lifelineMDD

Living Waters

Interreg
EUROPEAN UNION
Danube Transnational Programme
lifelineMDD

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Content

Mura-Drava confluence

Introduction

Rivers, lakes and wetlands provide many benefits for people and are among the most biodiverse places on the planet. Despite this, freshwater biodiversity is declining and habitats are disappearing. As living systems that are constantly changing, rivers are essential for many communities where life without living waters would be impossible.

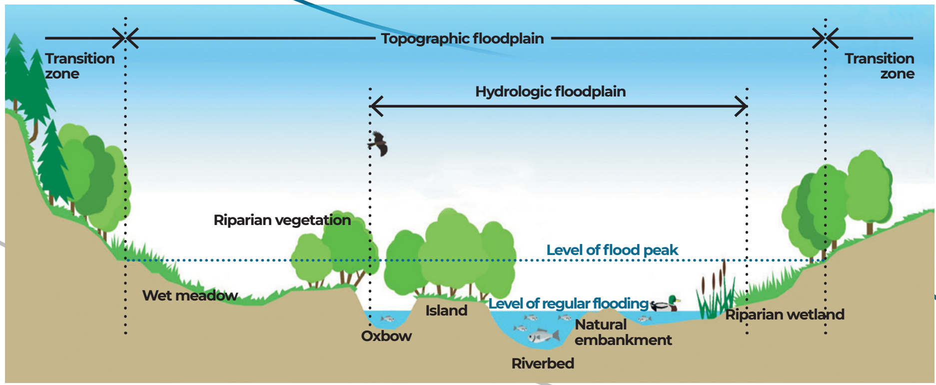
Many indicators can be used to determine the health of a river, from biodiversity to species density and water flow. The EU's Water Framework Directive, for example, uses indicators for biological, hydromorphological (river bank structure, river continuity, substrate of riverbed), physical-chemical and chemical quality. From an ecological point of view, a healthy river is an interconnected network of habitats, creating a mosaic of life that exists in a delicate balance, where each element has its function. Gravel in the riverbed provides the perfect structures for spawning of certain fish species; side channels are sanctuaries for young fish looking to escape predators. Meanwhile, floodplains provide food for a host of different species, filter drinking water and protect our communities from weather extremes and floods.

The aim of this publication is to explain the importance of dynamic rivers by focusing on fish species and emphasizing the importance of preserving a river's free flow and natural dynamics, not only to preserve habitats but also to provide benefits to communities that live near them and depend on their living waters.

The publication offers an overview of basic river terminology, as well as explanations of river dynamics, types of rivers, threatening factors, and the contribution of restoration to the conservation of fish and their habitats, as well as the positive impacts on our communities.

Transverse structure of the river corridor

According to Bayley, Peter, 1995. Understanding Large River-Floodplain Ecosystems. Bioscience, March, 1995, Vol. 45, No. 3, page 154, fig. 1. in FISRWG (10/1998). Stream Corridor Restoration, revised and added by Stoyan Nikolov, Stoyan Mihov and Ivan Hristov



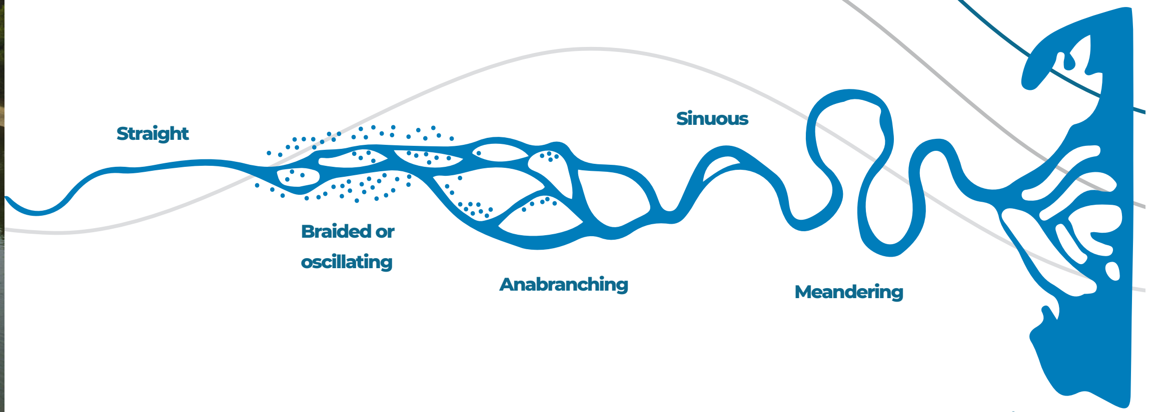
Gravel bar near Repaš

A beginner's guide to river anatomy

Freshwater habitats account for some of the richest biodiversity in the world, and rivers are vital, vibrant ecosystems for many species. Rivers are essential for the protection of numerous plant and animal species, and humans depend on them for various functions and services they provide. As the way we use rivers has an indirect impact on people's lives, people should understand some links and have a role in protecting rivers' and adjacent habitats' status. In order to understand how we can best contribute to river protection and reduce the risks affecting them, it is necessary to fully understand the role and functions that rivers fulfil.

The most basic component of a river corridor is the **riverbed**. This is a naturally lowered landform, usually used as a passageway for flowing water. The next component is the **floodplain** – the neighbouring part of the riverbed, flooded by high water at different intervals, from very often to seldom. The floodplain may be situated on just one or both river banks, depending on relief.

Although these are the components that make up each river, there are also different ways in which they create different types of rivers. We can classify them into two groups: **natural** river types, and types that are a result of human activity - **artificial** river types. Due to river regulations the majority of rivers have mostly artificial stretches but there are still some which have alternating natural and modified, or artificial stretches.

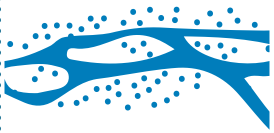


NATURAL RIVER TYPES

Straight

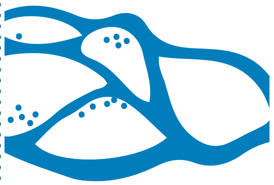
A **straight** river type occurs in upper river reaches close to the source, which is typical for Alpine mountain regions. Stretched river sections dig themselves into the soil (deep erosion) and create valleys, gorges and ravines.

Braided



A **braided** river divides into numerous branches and side channels, caused by a high bedload in combination with medium to high gradients. Often the entire valley floor is occupied.

Anabranching



An **anabranching** type is a mixed type between braided and meandering river forms. The course of the river already shows meander bends, but locally there are also river bed extensions with island formations (branches).

Sinuous

The river course of the **sinuous** type is more curved but has no or only a few meander bends. It occurs in wider river reaches, and some braiding with islands may occur locally.

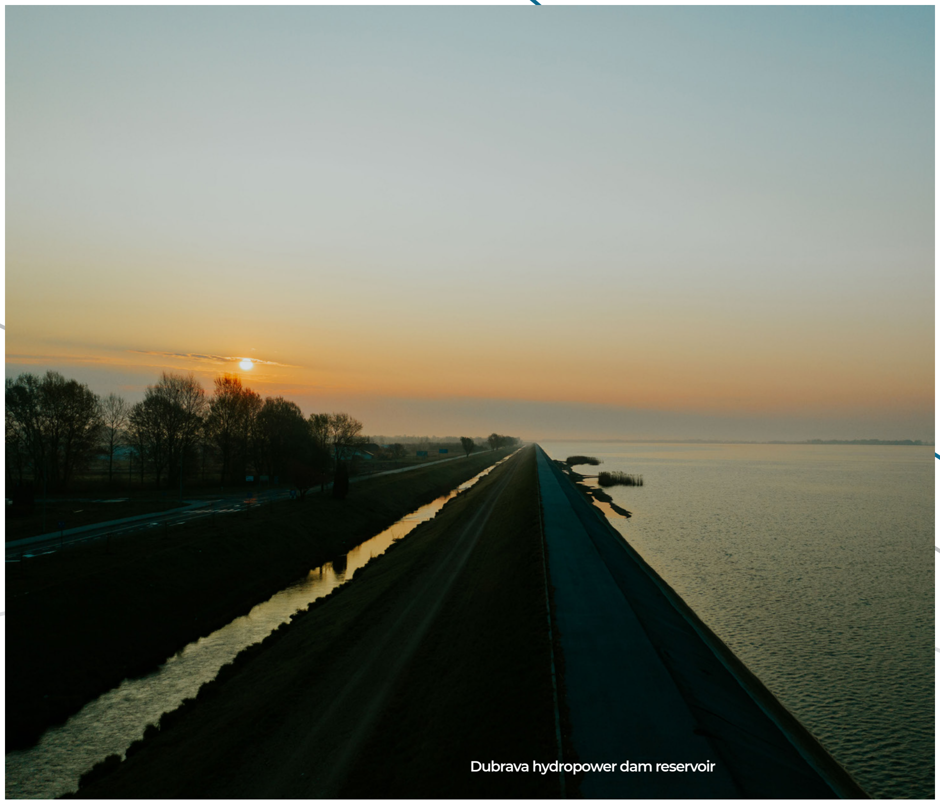
Meandering

The **meandering** river type describes a strongly winding river course, consisting of a sequence of successive river loops (“meanders”). Meander bends can “wander” and might touch in doing so, thereby cutting off isolated oxbows and shortening the course of the river. A special variant of a meandering river is an incised meander that cuts down into the bedrock and results in a meandering form of the river valley.

Artificial river types

Artificially modified stretches are created for different purposes - flood protection, navigation, hydropower needs, irrigation, flow regulation, recreation, water sports, etc. Very often a straight river type results from anthropogenic modifications (channelizations).

Dammed-up river types can be impoundments of run-of-the-river power plants or large reservoirs where water is accumulated for immediate or future use (e.g. power generation or flood control). In **regulated** rivers the banks are usually protected. They can either look similar to naturally flowing rivers or resemble narrow canals.



Dubrava hydropower dam reservoir

Common nase (*Chondrostoma nasus*)

European mudminnow (*Umbra krameri*)

Streber (*Zingel streber*)

Why connectivity matters

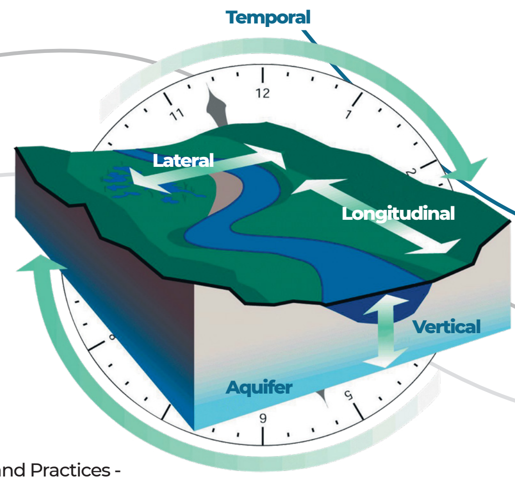
Rivers are living ecosystems that flow and constantly change. To understand river dynamics, it is necessary to look deep underwater without losing sense of the river's surroundings above water.

Rivers like the Mura, Drava and the Danube in the UNESCO 5-country biosphere reserve are complex systems with a multitude of habitats along a longitudinal and lateral gradient. This means that the dynamics of a natural river produces different physical conditions (water depth, flow velocity, substrate composition, water chemistry and temperature, etc.) at different points in the river.

While **longitudinal connectivity** refers to the pathway along the entire length of a stream and all processes that occur from the river source to the mouth, **lateral connectivity** refers to the connection of the main course of the river with side tributaries. Reinstating and the improvement of lateral and longitudinal connectivity benefits riverine species that depend on floodplains and backwaters to complete their life cycle processes. This is particularly relevant for many fish species that need a variety of habitats during their life cycle.

For example, the nase usually migrates upstream or into tributaries to spawn in relatively shallow, fast-flowing gravel sections of the river. Here, the eggs will develop, but juveniles will shift towards very slow flowing sections in search of food. As they grow larger, they will shift further downstream. If all necessary habitats are not available, the nase will be unable to complete its life cycle.

In addition, there are several species that are adapted to very specific conditions, like the mudminnow which needs warm, stagnant water bodies with lots of vegetation; or the streber, which lives on the bottom of fast flowing river sections with lots of gravel. Altogether, species population in a river depends on the longitudinal and lateral connectivity. The less connectivity there is, the lower the biodiversity will be.



The four dimensions of river connectivity.
Stream Corridor Restoration: Principles, Processes, and Practices - The Federal Interagency Stream Restoration Working Group (FISRWG) . GPO Item No. 0120-A; SuDocs No. A 57.6/2: EN 3/PT.653. ISBN-0-934213-59-3

Huchen (*Hucho hucho*)

Sterlet (*Acipenser ruthenus*)

Some sturgeon species, such as the sterlet, live exclusively in freshwater habitats. They inhabit rivers, lakes, ponds and other freshwater ecosystems. However, most sturgeon species spend the majority of their lives in saltwater, and migrate to freshwater only for spawning.

According to the IUCN "Red list of threatened species", sturgeons are the most endangered group of species in the world, with only a few natural habitats remaining across the world that provide them with adequate conditions for survival. One of the regions in Europe where natural sturgeon populations still exist is the lower course of the Danube River (downstream of the Iron Gate II Hydroelectric Power Plant) and the northwestern part of the Black Sea.

For sturgeons to breed, they need suitable spawning grounds. These are usually solid surfaces made of clay, gravel or stones where sturgeon larvae can shelter from predators and torrents in the nooks and crannies. However, field research is expensive and insufficient, leaving us with little information about the sites that are key sturgeon habitats along the Danube basin.

Threats to fish populations

Rivers have been shaping human lives since our ancestors first appeared on the evolutionary tree, when they started looking for ways of adapting nature to their needs. Extensive regulation heavily impacted freshwater ecosystems, leading to their degradation and causing them to become globally the most endangered ecosystems, with the biggest species decline. Due to flood protection, floodplains become split into active and inactive floodplains, the former between river and the flood protection dykes and often very small or non-existent, the latter outside of the flood dykes, on historical floodplains.

River channelization by construction of embankments for flood defence or for providing lands for agriculture led to loss of habitats but also to riverbed incision, which in the end affects water organisms and lowers groundwater levels.

Interrupting river courses by barriers such as **dams, hydropower plants, weirs, groynes and other transverse structures** affects the longitudinal connectivity (pathways along the entire length of a stream) and has a serious impact on migratory fish species, as such structures also disrupt the connectivity for sediment, water and nutrients. Migratory routes are very susceptible to the effects of physical barriers such as dams. After a dam is built, the fish remain trapped downstream in search of suitable spawning grounds, many of them unable to complete their journey to spawning areas upstream of the dam. Barriers also disrupt connectivity with floodplains which destroys essential habitats for fish spawning; some of them increase the risk of floods.

Another extreme effect of hydropower in terms of how it affects fish and other species is **hydropeaking**. It is the discontinuous discharge of water from hydropower plants due to peaks of energy demand which causes fluctuations of flow downstream of reservoirs. For fish, especially smaller species or the young fry, hydropeaking leads to

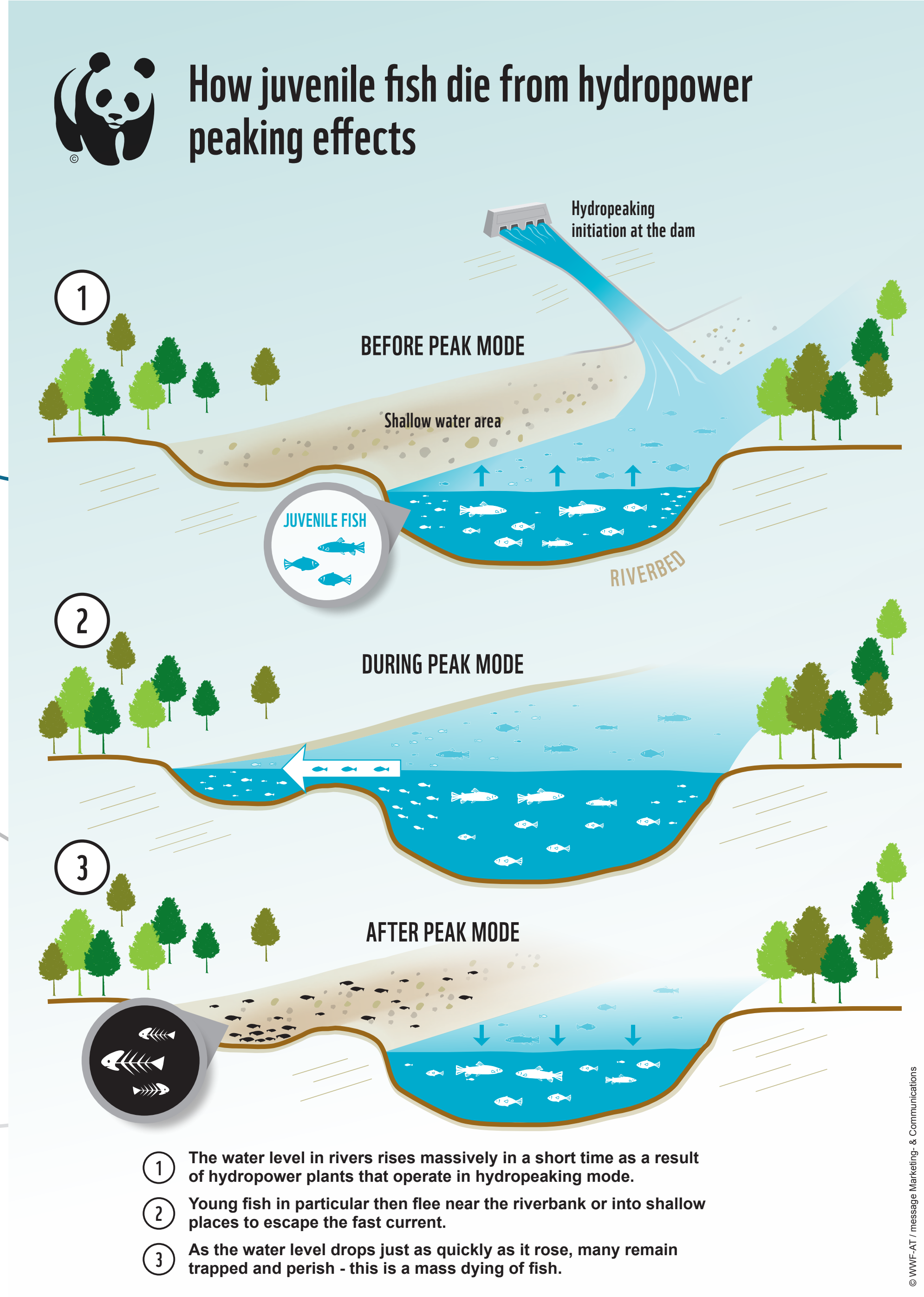
Flood protection dyke along the Kopački Rit Nature Park, cutting into the riverine landscape

Dubrava hydropower dam, last one on the Drava River

a trap - shallow waters are such fish' preferred area for swimming and feeding, so hundreds or thousands of such individuals are tricked into swimming to basically dry land, becoming trapped and eventually die. More often than not, water recedes completely and the little water that remains dries out before a second flooding occurs. This is typical on mountain rivers, while on alluvial rivers waves generated by ships might cause similar phenomena. Further threats that endanger fish populations, habitats, and entire ecosystems are **land use changes** with a multitude of negative effects through intensification and increased erosion, and the **draining of riparian wetlands** mostly for agriculture by cutting off their link with the river.

Sand and gravel are not just the most important food for rivers, but also two of the most extracted materials in the world, and their global demand is a driver behind the mining for these resources. Their uncontrolled exploitation irreversibly changes the appearance of rivers. Sediment deficits, already high due to hydropower dams, are exacerbated by mining, and change the river morphology causing rivers to become more narrow, even without channelization. Sediment-starving rivers show less tendency to form bars and suffer from channel incision. If the river has sufficient width and sediment supply, erosion and aggradation would often occur, with fresh depositions creating loosely packed gravel. Extraction of sand and gravel also has great impact on local communities since it leads to riverbed incision and lowering of groundwater levels, which is crucial for drinking water supplies. More information about sediment and related issues can be found in the ***Living sediment*** publication.

Water pollution is also closely related to our increased needs for resources, population growth, economic and technological development, intensive forms of



agriculture as well as the growth of living standards. Unfortunately, this development usually is not followed closely by equivalent improvement of water treatment that could mitigate some of these problems. Long-term deposition of waste materials from large industries can be a major challenge for the environment, as well as an intensive form of agriculture, relying too much on chemicals for pest control and fertilization, and being too close and without a buffer to the river. Pollutants that reach the river change its physical, chemical, and biological properties, endangering habitats of fish and other species.

Disconnected floodplains cannot act as natural filters anymore and fail to absorb harmful chemicals and other pollution.

Inland navigation is another major threat to fish habitats, mainly due to navigation-enabling activities that might include a variety of physical interventions in the riverbed, such as dredging or construction of structures to create a navigable fairway. The biggest pressure is that the extreme low water levels are the most critical to the species and to the fairway conditions. Ships travelling at a fast pace further cause waves with an effect in side


River Drava bottleneck with visible gravel bar and different types of river infrastructure

Construction boat near embankment

channels and wetlands similar to those of hydropeaking. Another effect comes from navigation itself: the faster a cargo vessel sails, the greater the physical forces caused by the vessel's passage resulting in drawdown, bow and stern waves as well as return currents, with significantly negative impacts on riverine habitats. The frequency of the ship traffic is also a significant impact, since the high traffic causes continuous pressure.

Unsustainable human practices throughout the centuries led to **climate change** and their consequences are reflected in our daily lives. The impact of climate change is even more severe on the nature that sustains us. More frequent and intense droughts, storms, heat waves or changing weather patterns are just some of the factors that impact freshwater ecosystems. Moreover, climate change leads to changing weather patterns which then consequently leads to a changed river flow. With the rise of air temperature, water temperature rises in freshwater ecosystems, also affecting the ability of fish to grow and reproduce. For freshwater ecosystems, the most important adaptation challenges are linked to greater runoff, erosion and nutrient loads.

Reversing the trend

To reverse negative trends for freshwater ecosystems, different solutions need to be implemented. From **commitment of decision makers**, implementation of **integrated river management**, **cross-sectoral and cross-border cooperation** to concrete **nature conservation** measures, and in particular **river restoration**.

The restoration of large rivers and reconnection of floodplains and their associated habitats has become a critical component of river ecosystem restoration. Functioning rivers and floodplains are of vital importance for people - they provide access to drinking water, flood retention, opportunities for tourism development and recreation, protect our communities from droughts and floods, reduce the impact of climate change, and have a positive impact on our health and wellbeing. When this functionality is compromised, it not only changes nature and natural flows but also affects people's daily lives. This was recognized by the UN and led them to declare this decade a decade of restoration. In the European Union, the Biodiversity Strategy for 2030 set a goal to restore at least 25,000 km of rivers into free-flowing rivers by 2030 through the removal of obsolete barriers and restoration of floodplains and wetlands. Also, new legally binding EU nature restoration targets are under development by the European Commission.

Rivers need to flourish and thrive, to flow freely and have a natural cycle, including different minor levels of floods throughout the year. Implementing river restoration activities could help replenish nature and biodiversity. It will help us to thrive too!

Mura Gradišče restoration site

Drava-Danube confluence

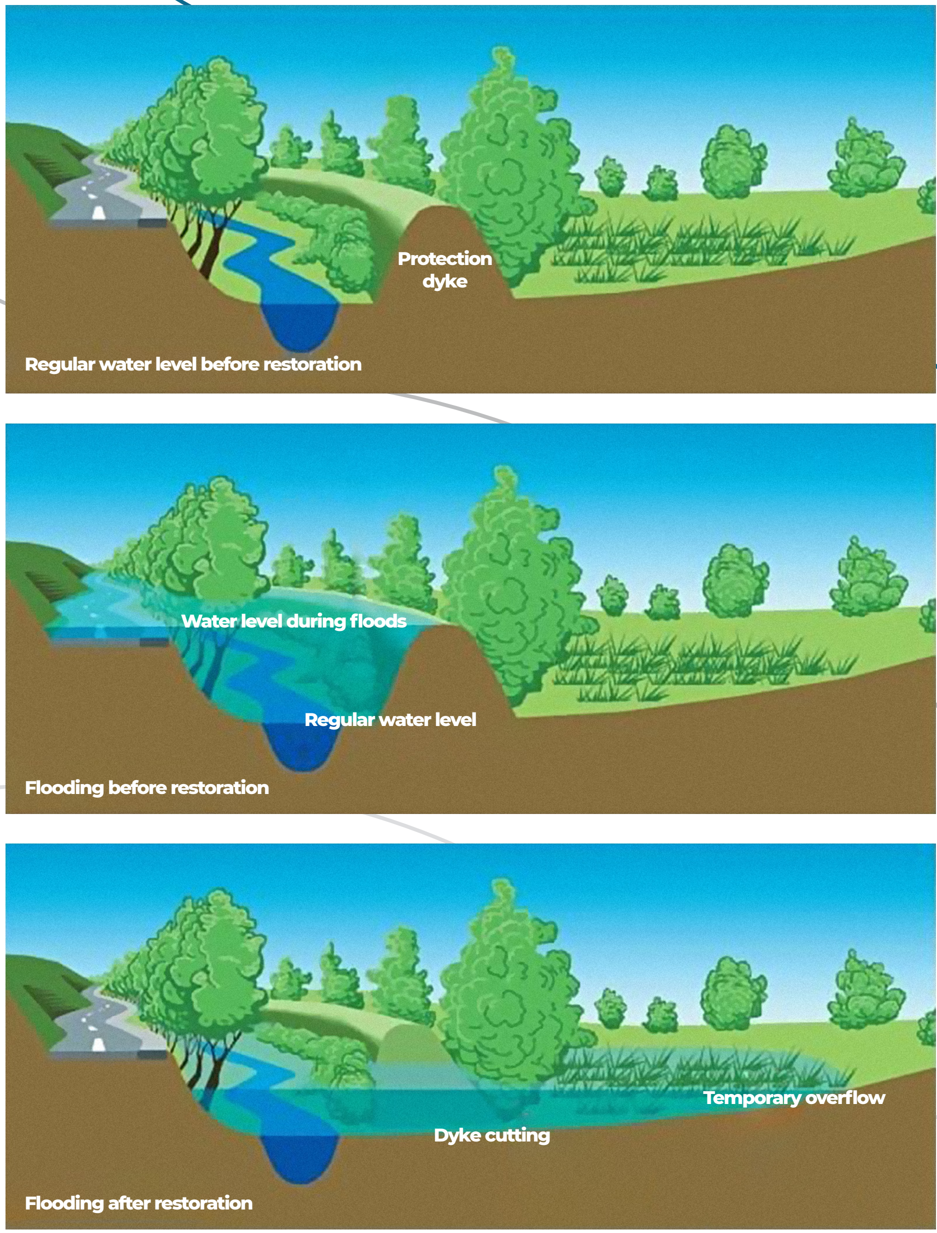
River restoration is the process of improving the ecological and hydromorphological status of a river. Re-establishing natural processes can reshape rivers to provide the diversity of habitats required for a healthy river ecosystem and ensure their long-term recovery. Some rivers have been extensively modified to accommodate societal needs for agriculture, energy, flood protection, and economic activity so it is not always possible to restore to a pristine condition.

When done properly, restoration should never increase flood risk, where human lives or vital infrastructure are at stake. In this context it is necessary to distinguish between the restoration of rivers in less populated areas or areas currently used for agriculture from those in settlements. Outside towns and villages, the dismantling of artificially modified rivers should be encouraged, looking to preserve and restore the riverine area. In an urban area, restoration is possible as well but the priority is to maintain the flow capacity and protect the area while at the same time supporting freshwater biodiversity.

River restoration in a transboundary river corridor needs an integrated approach to be effective, efficient, use synergies as much as possible and provide benefits not only locally but on a transboundary scale. The focus lies on measures for sediment mobilisation & improvement of the sediment balance.

In the scope of the lifelineMDD project, we are conducting scientific studies of biotic factors and abiotic framework conditions prevailing in the 5-country Biosphere Reserve Mura-Drava-Danube, and developing a River Restoration Toolbox showcasing *building bricks* for river restoration. These will serve as a basis for a science-based River Restoration Strategy - for decision makers and a broad network of institutions, stakeholders, and local communities, uniting them in their efforts to preserve and restore the biosphere reserve's most valuable natural resources - our rivers.

Effects of river restoration on flooding



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