the criteria for the pressure assessments (e.g. also river bed stabilisation structures for flood risk management like ramps of limited height were reported). Taking into account the comparison between 2015 and 2021, the number of significant interruptions decreased from 1,030 to 965, mainly due to increased data accuracy.

58% of the significant interruptions were reported to cause a water level difference of less or equal to 5 m under average conditions, 23% cause a water level difference between 6 and 15 m, and 7% are large dams with water level differences of more than 15 m. For the remaining 118 significant interruptions (12%) data on the water level difference is not available.

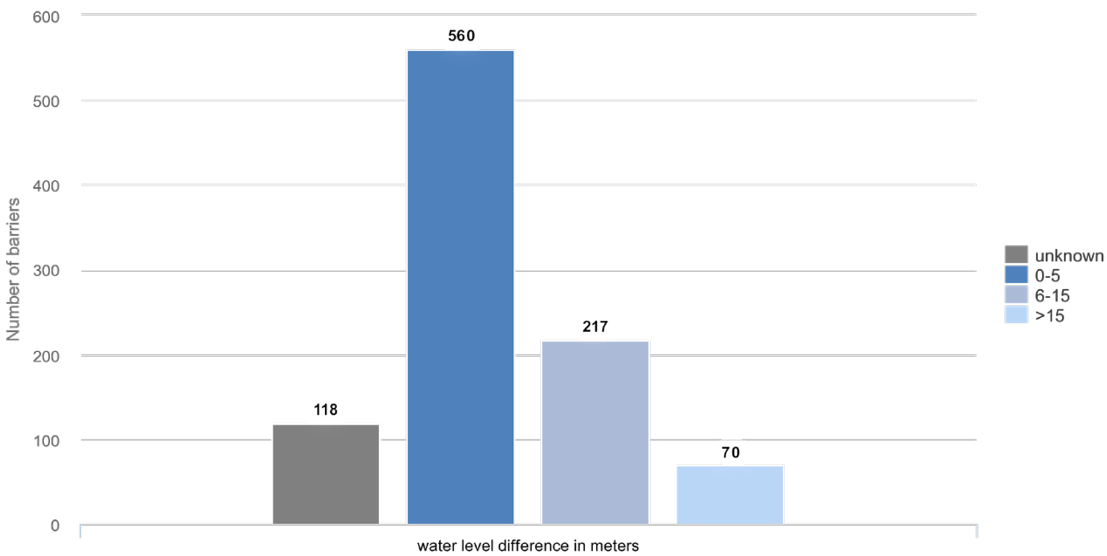


Figure 47: Number of interruptions of river continuity for fish migration classified by their height

312 of the significant interruptions were reported by the countries to be equipped with functional fish migration aids in 2021. 35 significant interruptions are passable on the Danube River and 277 significant interruptions on Danube tributaries. Including 13 significant interruptions with unknown passability, a total of 624 continuity interruptions (65%) will remain a hindrance for fish migration as of 2021 (46 significant interruptions on Danube River and 578 on tributaries) among which 90 significant interruptions are currently not passable but not relevant for the achievement of the GES/GEP (details see Map 14).

39 Rhithral are the headwater sections of rivers and potamal the lowland sections.

Out of the 975 water bodies in the DRBD, 357 are affected by significant interruptions for fish migration, out of which 93 are passable for fish. Consequently, 264 water bodies in the DRBD are significantly altered by interruption of river continuity and are un-passable for fish. This is 27% of the total number of DRBD water bodies (Table 18).

Table 18: Number of river water bodies significantly altered by interruptions of river continuity unpassable for fish species in DRBD

	Number of WBs	WBs with un-passable barriers	% of WBs with un-passable barriers
Danube River	63	20	32%
DRBD tributaries	912	244	27%
All DRBD rivers	**975**	**264**	**27%**

For the Danube River itself, 81 significant interruptions were identified on 27 water bodies, the majority of them located in the Upper Danube, out of which 35 interruptions are passable for fish by 2021. Although important progress on addressing this issue is made (e.g. 27 out of 65 migration barriers in Germany and 6 out of 10 migration barriers in the Austrian chain of hydropower dams have been equipped with fish migration aid), there are remaining significant interruptions of the AT/DE chain of hydropower dams, as well as the Gabčíkovo Dam (SK) and the Iron Gate Dams I & II (RO/RS). These significant interruptions of river continuity for the Danube River are posing problems, i.e. for long and medium distance migratory fish species.

More detailed information on the number of interruptions and associated main uses in the Danube River and tributaries per country is illustrated in Figure 48.

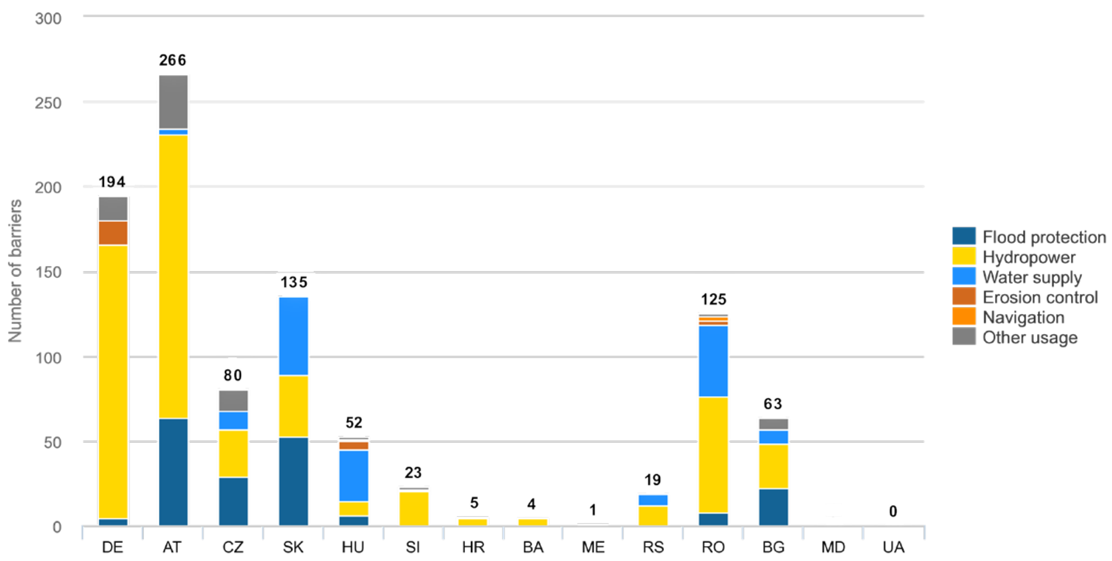


Figure 48: Number of interruptions and associated main uses in Danube River and tributaries per country[40]

2.1.6.2.2 Sediment Balance Alterations

Sediments are a natural part of aquatic systems. Many aquatic species rely on a natural sediment balance and the provision of type-specific habitats. During the past centuries, humans have strongly altered the Danube River and its tributaries. For the Danube River and its major tributaries flood protection, hydropower, water supply, commercial dredging, navigation, and land use (e.g. agriculture) are the main drivers for the alteration

40 *Transboundary continuity interruptions may be indicated for each country and are therefore double-counted in the total sum of the table, what was avoided in the respective figure.*

of the sediment regime. Analysis was prepared also separately for Upper Danube River (from source to rkm 1790), Middle Danube River (from rkm 1790 - 943) and Lower Danube River (from rkm 943 to mouth).

Human interference has led to a sediment deficit and an increased sediment transport capacity in the free-flowing sections, which in turn leads to riverbed incision as well as bank and coastal erosion. In impounded sections, on active floodplains and around groyne fields, a surplus of sediments dominates. Due to the reduced flow velocities, sedimentation occurs in the impoundments of run-of-river hydropower plants and reservoirs of storage hydropower plants. In case of major flood events, fine sediments can be remobilized. Such an event can lead to major problems for the river ecosystem and to sedimentation in the floodplain and settlements which can significantly increase damages and thus flood risk. These changes may also reduce navigation possibilities and hydropower production and negatively influence groundwater levels and connections. The quantitative sediment issue in the Danube River Basin was analysed within Interreg DTP DanubeSediment Project. The following paragraphs provide a general overview of the results gained in the frame of the DanubeSediment Project (see box), which are also summarized within this chapter on sediment balance alteration.

DanubeSediment Project

In 2004, ICPDR identified a sediment deficit in the Danube, naming dam construction and regulation works as the main pressures. In 2006, a Sediment Issue paper was prepared by Austria, Hungary and Romania in cooperation with ICPDR Secretariat in order to address sediment quality and quantity. The aspect of sediment quantity in the DRB was already mentioned in the DRBMP 2009 and considered as potential Significant Water Management Issue in 2013, since the sediment balance of most large rivers within the DRBD can be characterized as disturbed or severely altered. In order to propose appropriate measures for improving the situation, additional investigations related to the sediment balance and the significance of sediment transport were required on a basin-wide scale. To tackle this challenge, the Interreg DTP Project "DanubeSediment" (Danube Sediment Management - Restoration of the Sediment Balance in the Danube River; co-funded by the European Union ERDF and IPA funds in the frame of the Danube Transnational Programme) was launched in 2017. Policy makers, researchers, administrations, environmental organisations and companies from nine Danubian countries worked together in order to close knowledge gaps and strengthen governance in the Danube catchment.

In the DanubeSediment Project there were 4 key technical work packages (WPs). In WP 3 "Sediment Data Collection" the project partners collected data on sediment transport throughout the Danube and its main tributaries, at the monitoring station closest to the confluence, and evaluated the changes between current and historic data along the course of the Danube River. Joint measurement campaigns enabled a comparison of techniques and allowed to suggest a harmonized monitoring method for collecting sediment data. With these data, and information on riverbed changes as well as data on dredging and feeding the sources, sinks and redistribution of sediment throughout the Danube were analysed and reaches with erosion and sedimentation were identified within WP 4 "Danube Sediment Balance" as a first step towards a sediment balance. This information was supplemented by the analysis on long-term morphological changes.

Following the DPSIR (Drivers, Pressures, States, Impacts and Responses) approach the key drivers and pressures in the Danube River Basin that act on the sediment regime were identified and their impacts were described in WP 5 "Impacts and measures". Furthermore, good practice examples on sediment management measures already implemented in the Danube River Basin were collected and a Catalogue of sediment measures has been developed. In order to strengthen governance, in WP 6 "Sediment management" specific measures for reducing the impact of disturbed sediment balance (e.g. on the ecological status and on flood risk) were summarized in the "**Danube Sediment Management Guidance**" (DSMG, Habersack et al., 2019a).[41] Furthermore, the project prepared a "**Sediment Manual for Stakeholders**" (SMS, Habersack et al., 2019b)[42] in order to support international training workshops for relevant target groups (e.g. hydropower, navigation, flood risk). The document provides background information and concrete examples for implementing good practice measures in each field to assist the implementation of sediment related actions in the Danube River Basin and future programmes of measures. Furthermore, these documents contain general recommendations to improve sediment management (e.g. development of a basin-wide sediment management concept) and specific recommendations for the Upper, Middle and Lower Danube Delta and Coast as well as for different stakeholders.

First hydromorphological pressures related to sediment balance go back to the beginning of the 19th century, when systematic training works for flood protection and navigation were executed in large parts of the Danube River, consequently changing the river morphology. In the Upper Danube, the total river width was decreased on average by 39 % (the active width by 22 %) and in the Middle Danube by 12 % (the active width by 1 %). Additionally, the gradient of the Danube River was steepened by reducing the length of the river by about 100 km (-11 %) in the Upper Danube, about 30 km (-4 %) in the Middle Danube. The length of the Lower Danube was decreased by around 1 % and the mean total width was reduced by 4 %. This led to an increased sediment transport capacity in the free-flowing sections. Furthermore, the lateral exchange of sediments is hindered by bank protection measures, cut-off side channels (due to river regulation or incision of the riverbed) and flood dykes.

At the end of the 19th century and the beginning of the 20th century, at the Danube River the first transversal structures (weirs, dams) were constructed for hydropower use and water supply and longitudinal structures for flood protection even earlier.

Downstream of hydropower plants, e.g. HPP Freudenau, HPP Gabčikovo and HPP Iron Gate II, a lack of sediments can be observed leading to riverbed erosion and subsequently to incision of the riverbed. Main hydromorphological pressures related to sediment balance for the Danube and (within DanubeSediment Project) selected tributaries are shown on Figure 49. Furthermore, in general dredging (e.g. for navigation) has a significant influence on the sediment balance.

41 Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Babic-Mladenovic M., Cibilic A., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019a): Danube Sediment Management Guidance. Output 6.1 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.

42 Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019b): Sediment Manual for Stakeholders. Output 6.2 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.

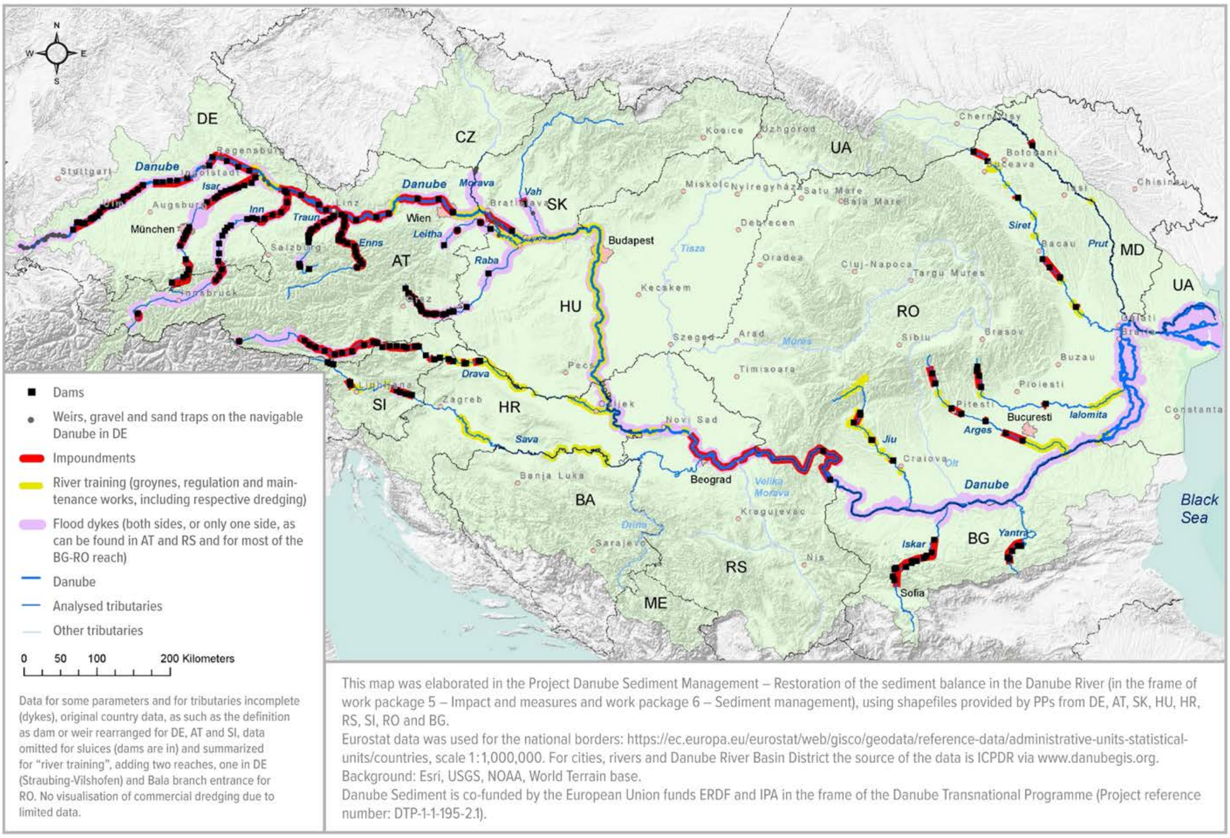


Figure 49: Overall pressures related to sediment regime for the Danube River and selected tributaries (Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019b). Sediment Manual for Stakeholders. Output 6.2 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.)

Based on the collected suspended sediment data, a balance for the Danube River and the major tributaries was prepared to compare the present situation (1986-2016) with the historic situation before the construction of the hydropower plants on the Danube River. The comparison highlights that the decrease of suspended sediment input from the tributaries (20-70% for tributaries with sufficient data for both periods), especially in the Middle and Lower Danube, leads to a reduction of suspended sediment transport in the Danube River. The chain of HPPs on the Upper Danube and especially the large reservoirs of Gabčikovo and Iron Gate I have an impact on the suspended sediment balance. All these HPPs contribute in varying degrees to the total sediment deficit in the Danube River. A portion of the sediments entering the reservoirs has already been reduced by impoundments and reservoirs upstream and at tributaries. 60% of the sediment is deposited in the HPP Gabčikovo reservoir and 60-80% of the sediment input in the HPP Iron Gate I reservoir (now less than at the beginning of the commissioning of the hydropower plant).

This data is calculated by comparing the monitoring stations upstream and downstream of the reservoirs as described in the DanubeSediment report "Analysis of Sediment Data Collected along the Danube". The sedimentation rate of HPP Iron Gate I (filling of the reservoir), based also on bathymetric surveys (sedimentation volume compared to the original reservoir volume), is 10-17%. As a consequence, the mean annual suspended sediment input to the Danube Delta and the Black Sea decreased by more than 60%, from former amounts of about 60 Mt/yr (into the Danube Delta) and 40 Mt/yr (into the Black Sea) to approximately 20 Mt/yr and 15 Mt/yr nowadays.[43] From Ceatal Izmail to the Black Sea, the suspended sediment load is decreasing,

43 *Measured at the monitoring station Ceatal Izmail for the input into the Danube Delta for 1931-1972 and 1986-2016; input to the Black Sea measured and summed up for the stations Periprava, Sfantul Gheorghe Harbour and Sulina for 1986 – 2016 and determined from the stations Periprava (measured), Sfantul Gheorghe Harbour and Sulina (back calculated) for 1961 – 1972.*

although there are also uncertainties at the last monitoring stations due to tidal influence from the Black Sea. The data set for bedload in the Danube River is significantly smaller and not sufficient for the creation of a bedload balance for the whole river system. The few stations where both suspended sediment and bedload data were collected, reveal that bedload ranges between 5-10% of the total load with higher local shares (e.g. ~20% downstream of HPP Gabčikovo due to sedimentation in the reservoirs and erosion of bed material downstream). Even though bedload makes up a smaller fraction of sediment transport, it is above all bedload transport that determines the river morphology, especially in free-flowing sections. In total about 733 rkm (29%) of the Danube River is dominated by erosion (56% when including 670 rkm with erosional trend in the Lower Danube) and 857 rkm (34%) of the Danube River by sedimentation. Along 241 rkm (10%) of the Danube River, a dynamic balance prevails, or no significant changes occur[44]. Danube river sections under sedimentation and erosion are presented on Figure 50.

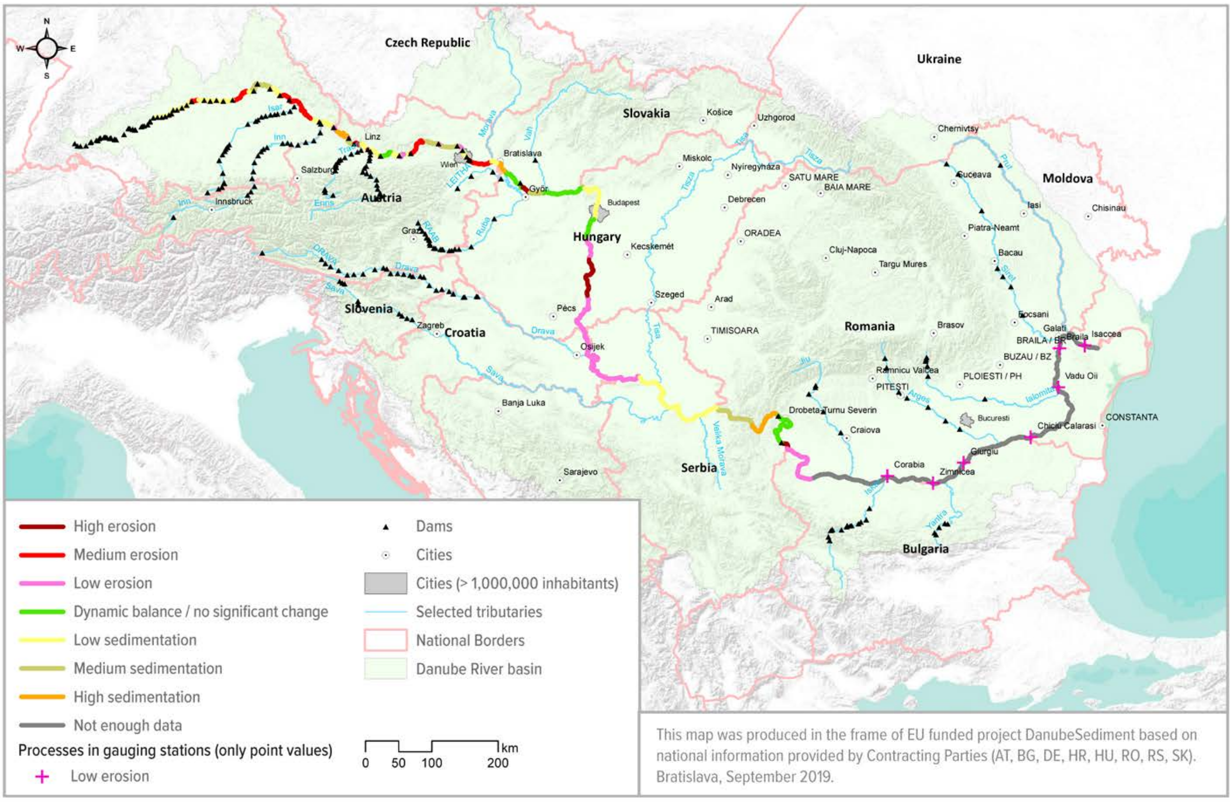


Figure 50: Danube River sections under sedimentation and erosion (Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019b). Sediment Manual for Stakeholders. Output 6.2 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.)

2.1.6.3 Morphological Alterations

Morphological alterations include pressures that are causing changes to river bed, banks and floodplains, i.e. changes of river depth and width variation, structure and substrate of the river bed and structure of the riparian zone. Within morphological alterations also pressures related to disconnection of wetlands/floodplains are included. Analysis of morphological pressures was already performed for the DRBMP 2009, DRBMP Update 2015 and DRBMP Update 2021.

44 *Reaches of sedimentation or erosion were identified for the Upper and Middle Danube as well as for a short section at the Lower Danube, meaning from rkm 2582 to rkm 750 for the period 1991-2017. For the greater part of the Lower Danube (670 rkm, from rkm 750 to 80), there was not enough data available for this period to evaluate changes in the riverbed in detail.*

This chapter provides a general overview on the current situation of morphological alterations. Additionally, reference morphological conditions for the Danube River were analysed within the DanubeSediment Project. The definition of the reference morphological conditions is based on existing historical maps from the period 1806-1910, where it is evident that in this period there were no systematic regulation works present on the Danube River. Comparison between the reference river morphological type of the Danube River (Figure 51) and present (altered) morphological type (Figure 52) shows that the former complex river morphology with meandering and sinuous river types and several multi-thread anabranching reaches in the Upper and Middle Danube has changed to a single-thread sinuous river type. At the same time, naturally formed sediment bars, islands, side channels and oxbow lakes have been drastically reduced.

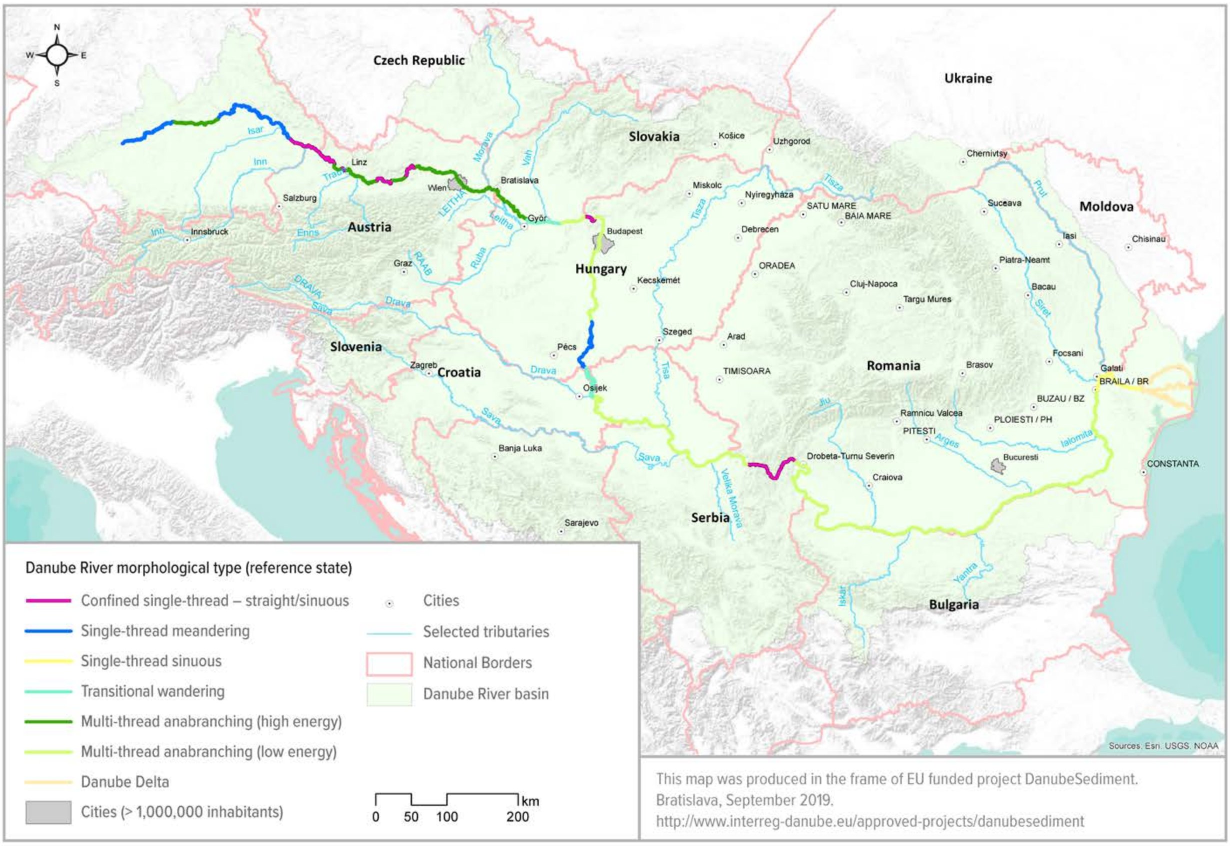


Figure 51: Danube River morphological type in reference state (Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019b). Sediment Manual for Stakeholders. Output 6.2 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.)

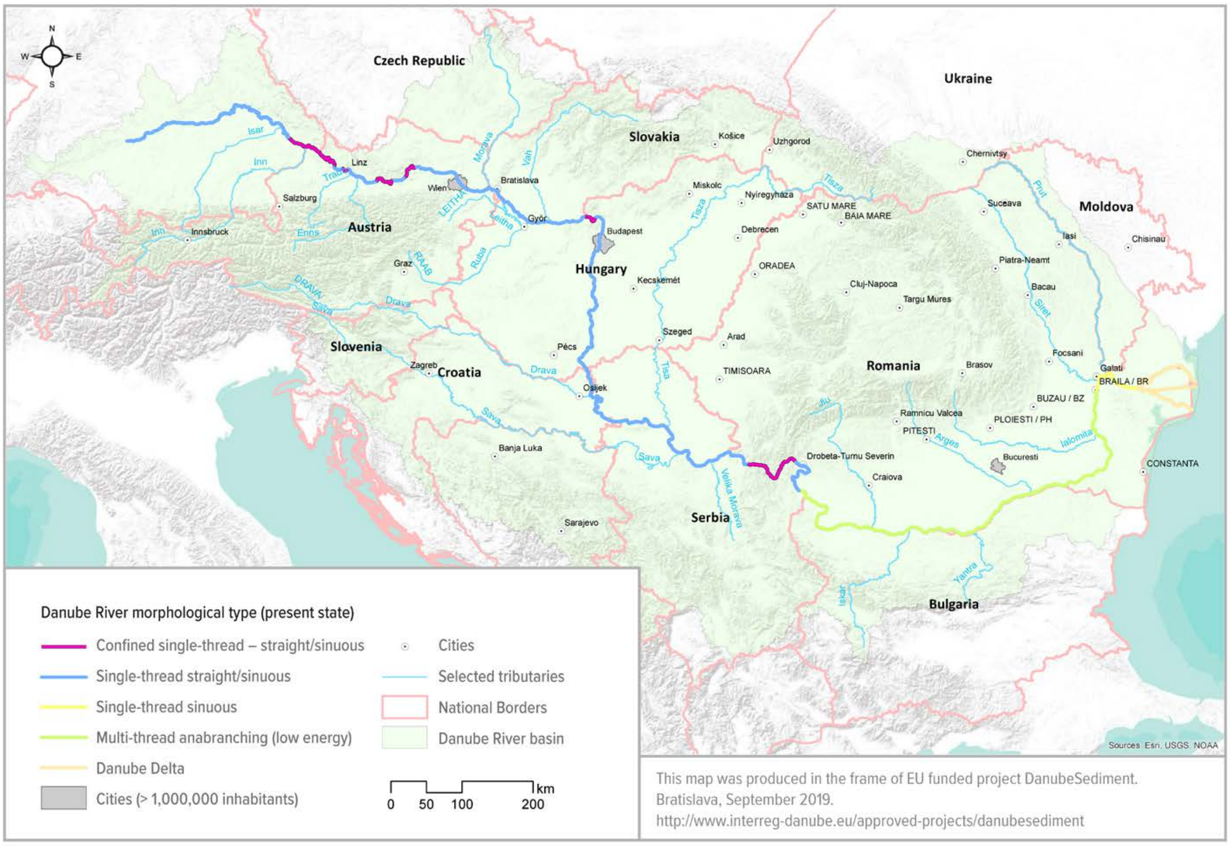


Figure 52: Danube River morphological type in present state (Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019b). Sediment Manual for Stakeholders. Output 6.2 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.)

2.1.6.3.1 River Morphological Alterations

Deterioration of the natural river morphological conditions influences habitats of the aquatic flora and fauna and can therefore impact river ecology and water status. Therefore, the WFD requires in Annex II the identification of significant morphological alterations to water bodies. Morphological alterations are mainly caused by river regulation works and intensive land use. As the main morphological pressures are recognized river straightening and re-profiling, river steepening, bank reinforcement, riverbed stabilisation, intensive use of the riparian zone and flood defence systems (changes of floodplains). Table 19 provides information on the applied criteria for the significant pressure assessment on morphological conditions.

Table 19: Morphological pressures, impacts and criteria for the significant pressure assessment

Morphological pressure	Impacts	Criteria for significant pressure assessment
River regulation works Intensive land use within riparian zone and active floodplain	Alteration of river depth and width variation, alteration of structure and substrate of the riverbed, alteration of structure of riparian zone	Morphological class assessment ≥ 3 (moderately altered) or class 2-5 (slightly altered to severely altered) in the two-class system

Aggregated information on the river morphological alteration was collected on the level of the water bodies. Since most countries have a five-class system (some countries have also seven-classes or three-classes system) in place for the assessment of the morphological condition, it was agreed to provide information on the morphological alterations of water bodies in the following three classes:

- Near-natural to slightly altered (class 1-2);
- Moderately altered (class 3);
- Extensively to severely altered (class 4-5).

In two countries a two-class system is in place, whereas data is indicated separately according to the following classification:

- Near-natural (class 1);
- Slightly altered to severely altered (class 2-5).

The pressure analysis concludes that 198 (20%, ~3,819 km) out of the total 975 river water bodies are near natural to slightly altered. 152 water bodies (16%, ~4,851 km) were reported to be moderately altered and 183 (19%, ~3,407 km) extensively to severely altered (see Map 15). 153 water bodies (16%, 7,760 km) reported in the 2-class system are near natural and 217 (22%, ~6,935 km) are slightly to severely altered. For the remaining 72 water bodies (7%, ~2,354 km) no information on the classification of river morphology is yet available.

The number of significant river morphological alterations in the Danube River and main Danube tributaries per Danube country is presented in Figure 53.

Considering criteria for significant pressures assessment (Table 19), 332 significant river morphological alterations are present on HMWB or AWB and 220 significant river morphological alterations on natural water bodies. Significant river morphology pressures are decisive criteria for designation of 126 HMWB out of 377 HMWB (of which 52 are provisionally HMWB) in the DRBD.

Since morphological data were not yet reported in the first cycle (2009), the comparison of reported data is possible only for the second and third cycle (i.e. 2015 and 2021). The length of water bodies that are under significant morphological alteration increased for class 3 from 4,450 km to 4,851 km and decreased for class 4-5 from 4,773 km to 3,407 km and class 2-5 from 8,831 to 6,935 km.

Due to different scoring systems, the comparison of results for significant morphological alteration is very difficult and further harmonisation efforts are required in the future towards a better comparable assessment of significant morphological alterations in the DRBD.

More detailed information on the length of water bodies in particular morphological class for the Danube River and tributaries per country is illustrated in Figure 64.

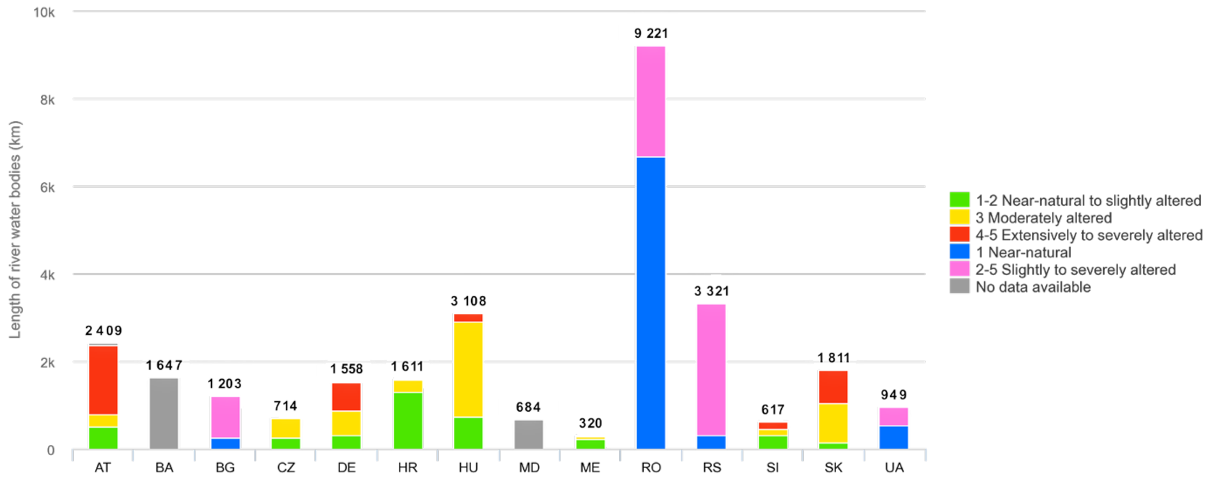


Figure 53: Length of water bodies in particular morphological class in Danube River and tributaries per country

2.1.6.3.2 Disconnection of Adjacent Floodplains/Wetlands

Wetlands/floodplains and their connection to adjacent river water bodies play an important role in the functioning of aquatic ecosystems by providing important habitats for fish as well as other fauna and have a positive effect on water status of surface and groundwater bodies. Connected wetlands/floodplains increase the retention capacity during flood events, may also have positive effects concerning drought mitigation and the reduction of nutrients, siltation of riverbeds, and mitigate adverse effects of climate change, water scarcity and droughts.

Analysis of disconnection of wetlands/floodplains was already performed for the DRBMP 2009, DRBMP Update 2015 and DRBMP Update 2021. This chapter provides a general overview on the current situation of disconnection of wetlands/floodplains.

River regulation works and intensive land use within riparian and adjacent land are recognized as the main pressures related to disconnection of wetlands/floodplains. Table 20 provides information on the applied criteria for the significant pressure assessment on disconnection of wetlands/floodplains.

Table 20: Disconnection of adjacent wetlands/floodplains, provoked alterations and criteria for the significant pressure assessment

Morphological pressure	Provoked alteration	Criteria for significant pressure assessment
River regulation works Intensive land use within riparian and adjacent land	Alteration of adjacent wetlands/floodplains	All disconnected wetlands/floodplains >500 ha and smaller ones of basin-wide significance, with a definite potential for reconnection or with potential for improvement of lateral connectivity within the active wetland/floodplain.

Table 21 shows the number of water bodies in the DRBD (in absolute numbers and percentage) which have the potential to benefit from reconnected wetlands/floodplains.

The criteria for significant pressures assessment (Table 20) apply to 42 wetlands/floodplains, of which 12 significant disconnection of adjacent wetlands/floodplains are present on HMWB or AWB and 30 significant disconnection of adjacent wetlands/floodplains on natural water bodies. One significant disconnection of adjacent wetlands/floodplains are decisive criteria for designation of HMWB in the DRBD.

Table 21: Number of water bodies with disconnected wetlands/floodplains, having a reconnection potential in the Danube River and main Danube tributaries

	Number of WBs	WBs with disconnected wetlands/floodplains and reconnection potential	% of WBs with disconnected wetlands/floodplains and reconnection potential
Danube River	63	11	17
DRBD tributaries	912	11	1
All DRBD rivers	**975**	**22**	**2**

The DRBMP 2009 concluded that compared to the 19th century, less than 19% of the former floodplain area (7,845 km^2 out of a once 41,605 km^2) remain connected to the Danube River. This is caused in particular due to the expansion of agricultural uses and the disconnection from water bodies due to river engineering works concerning mainly flood control, navigation and hydropower generation.

In total 144,659 ha of wetlands/floodplains have been identified to have a reconnection potential in the DRBD. Out of these 3,590 ha are totally, and 84,875 ha are partly reconnected where some of the required measures were already completed but further measures are planned, having positive effects on water status and flood protection improvement. The remaining wetlands/floodplains, covering an area of 56,194 ha, have a remaining potential to be re-connected to the Danube River and its tributaries (see Map 16).

The indication of no reconnection potential for wetlands/floodplains in many Danube countries (Figure 54) does not indicate that there are no wetlands/floodplains with reconnection potential or that there is no restoration taking place is these countries, since Figure 54 exclusively illustrates relevant information for the basin-wide scale for wetlands/floodplains with an area larger 500 ha.

Between 2009 and 2015, data collection criteria for wetlands/floodplains were specified and caused a reduction of reported wetlands/floodplains in 2015. Taking into account the comparison between 2015 and 2021, an increase of partly reconnected wetlands/floodplains can be recognized. More detailed information on reconnection of wetlands/floodplains per country is illustrated in Figure 54.

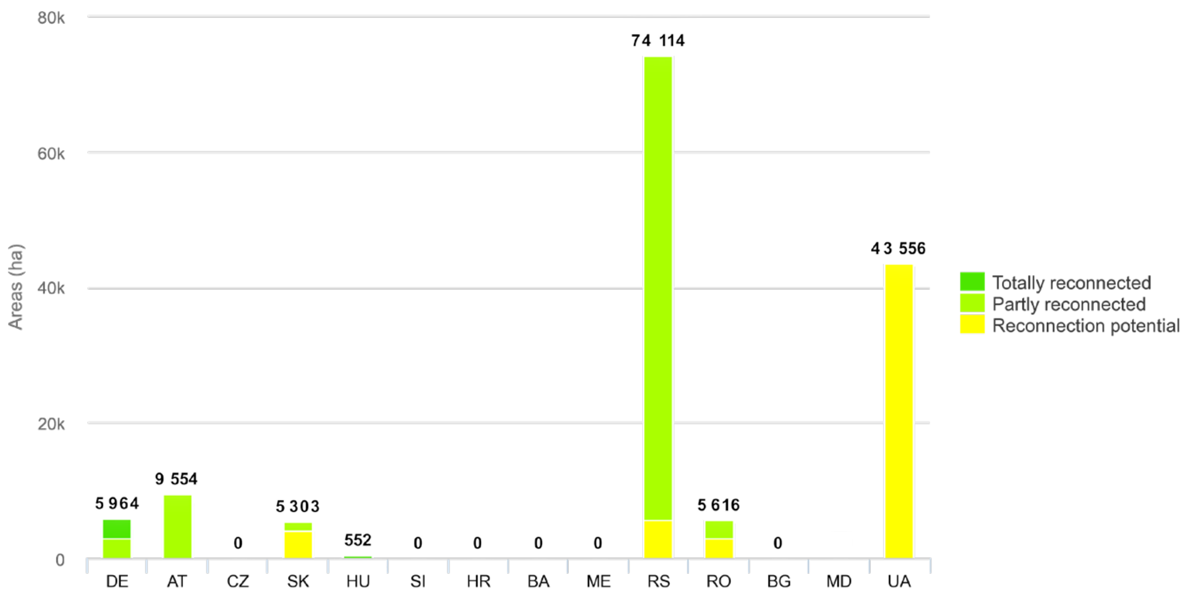


Figure 54: Area [ha] of DRBD wetlands/floodplains (>500 ha or of basin-wide importance) which are reconnected or with reconnection potential per country

Danube Floodplain Project

The EU-funded Danube Floodplain project (2018-2021) aimed to improve transnational water management and flood risk prevention while maximizing benefits for water status and biodiversity conservation. It improved the knowledge about integrative water management using floodplain restoration combined with classical and blue/green infrastructure, natural retention measures and the involvement of all related stakeholders.

In the Danube Floodplain Project, there were 3 key technical work packages:

1. **Floodplain Evaluation**[45], having as objective to identify and evaluate active and potential floodplain areas along the Danube River and selected tributaries (Desnățui, Krka, Morava, Sava, Tisza, Yantra). Methods for delineating active, potential and former floodplains were developed, resulting in 50 active and 24 potential floodplains identified and evaluated at the Danube River (see Figure 55).

Figure 55: Active and Potential Floodplains identified along the Danube River within Danube Floodplain Project (Output of the Interreg Danube Transnational Project Danube Floodplain co-funded by the European Union)

The Floodplain Evaluation Matrix (Habersack et al. 2015; Habersack and Schober 2020), which is a method for decision-makers and stakeholders to evaluate and compare river floodplains with hydrological and hydraulic, ecological, and sociological parameters on different spatial scales, were further developed and applied at the active and potential floodplains (see Figure 56). For each evaluated floodplain, a factsheet was created contenting general information (area, HQ100, etc.) about the floodplain and the results of the FEM-evaluation resulting in Danube Floodplain Inventory (DFInv). The identified floodplains and their results of the FEM-evaluation can be downloaded from the Danube Floodplain GIS (*http://www.geo.u-szeged.hu/dfgis/*). The applied methods and a basin-wide analyses of the evaluated floodplains along the Danube River can be found in D3.2.1 (Danube Floodplain 2021a).

45 *Adapted from DFP Deliverable D.3.2.1. Report on the evaluation of floodplains along the Danube River, output 3.1 Evaluated and ranked Danube floodplains.*

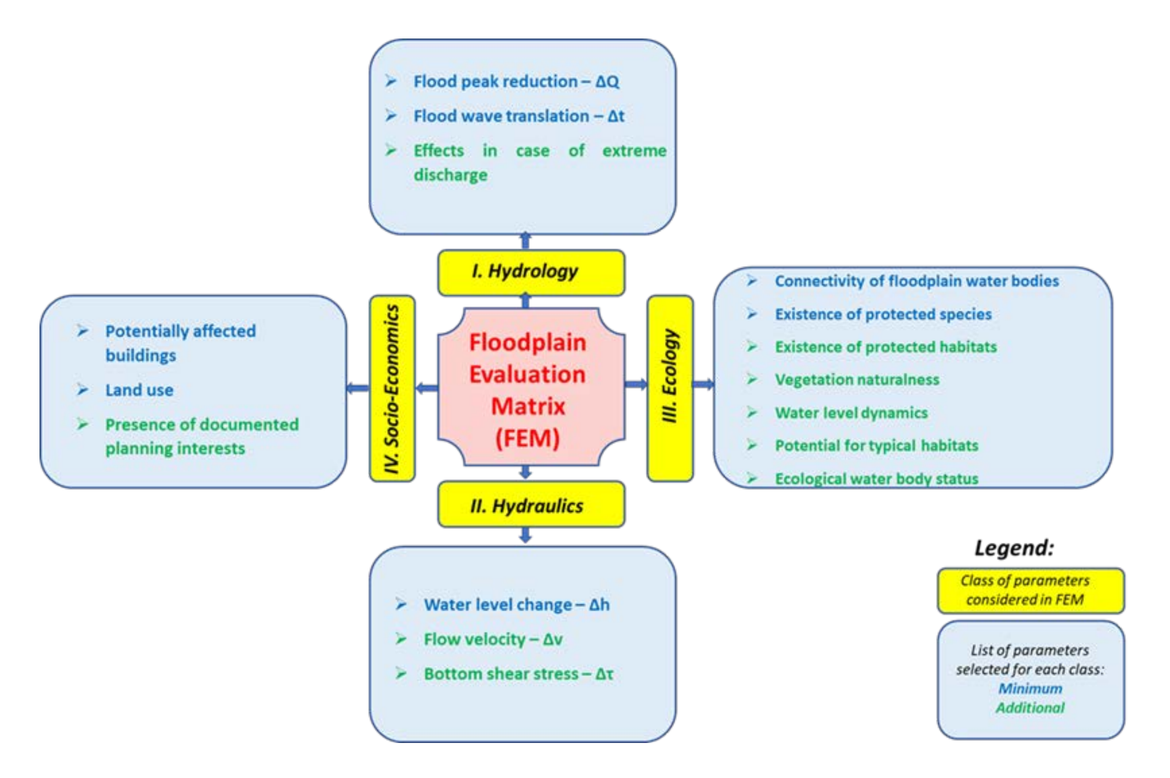


Figure 56: Floodplain Evaluation Matrix for the assessment of active and potential floodplains developed in the Interreg Danube Transnational Project Danube Floodplain co-funded by the European Union

2. **Flood preventions pilots**[46]: Five pilot areas, Begečka Jama (RS), Bistret (RO), Krka (SI) Middle Tisza (HU) Morava (SK, CZ) have been the subject of assessment having in view restoration scenarios by using the hydraulic models. Floodplain restoration scenarios were analysed with two-dimensional hydrodynamic models broadly used to quantify and evaluate river hydrodynamics. Considering the key results from 2D hydrodynamic models, the following can be highlighted: the models well reproduce the current state and demonstrate the effects of floodplain restoration in the pilot areas; the effects of the restoration scenarios to the reduction of the flood peak are variable and depend on the type of measure and scale of restoration, the investigated flood events, and the shape of the hydrograph; to affect the peak discharge, it is considered crucial not only to consider a single restoration measure but a combination of multiple measures, on the river channel, the floodplain extent, and the character of the floodplain (natural conditions). It is also recommended to investigate the lateral inflows from the tributaries, as the discharge conditions of the tributaries and the main river (e.g., Morava) can differ and shift the results.

Workshops were held in each pilot area in order to identify and evaluate the ecosystem services (ESS) and the planned measures for each area. The ecosystem services were mapping and monetization. Identifying and evaluating the ecosystem services of the affected area had as a result, the assessment of the effects of planned measures. With the help of ecosystem services, extensive information about the current situation of a region was captured.

46 *Adapted from DFP Deliverable D 4.1.2: Technical document concerning the homogenization of different models, as well as the basin wide assessment of the strategy measures' impact and efficiency as input for D 4.3.4 and D 4.3.2.; Deliverable D 4.3.4: Summary of used complex methodology and process description on hydraulic 1D and 2D, CBA, ESS, ecological assessment and stakeholder analysis; Deliverable D 4.4.3: Summary of general recommendations for a successful realization process, communicated to local, national, and international stakeholders in workshop activities and publications.*

For an in-depth evaluation, an extended cost-benefit-analysis (CBA) was carried out integrating ecosystem service into the traditional CBA approach. The evaluation of habitat provision was carried out based on habitat modelling in order to carry out a quantitative evaluation of the effects of the floodplain restoration measures planned for the Danube Floodplain pilot areas.

With an extended CBA, the project brought further evidence in favour of floodplain restoration measures to be implemented for the general benefit of the communities.

As a consequence of ESS estimation, the extended CBA justifies implementing different floodplain restoration measures in several cases. All these scenarios would not be categorized as profitable if evaluated with a standard CBA. Besides, the extended CBA might support the "realistic" restoration measure. Also, additional funding should be considered to cover the not fully profitable investment.

3. **Danube Floodplain Guide**[47]: Three key outputs have been developed:

DRB floodplain restoration and preservation manual (DFP Manual)

A comprehensive and technical document addressed to the multi-sectoral stakeholders (flood, water and environmental authorities; economic sectors – agriculture, local authorities; NGOs) involved in floodplain management on transnational, basin, sub-basin and local scale to improve flood risk mitigation in DRB. The DFP Manual includes the key findings of the project and will offer assistance for floodplain restoration measures, related actions and steps in the Danube River Basin for future approaches in the planning and implementing floodplain restoration and conservation processes. Hence, the DFP Manual proposes sequential steps starting from conceptual planning, preliminary activities, implementation and postimplementation actions, as well as evaluation of the projects related to these types of projects. The DFP Manual also provides a collection of good practice examples, addressed either to restoration but also to the conservation of floodplains, by highlighting the benefits in terms of floods, ecological status but also to the biodiversity and ecosystem services. The manual also refers to a general evaluation tool for assessing floodplain restoration projects, which was developed in the project. The so-called FEM-Tool (D4.4.2 – Danube Floodplain 2021b) uses input data from hydraulic modelling, ecosystem services (ESS) analysis, ecological assessments, habitat modelling, stakeholder and extended cost-benefit analysis to determine if a restoration project is recommended or not. For simplification and acceleration of the evaluation of floodplains and/or restoration projects, a QGIS plugin was programmed and can be downloaded using this link *https://github.com/boku-iwa/Floodplain-Evaluation-Matrix-Tool*. The FEM-Tool allows to: automatically delineate active floodplains; calculate some FEM-parameters; store the results of the FEM, stakeholder analysis, ecosystem services, habitat modelling; determine if a restoration project/ measure is recommended based on the FEM-results and create factsheets for each floodplain.

The DFP Strategic Guidance[48]

A strategic document seeks to improve awareness on challenges related to reducing flood risk by maintaining a balance between social, ecological and biodiversity aspects. It suggests floodplain restoration measures that can be implemented to reduce flood risk in the Danube River Basin. The key findings and suggested directions are described on a more general level targeting a wider audience of interested stakeholders, authorities and decision-makers. The content covers the main floodplain restoration and preservation approaches; a summary of a catalogue of potential "win-win" restoration measures

47 Adapted from DFP Deliverable 5.1 DRB floodplain restoration and preservation manual.

48 Adapted from DFP Deliverable 5.2 DRB Floodplain Management Strategic Guidance.

to mitigate flood risk while improving the ecological status/potential of the water bodies in relation to hydromorphological alterations. In order to help the target groups of the DRB Floodplain Management Strategic Guidance to have an insight how to convert the theoretical knowledge into practice, a brief practical summary highlights the necessary main steps for planning and implementing restoration projects where not only technical, ecological, but also social and economic aspects are considered in order to realize viable projects in practice.

Floodplain restoration, preservation action plan (DRB Floodplain restoration Roadmap)

Two action plans have been defined in the DRB Roadmap. First, an action plan for implementation of the measures defined in the (pre-)feasibility studies of the pilot areas address in a more detailed way scenarios and specific measures, effects, timelines and responsible authorities having in view the pilot areas. Second, an action plan for identified priority areas based on ranking process address to active floodplains with restoration demand but also to potential floodplains in a more general way.

Based on the project results, it can be concluded that:

1. Preservation of active floodplains: All 50 active floodplains (>500 ha) have to be preserved.

2. Restoration of all active floodplains: 26 floodplains show a high demand for restoration, a programme is necessary where concrete restoration projects for active floodplains are defined.

3. Implementation of identified potential floodplains: 24 identified potential floodplains have to be reconnected, concrete restoration projects should be defined. Additional potential floodplains should be identified and reconnected to the river system.

4. Involvement and engagement of stakeholders and decision-makers is key: Raising their awareness of the benefits (especially under the consideration of climate change and urbanization) of the preservation and restoration of floodplains is key for future sustainable floodplain management. A project focusing on the successful implementation of preservation and restoration projects conducted with stakeholders and decision-makers is needed to support the implementation of such projects.

5. Win-win effect of restoration and preservation of floodplains: The results of meso-scale biodiversity assessment in the pilot areas show that floodplain habitats, and thus biodiversity, can benefit from increasing the lateral connectivity, as intended by the majority of restoration scenarios. While the assessment on the meso-scale shows the general tendency for the development of habitats, a microscale analysis gives insights on the level of species or specific communities. However, this requires in-depth knowledge of the setting and cannot be obtained without extensive fieldwork. Integration of the WFD environmental objectives and flood risk management objectives requires moving away from the classical flood protection solutions to nature-based ones. Nature based solutions should be considered with priority, in this way actions for reducing the flood risk being completed with restoration and preservation of the natural properties of the floodplains. Agreement on the wide range of benefits provided by floodplain and river restoration could be ensured by using an approach rooted in ecosystem-based management when developing river basin and flood risk management plans.

2.1.6.4 Future Infrastructure Projects

In addition to already existing hydromorphological alterations, a considerable number of future infrastructure projects (FIPs) are at different stages of planning and preparation throughout the entire DRBD. These projects, if implemented without full consideration to effects on water status, are likely to provoke impacts on water status due to hydromorphological alterations and further barriers to migratory fish and other organisms. These projects need to be addressed accordingly, also considering the WFD Article 4(7) applicability assessment, and since the planning phase, it is needed to integrate green infrastructure, nature-based solutions and mitigation measures in order to reduce/cancel the potential impacts on water status/water potential. Furthermore, the Environmental Impact Assessment and Strategic Environmental Assessment Directives and related requirements also need to be taken into account, including requirements for coordinated (and/or joint procedures for) projects/strategies assessments with a view to environmental and water management aspects.

A list of FIPs of basin-wide importance has been compiled for DRBMP 2009, DRBMP Update 2015 and updated for DRBMP Update 2021 (see Annex 7). The following criteria were applied for the data collection (Table 22):

Table 22: Criteria for the collection of future infrastructure projects for the Danube River and tributaries

	Danube River	Other DRBD rivers with catchment areas >4.000 km^2
Criteria	Strategic Environmental Assessment (SEA) and/or Environmental Impact Assessments (EIA) are performed for the project	Strategic Environmental Assessment (SEA) and/or Environmental Impact Assessments (EIA) are performed for the project
	<u>or</u>	<u>and</u>
	project is expected to provoke transboundary effects	project is expected to provoke transboundary effects

All FIPs (until 2027) including brief descriptions (if provided) are compiled in Annex 7 and visualized on Map 17. The FIP analysis concludes that 28 FIPs have been reported for the DRBD. As indicated in Table 23, the majority of them (i.e. 18 FIPs) are located in the Danube River itself. In total, 17 (60%) are related to navigation, 6 (21%) to flood protection, and 2 (7%) to hydropower. The remaining three FIPs are located on two coastal water bodies (Cap Singol-Eforie Nord - CT02_B1 and Eforie Nord-Vama Veche - CT02_B2) having in view the project "Protection and rehabilitation of the coastal areas - Phase II".

The comparison of number of FIPs between 2009 and 2015 shows a significant decrease in number of FIPs (128 FIPs reported in 2009 and 39 in 2015), while the number of FIPs reported in 2015 and 2021 only slightly decreased (28 FIPs reported in 2021).

Table 23: Number of future infrastructure projects (FIPs) according to their main purpose in the Danube River and main Danube tributaries (including coastal water bodies)

	Flood protection	Hydropower	Navigation	Other	Total
Danube River	2		16		18
DRBD tributaries	4	2	1		7
All DRBD rivers	**6**	**2**	**17**		**25**
DRBD Coastal Waters				3	3

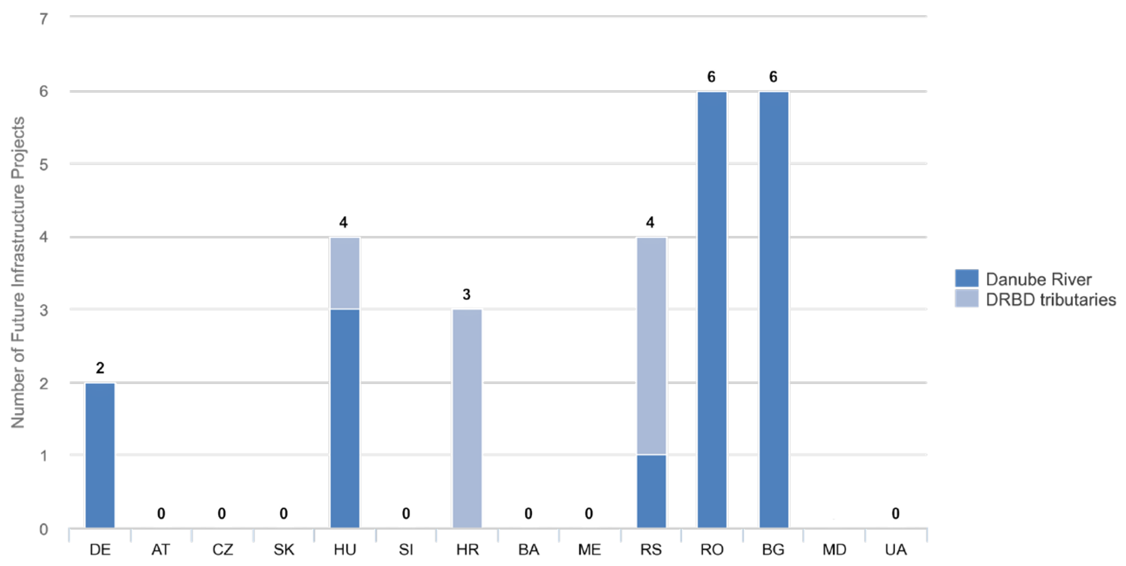


Figure 57: Number of FIPs in the Danube River and tributaries per country[49]

Related to reported data on FIPs, it can be concluded that navigation and flood protection are the key potential future drivers that may provoke impacts on water bodies in the DRBD by 2027. For 18 out of all 28 reported projects (64%), deterioration of water status is expected and for 20 projects (71%) exemptions according to WFD Article 4(7) are reported. Data included for RS is not based on an official WFD Article 4(7) application as there is no transposition of WFD exemptions in national water law yet. Details are summarized in Annex 7. Information on the economic relevance of different sectors can be obtained from the economic analysis (see Chapter 7).

2.1.7 Gaps and Uncertainties of the Hydromorphological Alteration Assessment

Hydromorphological alterations are strongly connected to human water uses and have been present on waters for centuries. Their negative impact on freshwater ecosystems have become increasingly apparent. Nevertheless, the requirement to measure and assess the impact of hydromorphological alterations on achieving of environmental objectives become evident only with the adoption of the WFD and other EU legislations.

The assessment of natural hydromorphological characteristics of water bodies and the connected alterations is still under development, not only databases are continuously developing and improving but methodologies are also updated between RBM planning cycles. There are also recognized differences in available databases and methodologies between countries due to different WFD implementation phases.

An important step forward in improving availability and accuracy of reported national data to ICPDR was made in the third planning cycle, but still further harmonisation of data on significant hydromorphological alterations and related measures is needed (primarily between countries on shared river basins). This is mainly related to assessment of morphological alterations and disconnection of wetlands/floodplains. Further activities are needed also for the identification and harmonisation of transboundary objects between DRBD countries.

Furthermore, hydromorphological assessments should be upgraded with the monitoring of habitats (i.e. for migratory fish species) to better define appropriate measures for reaching the environmental objectives. It is also necessary to improve cooperation between water management authorities and authorities responsible for nature protection and biodiversity.

49 The 12 projects given in the figure for BG and RO are sections of the same transboundary project „Fast Danube".

Numerous countries have upgraded their databases on (significant) hydromorphological pressures in this planning cycle. Also, methods for the hydromorphological assessment were upgraded. There is a need for further harmonisation of reported data that will also enable better comparison of data between river basin management plan updates, however it sometimes fails because of the continuously developing knowledge and changed criteria set for the assessment of an alteration. Additional harmonisation is needed also between data on significant hydmorphological pressures on national and international level and data reported on implementation of hydromorphological measures. Sediment balance alteration is recognized as a significant water management issue in the DRBD. The assessment of the sediment balance on rivers is to be further investigated because this is still less developed part of hydromorphological assessment in most DRBD countries. The significance of sediment quantity assessments is needed to be made aware in the countries and next steps for assessments are to be defined. Determination of significant pressures, impacts and setting of appropriate measures for sediment balance improvements and avoidance of further deterioration are crucial elements of the future steps.

2.1.8 Climate Change Impacts on Hydromorphological Alterations

Climate change is expected to modify precipitation and snow (ice) storage, increase of evaporation and decline in groundwater storage and recharge.[50] These modifications together with increase in extreme weather events will influence also hydromorphological conditions and consequently water status and achievement of environmental objectives.

One of the keyways in which climate change or other pressures affect river ecosystems is by causing changes in hydrological regime (river flow). Rivers vary geographically with respect to their natural flow regime and this variation is critical to the ecological status and health of water ecosystems[51]. River flow is therefore crucial element that influence also sediment dynamics and morphological conditions and vice-versa.

Rivers are dynamic systems, and they are constantly adjusting to changes in hydrological and sediment regime. However, the new temperature and precipitation regimes expected as a result of climate change will occur much more quickly than historical climate shifts[52] and because many rivers are already affected by hydromorphological pressures, their ability to adjust to changes may be impaired.

Negative effects of climate change will be more evident on hydromorphological altered rivers. Pressures most likely to intensify the negative effects include land use change and excessive water abstractions[53]. Additionally, ecological stress of climate change on dammed rivers are projected to be greater than on undammed rivers. Also channelized rivers are inherently more vulnerable to climate change[54]. They are also more exposed to increase of temperature, what leads to inappropriate habitats for numerous species.

50 *ICPDR (2018): ICPDR Climate Change Adaptation Strategy. https://www.icpdr.org/main/activities-projects/climate-change-adaptation (accessed 16 February 2021).*

51 *Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C. 1997. The natural flow regime: a paradigm for river conservation and restoration. Bioscience, 47 (1997), pp. 769-784. Postel, S., Richter, B. 2003. Rivers for life: managing water for people and nature. Island Press, Washington, DC, p 240.*

52 *IPCC (2007): Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press.*

53 *Kundzewicz, Z. W., Mata, L. J., Arnell, N. W., Döll, P., Jimenez, B., Miller, K., Oki, T. Sen, Z., Shiklomanov, I. (2008): The implications of projected climate change for freshwater resources and their management. Hydrological Sciences. Journal des Sciences Hydrologiques 53:3-10. Nelson, K., Palmer, M. A., Pizzuto, J., Moglen, G., Angermeier, P., Hilderbrand, R., Dettinger, M., Hayhoe, K. (2009): Forecasting the combined effects of urbanization and climate change on stream ecosystems: from impacts to management options. Journal of Applied Ecology 46:154-163.*

54 *O'Briain, R. (2019): Climate Change and European rivers: An eco-hydromorphological perspective. Ecohydrology https://doi.org/10.1002/eco.2099 (accessed 16 February 2021).*

Larger negative effects of climate change are foreseen for urbanised area, where usually also hydromorphological conditions are altered due to river engineering works and different types of water use. Yet many rivers are under hydromorphological pressures to some extent by human activities. Climate change will add to and magnify risks that are already present through its potential to alter rainfall, temperature and runoff patterns. All these changes will disrupt biological communities and sever ecological linkages[55]. Negative effects can be even more evident in case of multiple stressors - i.e. presence of pollution and hydromorphological alteration at the same time.

Free-flowing rivers in protected watersheds are expected to be the most resistant and resilient to climate change. In these watersheds temperature and flow changes are buffered compared to clear-cut or urbanised watersheds[56]. Water ecosystems with (near) natural hydromorphological conditions have also a higher purification capacity and are therefore more resilient to pollution. Thus, it is crucial to improve hydromorphological conditions and purification capacity to be prepared for new negative effects caused by climate change. Furthermore, rivers with preserved hydromorphological conditions are also more resilient to floods and droughts. They have positive impacts on status of groundwater bodies and are also causing local cooling effect.

There are recognized direct and indirect threats to hydromorphological conditions due to climate change:

- new hydromorphological alterations as a result of impacted hydromorphological processes (i.e., alterations of hydrological regime, sediment dynamics, morphological conditions) (Figure 43) and
- new man-made physical modifications as a result of further needs related to increased water demand for water supply, irrigation and other purposes, increased needs for navigation safety and improved flood protection (new future infrastructure projects).

Considering described changes, it is even more important to prevent rivers from further deterioration due to new man-made physical modifications. According to predictions, there will be increased needs for water supply and water demands. New river engineering works will be needed for navigation purposes and improving of flood protection schemes on urbanised and agricultural area. If societies choose to respond to climate change by building taller levees, hard river engineering solutions and larger dams (also on locations where this is not the only possible technical option), ecosystems will be put at greater risks[57]. Traditional river engineering approaches have a high tendency for reducing ecological resistance and resilience[58]. Thus, the best available water management practices have to be implemented within river basins to avoid and minimise negative effects of climate change.

55 *Palmer, M. A., Lettenmaier, D. P, LeRoy Poff, N., Postel, S. L., Richter, B., Warner, R. (2009): Climate Change and River Ecosystems: Protection and Adaptation Options. Environmental Management 44: 1053–1068. https://doi.org/10.1007/s00267-009-9329-1 (accessed 16 February 2021).*

56 *Nelson, K., Palmer, M. A., Pizzuto, J., Moglen, G., Angermeier, P., Hilderbrand, R., Dettinger, M., Hayhoe, K. (2009): Forecasting the combined effects of urbanization and climate change on stream ecosystems: from impacts to management options. Journal of Applied Ecology 46:154–163.*

57 *Seavy, N. E., Gardali, T., Golet, G. H., Howell, C. A. (2009): Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research. Ecological Restoration, 27(3)330-338. https://doi.org/10.3368/er.27.3.330 (accessed 16 February 2021).*

58 *Lake, P. S. (2013): Resistance, resilience and restoration. Ecological Management & Restoration, 14, 20–24. https://doi.org/10.1111/emr.12016 (accessed 16 February 2021).*

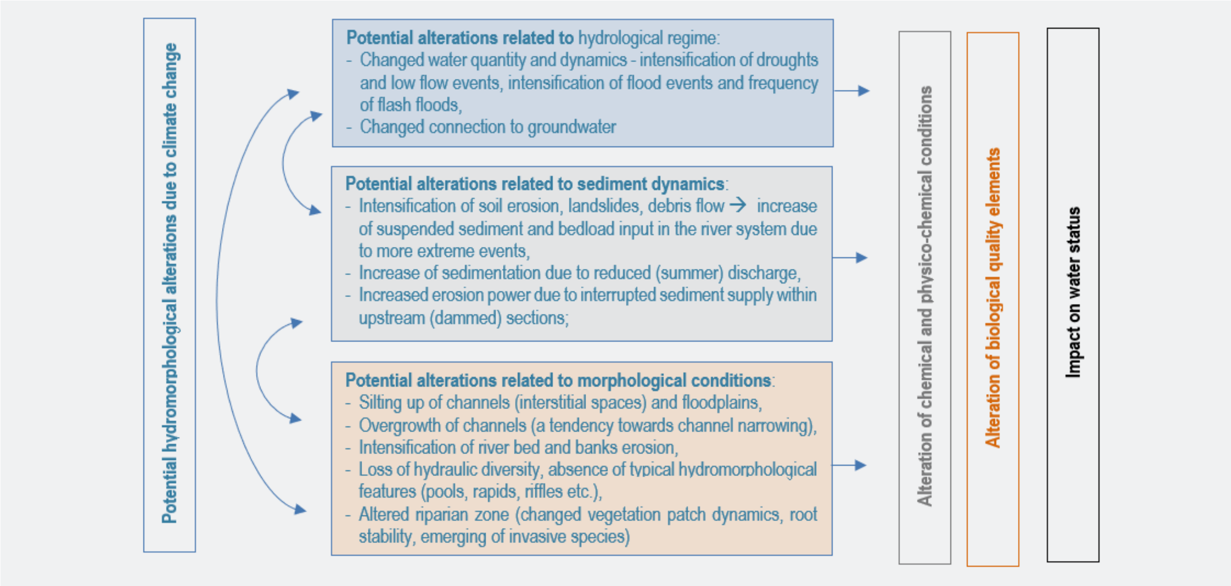


Figure 58: Potential hydromorphological alterations due to climate change

2.1.9 Other Issues

2.1.9.1 Quality Aspects of Sediments

While the aspect of sediment quantity is being tackled under the Significant Water Management Issue "Hydromorphological alterations" (see Chapter 2.1.6.2.2), further investigations as regards the quality aspect of sediment management are currently being undertaken in the Danube River Basin by the DTP-project "SIMONA" on Sediment-quality Information, Monitoring and Assessment System to support transnational cooperation for joint Danube Basin water management (2018-2021).

SIMONA Project

The SIMONA Project is the long-needed and timely response to the pressing demand of the effective use of sediment quality assessment for River Basin Management Plans according to the EU Water Framework Directive (WFD). Seventeen partners together with 13 associated partners, representing all Danube River Basin countries, have delivered a ready-to-deploy Sediment-quality Information, Monitoring and Assessment System to support transnational cooperation for joint Danube River Basin water management. The SIMONA Tool consists of harmonised sediment sampling, analysis and risk assessment (evaluation) protocols, practical guidelines, manuals, professional video movies, recommendations, solid case studies and training materials. The SIMONA methods have been tested, demonstrated and trained in the transnational Drava River, Upper Tisa and South Danube Test Areas. Moreover, the sampling, laboratory analysis and evaluation methods have been applied by the trained government experts in 2 designated national monitoring points forming the basis of Danube River Basin Sediment Quality Monitoring Baseline Network. All the procedures are supported by the SIMONA IT Tool which is an online application for the transparent sediment quality monitoring data collection, storage, management and visualisation, evaluation and reporting according to the EU WISE standards at the service of the national and international WFD practitioners' daily work. Together with experts trained in sediment quality monitoring by SIMONA, the project has also generated international cooperation between stakeholders concerning the monitoring of hazardous substances in water, in sediments and in biota.

So far, the characterisation of the sediment quality in the Danube was primarily based on the results of the Joint Danube Surveys. The monitoring activities showed that while concentrations of certain substances (organochlorinated compounds) in the solid phase were at low levels, heavy metals and polycyclic aromatic hydrocarbons occasionally occur at elevated concentrations requiring further research. Even though there are no specific measures addressing sediment quality proposed in Chapter 8 it must be emphasized that all those measures foreseen in the Joint Programme of Measures for hazardous substances will be relevant for sediment quality as well.

2.1.9.2 Invasive Alien Species

The DRBMP 2009, as well as its update from 2015 highlighted that the DRB is vulnerable to invasive alien species. Invasive alien species have become one of the major concerns for the Danube and their further classification and analysis is essential for an effective river basin management.

The Danube is exposed to an intensive colonisation by neobiota (non-indigenous, non-native or alien species - organisms that occur outside of their native distribution region; neozoa refers to alien animals) and their further spreading in both north-west and south-east directions throughout the basin.

Results of the JDS expeditions (JDS1, 2, 3 and 4) showed that neozoa dominated macrozoobenthic as well as fish fauna at many places in the Danube making thus their classification a crucial factor in the assessment of the ecological status. The ICPDR developed a common approach on how to deal with invasive alien species in the DRB. The methods for the assessment of the invasive alien species are being constantly updated[59] to evaluate their impact on the ecological status of the Danube. Moreover, the ICPDR adopted a joint position that the invasive alien species should not be considered *en-bloc* as having a negative impact on the ecological status unless a detailed integrative evaluation would prove this.

The ICPDR is collecting data on the distribution of non-indigenous species with the intention to carry out the assessment of the level of invasiveness towards the aquatic taxa. To ensure the comparability of results and avoid bias due to different methods used for taxonomic investigations, only the data from routine national monitoring and Danube surveys (JDS1 in 2001, AquaTerra in 2005, JDS2 in 2007, JDS3 in 2013 and JDS4 in 2019) have been taken into the consideration. The data from the last two Danube surveys (JDS3 and JDS4) on macroinvertebrates and fish were used to assess the level of biocontamination at JDS sites by the BioContamination Index (SBC Index[60]) as it is shown on Maps 17 and 18. The SBC assessment is derived from data on the number of non-indigenous species and their abundance in comparison to the total number of species and the community abundance. The index value ranges from 0 (“no” biocontamination) to 4 (“severe” biocontamination). It should be emphasized that the assessment of biological contamination, as a reflection of the level of pressure caused by the invasive alien species, should be observed independently from the ecological status assessment.

The level of biocontamination of the Danube River was estimated as moderate to high, with higher levels for the Upper (high to severe biocontamination) and Middle Danube (moderate to high biocontamination), in comparison to the Lower Danube (low biocontamination).

According to the results of the JDS3 and JDS4 macroinvertebrate and fish surveys (Map 18 and 19), the SBC Index indicated that majority of the sites could be characterized as highly to severely contaminated (SBC=4

59 *Paunović, M., Csányi, B., (2018): Guidance document on Invasive Alien Species in the Danube River Basin, ICPDR – International Commission for the Protection of the Danube River, Vienna, Technical Report, Version of March 2019, pp 67.*

60 *Arbačiauskas, K., Semenchenko, V., Grabowski, M., Leuven, R.S.E.W., Paunović, M., Son, M.O., Csányi, B., Gumuliauskaite, S., Konopacka, A., Nehring, S., van der Velde, G., Vezhnovetz, V., Panov, V.E., (2008): Assessment of biocontamination of benthic macroinvertebrate communities in European inland waterways. Aquat. Invasions 3, 211-230.* https://doi.org/10.3391/ai.2008.3.2.12 *(accessed 12 February 2021).*

and 3), while less sites have been characterized as moderately biocontaminated (SBC=2) or with low level of biocontamination (SBC=1).

Mean values of the SBC Index based on macroinvertebrates ranged from 1.53 (JDS3 dataset) and 0.86 (JDS4 dataset) for the Lower Danube, up to 3.18 (JDS3 dataset) 2.56 (JDS4 dataset) for the Middle Danube and 3.07 (JDS3 dataset) and 3 (JDS3 dataset) for the Upper Danube.

Mean values of the SBC Index for fish ranged from 1.86 (JDS3 dataset) and 1.9 (JDS4 dataset) for the Lower Danube, up to 2.17 (JDS3 dataset) and 2.56 (JDS4 dataset) for the Middle Danube and 3.2 (JDS3 dataset) and 3 (JDS4 dataset) for the Upper Danube.

The reduced pressure caused by bioinvasion recorded for the Lower Danube compared to the Middle and Upper sections could be explained by the fact that Ponto-Caspic species are considered as native in this section, while for the Middle and Upper Danube, species of Ponto-Caspic distribution are considered as non-native.

Based on the results of JDS2, JDS3 and JDS4, the Danube River is significantly exposed to non-native species – 25 neophytes, 34 non-native aquatic macroinvertebrates and 17 non-native fish were recorded. Comparison of Danube Surveys data (JDS1-JDS4) clearly showed a constant impact of invasive alien species on native biota and a considerable increase of the number of non-native aquatic macroinvertebrate species. As a specific example the allochthonous *Neogobius* fish species can be given which were found in high or even dominating abundance along the rip-rap protected banks in the upper and middle course of the Danube.

In future, it is important to evaluate accurately and rationally the real pressure of each invader to native ecosystems, because of its influence on the native biota should not be considered a priori as negative. In particular, the following actions are to be taken:

- A systematic monitoring of invasive alien species is needed to summarize the state-of-the-art knowledge at the basin-wide level;
- It is of high importance to improve a methodology on how to assess invasive alien species as a specific pressure in the frame of the WFD compliant ecological status assessment. This issue includes developing reliable metrics that indicate the level of pressure caused by biological invasions, as well as clarifying the impact of this parameter on the ecological status assessment. More research is needed to properly deal with this issue;
- Only aquatic species will be taken into the consideration for all assessments;
- So far, the work of the ICPDR on the invasive alien species has been focused on the Danube. In future, the invasive alien species monitoring and assessment has to be extended to major tributaries and associated water bodies;
- The Black List of Danube invasive alien species includes all aquatic taxa that are on the list of invasive alien species of EU concern, and it also includes invasive species specific for the DRB. It is necessary to regularly update the Black List of Danube invasive alien species based on the new monitoring results;
- The presence of invasive alien species in a river water body cannot automatically be considered as an adverse impact to the ecological status. Invasive alien species should be used together with the native species as indicators for the influence of the existing pressures. A deterioration of the ecological status due to extreme dominance of invasive alien species is revealed by the decrease of indicators of the functionality of the ecosystem;
- Difficulties in management of invasive alien species are evident and are still an open issue;

- The Commission will review the application of the EU Regulation No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species by 1 June 2021. This will include the review of the Union list, the action plans, surveillance systems, customs controls and the obligations for eradication and management. The outcomes of this review will be used for further update of the invasive alien species monitoring and assessment in the DRB.

The importance of improvement of management practices based on the results of EU member states activities and in respect to development of measures towards suppressing the pressures caused by the invasive alien species is clearly recognized.

2.1.9.3 Macro- and Microplastics

Plastic pollution of freshwater environments is ubiquitous, and it is becoming an issue of key concern all around the world. That is why the ICPDR decided to include the pollution by macro and microplastics into the next river basin management planning cycle.

Plastic particles are ingested by a wide range of animals and the transfer of these particles to aquatic food webs is of growing concern. Very little is known about the potential toxicity of plastics to freshwater organisms. Scarce is also information about the occurrence of microplastics in the Danube River Basin. The level of awareness of the riverine litter varies between the Danube countries but in majority of the countries, it is considered as a topic of growing importance. It is also necessary to mention that in several Danube countries, the riverine litter management is not addressed as a self-standing topic, but it is covered by a national strategy for waste management. In most of the Danube countries, there is no difference in awareness or interest concerning microplastics (plastic particles with less than 5mm diameter) versus larger sized litter although the attention to the damage of microplastics to the environment, people and animals is growing in recent years especially due to growing research-based evidence on the national as well as international level.

Some knowledge regarding quantities (and/or types) of litter in national riverine systems is available in DE, AT, HU and SI while the knowledge on sources and pathways of litter into national riverine systems is rare and is subject of ongoing or intended research activities (e.g. a project on empirical based modelling of the sources and pathways of (micro)plastics within the upper Danube catchment; *www.micbin.de*)

The best way of reducing litter and micro plastics entering the water systems is reduction at the sources. Examples and best practices are:

- In general, good waste management infrastructure including separate collection systems and landfill bans;
- Product measures such as reducing the use of lightweight plastic bags and phasing out of the use of microbeads in cosmetics;
- Public "Cleaning days". Such initiatives not only prevent litter from entering the environment/rivers, but they also raise public awareness;
- Implementation of the Directive (EU) 2019/904 on the reduction of the impact of certain plastic products on the environment (Single-Use Plastics Directive).

An example of practical activities in the Danube River Basin is the Tid(y)Up Project aiming to reduce the plastic pollution in the Tisza River and investigating plastic pollution and its effect on the Danube and the Black Sea. In Tid(y)Up project partners develop and launch a set of integrated actions, consult and provide tools for relevant stakeholders and initiate long term transboundary and intersectoral cooperation with the aim of monitoring and eliminating the plastic pollution[61].

2.2 Surface Waters: Lakes, Transitional Waters, Coastal Waters

2.2.1 Surface Waters: Lakes

In the DRBD, seven lakes are identified as being of basin-wide importance: Neusiedler See/Fertő-tó consisting of two water bodies (AT/HU), Lake Balaton (HU), Tisza-tó (HU), Lake Ialpuh (UA), Lake Kuhyrlui (UA) and Lake Razim/Razelm (RO). Table 24 summarises whether significant hydromorphological alterations and/or chemical pressures are affecting the DRBD lakes.

Lake Balaton, with its 594 km², is the most important tourist destination in Hungary. The highest interest is in the good water quality, which is sustained by the Little Balaton system – a pre-filtering area on the largest sub-basin of the lake. During 2020, dredging was performed to remove sludge rich in nutrients which also helped to sustain the good water quality. Dredging is expected to continue in the following years. Also, waste water from the river basin is diverted to other catchments in order to attain the main goals. The water level of the lake is regulated with the aim to ensure higher water levels during summer. Water level regulation moves within wide limits, low water levels depend on meteorological conditions. The banks of Lake Balaton are modified by reinforcements in more than 50%.

Tisza-tó (Lake Tisza) is a large reservoir on the river Tisza in Hungary (121 km²). The aim of the construction was to secure the water supply for the Hungarian Lowland which has been cut off the river by the building of the flood defence system. The reservoir also provides extra water for downstream sections in summer that helps to maintain the water level necessary to ensure drinking water abstraction remains operational in the city Szolnok. The lake has become one of the most important nature protection areas of the country. One of its four basins is used primarily for tourism (e.g. jet-ski, motor boots) while the other three has allow for soft tourism (angling, educational trails, bird watching, bathing). For winter, the water level of the lake is significantly reduced, and it functions as wetland.

The Neusiedler See/Fertő-tó, a UNESCO World Heritage Site, is the most western occurrence of European steppe lakes with its typical saline water and a mean depth of only one metre. The lake with a total extent of 320 km^2 is situated in Austria (245 km²) and Hungary (75 km²). The Hungarian as well as the Austrian parts of the lake with their extensive reeds (55 km² in the Hungarian and 180 km² in the Austrian part) are protected under Natura 2000 and the Ramsar Convention. In 1994, the Austrian National Park Neusiedler See-Seewinkel and the Hungarian National Park Fertö-Hanság Nemzeti Park were merged to create a cross-border National Park. The lake is unaffected by significant hydromorphological pressures. On the Hungarian shore only one bathing place and one harbour for small ships are present in the settlement Fertőrákos. In the Austrian parts of the lake, there are seven bathing sites and several harbours for recreational navigation. The water level of the lake is regulated for multiple purposes. This includes flood protection and mitigation, extreme droughts, ecological concerns, tourism and navigation. Bilateral co-ordination is based on the Austrian-Hungarian Water Treaty (signed 1956). Since 1965 (the beginning of modern water level regulation) the mean water level has risen compared to the period after the construction of Hansag channel system at the end of 19th century. During the last years, observations and research have detected signs of climate change impacts. This may increase challenges resulting from future drought situations.

61 *For more information on the Tid(y)Up Project follow: http://www.interreg-danube.eu/approved-projects/tid-y-up (accessed 15 October 2021).*

Lake Razim is a natural lake water body, which was originally marine but gradually cut off from the Black Sea and has now turned into a freshwater lake. The Razim-Sinoe lake complex (lagoon) is the largest lake complex on the north-western shore of the Black Sea, being also part of the Danube Delta Biosphere Reserve (Natural World Heritage and Ramsar site). To the west it is delimited by the edge of the North Dobrogea plateau. To the north and west of the Doloșman head it presents abrasion cliffs dug both in limestone and Triassic conglomerates and in Cretaceous marls. The similar steep shores could be found on the islands of Popina, Gradistea and Bisericuta inside Lake Razim (Razelm). To the north and east, the coast is formed by the low and swampy edge of the Dranov island. To the southeast, north of Gura Portita, it is formed by the coast from the Periteasca-Leahova area, and to the south, by the coastal belts which separates the Sinoe lake from the sea. The Razim lake has wide festooned shores, presenting several large bays (Holbina, Fundea). It continues south of Dolosman Head and extends west with Golovita Lake, which enters into land through Ceamurlia Bay. It communicates with Golovita Lake through a wide opening between Cape Dolosman and Bisericuta Island. The supply from the Danube (Sfantu Gheorghe branch) is ensured through the Dunavat and Dranov canals), it communicates with the Lake Babadag through the Enisala canal. The maximum depths in Razim lake drop to 3 m in the southern part, and the average depths are generally below 2 m. The surface of Lake Razelm is 393 km², being the largest natural lake in Romania. Considering the WFD terms, the Lake Razim is a natural water body which does not present significant hydromorphological pressures.

Ialpuh and Kuhurlui lakes are entirely located within the floodplain of the Danube and are a continuation of the river Ialpuh valley that once flowed into the Danube. With an area of 145 km², Ialpuh is the largest freshwater lake in Ukraine. Its average depth is about 2 m. In the southern part, the lake is connected to lake Kuhurlui through a narrow strait. About 50 years ago, this strait was wider, but was narrowed during the construction of the road, which led to a decrease in water exchange in the lake Ialpuh. Kuhurlui lake has an area of approximately 85 km² and depth ranges from 0.6 to 2 m. Its hydrological regime depends on the Danube. In the sand bar that separates the lake from the Danube, there are several channels through which water flows into the lake from the river. Previously, this was a natural process, but now the flow of water from the Danube is regulated by sluices. In spring, when the water is high, the water from the Danube fills both lakes. And this is the main source of water for the lakes, since the rivers flowing into the Ialpuh are practically dry. Risk assessment of both lakes is not finalized yet. Nevertheless, it can already be assumed that both lakes will be assessed as such where there is a risk. Alterations of the hydrological regime, some changes in morphology (including siltation), water abstraction for drinking water (Bolgrad) and irrigation, as well as pollution with organic, nutrient and hazardous substances allow making this conclusion. The main sources of lake pollution are untreated wastewater from settlements, food industry, persistent pesticides, which were used in Soviet times both in Republic of Moldova and Ukraine. Furthermore, this area is suffering from severe droughts recently (e.g. in spring 2020).

Hydromorphological alteration – lakes

Undisturbed hydromorphological conditions are prerequisite for good ecological status. Hydrological regime and morphological conditions are main hydromorphological elements on lakes and thus alterations of those elements were analysed in the DRBD. Lake water level fluctuations are recognized as a significant pressure related to hydrological regime. It is relevant for lakes that are used as a storage lake. As a significant pressure related to morphological conditions significant reduction of shallow water due to bank enforcement/ settlement development are recognized. This significant pressure is reported dependant on lake type and is applicable for lowland lakes with large littoral zones.

Table 24: Presence of significant hydromorphological alterations and chemical pressures affecting DRBD lake water bodies

Country	Lake	Area (km²)	Hydrological alteration	Morphological alteration	Chemical pressure
AT	Neusiedler See	245	No	No	No
HU	Fertő	75	No	No	Yes
HU	Balaton	594	No	Yes	No
HU	Tisza-tó	121	No	No	Yes
RO	Razim	393	No	No	No
UA	Kuhyrlui	85	Yes	No	Yes
UA	Ialpuh	145	Yes	No	Yes

Out of 7 lake water bodies, significant hydrological pressures were reported for 2 lake water bodies and significant morphological pressures were reported for 1 lake water body.

2.2.2 Surface Waters: Transitional and Coastal Waters

Transitional waters are located in Romania and Ukraine within the DRBD. Two transitional water bodies were reported by Romania – Lake Sinoie and the Black Sea waters from the Chilia mouth to Periboina. Ukraine reported 1 transitional water body (Black Sea), Furthermore, 4 coastal water bodies are located in Romania.

Hydromorphological alteration – transitional and coastal waters

Morphological conditions and tidal regime are main hydromorphological elements on transitional and coastal waters. As the main hydromorphological pressures on these elements are recognized: i) transitional and coastal water management, ii) estuarine/costal dredging, iii) marine constructions, shipyards and harbours, iv) marinas, v) tidal barrages/weirs, vi) land reclamation and polders, vii) coastal sand suppletion (safety) and viii) barriers.

None of the transitional water bodies located in Romania and Ukraine were reported to be under significant hydromorphological pressures. However, for two out of four coastal water bodies significant hydrological alterations (i.e. marine constructions, shipyards and harbours) were identified and are decisive for their classification as HMWB.

Table 25: Presence of significant hydromorphological alterations affecting DRBD transitional and coastal water bodies

Type	Country	Name	Area (km²)	1st (main) reason for hydromorphological alteration	Decisive HMWB
Coastal waters	RO	Periboina-Cap Singol	348.41		
	RO	Mangalia	2.67	Marine constructions, shipyards and harbours	Yes
	RO	Cap Singol-Eforie Nord	94.51	Marine constructions, shipyards and harbours	Yes
	RO	Eforie Nord-Vama Veche	126.22		
Transitional waters	RO	Lac Sinoie	169		
	RO	Chilia-Periboina	708		
	UA	Black sea	242		

2.3 Groundwater

Key findings and progress

The types of pressures on groundwater bodies of basin-wide importance are similar to those in 2015. Pollution by nutrients (ammonium, nitrates, phosphates and sulphates) from diffuse sources is the key factor posing significant pressure on the chemical status while the over-abstraction is the key pressure affecting quantitative status of groundwater bodies. The number of groundwater bodies of basin-wide importance not achieving good quantitative status has decreased since 2015, one groundwater body improved from poor to good status. Deterioration of chemical status since 2015 was observed for two groundwater bodies of basin-wide importance. Further details are presented in tables 25 to 28.

According to WFD Article 2 the term *groundwater* refers to all water that is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. An *aquifer* is a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater. Finally, a *body of groundwater* means a distinct volume of groundwater within an aquifer or aquifers.

The analysis and review of groundwater bodies (GWBs) in the DRBD, as required under WFD Article 5 and WFD Annex II, was updated in 2020 and its results are presented in this plan.

In 2019, SK/HU Transboundary commission adopted the proposal of creating a new GWB-12 on Ipel/Ipoly and adopted the thermal Hungarian GWB as an additional part of GWB-11. The ICPDR adopted GWB-12 at StWG-17 in June 2019. The transboundary GWBs or groups of GWBs of basin-wide importance are listed in Table 26 and illustrated in Map 4.

Transboundary GWBs of basin-wide importance were defined as follows:

1. Important due to the size of the groundwater body i.e. an area >4,000 km² or
2. Important due to various criteria e.g. socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria need to be agreed bilaterally.

Other GWBs, even those with an area larger than 4,000 km², that are fully situated within one country of the DRBD are dealt with at the national level. More detailed characteristics of the 12 transboundary GWBs of basin-wide importance, as well as their status assessment, are given in the Annex 8.

Table 26: Transboundary GWBs of Danube basin wide importance

GWB	Nat. part	Area [km²]	Aquifer characteristics		Main use	Overlying strata [m]	Criteria for importance
			Aquifer Type	Confined			
1	AT-1	1,650	K	Yes	SPA, CAL	100-1000	Intensive use
	DE-1	4,250					
2	BG-2	13,034	F, K	Yes	DRW, AGR, IND	0-600	> 4000 km²
	RO-2	11,340					
3	MD-3	9,662	P	Yes	DRW, AGR, IND	0-150	> 4000 km², GW use, GW resource
	RO-3	12,646					
4	BG-4	3,308	K	No	DRW, AGR, IND	0-10	> 4000 km²
	RO-4	2,187	F-K	Yes			
5	HU-5	4,989	P	No	DRW, IRR, IND	2-30	> 4000 km², GW resource, DRW protection
	RO-5	2,227					
6	HU-6	1,034	P	No	DRW, AGR, IRR	5-30	GW resource, DRW protection
	RO-6	1,459					
7	HU-7	7,098	P	No	DRW, AGR, IND, IRR	0-125	> 4000 km², GW use, GW resource, DRW protection
	RO-7	11,355		Yes			
	RS-7	10,506		No			
8	HU-8	1,152	P	No	DRW, IRR, AGR, IND	2-5	GW resource, DRW protection, dependent ecosystem
	SK-8	2,186					
9	HU-9	750	P	No	DRW, IRR	2-10	GW resource, DRW protection, dependent ecosystem
	SK-9	1,470		Yes			
10	HU-10	493	K	No	DRW, OTH	0-500	GW resource, DRW protection, dependent ecosystem
	SK-10	598	K, F				
11	HU-11	3,337	K	Yes	DRW, SPA, CAL	0-2500	Thermal water resource
	SK-11	563	F, K				
12	HU-12	146	P	No	DRW, AGR	0–10	DRW protection, dependent ecosystem, GW resource
	SK-12	198					

GWB	ICPDR GWB code which is a unique identifier and the name
Nat. part	Code of national shares of ICPDR GWB
Area	Area of national shares in km²
Aquifer characterisation	Aquifer Type: **P** = porous/**K** = karst/**F** = fissured. Multiple selections possible. Main type should be listed first. Confined: **Yes** /**No**
Main use	**DRW** = drinking water / **AGR** = agriculture / **IRR** = irrigation / **IND** = Industry / **SPA** = balneology / **CAL** = caloric energy / **OTH** = other. Multiple selections possible.
Overlying strata	Indicates a range of thickness (minimum and maximum in metres)
Criteria for importance	If size < 4,000 km² criteria for importance of the GW body have to be named, they have to be bilaterally agreed upon.

This chapter summarises the significant pressures that have been identified for the 12 transboundary GWBs of basin-wide importance. An indicative overview of these pressures is presented below, whereas detailed information on the relevant pressures for each groundwater body is given in Annex 8.

The basic principles and assessment of pollution sources for surface waters described above also provide relevant background information for groundwater due to the very close interrelation between the two water categories. Specifically, synergies between groundwater and the three SWMIs of organic, nutrient and hazardous substance pollution are of importance.

2.3.1 Groundwater Quality

For all six national shares failing good groundwater chemical status, which are located in five transboundary GWBs of basin wide importance, diffuse sources of pollution were reported as significant pressures causing *poor* status. Seven transboundary GWBs (and in total 19 national shares) are in good chemical status. Out of these, for HU-5 significant upward trends were identified for nitrates, ammonium, conductivity and sulphates and for SK-8 and SK-9 a significant upward trend was observed for phosphates. The overall assessment of significant pressures on the chemical status identified pollution by nitrates, ammonium, phosphates, sulphates and chlorides from diffuse and point sources as the key factor. The major sources of the diffuse pollution are agricultural activities, non-sewered population and urban land use. Leakages from contaminated sites and waste disposal sites and discharges from wastewater treatment plants are significant point sources of pollution.

Compared to the status assessment in 2015, four national shares (in three GWBs), which were in poor status, have still the same status, and good status of two national shares (in two GWBs) in 2015 deteriorated to poor in 2021.

2.3.2 Groundwater Quantity

The assessment of pressures on groundwater quantity of the 12 transboundary GWBs of basin-wide importance showed that the direct and indirect over-abstraction prevented the achievement of good quantitative status for three national shares (in two GWBs). Compared to the status assessment in 2015, three national shares, which were in poor status, still remain at the same status, one national share that was in poor status in 2015 is now identified as of good status and one national share that was in good status in 2015 is now in poor status.

2.4 Effects of Climate Change (Drought, Water Scarcity, Extreme Hydrological Phenomena and other Impacts)

With the publication of successive IPCC Assessment Reports, most recently the 6th Assessment Report of 2021[62], human influence on the climate system and impacts on human and natural systems due to recent climate changes has also been recognized by scientific research. Anthropogenic emissions and atmospheric concentrations of CO2 and other greenhouse gases as drivers of climate change have increased since the pre-industrial era, driven largely by economic and population growth. As a result, atmospheric and ocean temperatures have increased, the global mean sea level has risen and ice and snow cover have receded, not only in polar regions, but also, for example, in the mountain ranges of continental Europe. These changes have been accompanied by a slow shift in mean temperature and precipitation. At the same time, many regions are facing higher uncertainty due to more frequent and pronounced extreme weather phenomena, such as hot temperature extremes and heavy precipitation events.

62 6th IPCC Assessment Report to be downloaded from https://www.ipcc.ch/assessment-report/ar6/ (accessed 15 October 2021).

Important climate change impacts related to the Danube River Basin are shifts in precipitation patterns and snow cover and an increase in the frequency of flooding/flash flooding and droughts. Simulations show both a future increase in the intensity and frequency of dry periods, hot days and heat waves and local and regional increases in heavy rainfall. Higher temperatures are also expected to lead to an increase in evapotranspiration rates, affecting vegetation, rivers and lakes and ultimately the water balance of the whole region. Consequently, climate change will have a wide range of effects in the Danube River Basin. For example, two highly significant phenomena that will be exacerbated by climate change in the future are drought and water scarcity.

Both pose significant risks to the stability of water dependent aquatic and terrestrial ecosystems and may influence the achievement of the good status of all waters. Furthermore, both have severe economic consequences for society and for most economic sectors, particularly drinking water supply, agriculture, energy and transport, and crucially both also pose significant risks to the stability of water dependent aquatic and terrestrial ecosystems. In addition, the region will face other known impacts of climate change, e.g. rising water temperatures or an increase in extreme precipitation events.

To reduce and manage the risks posed by climate change, both adaptation and mitigation measures are urgently needed. While adaptation is the process of adjustment to the actual or expected climate and its effects, mitigation is the process of reducing emissions to limit future climate change. Effective implementation of such measures depends on coherent policies and cooperation on all scales – international, regional and national – and requires integrated responses that link mitigation and adaptation with other societal objectives. Drought and water scarcity can have widespread impacts on water-dependent sectors, such as agriculture, water supply (drinking water), energy (hydropower), industry (cooling water), transport and navigation, and recreation. Hydromophological alterations can cause also impacts on groundwater bodies and thus on water dependent terrestrial ecosystems can suffer long-term damage, whilst increased water temperatures, higher pollutant concentrations and reduced oxygen levels can pose a serious threat to sensitive aquatic species, especially if there is no natural access to alternative habitats.

The cross-cutting character of this SWMI, vis-à-vis the other SWMIs identified for the DRB but also in the wider context of European Water Policy, is reflected in the necessity for mitigation of and resilience to extreme hydrological phenomena at both ends of the spectrum (i.e. flooding and drought). The main aim is therefore to ensure that measures taken in the context of other, pressure specific SWMIs (e.g. focussed on particular issues relating to pollution or hydromorphology) are "climate proof". This means that the respective measures must achieve the desired results without negative and unintentional side effects even under changed climate conditions. This will be ensured by integrating climate change into the approaches adopted within recognized SWMIs as well as via coordinated implementation of the WFD and FD and other environmental Directives in the DRB.

3 PROTECTED AREAS

In the context of this plan, the objectives for protected areas are determined by WFD Article 4(1)(c), requiring Member States to "achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of this Directive unless otherwise specified in the Community legislation under which the individual protected areas have been established".

The protected areas to be considered are listed in WFD Annex IV. Furthermore, the WFD requires a "register or registers of all areas lying within each river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water" to be established (WFD Article 6).

At the Danube basin-wide scale, protected areas for the protection of habitats and species, nutrient sensitive areas, including areas designated as nitrates vulnerable zones (see Map 31), and other protected areas in non-EU MS have been compiled and are updated. Other types of protected areas according to WFD Article 6 and WFD Annex IV (e.g. areas designated for the abstraction of water intended for human consumption under WFD Article 7, areas designated for the protection of economically significant aquatic species, or bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 76/160/EEC, repealed by Directive 2006/7/EC) are not addressed at the basin-wide level but are subject to national registers.

Table 27 provides an overview on the registers of protected areas required by WFD Article 6 and WFD Annex IV to be kept under review and up to date. The table furthermore provides information on whether the register was established and is regularly reviewed at the Danube basin-wide and/or national level.

Table 27: Overview on established registers for protected areas

Type of protected area	Corresponding legislation	Register established and regularly reviewed at		Comment
		Danube basin-wide level (Part A)	National level (Part B)	
Areas designated for the abstraction of water intended for human consumption	EU Drinking Water Directive 80/778/EEC as amended by Directive 98/83/EC	-	x	Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption repealing Directive 98/83/EC as of 13 January 2023
Areas designated for the protection of economically significant aquatic species	EU Shellfish Directive 79/923/EEC and Freshwater Fish Directive 78/659/EEC	-	-	EU Shellfish and Freshwater Fish Directives Repealed by WFD 2000/60/EC with effect from December 2013
Bodies of water designated as recreational waters, including areas designated as bathing waters	EU Bathing Waters Directive 76/160/EEC	-	x	Repealed by Directive 2006/7/EC
Nitrates vulnerable zones	EU Nitrates Directive 91/676/EEC	x	x	Updated for DRBMP Update 2021
Nutrient sensitive areas	EU UWWT Directive 91/271/EEC	x	x	Entire DRB is considered as a catchment area for the sensitive area under Directive 91/271/EEC Article 5(5)

Type of protected area	Corresponding legislation	Register established and regularly reviewed at		Comment
		Danube basin-wide level (Part A)	National level (Part B)	
Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection	EU Habitats Directive 92/43/EEC and EU Birds Directive 79/409/EEC	x	x	Water-relevant Natura 2000 sites
Other protected areas in non-EU Member States (e.g. Nature and Biosphere Reserves)	-	x	x	Relevant for non-EU Member States

Map 20 illustrates water-related protected areas >500 ha designated for the protection of habitats or species where maintenance or improvement of the water status is an important factor in their protection (including Natura 2000 sites)[63]. Furthermore, the map visualises protected areas in the non-EU MS. Annex 11 includes a detailed inventory of the protected areas as illustrated in Map 20.

Figure 59 provides an overview of these protected area types for the DRBD. Out of a total of 1,737 protected areas, 1017 (59%) have been designated following the EU Habitats Directive and 358 (21%) are bird protected areas (EU Birds Directive). 40 (2%) areas are protected under both the Habitat as well as Birds Directive. All of them are Natura 2000 sites designated in EU MS. 322 (19%) are protected area types reported by non-EU MS and are mainly nature reserves and Biosphere Reserves. A significant share of designated Natura 2000 sites is located along the Danube River.

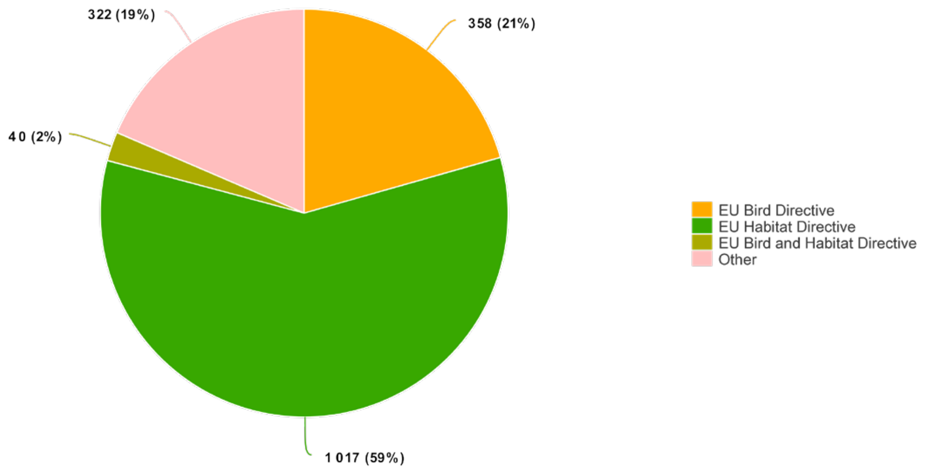


Figure 59: Overview on number of WFD water relevant protected areas under the EU Habitats Directive and EU Birds Directive including reported areas for non-EU MS

Sturgeons in the DRB are threatened by extinction[64]. They are flagship species, also representing other long-distance migratory fishes. Protecting them will mean integrating nature protection policy with water policy in the Danube River Basin wherever possible, in order to create synergies and avoid potential conflicts. Different measures outlined in the DRBMP Update 2021 will contribute, i.e. the improvement of habitats and the establishment of migration Sroutes. One of the results of the MEASURES Project was the identification of those Natura 2000 sites which are most relevant for the conservation of sturgeons. Further details about the MEASURES Project and sturgeon conservation in the Danube River Basin can be found in Chapter 6.7.

63 *Natura 2000 designation under the EU Directive 92/43/EEC and Directive 79/409/EEC.*

64 *Five Danube sturgeon species are listed in Annex V of the EU Habitats Directive, assessed with unfavourable-bad conservation status by almost all Member States in the latest reporting of the Habitats Directive.*

The Pan-European Action Plan for Sturgeons

First decisive steps in sturgeon conservation on the Danube River Basin date back to 2005 with the development of the "Action Plan for the conservation of Danube River sturgeons" under the Bern Convention. In 2009, DRBMP 2009 was adopted, followed by the DRBMP Update 2015, both specifying important key measures for sturgeon conservation in the field of the ICPDR. The Danube River Basin Management Plans and its Joint Programme of Measures as well as the national River Basin Management Plans of Danube countries include relevant measures for Danube sturgeon conservation activities to ensure fish migration. This includes ensuring the unimpeded proper function and viability of migration routes/ improving the migration routes, the existence of appropriate spawning grounds, appropriate ecology and water quality along migration routes and at spawning grounds.

In addition, measures were taken on the national level to protect sturgeons from extinction. Most Danube range states and all Black Sea range states (including Russia, Turkey and Georgia) have fully and permanently prohibited fishing for all sturgeon species (river and sea). The time limited (5-year) sturgeon fishing bans from Bulgaria and Romania, which expire in 2021, thus form an exception. In 2021, the fishing ban order of Romania entered into force for an unlimited period of time. Bulgaria has renewed the 5-year time limit of its ban until 2025. Only for sterlet, Austria, Slovakia and Croatia regulate recreational fishing through the introduction of closed seasons and catch size limits. For Austria, it must be noted that three federal states have spared sterlet completely from fishing all year round, effectively meaning it is protected while three other Austrian federal states have restrictions for recreational sterlet angling as set out above.

"To secure viable populations of Danube sturgeon species and other indigenous fish species by 2020" became an important target within the EUSDR. In 2012, the "Danube Sturgeon Task Force" (DSTF) was created in the frame of the EUSDR Priority Area 6 (Biodiversity) and reinforced in 2018.

Following the adoption of the DRBMP Update 2015 and the approval of the ICPDR Sturgeon Strategy in 2017, recent policy developments and project activities substantially support the continuation of ongoing and jointly coordinated efforts in sturgeon conservation activities in the Danube River Basin.

The first European Sturgeon Conference was jointly organised by the ICPDR and Austria in the framework of the Austrian EU Presidency in July 2018. The Conference aimed to raise awareness to the challenges in place and to trigger comprehensive action for sturgeon conservation and restoration in the Danube Basin as well as at pan-European level[65]. It paved the way forward for the Pan-European Action Plan for Sturgeons (PANEUAP) which was adopted by the Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)[66] in November 2018. The PANEUAP was endorsed for implementation under the Habitats Directive in May 2019. It sets the framework to conserve the last surviving sturgeon populations, protect and restore their habitats and migration routes, urgently end their illegal fishing and by-catch and reintroduce the species to a number of rivers. The PANEUAP aims to have effective and coordinated recovery/reestablishment programs in place, which will stop the decline of existing populations and secure genetic diversity, establish ex situ living gene banks for each species and relevant subunits, eliminate overexploitation and illegal trafficking of sturgeons and their products, ensure sufficient monitoring of sturgeon populations, identify and effectively

65 *https://www.icpdr.org/main/high-level-conference-for-the-protection-of-sturgeons (accessed 12 February 2021).*

66 *https://www.coe.int/en/web/bern-convention (accessed 12 February 2021).*

protect existing habitats, while potential habitats are mapped and restoration is ongoing, restore historic migration corridors and establish a coordination structure for the implementation of this plan.

The Conference "Conservation of Danube Sturgeons - a challenge or a burden?" held in Galati (Romania) in October 2019 addressed actions needed to conserve the critically endangered population of sturgeons in the entire Danube Basin by supporting the concrete implementation of the PANEUAP in the Danube Basin. The Conference was the first such event with participation of fisheries authorities, water management authorities, environmental authorities, scientists and stakeholders of both the DRB States and the Black Sea States. As a result of the Conference, the Galati Declaration[67] was adopted and includes key messages to decision-makers from all relevant institutions and other stakeholders as a basis for shaping future actions and the way forward to saving sturgeons from extinction. The Galati declaration will serve as an implementation guide for the PANEUAP under the Bern Convention and the EU Habitats Directive.

Download the PANEUAP:
https://ec.europa.eu/environment/nature/conservation/species/action_plans/
(accessed 16 February 2021).

67 https://danube-sturgeons.org/wp-content/uploads/2019/11/Galati-Declaration-on-Danube-Sturgeon-Conservation.pdf (accessed 12 February 2021).

4 MONITORING NETWORKS AND STATUS ASSESSMENT

4.1 Surface Waters

According to the WFD, good ecological and chemical status has to be ensured and achieved for all surface water bodies. For those identified as heavily modified or artificial, good ecological potential and chemical status has to be achieved and ensured.

Monitoring results according to the WFD serve the validation of the pressure analysis and an overview of the impacts on water status is required in order to initiate measures.

Ecological status/ecological potential

Ecological status results from assessment of the biological status of all WFD biological quality elements (fish, macrozoobenthos, phytoplankton, phytobenthos and macrophytes) and the supportive physico-chemical parameters (general and specific pollutants) as well as hydromorphological parameters (hydrological regime, river continuity and morphological conditions), following the principles stipulated in the WFD Annex V.

Ecological potential includes the same biological and physico-chemical parameters and reflects given hydromorphological changes. It is assessed for heavily modified as well as artificial water bodies and aims for specific environmental objectives than ecological status.

Ecological status for surface water bodies is assessed based on specific typologies and reference conditions, ecological potential being based on reference approach and mitigation measures approach which have been defined by EU MS according to WFD Annex V.

Chemical status

Chemical status has to meet the requirements of environmental objectives for surface waters outlined in WFD Article 4(1). To meet the good chemical status, the environmental quality standards established in line with the WFD Article 16(7) by EU Directive 2008/105/EC on environmental quality standards in the field of water policy, amended by Directive 2013/39/EU, must not be exceeded.

The overall results of the status assessment can be found in Chapter 4.1.5. These results build mainly upon the outcomes of the TNMN (4.1.1) and the JDS4 (4.1.2).

4.1.1 Surface Water Monitoring Network under the Transnational Monitoring Network

In line with the provisions of the DRPC, the TNMN in the DRB has been in operation since 1996 (see Map 21). The major objective of the TNMN is to provide an overview of the overall status and long-term changes of surface water and, where necessary, groundwater status in a basin-wide context (with particular attention paid to the transboundary pollution load). In view of the link between the nutrient loads of the Danube and the eutrophication of the Black Sea, the monitoring of sources and pathways of nutrients in the DRB and the effects of measures taken to reduce the nutrient loads into the Black Sea are an important component of the scheme.

The TNMN laboratories have a free choice of standardized analytical method, providing they are able to demonstrate that the method in use meets the required performance criteria. To ensure the quality of collected data, a basin-wide Analytical Quality Control (AQC) programme is regularly organized by the ICPDR for the national laboratories providing data for TNMN.

To meet the requirements of both the WFD and the DRPC, the TNMN for surface waters consists of the following elements:

- Surveillance monitoring 1: Monitoring of surface water status;
- Surveillance monitoring 2: Monitoring of specific pressures;
- Operational monitoring;
- Investigative monitoring.

Surveillance monitoring 2 is a joint monitoring activity of all ICPDR Contracting Parties, which produces data on concentrations and loads of selected parameters in the Danube and major tributaries. Surveillance monitoring 1 and operational monitoring is based on collection of data on the status of surface water and groundwater bodies in the DRBD, to be published in the DRBMP. Investigative monitoring is primarily a national task. However, on the basin-wide level, the Joint Danube Surveys (JDS) serve the investigative monitoring as required e.g. for harmonisation of existing monitoring methodologies; filling information gaps in WFD monitoring networks; testing new methods; or checking the impact of "new" chemical substances in different matrices. JDSs are carried out every 6 years.

ICPDR Strategy on Adaptation to Climate Change highlights the following guiding principles for adaptation to climate change in the sector of monitoring and status assessment:

- Maintain both surface and groundwater surveillance monitoring sites for long time series. Set up an investigative monitoring programme for climate change and for monitoring climate change "hot spots" and try to combine them as much as possible with the results from the operational monitoring programme.
- Include reference sites in long term monitoring programmes to understand the extent and causes of natural variability and impact of climate change.

In response to the provisions of the ICPDR Strategy on Adaptation to Climate Change, the ICPDR decided to upgrade the TNMN by including the monitoring of impacts of the climate change. The ICPDR monitoring experts agreed to start with the data on Danube water temperature. For such monitoring long-term datasets must be employed and the availability of such data in the Danube countries was explored. The countries were asked to deliver the raw data on water temperature for (at least) last 50 years. So far, the analysis has been done for the Austrian, Bulgarian, Slovak and Serbian data sets, as only those covered the time period suitable for a sufficiently robust statistical analysis. Trend analyses have shown that the air temperature has increased since the 1970s and thus also the water temperature. Figure 60 shows the course of the annual mean values of the water temperature at five measuring points of the Danube. The water temperature has risen significantly since the mid-1970s. The gradient is between 0.035 ° C/Year (Kienstock) and 0.054 ° C/Year (Bezdan).

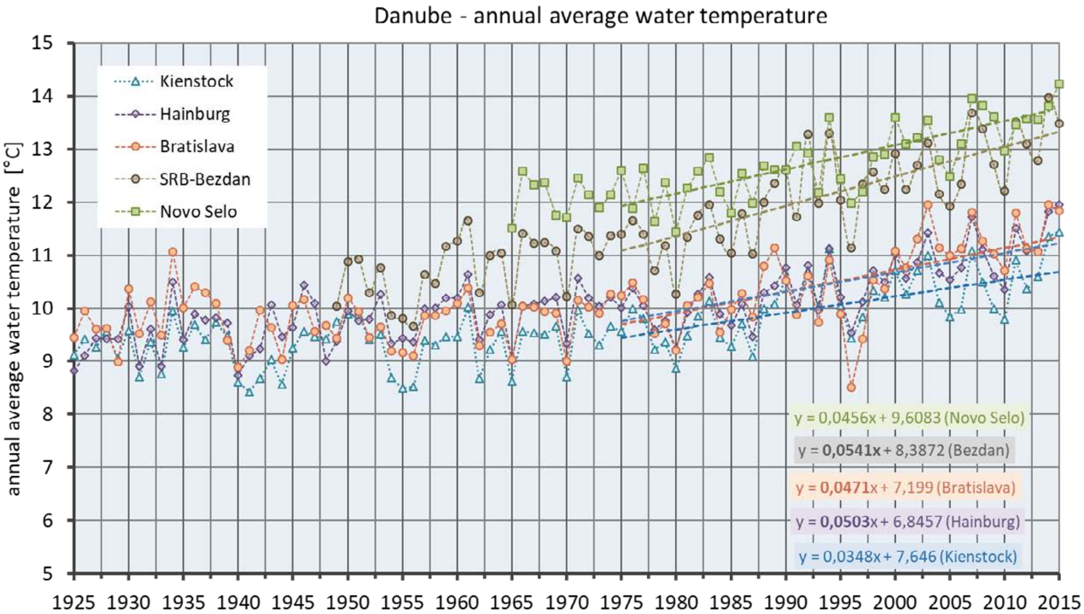


Figure 60: Annual average water temperature 1925-2015 at the measuring points AT-Kienstock, AT-Hainburg, SK-Bratislava, RS-Bezdan and BG-Novo Selo

Figure 61 and Table 28 show the absolute changes in the water temperature at the measuring points, for each month of the year and as the mean value over the months of the four seasons. The biggest change occurred in the months of July and August, with an increase in the water temperature between 2.2 and 3.4 °C. The smallest increase is seen in February with 0.5 to 1.2 °C. Accordingly, the water temperature rose sharply in the summer months - June, July and August - with changes of 2 to 3 °C.

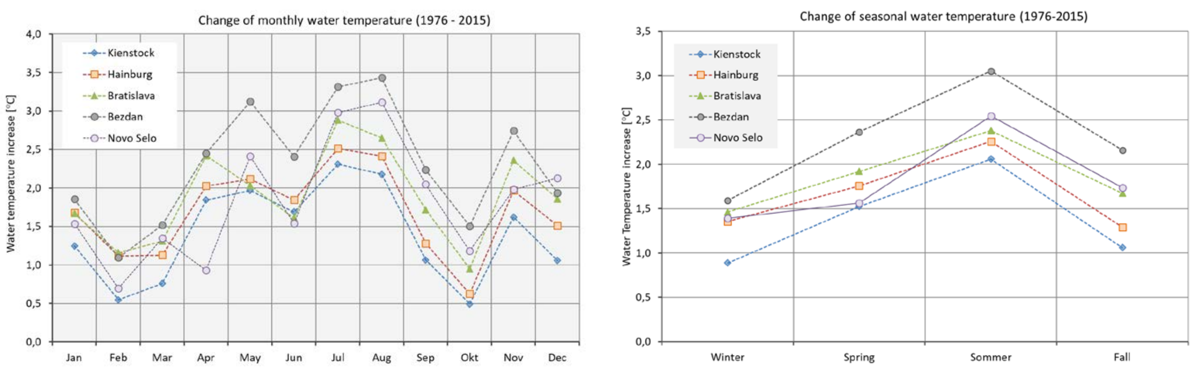


Figure 61: Change of the water temperature (trend) in the months (left picture) and in the seasons

Table 28: Absolute changes of the water temperature [°C] in the period 1976-2015 at five measuring points of the Danube (bold figures show significant change)

Site name	River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Winter	Spring	Summer	Fall	Year
Kienstock	Danube	1.25	0.55	0.76	**1.84**	**1.97**	**1.69**	**2.31**	**2.18**	1.06	0.49	**1.62**	1.06	0.89	**1.52**	**2.06**	**1.06**	**1.40**
Hainburg	Danube	**1.68**	1.12	1.13	**2.03**	**2.12**	**1.84**	**2.51**	**2.41**	**1.28**	0.62	**1.97**	**1.51**	**1.36**	**1.76**	**2.26**	**1.29**	**1.68**
Bratislava	Danube	**1.67**	1.16	1.31	**2.42**	**2.03**	**1.61**	**2.88**	**2.65**	**1.72**	0.95	**2.36**	**1.86**	**1.46**	**1.92**	**2.38**	**1.67**	**1.88**
Bezdan	Danube	**1.86**	1.09	1.52	**2.45**	**3.12**	**2.41**	**3.32**	**3.43**	**2.23**	**1.50**	**2.74**	**1.93**	**1.59**	**2.36**	**3.05**	**2.16**	**2.30**
Novo Selo	Danube	**1.54**	0.70	1.35	0.93	**2.41**	**1.54**	**2.98**	**3.11**	**2.05**	**1.18**	**1.98**	**2.13**	**1.39**	**1.56**	**2.54**	**1.74**	**1.82**
Trend of monthly, seasonal and annual water temperature in °C for the period 1976-2015, linear regression																		

The countries continue to monitor the water temperature so it is expected that in the future RBM cycles data for more stations in the DRB will be available.

4.1.2 Joint Danube Survey 4

JDS4 was organized on the Danube River including its major tributaries, with a sampling programme focused on 51 sites nominated by the ICPDR experts. Seven additional groundwater sites and 11 urban wastewater treatment plants (WWTPs) were nominated by the ICPDR to widen the scope of the survey. The ambitious programme of JDS4 necessitated the inclusion of additional specific sampling sites for passive sampling, eDNA analysis of fish and microbiological as well as microplastics monitoring. Following the survey's completion in autumn 2019, the collected samples were analysed in laboratories and scientific institutes across Europe[68].

The key objectives of JDS4 were focussed on providing an opportunity for harmonization and training in WFD related monitoring and on covering the information gaps for the Danube River Basin Management Plan Update 2021. JDS4 biological monitoring provided a homogeneous internationally coordinated scientific snapshot of the whole Danube at a given time. To strengthen the links to WFD, an indication of the ecological status was presented for the sites using a harmonised approach regardless of whether or not these sites were located in natural or heavily modified water bodies. The WFD assessment of the ecological status for each water body being a legally mandatory task for the EU Member States is based on a complex methodology requiring monitoring activities over a certain timespan and thus from legal and logistical reasons it could not be carried out during JDS4.

Biological quality elements indicating pressure from nutrients and oxygen depletion by biodegradable substances – phytoplankton, macrophytes, phytobenthos, partly macrozoobenthos – indicated a good status at many sites and pointed at local pressure only. Fish and macrozoobenthos however indicated impacts induced by hydromorphological pressures at most of the sites. In general, an improvement of the indicative ecological status since the previous surveys is not visible along the whole length of the Danube except for some sites. Trends of deteriorating status may also be linked to the use of more effective methodologies and increasing pressure from invasive alien species.

In total 76,265 specimens of 72 fish and three jawless species were detected during JDS4. This underlines the importance of the Danube as a substantial source of fish biodiversity in Europe. Taking into account this high diversity of fish taxa, it is believed that effective restoration measures can help to improve the ecological status in order to meet the WFD goals.

JDS4 results reconfirmed that the Danube River and its main tributaries are under considerable influence from biological invasions. The number of alien species recorded and the values of the pressure indices revealed a better situation in the Lower Danube when compared to Upper and Middle reaches, mainly because the Lower Danube can be considered as a native area of distribution for Ponto-Caspian taxa, which are considered alien to the Middle and Upper Danube.

Compared to results from previous JDSs, an increase in the number of identified alien species has been recorded but the data analysis shows that the pressure caused by biological invasions is relatively stable. The reason is that not all alien species are also invasive therefore the assessment of bioinvasion pressure has to take this into account.

68 http://www.danubesurvey.org/jds4/publications *(accessed 14 September 2021).*

JDS4 provided an excellent opportunity to evaluate (e)DNA-based approaches in an applied, international and highly integrative setting. The fish community of the Danube, its macrozoobenthos (MZB), phytobenthos and sediment fauna were assessed using group-specific metabarcoding approaches. While a certain degree of methodological variation still exists, the outcomes clearly demonstrate the huge potential of DNA and environmental DNA-based approaches for biodiversity and ecological risk and status class assessments: eDNA water analysis of fish revealed most of the taxa also detected by the traditional fish survey, but was particularly effective in detecting the hard-to-capture benthic taxa (including endangered sturgeon species). The (e)DNA-based taxalists of the MZB likewise covered many of the traditionally assigned species but included a plethora of additional chironomid and oligochaete species. Molecular ecological status class assessments based on presence-absence values of MZB species were also largely congruent to traditional abundance or presence-absence-based outcomes. Although the molecular assessment of the phytobenthos revealed fewer species than traditional light microscopy, many more taxa were detected, which await a species-level taxonomic annotation in the future. Metabarcoding of the sediment community enabled the comprehensive assessment of the meiofaunal community (i.e. an often neglected but ecologically highly sensitive component of the Danube biodiversity) and the molecular inference of fine sediment quality based on local community structures of vulnerable nematode species. Finally, all (eDNA)-based taxalists were compiled to effectively inform invasive alien species detection in the Danube River Basin.

In a pilot comparison exercise, the indicative status for benthic invertebrates based on the Austrian indices SI and MMI and on eDNA were calculated for three JDS4 sampling sites and the results were found to be astonishingly similar to each other. In another exercise, intercalibration common metrics were used for ecological assessment of sites using data from classical fish survey and from eDNA analysis. For 46% of the sites the same status class was found and for 70% of the sites the final classification of reaching or failing the WFD objective of good status was identical.

The application of (e)DNA-based tools during JDS4 has been found very effective for a comprehensive assessment of the Danube biodiversity (i.e. fish, macrozoobenthos, phytobenthos, sediment community and invasive alien species detection) and showed very promising potential for ecological status class assessments. A complementary approach of traditional assessment techniques and (e)DNA-based tools has a promising potential for WFD ecological status assessments.

Assessment of faecal pollution of the Danube showed that 78% of samples displayed little or moderate pollution levels as it can be expected for rivers with state-of-the-art wastewater management. 19% samples showed critical and 3% samples strong pollution levels. No site with an excessive pollution level was observed during JDS4.

The analysis of antibiotic resistant bacteria showed a significant increase in multi-resistance (acquired resistances to antibiotics from three or more tested antibiotic classes). The accumulation of resistance mechanisms in the Danube River *E. coli* population has continued over the last six years. The most common resistances were those to ampicillin and tetracycline. No resistances were detected to imipenem, meropenem, tigecycline, amikacin and colistin.

Comparison of the nutrients data produced over last 20 years within the four JDS and by ICPDR annual TNMN monitoring showed a high degree of comparability, despite the variability in sampling dates and personnel.

Nineteen priority substances regulated in the WFD were analysed in water. Only for cypermethrin and cybutryne the concentrations above the Environmental Quality Standards (EQS) were observed at a few sampling sites. All other priority pollutants showed concentrations below the respective EQS.

Ten substances from the EU Watch list were analysed in water and elevated concentrations were detected for the pharmaceutical diclofenac, the natural hormone 17-beta-estradiol and the insecticide imidacloprid.

The results for mercury and brominated diphenylethers in biota showed concentrations higher than the EQS at all sites. Both compounds are considered as ubiquitous persistent, bioaccumulative and toxic substances. Whether the existing mitigation measures for these compounds are effective has to be shown in future monitoring programs. For dioxins and dioxin-like compounds, heptachlor and fluoranthene the concentrations higher than the biota EQS were found at only a few sites.

The analysis of groundwater showed that in many cases the bank-filtration process contributes to a smaller number of substances and lower concentrations being detected in groundwater than in the Danube River. Nevertheless, this effect cannot be generalised and is compound- and site-specific. For many of the detected substances the situation is opposite and the concentration in groundwater is often higher than in the Danube. None of the pesticide substances and metabolites for which European quality standards for groundwater and drinking water exist, have exceeded these standards. However, for bisphenol A, all seven detected concentrations in groundwater would have exceeded the discussed drinking water quality standard of 0.01 µg/L by 9- to 16-times.

Current chemical river pollution monitoring is focussed on target analysis of Priority Substances and on River Basin Specific Pollutants. In addition to that few emerging chemicals from the EU Watch List are being investigated. The strategy to overcome the limits of classical target analysis includes wide-scope chemical target screening and non-target screening approaches in combination with effect-based monitoring which are on the threshold to become regular tools for WFD-compliant monitoring. A handful of diverse target screening methods were applied during JDS4 focussing on several thousands of compounds. Hundreds of compounds were detected. This comprehensive use of screening techniques enabled their comparison to be made, and interlaboratory trials and training for the Danube laboratories to be completed. Acquiring this huge dataset from screening methods (>2,600 substances from wide-scope target screening, >65,000 substances used for suspect/non-target screening and altogether >300,000 results) made it possible to perform prioritisation of pollutants in water, biota, sediment, wastewater and groundwater (using the prioritisation framework of the NORMAN Association) leading to specification of tens of substances with the proven most adverse effects to the Danube ecosystem.

The first ever comprehensive screening of microplastics along the whole Danube established a baseline of pollution by microplastics in the DRB. In all water samples plastic polymers were detected and polyethylene was detected as the most abundant component of microplastics in almost all water samples. The screening of mussels discovered the presence of microplastics at all sites and revealed polyethylene terephthalate as the dominant plastic pollutant.

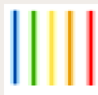
The results of the radiometric analysis of the JDS4 sediment samples showed that the radio-ecological development of the Danube continues to be promising. There is currently no indication of hazardous man-made radioactive contamination of the Danube ecosystem compartments.

The findings of JDS4 are supportive to the implementation of the WFD providing an extensive homogeneous dataset acquired by the WFD compliant methods. Even though these data have no ambition to replace the national data used for the assessment of the ecological and chemical status they are an excellent reference database which can be used for WFD assessment methods harmonization throughout the Danube River Basin and for the new derivation and prioritization of the Danube River Basin Specific Pollutants.

4.1.3 Confidence in the Status Assessment

Actual confidence levels achieved for all data collected for a RBM plan should enable meaningful assessments of status in time and space. According to WFD Annex V, estimates of the level of confidence and precision of results provided by monitoring programmes shall be given in the plan. For this purpose, a three-level confidence assessment system was agreed for surface water bodies (regarding both ecological and chemical status in the DRBD). This system is in line with the provisions of the WFD Reporting Guidance 2022[69]. General indication/guidance on confidence levels for ecological and chemical status are described in Figure 62 and Figure 63 and is illustrated in Maps 23 and 24a.

Confidence level of correct assessment	Description	Illustration in map
HIGH Confidence	**All of the following criteria apply:** **Biology:** · WFD-compliant monitoring data; · Biological monitoring complies fully with preconditions for sampling/analysis; · Methods being compliant with the WFD requirements which successfully have been/are part of the intercalibration exercise or in case intercalibration process was not possible they were approved as WFD compliant by European Commission. **Chemistry:** · National EQS available for specific pollutants and sufficient monitoring data (WFD compliant frequency) available	

MEDIUM Confidence	**One or more of the following criteria apply:**
	Biology:
	· WFD compliant methods not included in intercalibration process at EU level;
	· WFD compliant monitoring data, but:
	  · biological results not in agreement with supportive quality elements or
	  · only few biological data available (possibly showing different results);
	· Medium confidence in grouping of water bodies;
	· Biological monitoring does not comply completely with preconditions for sampling and analysis
	(e.g. use of incorrect sampling period).
	Chemistry:
	· National EQS available but insufficient data available (acc. to WFD);
	· Medium confidence in grouping of water bodies.
		

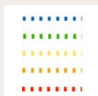
LOW Confidence	**One or more of the following criteria apply:** **Biology:** · No WFD-compliant methods and/or monitoring data available; · Simple conclusion from risk assessment to EQS (updated risk assessment is mandatory). **Chemistry:** · No national EQS available for specific pollutants, but data available (pollution detectable).	

Figure 62: General indication/guidance on confidence levels for ecological status

69 http://cdr.eionet.europa.eu/help/WFD/WFD_780_2022 *(accessed 12 February 2021).*

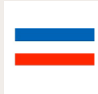
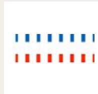
Confidence level of correct assessment	Description	Illustration in map
HIGH Confidence	**Either:** No discharge of priority substances; **Or all of the following criteria apply:** · Data/measurements are WFD-compliant (12 measurements per year); · Aggregation (grouping procedure) of water bodies in compliance with WFD shows plausible results.	
MEDIUM Confidence	**All of the following criteria apply:** · Data/measurements are available; · Frequency is not WFD-compliant (less than 12 measurements per year available); · Medium confidence in grouping of water bodies.	
LOW Confidence	**One or more of the following criteria apply:** · No data/measurements available; · Assumption that good status cannot be achieved due to respective emission (risk analysis).	

Figure 63: General indication/guidance on confidence levels for chemical status

4.1.4 Designation of Heavily Modified and Artificial Water Bodies

Economic development and social needs have substantially physically changed rivers and other waters e.g. for flood control, navigation, agriculture, hydropower generation, water supply and other purposes. Surface waters have been used as an economic resource and canals and reservoirs have been created where no water bodies previously existed.

One of the key objectives of the WFD is to ensure that water bodies meet "good ecological status". However, aquatic ecosystems which are part of modified water bodies may not be able to meet this standard considering the uses connected with such water bodies. This is why the WFD allows to designate some surface waters as heavily modified water bodies or artificial water bodies whereby specific environmental objectives are applied. They will need to meet the "good ecological potential" criterion for these ecosystems and "good chemical status". Hence, artificial and heavily modified water bodies will still need to achieve the same low level of chemical contamination as other water bodies. A series of conditions have to be met to designate water bodies in these categories.

4.1.4.1 Approach for the Designation of Heavily Modified Water Bodies

WFD Articles 4(3) and 5 as well as WFD Annex II allows inter alia for the identification and designation of artificial and heavily modified water bodies. A surface water body is considered as artificial when created by human activity. Heavily modified water body (HMWB) means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of WFD Annex II.

According to those provisions, EU MS may designate a body of surface water as artificial or heavily modified, when:

- its hydromorphological characteristics have substantially changed so that good ecological status cannot be achieved and ensured;
- the changes needed to the hydromorphological characteristics to achieve good ecological status would have a significant adverse effect on the wider environment or specific uses;

- the beneficial objectives served by the artificial or modified characteristics of the water body cannot, for reasons of technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option.

The designation of a water body as heavily modified or artificial means that instead of ecological status, an alternative environmental objective, namely ecological potential, has to be achieved for those water bodies, as well as good chemical status.

The DBA 2004 included provisionally identified HMWBs, and artificial water bodies (AWBs) on the basis of specific basin-wide criteria. For the DRBMP 2009, the Danube countries reported the nationally identified artificial and heavily modified water bodies. Updated information on the designation of AWBs and HMWBs was reported by the Danube countries for the DRBMP Update 2015 and 2021.

4.1.4.1.1 Surface Waters: Rivers

The DRBMP 2009 included the final HMWB designation for EU MS. The non-EU MS performed a provisional identification based on criteria outlined in the DBA 2004, whereas all water bodies have been fully considered for the designation.

The designation of HMWBs for rivers and transitional waters was performed for:

a. The Danube River;
b. Tributaries in the DRBD >4,000 km^2.

For the Danube River, the Danube countries agreed on a harmonised procedure for the final HMWB designation (the designation for HR, RS and UA was provisional) and on specific criteria for a step-by-step approach.

The HMWB designations for the tributaries are based on national methods and respective reported information. However, the preconditions for the basin-wide final HMWB designation (regarding both the Danube River and tributaries >4,000 km^2) are to follow the EC HMWB CIS[70] guidance document.

4.1.4.1.2 Surface Waters: Lakes, Transitional Waters and Coastal Waters

The HMWB/AWB designations for coastal and lake water bodies are based on national methods and the respective reported information is summarised below.

4.1.4.2 Results of the Designation of Heavily Modified and Artificial Water Bodies

4.1.4.2.1 Surface Waters: Rivers

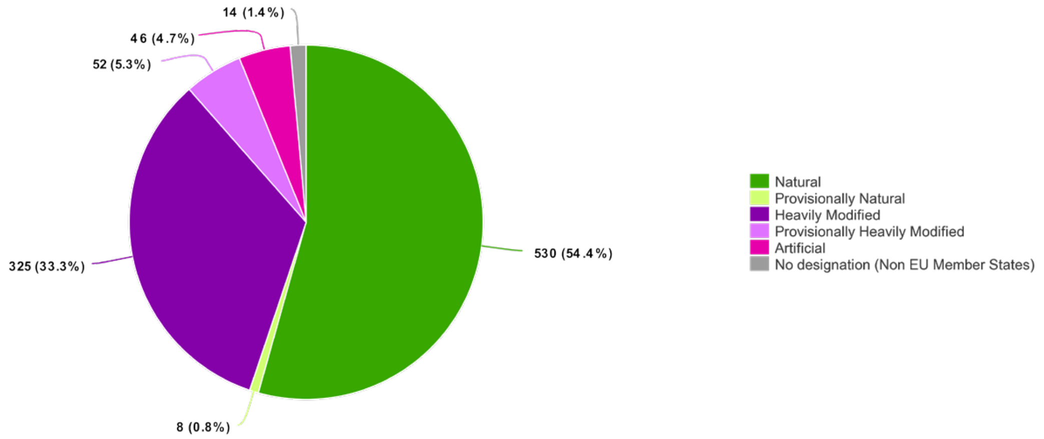
Figure 64 and Table 29 provide information on the designation of DRBD rivers into Natural Water Bodies, HMWB and AWB. Out of overall 975 river water bodies in the entire DRBD (Danube River and DRBD Tributaries) a total number of 377 are designated heavily modified (325 final and 52 provisional HMWBs). These are 39% of the water bodies. This means that 12,750 rkm out of a total 29,127 rkm are heavily modified (38% final HMWBs and 6% provisional HMWBs) due to significant physical alterations. Further, 46 water bodies are AWBs. The results are also illustrated in Map 22.

70 EC CIS Guidance documents can be found here: https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm (accessed 11 September 2021).

The most significant canals, largely intended for navigation, are the Main-Danube Canal in DE, the Danube-Tisza-Danube Canal System in RS and the Danube-Black Sea Canal in RO.

Table 29: Designated HMWBs in the DRBD (expressed in rkm, number of water bodies and percentage)

Rivers – Danube River Basin District (DRBD)		
Total number of WBs: 975	Total number of HMWBs: 377 (352 final and 52 provisional HMWB)	Proportion HMWB (number): 39%
Total WB length (km)[71]: 29,127	Total HMWB length (km): 12,750 (11,012 final and 1,738 provisional HMWB)	Proportion HMWB (length): 44%
The Danube River		
Total number of WBs: 63	Total number of HMWBs: 34 (30 final and 4 provisional HMWB)	Proportion HMWB (number): 54%
Total length of water bodies (km): 5,003	Total HMWB length (km)[72]: 3,350 (2979 final and 371 provisional HMWB)	Proportion HMWB (length): 67%



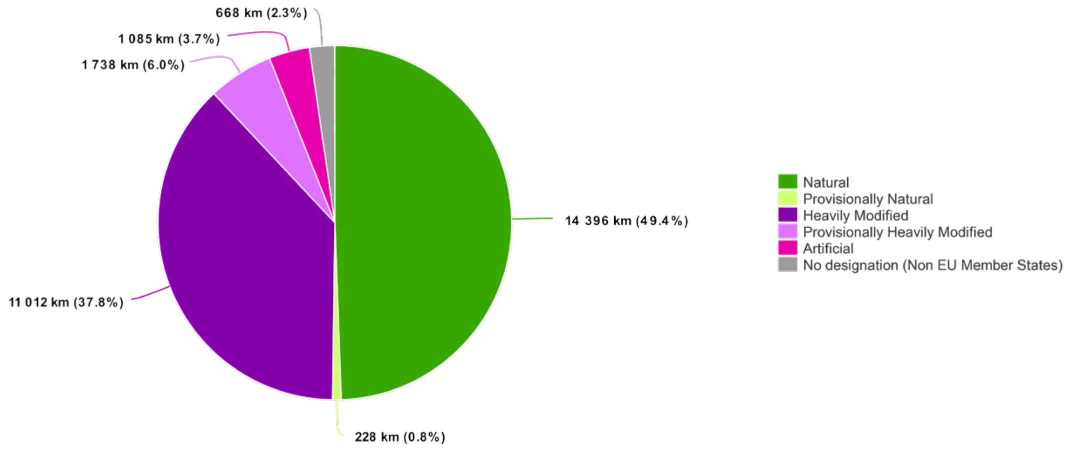


Figure 64: HMWBs, AWBs and natural water bodies in the DRBD, indicated in number of river water bodies and length (River km)

HMWB designation for the Danube River

Out of a total of 63 Danube River water bodies, 34 water bodies were designated as heavily modified, out of which 4 water bodies were designated as provisionally heavily modified by the non-EU MS (Table 29). There-

71 *Including double-counting for transboundary water bodies.*

72 *Including double-counting for transboundary water bodies.*

fore, 3,350 rkm of the total length of Danube River water bodies have been designated as HMWB. No artificial water body has been designated for the Danube River itself. The results are illustrated in Map 22.

4.1.4.2.2 Surface Waters: Lakes, Transitional Waters and Coastal Waters

Out of 7 lake water bodies, 6 were not designated as heavily modified and one as artificial water body.

Out of the 3 transitional water bodies, none was designated as heavily modified. Out of the 4 coastal water bodies, 2 were designated as heavily modified and none was identified as artificial.

4.1.5 Ecological Status/Potential and Chemical Status

In this chapter, the results of the monitoring programmes concerning the ecological and chemical status of rivers, lakes, transitional waters and coastal waters are presented. More detailed results of the classification of all assessed surface water bodies according to particular biological, physico-chemical parameters (general and specific pollutants), hydromorphological and chemical quality elements is provided in Annex 9.

A special analysis of classification results is being carried out for the transboundary river water bodies to highlight and clarify the discrepancies in status assessment between the neighbouring countries. This analysis aims to help countries in coordinating their reporting on transboundary water bodies. Annex 10 provides an overview of the transboundary surface water bodies in the Danube River Basin reported by Danube countries, for which the analysis of water body delineation and classification is being carried out. The mandate for harmonisation of the delineation and the status of the transboundary surface water bodies is not within the ICPDR, but with bilateral river commissions, in case they exist, or for other forms of bilateral coordination between the neighbouring countries.

As it is mentioned in Chapter 1.3, a number of countries performed changes in water body delineation and in the assessment systems for BQEs, which do not allow any comparison of water status between 2015 and 2021. Therefore, a comparison analysis for the whole DRB would be incomplete and it will be carried out in the next river basin management period for working purposes only. Rivers

For the *ecological status/potential* information was received from AT, BA (part of the data), BG, CZ, DE, HR, HU, MD (part of the data), ME, RO, RS (part of the data), SI and SK. *Ecological status/potential* data is missing from UA. Figure 65 illustrates the water status regarding *ecological status/potential* for the length (rkm) of river water bodies as well as the share of existing data gaps. Out of a 29,127 rkm network in the DRBD, *good ecological status* or *ecological potential* is achieved for 7,006 rkm (24.1%).

Information on *chemical status* is shown in five figures and maps as follows: Chemical Status of Surface Water Bodies (displaying overall chemical status in water and biota) in Figure 67 and Map 24e; Chemical Status of Surface Water Bodies (priority substances in water) in Figure 68 and Map 24a; Chemical Status of Surface Water Bodies (priority substances in water without ubiquitous substances according to Directive 2013/39/EU: i.e., without brominated diphenylethers, polyaromatic hydrocarbons, tributyltin compounds, perfluorooctane sulfonic acid and its derivatives, dioxins and dioxin-like compounds, hexabromocyclododecanes, heptachlor and heptachlor epoxide, mercury) in Figure 69 and Map 24b; Chemical Status of Surface Water Bodies (priority substances in biota) in Figure 70 and Map 24c; Chemical Status of Surface Water Bodies (priority substances in biota without brominated diphenylethers and mercury) in Figure 71 and Map 24d. This set of maps and figures provides overall information on chemical status (including those for water and biota) as well as the situation after filtering out the most problematic ubiquitous substances, which are usually "resistant" against programme of measures and thus are not good indicators of progress. Complete information for all four types of *chemical status* was received only from DE and SI. Partial data for all four types of chemical status was received from AT, CZ, RO and SK. Data for only some types of *chemical status* (one or two types) was received from BA, BG, HR, HU, MD, ME and RS. No data for chemical status was received from UA.

Out of a 29,127 rkm network in the DRBD, *good chemical status* was achieved for 10,495 rkm (36.0%). For priority substances in water, good chemical status was achieved at 19,725 rkm (67.7%). After neglecting the ubiquitous substances, the percentage of good chemical status was slightly increased to 73.8% but a significant portion of data is still missing. For priority substances in biota, good chemical status was not achieved in any water body and despite a great portion of data for biota is still missing, the impact of ubiquitous substances on the chemical status in biota is significant: without brominated diphenyl ethers and mercury the *good chemical status* was achieved at 8,227 rkm (28.2%). Details on the confidence levels of the status assessment are provided in Map 23, Map 24a and Annex 9.

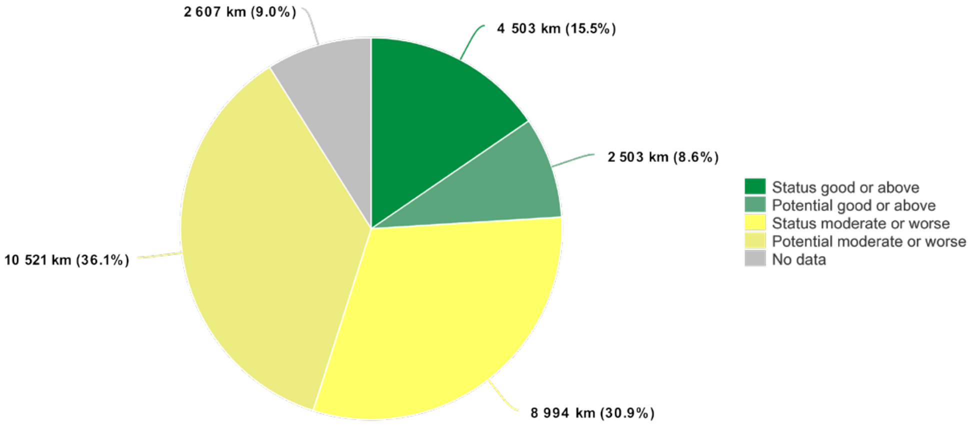


Figure 65: Ecological status and ecological potential for river water bodies in the DRBD in 2021 (indicated in length in km)

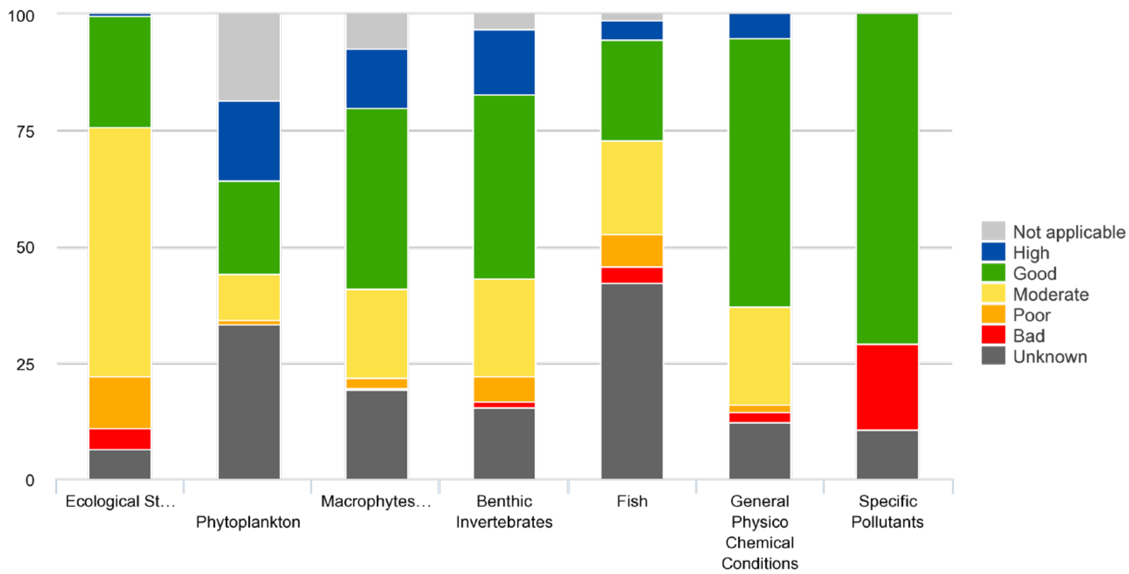


Figure 66: Ecological status: classification of biological quality elements and physico-chemical conditions (indicated as % of the total length)[73]

73 *In case of specific pollutants red colour means exceedance of environmental quality standard. The supportive hydromorphological quality elements are used for the assessment of ecological status, but they are relevant only for high ecological status.*

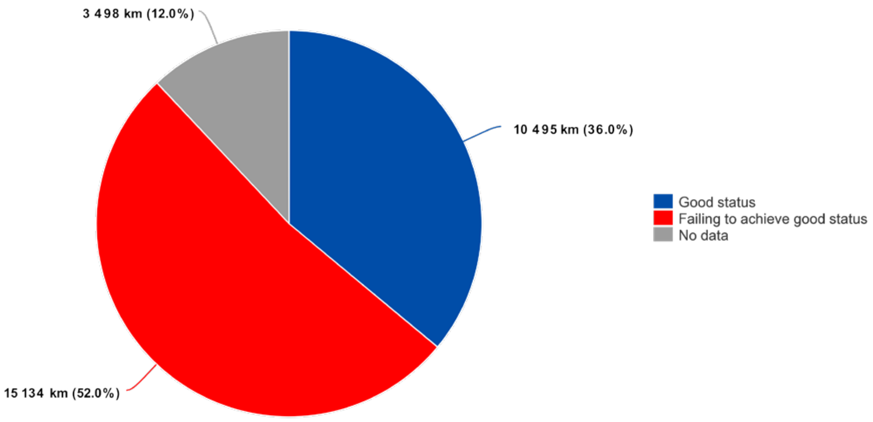


Figure 67: Chemical status of river water bodies in the DRBD in 2021 displaying overall chemical status in water and biota (indicated in length in km)

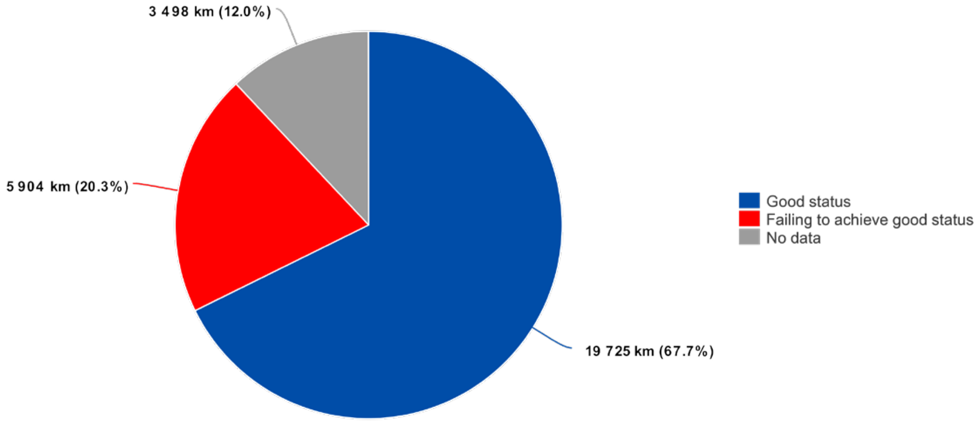


Figure 68: Chemical status of river water bodies in the DRBD in 2021, based on priority substances in water (indicated in length in km)

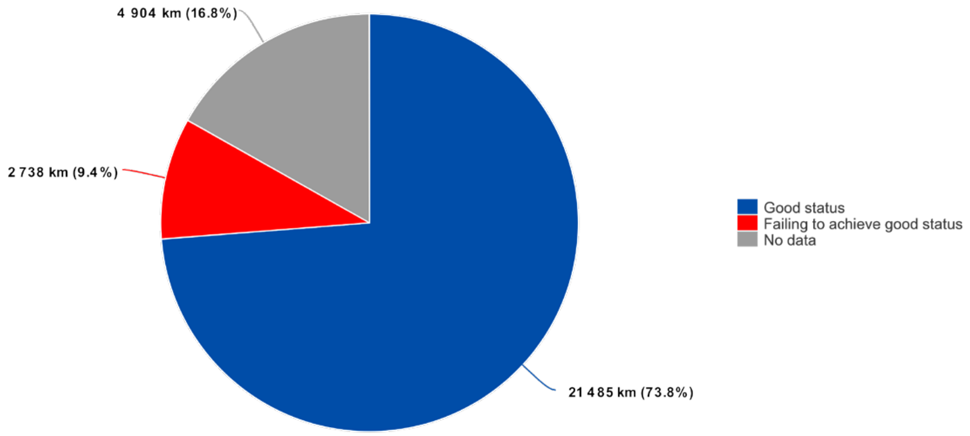


Figure 69: Chemical Status of river water bodies in the DRBD in 2021 based on priority substances in water without ubiquitous substances according to Directive 2013/39/EU (indicated in length in km)

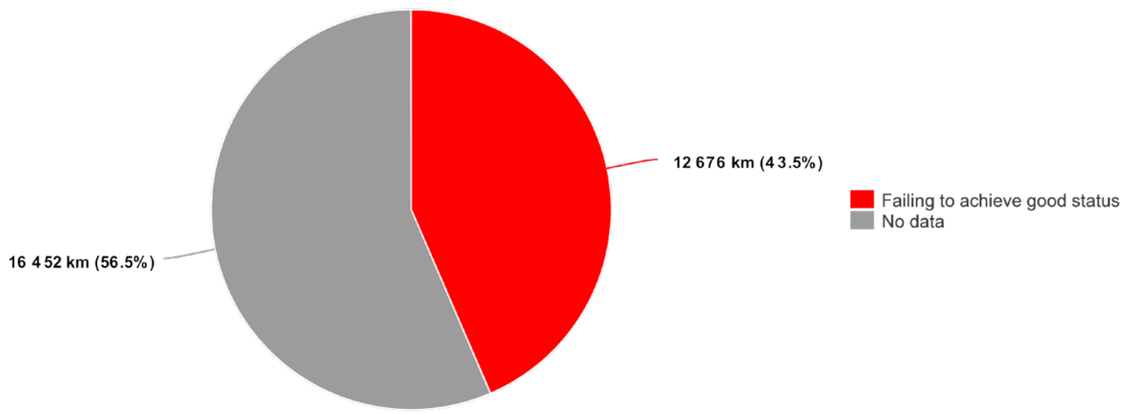


Figure 70: Chemical status for river water bodies in the DRBD in 2021 based on priority substances in biota (indicated in length in rkm)

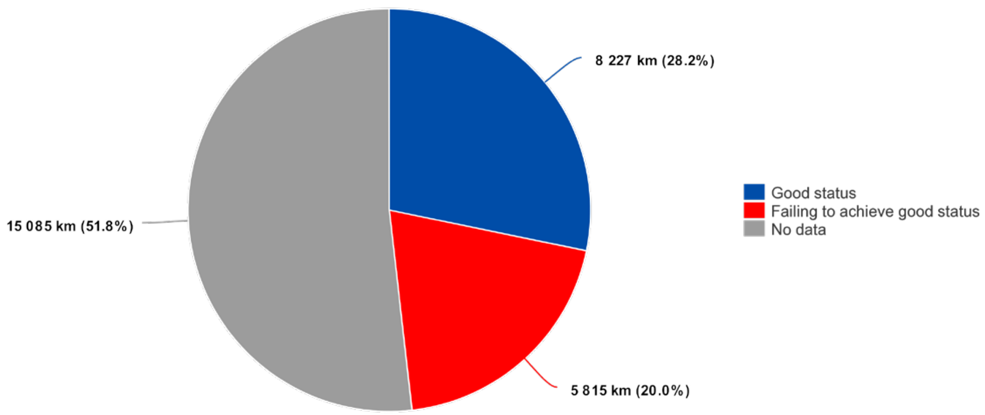


Figure 71: Chemical status for river water bodies in the DRBD in 2021 based on priority substances in biota without brominated diphenyl ethers and mercury (indicated in length in rkm)

4.1.5.1 Lakes and Transitional Waters

Seven lake water bodies have been delineated in the DRBD, five of them were evaluated and out of these, three achieved *good ecological status.* Five lake water bodies achieved *good chemical status* for Priority Substances in water. Four lakes were evaluated for chemical status in biota and all had a *poor chemical status* (but only one of them had a *poor chemical status* in case the ubiquitous substances were not taken into account). Out of five lakes in which chemical status was assessed only one achieved the overall good chemical status.

Two out of three transitional water bodies were evaluated and none of those achieved *good ecological status.* Both transitional water bodies achieved *good chemical status* in water. The *chemical status* in biota was not evaluated.

4.1.5.2 Coastal Waters

All four coastal water bodies were evaluated, none was reported to achieve *good ecological status/ potential* and all achieved *good chemical status* in water. The *chemical status* in biota was not evaluated.

4.1.6 Gaps and Uncertainties of Status Assessment of Surface Water Bodies

The assessment of the ecological status according to the requirements of the WFD has been improved remarkably in the Danube River Basin and a significant support to this process was provided by the international harmonisation activities in the frame of the JDS4.

WFD-compliant biological sampling methods for small and medium sized rivers are already part of standard monitoring programs in most of the Danube countries. More problematic are the assessment methods for the ecological status in large rivers due to the difficult definition of reference conditions, the presence of multiple pressures and the influence of invasive alien species and climate change effects on biological communities.

The way forward presented in the DRBMP Update 2015 necessitated that the missing sampling and assessment methods shall be developed and that the already existing sampling and assessment methods should be transferred between the countries and adapted to the local needs. Special attention was suggested to be given to further development of ecological assessment methods for phytobenthos, phytoplankton, macrophytes and fish. Information exchange between the national experts was considered to be an important prerequisite for this process. All these recommendations had been materialised during the JDS4. The new active approach applied in JDS4, which included the training workshops for each biological quality element organized prior to the survey, provided an excellent opportunity for harmonization and training in WFD related monitoring. Some uncertainties concerning fish assessment are remaining though.

In addition, there is a lack of experiences with methods for ecological potential assessment for HMWB stretches of the Danube and its tributaries (including reservoirs). Future activities have to be focused on sharing knowledge and harmonizing methods among the Danube countries how to assess the ecological potential for relevant biological communities (especially for benthic invertebrates and fish). This should include experience with MEP setting and selection of relevant BQE and relevant metrics.

JDS4 reconfirmed that further work has to be done in the field of collecting basic information on the distribution of invasive alien species and their influence on native biota. Specific effort should be focused on development of effective tools for the assessment of the level of pressures caused by the bioinvasions, as well as for designing the appropriate mitigation measures. To proceed with the assessment work, the Black List of Danube invasive alien species has to be further updated. The assessment shall respect the provisions of the EU Regulation No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species.

A factor, which adversely affects the chemical status in 2021 when compared to previous plans, is that certain Priority Substances from the Directive 2013/39/EU were not analysed before as they were not included in the Directive 2008/105/EC and in most of the Danube countries the EQSs set out in the Directive 2008/105/EC were applied for the DRBMP Update 2015. Other factors with an adverse impact are lowering of EQS of some Priority Substances from the Directive 2008/105/EC and inclusion of biota as a relevant matrix. In case the new Priority Substances (or PS with lower EQS or PS in biota) were analysed for DRBMP Update 2021 and the EQS were exceeded in some water bodies, which had good chemical status in 2015, the result was status deterioration despite no new pressures occurred.

A specific problem in the assessment of the chemical status are the ubiquitous Priority Substances, which are responsible for a significant part of the non-compliance. The problem with mercury was observed already in the DRBMP Update 2015 when the results of monitoring of mercury in biota led to failure in achieving good chemical status in all those countries, in which mercury was monitored. Therefore, a separate map for mercury was presented in 2015. As for the DRBMP Update 2021 more Danube countries analysed the ubiquitous Priority Substances, it was decided to present in this plan the chemical status on four maps showing the chemical status for all Priority Substances and for Priority Substances without ubiquitous substances both in water and in biota. This set up enables a much better indication of progress by filtering out the most problematic substances, which are more "resistant" against the programme of measures.

It has to be also mentioned that in some countries certain Priority Substances are still not analysed because of lacking analytical instrumentation and because no proper or sufficiently sensitive methods are available (e.g. for PFOS, dioxins, dicofol, cypermethrin, benzo(a)pyrene, dichlorvos, HBCDD, heptachlor and heptachloroepoxide). Here the monitoring practices need further improvement in terms of method development, capacity building and enhancing of equipment.

4.2 Groundwater

4.2.1 Groundwater Monitoring Network

The transnational groundwater management activities in the DRBD were initiated in 2002 and were triggered by the implementation of the WFD. Monitoring of the transboundary GWBs of basin-wide importance has been integrated into the TNMN of the ICPDR. For groundwater monitoring under the TNMN (GW TNMN) a 6-year reporting cycle has been set, which is in line with reporting requirements under the WFD. GW TNMN includes both quantitative and chemical (quality) monitoring. It shall provide the necessary information to: assess groundwater status; identify trends in pollutant concentrations; support GWB characterisation and the validation of the risk assessment; assess whether drinking water protected area objectives are achieved and support the establishment and assessment of the programmes of measures and the effective targeting of economic resources. To select the monitoring sites, a set of criteria has been applied by the countries, such as aquifer type and characteristics (porous, karst and fissured, confined and unconfined groundwater) and depth of the GWB (for deep GWBs, the flexibility in the design of the monitoring network is very limited). The flow direction was also taken into consideration by some countries, as well as the existence of associated drinking water protected areas or ecosystems (aquatic and/or terrestrial).

The qualitative monitoring determinants of GW TNMN, which are set as mandatory by the WFD, include dissolved oxygen, pH-value, electrical conductivity, nitrates and ammonium. The measurement of temperature and set of major (trace) ions is recommended as they can be helpful to validate the WFD Article 5 risk assessment and conceptual models. Selective determinants (e.g. heavy metals and relevant basic radionuclides) would be needed for assessing natural background concentrations. It is also recommended to monitor the water level at all chemical monitoring points in order to describe (and interpret) the physical status of the site and to help in interpreting (seasonal) variations or trends in chemical composition of groundwater. In addition to the core parameters, selective determinants will need to be monitored at specific locations, or across GWBs, where the risk assessments indicate a risk of failing to achieve WFD objectives. Transboundary water bodies shall also be monitored for those parameters that are relevant for the protection of all uses supported by groundwater.

As regards quantitative monitoring, WFD requires only the measurement of groundwater levels but the ICPDR has also recommended monitoring of spring flows; flow characteristics and/or stage levels of surface watercourses during drought periods; stage levels in significant groundwater dependent wetlands and lakes and water abstraction as optional parameters.

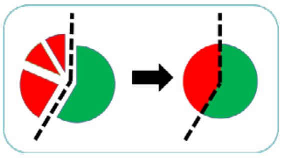
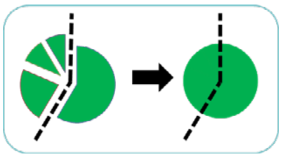
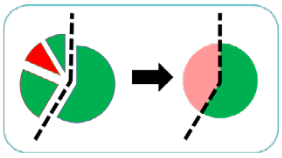
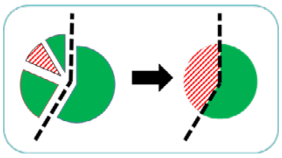
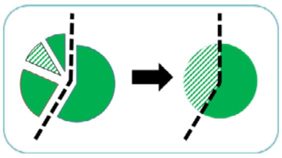
Information on the groundwater monitoring network density is provided on Map 4.

4.2.2 Status Assessment Approach and the Aggregation Confidence Level

The results of the status assessment of the 12 transboundary GWBs of basin-wide importance are provided for the whole national part of a particular ICPDR GWB (so called: aggregated GWB). If a national part of an ICPDR GWB consists of several individual national-level GWBs, then ***poor status*** in one national-level GWB is decisive in characterising the whole national part of an ICPDR GWB as having ***poor status***.

To indicate the diversity of different status results of individual GWBs within aggregated groundwater bodies a concept of the aggregation confidence levels was developed by the ICPDR. The reason of introducing these specific confidence levels for DRBMP (see Table 30) was the need to distinguish between the cases when all individual GWBs in an aggregated GWB have the same status (high confidence) or not (medium confidence) or the assessment is based on the risk assessment data (low confidence). Information about the WFD-related confidence levels of status assessment for the individual national (non-aggregated) GWBs can be found in the national plans and in WISE. The aggregation confidence for the whole national part of an ICPDR GWB is illustrated in maps. More detailed description of the technicalities of the GW TNMN and groundwater status assessment are given in the ICPDR Groundwater Guidance[74].

Table 30: Aggregation confidence levels for groundwater

High confidence 1.) Status assessment is based on WFD compliant monitoring data. 2.) If the national part of an ICPDR GWB (the aggregated GWB) is formed by more than one GWB or groups of GWBs, all have the same status.	 
Medium confidence 1.) Status assessment is based on WFD compliant monitoring data. 2.) If the national part of an ICPDR GWB is formed by more than one GWB or groups of GWBs, not all have the same status.	
Low confidence - The status assessment of at least one individual GWB is based on risk assessment data.	 

Poor Status *Good Status* *Poor/Good Status based on Risk Assessment*

74 *ICPDR (2016): IC 141 ICPDR Groundwater Guidance.*

4.2.3 Status of Groundwater Bodies of Basin-Wide Importance

A summary overview of the chemical and quantitative status for the 12 transboundary GWBs is presented in Table 31 and Table 32. These tables also provide an overview of the results of the risk assessment carried out in 2013 and 2019, of the status assessment made in 2015 for the DRBMP Update 2015 and of the significant pressures in 2015 and 2021 as well as the future significant pressures expected by 2027.

Table 31: Groundwater QUALITY: Risk and Status Information of the ICPDR GW-bodies over a period of 2013 to 2027

		Danube RBM Plan 2015						Danube RBM Plan 2021					
GWB	Nat. part	Status 2015	Status Pressure Types 2015	Significant upward trend (parameter)	Trend reversal (parameter)	Risk 2013→2021	Risk Pressure Types →2021	Status 2021	Status Pressure Types 2021	Significant upward trend (parameter)	Trend reversal (parameter)	Risk 2019→2027	Risk Pressure Types →2027
GWB-1	AT-1	Good	-	-	-	-	-	Good	-	-	-	-	-
	DE-1												
GWB-2	BG-2	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-2									Cl			
GWB-3	MD-3	Good	-	-	-	Risk	PS, DS, WA	Good	-	-	-	-	-
	RO-3					-	-						
GWB-4	BG-4	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-4							Poor	DS			Risk	DS
GWB-5	HU-5	Poor	DS	SO_4	-	Risk	DS	Poor	DS	NO_3, NH_4, EC, SO_4		Risk	DS
	RO-5			NH_4						Cr, Pb			
GWB-6	HU-6	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-6												
GWB-7	HU-7	Poor	DS	NO_3	-	Risk	DS	Poor	DS	-	-	Risk	DS
	RO-7	Good	-	-	-	-	-	Good	-	-	PO_4, Cl	-	-
	RS-7	Good*	-			-	-	Good	-	-	-	-	-
GWB-8	HU-8	Good	-	-	-	-	-	Good	-	-		-	-
	SK-8	Good		NH_4, NO_3, Cl, As, SO_4			PS, DS			PO_4	NH_4**, Cl**, SO_4, TOC	Risk	PS, DS
GWB-9	HU-9	Good	-	-	-	-	-	Good		NH_4	-	Risk	DS
	SK-9							Poor	DS, PS	PO_4	NH_4		
GWB-10	HU-10	Good	-	-	-	-	-	Good	-	-	-	Risk	PS
	SK-10												
GWB-11	HU-11	Good	-	-	-	-	-	Good	-	-	-	-	-
	SK-11	Unknown		Unknown*									
GWB-12	HU-12	Good	DS	NO_3	-	Risk	-	Good	-	-	-	-	-
	SK-12	Poor	DS	SO_4				Poor	DS	-	-	Risk	DS

'-' means 'No'; * The status information is of low confidence as it is based on risk assessment; ** The trend was partially reversed, it means for some sites identified with significant upward trends in the 2nd RBMP. TOC - total organic carbon

Table 32: Groundwater QUANTITY: Risk and Status Information of the ICPDR GW-bodies over a period of 2013 to 2027

		Danube RBM Plan 2015				Danube RBM Plan 2021			
GWB	**Nat. part**	**Status 2015**	**Status Pressure Types 2015**	**Risk 2013→2021**	**Risk Pressure Types →2021**	**Status 2021**	**Status Pressure Types 2021**	**Risk 2019→2027**	**Risk Pressure Types →2027**
GWB-1	AT-1 DE-1	Good	-	-	-	Good	-	-	-
GWB-2	BG-2 RO-2	Good	-	-	-	Good	-	-	-
GWB-3	MD-3 RO-3	Good	-	-	-	Good	-	-	-
GWB-4	BG-4 RO-4	Good	-	-	-	Good	-	-	-
GWB-5	HU-5	Poor	WA	Risk	WA	Poor	WA	Risk	WA
	RO-5	Good	-	-	-	Good	-	-	-
GWB-6	HU-6 RO-6	Good	-	-	-	Good	-	-	-
GWB-7	HU-7	Poor	WA	Risk	WA	Poor	WA	Risk	WA
	RO-7	Good	-	-	-	Good	-	-	-
	RS-7	Poor*	WA	Risk	WA	Poor	WA	Risk	WA
GWB-8	HU-8	Poor	WA	Risk	WA	Good	-	-	-
	SK-8	Good	-	-	-				
GWB-9	HU-9	Good	-	-	-	Poor	OP	Risk	OP
	SK-9					Good	-	-	-
GWB-10	HU-10	Good	-	-	-	Good	-	-	-
	SK-10							Risk	WA
GWB-11	HU-11	Good	-	-	-	Good	-	-	-
	SK-11	Unknown							
GWB-12	HU-12 SK-12	Good	-	-	-	Good	-	-	-

*'-' means 'No'; * The status information is of low confidence as it is based on risk assessment.*

Explanation to Table 31 and Table 32

GWB	ICPDR GWB code which is a unique identifier.	
Nat. part	Code of national shares of ICPDR GWBs	
Danube RBM Plan 2015	**Danube RBM Plan 2021**	
Status 2015	**Status 2021**	**Good / Poor / Unknown**
Status Pressure Types 2015	**Status Pressure Types 2021**	Indicates the significant pressures causing poor status in 2015. **AR** = artificial recharge, **DS** = diffuse sources, **PS** = point sources, **OP** = other significant pressures, **WA** = water abstractions
Significant upward trend (parameter)	**Significant upward trend (parameter)**	Indicates for which parameter a significant sustained upward trend has been identified.
Trend reversal (parameter)	**Trend reversal (parameter)**	Indicates for which parameter a trend reversal could have been achieved.
Risk 2013 ► 2021	**Risk 2019 ► 2027**	**Risk** / - (which means 'no risk')
Risk Pressure Types ► 2021	**Risk Pressure Types ► 2027**	Indicates the significant pressures causing risk of failing to achieve good status in 2021. **AR** = artificial recharge, **DS** = diffuse sources, **PS** = point sources, **OP** = other significant pressures, **WA** = water abstractions

4.2.3.1 Groundwater Quality

Processing the data from the TNMN groundwater monitoring programmes, the results on chemical *status* of the transboundary GWBs of basin-wide importance were collected and are shown on the Map 26. The characterisation of the GWBs, a description of the methodologies how chemical status was assessed, information on threshold values including their relationship to natural background values and environmental quality objectives, and finally a description of the methodologies for trend and trend reversal assessment is provided in the Annex 8.

Out of 12 transboundary GWBs of basin-wide importance (all 25 national parts evaluated), *good chemical status* was observed in seven GWBs (with 14 national shares) and five transboundary GWBs are in poor chemical status. Within these five GWBs failing to achieve good status, five national shares are in good status and six are in poor status.

Altogether, *good chemical status* was identified in 19 out of 25 national shares of the 12 transboundary GWBs and six are in *poor chemical status*. Four national shares were already in a poor status in 2015 and for two national shares, the chemical status deteriorated from good to poor status. One national share which was of unknown status in 2015 is now identified as of good status. All six national shares in poor status and also three national shares in good status are at risk of not achieving good status in 2027.

Diffuse and point source pollution by nitrates, ammonium, phosphates, sulphates and chlorides is the cause of the *poor* classification and the same five substances together with trichloroethene and glyphosate cause *risk* of failing good chemical status.

The overview of reasons for failing good groundwater chemical status is displayed in Table 33.

Table 33: Reasons for failing good groundwater CHEMICAL status in 2021 for the ICPDR GW-bodies

GWB	GWB Name	Nat. part	Year of status assessment	Chemical Status 2021	Which parameters cause poor status	Failed general assessment of GWB as a whole	Saline or other intrusion	Failed achieve-ment of Article 4 objec-tives for associated surface waters	Significant damage to GW dependent terrestrial ecosystem	Art 7 drinking water protected area affected
				good / poor	parameter	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)
GWB-1	Deep GWB – Thermal Water	AT-1	2020	Good	-	-	-	-	-	-
		DE-1								
GWB-2	Upper Jurassic – Lower Cretaceous GWB	BG-2	2019	Good	-	-	-	-	-	-
		RO-2	2017							
GWB-3	Middle Sarmatian - Pontian GWB	MD-3	2018	Good	-	-	-	-	-	-
		RO-3	2017							
GWB-4	Sarmatian GWB	BG-4	2019	Good	-	-	-	-	-	-
		RO-4	2017	Poor	NO_3	Yes				
GWB-5	Mures / Maros	HU-5	2020	Poor	NO_3, SO_4, NH_4, Cl,	-	-	-	-	Yes (NO_3, SO_4, NH_4, Cl)
		RO-5	2017		NO_3	Yes				-
GWB-6	Somes / Szamos	HU-6	2020	Good	-	-	-	-	-	-
		RO-6	2017							
GWB-7	Upper Pannonian – Lower Pleistocene / Vojvodina / Duna-Tisza köze deli r.	HU-7	2020	Poor	NO_3	Yes (NO_3)	-	-	-	-
		RO-7	2017	Good	-	-				
		RS-7	2019	Good	-	-				
GWB-8	Podunajska Basin, Zitny Ostrov / Szigetköz, Hanság-Rábca	HU-8	2020	Good	-	-	-	-	-	-
		SK-8	2013-2018							
GWB-9	Bodrog	HU-9	2020	Good	-		-	-	-	-
		SK-9	2013-2018	Poor	NH_4, PO_4	Yes				
GWB-10	Slovensky kras / Aggtelek-hgs.	HU-10	2020	Good	-	-	-	-	-	-
		SK-10	2013-2018							
GWB-11	Komarnanska Kryha / Dunántúli-khgs. északi r.	HU-11	2020	Good	-	-	-	-	-	-
		SK-11	2013-2018							
GWB-12	Ipel / Ipoly	HU-12	2020	Good	-	-	-	-	-	-
		SK-12	2013-2018	Poor	NO_3, SO_4, PO_4	Yes				

*'-' means 'No'; * The status information is of low confidence as it is based on risk assessment.*

4.2.3.2 Groundwater Quantity

The results for the quantitative status of the transboundary GWBs of basin-wide importance are presented on Map 24.

Out of 12 transboundary GWBs (all 25 national shares evaluated), *good quantitative status* was observed in nine GWBs (with 18 national shares) and three transboundary GWBs (with 7 national shares) are in poor quantitative status. Within these three GWBs failing to achieve good status, three national shares are in good status and four are in poor status. Altogether, *good quantitative status* was identified in 21 out of 25 national shares of the 12 transboundary GWBs and four national shares are in *poor quantitative status.*

Compared to the status assessment in 2015, three national shares, which were in poor status, still remain at the same status, one national share that was in poor status in 2015 is now identified as of good status and one national share that was in good status in 2015 is now in poor status.

Five national shares (four currently at poor status and one at good status) are at risk of failing good quantitative status by 2027.

The *poor quantitative status* is caused in three cases by the exceeding of available groundwater resources; in two cases by significant damage to groundwater dependent terrestrial ecosystems and in one case by affected legitimated uses of groundwater. The overview of reasons for failing good groundwater quantitative status is displayed in Table 34.

Table 34: Reasons for failing good groundwater QUANTITATIVE status in 2021 for the ICPDR GW-bodies

GWB	GWB Name	Nat. part	Year of status assessment	Quantitative status 2021	Exceedance of available GW resource	Failed achievement of Article 4 objectives for associated surface waters	Significant damage to GW dependent terrestrial ecosystem	Uses affected (drinking water use, irrigation etc.)	Intrusions detected or likely to happen due to alterations of flow directions resulting from level changes
				good / poor	Yes / - / Unknown	Yes / - / Unknown	Yes / - / Unknown	Yes / - / Unknown If yes, which?	Yes / - / Unknown
GWB-1	Deep GWB – Thermal Water	AT-1	2020	Good	-	-	-	-	-
		DE-1							
GWB-2	Upper Jurassic – Lower Cretaceous GWB	BG-2	2019	Good	-	-	-	-	-
		RO-2	2017						
GWB-3	Middle Sarmatian - Pontian GWB	MD-3	2017	Good	-	-	-	-	-
		RO-3							
GWB-4	Sarmatian GWB	BG-4	2019	Good	-	-	-	-	-
		RO-4	2017						
GWB-5	Mures / Maros	HU-5	2020	Poor	-	-	Yes	-	-
		RO-5	2017	Good			-		
GWB-6	Somes / Szamos	HU-6	2020	Good	-	-	-	-	-
		RO-6	2017						
GWB-7	Upper Pannonian – Lower Pleistocene / Vojvodina / Duna-Tisza köze deli r.	HU-7	2020	Poor	Yes	-	Yes	-	-
		RO-7	2017	Good	-	-	-	-	-
		RS-7	2019	Poor	Yes	Unknown	Unknown	Yes	Unknown
GWB-8	Podunajska Basin, Zitny Ostrov / Szigetköz, Hanság-Rábca	HU-8	2020	Good	-	-	-	-	-
		SK-8	2013-2017						
GWB-9	Bodrog	HU-9	2020	Poor	Yes	-	-	-	Unknown
		SK-9	2013-2017	Good	-				-
GWB-10	Slovensky kras / Aggtelek-hgs.	HU-10	2020	Good	-	-	-	-	-
		SK-10	2013-2017						
GWB-11	Komarnanska Kryha / Dunántúli-khgs. északi r.	HU-11	2020	Good	-	-	-	-	-
		SK-11	2015-2017						
GWB-12	Ipel / Ipoly	HU-12	2020	Good	-	-	-	-	-
		SK-12	2013-2017						

*- means 'No'; * The status information is of low confidence as it is based on risk assessment.*

4.2.3.3 Gaps and Uncertainties of Status Assessment of Groundwater Bodies

The Danube countries used a broad spectrum of different methodologies for the delineation and characterisation of GWBs; the assessment of the chemical and quantitative status; the establishment of threshold values, trend and trend reversal assessment. Despite there being overall coordination facilitated by the ICPDR Groundwater Task Group, further harmonisation of the national methodologies is still needed. Data gaps and inconsistencies are still available in the collected data, resulting in uncertainties in the interpretation of data.

To achieve a harmonisation of data sets for transboundary GWBs, there is a need for intensive bi- and multilateral cooperation. In addition, the interaction of groundwater with surface water or directly dependent ecosystems need further attention for which technical guidance is available at European level.

5 ENVIRONMENTAL OBJECTIVES AND EXEMPTIONS

5.1 Management Objectives

In order to make the planning approach on the basin-wide level complementary and inspirational to national planning and implementation, strategic visions and specific operational management objectives have been defined for each Significant Water Management Issue and for groundwater. These visions provide a common basis on which all the Danube countries can move towards the agreed aims of basin-wide importance by 2027, with the ultimate aim of achieving the overall WFD environmental objectives. The visions are based on shared values and describe the core objectives for the DRBD with a long-term perspective. Nonetheless, the DRBMP, which refers to the basin-wide scale (Part A), may differ from the national RBM Plans (Part B) regarding operational details of the specific objectives.

The respective management objectives provide a general description of the necessary steps towards achieving the environmental objectives set for 2027. They are less detailed than corresponding descriptions in the national RBMPs but go beyond the broad principles expressed in the DRPC and Danube Declaration.

The DRBD basin-wide management objectives are:

a. describe the measures that need to be taken to reduce/eliminate existing significant pressures for each SWMI and groundwater on the basin-wide scale and
b. help to bridge the gap between measures on the national level and their agreed coordination on the basin-wide level to achieve the overall WFD environmental objective.

Based on the management objectives to be realised by 2027, measures reported from the national to the international level have been compiled in such a way that they give an estimation of their effectiveness in reducing and/or eliminating existing pressures/impacts on the basin-wide scale. The visions and management objectives are listed for each SWMI and groundwater in Chapter 8 (The Joint Programme of Measures), which includes the relevant conclusions regarding the achievement of the management objectives.

5.2 WFD Environmental Objectives and Exemptions

The WFD requires the prevention of water body status deterioration, as well as the achievement of the following environmental objectives:

a. good ecological/chemical status of surface water bodies;
b. good ecological potential and chemical status of HMWBs and AWBs;
c. good chemical/quantitative status of groundwater bodies.

The DRBMP Update 2021 provides an updated overview of the status assessment results for both surface water bodies and groundwater bodies for the whole DRBD (see Chapter 4). The deadline for meeting the environmental objectives was 2015. According to WFD Article 4(4), exemptions regarding the 2015 deadline were and are admissible for reasons of technical feasibility, disproportionate costs or if natural conditions do not allow timely improvement in the water body status. An extension of the deadlines beyond 2027 is only possible in relation to natural conditions (WFD Article 4(4)(c)).

EU Member States are now embarking on the third WFD management cycle for which extensions for reasons of technical feasibility or disproportionate costs are possible for the last time according to WFD Article 4(4). Where the improvement of water status still requires the implementation of measures, this must be ensured by 2027 at the latest.

The application of less stringent environmental objectives according to WFD Article 4(5) remains possible in the third management cycle, but the conditions that have to be met for such an exemption are strict.

According to WFD Article 4(6), a temporary deterioration of the status of a water body is possible if this is the result of natural causes or force majeure which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents which could not reasonably have been foreseen. HU is considering applying WFD Article 4(6) in in the context of prolonged drought situations.

Furthermore, new sustainable human development activities might cause a deterioration of water status. The WFD allows for the application of exemptions from the achievement of the environmental objectives in case certain conditions as outlined in WFD Article 4(7) are met. Necessary Future Infrastructure Projects (FIP) may require an exemption according to WFD Article 4(7) if their realisation is expected lead to unavoidable water status deterioration. It is important to note that whilst the application of WFD Article 4(7) allows new modifications to the physical characteristics of a body of surface water in certain circumstances, i.e. in order to improve conditions for inland navigation, such an exemption is always conditional to ensuring that "all practicable steps are taken to mitigate the adverse impact on the status of the body of water". With this in mind, it is important that the planning of FIP includes measures to bring them in line with the SWMI objectives, e.g. by excluding negative impacts on important fish habitats (e.g. sturgeon spawning sites), adjacent protected areas and riverbed erosion. Further details on FIPs in the DRB are provided in Chapters 2.1.6.4 and 8.1.5.4 as well as Annex 7 and Map 17.

Further details on the application of exemptions are part of the national Part B reports.

Exemptions according to WFD Articles 4(4) to 4(7) may only be applied if the conditions specified in WFD Article 4(8) and WFD Article 4(9) are met. For example, an exemption is not permissible if it permanently renders the achievement of the objectives in other water bodies impossible.

For the 975 river water bodies of the DRBD[75], it can be summarised that WFD Article 4(4) is applied for 548 river water bodies (56%) and WFD Article 4(5) for 79 river water bodies (8%). WFD Article 4(7) is applied in 15 river water bodies (2%). In 368 river water bodies (38%) no exemptions are applied.

WFD Article 4(4) exemptions were reported for 3 (out of 7) lake water bodies, 2 (out of 3) transitional water bodies and 2 (out of 4) coastal water bodies of the DRBD. WFD Article 4(5) exemptions were reported for no lake, transitional or coastal water bodies. WFD Article 4(7) is applied in 2 coastal water bodies.

The surface water bodies for which exemptions according to WFD Articles 4(4) and/or 4(5) and/or 4(7) have been applied are shown in Map 27a for exemptions concerning the ecological status and in Map 27b for exemptions concerning the chemical status.

For the 12 transboundary groundwater bodies of basin-wide importance in the DRBD, WFD Article 4(4) is applied for quality in 5 groundwater bodies and for quantity in 3 groundwater bodies. Details are illustrated in Map 28.

75 Including EU MS and non-EU MS.

6 INTEGRATION ISSUES

The integration with other sector policies is an important issue in the Danube River Basin in order to create synergies and avoid potential conflicts. Activities are ongoing to continuously implement and further intensify the exchange with different sectors such as inland navigation, hydropower, agriculture, and nature protection including sturgeon conservation activities. Opportunities for basin-wide level exchange between the sectors also have to be identified and followed up. Platforms for stakeholder exchange have been established within different projects in the DRB (e.g., Migratory Fish Networks within the MEASURES projects) and should be used for further stakeholder activities. Considerable efforts are also being made towards the coordination of water management with the sustainable management of floods according to the FD as well as the marine environment and the Black Sea, taking into account the MSFD. The institutional cooperation in the ICPDR with other sector policies was positively acknowledged and highlighted in the 5th WFD Implementation Report[76]. The European Commission also recommended continuing and intensifying existing efforts on integration issues, particularly to ensure the sustainability of Future Infrastructure Projects (FIPs) in line with WFD requirements.

6.1 River Basin Management and Flood Risk Management

Flood events are natural phenomena of all river systems but, as has occurred over recent years in the Danube Basin, they can often have disastrous social, economic, and environmental consequences.

Future climate change is expected to increase the magnitude and frequency of flood events and the coming decades are likely to see a higher flood risk in Europe. While flooding cannot be prevented entirely, preserving and returning rivers and floodplains to a more natural state and implementing sustainable measures across the basin can greatly reduce the likelihood of flood events and the damage they cause. The increasing overall damage might reduce if the land use along rivers change and such land uses appear, supported and spread, which consider water retention.

Being aware of the basin-wide relevance of flood risks, the ICPDR decided to develop its flood protection policy, which was formalised by adoption of the ICPDR Action Programme on Sustainable Flood Protection in the Danube River Basin in 2004. The Action Programme has been elaborated in line with the principles of the FD, which aims to assess and manage adverse negative effects of floods to human health, the environment, cultural heritage and economic activity. Though the Action Programme preceded the FD, it is fully compliant with its principles. Hence, after the FD entered into force, the implementation of the Action Programme and the FD became one and the same process in the frame of the ICPDR.

The FD is in line and to be coordinated with the WFD, by means of a river basin approach and a six-year cycle of implementation, revision and update. Planning and management under both Directives generally use the same geographical unit (i.e. the DRBD) and there is an interaction of legal and planning instruments in many countries.

76 *COMMISSION STAFF WORKING DOCUMENT International Cooperation under the Water Framework Directive (2000/60/EC) - Factsheets for International River Basins Accompanying the document REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Second River Basin Management Plans First Flood Risk Management Plans.*

Each FD cycle of implementation has three steps

1. the Preliminary Flood Risk Assessment (PFRA) including an identification of areas of potential significant flood risk (APSFR).
2. and then reviewed, and if necessary updated flood hazard risk maps (FHRM) have to be prepared for these APSFRs.
3. Flood Risk Management Plans (FRMP) have to be established which need to be coordinated with the river basin management plans according to the WFD. FRMPs, shall include appropriate objectives and prioritised measures for achieving these objectives.

The coordination of the WFD and the FD offers the opportunity to optimize the mutual synergies and minimise conflicts between varying interests, aiding the efficiency of the implementation of measures and increasing the efficient use of resources. Member States are asked to take appropriate steps to coordinate the implementation of both Directives.

In order to address the coordination between the WFD and the FD in the ICPDR, a discussion paper "Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits" was jointly developed by the Hydromorphology Task Group (HYMO TG) and Flood Protection Expert Group (FP EG) of the ICPDR. It is a living document, which can be continuously updated and completed with good practice examples. The document outlines objectives and measures of the WFD and FD and describes potential conflicts. It highlights synergies between WFD and FD objectives and measures with a particular focus on win-win solutions.

A holistic approach is also needed with respect to drought management, as some FD measures (e.g. NWRM) have a positive influence on mitigating drought risk. Moreover, floods are a natural phenomenon and the high probability (low impact) floods can even have obvious benefits for society and ecosystems, e.g. for groundwater recharge or for fish reproduction.

Thus, an integrated flood risk management approach is applied in the DFRMP focusing on prevention, protection and preparedness. In this framework, providing space for rivers and alluvial flooding in areas where human and economic stakes are relatively low, represents a more sustainable way of dealing with floods. The conservation and the restoration of the natural functions of wetlands and floodplains, with their ability to retain floodwaters and reduce the flood peak, are a key feature of this approach, allowing important opportunities for synergies with the WFD implementation.

However, such Natural Water Retention Measures[77] for flood mitigation need to be promoted and increasingly implemented. In order to give them a boost, regulatory instruments and incentives should be developed and enhanced. Opportunities towards gaining synergies and key issues requiring coordination are clearly seen for the programmes of measures of the DRBMP and the DFRMP Update 2021. This also brings new opportunities to reach sectors (e.g. agriculture), which would also have role in achieving FD and WFD objectives. More information about natural water retention measures can be found in the Danube Flood Risk Management Plan Update 2021.

Conserving wetlands through nature-based solutions and ensuring resilience to disasters creates a link not only between the WFD and the FD but it covers the Nature Directives as well (see Chapter 6.3) and addresses also goals of the new Biodiversity Strategy for 2030.

77 *http://nwrm.eu/ (accessed 12 February 2021).*

The achievement of synergies between flood risk management and river basin management in practice needs to be ensured mainly at the national, regional and local level as the implementation of measures is a national task. Cross-border and basin wide projects are also implemented in order to support the approach and share the knowledge in Danube countries. One of these projects is the Danube Floodplain project (2018-2021), the main objective of which is to improve transnational water management and flood risk prevention while maximizing benefits for biodiversity conservation.

In order to ensure a coordinated application of both directives as well with regard to public consultation, a coordinated public consultation and communication plan for both, the WFD and FD has been put in place by the ICPDR to assist with the development of the DRBMP and DFRMP Update 2021. The document serves as a blue-print for participation, outlining integrated consultation measures to be carried out, including inter alia a joint WFD-FD workshop and Stakeholder Conference.

6.2 River Basin Management and the Marine Environment

Globally, the oceans represent 71% of the Earth's surface and, thanks to their volume, 99% of the habitable space on Earth. They provide habitats for rich (yet often unknown) marine biodiversity and they are home to the largest known creatures. The oceans also support essential services for people, such as food provision, climate regulation and recreation. Protecting the marine environment is not only crucial for the conservation of biodiversity but also for the wellbeing of humans and the planet. However, the marine environment and its ecosystems are subject to multiple pressures and impacts from human activities, such as fishing, seabed disturbance, pollution or global warming. The aim of the MSFD, adopted in June 2008, is to protect more effectively the marine environment across Europe. It aims to achieve good environmental status (GES) of the EU's marine waters, providing ecologically diverse and dynamic oceans and seas, which are clean, healthy and productive, by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The MSFD is one of the most ambitious international marine protection legal frameworks, aligning the efforts of 23 coastal and 5 landlocked States – in coordination with non-EU MS – to apply an ecosystem-based management and to achieve good environmental status in 5,720,000 km^2 of sea surface area across four sea regions, an area one fourth larger than the EU's land territory.

The implementation of key milestones of the MSFD is reviewed and updated every 6 years. This includes inter alia:

1. Assessment of the current environmental status of national marine waters and the environmental impact and socio-economic analysis of human activities in these waters; Determination of what GES means for national marine waters; Establishment of environmental targets and associated indicators to achieve GES by 2020.
2. Establishment of a monitoring programme for the ongoing assessment and the regular update of targets.
3. Development of a programme of measures designed to achieve or maintain GES by 2020.

With the first MSFD programmes of measures, Member States have already made significant efforts to protect the marine environment, integrating various national, EU and international policies and covering the existing gaps with new cost-effective measures.

The European Commission adopted a report on the first implementation cycle of the MSFD in June 2020. This report shows that while the EU's framework for marine environmental protection is one of the most comprehensive and ambitious worldwide, it needs to be enhanced to be able to tackle predominant pressures such as overfishing and unsustainable fishing practices, plastic litter, excess nutrients, underwater noise and other types of pollution.[78]

Many of the pressures affecting the riverine and marine environment are generated on land. Therefore, the MSFD and the WFD target a similar range of pressures and drivers (human uses and activities) and share a large number of measures. Measures under the MSFD for marine eutrophication, contaminants, hydrographical changes and biodiversity draw on those submitted under the WFD.

MSFD Article 6 outlines regional cooperation requirements, another important aspect of marine environmental protection. Where appropriate and necessary, all Member States in the catchment area of a marine region or sub-region, including land-locked countries, are required to cooperate and coordinate their actions. In the same spirit, the preservation of Europe's natural environment, including oceans and seas, is also a crucial part of the Green Deal and the new EU Biodiversity Strategy for 2030 (see Chapter 6.3).

The Danube River Basin is directly linked with marine waters because the Danube discharges into the Black Sea. In 2012 the ICPDR adopted a resolution declaring "the willingness of the ICPDR to serve as platform facilitating the coordination with land-locked countries required under MSFD Article 6(2) and to contribute hereby to a close coordination of the implementation of the WFD in the Danube River Basin and the MSFD in the Black Sea Region".

The ICPDR and the International Commission for the Protection of the Black Sea (ICPBS) signed a Memorandum of Understanding (MoU) on common strategic goals as early as 2001. A Joint Technical Working Group of the two commissions has been in place since 1997. Its work is focused on better understanding the impact of the Danube discharge (including sediments, pollution, etc.) on the ecosystem of the Black Sea. ICPDR will continue its efforts in supporting this work.

Romania and Bulgaria, the EU MS of the Danube basin sharing the Black Sea waters, are working on the implementation of the MSFD, i.a. by elaborating different criteria, targets and indicators of descriptors defining GES, which include e.g. biodiversity, alien species, fisheries, eutrophication or the concentration of contaminants. Both countries take all efforts to promote the MSFD in the ICPBS and to coordinate with the land-locked countries via the ICPDR.

There are various issues requiring coordination between the WFD and the MSFD. The management of pollution from point and diffuse sources such as nutrients (causing human induced eutrophication) and hazardous substances, as foreseen in the DRBMP, is of particular importance for the Black Sea. Other issues include e.g. the migration of anadromous migratory fish species like sturgeons from the Black Sea to the upper reaches of the Danube. With respect to the latter, the ICPDR and Contracting Parties will use the dialogue between ICPBS and ICPDR parties to analyse and agree on sturgeon conservation action.

78 *https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm (accessed 12 February 2021).*

6.3 River Basin Management and Nature Protection

With its integrated approach and aim to achieve, inter alia, a healthy aquatic ecosystem and terrestrial ecosystems dependent on water and "good status" for all waters, the WFD is closely related to nature protection legislation and policies.

This is in particular the case for the EU Habitats Directive 92/43/EEC and EU Birds Directive 79/409/EEC, but also the EU Green Infrastructure Strategy, as well as national nature protection legislation.[79] Together, the 'Birds' and the 'Habitats' Directives are the backbone of the EU's biodiversity policy as they protect Europe's most valuable species and habitats. The protected areas designated under these directives form the so-called Natura 2000 network. Both the nature directives and the WFD share the aim of ensuring healthy aquatic ecosystems while at the same time seeking to achieve a balance between water/nature protection and the sustainable use of nature's natural resources.

As far as water bodies in water-dependent protected areas are concerned, measures under the WFD and the Birds and Habitats Directives need to be coordinated between the responsible authorities for nature conservation and water management, and included in the WFD Programme of Measures. Ongoing dialogue at the national level on the WFD Programmes of Measures can help to avoid conflicts that could arise from different objectives of WFD and the Birds and Habitats Directives and ensure that the opportunities to achieve joint benefits are recognized.

Infrastructure projects which are fully or partly located in protected freshwater habitats and which are likely to have a significant effect must be carefully planned and assessed in order to avoid conflicts. Promoting green infrastructure and nature-based solutions should – as much as possible – be the basis of any planning. Habitats Directive Article 6(3) provides for an appropriate assessment of the impacts of such plans or projects. Only if no reasonable scientific doubt remains as to the absence of adverse effects on the integrity of the site, can the competent authorities give their consent. If doubts remain, the precautionary and preventive principles have to be applied and the plan or project cannot go ahead unless Habitats Directive Article 6(4) requirements are met, which are in principle similar in character to WFD Art 4(7).

In this context, the Environmental Impact Assessment[80] and Strategic Environmental Assessment[81] Directives and related requirements also need to be taken into account, including requirements for coordinated (and/or joint procedures for) projects/strategies assessments with a view to environmental, nature and water management aspects.

Hence, good integration of WFD and nature protection related legislation and policies do not only increase efficiency in the implementation but can also diversify the range of funding sources for measures, both from public funding programmes or through innovative finance schemes. The involvement and commitment of the public and of all stakeholders is crucial to the success of nature protection in the DRB.

With the launch of the EU Green Deal[82] and the adoption of the new EU Biodiversity Strategy for 2030[83], an additional emphasis has been placed on river basin management, increased efforts to protect and restore

79 See also more information in EC publication "Links between the Water Framework Directive and Nature Directives", https://ec.europa.eu/environment/nature/natura2000/management/docs/FAQ-WFD%20final.pdf (accessed 12 February 2021).

80 Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

81 Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (SEA Directive).

82 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (accessed 12 February 2021).

83 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/eu-biodiversity-strategy-2030_en (accessed 12 February 2021).

natural ecosystems as well as the sustainable use of resources. This is essential to preserve and restore biodiversity in lakes, rivers, wetlands and estuaries, and to prevent and limit damage from floods. In addition to launching new initiatives, the European Commission will work with the Member States to step up the EU's efforts to ensure that current legislation and policies relevant to the EU Green Deal are enforced and effectively implemented. With the EU Green Deal and its aims to protect, conserve and enhance the EU's natural capital, come significant investment needs which require the involvement of both the public and private sector. The proposal for a European Green Deal includes the mobilisation of 1 trillion € for investments in sustainable development and 100 billion € in the period 2021-2027 for technical and financial assistance to the most affected regions in the transition to sustainable development.

The new EU Biodiversity Strategy also comprises an associated comprehensive, ambitious, long-term "Action Plan" for protecting nature and reversing the degradation of ecosystems. Concerning the inland aquatic environment, the EU Biodiversity Strategy outlines the need for greater efforts to restore freshwater ecosystems and the natural functions of rivers in order to achieve the objectives of the WFD. This can be done by removing or adjusting barriers that prevent the passage of migrating fish and improving the flow of water and sediments. According to first estimates, this will involve returning at least 25,000 km[84] of rivers to free-flowing conditions by 2030, primarily through the removal of obsolete barriers and the restoration of floodplains and wetlands. Member State authorities are also required to review water abstraction and impoundment permits and implement ecological flows in order to achieve good status or potential of all surface waters and good status of all groundwater by 2027 at the latest, in accordance with the WFD. The new Biodiversity Strategy estimates annual investments of least 20 billion €.

Work of the ICPDR and its contracting parties can contribute significantly to the goals of the EU Biodiversity strategy. Measures to achieve good ecological status and good ecological potential contribute to the restoration of degraded habitats or can even create new ones which are beneficial for a wide range of species (e.g. fish, reptiles, mammals, amphibians, mussels), some of them even either classified as endangered by IUCN (e.g. the Danube sturgeons, Danube salmons, freshwater pearl mussels) or under special protection by the EU Birds and Habitats Directive (e.g. European beaver, European otter, European pond turtle, fire-bellied toads). The use of Natural Water Retention Measures[85] for flood mitigation similarly contributes to preserving and restoring biodiversity. Water management initiatives by ICPDR to restore river continuity in the Danube and its major tributaries (such as the WePass project to overcome the obstacles of the Iron Gates dams), the identification of key habitats with a view to initiating creation and protection of ecological corridors along the Danube and its main tributaries (MEASURES project) and making the preservation of the Danube sturgeon species a flagship project represent important efforts to preserve biodiversity in the Danube catchment and are further examples of how the work of ICPDR and Contracting Parties can feed into and contribute to the attaining of the objectives of the EU Biodiversity strategy.

The work of the ICPDR and its Contracting Parties on water management and the implementation of the EU Biodiversity Strategy can be mutually supportive, as demonstrated by the particular strong links between the new EU Biodiversity Strategy and the ICPDR's sturgeon conservation activities. The following elements of the EU Biodiversity Strategy are of particular relevance for sturgeon conservation:

- measures to ensure non-deterioration in conservation trends and status of protected species and habitats,
- measures to improve aquatic and marine biodiversity and improve the status of species currently in unfavourable status,

84 European Commission: https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_886 (accessed 12 February 2021).

85 http://nwrm.eu/ (accessed 12 February 2021).

- reduction of catches allowing full recovery of by-catch in marine ecosystems of species threatened by extinction and
- the restoration of freshwater ecosystems and the natural functions of rivers.

Thus, there is significant potential for synergies between the WFD, nature protection related EU legislation, the European Green Deal, the new EU Biodiversity Strategy and measures to protect and conserve sturgeons and protect and restore habitats and migration corridors in the PANEUAP, the ICPDR Sturgeon Strategy, the EUSDR and the DSTF Sturgeon 2020 programme, creating opportunities to assist the ICPDR and Contracting Parties in improving the quality of the Danube River and its tributaries. By acknowledging these connections, synergies can be developed, saving resources and helping to reach multiple goals for the significant number of protected areas located along the Danube and its tributaries (see Map 20). The integrated implementation of related legislation also supports coordination with other related directives (such as the Renewable Energy Directive) as well as with European regional strategies and relevant policy fields like transportation (inland navigation) and the European Common Agricultural Policy. The ICPDR and its contracting parties are determined to play an active role in exploiting all of these synergies. To this end, they will redouble efforts to ensure that appropriate measures are implemented and to take full advantage of the relevant opportunities provided by the EU's Green Deal.

Where necessary, cooperation with competent authorities at all levels and in all sectors will be strengthened. Dialogue with ICPDR observers and other relevant stakeholders in the Danube Basin will continue to play a central role, with a view to maximising the effectiveness of these measures and ensuring that developments in sectors concerned remain compatible with the objectives set out in this DRBMP. This will include continuing and enhancing the close cooperation with the EU Strategy for the Danube Region (EUSDR), in particular in view of the relevance of the DRBMP for the implementation of EUSDR Priority Area 4 on Water Quality and Priority Area 6 on Biodiversity.

6.4 Inland Navigation and the Environment

Inland navigation can contribute to making transport more environmentally sustainable, particularly where it can act as a substitute for road transport. It can, however, significantly influence river ecosystems, potentially jeopardizing the goals of the WFD.

Recognising this potential conflict, the ICPDR, in cooperation with the Danube Commission (on Navigation) and the International Commission for the Protection of the Sava River Basin, initiated a cross-sectoral discussion process involving all relevant stakeholders and NGOs. This led to the "Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin", which was finalised in October 2007 and subsequently endorsed by the Commissions involved.

The Joint Statement summarises principles and criteria for environmentally sustainable inland navigation on the Danube and its tributaries, including the maintenance of existing waterways and the development of future waterway infrastructure. These include, inter alia, the following:

- Establishment of interdisciplinary planning teams, involving key stakeholders, experts from different organisations (governmental and non-governmental) and independent (international) experts to ensure a transparent planning process;
- Defining joint planning objectives and goals of inland waterway transport and river/floodplain ecology;
- Ensuring flexible funding conditions, enabling integrated planning (including the involvement of all stakeholder groups) and adaptive implementation as well as monitoring;

- Monitoring the effects of measures and – where necessary – adapting them;
- Promote as much as possible non-structural measures and minimise the impacts of structural interventions through mitigation and/or restoration and giving preference to reversible interventions;
- Promote as much as possible green infrastructure and nature-based solutions.

In the frame of yearly meetings, exchange on the experiences with the application of the Joint Statement is shared amongst administrations, stakeholders and environmental groups.

Beyond this ongoing exchange process, there is a series of guidance documents and manuals, primarily aimed at waterway managers.

A "Manual on Good Practices in Sustainable Waterway Planning" was developed in the frame of the EU PLATINA project (2008-2012), in order to provide further guidance on how to apply integrated planning principles of the Joint Statement. The manual outlines practical steps for integrated planning processes for inland waterway transport projects towards sustainable solutions taking into account both the needs of inland navigation and the environment.

The Danube STREAM project (2017-2019)[86] has developed a similar manual, focusing on ongoing fairway maintenance measures rather than projects. The "Manual on Environmentally Sound Waterway Management in the Danube River Basin" contains a model procedure for achieving Good Navigation, Good Ecological and Favourable Conservation Status.

In 2014, the "Fairway Rehabilitation and Maintenance Master Plan for the Danube and its navigable tributaries"[87] was elaborated in the frame of the EU Strategy for the Danube Region (EUSDR Priority Area 1a). The purpose of the Master Plan is to increase transparency in the area of fairway maintenance in terms of problems, activities undertaken and planned, and to highlight national needs and short-term measures in the field of fairway rehabilitation and maintenance. In order to take into account the implementation status of the Master Plan to date as well as new developments in waterway management and changed framework conditions (e.g. climate change), the Master Plan is being updated in 2021. All rehabilitation and maintenance measures proposed and monitored within the context of the Master Plan (surveying, fairway relocation, dredging and better information) have the character of reversible interventions, as recommended by the Joint Statement.

Several new initiatives and actions involving different actors were launched in the intervening years in order to support the process of making inland navigation and transport more environmentally sustainable. For example, another initiative to support integrated planning of inland waterways transport was launched in 2017. Based on a proposal of the three Directorate Generals of the European Commission – Environment (DG-ENV), Regional and Urban Policy (DG-REGIO) and Mobility and Transport (DG-MOVE) – a Mixed Environment Transport External Expert Team (METEET) on Integrated Planning of Inland Waterways Transport (IWT) Projects was set up. METEET is designated to assist competent inland waterways transport authorities on a voluntary basis with the objective to foster an integrated approach when developing infrastructural projects in the field of inland navigation. Several training missions with the involvement of actors from the navigation and environment side have already taken place (Serbia, Slovakia, Croatia).

Relevant activities are also coordinated beyond the boundaries of international river basins. A Correspondence Group for the Setting of Appropriate Objectives for Rivers and Canals was set up by the Central Commission for the Navigation of the Rhine (CCNR) with representatives from Member States and River Commissions. As

86 For more information please follow: http://www.interreg-danube.eu/approved-projects/danube-stream (accessed 14 November 2021).

87 For more information please follow: http://www.fairwaydanube.eu/master-plan/ (accessed 15 October 2021).

Member States highlighted that objectives as set in the TEN-T Regulation (such as draught not less than 2.50 m) are not suitable for free-flowing rivers such as the Rhine and Danube, draught/fairway depth requirements shall be expressed in relation to reference water levels. On the Upper Danube in Austria this, for instance, would practically entail a fairway depth of 2.5 m at Low Navigable Water Level (ENR), i.e. on 94% (343 days) of the year, calculated on the basis of the discharge observed over a period of 30 years with the exception of ice periods. The Correspondence group acted as a think tank in the years 2018 and 2019, elaborating proposals for a possible future revision of the TEN-T Regulation. The correspondence group closed its activities during summer 2019, whereby their final result was reported to the NAIADES sub-group on Good Navigation Status.

Between 2016-2017 the elaboration of a study on "Good Navigation Status" for inland waterways was contracted by the European Commission (DG MOVE). The purpose of the study was to substantiate the requirements of the GNS concept "Rivers, canals and lakes are maintained so as to preserve Good Navigation Status while respecting the applicable environmental law" that, according to Regulation 1315/2013, has to be achieved by 31 December 2030 (and preserved thereafter) for the entire TEN-T inland waterway network. The key principles of the Joint Statement were integrated in this model description. These guidelines towards achieving GNS have been published by the European Commission (*https://publications.europa.eu/*, accessed 16 February 2021). In 2019 a so-called NAIADES sub-group on Good Navigation Status was initiated by DG MOVE. The sub-group consists of Member States representatives and stakeholders. They have further elaborated the concept of Good Navigation Status, by proposing realistic minimum requirements that are differentiated according to corridor-specific hydromorphological and hydrological conditions.

Additional information on navigation projects is provided in the context of the application of WFD Article 4(7) (see Chapter 5) and so-called Future Infrastructure Projects (FIPs) in Chapters 2 and 8 as well as in Annex 7.

As a follow-up to discussions during the public consultation process of the DRBMP Update 2015, the ICPDR HYMO TG started an information exchange on vessel induced waves and their impacts on the aquatic environment. First measurements were performed at the Austrian Danube River (free flowing stretch east of Vienna) and provided the following results from scientific perspective (Liedermann et al., 2014; Schludermann et al., 2014)[88]:

Vessel induced waves at the Austrian Danube River

The wave characteristics of the main ship types and the interaction of the vessel-induced waves with three different bank types can be explained as follows:

Passenger ships were found to generate displacement waves characterized by a pronounced first primary wave with a large drawdown (trough) followed by a large crest and a series of smaller oscillatory waves. This means that this type of ship produces a large first wave, which causes a strong decline of the waterline and then a strong surge, which is followed by many small similar events. They also produced the biggest wave height (up to 0.65 m) among all ship types.

High-speed passenger ships induced waves of high frequency with a wave period ranging between 3 and 6 seconds, but smaller maximum wave heights. This means that this ship type produces a lot of fast waves of medium heights.

Bulk carriers were found to have similar characteristics as passenger vessels, with a pronounced drawdown (trough) of the first primary wave but followed by a comparatively damped crest (oscillatory

88 Liedermann, M., Tritthart, M., Gmeiner, P., Hinterleitner, M., Schludermann, E., Keckeis, H., Habersack, H. (2014): Typification of vessel-induced waves and their interaction with different bank types, including management implications for river restoration projects HYDROBIOLOGIA, 729(1), 17-31. Schludermann, E., Liedermann, M., Hoyer, H., Tritthart, M., Habersack, H., Keckeis, H. (2014): Effects of vessel-induced waves on the YOY-fish assemblage at two different habitat types in the main stem of a large river (Danube, Austria) HYDROBIOLOGIA, 729(1), 3-15.

system). The largest wave events had comparable heights but the majority of the events were substantially smaller than waves originating from ordinary passenger and high-speed passenger ships.

It can be summarized that a higher fairway depth reduces wave height. The vessel's speed generally has a very big influence on the height of the waves. The analyses have shown that a reduction in speed – at least in ecologically sensitive areas a measure like this could be considered – by 5 km h−1 for passenger ships leads to a decrease of about 14 cm in primary wave height. Also, the distance of the passing vessel to the shore has a high influence on the wave height: A relocation of the shipping fairway of 50 m from sensitive shore areas would result in a mean decrease of 8 cm in wave height (calculated for high-speed passenger vessels). The influence of morphology of the different bank types on wave height was shown to be substantially high. Especially, the bank water depth (resulting from morphology and discharge) influences wave breaking and wave damping and thus controls the primary wave height near the shores. Another parameter influencing the wave impact is the hull form of the ships. As waves are a signal of wasting energy, an energy-efficient bow/hull-form automatically reduces wave energy although they may reduce the economic performance of a vessel due to less cargo transported.

When it comes to consequences for survival of juvenile fish fauna, one of the most important parameters influencing the survival is drawdown. Wave height and vessel-induced drawdown are prominent factors, which influence the drift-density of early developmental stages of fish. These factors are strongly linked to the river-morphological conditions (i.e. slope, water depth, etc.) and thus reveal also mesohabitat-specific patterns.

As a conclusion from the measurements at the Austrian Danube River, it became clear that ship-induced waves affect the juvenile fish of the Danube in the free-flowing stretch east of Vienna. These impacts can be reduced, but not completely eliminated, by means of packages of measures on the part of shipping (speed, ship type and ship size to optimize the characteristics of the ships to minimize the "production" of waves) as well as appropriate river restoration measures.

Danube countries are encouraged to perform similar studies on the impact of waves on fish and needed measures in other representative stretches of the Danube with the aim of developing a comprehensive set of measures for the whole Danube and its tributaries. The implementation of such measures would have to be negotiated with the navigation sector e.g. in the frame of the Joint Statement process or the EUSDR.

Another emerging challenge that could potentially require further investigations and measures is the impact of the growing passenger transport on water quality due to a lack of suitable waste collection and treatment facilities on land. The ship waste collection issue was investigated by the COWANDA Project[89] with the main objective of advancing and harmonizing the available ship waste management systems of the Danube countries (e.g. waste prevention, network of ship waste reception facilities, payment procedures, information services) and developing a binding International Ship Waste Convention on the Danube. The international convention harmonises, coordinates and guides the future development of ship waste management systems along the Danube in order to decrease the risk of illegal discharges of ship waste and thereby support the protection of river ecosystems of the Danube. The implementation of the convention needs to be ensured.

89 *More information can be found here: https://navigation.danube-region.eu/co-wanda-convention-for-waste-management-for-inland-navigation-on-the-danube/ (accessed 17 October 2021).*

6.5 Sustainable Hydropower

The increased production and use of energy from renewable sources, together with reductions in energy consumption and increased energy efficiency, constitute important steps towards meeting the need to reduced greenhouse gas emissions to comply with international climate protection agreements. The development of further renewable energy production capacity in line with the implementation of the EU Renewable Energy Directive 2018/2001/EU and the accompanying financial support schemes represent a significant driver for the development of hydropower generation in the countries of the DRB. At the same time, Danube countries are committed to the implementation of water, nature and other environmental legislation.

Aware of the fact that hydropower plants offer an additional reduction potential for greenhouse gases but also recognizing their potential negative impacts on riverine ecology, the Ministers of the Danube countries decided in 2010 that general Guiding Principles on integrating environmental aspects into the use of hydropower should be established for the DRB (detailed information on relevant pressures and impacts is provided in Chapter 2.1.5).

In the frame of a broad participative process launched in 2011, "Guiding Principles on Sustainable Hydropower Development in the Danube Basin" were elaborated with the aim of ensuring that environmental concerns are integrated into processes relating to hydropower development, dealing with the potential conflict of interest from the beginning. As well as outlining background information on the relevant legal framework and statistical data, the Guiding Principles address the following key issues regarding the sustainability of hydropower:

1. General principles and considerations (the principle of sustainability, holistic approach in the field of energy policies, weighing of public interests, etc.);
2. Technical upgrading of existing hydropower plants and ecological restoration measures;
3. Strategic planning approach for new hydropower development;
4. Mitigation measures.

The Guiding Principles were adopted by the ICPDR in June 2013 and are available in Bosnian, Croatian, Czech, German, Slovak, Slovene and Ukraine language.[90]

In order to support the process of the practical application of the "Guiding Principles", regular Hydropower Workshops are organised by the ICPDR to exchange on experiences in place in Danube countries e.g. with regard to linking technical upgrading of existing plants with ecological restoration measures, strategic planning approaches for new hydropower development, setting up national stakeholder processes, or with regard to the application of mitigation measures.

The most recent ICPDR Hydropower Workshop took place in March 2021; due to the COVID-19 pandemic it was organised online.

In 2017, participants of the ICPDR Hydropower Workshop concluded that whilst progress has been made in applying and promoting the ICPDR Guiding Principles, more action is necessary at the national and local authorities level. Further strengthening of national implementation and legislation towards compliance with EU legislation is needed. This was also reiterated in 2021 when participants highlighted the importance to accelerate and improve implementation to reach WFD objectives in 2027 as well as to aim at a better integration of sectoral policies and a transparent application of WFD Article 4.7. Priority should be given to upgrading existing hydropower plants and there is a need for a coherent framework for site selection and project

90 *The "Guiding Principles" in different Danube countries languages can be downloaded here: https://www.icpdr.org/main/activities-projects/hydropower (accessed 12 February 2021).*

assessment with a high level of engagement between operators, NGOs and local communities. Furthermore, impacts of hydropower development on river ecology/biodiversity need to be addressed, ranging from hydromorphological pressures to sediment related measures – including the demand for pilot sites – and sufficient monitoring as a key for dialogue.

Additionally, the ICPDR Guiding Principles need to be brought to the attention of the stakeholders to encourage their application. A great advantage of the regular ICPDR Hydropower Workshops is seen in the exchange of experiences among Danube countries, helping to learn from good practice and to avoid the repetition of past "mistakes". This is of particular importance against the backdrop of current market conditions for hydropower that have proved difficult to predict and where big changes are underway in different regions and individual Danube countries. Exchanging experiences on the dialogue with institutions responsible for energy and climate for example on phasing out financial support schemes for hydropower or meeting obligations related to impact mitigation are also recommendable. As such it was concluded at the ICPDR Hydropower Workshop in 2021, that the role of the ICPDR as an enabler for multi-stakeholder dialogues will continue to be an important one in the future.

Undoubtedly, hydropower will remain an important pillar of the Danube region's renewable electricity portfolio. However, in relative terms its contribution to overall production is expected to fall due to the expected massive expansion of wind power and solar photovoltaic system while the impact on riverine ecosystems will remain an outstanding water management challenge as mitigation measures are being implemented at varying speed and effectiveness across the Danube basin. Generally, the strategic need for additional hydropower development should be defined in an overall power system planning process. An essential objective of such a planning process should be the development of a robust and climate resilient generation portfolio. In this context, site selection and project assessment for hydropower should be based on common frameworks and guidelines in order to identify the "best" available projects from an energy-economic and ecological perspective. High environmental and social standards have to be applied independent of project size and with regard to small hydropower, the assessment of cumulative ecological effects is required.

The hydropower sector can improve its environmental performance by a) upgrading of existing hydropower plants both in terms of power generation and environmental mitigation (e.g. installing functioning fish passes (e.g. Iron Gates), habitat restoration) as well as removal of dams (esp. obsolete ones) and b) committing to biodiversity conservation objectives (e.g. action plans for migratory fish), sediment management, and environmental flows and c) contributing appropriately to covering the cost of mitigation measures in line with the polluter pays principle.

Ultimately, hydropower projects need to provide tangible benefits to local communities and people to achieve social acceptance for a further hydropower development. In order to ensure the sustainability of hydropower and for obtaining a better shared understanding on the topic, the ICPDR will continue being a neutral platform for exchange of experiences in the application of ICPDR Guiding Principles (case studies, strategic planning, cost-efficient measures to mitigate negative impact of hydropower). This will, in particular, help to facilitate communication between water managers and relevant actors from the energy sector, in order to ensure the coherence between energy policies and river basin management planning. As a follow-up to the ICPDR Hydropower Workshop in 2017, a study on the knowledge base on key social and economic drivers of hydropower development in the Danube River Basin to support integration of the energy sector and all relevant stakeholders was launched in 2018.[91] The results of which were presented at the ICPDR Hydropower Workshop in March 2021. Also, the Danube countries will continue to consolidate and update existing data on the location and generation capacity of hydropower plants in the DRB, with the aim of producing a new map similar to

91 https://www.icpdr.org/main/activities-projects/hydropower (accessed 12 February 2021).

Map 27 in the DRBMP Update 2015. Due to issues relating to data availability and harmonisation, this process could take several years.

6.6 Sustainable Agriculture

The ICPDR strongly supports the EC efforts made for achieving sustainable agriculture thus ensuring the profitability of agriculture and the vitality of rural areas, safeguarding water resources and achieving and maintaining good status of ground- and surface water resources. The ICPDR initiated a dialogue with the agricultural sector to help the national agri-environmental policy making of the Danube countries resulted in publishing the Guidance Document on Sustainable Agriculture[92].

The initiative is driven by the recognition that improving the socio-economic situation in the agricultural sector is a prerequisite for a successful implementation of agri-environmental policies. Water and agricultural policies should be designed and harmonised in a way that income losses for the farmers are minimised or compensated when implementing measures to protect water bodies. Policies should seek win-win solutions wherever possible. However, finding the way towards these objectives needs to change the paradigm: policies should be shifted from the traditional, purely command-control type regulative enforcement to more balanced approaches, taking into account the perspective of farmers' economic benefits. This new direction should be based on open dialogue, mutual trust and common understanding that is expected to result in willingness to make certain compromises by both sectors. With the paradigm change the initiated dialogue sets an ambitious objective: to develop a policy guidance in order to support decoupling future agricultural development from increasing nutrient pollution of surface and ground waters and from prolonged water scarcity. In this way, it may contribute to achieving sustainable agriculture by balancing the economic, ecologic and social aspects of agriculture and rural development.

The guidance development is fully in line with the current political momentum of aligning water and agricultural policies at the EU level, i.e. the stronger ambitions of the proposed CAP post 2020 regarding environmental protection and climate change adaptation and the Green Deal and its Zero pollution ambition, the Farm to Fork Strategy[93] and Biodiversity Strategy for 2030. The guidance paper recommends sound policy instruments, financial programs and cost-efficient agricultural measures to protect water bodies for decision makers in the agri-environmental policy field. It offers Danube countries support for the preparation and implementation of their tailor-made national agri-environmental policies, CAP Strategic Plans and relevant strategies of the River Basin Management Plans in good synergy.

The primary focus of the guidance is sustainable nutrient management related to agriculture and rural land management. However, bearing in mind the strong linkage of the drought issue to agricultural water management, the scope of the guidance document was extended to the drought issue besides the nutrients. Moreover, pesticide pollution related to agriculture is also an emerging issue to be tackled. Further editions will broaden the scope towards pesticides and other harmful substances.

The guidance is to be considered as a living document subject to further update and fine tuning, particularly in line with the finalization of the legislative proposal of the CAP post 2020 and taking into account additional inputs of the agricultural sector. The potential amendments and implementation aspects are planned to be discussed on joint follow-up workshops of the water and agricultural sector and relevant stakeholders.

Additional information is provided in Chapter 8.1.2.3.

92 *http://www.icpdr.org/main/icpdr-publishes-guidance-document-and-policy-paper-sustainable-agriculture (accessed 17 November 2021).*

93 *COM (2020) 381 final Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system.*

6.7 Sturgeon Conservation

Sturgeons are among the oldest and largest fish still living in freshwaters. However, they have become the most threatened group of animals globally (IUCN) and are on the brink of extinction. This ancient migratory fish traces its origins back to 200 million years ago and historically could grow up to seven metres in length, with a potential life span of up to a hundred years. There are six sturgeon species native to the Danube River Basin. Once present in large, viable populations - partly migrating as far as Regensburg on the Upper Danube and contributing greatly to the stocks of the Black Sea, their populations have drastically been reduced due to overfishing, and are still showing a negative populations trend.

The beluga or great sturgeon is the most famous, though unfortunately this is mainly due to its relevance for the caviar trade. It is impressive in size, measuring up to seven metres, although the maximum length for the Danube is probably more in the range of 4,5 metres. The other species are the Danube or Russian sturgeon, the fringebarbel or ship sturgeon, the sterlet, the stellate or starred sturgeon and the common or European sturgeon. Of the six native Danube sturgeon species, the common sturgeon is extinct, the ship sturgeon is now considered regionally extinct in the Danube with no records of live animals or eDNA since 2009. The Russian sturgeon, once the most abundant sturgeon species of the Danube, has only been observed in single numbers over the past years. The numbers and the natural reproduction of stellate sturgeon and Beluga sturgeon are rapidly declining. The sterlet is considered endangered in the Lower and Middle Danube and nearly extinct in the Upper Danube.

Table 35: Overview of Danube sturgeon species and their status and trend according to IUCN[94]

Species	Also known as	Status	Trend
		According to IUCN	
Acipenser gueldenstaedtii	Danube sturgeon or Russian sturgeon	Critically endangered	Decreasing
Acipenser nudiventris	Ship sturgeon or Fringebarbel sturgeon	Critically endangered (extinct in DRB)	Decreasing
Acipenser ruthenus	Sterlet	Vulnerable (endangered for the DRB)	Decreasing
Acipenser stellatus	Stellate sturgeon	Critically endangered	Decreasing
Acipenser sturio	Common sturgeon, European sturgeon, (formerly also referred to as Atlantic sturgeon)	Critically endangered (extinct in DRB)	Decreasing
Huso huso	Beluga sturgeon or Great sturgeon	Critically endangered	Decreasing

In view of the critical state of the Danube sturgeon stocks and the already elevated risk of their extinction in the near future, any additional or increased pressures, whether from removal of individuals or deterioration in habitats and migration corridors, accelerate the extinction risk. Urgent action is required if the risk of their extinction is to be reduced and the Danube sturgeon species conserved for future generations.

The factors driving sturgeons to extinction are manifold and range from historical legal over-exploitation to illegal fishing, by-catch and trafficking today (stemming from improper fishery management and insufficient legal enforcement of fishing bans), blocked migration routes through dams and loss or degradation of habitats to other negative pressures such as pollution and fish kills.

94 https://www.iucnredlist.org/ (accessed 12 February 2021). The new IUCN assessment was ongoing at time of publishing of the DRBMP Update 2021; table 34 includes expected changes to existing ratings in brackets, based on communication of the IUCN Sturgeon Specialist Group (https://dstf.info/wp-content/uploads/2021/08/Sturgeon-Conservation-Endorsement-Letter.pdf (accessed 15 October 2021)).

In order to ensure the maximum effectiveness and efficiency of the approaches for the recovery of Danube sturgeon populations, it is essential to ensure that similar and coordinated approaches are applied in the Black Sea Basin for stocks that are shared with the Danube River Basin.

Sturgeons depend on an interlinked network of habitats from rivers to the sea that provide them with suitable conditions to complete their life cycles, feed, disperse, repopulate, balance fish biomass and genetically exchange. The availability of different habitat types provides the basis for: (1) different species and their habitat niches/requirements, (2) changing requirements concerning species specific demands to close the life cycle, (spawning ground, nursery and feeding habitats), (3) a daily migration to night and feeding habitats, and (4) facultative refugia from harsh environmental conditions.

The status of migratory fish is a parameter of the ecological condition and key indicator of the entire Danube River Basin. The Danube River is not only a key migration route itself, it is also of special importance for those species migrating from the Black Sea and connects all tributaries in the basin for migration.

In general, all fish species of the Danube River Basin are migratory; however, the importance of migration for the viability of fish populations varies considerably among them. Differences exist in terms of migration distances, direction (upstream, downstream, and lateral), spawning habitats, seasons and the life stage for which migration takes place. For the sturgeons, what matters in terms of migration corridors and habitats is thus the integrity of the network at the scale of the basin and its interconnection with the conditions for sturgeons in the Black Sea.

The Iron Gate Dams I & II, the Gabčíkovo Dam and in part the chains of hydropower plants in Austria and Germany represent significant migration barriers for fish. Migratory fish, such as sturgeons as flagship species but also shads and medium distance migrants such as nase or barbel are particularly affected, since they are prevented from moving up or downstream between their spawning grounds and areas used at other times in their life cycle.

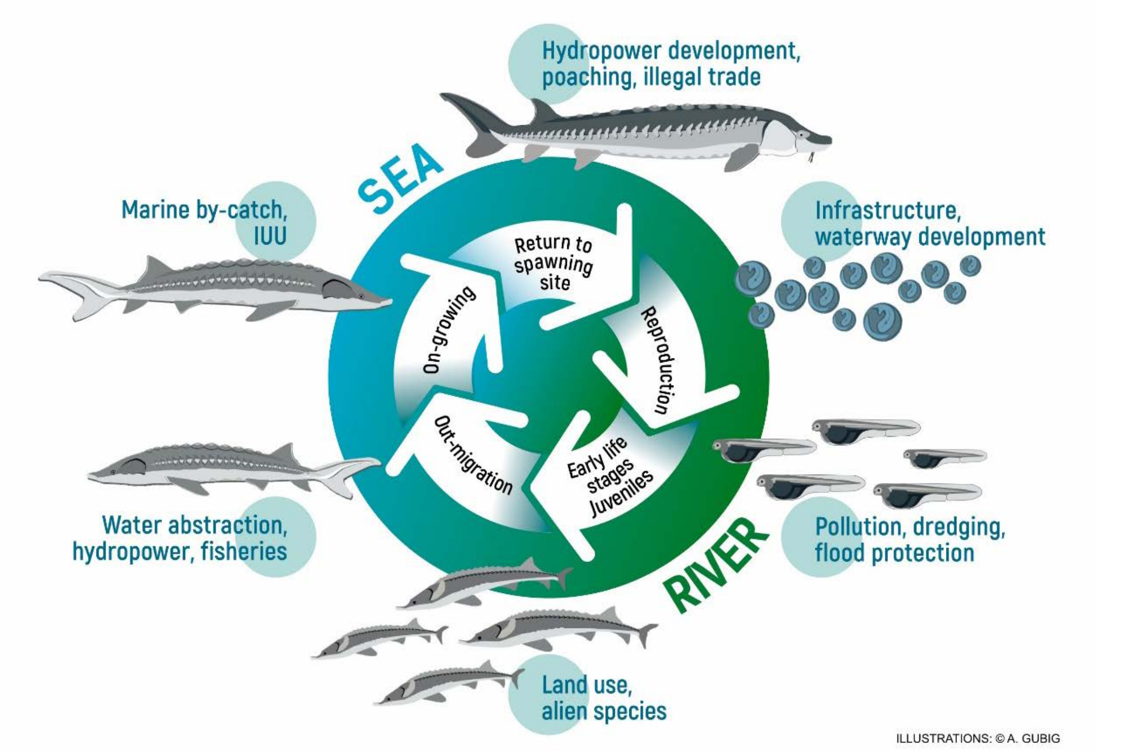


Figure 72: Sturgeon life cycle. A typical life cycle of migrating sturgeons showing adverse impacts on the various life cycle phases. © WSCS & WWF

The implementation of measures enabling sturgeon migration across these dams would open up large areas of the Danube River Basin and could thus contribute significantly to the recovery of the Danube sturgeon populations and medium distance migrators while also helping achieve the goals of the EU Water Framework, Habitats Directives and European Biodiversity Strategy 2030. All concerned ICPDR parties will work towards the swift implementation of such measures.

Although no longer present at their historical levels, different sturgeon species are nevertheless still present within the whole Danube River Basin (in particular in the lower DRB, but with regard to the sterlet also in the middle DRB, and in the upper DRB). Therefore, sturgeons are an issue of basin-wide concern and actions are required on the basin-wide scale.

Creating ecological corridors: The MEASURES Project

The Interreg Project MEASURES (Managing and restoring aquatic EcologicAl corridors for migratory fiSh species in the danUbe RivErbaSin), implemented from June 2018 to July 2021, explored the options for protecting and restoring this ecological corridor not only for sturgeons, but also for other Danubian migratory fish. The MEASURES Project aimed to create ecological corridors by identifying key habitats and initiating protection measures along the Danube and its main tributaries. MEASURES analysed national strategies and policy relevant for migratory fish, identifies and assesses habitats and its properties and demonstrated the need for conserving and/or re-establishing physical continuity, fostering healthy and viable fish populations. As a final output, MEASURES provides strategic advice and guidance, which was developed in close cooperation with national stakeholders concerned with the protection and restoration of the Danube ecological corridor and the conservation of migratory fish species. Such a strategic document, harmonized on basin-wide scale while accounting for national situations and needs, takes an important step beyond the most needed efforts for sturgeons. It should obtain sufficient support for implementation from relevant national policy and administration.

Within the project, a map and database was being developed, including information on geographical locations of sturgeon habitats in the Danube and its tributaries. The sturgeon records compiled by all project partners are as comprehensive as possible, but not complete and are not meant to depict the complete status or distribution of the respective species. The intention is to provide a current picture of known sturgeon observations in the Danube River Basin. The displayed data on the maps include five species: *Acipenser nudiventris* (most probably extinct in the Danube), *Acipenser gueldenstaedtii*, *Acipenser ruthenus*, *Acipenser stellatus* and *Huso huso*. The data of sturgeon habitats were derived from various sources such as publications, grey literature, project reports, books, field surveys, historical data, or fisheries data and were collected by project partners/countries (listed below). Additionally, habitats were separated in observations before (n=136) and after (n=889) the construction of the Iron Gate dams (i.e. before/after 1972). Some recordings date back to the 15th century.

Four habitat types were identified: spawning habitats, nursery habitats, wintering habitats, feeding habitats.

Project Website: *http://www.interreg-danube.eu/approved-projects/measures* (accessed 16 February 2021).

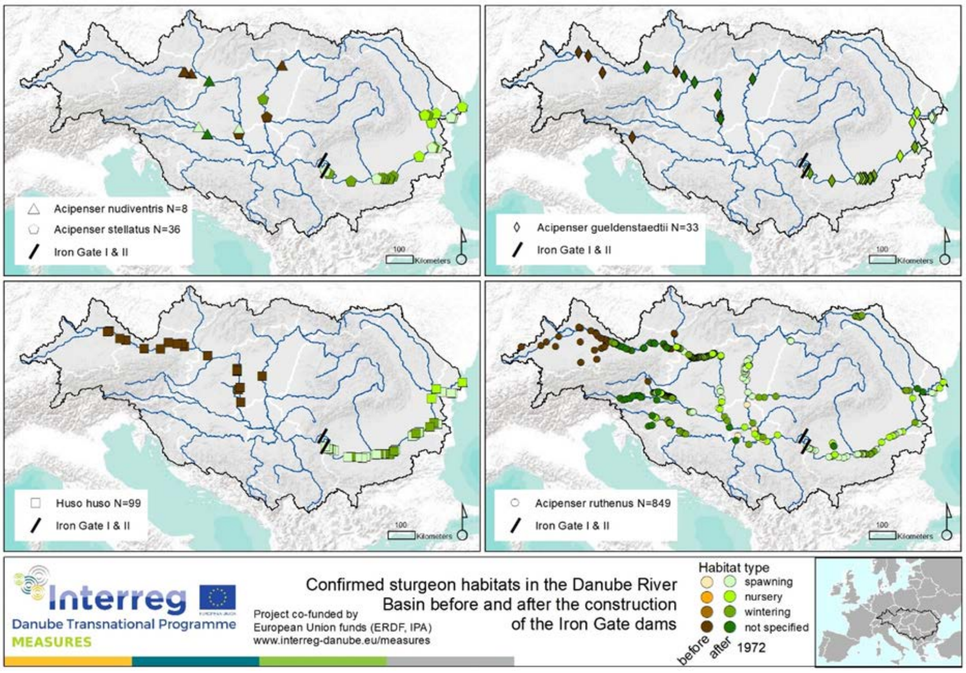


Figure 73: Confirmed Sturgeon Habitats in the Danube River Basin before and after the Construction of the Iron Gate dams (Outcome of MEASURES Project, Interreg, Danube Transnational Programme, co-funded by European Union funds (ERDF, IPA), as of August 2020)[95]

Sturgeon conservation in the Danube River-Black Sea system requires urgent action, based on a basin-wide and interdisciplinary approach.

The ICPDR Sturgeon Strategy[96] approved by the ICPDR in 2017 highlights the ICPDR's key competencies in Danube sturgeon conservation activities, such as supporting the restoration of lost and altered habitats, the prevention of further habitat degradation, measures to enable fish migration and improve water quality. Furthermore, it outlines the ICPDR's Sturgeon Communication Strategy, an awareness-raising document that defines target groups, key measures and communication tools and channels.

Other activities, which require cooperation with other partners who are competent in these matters, include governance-related measures such as capacity building and law enforcement, the establishment of living gene banks and conservation stocking (ex-situ conservation), an effective control of poaching and fishing as well as trade in sturgeon products (caviar) and combating overexploitation of the fish stock. These measures are coordinated and managed by the ICPDR and the ICPDR Contracting Parties, as appropriate, including water administration and other responsible national players in Danube countries, and where relevant, through contacts with and implemented by the appropriate international players to ensure the effectiveness of the measures (see also Chapter 3). In this context Contracting Parties will also review their own activities and plans in the light of the results of the MEASURES project.

The way forward for conservation of the sturgeons in the Danube has been clearly set out. Utmost priorities are to continue with efforts to put conservation hatcheries in place to save the genetic potential of sturgeon in the wild, continuing efforts at the Iron Gate to make this obstacle passable for sturgeons, to implement effective protection of wild sturgeons against capture as well as the other top priority urgent actions set out below.

95 The displayed data on the map include five species, Acipenser nudiventris (most probably extinct in the Danube), Acipenser gueldenstaedtii, Acipenser ruthenus, Acipenser stellatus and Huso huso. The majority of the data covers the past 10 years, while some dates back to the 15th century. Existing data of confirmed sturgeon habitats derived from various sources such as publications, project reports, books, field surveys, historical data, grey literature or fisheries data was gathered by each MEASURES project country/partner. Additionally, potential habitats were identified based on the analyses of bathymetric and navigation maps by means of expert judgement.

96 https://www.icpdr.org/main/activities-projects/sturgeons-danube-basin (accessed 12 February 2021).

Saving the Danube sturgeon species is a truly multi-level governance challenge which will require the involvement of many disparate sectors and authorities at different administrative levels and many different economic stakeholders and civil society. There is no single sector or territorial jurisdiction where the long-term effectiveness of conservation measures does not depend on measures being taken in other sectors or in other territorial jurisdictions. Effective action therefore requires effective coordination of action between different territorial jurisdictions and the relevant international organisations and authorities. The ICPDR and the Contracting Parties are committed to playing a crucial role by maintaining dialogue and discussion with other key actors to ensure, as far as possible, that the necessary action listed in Table 32 is taken. In this regard, follow up measures to the projects mentioned above should be considered as well as the organisation of a multisectoral conference for all stakeholders, including those from the Black Sea cooperation context, with the aim to assess gaps and discuss the need for further actions.

Finally, as implementation efforts are intensified, coordinated monitoring of sturgeon populations (in the DRB as well as in the Black Sea and its catchment) and access to a shared dataset on sturgeon related issues will also become increasingly important management tools. Population monitoring will be important to inform assessments of whether strategies and measures taken are having the expected or desired impacts. Shared datasets are important to inform decision-making by Contracting Parties and their competent authorities and to ensure the coherence and consistency of measures implemented by different authorities.

The Bern Convention's Pan-European Action Plan for sturgeon conservation (see Chapter 3) sets out all the actions that need to be taken in order to ensure the effective conservation of sturgeons. The high priority issues and measures which need to be addressed with particular urgency in the Danube Basin in order to avoid the extinction of Danube sturgeons as well as supportive actions are summarised in Table 36 below as well as in Annex 12. They are supported unequivocally by the ICPDR.

Table 36: Overview of key measures to avoid the extinction of Danube sturgeons and necessary supportive actions

Description of measure /action	Key measure to avoid the extinction of Danube sturgeons	Necessary supportive action	Further details are available under
1. Ex situ broodstocks/ Reproduction and release programmes	X		*https://dstf.info/wp-content/uploads/2021/06/DSTF-WSCS-Recommendations-for-Ex-Situ-Sturgeon-Conservation.pdf* (accessed 15 October 2021)
2. Follow-up of the We Pass project	X		*https://www.we-pass.org/* (accessed 16 February 2021)
3. Effectively enforced multi-decadal fishing bans	X		*https://dstf.info/wp-content/uploads/2020/09/DSTF-Fishing-Moratorium-Paper.pdf* (accessed 16 February 2021)
4. Habitats, Migration Corridors and Controls on Infrastructure Development	X		*http://www.interreg-danube.eu/approved-projects/measures* (accessed 16 February 2021)
5. Monitoring and control of by-catch in marine fisheries	X		*http://www.interreg-danube.eu/approved-projects/measures* (accessed 16 February 2021)
6. Coordination with sturgeon conservation in the Black Sea Basin	X		*https://rm.coe.int/pan-european-action-plan-for-sturgeons/16808e84f3* *https://danube-sturgeons.org/the-project/* (accessed 16 February 2021)
7. Sturgeon Population Monitoring		X	e.g. *http://www.europeantrackingnetwork.org/* (accessed 16 February 2021)
8. Establishment and maintenance of a Danube Migratory Fish Database		X	e.g. *http://www.interreg-danube.eu/approved-projects/measures* (accessed 16 February 2021)

Re-establishing sturgeon migration through the Iron Gate: We Pass and Pilot Project (We Pass 2)

In November 2018, the ICPDR together with partners from Romania (DDNI) and Serbia (Jaroslav Černi Institute), CDM SMITH and OAK Consultants, as well as the Norwegian Institute for Nature Research, started to implement the "We Pass - Facilitating Fish Migration and Conservation at the Iron Gates" project funded by the European Commission. The Iron Gate Hydropower and Navigation System (HPNS) is one of the largest engineering projects ever undertaken in Europe, built to provide cost effective and permanent utilization of available hydropower and to create adequate conditions for navigation along the Iron Gate stretch of the Danube. However, the Iron Gate I & II are also an obstacle for migratory fish such as the sturgeon, because they block access to the middle Danube and its large tributaries Drava, Sava and Tisza, all of which are extremely important habitats for the spawning and nursing of migratory fish.

The aim of the project is to support the implementation of activities identified in the Terms of Reference for the Feasibility Study analysing options for fish migration at Iron Gate I & II, which were adopted by the ICPDR in December 2016 concluding that such a technical solution should be possible, but further detailed investigations are needed. Activities within the We Pass project include technical investigations, biological monitoring activities as well as technical basic modelling tasks with results being available in 2021. In order to ensure the execution of the full feasibility study political commitment and secured funding possibilities are needed to continue the ongoing efforts to ensure sturgeon migration across the Iron Gate dams.

An important contribution is provided by the European Parliament which has ensured the availability on the EU 2020 budget of 2 million € for a pilot project (Pilot Project: Making the Iron Gates Dams Passable for Danube Sturgeon, ENV/2020/OP/0037) to assess technical solutions for making the Iron Gate dams passable for Danube sturgeons. They will provide a significant contribution to improving ecological connectivity in the Danube Basin by reconnecting the Lower Danube with the Middle Danube. Decisions have not yet been taken about how this work will be carried out. In any case, it is expected that the decision-making-process regarding the implementation of solutions for the issue of fish migration across the Iron Gate will benefit from the results of the assessments carried out by the pilot project. In March 2021, the European Commission commissioned CDM Smith (together with ICPDR, and its partners i.a. from Romania and Serbia) with the "Pilot Project: Making the Iron Gates Dams passable for Danube Sturgeon", also called We Pass 2, to conduct a feasibility study analysing the options to establish fish migration at the Iron Gate that includes a) a concept of preliminary design of fish pass(es) at Iron Gates comprising all the technical elements; and b) a cost estimate for the construction of the fish pass(es). The pilot project started in April 2021 and runs for three years until March 2024.

In the context of the DRBMP Update 2015 as well as the ICPDR Sturgeon Strategy of the year 2017, the ICPDR Contracting Parties concluded that if the results of the investigations at the Iron Gates dams I and II prove positive, the respective measures should be implemented step by step and a similar feasibility study will also be performed for the Gabčíkovo Dam. Slovakia reiterates its commitment to initiate this preparatory work for the Gabčíkovo Dam.

Ex-Situ Conservation Hatcheries Project Upper Danube

As a direct follow up of the first European Sturgeon Conference efforts focused inter alia on the conservation of the genetic potential of the shrinking sturgeon population still living in the wild in the Danube region. A feasibility study on the establishment of living gene banks in facilities outside the river proper ("ex situ") was initiated by the ICPDR in 2019, funded by the ICPDR and Austria. The study focused on the necessary genetic size of the captive stock, water and space requirements, the cost for constructions, equipment and operation. Subsequently locations were evaluated on their suitability with regard to Danube water access, flood risk, accessibility and availability, considering the need to establish at least two sites to reduce the risk of losing genetic families, e.g. in case technical failures or environmental impacts in a facility. In parallel, first steps to identify suitable paternal specimens in commercial hatcheries have been undertaken and the collection of several individuals started. Potential co-financiers have been identified and discussions started on the co-funding for construction and operation of facilities in three Danube countries.

Concepts for the establishment and operations of ex-situ breeding facilities in the Upper, Middle and Lower Danube have been developed. The high costs involved for such facilities require funding commitments from various co-funders, among which EU financial programmes will play a key role. The methodology is based on the LIFE-Sterlet project (*http://life-sterlet.boku.ac.at/*, accessed 16 February 2021) (2015-2021) which successfully proved the viability of streamside rearing methods and released over 200.000 juvenile sterlets into the Danube (2015-2021).

A genetic conservation manual for ex-situ Danube sturgeon live gene stocks to assist the development of supportive restocking (MEASURES 2021c) and guidelines for ex-situ facilities have been developed.[97] Furthermore, recommendations for the establishment of conservation hatcheries and conservation stocking (2021) were jointly elaborated by a Working Group of the DSTF and the World Sturgeon Conservation Society (WSCS).[98]

LIFE 4 Danube sturgeons

Starting 2012, WWF implemented two consecutive EU co-funded LIFE projects, focused on the issue of illegal fishing and trade in sturgeon products in the Lower Danube region (*https://danube-sturgeons.org/*, accessed 16 February 2021). As a result of the projects, legal gaps (i.e. no border controls of wildlife trade in Ukraine) have been closed, fishing regulations improved in Bulgaria and Ukraine, and as of January 2019 a new fishing ban for Sterlet introduced in Serbia. The engagement with and training for enforcement authorities resulted in increased control activities mainly by different police departments, who are now motivated and equipped with the knowledge needed to investigate illegal activities. Yet enforcement authorities are often lacking basic resources in staff and equipment (fuel, boats) to undertake sufficient controls. Trust-building measures with 1.000 fishermen – the most affected target group of the fishing ban – resulted in fishermen sharing valuable information about illegal activities in their communities. Their acceptance and engagement in conservation efforts is crucial to be maintained and alternative income possibilities substituting the loss of income through fishing bans must be a future priority to win their support.

The project also proved that illegal fishing and trade are ongoing today. Official data from enforcement authorities (01/2016 to 12/2020) in Bulgaria, Romania and Ukraine revealed at least 214 cases of illegal activities targeting sturgeon (including poaching, use of illegal gear or illegal trade). A minimum of 602 sturgeon specimen were seized. A market survey along the trade chain analysed 145 sturgeon meat and caviar samples from Bulgaria, Romania, Serbia and Ukraine. Isotope and genetic analysis proofed

97 *http://www.interreg-danube.eu/approved-projects/measures/outputs* (accessed 15 October 2021).

98 *https://dstf.info/wp-content/uploads/2021/06/DSTF-WSCS-Recommendations-for-Ex-Situ-Sturgeon-Conservation.pdf* (accessed 15 October 2021).

that 30% of all samples were sold illegally and 19% came from wild-caught sturgeons.[99] In 2019, 20.000 Russian sturgeon and in 2020 more than 7.000 Beluga sturgeon, both of proven Danube origin, were released by WWF. Several national sturgeon research activities (including monitoring projects) were also ongoing over the years, in particular in Romania.

99 https://danube-sturgeons.org/wp-content/uploads/2021/04/Market-survey-final.pdf *(accessed 15 October 2021).*

7 ECONOMIC ANALYSIS

7.1 Role of Economics in the WFD

The WFD with its clear environmental focus requires that river basins are also described in economic terms. This „economic analysis" forms a foundation on which to base the subsequent steps. This means that the planning of measures, for example, should combine all three aspects of sustainability (considering environmental, economic and social concerns), e.g., in order to ensure cost effectiveness.

Economic principles are addressed in the WFD mainly in WFD Article 5 (and WFD Annex III) as well as WFD Article 9. In WFD Article 5 EU MS are required to perform an economic analysis of water uses. Furthermore, WFD Article 9 requires that by 2010, EU Member States had to take account of the principle of cost-recovery (CR), including environmental and resource costs (ERC). In addition to this direct requirement, the WFD refers implicitly to economic principles in many of its Articles.

A first economic analysis of water uses (based upon the requirements of WFD Article 5) was carried out in the Danube River Basin in 2004, in the framework of the first Danube Basin Analysis (DBA). A summary of this economic analysis was included in the DRBMP 2009 as required by WFD Article 13 and WFD Annex VII, referring to WFD Article 5 and WFD Annex III. The required update of the economic analysis was performed for the 2013 Update of the DBA (included in the DRBMP Update 2015), which has now again been updated for inclusion into the DRBMP Update 2021. For the DRBMP Update 2021, the economic analysis was made on the basis of data received from all Danube countries, except Republic of Moldova.

7.2 Description of Relevant Economic Water Uses and Economic Meaning

According to WFD Article 5 and WFD Annex III, an economic analysis of water uses had to be carried out (and has to be reviewed, if necessary, every six years). The aim is to assess both the importance of the main water uses for the economy and the socio-economic development of the river basin; this economic analysis has now been updated at the Danube River Basin level.

Table 37 presents basic socio-economic data covering all fourteen countries cooperating in the frame of the ICPDR. As it can be observed, a considerable difference in the GDP per capita figures exists among the Danube basin countries, demonstrating a significant difference in the economic activities of Danube Countries. This big gap among the countries is reduced slightly when GDP per capita figures are expressed in Purchase Power Parities (PPP), as can be seen in Figure 74.

Table 37: General socio-economic indicators of Danube countries

Country	Population within the DRBD	Share of population within the Danube Basin[100]	National GDP 2019 (World Bank)	GDP 2019 per capita (World Bank)	GDP 2019 per capita[101] (World Bank)
	in Mio.	in % of total population	in Mio. US$	in US$ per capita	in PPP/International $ per capita
Austria	8.4 (2018)	95.4%	445,075	50,137	58,946
Bosnia and Herzegovina	3.2 (2013)	84.75%	20,164	6,108	15,883
Bulgaria	3.57 (2011)	48.47%	68,558	9,828	24,789
Croatia	2.9 (2011)	67.8%	60,752	14,936	30,140
Czech Republic	2.7 (2018)	25.4%	250,680	23,494	43,299
Germany[102]	10.07 (2016)	12.2%	3,861,123	46,445	56,278
Hungary	9.8 (2018)	100%	163,469	16,731	34,507
Republic of Moldova	Not available	Not available	11,968	4,503	13,627
Montenegro	0.18 (2011)	28% (2011)	5,542	8,908	23,189
Romania	19.5 (2018)	97.4%	250,077	12,919	32,297
Serbia[103]	7 (2018)	99.8%	51,475	7,412	19,013
Slovakia	5.2 (2018)	96.13%	105,079	19,266	34,066
Slovenia	1.82 (2020)	86,5%	54,174	25,946	40,983
Ukraine	3.03 (2018)	7.21%	153,781	3,659	13,341

Note: World Bank data retrieved January 2021.

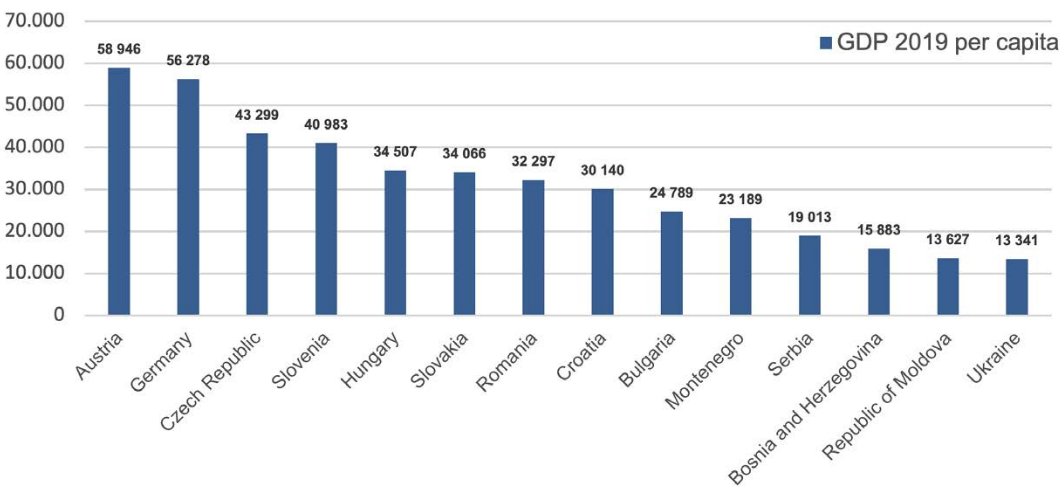


Figure 74: GDP per capita (PPP/International $) of Danube countries (2019)

GDP rose in all Danube countries significantly since 2013, frontrunners being Republic of Moldova (+50.1%), Romania (+34.7%), Montenegro (+25.5%), Bulgaria (+25.8%) and the Czech Republic (+20%). An exception is Ukraine, where GDP and GDP/capita has fallen due to the ongoing crisis in the Eastern part of the country.

100 National contributions.

101 GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States.

102 Data on population from 2016, which represents the most recent comparable national data available on the level of river basins.

103 The data from Serbia do not include any data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

According to the European Commission´s Summer 2020 Economic Forecast, because of the COVID-19 pandemic the "European economy entered a sudden recession in the first half of… [2020] …with the deepest output contraction since World War II. A string of indicators suggests that the euro area economy has operated at between 25% to 30% below its capacity during the period of the strictest confinement. Overall, the euro area economy is forecast to contract by about 8 ¾% in 2020 before recovering at an annual growth rate of 6% next year [in 2021]. These projections are somewhat lower than in the spring forecast and point to an incomplete recovery as output at the end of 2021 is expected to be about 2% lower than before the crisis and about 4 ½% below the GDP level forecast in winter"[104].

7.2.1 Characteristics of Water Services

WFD Article 2(38) states that: „Water services" means all services which provide, for households, public institutions or any economic activity:

- Abstraction, impoundment, storage, treatment & distribution of surface water or groundwater;
- Wastewater collection and treatment facilities which subsequently discharge into surface water.

Three Danube countries - Germany, Montenegro and Croatia - defined water services as encompassing the services water supply and wastewater collection/treatment. In Austria the term water services is used extensively. The water services water supply and wastewater collection/treatment are included in cost recovery calculations in accordance with WFD Article 9.

Nine other countries interpreted the WFD definition to encompass more than these two services. In the Czech Republic, for example, further water services (beside water supply and wastewater collection/treatment) are rivers and river basin management; surface water abstraction; GW abstraction; discharge of wastewater into surface water; discharge of wastewater into GW; impoundment for the energy production; navigation – only recreation. Slovakia defined three additional water services („use of hydro-energy potential of water-course; abstraction of energy water from watercourse; abstraction of surface water from water-course") and included these into CR calculations already in the first cycle. Hungary defined public water supply, public wastewater collection and treatment, agricultural water supply (irrigation, fishponds, other), damming and storage for hydropower production, own water abstraction as water services, whereas Romania and Bosnia and Herzegovina each defined a great number of water services (13 in Bosnia and Herzegovina, 6 in the case of Romania). Bosnia and Herzegovina, however, did not include these in their cost recovery assessments. Ukraine defines water services as water supply, wastewater collection and treatment, agricultural, fish farming, surface water abstraction and the use of hydro-energy potential.

Bulgaria subdivided the water services according to the economic sectors, i.e. public water supply, public collection of waste water, public treatment of waste water, individual water supply in industry, individual water supply in agriculture for irrigation, individual water supply for stock-breeding, producing of electric power by hydropower plant, protection of harmful impact of water, conservation of water, navigation and other activities connected with navigation, and individual drinking water supply are each defined as individual water services. Bulgaria states that CR results will be available later in 2020 (regarding financial costs) and 2021 (full CR incl. environmental and resource costs) (for more detailed information on water services, see Annex 13).

Basic information regarding water supply and connection rates are presented in Table 38 below. The table shows for a number of countries high connection rates above 90% to public water supply (Austria, Bulgaria,

104 https://ec.europa.eu/info/business-economy-euro/economic-performance-and-forecasts/economic-forecasts/summer-2020-economic-forecast-deeper-recession-wider-divergences_en (accessed 12 February 2021).

Czech Republic, Germany, Montenegro and Hungary). Other countries show significant improvements in the percentage of households connected in relation to the 2015 Update of the DRBMP. Frontrunners are Bosnia and Herzegovina (+10%) and Romania (+7%).

Table 38: Water supply and connection rates in the Danube River Basin countries (if not indicated otherwise, the data refers to the national level, reference year 2018)

Country	Water supply production (industry, agriculture and households from public systems)	Supply to households	Population connected to public water supply
	in Mio. m³	in Mio. m³	in %
Austria	706 (2014-2018 average)	494 (2014-2018 average)	91.8
Bosnia and Herzegovina	320	108	70
Bulgaria	167.79 (DRBD), 352.01 (national)	124.25 (DRBD), 252.82 (national)	99.51 (national), 99.79 (DRBD)
Croatia	473 (DRBD), 473 (national)	242 (DRBD), 242 (national)	86 (DRBD), 86 (national)
Czech Republic	609.7	327.8 (national)	94.7
Germany[105]	810 (DRBD)	479.3 (DRBD)	99.1 (DRBD)
Hungary	627.9	342.7	95.3
Republic of Moldova	Not available	Not available	Not available
Montenegro	27 (2015)	16 (2015)	94 (2019)
Romania	6416	1085	69.4
Serbia[106]	654	424	87
Slovakia	2099.92 (DRBD), 2112.27 (national level)[107]	287.89 (DRBD), 293.39 (national)	89.25
Slovenia	170.7	79	93 (2019)
Ukraine	236.06	66.8	84,1 (urban), 24,1 (rural)

Source: Contributions from Danube countries; further information on connection rates regarding wastewater and sewage treatment can be found in Table 39 and Table 40. Note: National-level data is depicted in all cases except otherwise noted.

In several Danube countries, the water supply networks are in poor condition due to, for example, significant lack of long-term funding, a lack of maintenance and ineffective operation in some places. Leakage is generally high, in some cases 30-50% of the water is lost (e.g., in Hungary, the losses amount to 27.3%, and in the Czech Republic to 15.8%). The extent of piped drinking water supplies to households varies between urban and rural areas, with rural populations in some countries less well provided. The share of the population connected to public water supply systems varies from under 13% in rural Republic of Moldova (in 2015) to over 99% in Bulgaria and Germany, but generally increases, as Table 38 above shows.

The following two tables demonstrate the difference in the overall dimension of wastewater collection and sewage treatment that exists in the Danube river basin.

As can be seen in Table 39, in Germany and Austria the percentage of agglomerations (>2,000 "population equivalent"/PE) in which wastewater is collected and treated reaches 100% (regarding population, the numbers are nearly 100%); other countries in the Western part of the basin have quotas that are similarly

105 *Data from 2016, which represents the most recent comparable national data available on the level of river basins.*

106 *The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.*

107 *These numbers also include energetics including hydropower, cooling, fishponds, artificial snowing, other uses.*

high (the Czech Republic, Slovakia, Hungary). Further East, towards the new EU Member States and non-EU Member States, the share of the agglomerations in which wastewater is collected and treated gets smaller.

In comparison to the 2015 update of the DRBMP, some changes are recognizable. In the whole Danube basin, the number of PE with collection and treatment rose from 60 million to almost 63 million. Similarly, the number of PE without treatment fell from 16 million to 11 million.

Table 39: Wastewater Collection in the Danube River Basin[108]

Country	Number of agglomerations (>2000 PE)[109]						Population equivalent					
	Total	Collected and treated in WWTP	Collected but not treated	Addressed through IAS	Addressed through local systems	Not collected	Total	Collected and treated in WWTP	Collected but not treated	Addressed through IAS	Addressed through local systems	Not collected
DE[110]	653	653					12,379,029	12,365,946		13,083		
AT	604	604					13,841,359	13,754,871		86,488		
CZ	201	195		6			2,619,546	2,464,455		155,091		
SK	345	254	3	87		1	4,001,630	3,420,415	30,933	529,408		20,874
HU	615	549		65		1	13,657,862	11,648,962		1,457,217		551,683
SI	138	127	4	6		1	1,313,346	1,186,181	16,823	97,977		12,365
HR	136	31	27	56		22	2,808,237	1,474,532	512,575	557,685		263,445
BA	169	3	25		108	33	2,570,226	343,837	637,691		1,063,387	525,311
ME	7	3	1			3	143,900	55,880	27,502			60,518
RS[111]	342	28	94		213	7	6,096,930	735,187	3,547,975		1,674,254	139,514
BG	123	44	18	19		42	3,248,035	2,692,821	172,050	217,253		165,911
RO	1,849	300	39	13		1,497	19,973,439	11,996,029	442,538	372,860		7,162,012
MD	144	5	2			137	582,279	65,597	16,379		12,893	487,410
UA	310	13	15			282	1,929,646	560,470	88,454			1,280,722
Basin	**5,636**	**2,809**	**228**	**252**	**321**	**2,026**	**85,165,464**	**62,765,181**	**5,492,920**	**3,487,062**	**2,750,534**	**10,669,765**

The following Table 40 demonstrates the level of the treatment, and again shows the difference in the level of wastewater treatment in the Danube basin. As can be seen, treatment plants with only primary treatment were phased out in a number of countries, e.g., Austria, Czech Republic, Germany and Slovenia. At the same time, treatment plants with tertiary treatment and nutrient removal became more common, while plants with only secondary treatment declined sharply (from 1,003 agglomerations in the 2015 update of the DRBMP down to 888). The number of PEs with only secondary treatment declined accordingly, from 15.2 million in the 2015 update of the DRBMP to 7.3 million. Correspondingly, the number of agglomerations and PEs with tertiary treatment increased (from 1,827 agglomerations to 2,220, and from 44 million PEs to 54.3 million).

108 Source: Danube countries, data collection via ICPDR PM EG; reference year: 2018.

109 Classification based on the dominant technological level.

110 As the underlying data only include agglomerations with facilities to which the UWWTD applies (over 2.000 PE), they do not correspond to those published in the national economic analysis for the German part of the Danube river basin, which includes all facilities over 50 PE.

111 The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

Table 40: Sewage Treatment in the Danube River Basin[112]

Country	Number of treatment plants (in agglomerations >2000 PE)				Population equivalent			
	Total	Primary	Secondary	Tertiary	Total	Primary	Secondary	Tertiary
DE[113]	653		108	545	12,365,946		370,920	11,995,026
AT	604		3	601	13,754,871		5,488	13,749,383
CZ	180		26	154	2,464,455		122,757	2,341,697
SK	256	2	79	175	3,420,415	4,857	184,438	3,231,120
HU	599	33	99	467	11,648,962	328,900	1,982,913	9,337,149
SI	92		36	56	1,186,181		388,470	797,711
HR	46	9	26	11	1,474,532	109,694	1,085,013	279,824
BA	12	1	11	0	343,837	4,797	339,040	
ME	4		2	2	55,880		9,160	46,720
RS[114]	46	9	34	3	735,187	44,817	554,213	136,157
BG	45	3	10	32	2,692,821	5,103	319,311	2,368,408
RO	644	35	435	174	11,996,029	602,597	1,331,622	10,061,810
MD	13	6	7	0	65,597	31,050	34,547	
UA	14	2	12	0	560,470	23,521	536,949	
Basin	**3,208**	**100**	**888**	**2,220**	**62,765,181**	**1,155,336**	**7,264,840**	**54,345,005**

7.2.2 Characteristics of Water Uses

The WFD requires the identification of water uses: abstraction for drinking water supply, irrigation, leisure uses, industry, etc., and a characterization of the economic importance of these uses. Water use means water services together with any other activity having a significant impact on the status of water. Some countries defined more water uses as water services than others.

The following tables provide an overview of the economic importance of water uses in the Danube basin. As can be seen, agriculture represents an important economic sector in several Danube countries, such as Ukraine (10%), Serbia, Bosnia and Herzegovina, Montenegro and Croatia (around 5%), although the share in GDP is falling (in the case of Bosnia and Herzegovina, it dropped by almost 10%). On the contrary, in other Danube countries, mostly in the Western part of the basin, the share of agriculture in national GDP is very low - in the Czech Republic, Slovenia and Slovakia, the share is only around 2%, in Austria and Germany even lower. Industry is significant in all Danube countries, contributing a significant share to the national GDP. Electricity generation does not exceed the 5% mark in any of the Danube countries, except for the Czech Republic (5.2%). Date on water use of these sectors is of interest, as different sectors use more or less water for the same economic output; typically, agriculture is a main water user, but obviously only if irrigation is included. As definitions of water use and methodologies to assess water use are different in the Danube countries, the data is difficult to compare between countries and sectors. Generally, it has to be noted that the service sector, although not listed here, can contribute significantly to GDP in spite of potential low water consumption.

112 Source: Danube countries, data collection via ICPDR PM EG; reference year: 2018.

113 As the underlying data only include agglomerations with facilities to which the UWWTD applies (over 2.000 PE), they do not correspond to those published in the national economic analysis for the German part of the Danube river basin, which includes all facilities over 50 PE.

114 The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

Table 41: Production of main economic sectors (national level) and related water volumes used

Country	Agriculture	Water Use in Agriculture	Industry	Water Use in Industry	Electricity Generation	Water Use in Electricity Generation
	Share of GDP (in %)	Million m³	Share of GDP (in %)	Million m³	Share of GDP (in %)	Million m³
Austria	1.1 (2017)	85 (2020)	27 (2017)	2,200 (2018)	2.5 (2017)	n.a.
Bosnia and Herzegovina	5.89	93 (2014)	13.23	184 (2014)	4.37	-
Bulgaria	4.3 (2017)	311.69 (national); 18.2 (DRB)	28 (2017)	3,995.41 (national); 2630.24 (DRB)	n.a.	3683.29 (national); DRB – n.a.
Croatia	5.2 (2015)	2.4	22.3 (2015)	17.9	2.25 (2015)	n.a.
Czech Republic	2.6	17.7	30.2	144	5.2	121.3 (this figure is also included in the row on “Water Use in Industry”)
Germany	0.6 (2016)	6.7 (2016, consumptive use without irrigation)				
(irrigated area in 2016 approx. 22 000 ha)	27.5 (2016)	approx. 1,900 (2016, includes consumptive use in energy sector)	0.01 (2016)	approx. 1,100 (2016, consumptive use in energy sector does not include hydropower; overlap with volumes given for “Industry”)		
Hungary[115]	4.2	356.8	22.4	95.7	1.5	3,160
Republic of Moldova	Not available					
Montenegro	6	-	16	-	0	-
Romania[116]	4.36	1,426.83*	22.8	3,904.33	0.68	369,823.35
Serbia[117]	6.3	54.54	14.5	86	3.4	4,132 (electricity, gas and steam supply)
Slovakia	1.82	22.5 (Danube part of SK and including irrigation)	25.67	132.24 (Danube part of SK)	2.45	1456,04 (thermo power plants, nuclear power plants and hydropower plants, of which hydropower plant data amounts to 1447,88 Mio.m^3)
Slovenia	2.1 (2020)	1.1 (2019)	88.4 (2020)	946	2.3 (2020)	91.434
Ukraine	10.14	2,029 (national); 152.6 (DRB)	17.57	3,980 (national); 3.317 (DRB)	3.14	2,679 (national); 0.037 (DRB)

Data is for 2018, if not otherwise noted.

Note: Definitions of water use and methodologies to assess water use are different in the Danube countries, as they fall into national competencies.

115 Data is for water abstraction (WFD Economic Analyses; source: Water resource fee statistic data from 2018). Agriculture includes irrigation, rice production, fishery and animal husbandry; industry includes manufacturing and mining; the volume used in electricity generation does not include in-situ use for hydro-power production.

116 Agriculture includes aquaculture and irrigation; industry are “industrial units”; electricity generation includes hydropower, thermopower and nuclear power.

117 The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

Table 42: Hydropower generation in the Danube River Basin

Country	Installed hydropower capacity	Electricity production from hydropower	Share of hydropower generation
	in MW	in GWh/year	in % of total electricity generation
Austria	14,516	41,175	60.6
Bosnia and Herzegovina	2,034 (DRBD)	6,519 (DRBD)	34 (DRBD)
Bulgaria	3,327 (State, 2016)	4,438 (State, 2016)	12 (State, 2016)
Croatia	2,199.5 (DRBD)	7,789.9 (DRBD)	57.1 (DRBD)
Czech Republic	742 (DRBD)	699 (DRBD)	3.2 (DRBD)
Germany	5,600 (State, 2016)	21,000 (State, 2019)	3.18 (State, 2019)
Hungary	57 (State)	222 (State, 2016)	0.7 (State)
Republic of Moldova		Not available	
Montenegro	368.1 (2017)	876.3 (2017)	55 (2018)
Romania	6,600 (DRBD)	1,7783 (DRBD)	27.62 (DRBD)
Serbia[118]	3,103 (DRBD)	1,1393 (DRBD)	33.7 (DRBD)
Slovakia	2,540.1 (DRBD), 2,542 (State)	3,909.84 (DRBD), 3,920 (State)	12.67 (State)
Slovenia	1,351 (State, 2020)	5.224 (State, 2020)	30.4 (State, 2020)
Ukraine	40.85 (DRBD)	119.13 (DRBD)	58.7 (DRBD)

Data is for 2018, if not otherwise noted.

Austria has the largest percentage of generated electricity based on hydropower (60% of total electricity generated). The share of hydropower is also relatively high in Ukraine and Montenegro (between 50 and 60%), Croatia, Slovenia, Romania and Serbia (around 30% on the national level, and close to 60% in the DRB), and although it is lower in Germany[119], a large proportion of German hydropower is produced in the DRB and the absolute amount of electricity produced from hydropower is high compared to other countries in the DRB. In other countries, like Slovakia, Bulgaria and Bosnia and Herzegovina, hydropower still plays an important role in the electricity system. However, in most Danube countries (with the exception of DE, HU and MD), hydropower currently represents the most important component of total renewable energy production (for more concrete information, see the study on „*Social and economic drivers for hydropower development in Danube countries*"[120]).

118 The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

119 Because of geographical differences, the distribution of hydropower plants in Germany varies considerably. About 83 % of installed power in Germany is located in the federal states Baden-Württemberg and Bavaria (2018), which make up parts of the German share of the DRB. In Bavaria the overall contribution of hydropower to gross power generation is 14.4 %, in Baden-Württemberg it is 7.3 %, whereas in Germany it is 3.1 % (in 2017; source: Agentur für Erneuerbare Energien - www.foederal-erneuerbar.de/ (accessed 12 February 2021)).

120 Neubarth (2020): Social and economic drivers for hydropower development in Danube countries (commissioned by ICPDR). To be downloaded here: https://www.icpdr.org/main/activities-projects/hydropower (accessed 12 February 2021).

Table 43: The significance of inland navigation in the Danube River Basin

Country	Freight transport on the entire Danube	Number of major ports[121]
	Million tons	Number
Austria	7.2 (2018)	8
Bosnia and Herzegovina	0.04	3
Bulgaria	n.a.	3
Croatia	5.80	2 (2015)
Czech Republic	n.a.	n.a.
Germany	3.7 (2016)	4 (2013)
Hungary (2017)	8.4	12
Republic of Moldova	Not available	
Montenegro	0	0
Romania	29.71	12
Serbia	11.68	14
Slovakia	5.57	3
Slovenia	Not available	
Ukraine	6.07	3

Source: national contributions; data for 2018, if not noted otherwise.

The table above shows that inland navigation related to the Danube does not play a major role in every Danube country, it is relevant only for some Danube countries as there is no commercial inland navigation in the countries on the edges of the Danube River Basin. The countries with the highest tonnage transported on the Danube are Romania and Serbia (with more than 10 million tons of cargo annually). Nevertheless, most other riparian countries also transport significant amounts. In comparison to the DRBMP Update 2015, the tonnages transported declined in all Danube countries, except Romania, Hungary (where it increased), and Croatia (same level).

7.3 Cost Recovery

This chapter summarizes information on CR approaches and methodologies used in the Danube countries based on national contributions (for more detailed information see Annex 13).

Cost recovery for specific water services is an important instrument to apply the polluter pays principle and is defined as the ratio between the revenues paid for a specific service and the costs of providing the service. The WFD requires that Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs.

Analysing CR approaches in general, but especially in transboundary basins with a variety of national approaches, faces several challenges. First, the application of economic and environmental principles into price setting and the degree of application of CR vary from one to another Danube country according to the specific legal and socio-economic conditions. Second, the approaches to CR and pricing vary inside the Danube countries as well, as it is often the local authorities who have the responsibility for setting the price and who therefore determine the degree of cost recovery of certain water services. On the other hand, there

121 *The definition of "major port" varies in the Danube countries and across the EU; here, a major port is understood as a port that plays a significant role in the international water transport.*

are countries where the national regulator sets prices based on its regulatory policy; however, these prices as well as the level of CR vary for individual water service providers according to their economic capability. Third, the topic touches on several challenging questions regarding methodologies and the understanding of, for example, ERC and „adequate cost recovery". Furthermore, a number of influencing factors are to be considered when analysing water prices, costs, or level of cost recovery in different countries with varying socio-economic structures (such as general price levels, local favourable or unfavourable conditions for water supply etc.).

Generally, all EU Danube countries have defined water services. The interpretation of what is to be considered a water service varies (see Chapter 7.2.1 above), as well as the consequences for CR calculations. For example, the definition of a certain activity as water service does not necessarily mean that this water service is included in cost recovery calculations, or that environmental and resource costs are included.

Also, the methods and underlying definitions that are relevant for calculating CR differ between Danube countries. Here, a variety of approaches can be observed: in some countries, CR is not calculated, or the information - which is sometimes difficult to obtain - is missing or unclear; often, only financial and/or operation and maintenance (O&M) costs are considered; some countries also included ERC into cost recovery calculations, although in these cases, a clear definition of ERC is missing (i.e., an underlying methodology to determine the ERC). Overall, nine countries clearly state that a CR ratio is available for water services in a quantitative manner.

Regarding ERC, the current understanding and approach to defining and/or calculating them varies among the Danube countries. A full and comprehensive methodology for calculating ERC is not reported by any Danube country, due to methodological difficulties and lack of information/data (only Bulgaria states that a methodology is in progress). Nevertheless, a pattern can be observed that is followed by the majority of Danube countries in a slightly different way. First of all, it has to be noted that „resource costs" are often understood not as „opportunity costs" (i.e., the costs of foregone opportunity), but as the costs of the resource itself, i.e., as a form of „abstraction price/cost". Environmental costs, on the contrary, are often defined as the costs that are associated with the discharge of wastewater into water bodies, and the costs for wastewater collection and treatment (and captured and internalized through the respective charges and fees - i.e., the underlying assumption seems to be that the wastewater charges/fees adequately cover the associated environmental damages; based on this assumption, the charges/fees are then equated with the environmental costs). The "cost-based approach" is consequently the methodology applied most often (eight times), followed by "expert judgement" (three times).

All Danube countries that reported this data state that cost recovery is applied through various forms of charges/fees, or taxes. Six countries state that in addition to charges/fees, permits which include restrictions/limitations in a way that ERC do not occur fulfil this role as well. Mitigation and/or supplementary measures seem to play a smaller role (five countries state that mitigation/supplementary measures contribute to ERC cost recovery, although on which basis such costs are calculated is not clear).

7.4 Projection Trends in Key Economic Indicators and Drivers up to 2027

In order to assess key economic drivers likely to influence pressures and thus water status, a Baseline Scenario (BLS) has been developed in the DRBMP 2009. In the current update of the Plan, the economic drivers are assessed using trend projections, based on the 2015 trends using national contributions. The trend projections focus on the most relevant drivers and pressures of socio-economic development and accompanying effects on water status (quality and quantity) but are not necessarily limited to the Danube RBD – in most countries, information on future trends is available only on the national level.

In the following, a short summary of the general trends is provided. Annex 13 presents the data that was available in the Danube countries in early 2020.

Estimating overall trends in socio-economic development is already a challenge in a single country, as such developments are dependent on many factors that cannot be influenced by states (such as global commodity prices, exceptional events such as the COVID-19 pandemic etc.). These challenges are aggravated in a region that consists of different countries using different methodologies and approaches in their statistics and national forecasts.

Nevertheless, some general trends can clearly be recognized. First, overall population in the Danube River Basin can be expected to decline, as only four countries are expected to have an increase in population until 2025 (AT, UA, DE and SK), though the regional distribution of the population is also changing in several countries, e.g., DE, where the expected moderate increase in population is specific to the Danube basin[122] whilst at the national level either stagnation or slight decrease is expected[123]. All other Danube countries are expected to have a similar or smaller population than today.

At the same time, as far as information and estimations are available, the economies are mostly expected to grow, although the COVID-19 pandemic adds great uncertainties to the prognoses and will almost certainly have negative effects on economic growth. There is not much information on agriculture, but it seems there is not much growth expected in this sector (except in Romania and Serbia). Industry is expected to grow slightly, along the growth figures of the previous years. Information on future water demand is scarce, Romania and Croatia report likely slight decreases, and the Slovakia a slight increase.

Some growth can be expected in two other sectors in some countries: electricity production from hydropower and biomass. This is a development which could have significant consequences for water status as both activities can have significant impacts on water bodies (biomass production through nutrient and pesticide leaching, hydropower through hydromorphological impacts).

A short table below summarizes the main figures. More detailed information can be found in Annex 13.

122 E.g. https://www.statistik.bayern.de/mam/statistik/gebiet_bevoelkerung/demographischer_wandel/demographische_profile/091.pdf (accessed 12 February 2021).

123 https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsvorausberechnung/_inhalt.html (accessed 12 February 2021).

Table 44: Summary of main socio-economic trends in the Danube countries

Country	Economic growth in agriculture until 2027	Economic growth in industry until 2027	Growth in energy production from hydropower until 2027	Growth in energy production from biomass until 2027	Population growth until 2027
Austria	Slight decrease in area. Agricultural production output on a constant level (2030).	Slight increase especially in chemicals, paper production and food production (2030).	< 5 % (2027)	n.a.	+3% (2020 -2027)
Bosnia and Herzegovina	n.a.	+1.6%/a	+1.87%/a	+1.1%/a	-2,6%
Bulgaria					Not available
Croatia	n.a.	n.a.	7,012 GWh	781 GWh	4.299,3 mio.
Czech Republic	Stagnation	Stagnation	+0.5 MW	n.a.	+2.3% (2029)
Germany	Expected to remain on the current level	Expected to grow moderately	Expected to remain on the current level	Expected to remain on the current level	Expected to grow moderately
Hungary	n.a.	n.a.	Expected to remain on the current level	Biomass and renewable waste expected to increase by 30% until 2027	-2.6% until 2025 (based on 2015 forecast)
Republic of Moldova			Not available		
Montenegro	n.a.	n.a.	n.a.	188 GWh until 2030	+/-0%
Romania	Appr. 2%/a	Appr. 1.9%/a	Expected to remain on the current level or slightly increase	+10%-20% until 2030	n.a.
Serbia[124]	+0.66%/a (until 2023), +1.52% (from 2024-2027)	+3.22%/a (until 2023), +3.44% (from 2024-2027)	+0.97%/a (until 2025), +0.79% (from 2026-2027)	+1.35%/a (until 2025), +1.39% (from 2026-2027)	-0.24%/a (until 2025), -0.15% (from 2026-2027)
Slovakia	n.a. (No official prognosis with impact of COVID-19)	Significant decrease (-6.7% in 2020 and +6.6% in 2021)	+7.19%	+43.9%	+0.22% (until 2025), +0.23% (from 2026-2027)
Slovenia	n.a.	n.a.	n.a.	n.a.	n.a.
Ukraine	+1.5%	+1.3%	Moderate growth	Expected to slightly increase	Expected to slightly increase

Note: Figures mostly based on estimations; not official numbers (for sources see Annex 13).

7.5 Economic Assessment of Measures

Cost-effectiveness analysis

A cost-effectiveness analysis (CEA) can be a support to decision making regarding the selection of the most cost-effective combinations of measures for inclusion in the Programme of Measures as described in WFD Article 11. However, WFD Article 5 and WFD Annex III do not stipulate CEA as a method for cost-effectiveness assessment.

Conducting a full CEA, however, faces significant challenges, most of them linked to data requirements and availability, e.g., on the costs of measures, or on the quantified effects in terms of reaching WFD objectives. These challenges apply to both the national (and sub-national), as well as the transboundary levels, where

124 The data from Serbia do not include data from the Autonomous Province Kosovo and Metohija - UN administered territory under UN Security Council Resolution 1244.

differing national approaches (e.g., scale of the assessments, different methodologies for assessments of the effects, difficulty to assess the costs in some cases) add to the general difficulties of performing a CEA.

A general challenge for performing a CEA, especially on an international or aggregated level, are the difficulties in getting comparable information on costs of measures in general at the national level. For example, the methods for estimating the costs on planned measures are heterogenous between Danube countries – one country might cover specific types of measures (e.g., basic or supplementary) or a specific sector (water supply) or might have parts of the territory outside the Danube basin (and only national-level data); often, cost information covers capital investment costs, but not operational and maintenance costs, which might be included in other estimates. Topic-wise, it is difficult to aggregate cost information on the basis of, for example, the SWMIs, as double-counting might occur due to measures fitting into several categories[125]. For example, challenges arise when comparing costs of measures in countries with very different socio-economic backgrounds/cost structures, when a quantitative assessment of the effects in relation to biological quality elements is necessary, or when definitions of measures differ in various countries. Furthermore, measures which are under implementation in particular for pollution reduction are to a large extent basic measures according to the WFD in several Danube countries.

This does not mean that water resource management in a basin wide/transboundary context excludes the use of a cost-efficient approach. On the contrary, in a transboundary context, the application of CEA can be a useful tool in assessing the effectiveness of measures. Achieving the nutrient reduction targets cost-effectively, for example, requires analysis of the costs and effects of potential measures. National approaches for incorporating cost-effectiveness assessments in modelling tools for planning nutrient reduction measures (e.g., in MoRE/MONERIS in Germany) or other measures (e.g., a methodology for a CEA for the evaluation of mainly HYMO measures in Slovakia) are being developed and their applicability and practicability is being examined. Also, in the case of flood protection, the advantages of a transboundary CEA are that it broadens the knowledge base, enlarges the set of available strategies and enables better and more cost-effective solutions. In addition, widening the geographical area considered enables measures to be located where they create the optimum effect. A CEA in the case of flood protection could be used to compare the costs of alternatives located upstream or downstream, or employing different approaches (e.g., natural water retention measures vs. more technical approaches).

An example for performing a transboundary CEA, though not specifically assessed/addressed in WFD terms, is the Romanian transboundary project: "Crisul Negru – Flood protection improvement" performed and financed under the transboundary cooperation programme between RO and HU in 2007-2013. In the frame of a prefeasibility study, the costs of alternative measures were being evaluated (criteria being decreased flood risk and extra storage capacity created), which was the starting point for Cost-Benefit-Analysis and Multi-Criteria-Analysis conducted at a later stage. Also, in the Danube Sediment Project - Restoration of the Sediment Balance in the Danube River, elements of a CEA were being employed. CEA is therefore an issue addressed primarily at national level.

125 These findings regarding the difficulties of estimation of costs of planned measures are confirmed also at the EU-level: "[...] the knowledge base on the costs of planned measures is heterogeneous and incomplete. Cost estimates often tend to cover capital investment costs only, with no corresponding estimates of annual operational and maintenance costs in many countries; and they often tend to be available for some measures, some areas or some sectors, varying across countries." EC-report: "Economic data related to the implementation of the WFD and the FD and the financing of measures", May 2021, pp.5.

However, transnational cooperation can help to tackle the following issues in the future in a coordinated manner:

- Framework of analysis: defining the methodology and scope of a future CEA.
- Data availability: costs of measures (catalogue of measures with harmonized average costs per, for example, km or ha).
- Better understanding of effectiveness of measures towards reduction of pressures.

As an integrated part of CEA, regardless of the purpose for which it is performed, dealing with different measures/options implicitly means different related costs, effects and thus effectiveness. Different cost may be associated with different financing options, an accurate approximation of the costs could be an advantage in identifying a proper financing source. To support the Danube countries in their efforts to improve cost assessment, the ICPDR facilitates data exchange, e.g., framework for comparative data analysis, and organises workshops, e.g., the Workshop on Financing HYMO measures in 2018 in Romania, in which national experience and approaches were compared and options and opportunities for harmonisation discussed and explored.

Cost-benefit analysis

The legal obligation of the WFD is to achieve "good status" and to avoid the deterioration of water status, with the possibility to apply exemptions in exceptional cases. The tool of the cost-benefit analysis (CBA) is of specific relevance for assessing the disproportionality of costs compared to benefits in the context of WFD Article 4 exemptions, which is an issue dealt with at national level. The assessment of disproportionality/ Cost-Benefit Analysis has therefore not been performed at the basin-wide scale. It needs to be noted that WFD Article 4 does not prescribe the use of CBA for the assessment of disproportionate costs. However, proportionate selection of different analytical approaches (cost-benefit analysis, benefits assessment, assessment of the consequences of non-action, distribution of costs, social and sectoral impacts, affordability, cost-effectiveness etc.) can be useful to inform decision making[126], and could be strengthened at the project level (local, but also national and transboundary scale) as in the example of the Crisul Negru project.

Approaches towards Disproportionality of Costs

According to the WFD, disproportionality of costs can be an argument for justifying exemptions from WFD objectives (WFD Article 4(4): time derogations/WFD Article 4(5): less stringent environmental objectives). It was employed by six Danube countries (for justifying time derogations; five countries also used it for justifying less stringent environmental objectives). One country did not employ disproportionality of costs.

A range of approaches and methodologies are used to determine if costs are disproportionate: three of the five countries use cost-effectiveness analyses, four „affordability" and four cost-benefit analyses in addition. In one country, also the loss of productivity is considered in the analysis of disproportionate costs, and in another the (not defined) "financial possibilities".

More detailed information on the application of WFD Articles 4(4) and 4(5) in the DRB can be obtained from Annex 13.

126 As stated by the Water Directors and in the CIS Guidance Document No. 20 on Exemptions to the Environmental Objectives.

7.6 Summary and Key Findings

There is considerable range in the GDP per capita figures of the Danube countries highlighting significant differences between Danube countries´ economic activity. This fact is also reflected in terms of the heterogeneity in levels of investments which were possible in the past on basic water services like water supply and wastewater treatment, leading to different levels of infrastructure development (e.g. regarding the levels of UWWT). Apart from the lack of available funds, shortcomings in capacities to absorb existing funds also remain an important issue.

Beside indices like GDP or GDP/capita, an index or indicator demonstrating the sustainability of economic growth could be used to assess whether such growth occurs at the cost of social issues or environmental assets. Efforts to develop such "Sustainability Indicators" take place in most Danube countries, mostly in the frame of the respective national sustainability strategies, but the approaches are too different to be compared. In the future, a harmonized Sustainability Indicator is needed to flank the strictly economic indices like GDP and GDP/capita.

Closing this gap remains one of the key challenges for the DRB and the WFD planning period 2022-2027. Cost-recovery is inter alia seen as a key tool for ensuring the financial sustainability of utilities, whereas socio-economic circumstances and affordability issues have to be taken into consideration. This can in particular be an issue for regions which are less advanced with regard to economic development, what is also reflected by significant differences in the figures on GDP contributions of different economic sectors like agriculture, industry or energy.

With regard to trends, the overall population in the DRB can be expected to decline slightly, while economies are mostly expected to grow – however, the COVID-19 pandemic is significantly increasing uncertainty and is already having a negative effect on economic growth. Sectors with significant consequences for water quality and quantity related aspects, such as agriculture, hydropower and production of energy from biomass, are also expected to grow, but less than in the 2015 update of the DRBMP foreseen.

Efforts will be required in order to close still existing knowledge gaps and further work remains regarding methodologies and possibly harmonized approaches e.g., on tools like cost recovery, including environmental and resource costs, in order to make best use of economic instruments offered by the WFD for water management planning at national level as well as in a transboundary context. Capacity building at the national /and or regional level for the development and selection of projects needs also be supported, as well as small-scale pilot projects showing the benefits of transboundary innovative financing. Cost-effectiveness or cost-benefits analyses and affordability are approaches for determining disproportionality of costs in case of justifying exemptions, and Danube countries could benefit from harmonized approaches.

8 JOINT PROGRAMME OF MEASURES

The JPM builds upon the results of the pressure analysis (see Chapter 2), the water status assessment (see Chapter 4) and includes, as a consequence, measures of basin-wide importance oriented towards the agreed visions and management objectives for 2027. It is based on the national programmes of measures and describes the expected improvements in water status by 2027. Priorities for the effective implementation of national measures on the basin-wide scale are highlighted and are the basis of further international coordination. Some additional joint initiatives and measures on the basin-wide level that show transboundary character are presented as well. They are undertaken through the framework of the ICPDR.

The JPM is structured according to the Significant Water Management Issues (organic, nutrient and hazardous substances pollution, hydromorphological alterations and effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts) as well as groundwater bodies of basin-wide importance. It follows the basin-wide management objectives for each SWMI and groundwater in order to achieve the WFD environmental objectives by 2027. An important step towards the achievement of these objectives is the implementation of the JPM from the DRBMP Update 2015, implemented between 2015 and 2021. For each of the SWMIs, with the exception of the newly introduced SWMI on effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts), information is provided on the state of play with regard to the implementation of these measures (according to WFD Annex VII B.3. and B.4.). More detailed information can be obtained from the national RBM Plans.

The JPM represents more than a list of national measures as the effect of national measures on the Danube basin-wide scale is also estimated and presented. The implementation of the measures of basin-wide importance is ensured through their respective integration into the national programme of measures of each Danube country. A continuous feedback mechanism from the international to the national and sub-basin level and vice versa will be crucial for the achievement of the basin-wide objectives, in order to improve the ecological and chemical status of water bodies.

The three SWMIs of organic, nutrient and hazardous substances pollution have been approached taking into account the specific inter-linkages between them. The basic principles of those inter-linkages are described in the respective SWMI sub-chapters. Regarding the conclusions on these three SWMIs but also hydromorphological alterations, as an important follow-up the improvement of understanding with regards to the linkages between respective DRBD river loads and the ecologic response in the DRBD rivers and the Black Sea will remain. This improvement should be based upon additional monitoring results and scientific investigations that will be available in the coming years.

As for the SWMI on effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts) interlinkages with measures of all other SWMIs are provided.

The JPM does not address basic and supplementary measures (WFD Article 11(3) & (4)) separately. However, as the supplementary measures are of importance on the national level, they have been taken fully into account and are therefore indirectly reflected.

8.1 Surface Waters: Rivers

8.1.1 Organic Pollution

8.1.1.1 Vision and Management Objectives

The ICPDR's basin-wide vision for organic pollution is zero emission of untreated wastewaters into the waters of the Danube River Basin District.

The following management objectives and recommended actions are to be implemented by 2027 as steps towards the vision:

- Further reduction of the organic pollution of the surface waters via urban wastewater discharges.
- Further reduction of the organic pollution of the surface waters from the major industrial and agricultural installations.
- Fostering sustainable development of the wastewater sector and strengthening the management and technical capacity of utility operators at UWWTPs and local/national administration people dealing with wastewater management.

8.1.1.2 Progress in Implementation of Measures from DRBMP Update 2015

In the first two management cycles significant investments have been made in the field of organic pollution control in the DRBD resulting in considerable reduction of organic pollution (see Annex 14). In addition, a wastewater initiative was launched in the DRB to strengthen capacity in the wastewater management sector and a wastewater recommendation paper has been published.

In the last fifteen years, Danube countries have invested ca €28 billion in wastewater infrastructure in line with the requirements of the UWWTD and the WFD. Since 2006, more than 6,000 municipality projects have been implemented and around 45 million PE have had collecting and treatment facilities constructed or upgraded, with almost 2,800 more planned or currently in progress to improve the services for 26 million people. In addition, almost 180 operating industrial facilities with direct surface water emissions are certified with updated technology standards according to the provisions of the IED. During the same time period, the percentage of municipalities and industrial facilities (bigger than 2,000 PE) connected to a sewer system and UWWTP or adequate individual treatment facilities also increased substantially (to almost 80% at the DRB level), demonstrating a significant improvement of wastewater services in the DRB.

8.1.1.3 Summary of Measures of Basin-Wide Importance

Despite the huge investments already made in the wastewater infrastructure, additional measures should be taken in the future. According to the presented assessments and the 10th Implementation Report[127] of the Urban Wastewater Treatment Directive (UWWTD)[128], financing and planning remain the main challenges

127 Tenth report on the implementation status and programmes for implementation (as required by Article 17 of Council Directive 91/271/EEC, concerning urban waste water treatment), COM (2020) 492 final.

128 Council Directive 91/271/EEC of 21 May 1991 concerning urban wastewater treatment.

facing the wastewater sector. The current level of investments in many EU MS is too low to reach and maintain compliance with the Directive in the long term. EU MS need to improve planning of investments, including plans for the renewal of wastewater infrastructure.

The objectives of the DRBMP 2009 and DRBMP Update 2015 were related to the accession treaty obligations of the new EU MS which were rather optimistic. Thus, the progress achieved is slower than it was originally planned and the objectives will probably be accomplished with a delay as the implementation of the respective measures is lagging behind in some countries. The transition period obtained by some EU MS for the implementation of the UWWTD requirements was considered as a funding prioritisation criterion, with high priority on the big and mid-sized agglomerations. This led to certain delay in the implementation at the smaller agglomerations.

Therefore, further development of the urban wastewater sector is needed in the next management cycle to help achieving the ICPDR's basin-wide vision for the reduction of organic pollution. Management activities are legally determined for the EU MS through several EU directives. The UWWTD (currently being revised) is driven by water quality protection and precautionary aspects and specifically focuses on the sewer system and wastewater system development. EU MS are obliged to establish sewer systems and treatment plants at least with secondary (biological) treatment or equivalent other treatment at all agglomerations with a load higher than 2,000 PE. This must have been finished until the end of 2005 in the EU MS, although the new EU MS had a shifted transition period to fulfil the requirements (e.g. by 2018), whilst Croatia has a transition period ending by 2023. Introduction of appropriate treatment at agglomerations with PE less than 2,000 is also required at those agglomerations where sewer systems exist. In addition, the UWWTD also states that individual and other appropriate systems (IAS) as exceptions shall be used to locally collect (and treat) wastewater if constructing a wastewater collection system is economically not feasible or did not result in environmental benefit. However, IAS must provide the same environmental protection as the required collection and treatment systems would deliver. EU MS must report their activities in the wastewater sector to the EC that makes them transparent to the public. Non-EU MS also intend to make efforts to achieve significant improvements. They are or will be constructing a specific number of sewer systems and UWWTPs until 2027 according to their national strategic plans.

Nevertheless, realistic planning of investments is needed in line with the WFD/DRBMP requirements and funding availability. Efforts should be made to reinforce the capacity of the countries to identify and prepare environmental investment projects and to foster the development of investment projects. Supporting non-EU MS to find appropriate financial sources and to achieve progress is still a challenge in the DRB and it should be further facilitated.

In new and non-EU MS, the most important issues are financing infrastructure projects, strengthening management and technical capacity, tariff setting and ensuring affordability, establishing proper legal framework, and reforming or restructuring the utility sector. For other EU MS, investment needs will be shifted towards the proper maintenance and rehabilitation of the existing infrastructure. In particular, in order to achieve sustainable wastewater management in the DRB, capacity should be strengthened at the national and local administration levels as well as at the utility level to improve financing, operational, and technological aspects of the wastewater infrastructure and services.

The situation of small agglomerations below 2,000 PE should also be addressed. Individual houses or small urban communities at whose scale construction of centralised conventional sewage collection and treatment systems is financially and/or technically disadvantageous should be equipped with appropriate small treatment facilities. Promotion of alternative decentralized treatment technologies in line with the national priorities and legislation should be further encouraged. These small-scale solutions should also be considered even for agglomerations above 2,000 PE, where construction of sewer systems and centralized treatment plants is not feasible therefore alternative methods (individual and other appropriate systems) are more cost-efficient and affordable. Adequate individual facilities (watertight storage tanks, septic tanks with infiltration fields, small domestic treatment plants and units) provide sufficient collection and treatment performance that allows discharging treated wastewater into small recipient water bodies or the soil.

The ICPDR published the Recommendation paper on Wastewater Management[129], that communicates the overall challenges, specific needs and potential solutions related to wastewater management in the DRB. Moreover, it aims at highlighting certain aspects of the current legislation from technical perspective that have been emerging in the Danube countries and might be useful for the on-going UWWTD revision process at the EU level. It also provides several recommendations and potential actions for national policy making to improve wastewater management.

ICPDR recommendations towards sustainable wastewater management

- Countries should carefully prepare the national UWWTD implementation programmes along with a financial plan concerning the necessary investments, project time schedules, potential funding sources and the way of funding and the equity contributions. For non-EU MS it is crucial to develop a long-term strategic financial plan on the capital investments needed for the UWWTD compliance well before the EU accession. Accession countries should negotiate an appropriate implementation deadline taking into account the economic, institutional and affordability challenges.
- Countries need to prioritize the investment projects, starting with those with the highest environmental and societal benefits at the least costs, target pollution hot-spots and significantly contribute to reach WFD objectives. Countries need to ensure that the necessary technical and institutional capacity is available at both, national and local level so that the investment projects can be smoothly implemented. At the administrative level there is a high demand for qualified experts dealing with wastewater management related project development and implementation. In some cases, the countries are not able to submit a bankable project proposal or the preparation and contracting phase is slow due to administrative burdens. For better absorbing available funds, people with proper organizational and strategic skills at the central and local administration are crucial. Moreover, at the level of water authorities, the regulation and control over the implementation issues are important aspects that need appropriate knowledge. The planned investments need to be fully correlated with and justified by the implementation programmes.
- Danube countries should establish close coordination and efficient information exchange between the administration and regulatory bodies, financing institutions and utilities with clear roles and responsibilities. It may be necessary to consolidate or restructure the wastewater sector (geographic coverage, operating companies) in order to provide high-quality services.
- At local administration and utility level, a thorough and careful planning of operational and maintenance costs and ensuring sustainable financing of services are highly important. Choosing the most feasible technological variant should be based on financial considerations besides the required technical quality environmental performance. Detailed knowledge on operational and maintenance costs including asset depreciation and future reinvestments is essential to ensure and strengthen financial viability of the utilities. If system operation and reinvestment are not financially sustainable, there is a risk of decline in service quality and status deterioration of the receiving waters.

129 http://www.icpdr.org/main/icpdr-publishes-recommendation-paper-wastewater-management (accessed 14 September 2021).

- Full cost-recovery of wastewater services (including service provision costs and depreciation) should be ensured by setting appropriate tariffs. The UWWTD implementation requires substantial investments, which result in an increase of the operating expenses. This necessarily leads to tariff increases, which may trigger affordability issues for the low-income population. Affordability challenges have to be addressed through targeted social subsidies for the poorest population and by providing subsidized access to basic sanitation services for vulnerable society groups.
- Well-developed national trainings targeting the operation and maintenance of wastewater infrastructure are crucial to ensure not only a qualified workforce but also efficient and sustainable wastewater treatment. Countries are encouraged to develop national wastewater management training programs and curricula, making use of the on-going capacity building programs developed by the International Association of Water Service Companies in the Danube River Catchment Area (IAWD) for the Danube region. The Danube Learning Partnership (D-LeaP)[130] is designed as a regional, integrated and sustainable capacity building initiative and provides a comprehensive curriculum to the staff of water and wastewater utilities located in the Danube region.
- All Danube countries are advised to make efforts to modernize the wastewater infrastructure and services, to establish a strategy for infrastructure renovation and to secure sufficient financing and knowledge in order to maintain and increase long-term efficiency. Countries should make use of the technological innovations, smart devices, digital technologies and automatized techniques for enhancing and upgrading their wastewater databases, on-site monitoring systems, operational and control mechanisms and analytical laboratories.
- Wastewater should be considered as a resource rather than polluted water to be discharged after treatment. Countries are encouraged to explore the innovative technologies and alternative options, which can help closing the water, energy and nutrient flux cycles at the local scale towards a sustainable resource management. This may also improve the financial sustainability of the services. In case of new plants, these aspects should be considered already in the design phase. Countries should elaborate sludge management strategies to make use of the large amount of produced sewage sludge for energy production, phosphorus recovery or agricultural fertilization (direct application or composting) rather than dumping or eliminating it as waste. This should be accompanied by the development of an enabling policy and financial framework, transparent database, studies on costs and impacts and a public consultation process. In the climate change context, water reuse (along with quality standards) and energy efficient plants should be promoted.
- Countries need to establish an appropriate legal, administrative, financial and regulatory framework for service provision at small agglomerations and for applying IAS. Countries should discover the potential of decentralized systems and nature-based solutions with low operational requirements and costs, which may offer a more suitable cost-effective alternative to be considered. Rural wastewater management is often a forgotten challenge and is overshadowed by the large-scale centralized investment projects. While investment priorities are usually set to mid-sized and large agglomerations, construction projects and service provision are often lagging behind in small agglomerations and rural communities below 2,000 PE where lack of management and technical capacity and affordability issues may further hinder measure implementation and which are often facing demographic issues.
- Countries should support organizing workshops, demonstration events, trainings and exchange on technical measures related to alternative solutions and emerging issues, such as sludge manage-

130 https://www.iawd.at/eng/about/d-leap/ (accessed 14 September 2021).

ment options, energy optimization methods, technologies to remove emerging chemicals and small scale and nature-based treatment facilities.

- Countries are encouraged to conduct specific investigations on the emerging chemicals in urban wastewater and the potential removal rates of the conventional treatment technologies for certain indicator compounds. The fourth treatment stage to target micropollutants should be introduced gradually, first targeting emission hot-spots and water bodies at risk.
- Countries should be aware that management of urban runoff is of growing relevance, especially in the climate change context. Rainwater infiltration and water retention should be supported by maintaining urban green areas, applying pervious surfaces and establishing infiltration ponds in order to reduce runoff and the accompanied pollution. Pollution from combined sewer overflows should be controlled at least by retention ponds or vegetative filters before discharges wherever possible. Similar measures might be considered to treat polluted urban runoff. Specific investigations might be needed to understand the hydraulic and water quality characteristics of the runoff events.

The ICPDR in cooperation with the World Bank and the Danube Water Program[131] and with support of the Priority Area 4 (Water Quality) of EU Strategy for the Danube Region[132], launched an initiative to guide and support Danube countries in achieving sustainable wastewater management by developing and implementing capacity building programs and information exchange in wastewater management and by facilitating proper dialogue among the international financing institutes, national and local administration bodies and utilities. The initiative aims to provide interested and committed government and utility representatives from the Danube region with the appropriate knowledge, exposure and expertise to support modernization efforts in wastewater management sector and development of optimal sector policies.

ICPDR-World Bank-Danube Water Program Wastewater initiative for capacity building

For most of the countries in the DRB, managing wastewater remains an important challenge with respect to reach water resources protection targets and also in the context of their EU accession and harmonization process. The UWWTD and the WFD mandate significantly higher levels of collection and treatment than it is currently the case in many Danube countries. These obligations require substantial investments with associated costs and implications. The new infrastructure that is being or needs to be built for compliance with those Directives creates financial, technical and management strains for national and local authorities, utilities and service providers in the region.

Building upon previous activities on wastewater management by the World Bank under the Danube Water Program and ICPDR, the aim of the initiative is to provide regional knowledge exchange opportunities on topics relevant to the national wastewater management sectors and implications for necessary actions to reach UWWTD compliance. Although different international and regional wastewater programs are already in place, there is still a need and space for a targeted activity on regional level that would focus on those aspects of wastewater management, which are very important but were left out of focus up to now.

There is a particular need for a targeted wastewater management activity on regional level, focusing on: a) financial sustainability of wastewater management (present and future), b) rural and small-scale wastewater management, c) sewage sludge management and d) emerging contaminants. While the

131 *https://www.iawd.at/dwp (accessed 12 February 2021).*

132 *https://waterquality.danube-region.eu/ (accessed 14 September 2021).*

geographic focus is intended to be on countries of the DRB (both EU and non-EU members), the initiative will also bring in relevant knowledge and expertise from outside the region.

Organic pollution stemming from industrial facilities and large farms should also be further addressed by the Danube countries. For EU MS the Industrial Emissions Directive (IED, currently being revised)[133] dictates that authorities need to ensure that pollution prevention and control measures at the major industrial units are up-to-date with the latest Best Available Techniques (BAT) developments. The industrial plants covered by the Directive must have a permit with emission limit values for polluting substances to ensure that certain environmental conditions are met. Application of BAT in the large industrial and agro-industrial facilities was mandatory in EU MS till the end of 2007, with a gradual transition period for some new EU MS. It is expected that all relevant facilities in the EU MS will meet the IED requirements according to the legal deadlines. Reporting is also obligatory according to the E-PRTR Regulation[134], information on these industrial facilities must be available for the public. For this purpose, emission data of facilities from different industrial sectors and over a certain capacity threshold have to be uploaded to the E-PRTR database. Application of BAT is recommended for non-EU MS, especially for some special industrial sectors, like chemical, food, chemical pulping and paper-making industry. Implementation of other Directives like the Nitrates Directive (ND)[135] and the Sewage Sludge Directive (SSD)[136] that respectively concern the fate of nutrients and hazardous substances have also benefits for organic pollution reduction. Regulation of the manure and sewage sludge application at the agricultural fields positively affects the diffuse organic pollution as well reducing organic matter available at the fields for run-off and sediment transport. Similar regulatory actions are recommended for the non-EU MS.

8.1.1.4 Future Development Scenarios

Urban wastewater sector

Baseline scenario by 2021

EU MS: The baseline scenario assumes the establishment of public sewer systems at all agglomerations with population equivalents more than 2,000 and connection of these agglomerations to UWWTPs with appropriate technology through the implementation of the UWWTD in line with the agreed national objectives. It is expected that despite current implementation delays in some countries, all EU MS will comply with the obligations of the UWWTD by 2027.

Non-EU MS: Construction/upgrading of a specific number of wastewater collecting systems and UWWTPs (with specified treatment technology) is assumed in line with the national planning (reported by the non-EU MS).

Vision I Scenario

This scenario goes beyond the midterm scenario. It is based on the assumption that the full technical potential of wastewater treatment regarding the removal of organic material and nutrients is exploited for both, the EU and non-EU MS. The scenario assumes that agglomerations above 10,000 PE are equipped with N and P removal, whereas all agglomerations below 10,000 PE are equipped with secondary treatment. Moreover, it

133 Directive 2010/75/EU of the European Parliament and the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

134 Regulation (EC) No 166/2006 on the establishment of a European Pollutant Release and Transfer Register.

135 Council Directive 91/676/ EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources.

136 Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.

assumes implementation of IAS for 5% (agglomerations above 10,000 PE) and 10% (agglomerations below 10,000 PE) of the total PE at those agglomerations where wastewater collection and treatment is currently substantially lagging behind.

Vision II Scenario

In addition to Vision I Scenario, this scenario assumes higher proportion of IAS instead of extensive construction of sewer systems. For small agglomerations below 5,000 PE 40%, otherwise 20% IAS proportion is assumed.

8.1.1.5 Estimated Effect of Measures on the Basin-Wide Scale

Maps on the above-described scenarios for urban wastewater sector are presented in Map 29-30 showing the envisaged future infrastructural developments in sewer system and wastewater treatment technology (Baseline and Vision I scenarios). The change in the connection rates of the basin-wide wastewater load (PE) to different collection and treatment systems is shown in Figure 75 and Annex 3. Towards the vision scenario, the amounts of unconnected and untreated PE are gradually decreasing to zero. In the next management cycle about 8 million PE will be connected to sewer (7 million) or IAS (1 million) and consequently to treatment plants. Vision I and II scenarios would achieve 100% collection and treatment in the DRB with IAS proportion of 5 million and 8.5 million PE, respectively. Estimated impact of the baseline scenario on BOD emissions is presented in Figure 76 and Annex 3. Besides discharges directly entering surface waters (190,000 tons BOD per year, 440,000 tons COD per year) the emissions released to soil and groundwater via not or inappropriately collected wastewater are also remarkable for the reference status (300,000 tons BOD per year and 540,000 tons COD year). The baseline scenario by 2027 estimates that soil emissions via uncollected wastewater will significantly decrease due to the construction of sewer systems. This would raise the inputs of surface waters through connection to treatment plants and the subsequent concentrated discharges. However, as the treatment levels will be more enhanced resulting in higher removal rates, the overall surface water emissions will also decline. For BOD, 13% decrease in the surface water discharges is expected, whereas soil emissions via urban wastewater discharges will drop by about 60%. Despite the significant progress expected the baseline scenario will probably not ensure the full achievement of the WFD environmental objectives by 2027 as a number of agglomerations will not have appropriate collection and treatment system established.

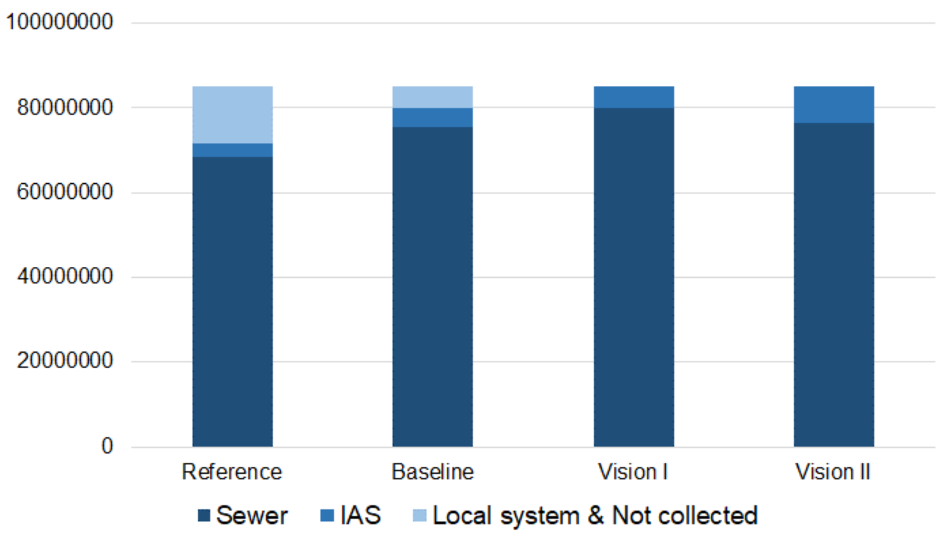


Figure 75: Total wastewater load (PE) of the agglomerations according to collection systems and future scenarios

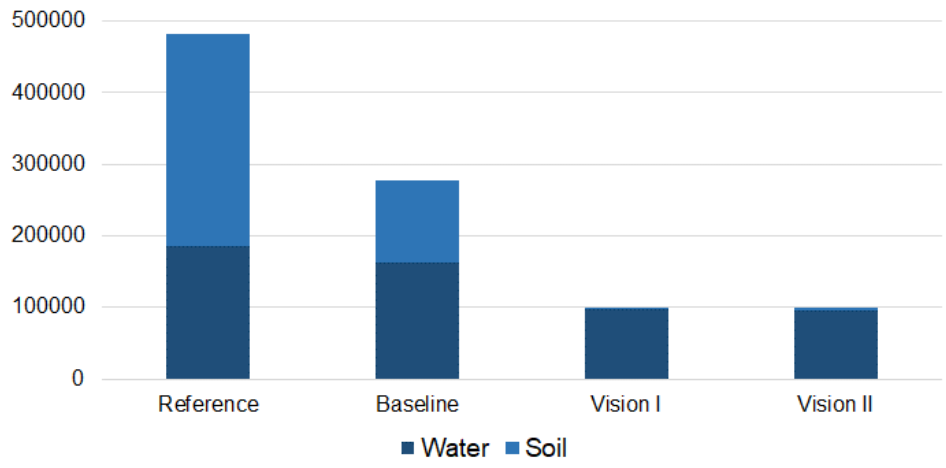


Figure 76: BOD emissions into surface waters and soil via urban wastewater according to future scenarios (expressed in tons per year)

According to the vision scenario the not appropriately collected and not treated fluxes will further decrease towards the desired condition (no uncollected and untreated wastewater) due to the further developments, particularly in the non-EU MS. Despite the high connection rates to treatment plants the BOD surface water emissions will drop by 47% in comparison to the reference status due to the enhanced elimination efficiency for organic substances. Soil BOD emissions would be dramatically reduced according to the vision scenarios by about 99%. For organic substances, the higher share of IAS (Vision II) would not result in further significant reduction of water pollution. Estimated changes of the emissions at national level are presented in Annex 3.

8.1.2 Nutrient Pollution

8.1.2.1 Vision and Management Objectives

The ICPDR's basin-wide vision for nutrient pollution is the balanced management of nutrient emissions via point and diffuse sources in the entire Danube River Basin District that neither the waters of the DRBD nor the Black Sea are threatened or impacted by eutrophication.

The following management objectives and recommended actions are to be implemented by 2027 as steps towards the vision:

- Further reduction of the total amount of nutrients entering the Danube and its tributaries and the nutrient loads transported into the Black Sea.
- Further reduction of the nutrient point source emissions from UWWTPs and industrial facilities.
- Further reduction of the diffuse nutrient pollution of ground and surface waters from agriculture and rural land management.
- Supporting the alignment of water and agricultural policies and contributing to capacity development and knowledge transfer in the agricultural sector.

8.1.2.2 Progress in Implementation of Measures from DRBMP Update 2015

A wide range of measures addressing both, the point source and diffuse emissions have been implemented in the first two management cycles (Annex 15). In addition, a dialogue with the agricultural sector has been initiated to better align water and agricultural policies in the DRB.

Since 2006, over 1,700 municipalities and more than 35 million PE have had treatment plants with nutrient removal technology either constructed or extended in compliance with the UWWTD and WFD requirements. About €12 billion have been invested for these projects. Besides this, almost 500 more are planned or in progress by the end of 2021 to serve an additional 13 million PE. During the same time period, the percentage of people connected to nutrient removal in mid-sized and big settlements has reached 75%.

Nitrates Action Programmes according to the obligations of the ND with mandatory rules on manure and fertilizer application are being implemented for more than 60% of the DRB (Map 31). For agricultural areas in EU MS across the DRB, 70% are determined for direct support linked to cross-compliance and about 20% receive additional subsidies for implementing environmentally-friendly measures. In the last decade, more than €95 billion has been spent in the DRB countries to support farmers and finance best management practices. These financial mechanisms have been linked to the CAP and similar national programs in the non-EU MS.

8.1.2.3 Summary of Measures of Basin-Wide Importance

The measures under implementation have been substantially contributing to the reduction of nutrient inputs into surface waters and groundwater in the DRBD but further efforts are still needed. Continuation of measures implementation in urban wastewater, industrial, market production and agricultural sectors is necessary in the next management period. As the point source pollution for nutrients and organic substances are highly interlinked their regulation is partially ensured by the same measures to be implemented. In the EU MS, the UWWTD requires more stringent removal technology than secondary treatment for agglomerations discharging into sensitive areas, i.e. water bodies that are eutrophic, sensitive to eutrophication or subject to drinking water abstraction purposes and at risk of high nitrate concentration. There are two options for satisfying the requirements, either all treatment plants with a load higher than 10,000 PE have to be equipped with tertiary treatment (nutrient removal with specified effluent concentrations or minimum removal rates) or a reduction of at least 75% in the overall load of phosphorus and nitrogen entering all UWWTPs has to be achieved. Moreover, all agglomerations in the catchment area of a sensitive area shall meet the more stringent technology requirement. Countries may also opt for applying the more stringent technologies in their entire territory instead of identifying sensitive areas.

Implementation of the UWWTD in the DRB has a strong regional perspective and transboundary aspect. Since the Black Sea was significantly suffering from eutrophication, the receiving coastal areas have been designated by Romania in 2007 as a sensitive area under the UWWTD. As a consequence, more stringent treatment technology than secondary treatment is needed at least at the medium-sized and large treatment plants (>10,000 PE) in the EU MS of the entire DRB, being the relevant catchment area of the Black Sea north-west shelf. Old EU MS had to establish nutrient removal technology by the end of 1998, new EU MS obtained longer implementation period. More stringent technology is strongly suggested for the non-EU MS as well in order to ensure a consistent development strategy in wastewater sector. The implementation of the IED in the EU MS and BAT recommendations in non-EU MS can significantly reduce industrial and agricultural point source nutrient pollution.

The measures implemented in the urban wastewater sector might have short-term negative impacts if establishment of public sewer systems is not accompanied with adequate nutrient removal technology before discharging into the recipients. Simple collection and concentrated discharge of wastewater without sufficient tertiary treatment usually cause higher nutrient pollution of surface water bodies than dispersed smaller wastewater discharges from septic tanks that percolate into groundwater and reach surface waters via subsurface flow.

Application of phosphate-free detergents in laundry is a great example for source control by reducing P inputs from laundry wastewater. Introduction of phosphate-free detergents is considered to be a fast and efficient measure to reduce P emissions into surface waters. For the large number of settlements smaller than 10,000 PE the UWWTD does not legally require P removal. Reduction of phosphate in detergents could have a significant influence on decreasing P loads in the Danube, particularly in the short term before all countries have built a complete network of sewers and UWWTPs. The ICPDR has been highly supporting the introduction of the phosphate-free detergents in the Danube countries which committed themselves at ministerial level to initiate the introduction of a maximum limit for the phosphate content of the consumer detergents. The Detergents Regulation[137] prescribes limitations on the phosphate contents of a detergent dose in a laundry/dishwashing cycle. The Regulation has to be implemented in all EU MS and similar efforts are either already in progress (e.g. in Serbia a Regulation was adopted in 2015 legally banning the phosphate-rich detergents) or recommended to be made in non-EU MS.

Diffuse pathways have a dominant share in the total nutrient emissions, therefore implementation of measures addressing land management has high importance. According to the assessments of the recent Implementation Report of the ND[138] additional actions are needed to reduce and prevent pollution of the ground waters and to avoid eutrophication of the coastal waters. Groundwater quality has improved since the adoption of the Directive, however the further improvement has been very slow since 2012. Eutrophication is a major problem for all types of surface waters, as inland, transitional, coastal and marine water are still severely affected. Despite of considerable efforts on designing and applying measures to mitigate nitrates losses in waters, the level of implementation and enforcement is still not sufficient to reach the objectives of the Directive. The main challenges are how to systematically manage reducing nutrient losses from agriculture and how to adequately adapt measures to pollution hotspots.

Countries should intensify their efforts to identify and implement measures to meet the environmental objectives of the WFD and DRPC and to reduce nutrient pollution particularly via diffuse pathways from agriculture. To support the elaboration of basin-wide management strategies with the ultimate aim to reduce nutrient loads of surface and coastal waters, large scale nutrient emission estimations and scenario analyses are of particular importance (using assessment tools such as the MONERIS model). Despite the comprehensive analyses conducted to trace the nutrient fluxes within the basin there is a need to fill knowledge gaps regarding the linkages between nutrient emissions and their impacts, especially the Black Sea ecosystem responses to Danube nutrient loads. In addition, better understanding is necessary on the economic drivers and future development of the agriculture and the cost-efficiency of measures and their combinations.

A key set of measures to reduce nutrient inputs and losses related to farming practices and land management has been identified as appropriate management tools to be applied in agricultural areas. Agricultural N pollution of ground and surface water is regulated by the ND in the EU MS. It requires designation of Nitrate Vulnerable Zones (NVZs) that are connected to waters polluted by nitrate or sensitive for nitrate pollution or alternatively,

137 Regulation (EU) No 259/2012 of the European Parliament and of the Council of 14 March 2012 amending Regulation (EC) No 648/2004 as regards the use of phosphates and other phosphorus compounds in consumer laundry detergents and consumer automatic dishwasher detergents.

138 Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2016–2019, COM (2021) 1001 final.

to apply the whole territory approach. In the zones (or over the whole territory) the amount of nitrate that is applied on agricultural fields in fertilizer or manure is limited and the application is strictly regulated through Nitrates Action Programmes with basic mandatory measures. The most vital measures which have to be implemented are the maximum applicable amount of manure, the time periods when fertilizer application is prohibited, the required storage capacity for manure and the specific conditions under which fertilization is banned (e.g. on high slopes, in buffer strips and under unfavourable weather conditions). Moreover, codes of good agricultural practices are also recommended to be respected outside the NVZs on voluntary basis to ensure low N emissions entering the groundwater and river network. In the DRB, both options (NVZs and whole territory approach) are applied. Similarly, to the UWWTD, a consistent but still flexible implementation of the whole territory approach might potentially be considered over the entire DRB, which would ensure a minimum set of basic standards to be applied everywhere while targeting stricter requirements to pollution hot-spots. This would give the possibility to the Danube countries to tailor their national programs and standards according to their regional conditions and needs. Action programmes that allow for a more flexible approach at farm level can increase farmers' acceptance and engagement.

Measures related to the concept of Best Management Practices (BMPs, the most effective and practical methods of preventing or reducing non-point source nutrient pollution from croplands and animal farms) are also suggested to be adopted in the entire DRB. The concept has been applied to different extent in the countries to manage inter alia diffuse nutrient emissions that is partly covered by the ND for nitrate pollution in the EU MS. It concerns appropriate land management activities (source and transport control measures) that are able to prevent, control and minimize the input, mobilization and transport of nutrients from fields towards water bodies. They cover a wide range of measures including nutrient management (e.g. nutrient balance calculations, optimization of fertilization), modified cultivation methods (restricted crop rotation, catch crops, green manure crops), land use changes (maintenance of grasslands, buffer strip allocation), soil conservation (erosion control techniques, ensuring proper soil coverage, maintenance of humus content in topsoil, maintenance of tile drainage systems) and additional natural water retention measures (wetlands, grass filters and grassed waterways). Hydromorphological and flood protection measures (e.g. restoration and conservation of wetlands and floodplains, establishment of riparian buffer zones) provide with positive impacts on nutrient retention adjacent water courses. They also affect land use by replacing croplands with e.g. wetlands or disconnect agricultural fields from water bodies that prevent direct emissions. A catalogue of measures is provided in the ICPDR Guidance Document on Sustainable Agriculture.

The critical area concept is an emerging approach in several countries that aims to find technically and economically feasible measures. It considers that management activities should focus on those areas where the highest emissions come from and where the highest fluxes from land to water probably are transported. Targeting management actions to these critical fields can provide cost-efficiency (high river load reduction at minimal implementation costs and area demand). Nevertheless, it should be taken into account that due to the longer time necessary for an effective management of diffuse nutrient pollution to take effect (longer residence time of groundwater, stored nutrients in bottom sediment of reservoirs), the water quality impacts of any changes in agriculture induced by the implementation of the ND or BMP recommendations will probably not be instantly visible but after several years or even decades only.

Significant efforts are needed to design targeted financial instruments and to appropriately finance agricultural measures. Countries should make use of the Common Agricultural Policy (CAP) reform. The new EU

CAP proposal[139] provides a multi-pillar financing mechanism to help farmers to overcome the challenges of soil and water quality, biodiversity and climate change, environmental challenges and societal expectations. The suggested regulation comprehends increased ambitions towards environmental and climate protection. MS are obliged to make a greater overall contribution to the achievement of the climate- and environmental objectives compared to the previous programming period. In total, 40% of the CAP budget will have to be climate- and environment-relevant and support biodiversity objectives.

The new CAP aims at strengthening the connection of CAP support to the compliance of farmers with obligations to protect the environment, public, animal and plant health as well as animal welfare established as conditions for area related payments. A new so-called "enhanced conditionality" is proposed as an integral part of the future CAP framework, which would replace the current "Greening" and cross-compliance by updating the former Statutory Management Requirements (SMR) and Good Agricultural and Environmental Conditions (GAEC) and integrating the "Greening" practices into the new GAEC. It would set the baseline for more ambitious and sustainable agricultural commitments through the adoption of good farming practices and standards by farmers. The introduction of the WFD and the Sustainable Use of Pesticides Directive (SPD)[140] into the conditionality would support their implementation and the achievement of their specific objectives. In addition, new conditionality elements could potentially have a positive impact on water quality and carbon dioxide sequestration in the soils. Such an addition would bring a dedicated tool for optimizing on-farm nutrient management and would protect peatlands and wetlands. Moreover, on every farm at least 3% of arable land will be dedicated to biodiversity and non-productive elements. Enhanced conditionality would be mandatory for EU MS to implement and for those receiving direct payments to comply with.

The post-2020 CAP envisages requiring all EU MS to prepare a CAP Strategic Plan, where specific objectives would have to be achieved through targeted actions for improving the economic, social and environmental performance of the agricultural sector and rural areas. Also, CAP Strategic Plans at the national level should pay particular attention to the benchmarks and requirements on environment- and climate-related objectives. They should ensure that the respective specific objectives of the CAP are fulfilled and the targets of the Green Deal, the 'Farm to Fork' Strategy and Biodiversity Strategy for 2030 are appropriately addressed.

According to the proposal, the new conditionality would link farmers' income support to the application of environment- and climate-friendly farming practices. Moreover, agri-environment-climate commitments and eco-schemes would also be important elements of the CAP Strategic Plans and would support farmers in maintaining and enhancing sustainable farming methods going beyond mandatory requirements and relevant conditions. In this context, the focus will be shifted from compliance to better environmental and climate performance, in terms of improved nutrient management, reduced emissions and storing carbon in soil. At least 35% of each rural development national allocation would have to be dedicated to environmental and climate measures with the possibility of higher EU contribution in the funding. The new eco-scheme measures, which are to be defined by the EU MS and to be funded from national direct payment allocations, would also address the environmental and climate objectives of the CAP. MS must allocate at least 25% of their income support budget to eco-schemes. Within the new multiannual financial framework (2021-2027), over 100 billion EUR will be invested to fund environmentally friendly farming practices and agri-environmental measures from both direct payment and rural development pillars.

139 Proposal for a Regulation of the European Parliament and of the Council establishing rules on support for strategic plans to be drawn up by Member States under the Common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulation (EU) No 1305/2013 of the European Parliament and of the Council and Regulation (EU) No 1307/2013 of the European Parliament and of the Council.

140 Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides.

In close connection to the CAP-post 2020, efforts are needed in all EU Danube countries (but also in non-EU MS) to appropriately promote best management practices and to finance agricultural measures. In particular, measures which are compatible with the WFD requirements should have a stronger focus in the financing programs. Besides regulatory actions to comply with basic standards, persuading farmers with economic incentives can further ensure higher nutrient use efficiency and better implementation of measures. Soil-friendly farming systems and practices to preserve and improve soil structure, organic matter content, nutrient/water retention capacity and fertility should be promoted. Advisory services and the Agricultural Knowledge and Innovation Systems providing farmers with technical support and appropriate information on modern (digital) technologies and innovative tools, on how to comply with the rules and to properly implement best practices should be enhanced to improve and modernise agricultural practices. Moreover, appropriate demonstration projects and funding schemes are needed to identify and promote financially viable solutions between agriculture and nature conservation, in particular for the implementation of natural water retention measures and restoration of wetlands/floodplains.

In order to effectively engage the agricultural sector to change land use or land management practices, which is necessary for facilitating the implementation of larger scale projects on floodplain/wetland restoration, the following incentives should be created:

- opening CAP 1st pillar direct payments (eco-schemes) for water retention on arable lands,
- amending land use regulations to support water retention on agricultural lands,
- including WFD compensation schemes for restrictions on land use into CAP 2nd pillar such as water drainage, time of seeding or irrigation due to conservation measures.

Fostering nature-based solutions

FRAMWAT Project[141]: Framework for improving water balance and nutrient mitigation by applying small water retention measures

Finalized in 2020, the FRAMWAT Project contributed to narrow knowledge gaps and implementation deficiencies regarding the natural (small) water retention measures (N(S)WRM) that are great examples for multi-beneficial measures in agricultural and rural areas contributing to flood, drought and pollution mitigation at the catchment scale. In the frame of the project, beneficial tools and methods were developed (i) to identify locations in a river basin where N(S)WRM are needed, (ii) to support the evaluation of cumulative effectiveness of N(S)WRM at river basin scale, (iii) and to facilitate the implementation of N(S)WRM through guidelines including policy options and cost analysis. The FRAMWAT Project also elaborated example Action Plans in cooperation with regional authorities for several pilot river basins potentially serving as detailed instructions on how to apply N(S)WRM at the catchment scale.

IDES Project[142]: Improving water quality in the Danube river and its tributaries by integrative floodplain management based on Ecosystem Services

Being implemented between 2020 and 2022, the IDES Project aims to improve water quality by developing an integrative floodplain management based on the Ecosystem Services concept. The project will identify the retention potential of floodplains by applying the model MONERIS and integrate multiple interests along the river to accelerate the joint implementation of a sustainable water quality management along the Danube. The new IDES tool will help to derive optimized, nature-based solutions by assessing all relevant ecosystem services in an unbiased way, their trade-offs and synergies. Based on

141 *https://www.interreg-central.eu/Content.Node/FramWat.html (accessed 17 November 2021).*

142 *http://www.interreg-danube.eu/ides (accessed 17 November 2021).*

the results of Danube wide assessment and in pilot areas, national action plans with prioritized areas and a joint strategy for improving water quality at transnational level will be developed.

To address the above-mentioned multi-dimensional challenges and to achieve the ambitious objectives of both, the WFD and the new CAP, agriculture and water management need to be well aligned by coordinated strategies and joint actions to ensure the protection of water resources, the economic livelihood of the farmers and the production of high-quality food. However, at the regional scale of the DRB, a proper dialogue between the water and agricultural sector and coordinated policy tools have not been fully established yet. To address this shortcoming, the Danube countries, in close cooperation with the agricultural sector, started a broad discussion process and developed the ICPDR Guidance Document on Sustainable Agriculture.

To achieve its ambitious goal the guidance paper recommends sound policy instruments, financial programs and cost-effective agricultural measures to protect water bodies for decision makers in the agri-environmental policy field. It offers Danube countries support for the preparation and implementation of their tailor-made national agri-environmental policies, CAP Strategic Plans and relevant strategies of the RBMPs in good synergy. The recommendations provide the Danube countries with a framework to adjust their national agri-environmental policies. They on one hand give specific advice on how to implement more efficiently existing legislation and on the other hand help countries to better identify, target and finance additional measures going beyond legal obligations. Thus, the guidance should act as a strategic policy framework providing consistent approaches into which the Danube states are encouraged to integrate their individual national methods. It lays down the basis for designing cost-effective, targeted national measures according to national needs and conditions taking into account that no "one size fits all" standardisation could work in the DRB.

Guidance Document on Sustainable Agriculture – Key messages

In order to address the environmental and sustainability challenges of agricultural production in the DRB with higher ambitions and to effectively contribute to the objectives of the Green Deal, **Danube countries are particularly encouraged to:**

1) Design flexibly the obligatory measures under the CAP enhanced conditionality.
2) Examine closely the potential of the new, flexible and potentially very effective voluntary 'eco-schemes', in particular for supporting agro-economy, agro-forestry, organic farming, precision farming and carbon farming practices.
3) Commit to the development of DRB-specific approaches for voluntary agri-environment-climate interventions with particular focus on development and implementation of collective / cooperative approaches and result-based payment schemes for more sustainable soil and water management.
4) Make a significant investment in strengthening Farm Advisory Systems and building an Agricultural Knowledge and Innovation Systems for sustainable agriculture in the DRB and pay much greater attention to capacity building of all actors (farmers, advisers, researchers, small and medium-sized enterprises etc.).
5) Strongly and actively recommend and promote applying nutrient management planning in the farming practices to assist farmers in an efficient use of fertilizers at field level adjusted to crop nutrient demand and soil nutrient content via information, knowledge exchange and advisory activities funded in the new CAP Strategic Plans.
6) Develop and maintain advanced regional drought monitoring and forecasting systems with special emphasis on early detection, along with drought risk and impact assessment tools.

7) Elaborate drought management plans and set up operational management models focusing on preventive and early responses in order to enhance resilience and preparedness.
8) Put emphasis on soil management practices and support farmers to properly implement erosion control, soil conservation and natural water retention measures.
9) Make use of the funding instruments to compensate certain difficulties and constraints (e.g. natural disadvantages, constraints related to WFD implementation and NATURA 2000 sites).
10) Promote community-led local developments under the LEADER programme and the concept of Smart Villages as an emerging and potentially well-suited opportunity for rural communities in the DRB making the best use of technology and social innovation.

In addition, **Danube countries are advised to consider the following recommendations for policy making:**

- It is crucial to establish a proper partnership-dialogue between the agricultural and water sector to develop a cross-sectoral and mutual understanding of needs, expectations and constraints of the two areas.
- Active and early involvement of environmental authorities in the preparation of CAP Strategic Plans as well as taking environmental knowledge and planning tools into closer consideration should be achieved to support the design of relevant and effective agri-environmental policies at national level. There is a huge need for finding synergies between the CAP interventions and the measures identified in the RBMPs in order to contribute to the achievement of the environmental objectives of the WFD.
- Countries should define national standards for obligatory measures with flexibility to tailor the implementation of these standards to specific local or regional needs and characteristics.
- Measures controlling nutrient pollution should be targeted on emission hot-spots, those areas where there is a significant risk of local resource loss (e.g. via soil erosion or leaching) or water pollution (due to high transfer rate of nutrients or vulnerability of water bodies) and the requirements should be adjusted to the risks accordingly.
- Specific attention should be paid to the farming structure in the countries, certain environmental standards and targets should be achieved everywhere, whereas the standards might be differing for different farm structures.
- Countries are encouraged to take into account favourable and disadvantaged areas, crop rotation, environmental impacts, water body vulnerability and potential administrative burden when designing and implementing measures.
- Voluntary measures should be attractive, practicable and financially acceptable for farmers, particularly those that would lead to additional costs or result in income losses for the farmers when adopting and implementing them.
- Advisory services should support digital transition in agriculture including modern technologies, accompanied by smart devices and digitised supporting tools.
- Countries are encouraged to acknowledge drought as a national priority. Policy coherence, coordinated legal approaches and harmonized implementation related to drought on the national/regional level are essential for successful drought management, supported with sufficient resources.
- It is necessary to introduce available practical tools into daily work routine (i.e. using national data sets, operational use of tools in institutions, etc.) and to share knowledge on good practices to better support and guide drought management activities.

The guidance outlines two land management categories according to soil productivity and land conditions and recommends a set of measures for both constellations. Favourable areas with high soil productivity and good climate conditions may attract investments and sustainable intensification to increase competitiveness. This would lead to a desirable sustainable development to improve the economic situation in rural areas, would give perspectives to people to stay and live there but would also fully integrate natural resources protection. A clear legal framework and an efficient implementation of cross-compliance/conditionality and "greening"/eco-schemes should be the focus here, backed up by appropriate control schemes. On the other hand, disadvantaged areas - i.e. areas with limited productivity, natural constraints or unfavourable social conditions - are threatened by depopulation and land abandonment, which need to be counteracted by integrated rural development programs including an economic basis for site-specific, traditionally extensive agricultural systems. In these regions but also in areas of high ecologic interest (e.g. riparian zones, floodplains and wetlands) agri-environmental programmes and compensations for ecosystem services (e.g. biodiversity, landscape maintenance and biotope management) and other income options for the agricultural sector like sustainable tourism are necessary. In both cases, competent advisory services, for which recommendations are also provided, should be part of any solution.

8.1.2.4 Future Development Scenarios

Urban wastewater sector

Baseline scenario by 2027

It concerns the complete implementation of the UWWTD in the EU MS and implementation of the related commitments in the non-EU MS.

Vision I and II Scenarios

It assumes establishment of N and P removal technology for all agglomerations above 10,000 PE and secondary treatment for all agglomerations below 10,000 PE in all countries. Vision I scenario assumes lower, whereas Vision II considers higher proportion of IAS (see Chapter 8.1.1.4)

Detergents sector

Baseline scenario by 2027

Full implementation of the Regulation on phosphate-free detergents in all DRB countries (laundry and dishwasher) is expected.

Vision Scenario

Same as before.

Agricultural sector

Baseline scenario by 2027

A set of basic measures and best management practices are expected based on the most realistic estimates of the countries for future agricultural development in the agricultural sector and implementation of measures foreseen by the countries. In EU MS the measures are in compliance with the ND the requirements of the CAP first pillar and also include agri-environmental measures supported by the CAP rural development programmes. In non-EU MS a set of best agricultural practices is expected to be implemented. For the scenario assessment, national scale values on changes in N-surplus and tile drained areas were used based on reported data by the DRB countries. For erosion control, additional measure implementation was considered for 10% of the steep slope agricultural fields (> 8%) resulting in 50% soil loss reduction (e.g. strip-cropping, mulching, crop rotation, conservation tillage, intercropping). Existence of fully implemented buffer zones along surface water bodies was assumed in the NVZs or in the whole country territory according to the ND implementation in the EU MS. In addition, grass buffer zones are assumed to be established for 10% of the surface water bodies in non-EU MS.

Vision I Scenario

This scenario describes sustainable agricultural development and balanced nutrient management. It assumes the full realization of the EU Zero Pollution Targets[143] within the Green Deal for nutrients, i.e. lowering the nutrient losses by 50% at the EU level. For nitrogen, it concerns the net nitrogen surplus, for which the half of the current EU average is assumed as a future basin-wide mean value (7.5 kg N per hectare and year plus regionally differing current atmospheric deposition). For phosphorus, soil erosion rates over the tolerable soil loss value (1.0 ton per hectare and year[144]) were reduced by 50%, assuming effective erosion control practices in place. On the top of this, efficient implementation of the ND is expected in all Danube countries (EU MS: existing NVZs or whole territory, non-EU MS: whole territory) including at least grass buffer strip establishment.

Vision II Scenario

This scenario goes beyond the Vision I scenario and assumes the establishment of effective riparian buffer zones for 50% of the surface water bodies within the NVZs (vegetated strips with higher nutrient retention).

Climate change

Climate change effects were investigated by calculating diffuse nutrient emissions for a representative "dry" and "wet" year (both taken as extremes from the last two decades), replacing average hydrology with precipitation and discharge of the extreme years and assuming measure implementation according to Vision I scenario.

8.1.2.5 Estimated Effect of Measures on the Basin-Wide Scale

Urban wastewater and detergents

According to the forecasted development of the wastewater treatment infrastructure under the baseline scenario (Figure 77 and Annex 3), about 8 million PE will be additionally connected to tertiary ensuring high nutrient elimination rates. In addition, ca 2 million PE will be connected to secondary treatment and 1 million PE to IAS. The Vision scenarios will upgrade the inappropriate systems to nutrient removal, secondary treatment or IAS with a dominant proportion of nutrient removal (ca 70 million PE).

Similarly to the organic pollution, higher connection rates and introduction of higher level technologies at treatment plants will result in decreasing soil nutrient emissions via urban wastewater under the baseline scenario (Figure 78 and Annex 3). However, surface water emissions are expected to be increased because of the higher wastewater load reaching the UWWTPs in comparison to the reference status. For N, 14% emission increase is expected, whereas P surface water emissions will slightly rise by 4%. Nevertheless, soil emissions via urban wastewater discharges are expected to decline by 53% (N) and 56% (P). Despite the significant

143 *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil', COM/2021/400 final.*

144 *Verheijen, F. G. A., Jones, R. J. A., Rickson, R. J. & Smith, C. J. (2009). Tolerable versus actual soil erosion rates in Europe. Earth-Science Reviews, 94, 23-38, https://doi.org/10.1016/j.earscirev.2009.02.003.*

progress expected the baseline scenario will probably not ensure the full achievement of the WFD environmental objectives by 2027 as a number of agglomerations above 10,000 PE will not have more stringent treatment technology put in place.

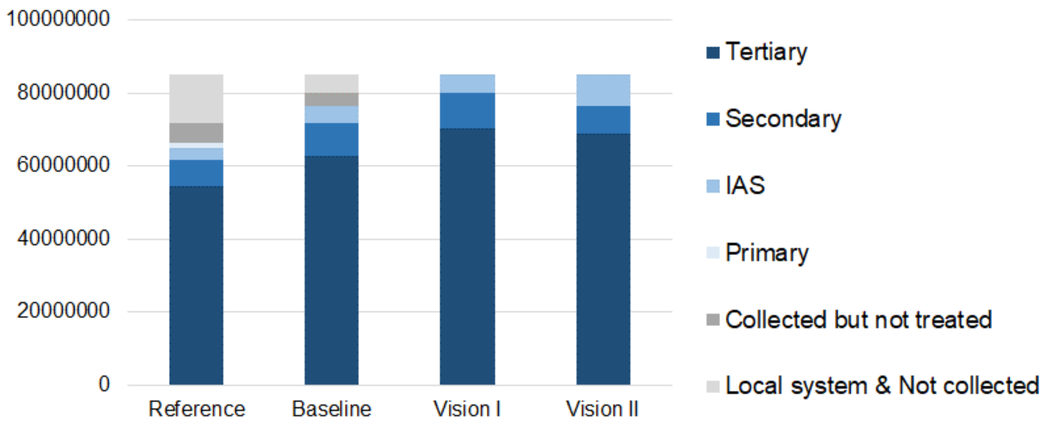


Figure 77: Total wastewater load (PE) of the agglomerations according to treatment systems and future scenarios

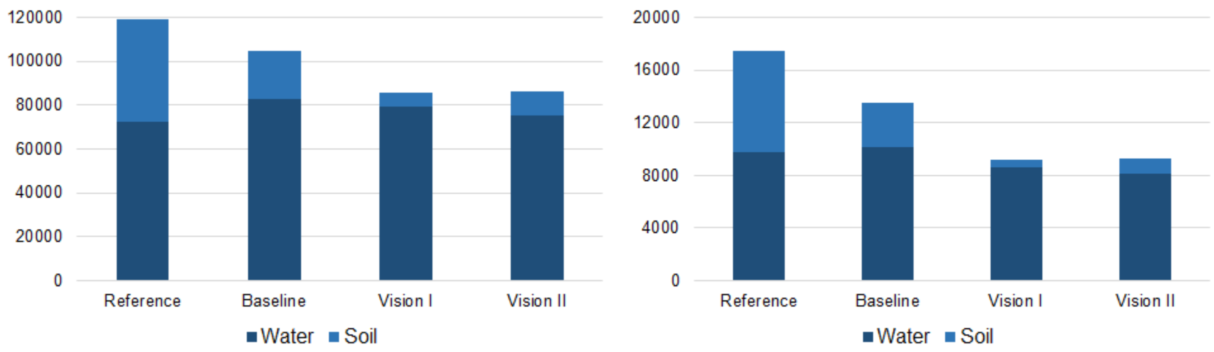


Figure 78: TN (left) and TP (right) emissions into surface water and soil via urban wastewater according to future scenarios (expressed in tons per year)

The long-term future scenario with low IAS proportion (Vision I) represents slight reduction of emissions as compared to the baseline situation since the measures will address agglomerations in non-EU MS with currently untreated wastewater discharges. However, for N even the Vision I scenario will result in 10% emission increase in comparison to the reference status. For P, 12% (TP) decrease is estimated. Soil emissions will reduce by 87% and 92%, respectively. The simulated emission increase for N indicates that nutrient-removal at all UWWTPs above 10,000 PE cannot substantially reduce the N emissions at the basin-wide level. Nevertheless, they are important measures at the local or regional scale and also at national level for certain countries (see Annex 3).

Vision II scenario demonstrates that the higher IAS proportion could further decrease the overall nutrient emissions at the basin-wide level provided that adequate individual solutions are applied. For the hypothetic values of 20% and 40% IAS proportion an additional 5-6% surface water emission reduction could be achieved that could be even higher in case higher proportion of IAS is realized. However, soil emissions would remain higher.

Agriculture

Results of the scenario analysis for agriculture is presented in Figure 79 and Annex 5. The baseline scenario in agriculture would lead to a slight decrease of the current nutrient emissions (N: 9%, P: 5%). For N, the measures to be implemented in the next cycle will have more visible impacts in 2027 since they affect the overall N surplus of the agricultural areas. In addition, emission values reflect the changes in N surplus over the past decades through the delay caused by the groundwater residence time. For P, better implementation of agri-environmental measures (e.g. modified crop rotation, erosion control or riparian zones) will concern a small proportion of the catchment area resulting in a slight emission reduction.

The Vision I scenario, which assumes low long-term surpluses and high utilization of best agricultural practices, predicts a substantial decrease in surface water emission from the agriculture. According to the model simulations, 34% (N) and 24% (P) emission decrease could be realized at the basin-wide level by proper agricultural management. Nevertheless, regions with currently very low N-surplus would show increasing N emissions from agriculture due to the intensification (higher surplus) of the agriculture under the vision scenario in comparison to the current conditions (see Annex 5). P emissions decrease in each country because of the assumed effective soil protection measures.

The vision II scenario would result in higher emission reduction of 36% (N) and 32% (P) because of the more effective nutrient retention provided by the riparian buffer zones.

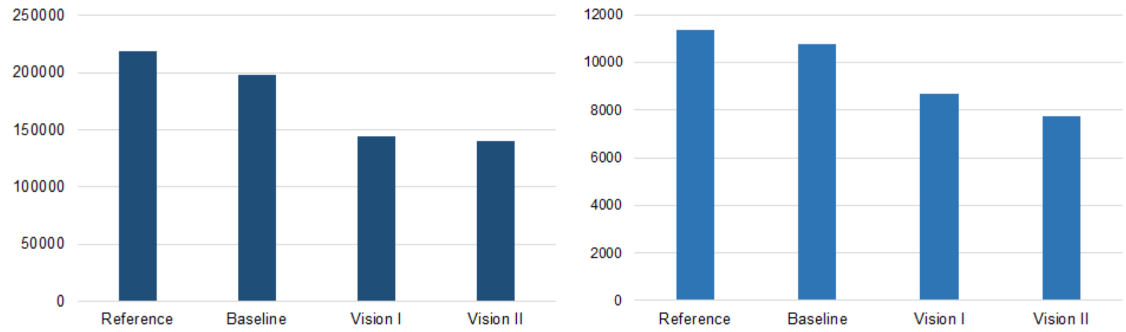


Figure 79: TN (left) and TP (right) emissions via agriculture according to future scenarios (expressed in tons per year)

Total nutrient emissions and river loads

Combined effects of the scenarios in urban wastewater, detergents and agricultural sectors on basin-wide emissions and river loads are presented in Figure 80, Figure 81 and Annex 5, whilst spatial distribution of the emissions according to the vision scenario is shown in Map 32a-d. The baseline scenario estimates a slight decrease for N and P emissions by 6% and 8%, respectively. River loads are expected to drop by ca 5% for both N and P. Therefore, the baseline scenario will probably not ensure the full achievement of the WFD/DRPC environmental objectives by 2027 as the nutrient emissions and river loads will remain at a high level for many water bodies in the DRB and for the Black Sea as well.

According to the Vision I scenario, the total N and P emissions are expected to decrease by 22% and 24%, respectively. These results indicate that under the assumed vision conditions a relatively high emission reduction can be achieved. Significant emission reductions are simulated for the vast majority of the countries (Annex 5). Vision II scenario (combining Vision I for the wastewater and Vision II for agriculture) would be able to achieve even higher emission decline (N: 24%, P: 30%). The evolvement of the river loads shows a similar trend than that of the emissions (ca 22% reduction for both nutrients by Vision I, around 25% for Vision II).

According to the simulated vision scenarios, the river loads transported to the Black Sea can be significantly reduced towards or even below the level of around the 1960ies if nutrients are properly managed in the basin.

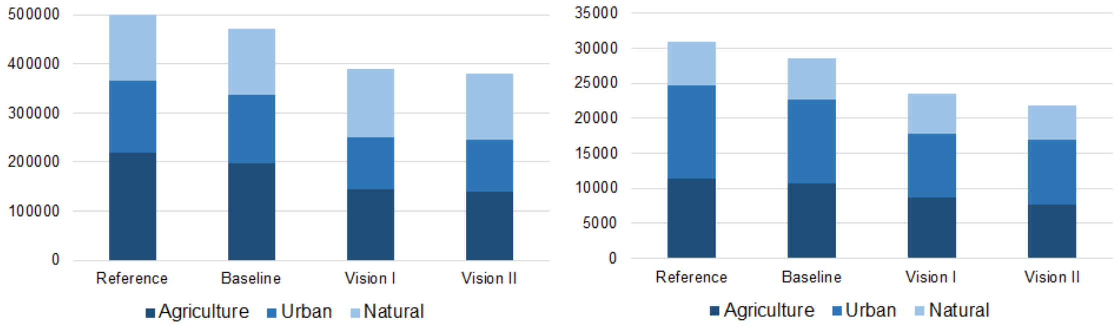


Figure 80: TN (left) and TP (right) total emissions from the main source areas according to future scenarios (expressed in tons per year)

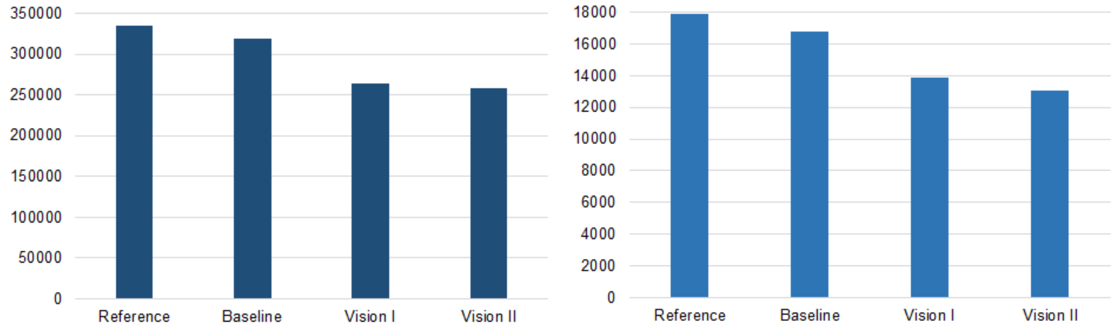


Figure 81: TN (left) and TP (right) river loads to the Black Sea according to future scenarios (expressed in tons per year)

Climate change impacts

The simulated “dry” and “wet” condition scenarios represent the impacts of the changing hydrology on the diffuse emissions under the vision scenario. For the dry conditions, lower runoff, hence lower emissions are expected. On the other hand, in wet years, the runoff and potentially the soil erosion are more significant resulting in rising emissions. For the dry conditions, 12% (N) and 14% (P) diffuse emission reduction is forecasted in comparison to Vision I scenario (Figure 82). In case of the wet conditions, 30% (N) and 32% (P) emission increase is projected. As compared to the reference situation, the vision measures and climate change impacts could significantly lower the diffuse emissions (N: 36%, P: 40%), whereas in wet years the emissions could be similar to the reference values.

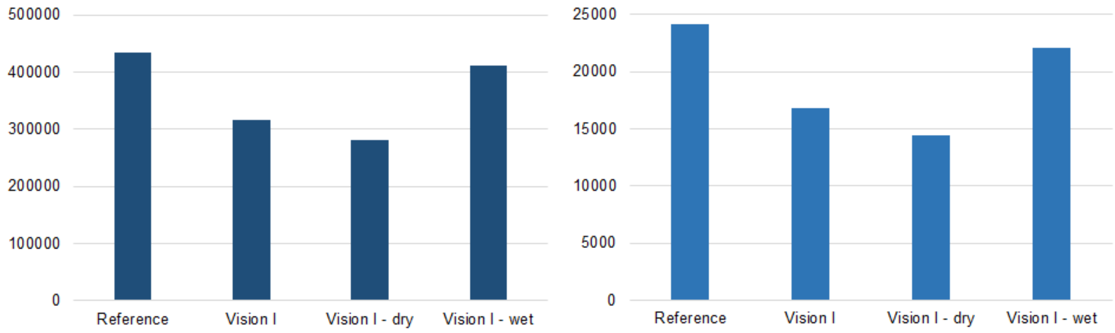


Figure 82: TN (left) and TP (right) total diffuse emissions according to climate scenarios (expressed in tons per year)

8.1.3 Hazardous Substances Pollution

8.1.3.1 Vision and Management Objectives

The ICPDR's basin-wide vision for hazardous substances pollution is no risk or threat to human health and the aquatic ecosystem of the waters in the Danube River Basin District and Black Sea waters impacted by the Danube River discharge.

The following management objectives and recommended actions are to be implemented by 2027 as steps towards the vision:

- Closing knowledge gaps on the hazardous substances of DRB relevance.
- Further elimination/reduction of the amount of hazardous substances entering the Danube and its tributaries.
- Further reduction of the point source emissions from UWWTPs and industrial facilities.
- Further reduction of the diffuse pollution of agricultural chemicals and harmful substances used in rural land management activities.
- Further mitigation of the risk of accidental pollution events at industrial and mining facilities.
- Further maintenance and enhancement of the Danube AEWS.

8.1.3.2 Progress in Implementation of Measures from DRBMP Update 2015

Measures implemented to control organic and nutrient pollution are also useful for hazardous substances. In addition, Danube countries have taken significant steps in order to close the information gap on hazardous substances pollution including UWWTP sampling, basin-wide emission modelling and formulating policy recommendations for managing hazardous substances pollution. Moreover, practical tools have been developed to assess the safety conditions of TMFs along with policy recommendations.

Since 2006, at about 30 UWWTPs targeted technologies have been added to remove hazardous pollutants from wastewater. In addition, at more than 100 UWWTPs specific disinfection technologies are used that are partly able to remove organic micropollutants. On top of these, Danube countries have taken important steps to close knowledge gaps on hazardous substances by compiling emission inventories, conducting targeted campaigns on UWWTP inflow and effluent analysis, organizing specific sampling campaigns (JDS4) and supporting scientific projects on modelling and monitoring (e.g. SOLUTIONS, Danube Hazard m^{3}c Projects). A specific project has been implemented on strengthening the safety of TMFs in the DRB (Danube TMF Project).

8.1.3.3 Summary of Measures of Basin-Wide Importance

Despite the substantial progress achieved in many aspects of the hazardous substances pollution the state-of-the-art knowledge needs to be improved and the implementation of measures should further progress in the future to appropriately manage the problem. Measures to address hazardous substances releases should be further implemented in various fields. Appropriate treatment of urban wastewater and application of BAT in the industrial plants and large agricultural farms are elementary measures and can significantly contribute to the mitigation of hazardous contaminations. Implementation of the UWWTD and IED in EU MS is also highly beneficial for the reduction of hazardous substances pollution. In non-EU MS the considerable efforts to be made in order to develop and improve the wastewater sector and industrial technologies will have also positive effects on water quality related to hazardous substances pollution. Nevertheless, the conventional treatment technologies do not provide appropriate removal for many of the emerging chemicals. More enhanced technologies such as activated carbon filters, UV-treatment or ozone treatment can more effectively eliminate these substances therefore introduction of the fourth treatment level might be considered by the Danube countries in the future.

The Environmental Quality Standards Directive (EQSD)[145] interconnected with the WFD intends to regulate water pollution of priority substances by setting up EQS values for the priority substances and mandating to phase out priority hazardous substance emissions and to reduce priority substances releases for water dischargers. Reporting on emissions, discharges and losses of these substances is also obligatory. Other EU legal documents like the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[146], the Plant Protection Products Regulation[147] or the Biocidal Products Regulation[148] aim to minimize the release of chemicals in order to protect human health and environment. For instance, they lay down rules for the authorisation of products containing dangerous chemicals and regulating their placing on the market, enforce substitution or exclusion of certain substances, ensure the safe application of products containing dangerous chemicals and prescribe emission limits for the hazardous substances. The objectives and actions of the EU Chemicals Strategy[149], EU Strategic Approach to Pharmaceuticals in the Environment[150], linked to the EU Pharmaceutical Strategy[151], and the Strategy for Plastics in a Circular Economy[152] should be considered for the future management of chemicals, pharmaceuticals and plastics/microplastics in the DRB.

The release of agricultural chemicals is controlled by the SPD by reducing the risks and impacts of pesticide use on human health and the environment and emphasizing the use of Integrated Pest Management (IPM). EU MS are obliged to draw up a National Action Plan to implement a set of actions including inspection of pesticide application equipment, prohibition of aerial spraying, protection of the aquatic environment and drinking water, limitation of pesticide use in sensitive areas, trainings on pesticides use, awareness raising on the risks of pesticides and reporting on poisoning incidents. Integrated pest management promotes environmentally-friendly application of pesticides based on all available information and tools and prefers low pesticide input methods, the least harmful practices and products and low or non-chemical and natural methods.

145 Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council.

146 Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

147 Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.

148 Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products.

149 Communication from the Commission to The European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Chemicals Strategy for Sustainability - Towards a Toxic-Free Environment, COM/2020/667 final.

150 COM (2019) 128 Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee on the European Union, Strategic Approach to Pharmaceuticals in the Environment.

151 Communication from the Commission to The European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Pharmaceutical Strategy for Europe, COM/2020/761 final.

152 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, a European Strategy for Plastics in a Circular Economy, COM/2018/028 final.

The progressive development of the urban wastewater sector increases the quantities of sewage sludge that requires disposal. The SSD (currently being revised) seeks to encourage the use of sewage sludge in agriculture and simultaneously regulates its use in such a way as to prevent harmful effects on soil, vegetation, animals and human beings. Detailed recording is required on the circumstances of sewage sludge application in agriculture and a set of limit values for concentrations of heavy metals in sewage sludge intended for agricultural use and in sludge-treated soils is assigned. Therefore, implementation of the SSD helps to avoid hazardous substances pollution by restricting the application of contaminated sludge to agricultural fields. Management actions similar to those of the EU MS are recommended for the non-EU MS. Sustainable pesticide usage in the agriculture can also be managed by some BMP measures that are on-going activities in both EU and non-EU MS.

To avoid major accidental pollution events, EU MS are obliged to implement the Seveso[153] and the Extractive Waste[154] Directives. Operators of the facilities/mines under the umbrella of the Directives have to develop a safety management system, provide safety reports and information for the public and elaborate emergency plans for both, the internal and surrounding areas of the establishments. Moreover, Parties of the United Nations Economic Commission for Europe (UNECE), Convention on the Transboundary Effects of Industrial Accidents[155] have to fulfil the obligations of the Convention. It aims to prevent accidents and to mitigate their effects if required and also promotes active international cooperation regarding accident risk mitigation.

Despite the fact that many measures have been taken for progressive reduction of priority substances discharges and for phasing-out emissions, discharges and losses of hazardous ones (including banning at EU level), these pollutants are still found in the aquatic environment having ubiquitous persistent, bioaccumulative and toxic features and leading to failing good chemical status of surface water bodies. The sources of hazardous substances pollution are still not fully understood; only scarce information is available on point source emissions from industrial inventories and the understanding on diffuse emissions from agricultural and urban areas is very limited.

Further efforts are needed to close knowledge gaps on the monitoring of hazardous substances in surface waters and to identify which priority substances and other emerging chemicals are of basin-wide relevance. Even though several measures have been implemented for reducing priority substances discharges and for phasing-out hazardous ones (including banning at EU level), these pollutants are still found in the aquatic environment having ubiquitous, persistent, bioaccumulative and toxic features and leading to failing good chemical status of surface water bodies. Moreover, the information gap on the emission sources contributing to hazardous substances contamination of the surface waters should be narrowed. Compilation of the basin-wide inventory on discharges, emissions and losses have to be continued in a comparable and coordinated way. In particular, the lack of high-quality monitoring data on priority substance discharges from wastewater effluents has to be addressed by additional specific sampling campaigns building on the experiences of the pilot studies carried out in the frame of the SOLUTIONS Project and the JDS4. This will ensure to have a consistent picture on the point source emissions of the relevant hazardous substances.

153 Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC.

154 Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC.

155 United Nations Economic Commission for Europe (2013): Convention on the Transboundary Effects of Industrial Accidents.

UWWTP inflow and effluent monitoring in the framework of JDS4

The JDS4 investigated the potential removal rates of 11 WWTPs for 20 indicator substances. Six out of the 20 indicator substances showed high average removal rates (> 80%). Medium removal rates (27-75%) were observed for eight substances, whereas poor elimination (<5%) or even negative removal rates were observed for six substances. In total, 8 out of the 20 indicator contaminants were eliminated with a removal rate below 50%. Moreover, samples were analysed by in vitro bioassays. The effect-based analyses indicated that the currently used wastewater treatment technologies in the DRB are unable to remove efficiently groups of chemicals of emerging concern causing specific adverse effects like estrogenicity, enzymatic activity, xenobiotic metabolism and oxidative stress.

In addition, determining sources and pathways of hazardous substances emissions and quantifying water emissions and loads should be further addressed building on the previous studies of the SOLUTIONS Project. Using regionalized pathway modelling adapted to the DRB conditions can ensure better understanding of inputs and fluxes of hazardous substances.

The ICPDR is supporting the Danube Hazard m^{3}c Project on managing hazardous substances pollution. The project is focused on monitoring, modelling and management of selected hazardous substances (heavy metals, pharmaceuticals, pesticides, industrial chemicals) in the DRB. It also contributes to capacity strengthening to be provided for the national water administrations by organising training events and elaborating management guidelines.

Danube Hazard m^{3}c builds on three elements of water governance, namely measuring, modelling and management, complemented by capacity building. The project aims in particular to improve the knowledge and understanding of the status quo of hazardous substances water pollution in the DRB, by integrating and harmonizing available existing data of hazardous substances concentration levels and by modelling emissions at catchment scale in pilot regions. Though not being the main focus of the project, targeted measurement campaigns must be carried out to fill critical gaps needed to provide a robust basis for modelling and management. A further goal is to enhance the transnational management of hazardous substances water pollution, through: i) coordinated prioritization of transnational measures with consideration of territorial needs, pursued through basin-wide emission modelling (see the preliminary results for the DRB in Chapter 2), assessment of management scenarios and elaboration of policy recommendations and ii) tailor-made training activities.

Recommendations for managing hazardous substance pollution

Knowledge-based identification and prioritization of measures

In many river basins, including the DRB, consistent emission inventories for indicator substances are currently lacking, especially with respect to diffuse sources of pollution. Diffuse emission inventories at the scale of the DRB necessarily rely on modelling. The DHSM developed by the Danube Hazard m^{3}c Project features a good representation of all relevant pathways to the aquatic environment, while it maintains the link with activities or sources. Thus, emissions can be traced back to sources, and the impact of measures at the source can be evaluated.

Further, well-designed and targeted monitoring efforts throughout the DRB over longer periods are strongly needed. Such efforts should be focusing on a limited but well selected number of substances. This is essential to provide a good empirical basis for the model and thus for the improvement of emission inventories and for the selection of the most-effective combination of measures. The establishment of an indicator substances list for upcoming emission inventories is a basin-wide task.

Two complementary and necessary approaches for the overall assessment of measures and developments and thus to ensure a long-lasting management of emerging pollutants are: i) non-target screening for the identification of unexpected substances (e.g. in the effluent of industrial discharges) and ii) effect-based bioassays for toxicology to be carried out both in pathways and in water bodies.

Capacity building activities within the DRB countries are highly welcomed. This should be related (a) to the use of the DHSM to create conditions for wide acceptance of this model at both national and transboundary level, and (b) to enable the above-mentioned consistent monitoring efforts.

Pollution Control Options and developments affecting hazardous substances pollution

Policies controlling hazardous substances pollution should be source- and pathway-related rather than focussed on individual substances. A set of measures and best management practices are listed from source control to end-of-pipe interventions targeting various sectors and emission pathways.

Use regulation

In view of the continuous introduction of increasing numbers of chemicals, use regulation (control at source) is important. That is why implementation and enforcement of the REACH Regulation, the Plant Protection Products Regulation and the Biocidal Products Regulation in EU-MS should have high priority. In non-EU-MS likewise, chemical use regulation needs to be prioritized. Especially the REACH Regulation regulates the use of hazardous substances in various products and calls for consideration of the whole life cycle of these products.

Usage regulation is evidently not sufficient, as substances causing problems in water systems have entered the market also in areas where full implementation of the related Directives has already been realized. This is to a certain degree unavoidable, for example in the case of pharmaceuticals where positive health effects often outweigh adverse environmental effects.

Improved solid waste management

Many hazardous substances are stored in our "technosphere", as they are used in in textiles, construction materials, consumer products, etc. This includes already banned or severely restricted hazardous substances, such as PFOS, flame retardants, pesticides/biocides, mercury and cadmium. Careful management of solid waste avoids leakages to surface waters and soils of such substances. Strict bans and controls on illegal dumping are needed. Selective collection of hazardous substances by the general public (free and easily accessible), such as the collection of paints, solvents, oils, medicines, pesticides used in retail gardens, household cleaners, car tires, electronic waste, etc. can have a strong positive effect. Re-use should have preference over landfilling and incineration when possible.

Construction of sewer systems

Construction of wastewater collection systems in areas where they are not yet available is an ongoing activity in the DRB. Due to the construction of wastewater collection systems, a larger share of the generated wastewater reaches receiving surface waters, with or without treatment. Therefore, this development tends to increase emissions to surface waters of hazardous substances present in domestic wastewater and wastewater from smaller commercial areas. In addition, stricter control of (illegal) stormwater and wastewater discharges to sewer systems can help reducing hazardous substances pollution.

Decoupling of stormwater collection systems

The decoupling of stormwater collection systems from wastewater collection systems may have different and opposite effect on hazardous substances emissions. On one hand, the decoupling reduces combined sewer overflows and reduces the loading to UWWTPs, which will result in lower emissions of hazardous substances present in wastewater. On the other hand, the decoupling also reduces the stormwater volume that passes UWWTPs and therefore increases the emissions to surface waters of hazardous substances present in stormwater

Construction and improvement of UWWTPs

The emissions of hazardous substances present in domestic wastewater can be abated by the ongoing implementation of conventional treatment (including N and P removal) and advanced wastewater treatment targeting at hardly or not biodegradable substances by advanced oxidation, adsorption or filtration steps. Though not all hazardous substances are effectively removed in conventional wastewater treatment plants (UWWTPs), even a limited removal will directly benefit surface water systems. Advanced fourth level treatment, to more effectively remove for example pharmaceuticals, is now under consideration in many countries and in some countries (Switzerland, Germany) already under implementation. Advanced level treatment may be included in an upcoming revision of the UWWTD. An important aspect is the operationalization of the polluter pays principle to cover the associated costs. It is worth noting that after fourth level treatment there are several possibilities for the utilization of treated water (e.g. irrigation, replenishment of water in sensitive or protected waters), which is now not possible in many cases, mainly because of the chemicals.

As hazardous substances partly end up in sewage sludge, the management of the sludge is important.

Increased storage in combined sewers

Measures to reduce combined sewer overflows, for example by providing more storage or improved management of available storage, are beneficial. Such measures reduce the volumes of wastewater being discharged to surface waters without full treatment. It is possible that climate change will cause increasing combined sewer overflow volumes as a result of more and heavier rainstorms.

Retention and filtration of combined sewer overflows and stormwater collection systems

Measures to enhance hazardous substances retention at combined sewer overflows and stormwater collection systems will reduce the emissions these emission in case substances can be removed by sedimentation with particles or by filtration. Such measures could be storage and retention basins, filtration ponds, etc. Contaminated sludge from such systems should be adequately managed

Green Cities and Sponge Cities

Measures to improve water retention and to combat the urban heat island effect in response to climate change also have an effect on hazardous substances emissions. Such measures provide storage and infiltration capacity, will reduce the collected stormwater volumes and therefore also reduce hazardous substances emissions via collected stormwater.

Control of industrial discharges

The control of industrial discharges can be an important measure to reduce hazardous substances emissions. Such discharges are often directly to surface waters, and an investment to avoid them or reduce them has a high environmental benefit. Emissions must be kept to a minimum during industrial production processes by BAT-compliant operation of facilities.

Measures to reduce the emissions to soils

Present emission levels via soil related pathways are controlled by a build-up of hazardous substances concentrations in soils over longer periods caused by various emissions to soils. These emissions stem from atmospheric deposition and from agriculture practices (fertilizer use, distribution of manure), with smaller contributions from domestic wastewater in areas without sewer systems and from the re-use of wastewater and/or sewage sludge. While measures taken to reduce emissions to soils are not expected to have a direct effect, they are nevertheless beneficial on the long run. This concerns the reduction of emissions to atmosphere (e.g. BAT requirement for industries like waste incineration plants and coal-fired power plants), the reduction of metal containing fertilizers and animal fodder, the reduction of the application of polluted wastewater and/or sludge in agriculture and the construction of sewer systems.

Measures to reduce transport between the soil systems and rivers

For some of the indicator substances, soil related pathways like erosion of top-soils, drainage flows and groundwater flows are responsible for a large share of the emissions to surface waters. Measures to reduce transport between the adjacent soil systems and rivers can be expected to directly reduce such emissions. This concerns for example the introduction of buffer strips, wetland and floodplain restoration, specific erosion reduction measures and local water conservation measures, for example in response to climate change.

Prevention of pollution from contaminated sites

Remediation of contaminated sites to prevent the contamination of surface waters either via surface or subsurface pathways is also an essential measure.

Best application practices for pesticides

Best application practices for pesticides need to be promoted to minimize environmental losses while maintaining the desired pest control in agriculture.

Avoidance of use of tar containing materials

PAH emissions can be reduced by avoiding the use of tar-based products for example in road surfaces and on ships' hulls.

Appropriate control of accidental pollutions is essential in order to mitigate adverse effects of hazardous substances spills. The Danube countries have made efforts in order to ensure effective and quick responses to transboundary emergency cases. The Danube Accident Emergency Warning System (AEWS) was developed to timely recognize emergency situations. It is activated if a risk of transboundary water pollution exists and alerts downstream countries with warning messages in order to help national authorities to put safety measures timely into action. The AEWS has been operated, maintained and enhanced by the ICPDR Secretariat.

In addition, activities on accident risk prevention should be continued in order to appropriately mitigate accidental pollution risk. Regular update of a basin-wide catalogue of hazardous industrial, abandoned and mining sites is an important future task to be accomplished. Besides identifying the most important potential accident hot-spots the ICPDR ensures that a proper platform for information exchange and know-how transfer is provided for the countries to facilitate risk management in the identified priority industrial fields and recommend particular preventive measures to be implemented. This can be supported by flagship projects and workshops with an active involvement of the ICPDR.

Recently, the ICPDR implemented the Danube TMF Project[156] (funded by the Advisory Assistance Programme of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, facilitated by the German Environment Agency (UBA)). The project aimed at contributing to narrow the knowledge gaps and to raise awareness on TMFs and their hazards in the DRB, ensuring to respect a common set of minimum standards and safety requirements in the DRB and strengthening the technical and management capacity at the concerned facilities and responsible authorities. Building on the TMF-Methodology developed by the UBA, practical tools were elaborated and adapted to the DRB conditions to consistently assess the hazard and risk of TMFs located in the DRB (THI and TRI methods, see the application results for the DRB in Chapter 2) and to evaluate their safety and recommend measures to improve safety conditions (amended TMF Checklist method). Moreover, within the project a demonstration regional training event was organised at Baia Mare in Romania to deepen the knowledge of invited TMF operators, environmental inspectors and competent authority experts on TMF management and to fine-tune the methodology based on field experiences. Competent authorities, TMF operators, concerned stakeholders and the public in the DRB are encouraged to apply these tools, which are intended to contribute towards limiting the number of accidents at TMFs and minimising the severity of their consequences for human health and the environment.

Building on the outcomes of the Danube TMF Project, the ICPDR published the Recommendation paper: Improving the Safety of TMFs in the DRB[157] to further raise awareness of the issue and provide recommendations at both the technical and policy-making level on how to ensure adequate safety conditions at the TMFs in the DRB. The paper emphasizes the need of adequate preventive measures to minimize the risk of TMF failures with potential casualties and ecological damages and to avoid substantial post-accident remediation costs.

Recommendations for sustainable management of tailings ponds

1) At policy-making level (policies and strategies):

- It is recommended to establish and maintain an open dialogue and close cooperation between water management sector and competent authorities responsible for mining waste management and civil protection (e.g. ministry of interior, energy or environment) in order to ensure policy alignment and coherence, efficient information exchange and coordinated accident prevention and contingency management.
- It is crucial to develop an enabling policy framework for implementing up-to-date industrial technologies and safety measures in compliance with the EU Seveso Directive, the EU Extractive Waste Directive and the respective BAT Reference Document and for establishing an effective inspection and performance control system.
- Danube countries should take further joint actions to prevent transboundary accidental pollution of surface waters in relation to TMF disasters in line with WFD Article 11.

2) At policy implementation level (actions and measures):

- Countries are encouraged to optimize the limited institutional capacity and financial resources by targeting the most hazardous TMFs where regular safety inspections are needed.

156 *"Capacity development to improve safety conditions of tailings management facilities (TMF) in the Danube River Basin – Phase I: North-Eastern Danube countries; funded by the German Federal Environment Ministry's Advisory Assistance Programme (AAP), https://www.umweltbundesamt.de/themen/nachhaltigkeit-strategien-internationales/kooperation-in-mittel-osteuropa-dem-kaukasus/projektdatenbank-des-beratungshilfeprogramms/verbesserung-der-sicherheit-bergbaulicher (accessed 12 February 2021).*

157 *http://www.icpdr.org/main/practical-tools-and-policy-recommendations-improve-safety-tailings-management-facilities-danube (accessed 14 September 2021).*

- Appropriate safety measures should be urgently taken in case of non-compliance with relevant technical standards and ensuring appropriate rehabilitation of closed and abandoned sites.
- It is recommended to link TMF hazard assessment to national or transboundary early warning systems in order to timely respond to potential accident events related to the identified hazard hot-spots.
- Development of specific contingency measures and disaster management plans are needed at the local level for the surrounding downstream area of TMFs associated with high risk.
- It is necessary of involving land-use planning aspects and risk mapping into the design, siting and licensing of new and existing (in case of capacity enlargement) TMFs in order to limit the number of potential receptors to be affected by and accident, in particular the vulnerable receptors.
- Countries are advised to organize capacity building programs with regular training events at national or regional level for facility operators and authority inspectors to strengthen their knowledge and skills in the field of accident prevention and contingency management.
- Danube countries are encouraged to make use of the UBA TMF Checklist as a consistent practical evaluation, self-assessment and training tool and adapt it to their national conditions where necessary to assess safety conditions of individual TMFs and to identify potential measures to be implemented to improve safety.
- Application of the UBA TMF Checklist and tool as education materials in the national mining curricula is highly recommended.
- It is recommended to openly communicate TMF risks, accident events, inspection results, capacity building events and disaster management exercises to the public and discuss safety issues with local communities in the form of public hearings, dissemination materials and social media tools to raise awareness of TMF safety, accident prevention and emergency management.

3) At technical level (basin-wide joint activities):

- Danube countries are encouraged to develop and regularly update national inventories on TMFs located in their territory, including basic parameters necessary to conduct hazard and risk assessments in line with the respective basin-wide activities (i.e. application of the UBA Tailings Hazard and Risk Index methods or similar screening tools).
- Danube countries should further carry out and update consistent and comparable hazard and risk assessments at national or basin-wide level to prioritize the most hazardous TMF hot-spots and to identify receptors of high relevance (population, environmental resources, socio-economic goods) potentially exposed to accident impacts.
- Danube countries should make use of the existing international platforms (ICPDR, UNECE) for knowledge transfer and information exchange, organizing demonstration training events and implementing basin-wide or regional projects on capacity building.

8.1.3.4 Estimated Effect of Measures on the Basin-Wide Scale

Due to the lack of reliable information on the sources of hazardous substances pollution a detailed assessment on the effects of measures to be implemented cannot be performed. However, such an assessment will be provided by the Danube Hazard m^{3}c Project by the end of 2022 along with policy recommendations and a management guidance. Nevertheless, a qualitative assessment is provided in Table 45 on the potential effect developments and measures on hazardous substances emissions to surface water.

Table 45: Effects of measures on hazardous substances emissions

Development or measure	Pharma-ceuticals	Industrial chemicals	Pesticides	Metals	PAHs
Use regulation	+	++	++	+	+
Construction of sewer systems	--	--	-	--	-
Construction of conventional WWTPs	++	++	+	++	+
Implementation of advanced wastewater treatment	++	++	+	0	0
Increased storage in combined sewers	+	+	+	+	+
Retention and filtration of combined sewer overflows	+	+	+	+	+
Decoupling of stormwater collection systems	+	+/-	+/-	+/-	+/-
Retention and filtration in stormwater collection systems	0	+	+	+	+
Green Cities / Sponge Cities	0	+	+	+	+
Industrial discharges control	0	+	0	++	0
Improved solid waste management	+	+	+	+	+
Reduced connectivity between rivers and adjacent soils	+0	0	+	++	++
Reduction of emissions to soil	(+)	(+)	(+)	(+)	(+)
Prevention of accidental discharges and pollution from contaminated sites	0	+	0	+	+
Best pesticide application practices	0	0	++	0	0
Avoidance of tar-based products	0	0	0	0	+

++ probably significant positive effect (increasing emissions)
+ positive effect with small or unknown significance (increasing emissions)
-- probably significant negative effect (decreasing emissions)
- positive effect with small or unknown significance (decreasing emissions)
+/- positive or negative effect (emissions can decrease or increase)
0 not relevant, or no effect expected
( ) indicates a time delay between measure and expected effect

Achievement of the WFD environmental objectives might not be possible by 2027 due to the existing knowledge gaps although the on-going activities on narrowing knowledge gaps and the measures to be implemented in the next management cycle will improve the situation.

8.1.4 Pollution Control Measures Addressing Adaptation to Climate Change Impacts

A number of multi-purpose measures can be identified that are able to address climate change impacts while beneficial also for pollution reduction. In urban areas the following actions can be considered useful to adapt to the impacts of climate change:

- storm water management in urban areas, including measures for mitigating runoff from storm water sewers and combined sewer overflows;
- water retention in urban areas (permeable paving, infiltration ponds, grassed surfaces, urban greening);
- wastewater reuse for irrigation;

- energy-efficiency in wastewater sector (optimized WWTP operation, biogas utilization, high efficiency pumps);
- water saving in households, public buildings and industrial facilities, reduction of water losses and leakage from pipes;
- supplementary measures in case of low-flow rivers and high instream concentrations caused by point sources according to the combined approach of the WFD (e.g. nutrient removal at small agglomerations).

In agricultural and rural lands, several measures can be implemented for multi-purposes:

- reconsidering and adjusting current land use forms, tillage systems, crop rotation and soil cover (soil conservation and erosion control);
- improvement of irrigation systems in terms of water and energy savings;
- implementing nature-based green infrastructure solutions, buffer strips and natural water retention measures to protect and enhance the water storage potential of landscape, soil, and aquifers;
- developing smart and efficient irrigation schemes and use precision technologies for irrigation and nutrient management, adjusted to the specific local conditions (right time, right amount, right place) and in combination with natural water retention measures;
- afforestation of abandoned arable lands and reforestation of former woodlands;
- maintaining and restoring wetlands/floodplains along rivers for flood mitigation, preserving biodiversity and retaining water and pollutants;
- managing and operating artificial reservoirs to capture and store excess water via runoff and retain pollutants.

8.1.5 Hydromorphological Alterations

The pressure analysis shows that surface waters of the DRBD are impacted by hydromorphological alterations to a significant degree. Hydrological alterations, interruption of river continuity for fish migration, sediment balance alteration and morphological alterations may impact water status and are therefore addressed as part of the JPM.

On the European level, measures related to the improvement of hydromorphological alterations are foreseen and required by the WFD. Therefore, the respective DRBD management objectives have an important role in guiding the joint improvement of ecological status/potential.

Measures addressing different hydromorphological alterations, planned to be implemented by 2021, were included in the JPM of the DRBMP Update 2015. The following chapters inter alia outline progress in the implementation of these measures. The starting point for the assessments are the measures which were indicated in the JPM of the DRBMP Update 2015, updated with information on the finally agreed measures in the national programs of measures and progress in measures implementation. Information on the implementation status is based on the assessments of the 2018 Interim Report which was updated with latest information for the reference year 2021. In case delays in the implementation are observed, different reasons were indicated, including e.g. conflicts related to land reclamation. Further detailed information for each country can be obtained from Annex 16. The ongoing implementation of measures provides the opportunity to monitor the effectiveness of measures (e.g. the performance of fish migration aids, re-connecting wetlands and floodplains). Exchange of experiences will be useful towards reaching more cost-effective programs of measures in the future. Furthermore, measures which are planned to be implemented on the basin-wide scale by 2027 are summarised for each hydromorphological alteration. It is also presented if the measures are not needed (due to already achieved environmental objectives) or are not applicable. A detailed list of hydrological alterations can be found in Annex 18. This chapter is based on updated data provided by all ICPDR Contracting Parties except for Bosnia and Herzegovina (partly), and Republic of Moldova.

8.1.5.1 Hydrological Alterations

8.1.5.1.1 Vision and Management Objectives

The ICPDR's basin-wide vision for hydromorphological alterations is the balanced management of past, ongoing and future structural changes of the riverine environment so that the aquatic ecosystem in the whole DRB can function in a holistic way and is represented with all type-specific native species.

The ICPDR's basin-wide vision for hydrological alterations is that they are managed in such a way, that the aquatic ecosystem is not negatively influenced in its natural development and distribution.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- Restoration/mitigation of hydrological regime and habitats to ensure improvement of water status/ water potential and aquatic ecosystems.
- For efficient implementation of the measures, it is recommended to prepare action plans at the national level based on the JPM with detailed description (specification and location) and timeline for measures implementation addressing hydrological alterations that will be implemented by 2027 by each country.
- Preparation of upgraded overview on implemented measures related to hydrological alterations within DRB.
- **Impoundments:** Most of the impoundments are designated as heavily modified water bodies and the good ecological potential (GEP) has to be achieved. Due to this fact the management objective foresees additional measures on the national level to improve the hydromorphological conditions in order to achieve and ensure the GEP, e.g. improvement of river morphology in the head sections of the reservoir (e.g. gravel bars and lateral widenings).
- **Water abstractions:** Ecological flow, ensuring that the biological quality elements are in good ecological status/potential, and the flow requirements for protected species and habitats are met.
- **Hydropeaking:** Half of the water bodies affected by hydropeaking are designated as heavily modified water bodies and the good ecological potential (GEP) has to be achieved. Therefore, the management objective foresees measures on the national level to improve the situation to achieve and ensure the GEP. Research projects in the 1st and 2nd River basin management cycle identified effective mitigation measures and assessed their impact on flexibility of electricity generation as well as on business economics and macroeconomic aspects. Feasibility studies were initiated by Austrian hydropower companies to identify appropriate mitigation measures to achieve good ecological potential in those water bodies impacted by hydropeaking.
- Harmonisation of methods for assessing significant pressures (mainly hydropeaking) and further implementation of monitoring for identification of negative impacts of hydrological alteration (mainly hydropeaking) on biological quality elements.

- Implementation of monitoring for assessing the effectiveness of implemented measures.
- Prevention of further deterioration of water bodies status/potential from the point of view of hydrological regime and implementation of transparent assessment of non-deterioration/achievement of good status/potential for new infrastructure projects (applicability assessment related to CIS Guidance No. 36). Implementation of efficient mitigation measures.
- Further collaboration between different authorities and stakeholders for seeking of common solutions (implementation of "win–win" measures).
- Further good practice promotion on national/international level and knowledge exchange on measures related to hydrological alteration (see Annex 19 on Hydromorphological lighthouse projects in the Danube River Basin); also via planned GEF DYNA project proposal).

8.1.5.1.2 Progress in Implementation of Measures from DRBMP Update 2015

Overall, in the DRBMP Update 2015, 67 measures addressing hydrological alteration (impoundments, water abstractions, hydropeaking) were indicated to be implemented by 2021. Data on measures were separately reported by countries (see Annex 16). Particular measures are also presented in Annex 19 (Practice example – lighthouse projects).

Impoundments

In total, 41 measures addressing impoundments were reported to be implemented by 2021, whereby 32 were finally agreed at national level. For 10 of the agreed measures the implementation was already completed,1 is in the construction phase, 2 are in the planning phase and for 22 of the measures the implementation was not started yet (see Table 46).

Table 46: Progress in implementation of measures on impoundments

Number of measures to be implemented by 2021		Implementation status			
Indicated in the DRBMP Update 2015	Finally agreed measures at national level	Not started	Planning on-going	Construction on-going	Completed
41	32	22 (63%)	2 (6%)	1 (3%)	10 (29%)

Water abstractions

In total, 22 measures addressing water abstractions were reported to be implemented by 2021, whereas 18 were finally agreed at the national level. 3 of the measures is completed and 3 are in the construction phase. Planning is ongoing for 11 measures and for 1 of the measure the implementation phase was not yet started (see Table 47).

Table 47: Progress in implementation of measures on water abstractions

Number of measures to be implemented by 2021		Implementation status			
Indicated in the DRBMP Update 2015	Finally agreed measures at national level	Not started	Planning on-going	Construction on-going	Completed
22	18	1 (6%)	11 (61%)	3 (17%)	3 (17%)

Hydropeaking

In total, 4 measures addressing hydropeaking were reported to be implemented by 2021 (Table 48). One measure was already completed, 1 in under constructions and 2 are in planning phase.

Table 48: Progress in implementation of measures on hydropeaking

Number of measures to be implemented by 2021		Implementation status			
Indicated in the DRBMP Update 2015	Finally agreed measures at national level	Not started	Planning on-going	Construction on-going	Completed
4	4	0 (0%)	2 (50%)	1 (25%)	1 (25%)

8.1.5.1.3 Summary of Measures of Basin-Wide Importance

As shown by the pressure analysis and water status assessment, hydrological alterations impact the water status of water bodies (see Chapter 2 and Chapter 4). Impoundments, water abstractions and hydropeaking remain key pressures that require measures on the basin-wide scale. In the following, the planned measures for each category of hydrological alteration are outlined. The information is also illustrated on Map 33, Map 34 and Map 35 in aggregated form on water body level. The map shows in which water bodies measures addressing hydrological alterations are planned. This can be a combination of different measures addressing different hydrological pressures.

Impoundments

In total, 422 impoundments are located in the DRBD rivers with catchment area > 4,000 km^2, 26 of them in the Danube River itself. For 48 impoundments, restoration/mitigation measures have already been implemented for the achievement of GES/GEP by 2021. For 204 impoundments restoration measures are planned to be implemented by 2027. For 93 impoundments no measures are necessary for the achievement of the GES/GEP. For 77 impoundments measures were not yet indicated (Figure 83). Table 49 further below provides more detailed information for each Danube country.

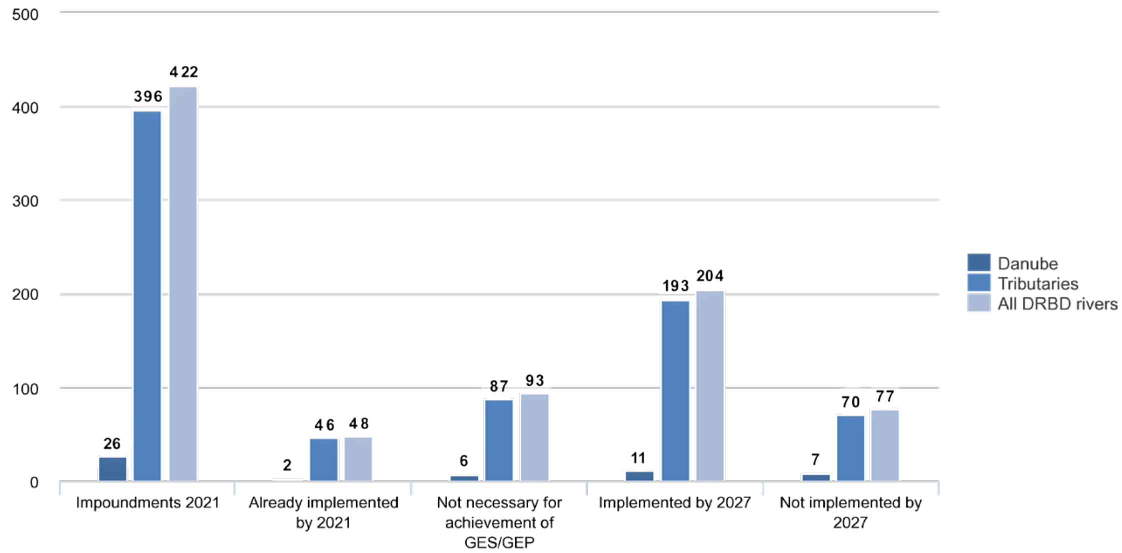


Figure 83: Number of impoundments and expected restoration measures addressing impoundments by 2027

Table 49: Number of impoundments and expected restoration measures addressing impoundments by 2027 per country[158]

Country	Impoundments 2021	Already implemented by 2021	Not necessary for achievement of GES/GEP	Implemented by 2027	Not implemented by 2027
DE	28	12	10	6	
AT	209	21		188	
CZ	6				6
SK	34				34
HU	32		32		
SI	9		1	8	
HR	3				3
BA					
ME	1				1
RS	33				33
RO	56	3	52	1	
BG	13	12		1	
MD					
UA					
Total	**424**	**48**	**95**	**204**	**77**

Water abstractions

In total, 69 cases of water abstractions were identified in the DRBD, 5 of them in the Danube River itself. For 3 water abstractions, ecological flow requirements for the achievement of GES/GEP have already been achieved in 2021. For 46 water abstractions, restoration measures are planned to be implemented by 2027 (Figure 84). For 18 water abstractions, no measures are necessary for the achievement of GES/GEP and

158 Transboundary impoundments may be indicated for each country and are therefore double-counted in the total sum of the table, what was avoided in the respective figure.

for 2 water abstraction measures will not be implemented by 2027. Figure 84 below provides more detailed information for each Danube country.

EU Guidance Document[159] on ecological flows provides support towards gaining a better shared understanding on ecological flows and ways to use them in river basin management planning.

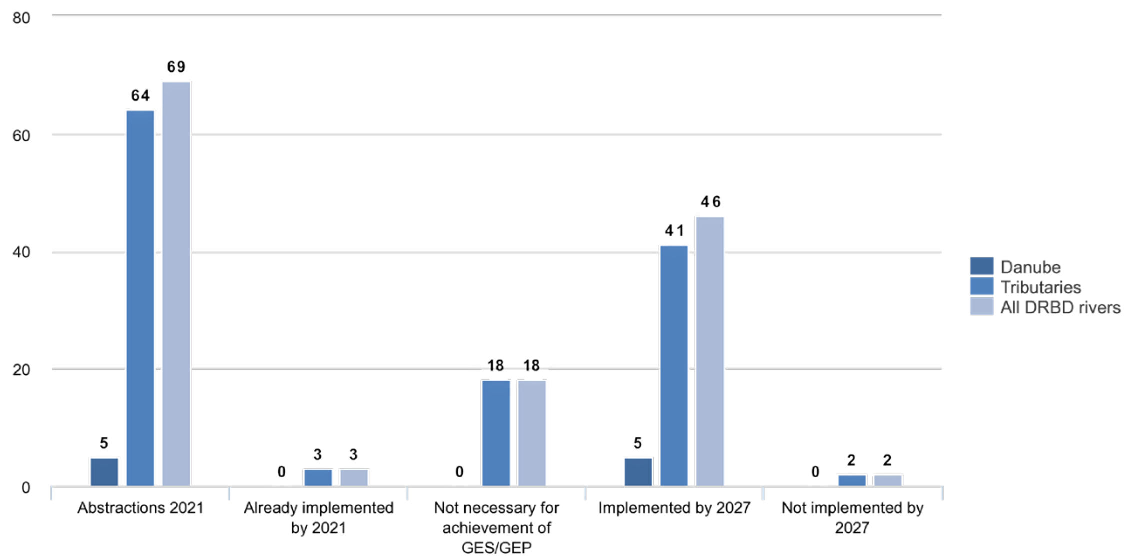


Figure 84: Number of water abstractions and expected restoration measures by 2027

Table 50: Number of water abstractions and measures addressing water abstractions by 2027 per country

Country	Abstractions 2021	Already implemented by 2021	Not necessary for achievement of GES/GEP	Implemented by 2027	Not implemented by 2027
DE	18		2	16	
AT	32	2		30	
CZ					
SK	7		7		
HU					
SI	3		3		
HR					
BA					
ME	1				1
RS					
RO	8	1	6		1
BG					
MD					
UA					
Total	**69**	**3**	**18**	**46**	**2**

159 EU Guidance Document No. 31 on "Ecological flows in the implementation of the Water Framework Directive".

Hydropeaking

In total, 42 cases of hydropeaking were identified in the DRBD, one of them in the Danube River itself. For 4 cases, restoration/mitigation measures have already been implemented by 2021 for the achievement of GES/GEP. For another 32 cases of hydropeaking restoration/mitigation measures are planned to be implemented by 2027 and for another 3 cases the restoration measures will not be implemented by 2027 (see Figure 85). For 2 cases, no measures are necessary for the achievement of GES/GEP and for one case, the measures are not yet determined. Table 51 further below provides more detailed information for each Danube country.

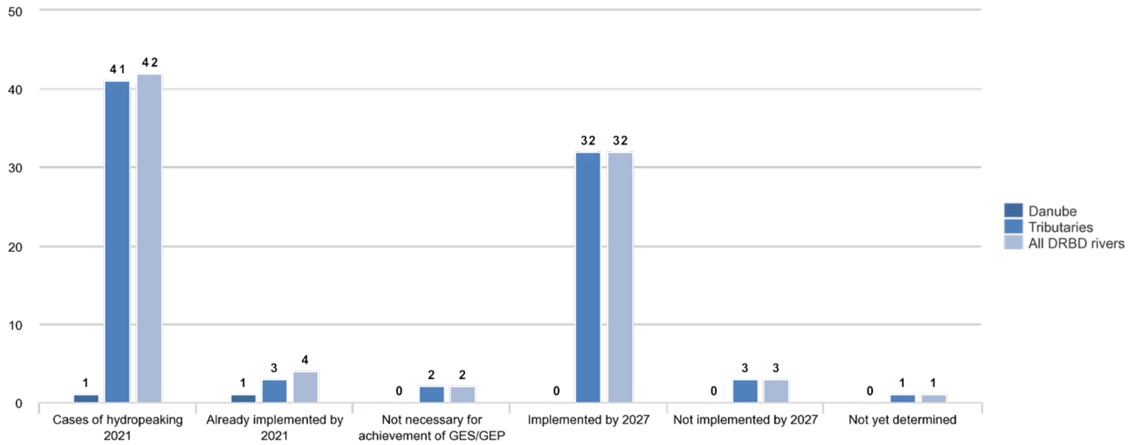


Figure 85: Number of cases of hydropeaking and expected restoration measures by 2027

Table 51: Number of cases of hydropeaking and measures addressing hydropeaking by 2027 per country

Country	Cases of hydropeaking 2021	Already implemented in 2021	Not necessary for achieve-ment of GES/GEP	Implemented by 2027	Not implemented by 2027	Not yet determined
DE	9	2		7		
AT	27	2		25		
CZ						
SK						
HU	2				2	
SI	2		2			
HR	1					1
BA						
ME	1				1	
RS						
RO						
BG						
MD						
UA						
Total	**42**	**4**	**2**	**32**	**3**	**1**

8.1.5.1.4 Estimated Effect of Measures on the Basin-Wide Scale

In total, more than 50 measures addressing hydrological alterations have been implemented between 2009 and 2015 and an additional 14 have been implemented between 2015 and 2021. Additional 282 measures are planned until 2027 (204 on impoundments, 46 on water abstractions and 32 on hydropeaking) for the achievement of GES/GEP.

Although the exact effect of the measures on the basin-wide scale is difficult to be assessed, further improvement of water status can be expected, i.e. by improving river morphology in the head sections of reservoirs, ensuring ecological flows and by addressing artificial flow fluctuations. Monitoring in combination with measures implementation and further research is expected to further clarify the effects of the measures on the basin-wide scale.

8.1.5.2 Interruptions of River Continuity and Sediment Balance Alteration

8.1.5.2.1 Interruptions of River Continuity for Fish Migration

8.1.5.2.1.1 Vision and Management Objectives

The ICPDR's basin-wide vision is that anthropogenic barriers and habitat deficits do not hinder fish migration and spawning anymore – sturgeon species and specified other migratory species are able to access the Danube River and relevant tributaries. Sturgeon species and specified other migratory species are represented with self-sustaining populations in the DRBD according to their historical distribution.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- Construction of fish migration aids and other measures at existing migration barriers as well as removing (e.g. obsolete) barriers to achieve/improve river continuity in the Danube River and in respective tributaries to support free-flowing river sections and ensure self-sustaining[160] sturgeon populations and specified other migratory fish populations.
- For efficient implementation of the measures, it is recommended to prepare action plans at the national level based on the JPM with detailed description (specification and location) and timeline for measures implementation addressing fish migration aids and other measures, including potential barriers for removal, to achieve/improve river continuity that will be implemented by 2027 by each country.
- Preparation of upgraded overview on implemented measures related to fish migration within DRB.
- The planning of measures addressing river continuity in the DRB should build on existing knowledge and evidence, i.e. the results of the ecological prioritisation approach and information from relevant projects (e.g. MEASURES) but should also take into account measures on habitat improvement in the reconnected river section (i.e. up-/downstream direction).
- Restoration of habitats and ecological corridors for migratory fish species, in particular sturgeons.

160 Populations that are maintaining a group size, age structure and genetic heterogeneity through natural reproduction and recruitment that is sufficient to ensure the long-term stability of the population without external support measures.

- Standardization and harmonization of methodologies for the assessment, prioritization, implementation of barrier/dam removal as well as for establishing passing solutions (including methods for assessment of fish pass effectiveness). Further investigations on enabling downstream migration of fish species.
- New barriers for fish migration imposed by new infrastructure projects will be avoided; unavoidable new barriers will incorporate the necessary mitigation measures like fish migration aids or other suitable measures already in the project design according to BEP and BAT.
- Closing the knowledge gaps on the possibility for sturgeon and specified other migratory species to migrate upstream and downstream through the Iron Gate I & II dams. First activities identified in the Terms of Reference for the Feasibility Study analysing options for fish migration at Iron Gate I & II at the Romanian-Serbian border, which were adopted by the ICPDR in December 2016, started in the year 2018 with the support of the EU-funded WePass project. The gathering of required hydrological, hydraulic, topographical and morphological data as well as the monitoring of fish behaviour were performed by Romanian and Serbian partners. The WePass 2 project started in 2021 and runs for three years until 2024. If the results of these investigations will be positive, the necessary financial resources should be raised and the respective measures to open the migration route at Iron Gate I & II should be implemented step by step and a similar feasibility study will be performed for the Gabčikovo Dam and in case of positive results also for the Upper Danube.
- Prevention of further deterioration of water bodies status/potential from the point of view of river continuity and implementation of transparent assessment of non-deterioration/achievement of good status/potential for new infrastructure projects (applicability assessment related to CIS Guidance No. 36). Implementation of efficient mitigation measures.
- Further good practice promotion on national/international level and knowledge exchange on measures related to river continuity for fish migration (see also Annex 19 on Hydromorphological lighthouse projects in the Danube River Basin); also via planned GEF DYNA project proposal).
- Establish working relations with authorities responsible for nature protection and biodiversity in Contracting parties to implement these measures.
- Extend working relations with the Black Sea Commission to successfully address the improvement of (long distance) migratory fish populations.

8.1.5.2.1.2 Progress in Implementation of Measures from DRBMP Update 2015

Overall, in the DRBMP Update 2015, 158 measures were indicated to be implemented by 2021 and 139 measures were finally agreed on national level to be implemented by 2021. Data on measures were separately reported by countries. Particular measures are also presented in Annex 19 (Practice example – lighthouse projects).

The measure implementation status in given in Table 52, 47 measures have been completed and 8 are in the construction phase. For 47 measures the planning process is on-going, while for 37 measures the implementation process was not started. No information was yet provided for 19 measures.

Table 52: Progress in implementation of measures on restoration of interruption of river continuity for fish migration

Number of measures to be implemented by 2021		Implementation status			
Indicated in the DRBMP Update 2015	Finally agreed measures at national level	Not started	Planning on-going	Construction on-going	Completed
158	139	37 (27%)	47 (34%)	8 (6%)	47 (34%)

Information on progress regarding the step-by-step approach to jointly ensure the achievement of the management objectives related to the restoration/mitigation of river continuity in the DRB and the elaboration of the Iron Gates feasibility study can be obtained further below.

8.1.5.2.1.3 Summary of Measures of Basin-Wide Importance

The DRBD rivers with catchment areas >4,000 km^2 are large to medium sized and include crucial living and spawning habitats, vital to the life cycles of fish species. These rivers are the key routes and starting points of fish migration for long and medium distance migratory fish species. The Danube River, for example, is not only a key migration route itself, it is also of special importance for those species migrating from the Black Sea and connects all tributaries in the basin for migration. The Protected Areas along the Danube are core areas, providing important habitats and acting as “biodiversity hotspots”.

The overall goal of restoration/mitigation of river continuity is free migration routes for the DRBD rivers with catchment areas >4,000 km^2, as this will be crucial for achieving and maintaining GES/GEP for the future.

In general, all fish species of the DRB are migratory, however, the importance of migration for the viability of fish populations varies considerably among them. Differences exist in terms of migration distances, direction (upstream, downstream, lateral), spawning habitats, seasons and the life stage for which migration takes place. DRB migration requirements are more relevant in lowland rivers than in headwater fish communities.

Long distance migrants (LDM), such as the Beluga sturgeon (*Huso huso*), formerly migrated from the Black Sea up to (what is termed) the Barbel region of the DRB. Medium distance migrants (MDM, so called potamodromous fish species) such as Nase (*Chondrostoma nasus*) and Barbel (*Barbus barbus*) migrate within the river over distances between 30 to 200 km within the Barbel and Grayling regions of the DRB[161]. In contrast, headwater fish species migrate over comparable short distances because their living and spawning habitats are closer to each other. Nevertheless, under a long-term perspective all fish species need open river continuity.

161 Waidbacher, H. & Haidvogl, G. (1998): Fish migration and fish passage facilities in the Danube: Past and present. In: Jungwirth, M., Schmutz, S. & Weiss, S. (eds.): Fish Migration and Fish Bypasses. Oxford, Fishing News Books, pp 85-98.

Overall, six long-distance migrants of the DRBD as well as nine DRBD medium distance migrants that are represented with the highest numbers in the Danube River and adjacent lowland rivers, are of key importance regarding continuity restoration/mitigation. The key MDMs have been selected out of overall 58 fish species that have been classified in the European FP7 Project EFI+. The technical report on the ecological prioritisation approach (Annex 17 of the DRBMP Update 2021 on the ecological prioritisation approach) will include more details on LDMs and MDMs.

Ecological prioritisation approach for river continuity restoration/mitigation in the DRB

One focus for measures in the DRBD is on establishing/improving migration for long and medium distance migrants of the Danube River and the connected lowland rivers that are addressed at the roof level.

In order to enable a sound estimation of where to target measures most effectively at the basin-wide scale, an ecological prioritisation of measures to restore river and habitat continuity in the DRBD was carried out for the DRBMP 2009. The elaborated approach provided indications on the step-wise and efficient implementation of restoration measures at the basin-wide scale. It provided useful information on the estimated effects of national measures in relation to their ecological effectiveness at the basin-wide scale and served as a supportive tool for a number of countries in the implementation of measures. Therefore, it also supports feedback from international to national level and vice versa.

In the Danube Declaration 2010 the Danube countries reconfirmed their commitment to further develop and make full use of the ecological prioritisation approach for measures to restore river and habitat continuity in order to ensure that they are ecologically most efficient. Therefore, the ecological prioritisation approach has been further developed and updated for the DRBMP Update 2015. Under consideration of updated input data, the prioritisation approach was once more updated for the DRBMP Update 2021.

Key migration routes for long and medium distance migrants of the DRB are addressed. Furthermore, the approach incorporates criteria related to the distance from the river mouths, reconnected habitat lengths, protected sites and habitat quality. The output of the approach is a calculated Prioritisation Index (PI = migratory habitat x (1 + first obstacles upstream + distance from mouth + reconnected habitat + protected site + number of pressures). This allows an estimation of where measures would be most effective from the ecological point of view for implementation on the basin-wide scale. Further details of the prioritisation approach will be highlighted in Annex 17.

At the moment, barriers within LDM habitats, which are equipped with fish migration aids are passable for MDM species but not yet for LDM species. Therefore, these barriers were also included in the PI calculation and highlighted in the map to show their current status. Since there are no standardised fish pass solutions for LDM-species, individual measures have to be taken. The adaptation of existing fish migration aids in Austria and Germany to allow the passage of LDM species will be necessary when these species are able to reach the respective barriers, which means, when the Iron Gates and Gabčíkovo are passable. The key findings of the ecological prioritisation approach are illustrated in Map 39. The results show that according to the defined prioritisation criteria continuity interruptions in the lower Danube (Iron Gates, two barriers) receive the highest priority. Also, in the Middle (Gabčíkovo Dam) and Upper Danube barriers with utmost priority are located.

In general, it can be stated that the importance to restore/mitigate upstream/headwater interruptions increases as soon as downstream continuity interruptions are restored/mitigated. However, low restoration priority indicated on the basin-wide level does not imply that no measures should be undertaken on the national level, as all fish species need undisturbed river continuity. Therefore, results of the proposed prioritisation are recommended to be used as a guideline for implementing ecological efficient measures. However, it has to be pointed out that ecological prioritisation is only one aspect in deciding which measures has to be implemented. Several other important aspects (e.g. technical, economic and/or administrative issues) exist alongside ecological prioritisation, which have to be taken into account when deciding at national level where priority measures will be implemented by 2027 and beyond.

The ecological prioritisation approach for continuity restoration/mitigation is addressing all reported river continuity interruptions in the DRBD. For the Danube River itself, as the key migration route in particular for long-distance migrants through the basin, in addition a specific step-wise approach for continuity restoration/mitigation is outlined as follows.

The Danube River and the restoration/mitigation of river continuity

The status of migratory fish, such as sturgeon (declared as a species of basin-wide importance in the framework of the ICPDR), is a parameter of the ecological condition and important indicator of the entire DRBD.

The Danube River itself is a key migration route and connects all tributaries for migration. The Iron Gate Dams I & II, in part the Gabčíkovo Dam, and the chains of hydropower plants in AT and DE represent significant migration barriers for fish. Migratory fish, such as sturgeon and medium distance migrators, are particularly affected, being unable to move up or downstream between their spawning grounds and areas used at other times in their life cycle.

The Danube countries have reported on the measures that will be undertaken by 2027 to ensure fish migration (where still needed) e.g. by the construction of fish migration aids. Measures that will be taken are intended to ensure both up and downstream migration of fish[162] and will also help to improve the migration of other fauna. The functioning and maintenance of function of fish migration aids is important to be monitored and assessed.

Figure 86 and Map 36 illustrate that, as of 2021, 965 interruptions of river continuity are located in the DRBD (81 of which are located in the Danube River). By 2027, 424 fish migration aids are planned to be constructed in the DRBD that should ensure the migration of all fish species and age classes according to best available techniques. For 90 continuity interruptions, no measures are necessary for the achievement of GES/GEP. No measures are yet indicated for 13 continuity interruptions and for 29 continuity interruptions measures are not applicable. For 97 continuity interruptions no measures are planned by 2027. More detailed information for countries can be obtained from Map 36. Table 53 further below provides more detailed information for each Danube country.

162 The restoration of downstream connectivity is still less advanced than it is for upstream fish passage. This is due to the fact that the re-establishment of connectivity started with upstream migration and that downstream migration problems have only been recognized and addressed more recently. Further details and information on possible solutions can be obtained from the ICPDR Technical Paper "Measures for ensuring fish migration at transversal structures".

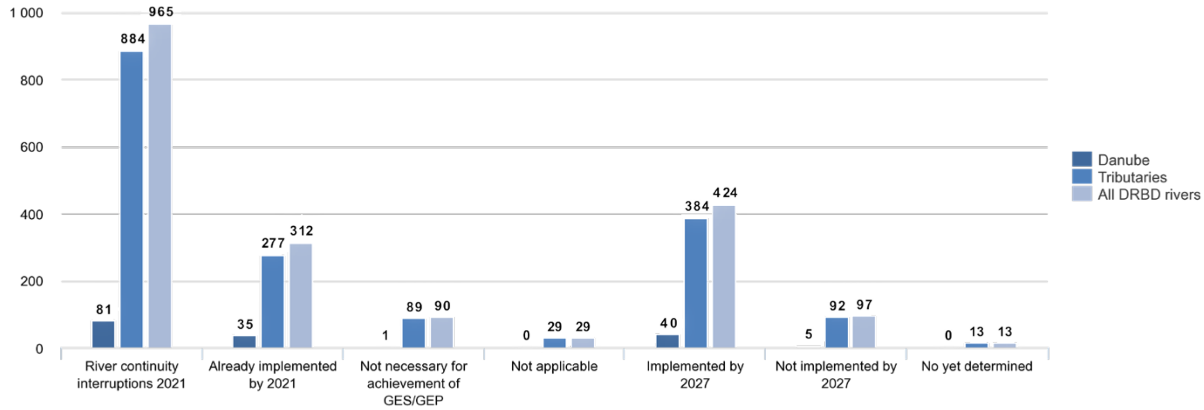


Figure 86: Number of continuity interruptions and expected restoration measures on river continuity for fish migration by 2027

Table 53: Number of continuity interruptions and measures on river continuity for fish migration by 2027 together per country[163]

Country	River continuity interruptions 2021	Already implemented by 2021	Not necessary for achievement of GES/GEP	Not applicable	Implemented by 2027[164]	Not implemented by 2027	No measures yet indicated
DE	194	72	18		99	5	
AT	266	139			127		
CZ	80	13			67		
SK	135	12			91	32	
HU	52	21		8		23	
SI	23	5			18		
HR	5	3			2		
BA	4					4	
ME	1					1	
RS	19	4					15
RO	125	17	70	1	5	32	
BG	63	26	2	20	15		
MD							
UA							
Total	**967**	**312**	**90**	**29**	**424**	**97**	**15**

Table 54 indicates that 264 water bodies out of a total number of 975 water bodies in DRBD remain affected by unpassable continuity interruptions in 2021, whereby 138 water bodies will be fully restored until 2027 and 13 partly (some of the interruptions in water bodies affected by multiple interruptions will be made passable).

163 Transboundary continuity interruptions may be indicated for each country and are therefore double-counted in the total sum of the table, what was avoided in the respective figure.

164 There is the intention to plan and build a fish pass at the Iron Gates (ongoing feasibility study). RO and RS agreed not to include these measures in terms of figures in the related table but to explain activities in related chapters of the We Pass and other projects, with explanation that measures will be implemented when the dedicated financial resources will be available, after the results of the assessment of possibility of opening fish migration route at the Iron Gates prove feasible from technical and economic point of view.

Table 54: Number of river water bodies with river continuity interruption and measures on river continuity for fish migration by 2027 and beyond (WB=water body)

	Total number of WBs	WBs affected by significant continuity interruptions in 2021	WBs affected by unpassable continuity interruptions in 2021	WBs restored for continuity by 2027	WBs to be partly restored for continuity by 2027
Danube River	63	27	20	13	1
DRBD tributaries	912	330	244	125	12
All DRBD rivers	**975**	**357**	**264**	**138**	**13**

8.1.5.2.1.4 Estimated Effect of Measures on the Basin-Wide Scale

Further progress will be made in the restoration/mitigation of river continuity for fish migration. 127 fish migration aids were completed in the period between 2009 and 2021. Another 424 measures on river continuity for fish migration are planned to be constructed until 2027. Map 39 illustrates where priority measures could be implemented to achieve the estimated highest ecological effectiveness of measures on the basin-wide scale.

In summary, the planned restoration/mitigation measures for establishing river continuity for fish migration are expected to significantly contribute towards the improvement of water status by 2027. Positive effects can mainly be expected for short and medium distance migrants, and also for long distance migrants in case continuity can be step-wise restored on the Danube itself, starting with the Iron Gate dams, as the key migration route.

8.1.5.2.2 Sediment Balance Alterations

8.1.5.2.2.1 Vision and Management Objectives

The ICPDR's basin-wide vision is a balanced sediment regime and an undisturbed sediment continuity. Type-specific natural bed forms and bed material as well as a dynamic equilibrium between sedimentation and erosion are provided. The balanced sediment regime enables the long-term provision of appropriate habitats for the type-specific aquatic communities and groundwater dependent terrestrial ecosystems.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- To gain deeper understanding of sediment quantity related problems, the establishment of a harmonized sediment quantity monitoring network will be discussed in the frame of the TransNational Monitoring Network (TNMN) and under the supervision of the Hydromorphology Task Group (HYMO TG), Monitoring and Assessment Expert Group and Flood Protection Expert Group.
- Application of results of EU Danube Sediment project, mainly:
- The Danube Sediment Management Guidance, providing recommendations towards an improved sediment balance in the Danube River Basin,
- The Manual for Stakeholders, offering assistance for sediment related actions in the Danube River Basin and future programmes of measures,

- A catalogue of measures in order to mitigate the impacts, available to support targeting measures to improve the sediment balance and continuity.
- Further investigation of main pressures related to sediment balance alteration (including dams and commercial sediment excavation). Further investigation of relation between pressures (related to sediment balance alteration) hydromorphological quality elements, biological quality elements and biodiversity.
- Prevention of further deterioration of water bodies status/potential form the point of view of sediment balance and implementation of transparent assessment of non-deterioration/achievement of good status/potential for new infrastructure projects (applicability assessment related to CIS Guidance No. 36). Implementation of efficient mitigation measures.
- Further collaboration between different authorities and stakeholders for seeking of common solutions (implementation of "win–win" measures.
- Further good practice promotion on national/international level and knowledge exchange on measures related to sediment balance alteration (updating of Danube Sediment catalogue of measures).

8.1.5.2.2.2 Progress in Implementation of Measures from DRBMP Update 2015

Within the DRBMP Update 2015 measures to improve sediment balance were not planned and reported. But nevertheless, there were measures implemented in Danube countries. Based on information provided by the project partners, the DanubeSediment Project provides a collection of sediment management measures. While this does not comprise a complete list of all measures implemented in the DRB, the collected examples clearly indicate that measures are in place, with efforts to improve the sediment regime. As can be seen from this survey, already several actions are taken at the Danube River itself, at many tributaries and in the catchment. Although the improvement of sediment regime might not always have been the main aim, it can be seen that various supporting measures were already implemented, especially in the Upper Danube River Basin. These measures were summarized in the "Sediment Management Measures for the Danube" prepared in the frame of the DanubeSediment Project.

In the catchment, the implemented measures are mostly in connection with agriculture and aim to reduce the input of fertile soil into the river system. The taken actions consider technical measures, that reduce soil erosion such as afforestation or retain the sediment like riparian buffer stripes and runoff retention basins. Few non-technical measures in form of organisational and administrative support such as the provision of water consultants (for farmers and land-users) were also reported. Furthermore, sediment transfer is improved by retrofitting check-dams to self-flushing barriers.

The collected measures against erosion in the free-flowing sections of the Danube River consists of river restoration measures such as removal of bank protection, river widening and the reconnection or revitalisation of side-channels. The removal of levees for an earlier inundation of floodplains was also already implemented. Hydraulic structures such as groynes and guiding walls were optimized in some reaches to be only active at low water levels and to reduce riverbed erosion and improve flow as well as habitat conditions. Gravel feeding and adding coarser material are applied or tested measures to increase the sediment supply and increase bed resistance. Intelligent dredging and feeding management (eventually in combination with a bedload trap) is applied to keep the sediments longer in the river system. Besides the before mentioned measures which were also applied at the Danube River, additional measures as to increase the length and width of the river via re-meandering or widening and consequently decrease the river slope and transport capacity were implemented at tributaries. Open revetment and the modification from weir to ramp are applied.

The measures against sedimentation are mainly focused on the remobilization of deposited sediments in reservoirs/impoundments. For coarser sediments, this is done by dredging. These coarser sediments are mainly kept in the river system and used to build structures in free-flowing sections or impoundments, which also improve habitat diversity. Another possibility is feeding sediments back downstream of the dam to compensate the effects of the barrier. An applied measure to remobilise fine material is flushing also in combination with flood events. Additional constructive measures (e.g. groynes and guiding walls) were implemented in impoundments at tributaries to optimize flushing management. Furthermore, adaptations at the existing weirs such as reducing the fixed weir height, reducing the width of the HPP or the installation of innovative hydropower plants (e.g. movable hydropower plant) aim to improve sediment continuity. Non-technical measures include for example the optimization of operating rules to improve sluicing and flushing.

8.1.5.2.2.3 Sediment Balance Related Measures of Basin-Wide Importance

The Danube Sediment Management Guidance prepared in the frame of the DanubeSediment Project provides useful recommendations for an improved sediment balance. While it is still too early to discuss the implementation of concrete measures until 2027, these recommendations provide a good basis for designing and streamlining the next steps towards an international, sustainable and basin-wide sediment management in the DRB that:

- is based on the understanding of the system and the underlying processes, supported by comprehensive sediment, hydrological and morphological data;
- aims to restore the sediment regime as much as possible and to find a dynamic equilibrium in the Danube River and its tributaries, by reducing the pressures of the water users and, at the same time, takes into account user needs as well as safety and ecological aspects;
- considers not only the current situation but also possible future changes, such as different types of land use or climate change.

Selection of suitable measures

For the selection of sediment measures it is recommended to follow a set of criteria to assess the effects of the measure, e.g. on the hydrodynamics, water level, sediment-dynamics, morphodynamics, ecology, as well as implications on different users (e.g. hydropower, flood protection). Adequate monitoring before, during and after the implementation will help to evaluate the success of the measure and give the chance to adapt the measure, if necessary, and to learn from the implementation for future measures.

While no concrete basin-wide technical measures are planned for sediment balance improvement within the DRBMP Update 2021 (but might be planned on national levels) the ongoing discussion about next steps towards a basin-wide sediment management is an important step to significantly contribute towards the improvement of the sediment regime in the DRB. It would be very important to use the time period until 2027 to start the establishment of a harmonized sediment quantity monitoring and to plan, implement and monitor pilot sediment measures to have a sound basis for the future. For this purpose, a comprehensive catalogue of sediment measures was prepared within the DanubeSediment Project, differentiating measures at the catchment, reach/section and local scale, with a further differentiation for free-flowing sections and impoundments, reservoirs and dams (see Figure 87).

Measures at catchment scale are of great importance as they allow to address problems where the sediment production takes place. The various measures aim at both reducing excessive fine sediment inputs (e.g. from agricultural areas) and improving the sediment continuity especially for coarser sediments, that supply downstream river reaches with bedload. In addition, legal and administrative measures as well as sediment management concepts are related to the catchment respectively the basin as they have a larger scope dealing with a variety of environments and aspects (e.g. land use, land use planning and regulation, rivers, flood protection, floodplains, lakes, inland navigation, energy production).

Measures at the reach/sectional scale are divided into measures in impoundments/reservoirs and measures in free-flowing sections. Measures in the impoundments/reservoirs mainly deal with the topic how to prevent sedimentation, route/remove/remobilize sediments and which adaptive strategies are available. The measures in the free-flowing sections in turn mainly deal how to increase sediment supply or reduce erosional tendencies.

Measures at local/point scale are grouped into measures at the dam and in the free-flowing sections. Measures at the dam mainly deal with the topic how to pass sediments respectively which installations are useful to increase the efficiency of sediment management measures like sluicing or flushing. Also included are innovative types of hydropower plants that try to incorporate sediment transfer already into the design. In the free-flowing section the measures aim at increasing supply by feeding, reduce erosion respectively sedimentation or to locally protect against bank erosion.

Catchment scale

Measures in the catchment

- Sediment management concept
- Raise awareness and capacity building
- Minimize urbanisation and construction of buildings on sloped terrain
- Minimize anthropogenically caused excessive debris flow / mass movements / land slides
- Improve / adjust land use and management
- Reduce surface runoff by infiltration and retention
- Reduce undesired (fine) sediment input
- Controlled sediment transfer at barriers (improve sediment continuity)
- Adapt to impacts of climate change

Reach / sectional scale

Measures in reservoirs / impoundments

- Minimize width of the impoundment / reservoir (by hydraulic structures)
- Sediment bypass (tunnel, channel)
- Off-stream reservoirs
- Sluicing
- Venting of turbidity currents
- Environmentally friendly flushing
- Flood conditioned flushing
- Optimize flushing/sluicing strategies for dams in series
- Prevent sedimentation by artificial turbulence (jet screens)
- Wet or dry dredging and reinsertion
- Bedload drift

Measures in free-flowing sections

- Enlarge morphological space of rivers
- River widening (artificial / self-forming)
- River bank restoration
- Increase river length to reduce slope
- Reconnection of side-channels / enhance floodplain erosion
- Opening or removal of flood dykes
- Relocation / set-back of flood dykes
- Removal of natural near-river levees (bank erosion / mechanical)
- Restore wetlands
- Coarse particle feeding (granulometric bed improvement)
- Break-up of bed armouring (artificial flood / mechanical)
- Intelligent dredging and feeding management
- Fairway shifting or narrowing

Bathymetric survey
Minimize / stop commercial dredging

Local / point scale

Measures at the dam

- Minimize dam width
- Minimize fixed weir sill height
- Construct local sediment bypass
- Modify weir fields to increase sediment continuity
- Install large bottom outlets / gates for venting, sluicing or flushing
- Route sediments through turbines
- Pressure scouring
- Open ship locks for local remobilization
- Apply local artificial turbulence
- Local dredging at intake structures
- Optimize operating rules
- Innovative hydropower plants
- Remove dam / weir

Measures in free-flowing sections

- Sediment feeding
- Optimisation of river engineering structures to reduce sedimentation
- Optimisation of river engineering structures to reduce erosion
- Install bedload traps (as part of intelligent dredging and feeding management)
- Remobilisation of consolidated gravel bars
- Local bank protection for objects
- Modify / remove barriers (weirs / ramps)

Figure 87: Overview on sediment management measures (Habersack H., Baranya S., Holubova K., Vartolomei F., Skiba H., Babic-Mladenovic M., Cibilic A., Schwarz U., Krapesch M., Gmeiner Ph., Haimann M. (2019a). Danube Sediment Management Guidance. Output 6.1 of the Interreg Danube Transnational Project DanubeSediment co-funded by the European Commission, Vienna.)

8.1.5.3 Morphological Alterations

8.1.5.3.1 River Morphological Alterations

8.1.5.3.1.1 Vision and Management Objectives

The ICPDR's basin-wide vision for morphological alterations is that rivers will be revitalized/ restored and maintained in a way, that aquatic species/populations are not negatively impacted, moreover, in a way that river restorations will support improvement of connection to groundwater bodies.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- Restoration/mitigation of river morphological conditions/alterations and habitats to ensure improvement of aquatic ecosystems and water status/water potential.
- For efficient implementation of the measures, it is recommended to prepare action plans at the national level based on the JPM with detailed description (specification and location) and timeline for measures implementation addressing the improvement of river morphology that will be implemented by 2027 by each country.
- Preparation of upgraded overview on implemented measures related to river restoration within DRB.
- Further harmonisation and upgrading of methods for assessing river morphology alterations (mainly on transboundary water bodies), including further investigations of negative effects of vessels (wave effects). Further harmonisation of criteria on significant pressure related to morphological alterations.
- Implementation of a harmonized monitoring to monitor negative effects of existing morphological alterations as well as monitoring to monitor the effects of implemented measures.
- Identification of important habitats and ecological corridors for migratory fish species and the assessment of their protection status (also considering results of the MEASURES project).
- Restoration of habitats of migratory fish species, in particular sturgeons.
- Seeking for integrated win-win solutions with synergies and benefits between WFD restoration/mitigation measures and flood protection measures/drought mitigation measures (implementation of natural based solutions and green infrastructure) as well as for biodiversity conservation; additional harmonisation of different interests where win-win solutions are not possible (i.e. urbanised area).
- "Consideration of ICPDR Discussion paper – Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and solutions" – within further planning of restoration/mitigation measures and future infrastructure projects.
- Prevention of further deterioration of water bodies status from the point of view of river morphology and implementation of transparent assessment of non-deterioration/ achievement of good status/ potential for new infrastructure projects (applicability assessment related to CIS Guidance No. 36). Implementation of efficient mitigation measures.
- Further intensified cooperation between water management authorities and authorities responsible for nature protection and biodiversity. Further collaboration with agricultural sector for identification of potential lands for river restoration (application of paradigm: more space for rivers).

- Closing the knowledge gaps; e.g. the ICPDR prepared a GEF project proposal "Danube River Basin Hydromorphology and River Restoration (DYNA)" with the aim to improve the morphological conditions, strengthening HYMO method development, application and capacity building in the Danube River Basin, with a particular focus on the beneficiary countries Bosnia and Herzegovina, Republic of Moldova, Montenegro, Serbia and Ukraine. The planned project will undertake a blend of regional and national actions that support the work of the countries and policies of the ICPDR and will be augmented by national and transboundary pilots demonstrating the potential of different approaches in addressing hydromorphological pressures. By exchanging experiences on the impact of mitigation measures implemented in the Danube catchment, recommendations for future measures can be elaborated.
- Further good practice promotion on national/international level and knowledge exchange on measures related to morphological alteration (see Annex 19 on Hydromorphological lighthouse projects in the Danube River Basin); also via planned GEF DYNA project proposal).

8.1.5.3.1.2 Progress in Implementation of Measures from DRBMP Update 2015

The measures related to river morphological alterations which were planned to be implemented between 2015 and 2021 are indicated in Table 55. Data on measures were separately reported by countries. Particular measures are also presented in Annex 19 (Practice example – lighthouse projects).

In total, 114 measures were indicated in the DRBMP Update 2015, whereas in total 105 measures were finally agreed on national level to be implemented by 2021.

The implementation status in Table 55 is referring to the end of 2021. 28 measures (27%) have been completed and 21 (20%) are in the construction phase. For 13 measures (13%) the planning process is on-going, while for 42 measures (40%) the implementation process was not yet started.

Table 55: Progress in implementation of measures on river morphological alterations

Number of measures to be implemented by 2021		Implementation status			
Indicated in the DRBMP Update 2015	Finally agreed measures at national level	Not started	Planning on-going	Construction on-going	Completed
114	105	42 (40%)	13 (13%)	21 (20%)	28 (27%)

8.1.5.3.1.3 Summary of Measures of Basin-Wide Importance

Aggregated information on water body level on the measures planned to be implemented until 2027 for the improvement of river morphological alterations is summarised as follows.

There are 552 water bodies, out of total 975 water bodies, with moderately to severely altered morphological conditions (or slightly to severely altered morphological conditions in case of 2-class assessment). As illustrated in Figure 88 and on Map 37, river morphological conditions were restored by 2021 for 46 water bodies and for 92 water bodies no measures are necessary for the achievement of GES/GEP. Morphological measures are planned to be implemented for 222 water bodies until 2027. There will be no measures implemented by 2027 on 192 water bodies. Table 56 provides more detailed information for each Danube country. Obtaining a clear picture on the possibilities for morphological measures implementation by 2027 is considered as a challenge at this stage but needs to be further analysed. More capacity will have to be budgeted and invested in project preparation including screening, prioritization of sites and stakeholder consultation. This since success in measures implementation often depends on the results of negotiations between authorities, landowners and communities. Morphological measures can also be taken combined with flood protection and drought mitigation measures. The exact location for the measures or concrete possibilities for implementation are therefore often still unknown at this stage.

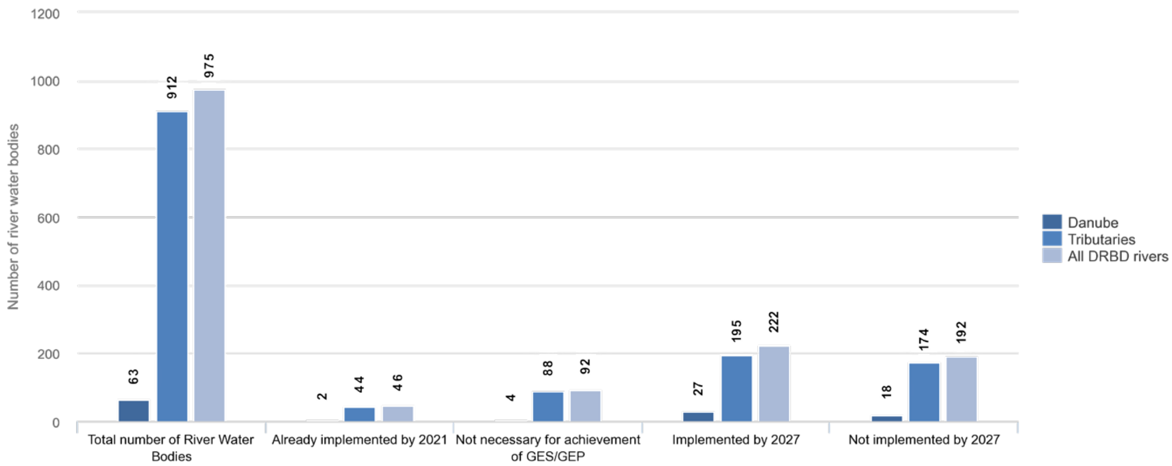


Figure 88: Number of water bodies with measures for the improvement of river morphological conditions by 2027

Table 56: Number of water bodies with measures for the improvement of river morphological conditions by 2027 per country[165]

Country	Number of River Water Bodies	Already implemented by 2021	Not necessary for achievement of GES/GEP	Implemented by 2027	Not implemented by 2027	Not yet determined
DE	58		23	33		2
AT	212	82		130		
CZ	32	7	10	15		
SK	51		9	30	12	
HU	59		13		46	
SI	27		17	10		
HR	84		61	20	3	
BA	56					56
ME	12		10		2	
RS	133		14		119	
RO	173	2	170	1		
BG	33	3	22	8		
MD	14					14
UA	31		21		10	
Total	**975**	**94**	**370**	**247**	**192**	**72**

8.1.5.3.1.4 Estimated Effect of Measures on the Basin-Wide Scale

Further progress will be made in the restoration/mitigation of river morphological conditions. Map 39 illustrates where priority measures could be implemented to achieve the estimated highest ecological effective-

165 On transboundary river water bodies values of morphological classes are reported separately for each country and may differ from each other.

ness of measures on the basin-wide scale. For a considerable number of water bodies no measures are yet determined. Further assessments will be required to clarify this issue.

8.1.5.3.2 Disconnection of Adjacent Wetlands/Floodplains

8.1.5.3.2.1 Vision and Management Objectives

The ICPDR's basin-wide vision is that floodplains/wetlands all over the DRBD are re-connected and restored. The integrated function of these riverine systems contributes to the development of self-sustaining aquatic populations, flood protection, climate change adaptation and reduction of pollution in the DRBD.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- Implementation of further measures for the protection and restoration of existing and the restoration of former (potential) wetlands/floodplains with reconnection potential with aim to achieve environmental goals (related to water status and biodiversity). Within measures implementation also other objectives related to flood protection, drought mitigation and pollution reduction have to be included (synergies between WFD-FD-HD/BD). Beneficial effects are expected to be manifold, including improvements like the provision of fish habitats for spawning, nursery and feeding.
- For efficient implementation of the measures, it is recommended to prepare action plans at the national level based on the JPM with detailed description (specification and location) and timeline for measures implementation addressing the reconnection and restoration of wetlands/floodplains that will be implemented by 2027 by each country.
- Intensification of implementation of nature-based solutions, natural water retention measures and green infrastructure measures.
- Preparation of upgraded overview on implemented measures related to reconnection of wetlands/floodplains within DRB.
- As 80% of the former wetlands/floodplains in the DRBD are considered to be disconnected, ongoing restoration/mitigation efforts and measures are needed in order to further improve the reconnection of former (potential) wetlands/floodplains in the entire DRBD. Activities on the implementation of the FD and the elaboration of the FRMP are significantly contributing to the compilation of inventories of connected and disconnected wetlands/floodplains and therefore increase the knowledge on reconnection potential.
- Harmonisation of methods for assessing significant pressures related to disconnected wetlands/floodplains and further implementation of monitoring for identification of negative impacts of disconnected wetlands/floodplains on biological quality elements.
- Application of results of EU Danube Floodplain project (2018-2021), mainly:
  - Further application of method for identification and delineation of floodplains,
  - Further application of method for assessing floodplains (FEM – Floodplain Evaluation Matrix) aiming for the definition of floodplains with highest restoration demands,

  - Application of Danube Floodplain Guidance and Manual with proposed floodplain measures and good practices – "win-win" measures for mitigation of flood risk and improvement of water status and biodiversity,
  - Implementation of Danube Floodplain roadmap with proposed action plan for measure implementation.
- Consideration of ICPDR Discussion paper – *Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and solutions* - within further planning of restoration/mitigation measures and future infrastructure projects including a more inclusive approach to restoration measures.
- Prevention of further deterioration of water bodies status/potential form the point of view of wetlands/floodplains and implementation of transparent assessment of non-deterioration/achievement of good status/potential for new infrastructure projects (applicability assessment related to CIS Guidance No. 36). Implementation of efficient mitigation measures.
- Further intensified cooperation between water management authorities and authorities responsible for nature protection and biodiversity. Further collaboration with agricultural sector for identification of potential lands for river restoration and reconnection of wetlands/floodplains (application of paradigm: more space for rivers).
- Further good practice promotion on national/international level and knowledge exchange on measures related to disconnection of adjacent wetlands/floodplains are needed (see also Annex 19 on Hydromorphological lighthouse projects in the Danube River Basin); also via planned GEF DYNA project proposal).

8.1.5.3.2.2 Progress in Implementation of Measures from DRBMP Update 2015

The measures on the reconnection of adjacent wetlands/floodplains which were planned to be implemented between 2015 and 2021 are indicated in Table 57. In total, 11 adjacent wetlands/floodplains, covering an area of 16,846 ha, were indicated in the DRBMP Update 2015 to be addressed by measures by 2021.

Construction works are ongoing for wetlands/floodplains with an area of 4,526 ha and planning is on-going for wetlands/floodplains with an area of 5,615 ha. For 9,093 ha, which are already partly reconnected, and 577 ha that are totally re-connected no further measures are planned (for more details see Annex 16). Particular measures are also presented in Annex 19 (Practice example – lighthouse projects).

Table 57: Progress in implementation of measures on reconnecting adjacent wetlands/floodplains

Area of adjacent wetlands/ floodplains with measures to be implemented by 2021	Implementation status				
Indicated in the DRBMP Update 2015	Not started	Planning on-going	Construction on-going	Completed partly re-connected	Completed, totally re-connected
16,846	0 (0%)	5,615 (28%)	4,526 (23%)	9,093 (46%)	577 (3%)

8.1.5.3.2.3 Summary of Measures of Basin-Wide Importance

Wetlands/floodplains play an important role in the ecological integrity of riverine ecosystems and are of significant importance when it comes to ensuring/achieving GES/GEP of adjacent water bodies (see Chapter 2.1.5

for details). As 80% of the former wetlands/floodplains in the DRBD are considered to be disconnected[166], ongoing restoration efforts and measures are needed in order to further improve the reconnection of wetlands/floodplains in the entire DRBD, although restoration projects have been undertaken by the Danube countries in recent years. Improvement of conditions is important also within actual floodplains, where rivers were regulated in the past and thus dynamic of flooding was changed.

The approach chosen for the JPM to protect, conserve and restore wetlands/floodplains is a pragmatic one, taking into account a background of 80% wetlands/floodplains loss. The Danube countries provide information on all wetlands/floodplains >500 ha and smaller ones of basin-wide significance, with a definite potential for reconnection, respective reconnection measures to be undertaken by 2027.

The analysis shows the area of wetlands/floodplains to be reconnected by 2027 for both the Danube River and its tributaries (Table 58). The inter-linkage with national RBM Plans is vital for wetlands/floodplains reconnection as significant areas are expected to be reconnected also to rivers with catchment areas <4,000 km^2 and with surface areas <500 ha having also positive effects on the water status and habitats of larger rivers.

Activities on the implementation of the FD and the elaboration of the Flood Risk Management Plans are significantly contributing to the compilation of inventories of connected and disconnected wetlands/floodplains and therefore increase the knowledge on reconnection potential. The value of the Flood Hazard Maps elaborated for the Danube Flood Risk Management Plan 2021 are in particular pointed out in this context. This is considered as important also due to the multiple benefits of wetlands/floodplains reconnection for flood and drought mitigation, groundwater recharge and climate adaptation[167]. Already existing studies[168] will be useful to be taken into account for this exercise.

Figure 89 and Map 16 illustrate that from the 144,659 ha of wetlands/floodplains areas, which were identified with potential for reconnection, 3,590 ha are already reconnected in 2021 also as a result of measures implementation from the DRBMP Update 2015. An area of 23,399 ha is planned to be reconnected by 2027. For 43,556 ha measures will not be implemented by 2027 and for 74,114 ha it is still not yet determined whether measures will be implemented. Table 58 further below provides more detailed information for Danube countries.

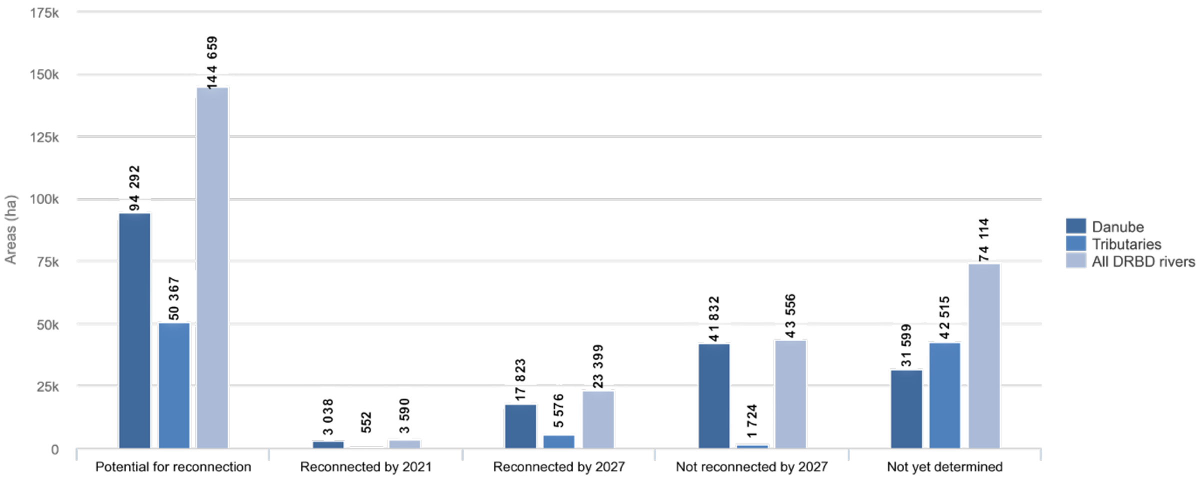


Figure 89: Measures for the reconnection of wetlands/floodplains by 2027 (areas in ha)

166 Danube Basin Analysis (2004): Danube Pollution Reduction Programme report: Evaluation of Wetland and Floodplain Areas in the DRB, 1999.

167 More information can be obtained from the EU Policy Document on Natural Water Retention Measures available at https://circabc.europa.eu/sd/a/2457165b-3f12-4935-819a-c40324d22ad3/Policy%20Document%20on%20Natural%20Water%20Retention%20Measures_Final.pdf (accessed 12 February 2021).

168 e.g. Ulrich Schwarz, FLUVIUS (2012): "Assessment of the Restoration Potential in the Transboundary UNESCO, Biosphere Reserve "Mura-Drava-Danube", Vienna; and Ulrich Schwarz, FLUVIUS (2010): "Assessment of the restoration potential along the Danube and main tributaries", Vienna (both commissioned by WWF).

Table 58: Measures for the reconnection of wetlands/floodplains by 2027 per country (areas in ha)

Country	Potential 2021	Reconnected by 2021	Reconnected by 2027	Not reconnected by 2027	Not yet determined
DE	5,964	3,038	2,926		
AT	9,554		9,554		
CZ					
SK	5,303		5,303		
HU	552	552			
SI					
HR					
BA					
ME					
RS	74,114				74,114
RO	5,616		5,616		
BG					
MD					
UA	43,556			43,556	
Total	**144,659**	**3,590**	**23,399**	**43,556**	**74,114**

8.1.5.3.2.4 Estimated Effect of Measures on the Basin-Wide Scale

In the period between 2009 and 2015, about 52,000 ha of wetlands/floodplains have been partly or totally reconnected, and their hydromorphological conditions improved respectively, followed by almost 10,000 ha between 2015 and 2021. Measures for another 23,399 ha are planned to be taken by 2027. Beneficial effects are expected to be manifold, including improvements in the functioning of the aquatic ecosystem like the provision of fish habitats for spawning, nursery and feeding. Next to being biodiversity hotspots helping to improve and secure water status, wetlands/floodplains play a significant role for flood retention and drought mitigation.

Within the Danube Floodplain Project also a catalogue of win-win measures specifically addressed to restoration and preservation of floodplains has been developed. It refers to designation of different measure, having multiple benefits in terms of reducing the flood risk, improvement of ecological and biodiversity conditions (Figure 90). The catalogue is structured on three categories:

- Technical works refers to engineering works which envisage the flood protection infrastructure (dikes, weirs, spillway);
- Floodplain morphology restoration (land cover and lateral branches) refers to engineering works which envisage the former or actual floodplain related area;
- River morphology restoration (river channel geometry alteration) refers to engineering works which envisage the river bed and river banks morphology.

Beside the win-win character, defined by the measure that can deliver to different objectives, the benefits in terms of ecosystem services is also included. The proposed catalogue presents a non-exhaustive list of measures selected on countries experience with floodplain restoration.

Catalogue of "win-win" restoration and preservation measures (for reaching flood protection, environmental, biodiversity objectives)		
Technical works (constructions)	**Floodplain morphology restoration (land cover and lateral branches)**	**River morphology restoration (river channel geometry alteration)**
- Dike relocation - Dike removal - Controlled breach within the dike - Lower river banks/dikes - Removal of weirs - Operational mode changing of reservoirs - Flood Friendly Culverts	- Convert land cover towards natural conditions - Changes in floodplain topography - Creating retention ponds - Increasing the roughness of floodplain (afforestation) - Creation and connection of new lateral channels/branches - Re-connection of lateral branches/ oxbows - Deepening lateral branches/ oxbows	- Increasing the roughness in the river channel. Restoration of natural substrate - Removing bank stabilizations / embankments - River bank re-vegetation - Implementing groynes, boulders or leaky barriers (wood) to initiate meandering - Change course of river (meandering) re-meandering - Removing ground sills, plunges

Figure 90: Catalogue of win-win restoration and preservation measures (Output of the Interreg Danube Transnational Project Danube Floodplain co-funded by the European Union)

Detailed analysis on the potential for reconnection, the establishment of an inventory, prioritisation and investigations on the different implications, what is planned to be accomplished until 2027 in coordination with the implementation of the FD, will help to gain further clarity on the estimated effects on the basin-wide scale.

Coordination of the WFD and the FD

According to FD Article 9 EU MS shall take appropriate steps to coordinate the application of the FD and of the WFD, focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in WFD Article 4.

Like the WFD, the FD requires a river basin approach, where member states develop plans to achieve the common and specific objectives of the two directives. EU MS already developed river basin management plans for the period 2009-2021, whereby the last cycle (2016-2021) coincides with the first flood risk management plans. The harmonised timelines for the WFD and FD management plans represent a great opportunity to incorporate all available status and pressure data in order to design synergistic Programmes of Measures (PoMs) that help achieve 'good status' while reducing flood risk.

Since flood protection is often identified as a main driver for hydromorphological alterations and measures to improve the hydromorphology may impact the flood risks, EU MS would benefit from implementing both directives in an integrated approach to maximise the synergies between the two policies and minimise conflicts between them. The integrated and coordinated planning under the WFD and FD has the potential to identify win-win measures that can deliver on the objectives of both policies.

An integrated approach is crucial also because of (future) climate change which might increase the magnitude and likelihood of flood events. While flooding cannot be prevented, restoring rivers to a more natural state and undertaking sustainable measures across the basin can greatly reduce their frequency and the damage they cause.

In 2015, the European Commission[169] communicated "Actions towards the "good status" of EU water and to reduce flood risks". This document highlights that measures such as the reconnection of the floodplain to the river, re-meandering, and the restoration of wetlands can reduce or delay the arrival of flood peaks downstream while improving water quality and availability, preserving habitats and increasing

169 Communication from the Commission to the European Parliament and the Council. The Water Framework Directive and the Floods Directive: Actions towards the "good status" of EU water and to reduce flood risks. COM (2015) 120 final, Brussels, 9.3.2015.

resilience to climate change. The EC also highlights EU funding possibilities EU MS should make use of such as LIFE integrated projects or Horizon2020.

Furthermore, the ICPDR discussion paper[170] lists potential conflicts but also highlights potential synergies between WFD and FD. For example, natural water retention measures can contribute to the fulfilment of both directives. Furthermore, the following recommendations were recognized in the paper:

- Implementation of concept "Giving more space to rivers"
- Prioritisation of measures
- Integrated planning on catchment scale to identify win-win solution
- Application and further investigation of effectiveness and efficiency of NWRMs
- Improvement of cooperation between experts and authorities
- Development and continuous upgrading of catalogue of measures
- Transparent assessment of impacts on WFD and FD objectives and application of WFD Article 4(7)
- Implementation of mitigation/restoration measures for reducing negative impacts.

8.1.5.4 Future Infrastructure Projects

8.1.5.4.1 Vision and Management Objectives

The ICPDR's basin-wide vision for future infrastructure projects is that they are conducted in a transparent way using best environmental practices and best available techniques in the entire DRBD – impacts on deterioration of the good ecological status/ecological potential and negative transboundary effects are fully prevented, mitigated or compensated.

Recommendations for management objectives and actions to be implemented by 2027 as steps towards the vision:

- For new infrastructure projects it is of particular importance that environmental requirements are considered as an integral part of the planning and implementation. Deterioration of the water ecological status/potential should only be allowed as set by the WFD (considering WFD Article 4(7) requirements). All practicable measures to prevent, mitigate or compensate (in case prevention and mitigation is not possible) negative effects will be implemented.
- Furthermore, the Environmental Impact Assessment and Strategic Environmental Assessment Directives and related requirements also need to be taken into account, including requirements for coordinated (and/or joint procedures for) projects/strategies assessments with a view to environmental and water management aspects.
- A Catalogue of mitigation/restoration measures was developed in the frame of ICPDR (2019) and can be used also for selection of mitigation/restoration measures for reducing the negative impacts of new infrastructure projects.

170 ICPDR (2019), Discussion paper – Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits. To be downloaded here: https://www.icpdr.org/main/resources/discussion-paper-coordinating-wfd-and-fd (accessed 16 February 2021).

- In the framework of the ICPDR guidance for targeted inter-sectoral cooperation, activities have been launched during the past years, such as for the navigation sector (Joint Statement process), hydropower (Guiding Principles) and a coordinated implementation of the WFD and FD. Efforts towards integration between different sectors, i.e. water management, navigation, hydropower and flood protection, will be continued. Pre-planning procedures should be conducted with stakeholder participation to ensure that impacts are avoided, and the best environmental option is chosen for new infrastructure projects.
- Improvement of ecological status/potential in case of new flood risk management measures, and improvement of ecological situation in case of required refurbishment/maintenance/reconstruction of existing structures by making best use of synergies.

8.1.5.4.2 Progress in Implementation of Measures from DRBMP Update 2015

In order to prevent and reduce basin-wide and transboundary effects from future infrastructure projects in the DRBD, the development and application of BAT and BEP is crucial. For new infrastructure projects, it is of particular importance that environmental requirements are considered as an integral part of the planning and implementation process, beside the involvement of stakeholders right from the beginning.

In the DRBMP Update 2015 the intention was indicated of further developing respective processes and guidance documents in this regard. Such a process was already started for the navigation sector (Joint Statement) in 2007 but similar approaches were launched in the frame of the ICPDR in the meantime and as part of the implementation of the JPM. In 2011 the elaboration of "Guiding Principles on Sustainable Hydropower Development in the Danube Basin" started. The document was finalized and adopted by the ICPDR in June 2013. Furthermore, exchange on sustainable flood risk management is ongoing in the frame of the coordinated implementation of the WFD and FD. Details on those processes can be obtained from Chapter 6 on integration issues.

8.1.5.4.3 Summary of Measures of Basin-Wide Importance

As analysed in Chapter 2, a significant number of FIPs (navigation and flood protection) may have negative impacts on water status by 2027 and need to be addressed accordingly. 28 FIPs have been reported for the DRBD according to the criteria (as outlined in Table 22 and are illustrated on Map 1). The majority of them is located in the Danube River itself.

For 11 FIPs, SEAs have been performed during the planning process. Further, EIAs have already been performed for 12 FIPs and are intended for another 13 FIPs. 17 FIPs are expected to have a negative transboundary impact on other water bodies and 18 FIPs are expected to provoke deterioration of water status, for which exemptions according to WFD Article 4(7) are applied (see Annex 7 for details).

The management objectives include precautionary measures (best environmental practices and best available techniques) that should be implemented to reduce and/or prevent impacts on water status. For new infrastructure projects, it is of particular importance that environmental requirements are considered as an integral part of planning and implementation right from the beginning of the process. In the framework of the ICPDR, respective guidance has been developed in this regard for inland navigation (Joint Statement) and hydropower (Guiding Principles). Both documents describe respective processes in detail and the organisation of regular meetings to facilitate the follow-up discussions will help the exchange of experiences for practical application. The management objectives also indicate precautionary measures with regard to sustainable flood risk management.

Table 59: Main purpose of future infrastructure projects (FIPs) by 2027 per country[171, 172]

Country	Flood protection	Hydropower	Navigation	Others
DE			2[173]	
AT				
CZ				
SK				
HU	3		1	
SI				
HR	3			
BA				
ME				
RS		2	2	
RO			6	3[174]
BG			6	
MD				
UA				
Total	**6**	**2**	**17**	**3**

8.1.5.4.4 Estimated Effect of Measures on the Basin-Wide Scale

Planning and implementing FIPs in a sustainable and integrated manner is a key issue, beside taking measures on already existing hydromorphological pressures. Integrating environmental legal requirements from the beginning in the planning processes will be fundamental for securing water status. It can be estimated that the already ongoing and planned further measures on inter-sectoral cooperation in the frame of the ICPDR will have a significant positive effect on the basin-wide scale in case properly implemented and reflected at the national level.

8.1.6 Hydromorphological Measures Addressing Adaptation to Climate Change Impacts

As hydromorphological pressures play an important role for the good (ecological) status of surface waters, the need for measures in this sector is, also with regard to increased resilience to climate change, of particular importance. Hydromorphological measures[175,] such as adaptation of land use in river basin, restoration of former (potential) floodplains[176] and conservation of actual floodplains, river revitalisation, creation of buffer strips (riparian zones), revitalisation of drainage systems and implementing of ecological flow positively

171 The 12 projects related to navigation indicated for BG and RO are sections of the same transboundary project „Fast Danube".

172 Data reported for RS is not based on an official WFD Article 4(7) application as there is no transposition of WFD exemptions in national water law yet.

173 Future infrastructure projects can have multiple purposes, e.g. the main purpose of the project "Straubing-Vilshofen" in Germany is twofold: improvement of flood protection, and navigation.

174 Two coastal water bodies (Cap Singol-Eforie Nord - CT02_B1 and Eforie Nord-Vama Veche - CT02_B2) are subject to WFD Article 4(7) having in view the project "Protection and rehabilitation of the coastal areas - Phase II".

175 Hydromorphological measures are in more detail described within Catalogue of Mitigation/Restoration Measures for the Danube River Basin (Overview) to be accessed on www.icpdr.org (accessed 15 October 2021).

176 Potential floodplains are former floodplains that can be restored (considering realistic possibilities for restoration).

contribute to minimize the effects of climate change. For some hydromorphological measures, there is also a close link to measures foreseen in FRMPs (e.g. restoration of former (potential) floodplains, conservation and restoration of actual floodplains) and link to drought management, while in general all hydromorphological measures support goals of EU Biodiversity Strategy for 2030.

Implementation of concept "Giving more space to rivers" is recognized as one of the most important recommendations for achieving common synergies and benefits between WFD and FD objectives. To reduce flood risk, high priority has to be put on a sound planning process followed by non-structural (spatial planning) measures. Emphasis has to be put on green measures (natural based solutions – NBS and natural water retention measures – NWRMs). However, for densely populated areas or areas with high land use pressure, and no availability of retention areas at hand, structural measures have to be applied by means of flood risk reduction.[177]

It is important that NBS/NWRM are applied from local to basin wide scale on a long-term basis and in cooperation with multiple partners (e.g. agriculture, hydropower). In that case, NBS/NWRM can cumulatively provide positive effects on flood peak reduction, prolongation of flood waves and minimisation of downstream negative impacts. Beside mitigation of floods problematic, those measures are also very important for mitigation of drought impacts and impacts of worsened water quality due to pollution.[178]

Potential hydromorphological measures related to climate change adaptation

Protective measures:
- Wise land use planning,
- Water abstraction controls (guarantee of environmental flows),
- Land purchases (preservation of water, riparian and adjacent land),
- Protection of river corridors, floodplains, wetlands (implementation of protective regimes) from further development and new men-made physical modifications,
- Transparent impact assessment of new physical modifications and definition of effective mitigation measures,
- Capacity building (technical assistance to local managers).

Reactive (enhancing) measures:
- Implementation of natural based solutions, natural water retention measures,
- Adaptation of land use in river basins,
- Restrictions of water use in periods with water deficits, prioritisation criteria in case of multipurpose water use,
- Upgrade of irrigation systems (increasing the irrigation efficiency),
- Water savings at the level of all uses and reducing leakages in water distribution networks,
- Adjustments of reservoir operation (related to water and sediment dynamics),
- Improvement/restoration of drainage systems,
- Adequate sediment management,
- River/floodplain/wetland restoration,
- Creation of riparian buffer strips.

Other measures:
- Efficient monitoring and further analysis of climate change effects and multi-stressors impacts on water ecosystems.

Figure 91: Potential hydromorphological measures related to climate change adaptation

177 ICPDR (2020): Coordinating the WFD and the FD: Focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits. Discussion paper. https://www.icpdr.org/main/wfd-fd-plans-published-2021 (accessed 16 February 2021).

178 EC (2014): A guide to support the selection, design and implementation of Natural Water Retention Measures in Europe. Final Report. http://nwrm.eu/guide/files/assets/basic-html/index.html#1 (accessed 16 February 2021). Ecofys (2016): Assessing Adaptation Knowledge in Europe: Ecosystem-Based Adaptation. Final Report. https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/ecosystem_based_adaptation_en.pdf (accessed 16 February 2021).

There is need for implementation of protective and reactive (enhancing) measures before the effects of climate change become severe. Protective measures are intended to maintain or increase resilience of rivers and water ecosystems (e.g. floodplains preservation). Reactive (enhancing) measures are intended for repairing damage or mitigating ongoing impacts. The highest need for those measures is needed for rivers and basins that are already affected by hydromorphological pressures.

Wise land use planning and protection of river corridors, floodplains and wetlands are main protective measures that bring benefits not only to water ecosystems quality but also to minimisation of negative effects of climate change. Within reactive (enhancing) measures, restoration of rivers, floodplains and wetlands are important. Crucial role within restoration play riparian zones, which can promote water infiltration, mitigate flood events and recharge groundwater. Beside hydrological benefits, they are also important because they enhance connectivity (ecological corridors), promote linkages between aquatic and terrestrial systems and represents thermal refuge (they absorb heat, maintain cooler water temperature by shading water from sunlight and the infusion of cold groundwater).[179]

For successful implementation of listed hydromorphological measures, there is need for good cooperation among multiple partners from different sectors. Especially in the light of climate change, it is also important to raise awareness for the necessity to increase the funding available for hydromorphological issues to a level similar to investments targeting pollution as well as to share the financial burden for projects with international / basin wide benefits. Additionally, partners from local to basin wide level have to be part of common process of adaptation to climate change.

8.2 Surface Waters: Lakes, Transitional Waters and Coastal Waters

No measures for lakes, transitional and coastal waters were reported.

8.3 Groundwater

This chapter summarizes the measures for the 12 GWBs of basin-wide importance in the DRB. An indicative overview of the measures is shown in Table 60. This table is showing both the progress in implementation of the DRBMP Update 2015 as well as the measures planned for the period 2021-2027. Detailed information on the relevant measures for each GWB is given in the Annex 8.

179 Seavy, N. E., Gardali, T., Golet, G. H., Howell, C. A. (2009): Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research. Ecological Restoration, 27(3)330-338. https://doi.org/10.3368/er.27.3.330; IUCN (2016): Nature-based solutions to address climate change. Paris, France. https://portals.iucn.org/library/sites/library/files/documents/2016-062.pdf (accessed 16 February 2021).

Table 60: GWBs at poor status and implemented measures

DRBD-GWB	GWB-4	GWB-5			GWB-7			GWB-8	GWB-9		GWB-10		GWB-12
National part	**RO-4**	**RO-5**	**HU-5**		**HU-7**		**RS-7**	**SK-8**	**HU-9**	**SK-9**	**HU-10**	**SK-10**	**SK-12**
Poor status (Chem or Quant)	**Chem**	**Chem**	**Chem**	**Quant**	**Chem**	**Quant**	**Quant**	**-**	**Quant**	**Chem**	**-**	**-**	**Chem**
Risk (Chem or Quant)	**Chem**	**Chem**	**Chem**	**Quant**	**Chem**	**Quant**	**Quant**	**Chem**	**Chem Quant**	**Chem**	**Chem**	**Quant**	**Chem**
Basic Measures (BM) – Article 11(3)(a)													
BM-01 BathingWater													
BM-02 Birds													
BM-03 DrinkingWater	MO	MO						MO					
BM-04 Seveso													
BM-05 EnvironmentalImpact													
BM-06 SewageSludge													
BM-07 UrbanWasteWater	CO	CO	MO		MO			CO	MO	CO			
BM-08 PlantProtectionProducts			MO		MO			MO		MN			MO
BM-09 Nitrates	MO	MO	MO		MO			MO	MO	MN			MO
BM-10 Habitats													
BM-11 IPPC													
Other Basic Measures (OBM) – Article 11(3)(b-l)													
OBM-20 CostRecovery-WaterServices													
OBM-21 EfficientWaterUse													
OBM-22 ProtectionWater-Abstractions			MP		MP						MN		
OBM-23 ControlsWaterAbstraction				MP		MP			MP			MN	
OBM-24 RechargeAugmentation-Groundwater													
OBM-25 PointSourceDischarge													
OBM-26 PollutantsDiffuse			MP		MP								
OBM-27 AdverseImpact													
OBM-28 PollutantDirect-Groundwater													
OBM-29 SurfacePriority-Substances													
OBM-30 AccidentalPollution													
Supplementary Measures (SM) – Article 11(4)&(5)	MO	MO	MP	MP	MP	MP		MO	MP	MN	MN		MO

** The information for RS-7 will be provided, when the national Plan is officially adopted.*

MO...*Measure implementation on-going after the end of 2020,* **CO**...*Construction on-going after the end of 2020,* **MN**...*Measure implementation not started by the end of 2020,* **MP**...*Measure implementation not started by end 2020, implementation of measure is planned.*

8.3.1 Groundwater Quality

8.3.1.1 Vision and Management Objectives

The ICPDR's basin-wide vision is that the emissions of polluting substances do not cause any deterioration of groundwater quality in the Danube River Basin District. Where groundwater is already polluted, restoration to good quality will be the ambition.

The following management objectives will be implemented by 2027 as steps towards the vision:

EU Member States, Candidate Countries and Non-EU Member States:

- Elimination/reduction of the amount of hazardous substances and nitrates entering the groundwater bodies in the DRBD to prevent deterioration of groundwater quality and to prevent any significant and sustained upward trends in the concentrations of pollutants in groundwater.
- Implementation of the management objectives described for organic, and nutrient pollution as well as for pollution by hazardous substances of surface waters (see above).
- Increase of the wastewater collection and treatment efficiency and level thereafter.
- Implementation of Best Available Techniques and Best Agricultural Practices.
- Reduction of pesticide/biocides emission in the DRBD.
- Close knowledge gaps concerning the presence of emerging substances in groundwater.

In addition, for EU Member States:

- Implementation of the principle concerning prevention/limitation of pollutants inputs to groundwater according to the EU Groundwater Directive (GWD, 2006/118/EC).
- Implementation of the EU Nitrates Directive (91/676/EEC).
- Implementation of the Sustainable Use of Pesticides Directive (2009/128/EC), the Regulation (EC) No 1107/2009 and Regulation (EU) No 528/2012.
- Implementation of Urban Wastewater Treatment Directive (91/271/EEC).
- Implementation of the Industrial emissions (Integrated Pollution Prevention and Control) Directive (2010/75/EU), which also relates to the EQS Directive 2013/39/EU.
- Implementation of the Industrial Emissions Directive (2010/75/EU).

8.3.1.2 Progress in Implementation of Measures from DRBMP Update 2015

National shares of transboundary groundwater bodies of basin-wide importance failing good chemical status and at risk of failing good status were reported by Hungary, Romania and Slovakia.

Hungary reported to continue implementing the UWWD and the EU Plant Protection Action Programme with some additional voluntary measures planned under the Common Agricultural Policy (CAP) 2021-27. The ongoing implementation of the Nitrates Directive with the Nitrate Vulnerable Zones (NVZ), which were revised in 2013, the Code of Good Agricultural Practice (GAP) and assisting voluntary agri- environmental measures are tackling nutrients pollution from agricultural activities.

Hungary also plans with the implementation of the CAP 2021-27 to elaborate, introduce and subsidise measures to support water protective agricultural practices in drinking water protection zones (e. g. forestation) and to introduce special practices for areas prone to erosion, excess water or droughts. In addition, water monitoring in Hungary will be strengthened by a 650k€ project which is going to be funded by DG Reform under the Technical Support Instrument (TSI 2021).

Since 2013, in line with the national legislation, the whole territory approach of the Nitrate Directive has been applied in Romania for the implementation of the national Action Plan for the protection of waters against pollution caused by nitrates from agricultural sources. Romania is in process of establishing safeguard zones and buffer zones for all drinking groundwater abstractions in order to prevent the water resources contamination. In addition, the implementation of a research study for the development of modelling tools for the evaluation of spatial and temporal pollutants migration is ongoing. This study will provide the evaluation methodology for groundwater status and for pollutant trends. The construction of collecting systems and the improvement of UWWTP is also ongoing in Romania.

Slovakia continues re-assessing whether safeguard zones and the restrictions in the DWPAs are sufficient in protecting drinking water resources. All efforts are made to meet the requirements arising from the implementation of Directive 2009/128/EC concerning the reduction of pesticides pollution from agriculture and implementation of this Directive into the national Law and the National action programme to achieve sustainable use of pesticides. Measures are being applied concerning the placing of plant protection products on the market according to Regulation No. 1107/2009 of the EU Parliament and of the Council. The measures under the Nitrates Directive are applied in the NVZs and the national regulation will be revised in Slovakia in 2021/2022. The continued application of measures according to the Rural Development Programme (2014–2020) is extended until 2022, when the new CAP enters into force. The measures include advisory services for agriculture, support for organic farming, managed agricultural and forestry activities in NATURA 2000 areas, etc. The continuing remediation and monitoring of priority contaminated sites listed in the Information System of Environmental Loads according to the State Remediation Programme of Environmental Loads (2022–2027) tackles point source pollution.

According to the Slovak Plan of Public Sewerage System Development for 2021–2027, sewer networks in two agglomerations (>2000 PE) and one WWTP need to be (re)constructed or upgraded. In addition, research, targeted monitoring, strengthening of control activities, education and training in the field of water protection for professionals and public (including schools) are aiming at protecting groundwater quality in Slovakia.

It has to be pointed out that the progress in implementation of the JPM reported in the chapters on pollution by organic substances, nutrients and hazardous substances for surface water bodies, has consequently a positive effect on the improvement of the chemical status of groundwaters.

8.3.1.3 Summary of Measures of Basin-Wide Importance

Taking into account that contamination by ammonium and nitrates is a key factor against achieving *good chemical status* of a significant portion of the GWBs of basin-wide importance, and in line with the management objectives, it is essential to eliminate or reduce the amount of ammonium and nitrates entering groundwater bodies in the DRBD. Prevention of deterioration of groundwater quality and any significant and sustained upward trend in concentrations of ammonium and nitrates in groundwater has to be achieved primarily through the implementation of the EU Nitrates Directive and also the UWWTD.

To avoid the presence of hazardous substances in groundwater aquifers, additional measures need to be taken as required under the following Directives:

a. Drinking Water Directive (80/778/EEC) as amended by the Directive 2020/2184 of the European Parliament and of the Council;
b. Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market;
c. Sustainable Use of Pesticides Directive (2009/128/EC);
d. Habitats Directive (92/43/EEC);
e. Integrated Pollution Prevention Control Directive (96/61/EC) as amended by IED 2010/75/EU.

To prevent pollution of GWBs by hazardous substances from point source discharges liable to cause pollution, the following measures are needed: an effective regulatory framework ensuring prohibition of direct discharge of pollutants into groundwater; setting of all necessary measures required to prevent significant losses of pollutants from technical installations; the prevention and/or reduction of the impact of accidental pollution incidents.

More detailed information on scenarios and specific actions to be taken to reduce or eliminate the presence of polluting substances in surface water bodies, which has a clear effect on the status of groundwaters, is given in other sections in Chapter 8.1.

It can be concluded that in agreement with the ICPDR's basin-wide vision, emissions of nitrates, other nutrients and relevant hazardous substances need to be sufficiently controlled so not to cause any deterioration of groundwater quality in the DRBD. Where groundwater is already polluted, restoration to good quality by a thorough implementation of the respective EU legislation is essential.

8.3.2 Groundwater Quantity

8.3.2.1 Vision and Management Objectives

The ICPDR's basin-wide vision is that the water use is appropriately balanced and does not exceed the available groundwater resource in the Danube River Basin District, considering future impacts of climate change.

The following management objectives will be implemented by 2027 as steps towards the vision:

EU Member States, Candidate Countries and Non-EU Member States:

- Over-abstraction of GW-bodies within DRBD is avoided by sound groundwater management.

In addition, for EU Member States:

- Implementation of WFD requirements that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction.

8.3.2.2 Progress in Implementation of Measures from DRBMP Update 2015

National shares of transboundary groundwater bodies of basin-wide importance failing good quantitative status were reported by Hungary and Serbia. Information on measures taken in Serbia is missing as the establishment of the national RBMP is still in progress.

Hungary focuses its efforts on measures for the inland excess water retention and on the development of a water information system for the electronic authorisation. Also, the planning of measures to protect the groundwater resources under the new CAP is ongoing. A new regulation on water management is elaborated to take action against the installation and use of illegal agricultural water wells.

8.3.2.3 Summary of Measures of Basin-Wide Importance

The ICPDR vision for groundwater quantity stipulates that water use in the DRBD has to be appropriately balanced taking into account the conceptual models for particular GWBs and should not exceed the available groundwater resource in the DRBD. In line with this vision, the over-abstraction of GWBs within the DRBD should be avoided by effective groundwater and surface water management. Therefore, appropriate controls regarding abstraction of fresh surface water and groundwater and impoundment of fresh surface waters (including a register or registers of water abstractions) must be put in place as well as the requirements for prior authorisation of such abstraction and impoundment. In line with the WFD, it must be ensured that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction.

The concept of registers of groundwater abstractions is well developed throughout the DRBD. The Ministry of Environment and Water in Bulgaria maintains a national register of abstraction permits. A central register of groundwater abstractions based on the National Water Law is updated annually in Slovakia. In Hungary, a Groundwater Abstractions register is published yearly and it contains data on the withdrawals of the operating, monitoring and reserve wells. In Bavaria, water suppliers are obliged to report annual data to local authorities on overall water abstraction and specific abstractions from spring sources. Bavaria and Austria cooperate on the annual preparation of a register of abstractions from the thermal water of the Lower Bavarian - Upper

Austrian molasses basin (GWB-1). In Romania, the National Administration "Romanian Waters" maintains the national register of abstraction permits according to the National Water Law.

To prevent deterioration of groundwater quantity as well as the deterioration of dependent terrestrial ecosystems, solutions for the rehabilitation (e.g. natural water retention) have to be explored. These should include restoration of wetland areas, which are in direct contact with aquifers.

8.3.3 Groundwater Measures Addressing Adaptation to Climate Change Impacts

At present there have not been identified any groundwater related measures for the 12 GWBs of basin -wide importance specifically addressing only the impacts of the climate change. It is advisable to use the measures already in place and to strengthen the general measures, which address climate change impacts.

The existing groundwater-related measures addressing the improvement of the quantitative and chemical status which will certainly support climate change adaptation include: the use of infiltration models to assess the changes of infiltration rates in lowlands including groundwater level monitoring to assess groundwater balance for these models; application of water saving methods and water regulation to protect groundwater quantity; update of soil erosion maps; reduction of infiltration of hazardous substances and trapping of nutrients by organic components of the soil; prevention of soil degradation by good agricultural practice shall protect groundwater quality.

8.4 Effects of Climate Change (Drought, Water Scarcity, Extreme Hydrological Phenomena and other Impacts)

8.4.1 Vision and Management Objectives

The ICPDR's basin-wide vision to deal with adaptation to and mitigation of water related effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts) is to make full use of our wealth of knowledge on River Basin Management to meet the challenges posed by climate change, to achieve resilience and ultimately sustain the inherent ecological and cultural value of the aquatic environment for the Danube River Basin. Preventive measures will be taken to mitigate impacts of climate change, to adapt to it and to minimise the related damages, thus reducing the vulnerability of aquatic ecosystems and water related ecosystems to climate change.

8.4.2 Summary of Measures of Basin-Wide Importance

As a frontrunner and pioneer among transboundary river basin commissions, the ICPDR adopted the first ICPDR Strategy on Adaptation to Climate Change in 2012. Based on this strategy, the ICPDR was able to integrate climate adaptation issues into the DRBMP Update 2015 and the DFRMP in 2015.

The 2018 Update of the ICPDR Strategy on Adaptation to Climate Change takes further steps to promote action in a multilateral and transboundary context. It serves as a reference document for national strategies and activities in general and, more specifically, gives guiding principles and outlines suitable adaptation measures for the national and international RBMPs and FRMPs and provides an overview of relevant background and framework conditions. The principles and measures included are widely recognized within and beyond the boundaries of the DRB and are also reflected in the new EU Strategy on Adaptation to Climate Change[180].

Addressing the effects of climate change, such as droughts and water scarcity, is essential for the achievement of WFD objectives, as illustrated by the need to ensure the quantitative status of groundwater bodies and to achieve good ecological status/potential in surface waters (including in terms of ensuring sufficient river flows) as specified by the WFD. Climate adaptation measures are often closely linked to other SWMIs for the Danube River Basin. For example, measures to mitigate hydromorphological alterations have to take the increased likelihood of water scarcity or other extreme hydrological phenomena into account. Those measures and natural and urban water retention measures are instrumental in increasing the resilience of ecosystems to these climate change impacts.

In 2020, the ICPDR commissioned a background document on the "Support in identification of future scope, technical solutions and next steps towards a Danube wide water balance", which builds upon outcomes of two activities performed within the framework of the ICPDR in 2019: 1) the Scoping Study on Knowledge Base and Overall Concept of the Project on Hydrological Modelling of Water Balance for the Danube River Basin, finalized in March 2019, and 2) a survey by means of the Questionnaire on the ICPDR water balance – Scope, possible alternative solutions and next steps – which (questionnaire) was prepared by the ICPDR Secretariat in July 2019, based on the Scoping Study and discussions within the ICPDR's RBM EG. The background document serves as input for further discussions in the ICPDR and tackles main issues of water balance development in the Danube River Basin, including basic definitions, discussion on the objectives and the scope, as well as operative questions of water balance development. The modelling approach and model selection are elaborated, organizational aspects are addressed and an overview of models applied in the Danube River Basin, and their key features, is provided. The outcomes will furthermore serve to narrow down the scope and technical details needed for drafting the Terms of Reference (project concept) for the water balance model development. The lead countries HU and RS guiding water balance activities within the ICPDR, together with core drafting group members from HU, RS, AT and RO, prepare a project concept for submission to the EU Interreg Danube Transnational Programme call in spring 2022.

The ICPDR is aiming to help Danube countries to better align water and agricultural policies by publishing a guidance document on sustainable agriculture. One of the main elements of the guidance is related to drought and water scarcity including management strategies and concrete measures to be implemented. In this respect, smart irrigation techniques should be promoted that are modern, efficient, water saving and adjusted to the specific conditions (e.g. soil moisture deficit, crop production). Maintaining water in the landscape (nature water retention measures) can help alleviate drought and water shortage. Agricultural producers would also benefit from in-situ monitoring support including detailed data on land, water, soil and meteorology as well as from modelled data and drought forecast.

Significant progress has also been made in the scientific domain, in raising awareness and providing support to governments. Several projects have contributed to widening the knowledge base in different research areas and regions, providing monitoring tools and management guidelines for policy-makers and water managers, e.g. with regard to droughts: DROUGHT-R&SPI, DEWFORA, PESETA and regional cooperation programmes such as EUROCLIMA. Multi-beneficial measures are also investigated (e.g. in the Danube Floodplain Project) and can ensure that relevant aspects (e.g. floods, hydromorphology and biodiversity) are addressed.

180 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change, COM/2021/82 final. To be downloaded from https://ec.europa.eu/clima/policies/eu-climate-action_en. (accessed 14 September 2021).

In addition, WMO and GWP CEE have been running a joint Integrated Drought Management Programme in Central and Eastern Europe (IDMP CEE) since 2015 that supports governments with the development of drought management policies and plans. In this context, there is also ongoing work in the frame of the Drought Management Centre for South-Eastern Europe (DMCSEE) to support activities in the region.

A major contribution was the implementation of the DriDanube Project and the preparation of the Danube Drought Strategy. The project aimed at increasing the society's resilience to the occurrence of drought in the Danube region by developing a regional drought monitoring tool and a strategic document on improved national response to drought.[181]

The updated DRBMP summarises the available knowledge base on the impacts of climate change in line with the cross-cutting character of this issue vis-à-vis the other SWMIs. This has also served to identify most relevant and appropriate measures for the JPM.

8.4.3 Estimated Effect of Measures on the Basin-Wide Scale

In a changing climate, the objectives of the WFD can only be met if expected climate change impacts, especially changes in the hydrological regime leading to an increased likelihood of drought and water scarcity, are taken into account when planning and implementing the programme of measures. The central positive effect of taking climate change into account, is that it helps to make other measures, i.e. those described in Chapters 8.1.1 to 8.1.3, as effective as possible in reducing pressures resulting from human activity. Typically, climate change adaptation measures will increase the overall resilience of existing ecosystems, generally making the measures "no-regret-measures" that work in favour of all WFD objectives, including the objective of non-deterioration. In short, "climate proofing" the programmes of measures at both the national and basin-wide scale can ensure that the JPM delivers the intended results in a cost effective and sustained way.

8.5 Financing the Joint Programme of Measures

For successfully implementing the Joint Programme of Measures and reaching "good status" in the Danube River Basin, it is necessary to mobilize adequate ways of financing the planned measures. This, although some measures in the DRBMP/JPM might be implemented without major investment of financial resources. The WFD implementation is a national responsibility and as such, the financing of measures is the responsibility of each national government (or private owners and operators of facilities which influence water quality).

A number of EU-supported funding programs are available for some of the measures. This is particularly important for new EU MS which will clearly rely upon EU funding for measures with regard to wastewater treatment, agriculture or hydromorphological alterations. As far as possible, funds available for other programs (CAP, LIFE, etc.) have been in the past, and can be in the future, utilized by EU MS to address a number of specific problems and to implement necessary measures.

The DRB is composed of both EU MS and non-EU MS. In general, the funding of measures in non-EU MS is more difficult than for those countries which have the legal obligation to fulfil the WFD. This is particularly the case because the general level of economic well-being in Danube countries varies significantly from west to east. In addition, non-EU MS do not have Cohesion Funds which they can draw upon to finance wastewater treatment or other necessary measures. Applying for and securing funds for financing the JPM also faces multiple challenges, especially in terms of skills and capacity for the sometimes complex application procedures and preparation of bankable project proposals.

181 For more information see http://www.interreg-danube.eu/approved-projects/dridanube (accessed 16 February 2021).

The challenges, problems and approaches for securing financing for the implementation of the JPM have been addressed in the frame of the ICPDR for the preparation of the DRBMP Update 2021, also considering the question how the financing of necessary measures in non-EU MS could be supported[182]. In the following, an overview is provided on the different SWMIs and cross-cutting issues, related key measures and possible financing sources and funding instruments (see Table 61) with the intention for being useful for the countries in securing financing opportunities for WFD implementation. More detailed information can be obtained from the table in Annex 21, which is organized by financing source/program, and which also includes a table that depicts which funding instruments have been used by which Danube countries in the last WFD implementation cycle.

The key funding instruments include the following:

- The European Regional Development Fund (ERDF) is aimed at economic, social and territorial cohesion in the EU.
- The European Social Fund Plus (ESF+) is the main financial instrument to strengthen Europe's social dimension, for investing in employment opportunities (especially of young people), better education, improvement of the situation of the most vulnerable people.
- The Cohesion Fund (CF) 2021-2027 invests in all regions on the basis of 3 categories (less-developed; transition; more-developed), determined by Gross National Income (GNI) and GDP/capita. New criteria are youth unemployment, low education level, climate change, and the reception and integration of migrants. It is of particular relevance for new EU Member States.
- The European Maritime and Fisheries Fund (EMFF) supports marine and fisheries policies in the EU. It is aimed at supporting the European fisheries sector towards more sustainable fishing practices, with a particular focus on supporting small-scale fishermen.
- The European Agricultural Fund for Rural Development (EAFRD) is the main instrument to finance the Rural Development and Agri-Environmental Programs of the EU Common Agricultural Policy.
- Horizon Europe is the funding programme for research and innovation for the period 2021-2027.
- LIFE is the EU's financing programme entirely devoted to environmental and climate-related objectives.
- INTERREG VI/European Territorial Cooperation (ETC) focus on cooperation between regions and countries.
- The Neighbourhood, Development and International Cooperation Instrument (NDICI) provides direct support for the EU´s external policies, including environmental protection.
- The Instrument for Pre-Accession Assistance (IPA III) provides (in the Danube RB) assistance for transition and institution building and funds cross-border cooperation.
- Invest EU, a new EU support programme from 2021-2027, provides bank guarantees, with the Invest EU Advisory Hub providing support and guidance.
- Finally, wherever appropriate, the EU temporary recovery instrument "NextGenerationEU" (a € 750 billion fund to help repair the immediate economic and social damage brought about by the COVID-19 pandemic) can and should be used for financing of WFD-measures in EU Member States. While this fund offers substantial new funding opportunities, the "Do No Harm principle" has to be considered when planning/executing new projects.

ERDF, ESF+, CF, EAFRD and EMFF together form the EU's five structural and investment funds (ESIF). For the European programming period 2021-2027, the European Commission changed the ESIF´s framework. The new framework combines the necessary stability in investment planning with the appropriate level of

182 E.g. during the HYMO-BIO Workshop on the financing of hydromorphological measures in September 2018 in Romania, and during all ECON TG meetings.

budgetary flexibility to cope with unforeseen events[183]. A mid-term review will determine if changes in the programmes are needed for the last two years of the funding period, based on emerging priorities, performance of the programmes and the most recent Country-Specific Recommendations. Within certain limits, transfers of resources will be possible within programmes without the need for a formal Commission approval. A specific provision makes it easier to mobilise EU funding as of day one in the event of a natural disaster.

Table 61: Overview SWMIs, measures and potential funding sources

SWMI and cross-cutting issues	Measures	Possible financing source/programme (EU)	Possible financing source/programme (non-EU)
Organic Pollution	UWWTP	ERDF, CF	NDICI, IPA III
	Industrial point sources (direct discharges)	ERDF, CF, ESF+ (capacity building/training)	NDICI, IPA III
	Animal feeding/breeding lots	EAFRD	NDICI, IPA III
Nutrient Pollution	Diffuse sources: agriculture	ERDF, EAFRD, LIFE, ESF+ (capacity building/training)	NDICI, IPA III
	Diffuse sources: atmospheric deposition	EAFRD (concerning agricultural atmospheric emissions)	NDICI, IPA III
	Diffuse sources: urban run-off	CF, potentially LIFE	Potentially LIFE, NDICI, IPA III
	UWWTP	ERDF, CF	NDICI, IPA III
	Industrial point sources (direct discharges)	ERDF, CF, ESF+ (capacity building/training)	NDICI, IPA III
	Animal feeding/breeding lots	EAFRD	NDICI, IPA III
Hazardous Substances Pollution	Industrial point sources (direct discharges)	ERDF, CF, ESF+ (capacity building/training)	NDICI, IPA III
	UWWTP	ERDF, CF	NDICI, IPA III
	Diffuse sources: urban run-off	ERDF (integrated sustainable urban development measures), CF, potentially LIFE	Potentially LIFE, NDICI, IPA III
	Diffuse sources: agriculture	EAFRD, LIFE, ESF+ (capacity building/training)	LIFE, NDICI, IPA III
	Diffuses sources: landfills, mining sites etc.	Possibly LIFE	Possibly LIFE, NDICI, IPA III
Hydromorpholo-gical Alterations	Interruption of river continuity and morphological alterations	CF, LIFE	LIFE
	Reconnection of wetlands/ floodplains	ERDF, CF (ecosystem-based measures regarding CC adaptation), LIFE, possibly EAFRD (Art. 30 NATURA2000/ WFD payments) (see below for more details)	LIFE, NDICI, IPA III
	Hydrological alterations (quantity and conditions of flow)	CF, LIFE	LIFE, NDICI, IPA III
Climate Change	Climate Change Mitigation	ERDF, CF, EMFF, LIFE, EAFRD	LIFE, IPA III, NDICI
	Climate Change Adaptation	ERDF, CF, EMFF, LIFE, EAFRD	LIFE, IPA III, NDICI

Furthermore, several additional instruments/organizations exist that are potentially relevant for acquiring financing in the context of WFD implementation for all pressures in the DRB. Instead of listing them in the table for each pressure individually, they are listed here:

183 Simplification Handbook: https://ec.europa.eu/regional_policy/sources/docgener/factsheet/new_cp/simplification_handbook_en.pdf (accessed 12 February 2021).

- Financing of measures through the European Green Deal (see also Chapter 6.3).
- HORIZON Europe, the EU research framework from 2021-2027, funds research in EU Member States and non-EU MS.
- The World Bank (IBRD/IDA) and the Global Environment Facility (GEF) provide mostly loans, but also grants, to developed and developing countries, also in the field of environmental protection and climate change adaptation (GEF, of course, has the focus on the environment).
- Other European and international banks (the European Investment Bank/EIB and the European Bank for Reconstruction and Development/EBRD) provide loans, mostly to the private sector (but possibly at reduced interest rates), supporting development, climate change adaptation and, mostly indirectly, environmental protection.

A summary about the main EU funds eligible for different elements of floodplain and wetland restoration was made available by WWF[184]. Additionally, the EU Commission provides a "Guidance on the 2030 Biodiversity Strategy river restoration targets", including an overview of funding instruments, current knowledge and guidance on data collection and monitoring[185]. The key elements of floodplain and wetland restoration and the available funding lines in the financing period 2014-2020 were[186]:

- For studies (feasibility, socio-economic analyses, applied research): different funding lines in the CBC/Interreg V-A program, Interreg Central Europe, the Danube Transnational Program, Horizon 2020, and LIFE+.
- For compensation and land purchase: Rural Development Programs, EARDF, and LIFE+.
- For training measures: Rural Development Programs and EARDF.
- For incentives for less intensive farming and land-use change: Rural Development Programs (national level).
- For field work: European Regional Development Fund, EARDF, and LIFE+.
- For monitoring: Horizon 2020 (if considered research).
- For communication and education: LIFE+ Communication or part of each project´s budget.
- For exchange of experience, authorities, lawyers, engineers and researchers: Interreg Europe, Interreg V-A/CBC, Interreg Central Europe, Danube Transnational Programme and Horizon 2020.

In order to increase incentives and gain the support of the agricultural sector for changes in land use or land use management necessary for floodplain/wetland restoration and as such also supporting the restoration of aquatic habitats, policy changes need to be explored/pursued. Examples include:

- opening CAP 1st pillar direct payments for natural water retention on arable lands;
- amending land use regulations to support natural water retention on agricultural lands;
- including in CAP 2nd pillar WFD compensation schemes for restrictions on land use such as water drainage, time of seeding, or irrigation due to conservation measures; and
- preparing a pipeline of projects including feasibility studies, stakeholder engagement, agreements with land-owners, technical design and permits and funding allocation.

184 http://wwf.panda.org/what_we_do/where_we_work/black_sea_basin/danube_carpathian/media/publications/ (accessed 12 February 2021).

185 The document is currently under review, and will be made available at the Commission´s website on the Biodiversity Strategy for 2030 (https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en) (accessed 14 September 2021).

186 National funding lines are not included.

Thus, new financing sources need to be opened for floodplain/wetland restoration and the necessary capacity building on the national level to be increased, e.g., from National Recovery and Resilience budgets, the Operational Programmes and higher CAP payments.

EU Strategy for the Danube Region (EUSDR) and INTERREG Danube Transnational Program

The EUSDR, a macro-regional strategy endorsed by the European Council in 2011, has inter alia the objective to facilitate and strengthen cooperative frameworks, which should utilise and support existing institutions, help Member States to implement EU legislation and should in particular support Member States and candidate countries in programming and effective use of EU funds and other financial mechanisms.

EUSDR's Priority Areas 4 (Water Quality) and 5 (Environmental Risks) are supporting measures implementation inter alia through projects development, facilitating direct financing support, assistance in project implementation and results dissemination including capitalisation of the results of different projects as well as via alignment of funding through Operative Programmes. The EUSDR e.g. issues Letters of Recommendations to project proposals matching the EUSDR objectives. The EUSDR has supported ICPDR-related successful international projects realisation and capitalisation like JOINTISZA, Danube Sediment, Danube Floodplain, MEASURES, DAREFFORT, DAREnet, DriDanube, SIMONA etc. The EUSDR Action Plan has been revised in 2019-2020. An exchange between EUSDR PA4/5 and the ICPDR was conducted in order to align the EUSDR and ICPDR objectives in the new Action Plan. Those objectives are planned to be financed in the MFF 2021-2027 period.

The INTERREG Danube Transnational Programme is a targeted EU funding instrument that was launched in early 2015 as part of the EU´s Cohesion policy package 2014-2020, replacing the former South East Europe Programme. The Danube Transnational Programme is built around four thematic priority axes, of which the second, "Environment and culture responsible Danube region", is of special importance to WFD implementation. The Danube Transnational Programme co-finances cooperation projects in line with the EUSDR Action Plan (Priority Axis 4.2).

In the period 2018-2019, the discussions about the future of EU Cohesion Policy 2020 and Interreg started. Many institutions and countries expressed publicly their views on how they see the future and several public consultations were launched to collect expectations towards the post-2020 period.

8.6 Linkage Between the International Danube Basin-Wide Level and the National Level

As outlined in Chapter 1.2, the management of the DRBD is based on three levels of coordination – Part A (international, basin-wide level), Part B (national level and/or the international coordinated sub-basin level for the selected sub-basins Sava, Tisza, Prut and Danube Delta), and Part C (Sub-unit level, defined as management units within the national territory). All plans together provide the full set of information.

The ICPDR serves as the coordinating platform between the countries to compile multilateral and basin-wide issues at Part A of the DRBD. Therefore, ensuring the linkage between Part A and the national level (Part B) of RBM Plans is of particular relevance for ensuring coherence. This, inter alia because the implementation of the measures in the JPM is primarily a national task and performed via national RBM and water management plans. Table 62 provides links to national RBM and water management plans, aiming to further improve the linkage between the international Danube basin-wide level and the national level.

Table 62: Information on national RBM and water management plans

Country	Where can the national RBM and water management plans be found?
Austria	*https://info.bmlrt.gv.at/themen/wasser/wisa/ngp.html* (accessed 16 October 2021)
Bosnia and Herzegovina	*www.fmpvs.gov.ba*; *http://www.voda.ba/plana-upravljanja-vodama-za-vodno-podrucje-rijeke-save-u-federaciji-bih-(2022.-2027.)*; *www.vladars.net*; *http://www.voders.org/dokumentacija* (accessed 16 February 2021)
Bulgaria	*http://www.bd-dunav.org/content/upravlenie-na-vodite/plan-za-upravlenie-na-rechniia-baseyn/purb-2022-2027-v-dunavski-rayon/*; *https://www.moew.government.bg/bg/vodi/planove-za-upravlenie/planove-za-upravlenie-na-rechnite-basejni-purb/planove-za-upravlenie-na-rechnite-basejni-2022-2027-g/* (accessed 16 February 2021)
Croatia	*https://narodne-novine.nn.hr/clanci/sluzbeni/dodatni/441070.pdf* (accessed 20 December 2021) for period 2016-2021; *https://mingor.gov.hr/o-ministarstvu-1065/djelokrug/uprava-vodnoga-gospodarstva-i-zastite-mora-2033/planski-dokumenti-upravljanja-vodama/plan-upravljanja-vodnim-podrucjima-2022-2027/5556* (accessed 20 December 2021) and *https://www.voda.hr/hr/planska-razdoblja/plansko-razdoblje-2022-2027* (accessed 20 December 2021) for period 2022-2027
Czech Republic	*http://eagri.cz/public/web/mze/voda/planovani-v-oblasti-vod/x3-planovaci-obdobi/* (accessed 16 February 2021)
Germany	*https://www.fgg-donau.bayern.de/wrrl/bewirtschaftungsplaene/index.htm* (accessed 16 December 2021)
Hungary	*www.vizeink.hu* (accessed 16 February 2021)
Republic of Moldova	-
Montenegro	*https://www.gov.me/mpsv* (accessed 27 October 2021)
Romania	*https://rowater.ro/consultarea-publicului/directiva-cadru-apa/materiale-utile/* (accessed 15 October 2021)
Serbia	-
Slovakia	*https://www.minzp.sk/voda/vodny-plan-slovenska/* (accessed 16 February 2021)
Slovenia	*https://www.gov.si/teme/nacrt-upravljanja-voda-na-vodnih-obmocjih/* (accessed 16 December 2021)
Ukraine	*https://www.davr.gov.ua/* (accessed 16 February 2021); *https://buvrtysa.gov.ua/newsite/* (accessed 20 December 2021)

In line with the river basin approach of the WFD and in order to further improve the coherence of the Part A and the Parts B of the DRBMP it is necessary to ensure that the national plans (Part B) make reference to the main findings of the Part A of the DRBMP.

Therefore, the national plans (Part B) should reflect the Significant Water Management Issues (SWMIs) identified on the basin-wide level and indicate how far they are relevant as well on the national level. In addition, there are a number of key products of the ICPDR which were highlighted in the ICPDR Ministerial Declaration 2016[187], in particular the

- Joint Statement Navigation,
- Guiding Principles on Sustainable Hydropower Development in the Danube Basin and
- ICPDR Strategy on Adaptation to Climate Change.

These ICPDR products, though not legally binding, are intended to serve as a common roadmap guiding national activities and supporting harmonization of actions at the basin-wide scale. Therefore, the national plans (Part B) should make reference to them and take them into consideration when developing national activities in the relevant fields.

187 https://www.icpdr.org/main/resources/danube-declaration-2016 (accessed 12 February 2021).

8.7 Applying the DPSIR Approach for the DRBMP Update 2021

Like the previous DRBMPs, the DRBMP Update 2021 is determined by the requirements of the WFD. For the corresponding planning procedure, the Danube countries followed the Drivers-Pressures-State-Impact-Response (DPSIR) Framework (see Chapter 1.5).

The current situation and recent and expected developments regarding the "Drivers" in sectors of particular relevance to river basin management, especially hydropower, inland navigation, agriculture and industries, were assessed in the economic analysis as summarized in Chapter 7. On this basis, conclusions regarding the observed or expected changes in the pressures-situation (see Chapter 2) were drawn. Information on "Drivers" and "Pressures" informed the optimisation of the monitoring programmes, which in turn provided the necessary data to assess "Status" and "Impacts" (see Chapter 4). This means that the pressures affecting water status have been identified, the reasons for failing to achieve the environmental objectives are largely known and the key factors on the basin-wide scale influencing water status have been identified. The systematic analysis of the corresponding data fed into the programme of measures, ensuring an adequate "Response" (see Chapter 8). A concerted effort was made to tackle the open issues identified in the DRBMP Update 2015. For example, a significant improvement of the data base, data harmonisation efforts and closing of knowledge gaps was achieved for the issue of sediment transport with the DanubeSediment Project.

However, the need to strengthen inter-sectoral approaches already highlighted in the 2015 Update still remains. For example, further gaps remain for specific issues such as invasive alien species. In addition, there is the wider issue of uncertainties in the planning process. Predicting the improvement of water status as a result of the implementation of measures is still posing a major challenge and making predictions on the improvement of water status is still considered immensely difficult. Also, the impact of climate change, especially drought and water scarcity, on the aquatic environment remains an additional, and possibly growing, source of uncertainty. Success, both in the next implementation cycle and in the long term, will require a better understanding of the complex interactions between natural and anthropogenically altered systems and sub-systems at different time scales[188]. Accompanying the implementation of measures with targeted monitoring and systematically updating the pressures assessments will provide the best possible foundation for understanding the multi-scale inter-linkages between the elements of the DPSIR approach for current and future WFD implementation cycles.

188 Grambow et al (2020): Die Wasserpolitik im Anthropozän – Überlegungen, wie wir in Europa in der Gewässerbewirtschaftung auf die umfassenden Herausforderungen eines neuen Erdzeitalters richtig reagieren können, DOI: 10.3243/kwe202.07.001. English translation available here: https://www.ewa-online.eu/e-water-documents.html (accessed 12 February 2021).

9 PUBLIC INFORMATION AND CONSULTATION

9.1 Objectives of Public Participation within the Legal Setting of the WFD

The ICPDR is committed to active public participation in its decision-making. The commission believes that this facilitates broader support for policies and leads to increased efficiency in the implementation of actions and programmes. Active consultation with stakeholders as well as the public takes place throughout the entire cycle of all ICPDR activities, ranging from developing policies, to implementing measures and evaluating impacts. A legal framework for this is provided by WFD Article 14 along with FD Articles 9 and 10.

9.1.1 Detailing Public Information and Consultation Activities for the Development of the DRBMP Update 2021 in a Changing Environment

With an increased awareness of environmental issues, a growing appreciation for the ways in which the environment affects public health, plus the more direct contact of social media, public participation in these processes is very much on the rise. The ICPDR is taking this opportunity to further open its doors and mechanisms to invite the public to participate in a variety of ways – and the public is growing increasingly engaged as a result. This is a vital shift, considering that environmental policy and management only succeed if key stakeholders feel engaged, and buy into the design of all the actions concerned.

Today, a 'bottom-up' approach means that people can share information and responsibilities; they can partake in the design of programmes; monitor and evaluate progress; and all without central management. Key forms of participation, such as the dissemination of information, public advocacy, public hearings and litigation, assist environmental decision-makers in identifying the concerns of the general public. A recent shift towards decentralising strategies also encourages the active participation of organized groups, communities, and citizens at a more local level.

9.1.2 A New Approach

So what does this mean for the ICPDR? One of the ICPDR's core principles is to encourage public participation in all our activities and decision-making wherever possible - so it most definitely means good things for all citizens of the Danube River Basin. The increasing number of ways in which the public can be reached is useful for broadening methods and putting together a new approach for engaging the public, exploiting rising awareness in order to facilitate broader support for policies and greater efficiency in their effective implementation.

Despite a broadening variety of communications activities, the ICPDR's three key pillars of "Cleaner, Healthier, and Safer" remain pivotal and timeless key aims that should be retained in all communications and guide all relevant events and actions.

9.2 ICPDR Observer Organisations

In keeping with commitments to engage the public, the ICPDR maintains a close relationship with a variety of organisations – representing public interest – defined by the DRPC as "Observers".

While Observers are not granted decision-making rights, they actively participate in all meetings of ICPDR Expert Groups and Task Groups, as well as plenary meetings (Standing Working Group and Ordinary Meetings). Active participation means that delegates of Observers have access to both information including all technical meeting documents as well as the right to contribute to all discussions.

Observers represent a broad spectrum of stakeholders in the Danube River Basin, covering social, cultural, economic and environmental interest groups adhering to the goals of the Convention. The connective tissue between Observers and the ICPDR is a shared 'community responsibility', essential to achieving long-term sustainable water management goals.

Institutionally, observers can include interest groups, non-government organisations (NGOs), and intergovernmental organisations (see Table 63). Observers are accepted upon approval by the ICPDR and have to meet a defined set of criteria laid down in "IC 185 Guidelines for Observers".

As of 2021, there are 24 organisations approved as observers, all of which had the opportunity to contribute to the development of this management plan through the relevant Expert Groups, Task Groups and plenary meetings.

Table 63: ICPDR Observers as of 2021

1.	Black Sea Commission (BSC)	13.	European Water Association (EWA)
2.	Carpathian Convention	14.	Friends of Nature International (NFI)
3.	Central Dredging Association (CEDA)	15.	Global Water Partnership (GWP/CEE)
4.	Danube Competence Center (DCC)	16.	International Association for Danube Research (IAD)
5.	Danube Civil Society Forum (DCSF)	17.	International Association of Water Supply Companies in the Danube River Catchment Area (IAWD)
6.	Danube Commission (DC)	18.	International Hydrological Programme of the UNESCO (IHP/Danube)
7.	Danube Environmental Forum (DEF)	19.	International Sava River Basin Commission (ISRBC)
8.	Danubeparks	20.	RAMSAR Convention on Wetlands
9.	Danube Tourist Commission (DIE DONAU)	21.	Regional Environmental Center for Central and Eastern Europe (REC)
10.	Danube Sturgeon Task Force (DSTF)	22.	VGB PowerTech e.V. (VGB)
11.	European Anglers Alliance (EAA)	23.	viadonau
12.	European Barge Union (EBU)	24.	World Wide Fund for Nature – Central and Eastern Europe (WWF-CEE)

9.3 Updating ICPDR Public Participation Practices

Previous DRBMP updates as stipulated in the WFD have been subject to public consultation. Carried out in three main phases, comments were collected from the public during the update, seeking their response on:

1. the timetable and work programme including public consultation measures;
2. significant water management issues (SWMIs) in the Danube River Basin;
3. the draft management plan;

These public consultations each spanned periods of at least six months, utilising the ICPDR network to gather and disseminate information. The resulting timetable and work programme as well as the proposed update to the plan was then published and made publicly accessible.

The update to proceedings for the DRBMP Update 2021 follows on with this programme of public consultation based on previous DRBMP updates. This forms an additional and more direct approach to public participation, along with information, promotion and educational initiatives aimed at keeping our stakeholders and the public well informed as a matter of daily business using social media, ad-hoc communications and queries, and maintaining our web presence.

9.4 Informing and Being Informed: Public Consultation for the DRBMP Update 2021

Communities can become more meaningfully involved in the work of the ICPDR if they are well informed - and have opportunities to inform the ICPDR in response - about its objectives and structure. As mentioned in Chapter 9.3, this is a constant concern and key activity for the ICPDR throughout the year. However, when it comes to the six-yearly DRBMP Updates, these channels for informational exchange become vital to the process at the level of public participation, with the public having the opportunity to directly feed into and shape the Update itself.

9.4.1 Informing the Public

Public information, educational initiatives and outreach activities are therefore already being utilized to support public involvement, in addition to the more general use of social media as a communication tool. The variety of tools and activities available to the ICPDR increases the ability to reply more swiftly than ever before. The ICPDR is engaged in the following public participation activities:

- public information dissemination. This includes social media posts, technical and public reports, brochures and general publications (e.g. Danube Watch) as up-to-date, effective and accessible as possible to the broadest audience;
- awareness-raising educational resources, including environmental education. This includes a variety of proposed new materials, awareness raising activities (e.g. the annual Danube Day festivities) and outreach, aiming to reach the youth of the Danube;
- public consultation activities, with an additional focus on getting to know our audience better. These can be events such as Q&A sessions regarding the development of River Basin Management Plans, and the opening of subject-related communication channels or consultation workshops. The use of ICPDR.org for publishing information about these issues is essential.

Acting early is important. By ensuring buy-in and a sense of ownership in our target audience at an early stage of the process, any basin/sub-basin approach will stand a better chance of success. The benefits of early engagement in the development and design of our two Plan Updates and projects include:

- increasing stakeholder awareness of the various issues in the related river basin district and sub-basins before environmental problems become worse and thus harder to resolve;
- fewer misunderstandings, fewer delays and more effective implementation and monitoring;
- the resulting smoother implementation of the DRBMP leads to more cost-effective solutions;
- all later decisions are more likely to receive public acceptance, commitment and support; attitudes to the decision-making process will also be generally improved.

9.4.2 Being Informed by the Public

Just as important as the ICPDR communicating with the public is the public communicating with the ICPDR. A key part of the ICPDR's communication strategies is direct consultation and enabling the public to send all of their comments and raise all of their concerns regarding Danube River Basin management issues. This could be suggestions for new wording in the draft plan, raising questions, providing fresh scientific or local/regional information - everything is of value.

Major activities happen at six-month intervals. For example, comments were collected on the draft timetable, work programme, and statement of consultation measures in the period from December 2018 to June 2019. The same was done for the consultation phase on the SWMIs – finalized in June 2020.

All comments on the draft DRBMP were collected via a dedicated email address (*wfd-fd@icpdr.org*), a bespoke online questionnaire, an online public consultation workshop 'Our Opinion – Our Danube', as well as via information campaigns in Danube Watch and on social media. All comments received throughout this process were taken into account during the review and finalisation of this document.

9.4.3 Comments Received in Writing

Until 30 September 2021, a total of 10 detailed statements, containing a total of 94 comments on the DRBMP Update 2021 were received from institutions. Additionally, 165 statements were also sent by individuals on the DRBMP Update 2021. Each of these comments, some of which are extensive documents relating to several different elements in the draft plan, were published online (*https://www.icpdr.org/main/activities-projects/public-consultation-results* (accessed 17 November 2021)) and processed for the Report on Public Consultation Activities.

9.4.4 The Voice of Stakeholders: Public Consultation Workshop

Due to the pandemic in 2021, the Public Consultation Workshop was reworked as an online-only event – proving a resounding success. The event titled 'Our Opinion – Our Danube' took place via Zoom, with the assistance on GWP-CEE on 29th & 30th June 2021, with over 200 participants in attendance, including representatives from key organisations and stakeholders. The plan was introduced at the workshop by ICPDR President Momčilo Blagojević of Montenegro and ICPDR Executive Secretary Ivan Zavadsky. The floor was then given to representatives of various stakeholder groups, starting with the next generation and a speech from President of the Sava Youth Parliament, Tana Bertić.

The 1½ day event covered both the DRBMP Update 2021 and the DFRMP Update 2021. Keynote speakers gave a short introduction to the Plans and nine key stakeholders had an opportunity to make short statements. The heart of the workshop, however, comprised of five topical sessions, or 'thematic areas' in a *'Danube Café'* format with moderated, interactive discussions. These topics were: (1) Organic, Nutrient and Hazardous Substance Pollution in Surface and Groundwater; (2) Hydromorphological Alterations and Integration Issues (flood risk management, hydropower, nature protection, navigation, agriculture); (3) Objectives and Measures of Flood Risk Management Plans; (4) Support to Implement Both Plans, Financing of the Measures; and (5) Communication & Public Participation.

Each of these group sessions was opened with a short introduction by an expert facilitator who also guided the discussion; two expert rapporteurs recorded the main items while a Miro board artist assembled inputs on a digital white board. Facilitators and rapporteurs rotated, so that all workshop participants eventually contributed to discussions in each thematic area. This ensured that all participants worked on elements from both draft management plans regardless of their professional background or level of pre-existing knowledge. Prior to the event, participants were provided with adequate information pertaining to each thematic area.

The key messages and main outcomes of these fruitful discussions can be found in a full report on the workshop, published here on ICPDR.org: *http://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/our_opinion_-_our_danube_-_icpdr_stakeholder_consultation_workshop_-_final_report_4.pdf* (accessed 17 November 2021).

9.4.5 Alternative Routes: Online Questionnaire

To expand the potential target groups of public consultation beyond expert stakeholders, a simple and easily accessible online questionnaire was developed and published via the ICPDR website for stakeholders and the public. This questionnaire related to general aspects of the DRBMP Update 2021, seeking to discover knowledge gaps in the general public. As such, it also served as an information tool to draw attention to the plan and the other public consultation measures – in particular, the Online Stakeholder Consultation Workshop and the opportunity to comment on the plans in writing. In 2021, this questionnaire also contained questions and information pertaining to the DFRMP Update 2021. While previous years saw two separate DRBMP/DFRMP questionnaires distributed, in 2021 the ICPDR combined the two separate plans into one single questionnaire. Combining them was the next logical step, with one workshop planned in 2021 covering both plan updates. The questionnaire had a more informative focus this time around, favouring feedback regarding public understanding of and satisfaction with the work over more complicated and open-ended questions.

The online questionnaire was made available in ten Danubian languages in addition to English. This questionnaire sought input from members of the public living in the Danube River Basin. It was designed to be both informative as well as to help find out more about public perception and knowledge of draft management plans in the River Basin. It surveyed opinions about the efficacy of the DRBMP since 2015, general knowledge about the Danube River Basin and attitudes towards proposed measures from the DRBMP Update 2021, such as the use of fertilisers or investments in wastewater treatment plants.

Results showed that participants were generally supportive of measures proposed in the plan; however, the format of the questionnaire did not allow for substantial comments. The questionnaires should therefore be seen primarily as an awareness raising and information tool and only secondarily as a consultation channel. In total, 232 people filled in the joint questionnaire for the DRBMP and DFRMP Updates 2021. Results were evaluated and are part of the Report on Public Consultation Activities (*http://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/ic_248_-_public_consultation_report_2021.pdf* (accessed 17 November 2021)).

9.4.6 Alternative Routes: Social Media

Aiming to further expand the potential reach of this consultation (especially within the general public who would not feel attracted to the other consultation measures), a social media campaign was implemented in parallel to the preparation for the stakeholder consultation workshop. The campaign relied on small and interesting pieces of information ("factoids") aiming to attract attention to water management issues, and ultimately the draft management plans. Additionally, three short clips were used to promote the public consultation process via social media. The social media posts were distributed via the ICPDR's own social media channels, with additional support requested from all Observers. Priority for this was given to Facebook, backed up with Twitter (hashtags #HaveYourSay, #Our Opinion, #Our Danube, and #OurOpinon#OurDanube) and LinkedIn during the consultation period. The social media campaign helped to cross-link the different consultation tools.

During a 14-day period around the Stakeholder-Workshop (20th June – 3rd July), almost 10% of the impressions based on campaign activities were generated (27.5k) with the relevant hashtag (#OurDanube) put to use 18 (131 in total) times.

In the period between 31st March – 30th September 2021, the campaign yielded 59 new Twitter followers; 143 new Facebook followers; 63 new Instagram followers; 13,033 interactions (Twitter mentions, retweets and Facebook stories created for the profiles to this group); as well as more than 300,000 impressions (the combined number of potential users who saw content associated with the Twitter & Facebook profiles connected to the relevant Twitter and Facebook accounts). A detailed overview of social media activities is included in the Report on Public Consultation Activities.

9.5 Ensuring Transparency: Reporting on Consultation Activities

In line with the ICPDR's principles of transparency, all comments collected throughout the public consultation process requesting changes or additions in the draft DRBMP Update 2021 were collected and taken into account by the relevant ICPDR Expert and Task group during the review and finalisation process which was completed by December 2021. A final report (*http://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/ic_248_-_public_consultation_report_2021.pdf* (accessed 17 November 2021)) covering the public consultation outcomes was published alongside the final Management Plan Updates in December 2021, giving a detailed account of the measures undertaken Additionally, a report was sent to all organisations and individuals that participated in the public consultation activities and was published on the dedicated 2021 public consultation page on ICPDR.org (*icpdr.org/main/activities-projects/public-consultation-draft-management-plan-updates-2021* (accessed 17 November 2021)).

9.6 Connections with National Level Public Consultation

The DRBMP is intended to provide a basis for basin-wide policy, augmented by national and sub-basin management plans. The basin-wide process of drafting these management plans was thus also developed in conjunction with national-level endeavours in the field of public consultation, thus taking into account specific priorities throughout the region. This supports the plan's position between the responsible authorities and interlinks national-level public consultation activities with those at basin-wide level. All information on national SWMI documents and draft RBM Plan consultation measures were thus collected and centrally published via ICPDR.org. Information on the ICPDR documents in question was in turn published on the respective national consultation websites. In addition to online resources and unified basin-wide planning documents, meetings of the ICPDR and its Expert Group for public participation further supported a basin-wide exchange on the national consultation work.

9.7 Connections with the Danube Flood Risk Management Plan Update 2021

All activities related to public consultation described in this chapter were sought to mirror to the greatest extent possible the steps towards the finalisation of the Danube Flood Risk Management Plan Update 2021 (DFRMP Update 2021). This applies in particular to the publication of the timetable and work programme including public consultation measures in 2019; and the public consultation measures for the draft management plan, which were linked to the draft DFRMP Update 2021. In adherence to this approach, both Plan Updates were covered by one joint online questionnaire. Furthermore, the Stakeholder Consultation Workshop was planned as a joint activity to highlight the interlinkages between both the DRBMP and the DFRMP. An additional benefit of addressing both draft plans within one questionnaire and one workshop was that it maximized efficiency, synergies and attendance.

10 KEY FINDINGS AND CONCLUSIONS

River Basin Management Plans provide the framework for operational integrated water resources management, by giving an overview of the key issues and challenges at hand and setting out the central objectives and required actions.

WFD Article 13 and WFD Annex VII set out the main requirements for River Basin Management Plans, specifying in that these must include, among other things

- a general description of the characteristics of the river basin district
- a summary of significant pressures and impacts of human activity on the status of surface water and groundwater
- a description of the monitoring programmes and the results they provide
- a summary of the economic analysis of water use and a summary of the programme or programmes of measures.

WFD Article 13 also states that *"In the case of an international river basin district extending beyond the boundaries of the Community, Member States shall endeavour to produce a single river basin management plan"*. The DRBMP Update 2021 meets these requirements. Chapters 1 to 9 provide rich and comprehensive information as do 39 maps and 21 annexes. The key conclusions and findings of the DRBMP Update 2021 are summarized in this Chapter.

Surface Water Bodies: Status assessment

Comparing to 2015 the percentage of the length of the river water bodies achieving good ecological status and good ecological potential decreased from 25% to 24.1% but the accuracy of any direct comparison is affected by the re-delineation of some surface water bodies. The assessment of the ecological status/potential according to the requirements of the WFD has been improved remarkably in the Danube River Basin and a significant support to this process was provided by the international harmonisation activities in the frame of JDS4. WFD-compliant biological sampling methods for small and medium sized rivers are already part of standard monitoring programs in most of the Danube countries. More problematic are the assessment methods for the ecological status in large rivers due to the difficult definition of reference conditions, the presence of multiple pressures and the influence of invasive alien species and climate change effects on biological communities. JDS4 reconfirmed that further work has to be done in the field of collecting basic information on the distribution of invasive alien species and their influence on native biota. Specific effort should be focused on development of effective tools for the assessment of the level of pressures caused by the bioinvasions, as well as for designing the appropriate mitigation measures.

As for the chemical status the comparison with 2015 can only be made for Priority Substances in water, for which the percentage of good chemical status dropped from 71% to 67.7% in 2021. This decrease is caused primarily by changes in the chemical status attributes and by more comprehensive monitoring information collected (more Priority Substances were analysed thanks to improved analytical methodologies, new Priority Substances from the Directive 2013/39/EU were analysed and the decrease of some EQS also affected the compliance) rather than by new pressures. For chemical status based on the Priority Substances in biota a dramatic difference is observed when excluding the brominated diphenyl ethers and mercury from the assessment. While the results for all Priority Substances in biota led to failure of achieving good chemical status in all assessed water bodies, the situation improved significantly after neglecting the ubiquitous brominated diphenyl ethers and mercury when 28.2% of water bodies achieved the good chemical status.

The persisting problem in the assessment of the chemical status is that in some countries certain Priority Substances are still not analysed because of lacking analytical instrumentation and because no proper or sufficiently sensitive methods are available (e.g. for PFOS, dioxins, dicofol, cypermethrin, benzo(a)pyrene, dichlorvos, HBCDD, heptachlor and heptachloroepoxide). Here the monitoring practices need further improvement in terms of method development, capacity building and enhancing of equipment.

Pollution of Surface Water Bodies and Related Measures

At the river basin scale, the urban wastewater sector generates about 190,000 tons per year of BOD and 440,000 tons per year of COD discharges into the surface water bodies of the DRB (reference year: 2018). The direct industrial emissions of organic substances total up to ca. 65,000 tons per year of COD for the reference year (2018). Since the reference year of the DRBMP 2009 (2005/2006) and the DRBMP Update 2015 (2011/2012) DRBMP a remarkable reduction of the BOD emissions via urban wastewater can be recognized. The recent figures are about 61% and 27% less than those of the DRBMP 2009 and the DRBMP Update 2015 thanks to the substantial development of the wastewater infrastructure in the last decades.

In the last fifteen years, Danube countries have invested ca €28 billion in wastewater infrastructure in line with the requirements of the UWWTD and the WFD. Since 2006, more than 6,000 municipality projects have been implemented and around 45 million PE have had collecting and treatment facilities constructed or upgraded, with almost 2,800 more planned or currently in progress to improve the services for 26 million people. In addition, almost 180 operating industrial facilities with direct surface water emissions are certified with updated technology standards according to the provisions of the IED. During the same time period, the percentage of municipalities and industrial facilities (bigger than 2,000 PE) connected to a sewer system and UWWTP or adequate individual treatment facilities also increased substantially (to almost 80% at the DRB level), demonstrating a significant improvement of wastewater services in the DRB.

Despite the huge investments already made in the wastewater infrastructure, additional measures should be taken in the future. In total, 20 million PE (24%) need basic infrastructural development; connection to public sewer systems and biological treatment needs to be ensured for 9 million PE, whereas 11 million PE need to access to collection system and tertiary treatment. More than 50% of the BOD surface water emissions via urban wastewater still stem from agglomerations with existing sewer systems but without treatment. Taking into account that these agglomerations represent only 6% of the total PE in the basin, implementation of measures for a relatively small proportion of the municipalities can result in substantial progress. Thus, these agglomerations should be prioritized. In the next management cycle, about 8 million PE will be provided with sewer system or IAS to appropriately collect wastewater and to convey it to treatment plants or to treat it locally. On the basin-wide level, 13% decrease in the BOD surface water discharges is expected, whereas soil BOD emissions via urban wastewater discharges will drop by about 60%.

Further efforts should be made to foster the development of investment projects in the wastewater sector. Supporting non-EU MS to find appropriate financial sources and to achieve progress is still a challenge in the DRB and should be further facilitated. Capacity building is necessary for both, the national/local administration and the utility operators to strengthen their management and technical skills and to improve financing, operational, and technological aspects of the wastewater infrastructure and services. The ICPDR in cooperation with the World Bank launched an initiative to support Danube countries in this respect by organising and facilitating knowledge exchange programs and events related to wastewater management, particularly on critical aspects like sustainable financing, rural wastewater management and sewage sludge management. Moreover, the ICPDR published the Recommendation Paper on Wastewater Management, that communicates the overall challenges, specific needs and potential solutions related to wastewater management in the DRB and provides several recommendations and potential actions for national policy making to improve wastewater management.

The estimated recent, basin-wide nutrient emissions for the reference period (2015-2018) are 500,000 tons per year TN and 31,000 tons per year TP. Similarly to the organic pollution, remarkable decrease is visible regarding the nutrient point source emissions in the Danube basin. The recently reported point source nutrient emissions are significantly lower in comparison to those of the DRBMP 2009 and the DRBMP Update 2015, the N emissions declined by 44% and 18%, the P discharges dropped by 56% and 22%, respectively. Diffuse emissions also dropped due to both, the low agricultural intensity in many countries and the measures implemented. The total N emissions decreased by 17% in comparison to the DRBMP Update 2015, whilst P emissions dropped by 19%. Diffuse emissions are dominating the total emission pattern (N: 87%, P: 78%), transporting nutrients from agricultural and urban areas into the water bodies. For N, subsurface flow (base flow and interflow) is the most important diffuse pathway with a proportion of 57%. For P, soil erosion (28%) generates the highest emissions. Regarding the sources, agriculture (N: 44%, P: 37%) and urban water management (N: 30%, P: 43%) are responsible for the majority of nutrient emissions indicating the necessity of appropriate measures to be implemented in these sectors. Historical trend analysis of nutrient river loads over the past decades shows a significant reduction in the transported nutrient fluxes to the Black Sea. However, the current long-term fluxes are still considerably higher than those of the early 1960ies which represent river loads under low pressures, indicating a further load reduction potential that might be exploited for the benefit of the Black Sea (N: 30%, P: 15%). This would require further reductions of both, point source and diffuse emissions generated in the DRB, with particular focus on pollution hot-spots. Nevertheless, in the last 5-10 years the measured loads are rather low and close to the Black Sea targets indicating significant water quality improvement.

Since 2006, over 1,700 municipalities and more than 35 million PE have had treatment plants with nutrient removal technology either constructed or extended in compliance with the UWWTD and WFD requirements. About €12 billion have been invested for these projects. Besides this, almost 500 more are planned or in progress by the end of 2021 to serve an additional 13 million PE. During the same time period, the percentage of people connected to nutrient removal in mid-sized and big settlements has reached 75%. Nitrates Action Programmes according to the obligations of the ND with mandatory rules on manure and fertilizer application are being implemented for more than 60% of the DRB. For agricultural areas in EU MS across the DRB, 70% are determined for direct support linked to cross-compliance and about 20% receive additional subsidies for implementing environmentally-friendly measures. In the last decade, more than €95 billion has been spent in the DRB countries to support farmers and finance best management practices. These financial mechanisms have been linked to the CAP and similar national programs in the non-EU MS.

The measures under implementation have been substantially contributing to the reduction of nutrient inputs into surface waters and groundwater in the DRBD but further efforts are still needed. Wastewater treatment for 16.5 million PE at agglomerations above 10,000 PE needs further improvement by introducing nutrient removal technology, out of which about 5.5 million concern treatment upgrade, whereas the rest (11 million PE) requires collection system and/or treatment plant construction. Diffuse pathways have a dominant share in the total nutrient emissions, therefore implementation of measures addressing land management has a high importance. Efforts are needed to ensure available financial instruments and to appropriately finance agricultural measures. In the next management cycle, about 8 million PE will be additionally connected to tertiary treatment ensuring high nutrient elimination rates. In addition, ca 2 million PE will be connected to secondary treatment and 1 million PE to IAS. Surface water nutrient emissions from point sources are expected to be increased because of the higher wastewater load reaching the UWWTPs in comparison to the reference status. For N, 14% emission increase is expected, whereas P surface water emissions will slightly rise by 4%. Nevertheless, soil emissions via urban wastewater discharges are expected to decline by 53% (N) and 56% (P). The baseline scenario in agriculture would lead to a slight decrease of the current nutrient emissions by 2027 (N: 9%, P: 5%). The baseline scenario estimates a slight decrease for the overall N and P emissions by 6% and 8%, respectively. River loads to the Black Sea are expected to drop by ca 5% for both N and P. According to the simulated vision scenarios, the river loads transported to the Black Sea can be significantly reduced towards or even below the level of around the 1960ies if nutrients are properly managed in the basin.

At the policy-making level, the agricultural sector needs to be addressed as significant amounts of nutrients stem from agricultural fields. The ICPDR Guidance Document on Sustainable Agriculture provides support for Danube countries to align water and agricultural policies, to seek synergies between CAP Strategic Plans and River Basin Management Plans and to decouple agricultural development from nutrient pollution and drought. The guidance paper recommends sound policy instruments, financial programs and cost-efficient agricultural measures to protect water bodies for decision makers in the agri-environmental policy field.

Danube countries have taken important steps to fill the existing data gaps in the field of hazardous substances pollution by developing pollution inventories, organising specific UWWTP sampling campaigns and supporting modelling activities. Point source emission data are available for 180 major industrial facilities with recorded surface water releases of 32 compounds. The UWWTP monitoring campaigns carried out in the framework of the SOLUTIONS Project and the JDS4 provided essential information on the point source emissions of emerging substances and the treatment efficiency of the UWWTPs for these chemicals. A priority list of substances associated with high risk and a wastewater related sub-list of the Danube River Basin Specific Pollutants have been elaborated. The ICPDR is actively supporting the Danube Hazard m^{3}c Project that has developed an emission model for basin-wide assessments of 17 representative chemicals, providing an insight into the pathway distribution of the analysed compounds. Moreover, policy recommendations and capacity building are also provided for effectively managing hazardous substances pollution in the DRB.

Since 2006, at about 30 UWWTPs targeted technologies have been added to remove hazardous pollutants from wastewater. In addition, at more than 100 UWWTPs specific disinfection technologies are used that are partly able to remove organic micropollutants.

Despite the substantial progress achieved in many aspects of the hazardous substances pollution the state-of-the-art knowledge needs to be improved and the implementation of measures should proceed in the future to appropriately manage the problem. Further efforts are needed to identify which priority substances and other emerging chemicals are of basin-wide relevance. In particular, the lack of high-quality monitoring data on emerging chemicals of high importance in wastewater effluents have to be addressed. In addition, diffuse emissions should be further assessed by regionalized pathway and transport modelling adapted to the DRB to get a better understanding on inputs and fluxes of hazardous substances in the DRB. The Danube Hazard m^{3}c Project delivered preliminary policy recommendations focusing on both, knowledge base establishment and measure implementation in various sectors, controlling sources and pathways of hazardous substances emissions.

Danube countries made significant efforts to complete and update the basin-wide inventories on Accident Hazard Sites and Tailings Management Facilities and to carry out consistent hazard and risk assessment of these sites. At the basin-wide level, a few hundreds of operating industrial facilitates and active or non-active tailings ponds associated with significant hazard of accident pollution can be identified.

Regular update of a basin-wide catalogue of hazardous industrial, abandoned and mining sites should be further accomplished, and implementation of safety measures should be promoted and reinforced to minimize the occurrence and adverse impacts of accident events. The ICPDR provides a platform for information exchange and know-how transfer for the countries to recommend practical hazard and risk assessment tools and preventive measures to be implemented. One highly relevant issue is the accident risk related to the TMFs, where capacity building programs with regular training events at national or regional level need to be organized for facility operators and authority inspectors to strengthen their knowledge and skills in the field of accident prevention and contingency management. The ICPDR in cooperation with the German Environment Agency implemented the Danube TMF Project to improve the safety conditions of the tailings ponds, providing Danube countries with practical tools to assess safety conditions of individual TMFs and to identify potential measures to be implemented to improve safety.

Hydromorphological Alterations of Surface Water Bodies and Related Measures

Hydromorphological alterations are significantly impacting water bodies in the DRBD and often hindering the achievement of environmental objectives. There are 269 water bodies out of 975 (28%) impacted by significant impoundments, 62 water bodies (6%) by significant water abstractions, 51 water bodies (5%) by significant hydropeaking, 357 water bodies (37%) by significant continuity interruptions (including 264 water bodies (27%) affected by unpassable interruptions), 552 water bodies (57%) by significant morphological alterations (including class 2-5 within the 2-class reporting system) and 19 water bodies (2%) with significant disconnection of wetlands/floodplains (considering definite reconnection potential). Based on these results, the main hydromorphological alterations in the DRBD are significant morphological alterations, continuity interruptions and impoundments.

Those hydromorphological alterations are also the main decisive criteria for designation of heavily modified water bodies in the DRBD. In most cases significant morphological alterations (124 water bodies) are decisive criteria, followed by significant continuity interruptions are (96 water bodies) and significant impoundments (83 water bodies). Significant water abstraction and significant hydropeaking are decisive criteria for designation of 3 HMWBs, while disconnection of wetlands/floodplains are decisive only for 1 water body.

In comparison to rivers where high number of significant hydromorphological alterations is reported, there are only 2 lakes (out of 7) under significant hydrological alteration and 1 lake under significant morphological alteration. There are no significant hydromorphological alteration reported for transitional waters, while there are 2 (out of 4) coastal water bodies under significant hydrological alteration.

There were numerous hydromorphological measures already implemented for improving of hydromorphological conditions in the period 2009-2021. 66 implemented measures were related to the improvement of hydrological alterations, mainly to impoundments and water abstractions. As of the year 2021, additional 5 measures addressing hydrological alterations are in the construction phase. 127 fish migration aids were completed; as for 8 fish migration aids the construction is on-going as of the end of 2021. 58 river restoration projects have been implemented and river morphological conditions were restored by 2021, while additional 21 river restoration projects are in construction phase. There have been 61,745 ha of wetlands/floodplains partly or totally reconnected; for additional 4,526 ha the construction of reconnection is still ongoing as of the end of 2021. Furthermore, numerous fish migration aids and river restoration projects are currently in the planning phase.

Additional measures are planned for the period 2021 to 2027. 204 measures are related to improvements of impoundments, 46 to water abstractions, 32 to hydropeaking, 424 to continuity interruptions and 222 related to water bodies affected by morphological alterations. There is also foreseen that additional 23,399 ha of floodplains/wetlands will be reconnected. In many cases, it was reported for significant hydromorphological alterations that GES/GEP is already achieved, thus no measures are needed for improvement of hydromorphological conditions.

Beside implementation of technical measures, it is also important to continue with upgrading of databases on hydromorphological pressures and improving of methodologies for hydromorphological assessments (e.g. monitoring of habitats for migratory fish species). This will enable better data harmonisation and data comparisons in the DRBD (especially important for assessment of morphological alterations and disconnections of wetlands/floodplains).

Also, further investigations on relations between hydromorphological and biological quality elements are crucial for best definition and prediction of significant hydromorphological alterations and consequently avoidance of negative impacts. Considering continuity interruptions, it is of high importance to further investigate negative impacts of interruptions on downstream fish migration.

Related to investigations, it is also important to continue with further analysing of synergies between flood protection measures and hydromorphological measures (implementation of non-structural measures, e. g. floodplain preservation/restoration).

Several basin-wide collaboration projects related to hydromorphology were implemented in last years (e.g. DanubeSediment and Danube Floodplain Project). It is important to transfer results of those projects to national and international level in order to make significant progress with restoring the sediment balance and floodplains and prevent further deterioration. It is very important to seek for synergies between different fields of work and propose common solutions that are supporting different goals (e.g. synergies between WFD, FD, HD and climate change adaptation objectives). It is also crucial to strengthen relation to EU Biodiversity Strategy for 2030 where importance of river restoration and ecological corridors is highlighted.

In addition, prioritisation of measures is crucial for systematic and effective water management planning. Thus, also the results of prioritisation approach for continuity restoration has to be considered within further water management planning.

Monitoring of measure effectiveness is an important part of every measure that is implemented. It also indirectly enables promotion of best practices of hydromorphological measures between countries in the DRBD. The knowledge gained during the monitoring and results on effectiveness have to be shared and further on used within the planning of future infrastructure projects. Those results will also help to prevent further deterioration of water status and to achieve environmental goals on water bodies within the DRBD.

Groundwater

Groundwater quality

Good chemical status was identified in 19 out of 25 national shares of the 12 transboundary GWBs and six national shares are in *poor chemical status.* Four national shares were already in a poor status in 2015 and for two national shares, the chemical status deteriorated from good to poor status. One national share which was of unknown status in 2015 is now identified as of good status. All six national shares in poor status and also three national shares in good status are at risk of not achieving good status in 2027. Diffuse and point source pollution by nitrates, ammonium, phosphates, sulphates and chlorides is the cause of the *poor chemical status* classification and the same five substances together with trichloroethene and glyphosate cause *risk* of failing good chemical status in 2027.

Taking into account that contamination by ammonium and nitrates is a key factor against achieving *good chemical status* of a significant portion of the GWBs of basin-wide importance it is essential to eliminate or reduce the amount of ammonium and nitrates entering groundwater bodies in the DRBD. Prevention of deterioration of groundwater quality and any significant and sustained upward trend in concentrations of ammonium and nitrates in groundwater has to be achieved primarily through the implementation of the EU Nitrates Directive and also the UWWTD.

To avoid the presence of hazardous substances in groundwater the measures as required under the EU Drinking Water Directive ((EU) 2020/2184), Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market and Sustainable Use of Pesticides Directive (2009/128/EC) need to be taken into account. The synergy with the implementation of the CAP 2021-27 has to be used.

To prevent pollution of GWBs by hazardous substances from point source discharges liable to cause pollution, the following measures are needed: an effective regulatory framework ensuring prohibition of direct discharge of pollutants into groundwater; setting of all necessary measures required to prevent significant losses of pollutants from technical installations; and the prevention and/or reduction of the impact of accidental pollution incidents.

The measures addressing pollution of surface water bodies by organic substances, nutrients and hazardous substances have a positive effect on the improvement of the chemical status of groundwaters.

It can be concluded that in agreement with the ICPDR's basin-wide vision, emissions of nitrates, other nutrients and relevant hazardous substances need to be sufficiently controlled so not to cause any deterioration of groundwater quality in the DRBD. Where groundwater is already polluted, restoration to good quality by a thorough implementation of the respective EU legislation is essential

Groundwater quantity

Good quantitative status was observed in nine transboundary GWBs (with 18 national shares) and three transboundary GWBs (with 7 national shares) are in *poor quantitative status*. Within these three GWBs failing to achieve good status, three national shares are in good status and four are in poor status. Compared to the status assessment in 2015, three national shares, which were in poor status, still remain at the same status, one national share that was in poor status in 2015 is now identified as of good status and one national share that was in good status in 2015 is now in poor status. Five national shares (four currently at poor status and one at good status) are at risk of failing good quantitative status by 2027.

The *poor quantitative status* is caused in three cases by the exceeding of available groundwater resources; in two cases by significant damage to groundwater dependent terrestrial ecosystems and in one case by affected legitimated uses of groundwater. The direct and indirect over-abstraction is the key pressure affecting quantitative status of groundwater bodies.

The over-abstraction of GWBs within the DRBD should be avoided by effective groundwater and surface water management. Therefore, appropriate controls regarding abstraction of fresh surface water and groundwater and impoundment of fresh surface waters (including a register or registers of water abstractions) must be put in place as well as the requirements for prior authorisation of such abstraction and impoundment. In line with the WFD, it must be ensured that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction.

To prevent deterioration of groundwater quantity as well as the deterioration of dependent terrestrial ecosystems, solutions for the rehabilitation (e.g. natural water retention) have to be explored. These should include restoration of wetland areas, which are in direct contact with aquifers. The ongoing efforts focus also on inland excess water retention and planning of measures to protect the groundwater resources under the new CAP is ongoing.

Effects of Climate Change (Drought, Water Scarcity, Extreme Hydrological Phenomena and Other Impacts)

At the end of 2019, the ICPDR adopted the "Effects of climate change (drought, water scarcity, extreme hydrological phenomena and other impacts)" as additional Significant Water Management Issue (SWMI) in the Danube River Basin. A related vision and operational management objectives have been agreed in 2020 to guide the Danube countries in the next 6 years WFD implementation cycle. The cross-cutting character of this SWMI, vis-à-vis the other SWMIs (organic, nutrient and hazardous substances pollution as well as hydromorphological alterations) identified for the Danube River Basin but also in the wider context of European Water Policy, is reflected in the necessity for mitigation of and resilience to extreme hydrological phenomena at both ends of the spectrum (i.e. flooding and drought). The main aim is to ensure that measures taken in the context of other SWMIs are "climate proof". This means that the respective measures must achieve the desired results without negative and unintentional side effects even under changed climate conditions. This will be ensured by integrating climate change into the approaches adopted within recognized SWMIs as well as via coordinated implementation of the WFD and FD and other environmental Directives in the Danube River Basin.

Protected areas

The protected areas classed as relevant at the Danube River Basin-wide scale mainly comprise areas for the protection of habitats and species. Approximately two thirds of the protected areas reported for the DRBMP 2021 Update were designated under the EU Habitats Directive. Protected areas are also a central issue for sturgeon conservation. As sturgeons are the flagship species for the Danube River Basin, Danube countries have a special interest in ensuring that water policy is coherent with international surgeon-related activities such as the Pan-European Action Plan for Sturgeons.

Integration Issues

The following integration issues, i.e. issues with a potential for both synergies and conflicts with other sector policies, were identified for the DRBMP Update 2021:

- **River Basin Management and Flood Risk Management**

The coordination River Basin Management and Flood Risk Management involves, above all, steps to coordinate the implementation of the respective Directives (FD and WFD). A central synergy is the conservation and the restoration of the natural functions of wetlands and floodplains. An additional synergy is also the implementation of natural water retention measures. An important activity is the Danube Floodplain project (2018-2021), the main objective of which is to connect flood risk prevention and biodiversity conservation with a focus on enhancing expertise and stakeholder involvement.

- **River Basin Management and the Marine Environment**

The Danube River Basin is directly linked with marine waters because the Danube discharges into the Black Sea. In 2012, the ICPDR adopted a resolution for coordination of the implementation of the WFD in the Danube River Basin and the MSFD in the Black Sea Region. Romania and Bulgaria, the EU MS of the Danube basin sharing the Black Sea waters, are working on the implementation of the MSFD. Both countries take all efforts to promote the MSFD in the ICPBS and to coordinate with the land-locked Danube countries within the ICPDR.

- **River Basin Management and Nature Protection**

There is significant potential for synergies between the WFD, nature protection related EU legislation, the European Green Deal, EU Biodiversity Strategy and specifically also for measures to protect endangered species and protect and restore habitats. The contracting parties of the ICPDR are redoubling their efforts to ensure that appropriate measures are implemented and will strive to take full advantage of the relevant opportunities provided by the EU's Green Deal.

- **Inland Navigation and the Environment**

Inland navigation is generally considered an environmentally sustainable substitute for road transport. It can, however, significantly influence river ecosystems, potentially jeopardizing the goals of the WFD. The so-called "Joint Statement" summarises principles and criteria for environmentally sustainable inland navigation on the Danube and its tributaries, including the maintenance of existing waterways and the development of future waterway infrastructure. A recent topic for a facts-based discussion has been that of vessel induced waves and their impacts on the aquatic environment, with first analyses being carried out in selected Austrian stretches of the Danube.

- **Sustainable Hydropower**

Hydropower plays an important role in renewable electricity production even though, in relative terms, its contribution to overall production is expected to fall in the Danube region. Dialogue and stakeholder involvement in this field is continuing on the basis established in 2011 with the "Guiding Principles on Sustainable Hydropower Development in the Danube Basin". These are now available in Bosnian, Croatian, Czech, German, Slovak, Slovene and Ukraine language.

- **Sturgeon Conservation**

Sturgeons, the Danube "flagship species", are on the brink of extinction. For their survival, they are reliant on a network of habitats from upstream rivers to the sea. Key measures and actions to prevent the extinction of Danube sturgeons are, for example, establishing reproduction and release programmes, effectively enforced fishing bans, improvement and protection of habitats and migration corridors, as well as comprehensive controls and monitoring. Additional information on sturgeon conservation is provided in the new Annex 12 of the DRBMP 2021 Update.

- **Sustainable Agriculture**

Agriculture is an important component of the economy in many Danube countries that needs large amounts of clean water to satisfy the increasing demand for high-quality food. However, intensive agriculture may cause quality and quantity problems of surface- and groundwater by pollution, over-abstraction and inappropriate land management endangering the status of the water bodies but also the sustainability of its own water resources. The ICPDR initiated a dialogue with the agricultural sector to help the national agri-environmental policy-making of the Danube countries and published the Guidance Document on Sustainable Agriculture that offers Danube countries additional support for aligning water and agricultural policies.

Economics

Socio-economic developments in the Danube River Basin are following similar pathways and trends to those in the past. Impacts of the COVID-19 pandemic and the ensuing disruption on different levels of the economies remain thus far unquantified. Nevertheless, there is considerable range in the GDP and GDP per capita figures of the Danube countries highlighting significant differences between Danube countries' economic activity. This fact is also reflected in terms of the heterogeneity in the levels of the necessary investments in infrastructure development. Apart from the lack of available funds, shortcomings in capacities to absorb existing funds also remain an important issue. With regard to trends, the overall population in the DRB can be expected to decline slightly, while economies are mostly expected to grow. However, the COVID-19 pandemic is significantly increasing uncertainty and is already having a negative effect on economic growth.

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